Fauna monitoring and staff training: *Western Shield* review—February 2003

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SUMMARY

Objectives

The objectives of *Western Shield* for fauna monitoring and staff training were to develop a methodology and establish monitoring sites in key areas under fox control and to ensure Department of Conservation and Land Management (CALM) staff were given appropriate training and guidelines to undertake the monitoring. The methodology and monitoring was to be of a standard to be able to demonstrate recovery or otherwise of extant and translocated fauna.

Achievements

Forty monitoring sites have been established in the south-west of Western Australia from Kalbarri National Park north of Geraldton to Fitzgerald River National Park on the south coast. Recovery of at least one of the mammal species present has been demonstrated at 22 of these sites. Increases of some reptile species has also been demonstrated.

A database (the Fauna File) for the recording and management of monitoring data has been developed and distributed to 16 work centres. Though further development is required, it has been readily adopted by these work centres and has facilitated the collation and presentation of data in this review.

A Fauna Management Course was evolved and has developed to facilitate the training of CALM staff to undertake fauna monitoring and other fauna management activities. Since 1997, 97 CALM staff (70 men and 27 women) have completed the course.

Difficulties

Limited resources have restricted the establishment of monitoring surveys using spotlighting, nest boxes or other techniques to monitor fauna not readily trapped. Poor fauna recovery and high staff turnover in some districts has reduced staff exposure to fauna and consequently limited the development of fauna survey competencies of staff in these districts.

Other than two species recovery plans there have been no generic criteria for successful recovery of fauna populations (see Mawson, this issue) and hence assessment of recovery may be subjective for some sites.

The development and maintenance of the Fauna File has been limited by time constraints on the custodian and some districts have experienced problems with bugs in the database or delays in acquiring updates on the database software. Time constraints on the *Western Shield* Zoologist have also made it difficult to service remote centres.

Incorrect or inconsistent use of *Western Shield* account codes has made it difficult to track expenditure on *Western Shield* fauna monitoring activities.

Potential economies

Survey effort at some sites has been above *Western Shield* requirements and some savings could be made by reducing the survey effort (e.g. number of traps or survey frequency) to within *Western Shield* standards. Reduction of monitoring sites could also achieve some savings but is not recommended on account of the high variation in monitoring results across sites.

The sharing of resources between neighbouring districts has the potential to create savings as well as enhancing the development of district staff.

Potential improvements

Formal annual reporting and reviewing of monitoring results from all sites is recommended now that a functional data collection and management system is in place and several years of data have been collated for the majority of sites. Integration of environmental data is also recommended. This activity will help to identify successes, problems and failures and aid the decision-making process for the 'adaptive management' of areas and species under *Western Shield*.

The capacity for district staff to be able to manage and use the data collected during monitoring activities is very important for maintaining the momentum for the *Western Shield* program. Further development of the Fauna File with particular emphasis on GIS functionality will greatly increase the capacity of districts to manage and use data and will increase monitoring efficiency. Improvements to the physical performance of the CALM intranet system could greatly increase the efficiency of central data management.

More resources are needed to further the development of The Fauna File database, the completion of accreditation requirements for the Fauna Management Course and the development and implementation of a field accreditation system for fauna survey skills.

INTRODUCTION

Western Shield is a predator control and fauna recovery program initiated by CALM. It covers 3.6 million hectares of state forest and conservation estate in the southwest of Western Australia, primarily covering the area from Kalbarri south and east to Cape Arid, with additional sites in Shark Bay, Cape Range and isolated locations of rock-wallaby populations in arid regions.

Fox control is achieved through the distribution of dried meat baits containing 4.5mg of monosodium fluoroacetate (1080) either by ground or aerial delivery, or a combination of both. The control of foxes by this method has facilitated the recovery of a number of mammal (and one bird and one reptile) species that remain extant in the southwest of WA. Five mammal species have become extinct in the south-west but have surviving populations elsewhere. The recovery of these species, and other species that have become locally extinct, can be further enhanced by translocation to suitable areas where fox control is being implemented.

An internal CALM document that outlined the objectives and the implementation of *Western Shield* was first prepared in 1995 (Burbidge *et al.* 1995). This document identified a network of 'Fauna Reconstruction Sites' and 'Species Recovery Sites' that would 'ensure both the conservation of currently existing threatened mammals and the reconstruction…of the original mammal fauna'. It also provided a list of the species that would benefit from this recovery program.

The mission, principles, priorities, objectives and strategies of *Western Shield* have since been formalised in the '*Western Shield* Fauna Recovery Program Strategic Plan July 1999 – June 2004' (CALM 1999). There is a focus on the recovery of extant fauna and on fauna reconstruction through translocation. The document provides an expanded list of proposed fauna reconstruction sites and species recovery sites by species and by CALM region.

The *Western Shield* program was formally launched in 1996 and has now been operating for over six years. Fauna monitoring sites have been established in southwest districts and translocations of fauna to some of these sites have been undertaken. Six training courses have been conducted to support the program by providing the appropriate skills to undertake these tasks. This report reviews the progress, efficiency and results of the fauna monitoring and staff training operations within the Nature Conservation Division following the terms of reference established by the CALM Corporate Executive.

OBJECTIVES OF *WESTERN SHIELD* FAUNA MONITORING

The key objective of *Western Shield* is to 'maximise the recovery of sustainable populations of vulnerable native fauna by reducing the impact of predation by foxes and feral cats' (CALM 1999).

At the time of this review, only foxes have been controlled at an operational scale and this has been achieved by the distribution of 1080 dried meat baits at a density of 5 baits/km^2. The baits are distributed by fixed-wing aircraft at a standard frequency of four times per year over the forest areas and larger reserves, and more frequently from the ground in smaller isolated reserves (up to once a month).

The objective of *Western Shield* fauna monitoring is to measure population trends of native fauna, whether extant or translocated, in areas subject to fox control to assess whether recovery is being achieved. There are two main aspects to consider: (1) have there been changes in population density; and (2) have there been changes in population distribution. A recovering population may be expected to show an increase in the number of individuals as well as spread into unoccupied areas of suitable habitat. This requires the use of repeatable techniques that can measure the relative changes in abundance over time and area. Fauna monitoring may also enable an assessment of the importance of factors other than fox predation. These include climate effects, predation by native predators, competition between native species and habitat choice in species that have been reintroduced to areas outside their current distribution.

Fauna targeted for recovery under *Western Shield*

The species of fauna that have suffered the most decline in Australia are primarily mammals ranging in weight from 35 g up to 5500 g, the 'critical weight range' (Burbidge and McKenzie 1989). Also included are some reptiles and ground-nesting birds. The species occurring in WA that fall into this category are listed in Table 1. Most of these species are particularly vulnerable to predation by introduced predators, mainly foxes, and several have shown remarkable recovery where foxes have been controlled.

Those species that are readily observed via simple survey methods, and have shown clear positive responses to fox baiting are targeted by *Western Shield* monitoring programs to measure the effectiveness of fox baiting at selected sites. These species are referred to as 'indicator species' (Table 1). Further recovery of the species listed in Table 1 will be achieved through their translocation to suitable fox baited sites. Species with a mean adult body weight of 500 g up to 2500 g are herein referred to as 'medium-size mammals'.

TABLE 1

Species that form the focus of *Western Shield* recovery activities. (Cons status = Conservation status: Schedule 1 = species listed as 'rare or likely to become extinct' under the *Wildlife conservation Act*; Priority = species listed on CALM's Priority Fauna list. Ind = Indicator species. Tran = Species subject to translocation proposals: CB = captive bred for translocation; WC = wild-caught for translocation; B= both CB and WC; CI= incubated in captivity for translocation).

COMMON NAME	SCIENTIFIC NAME	CONS STATUS	IND	TRAN
Chuditch	*Dasyurus geoffroii*	Schedule 1	X	CB
Dibbler	*Parantechinus apicalis*	Schedule 1		CB
Brush-tailed phascogale	*Phascogale tapoatafa*	Priority 3		
Red-tailed phascogale	*Phascogale calura*	Schedule 1		WC
Numbat	*Myrmecobius fasciatus*	Schedule 1		B
Bilby or dalgyte	*Macrotis lagotis*	Schedule 1		CB
Quenda	*Isoodon obesulus fusciventer*	Priority 4	X	WC
Western barred bandicoot or marl	*Perameles bougainville bougainville*	Schedule 1		CB
Woylie	*Bettongia penicillata ogilbyi*	Priority 4	X	WC
Boodie	*Bettongia lesueur lesueur*	Schedule 1		CB
Gilbert's potoroo	*Potorous gilbertii*	Schedule 1		CB
Rufous hare-wallaby or mala	*Lagorchestes hirsutus*	Schedule 1		CB
Banded hare-wallaby or mernine	*Lagostrophus fasciatus*	Schedule 1		CB
Black-flanked rock wallaby	*Petrogale lateralis lateralis*	Schedule 1		WC
Quokka	*Setonix brachyurus*	Schedule 1		
Tammar wallaby	*Macropus eugenii derbianus*	Priority 4	X	WC
Western brush wallaby	*Macropus irma*	Priority 4	X	
Brushtail possum	*Trichosurus vulpecula*	Not listed	X	
Western ringtail possum	*Pseudocheirus occidentalis*	Schedule 1		WC
Greater stick-nest rat	*Leporillus conditor*	Schedule 1		WC
Shark Bay mouse	*Pseudomys fieldi*	Schedule 1		CB
Western ground parrot	*Pezoporus wallicus flaviventrus*	Schedule 1		WC
Noisy scrub-bird	*Atrichornis clamosus*	Schedule 1		WC
Western bristlebird	*Dasyornis longirostris*	Schedule 1		WC
Malleefowl	*Leipoa ocellata*	Schedule 1		CI
Western swamp tortoise	*Pseudemydura umbrina*	Schedule 1		CB

SURVEY METHODOLOGY

There are a number of different survey methods that can be used to measure relative changes in abundance. Some key aspects to consider in choosing the most appropriate methodology are:

1. ***Sampling/observation technique*:** The choice of physical methods of capturing or observing fauna will depend largely on the target species, the information required, the resources available and the availability of the appropriate skills. Methods that accommodate the widest range of species will provide the greatest return for effort. The choices appropriate for Western Shield include:

   Trapping – various trap designs available to target different species

   Nest boxes – suit arboreal species that nest in hollows

   Hair tubes – suit species with unique hair characteristics

   Sighting surveys including spotlighting – suit species that are conspicuous when active

   Call surveys – suitable for birds and frogs

   Searching for scats, tracks and other traces.

2. ***Survey design*:** The layout or distribution (design) of the sampling/observation effort will influence the quality and quantity of information gained. The most appropriate design will depend on the area of interest and the area utilisation by target species. *Western Shield* is largely concerned with medium size mammals, most of which generally occupy home ranges of more than 2 ha, and the recovery of these species at the landscape level. The two main choices applicable to mammal sampling are grids and transects. While grid designs allow intensive sampling of small sites and provide detailed information on population densities and demographics of the species present, transects allow the sampling of a wider variety of habitat types and provide information on species occurrence and abundance at the landscape level. Transects are also better suited for detecting species that occur at lower densities across a range of habitats. Clearly, transects are the preferred choice to meet the objectives of Western Shield.

3. ***Sampling time and frequency*:** The most appropriate timing and frequency of sampling or observations is dependent partly on availability of resources and partly on the life histories and ecologies of the target species. Whilst it is acknowledged that the activity of some species vary between seasons and are more readily observed during particular times of the year it is the changes in abundance beyond seasonal influences that is of concern to the objectives of *Western Shield*. For the major indicator species, sampling once a year is sufficient to demonstrate any changes in abundance, however more than three years are required to demonstrate meaningful trends. It must be noted that seasonal variations in activity of some species is usually

associated with breeding and sampling should be avoided during the sensitive periods when it might interfere with the rearing of young. Where sampling targets shorter-lived species, for example rodents, small dasyurids, some reptiles and frogs, there is merit in sampling more than once a year.

4. ***Data and statistical analysis*:** Western Shield is firstly concerned with relative changes in the abundances of fauna as a measure of response to fox control. The most basic abundance estimate that can be applied to all methods is the number of samples or observations per unit effort. More complex abundance estimates can be applied to some sampling methods or combination of sampling methods where the appropriate data has been collected.

Using these factors, the most appropriate methods can be identified for each target species to reveal the most appropriate monitoring strategy for *Western Shield*. Table 2 shows the range of choices for each target species. Some sampling methods, particularly hair-tubes, trapping and spotlighting, are applicable to a range of species and are obvious choices for a monitoring strategy.

Most fauna monitoring for *Western Shield* was to be carried out by CALM district operations staff as part of their normal workload, but initially the pool of skilled and experienced operations staff was very limited. In addition, the nature of district operations is such that many tasks, especially in the field, are shared amongst several people depending on available resources and other district works. Therefore, limited skills, variations in individual abilities, and staff changes had to be considered along with training staff in the use of the survey methods within practical constraints of available resources and venues.

Hair-tubes

Hair-tubes are a low-cost method of surveying for the presence of a range of species that requires no animal handling in the field and has the potential to provide some limited abundance data. However, expertise is required to process and identify hair samples collected but such expertise is practically unavailable within CALM, or even Western Australia, on the scale that would be required to meet current monitoring program requirements. Even if training could be provided it is still beyond the practical limitations of most CALM districts to maintain a basic laboratory with suitably qualified staff. This would limit the degree to which individual districts could manage their own data collection which, in turn, has implications for motivating districts to maintain fauna monitoring activities when resources are limited. There is also a time lag between the collection and identification of hair samples that could lead to significant delays in data collation, especially if the availability of expertise is limited.

Despite limitations, hair-tubes are a useful method to employ for particular purposes. They have been used to survey for rare species in areas that are difficult to access (e.g. surveys for Gilbert's potoroo by CALM Science Division) and also by community groups to survey local areas not monitored by CALM. Hair-tubes have not been considered appropriate for a broadscale monitoring method for *Western Shield*.

Trapping

Eleven of the twenty-one species listed in Table 2 can be caught in small cage traps (20 cm x 20 cm x 56 cm, Sheffield Wire Co) and eight of these can be caught with varying degrees of success using universal bait (a mixture of rolled oats, peanut paste and sardines) in cage traps placed at 200 m intervals. Four of these species – chuditch, brushtail possum, quenda and woylie – are relatively widespread in the southwest forests and parts of the wheatbelt and south coast and have shown good responses to fox control in pre-Western Shield monitoring sites. Trapping transects using small cage traps baited with universal bait and set at 200 m intervals has been adopted as the standard survey method for *Western Shield* and remains one of the most appropriate survey methods. The standard transects use 50 or 100 cage traps which equates to 10 or 20 km of transect respectively. This provides good area coverage as well as sampling a variety of habitats. Elliott (type A) traps (9 cm x 10 cm x 33 cm, Elliott Scientific Equipment) may also be used at the same trap locations or placed on smaller separate transects. Transects are trapped for three to five nights (usually four nights) at least once a year, generally in autumn as this is the period when most species of mammal are least likely to have vulnerable young.

Percent capture rate is used as the most basic measure of abundance from trapping data. In this review, capture rates have been calculated for each day by site and species and then averaged over each trapping period to give a percent mean daily capture rate with a standard error. This method does not distinguish between newly caught animals and recaptures. All medium-sized mammals caught are tagged to identify individuals. Where appropriate and where data on individual identification is of a sufficient standard, the number of individuals known to be alive (KTBA) is calculated and provided to supplement the information provided by mean daily capture rates. KTBA provides a better indication of population size and is particularly useful for analysing monitoring data from sites used to source translocations. However, KTBA figures can be altered by every subsequent survey if captures include previously caught individuals that have eluded capture during the last preceding surveys, thus adding to the number of individuals known to be alive for each survey since its last previous capture. Figures for the latest surveys can therefore be proven to be underestimates by the next survey.

Tagging of animals

There are some problems associated with ear tags. Some animals such as quenda have small ears and a tendency to lose tags. The loss and replacement of ear tags can cause

problems with retaining individual identification. The ear tags are small to suit the size of the animals caught and many people find them difficult to read, consequently errors occur in reading and recording ear tags and this often leads to problems when entering data into the Fauna File database. Microchip implants are the best alternative for individual identification but the cost of the implants and the scanners make their use on a large scale too expensive.

Small mammals, reptiles and frogs are not marked for individual identification. Small mammals are ear notched once to indicate capture and usually marked with a temporary dye or similar to identify recaptures from the same survey period.

Spotlighting

At least five of the species listed in Table 2 can be readily observed at night using a spotlight. This method is particularly useful for species such as brush wallaby and western ringtail possum that are not easily trapped but are reasonably conspicuous at night with the aid of a spotlight. The standard spotlighting survey design under the *Western Shield* program is a driven road transect of at least 10 km. The density of vegetation significantly affects the visibility of fauna during surveys and transects are generally located through more open habitat. Visible activity of animals is highly variable over time along given transects and at least two consecutive nights of spotlighting is considered necessary to provide more consistent or reliable data. A sighting rate given as the number of sightings of particular species per 10 km is used as a measure of relative abundance.

Nest boxes

Some species are difficult to trap and are rarely observed by spotlighting. Of particular interest in the south west forests is the brush-tailed phascogale. This species is arboreal and nests in tree hollows and nest boxes have been used successfully to survey for its presence. A phascogale monitoring project was initiated in 1993 by Susan Rhind of Murdoch University and Alcoa of Australia Limited. The project used nest boxes and aimed to survey the presence of phascogales and to monitor their response to fox control and the impacts of the rehabilitation of bauxite mine sites. Nest boxes were erected at ten sites in state forest and rehabilitated mine sites, and phascogales were recorded in some of these sites (Rhind and Nichols 2000). Some of these sites were inherited by CALM with the intention of incorporating them into the *Western Shield* fauna monitoring program. Only one site, Julimar State Forest (proposed Conservation Park), is still monitored and has not shown any evidence of the presence of phascogales.

CALM districts encompassing the south west forests have been encouraged to establish transects of nest boxes to monitor brush-tailed phascogales. Nest boxes have been erected along W*estern Shield* monitoring transects in the northern half of Donnelly District (formerly Manjimup District). To date they have not been successful in showing positive signs of phascogale presence although phascogales have been recorded extensively in the Kingston and Perup forest areas.

Recording of survey data

Standard data recording sheets have been developed by the Western Shield Zoologist for use by district personnel to record survey data. The data sheets assist by prompting the recording of standard and specific information, and also facilitating the transfer of data into a database. Generally the data sheets have been used effectively, and they are filed and stored in district offices. The manner of filing has varied between districts and some standardisation in the filing of data sheets is required.

Although data sheets provide a reliable back up for digital data, the technology is now readily available in the form of data loggers to record field data digitally. Data loggers significantly speed up the process of collecting data and transferring it into databases and may be far more efficient than the traditional method of recording data on paper. Future trials may be conducted in CALM's South West Region where data loggers are already used in survey and monitoring work.

CURRENT MONITORING SITES AND METHODS

Monitoring sites have been established in the southwest from Geraldton to Esperance (including the wheatbelt). The number of sites in each CALM district varies greatly depending on the extent of 1080 baiting, connectivity of baited areas and the resources available. Many sites were identified as 'fauna reconstruction sites' in Burbidge *et al.* (1995) and in the strategic plan (CALM 1999). Other sites have generally been selected on the basis of the habitats represented, accessibility, and any known fauna populations or historical data. The selection of these sites, as well as the location of monitoring transects and grids, was largely determined by district staff with assistance from Science Division and Wildlife Branch. Trapping has been adopted as the main method of monitoring fauna recovery and the current monitoring sites and the survey design used are summarised in Figure 1 and Table 3 by CALM regions.

DEVELOPMENT AND USE OF THE FAUNA FILE DATABASE

The development of a generic database to store and manage data collected from fauna surveys began in 1995 by the author in order to service current research projects and District fauna survey requirements. A relational

TABLE 2

Survey methodology applicable to *Western Shield* target species (mammals). Methods (listed in order of suitability): TR = trapping, HT = hair-tubes, NB = nest boxes, SL = spotlighting, DS = driven daytime sighting survey, DG = survey for diggings, TS = tracks, scats and other traces. Trap types in parenthesis: sc = small cage traps, lc = large cage traps, br = Bromilow traps (see Kinnear *et al*. 1988), me = medium Elliott traps. Bait types: U = Universal; A = Apple; B = Bread; C = Chaff, M = Meat offal, O = Oats, S = Special mix with essences. Design = survey design. Interval = distance intervals between sampling points (e.g. traps). Optimum time: indicates the most appropriate time of year for monitoring. Dependent young: this refers to the period of time when females have dependent young; **!** indicates that trapping during this time period should be avoided.

SPECIES	METHODS	BAIT	DESIGN	INTERVAL	OPTIMUM TIME	DEPENDENT YOUNG
Chuditch	TR(sc), HT	U, M	Transect	200m	Dec-July	July-Nov !
Dibbler	TR(sc,me), HT?	U	Transect	20-100m	?	?
Brush-tailed phascogale	NBTR(sc,me), HT?	U	TransectTransect	200-300m 100-200m	Jan-June	July-Nov
Red-tailed phascogale	TR(me), HT?, NB?	U	Grid	20-100m	Feb-June, May best	Aug-Oct !
Numbat	DGDS		TransectTransect	200m	Oct-Dec	Nov-Dec
Bilby	TR(sc), DG, HT?	?	?	?	?	?
Quenda	TR(sc), HT, DG	U	Grid or Transect	50-200m	All year, April best	All year, low in April
Western barred bandicoot	TR(sc), HT?	U	Grid or Transect	50-200m	?	?
Woylie	TR(sc), DG, HT	U	Transect	100-200m	All year	All year
Boodie	TR(sc), DG, HT?	U	Transect	100-200m	?	?
Gilbert's potoroo	TR(sc), HT	S	Transect	20-50m	?	?
Rufous hare-wallaby	SL?, HT?		Transect		?	?
Banded hare-wallaby	SL?, HT?		Transect		?	?
Black-flanked rock-wallaby	TR(br)SL	A	TransectTransect	50-100m	?	?
Quokka	TR(lc)TS	A, O	Transect	20-50m	All year?	?
Tammar wallaby	TR(lc,br)SL	O, C	Transect	100m	Nov-April	May-Oct !
Western brush wallaby	SLTR(lc)	O, B	TransectTransect	100m	All year	?
Brushtail possum	TR(sc)SL, TS	U	Transect	100-200m	All year	Aug-Dec
Western ringtail possum	TR(sc mounted in trees) SL, TS	U	TransectTransect	100-200m	All year	Aug-Dec
Greater stick-nest rat	TR(me)	U	?	20-50m	?	?
Shark Bay mouse	TR(me)	U	?	20-50m	?	?

database to record all details of trapping surveys (i.e. trap locations, trap types, numbers of traps used, dates, species captured, morphometric details taken, etc.) was developed using Microsoft Access 2.0. It was made compatible with Geographic Information Systems (GIS) by accommodating geographic coordinates for survey sites and was also expanded to include spotlighting data and incidental observations of fauna. The design allowed some modest data manipulation and graphic report generation. This database application was named the Fauna File and the first version was distributed for use by District staff in 1997.

Distribution

The objective was to have a copy of the Fauna File available to each CALM district to record fauna monitoring activities and results, and to be able to utilise the data for management needs. Initially the distribution of the Fauna File involved setting it up on a single personal computer (PC) in each CALM district office. The district's coordinator for *Western Shield* fauna monitoring became the custodian of the district's database and was responsible for ensuring that data was entered and updated after each monitoring survey. The Fauna File was distributed in this way to fourteen district offices.

This system was cumbersome though it worked reasonably well considering the limitations. Data updates had to be transferred by disc to Wildlife Branch where all monitoring data is collated. This often resulted in delays in data updates though the graphic reports generated by the Fauna File allowed hard copies of monitoring results to be sent via facsimile to Wildlife Branch.

The more serious problems became evident when PCs were upgraded. Failure to make regular backups of data files left many districts vulnerable to the loss of entire data sets. In one instance, a computer upgrade resulted in the loss of over twelve months of monitoring data from St Johns Forest Block covering a crucial time following a woylie reintroduction that appears to have failed. Problems with the filing and storage of the original data have made it irretrievable to date. Districts have now been given instructions on making regular local backups of the Fauna File. A standard format for the filing and storage of original data sheets also needs to be implemented.

At the time when the Fauna File was first being distributed, the CALM office complex in Manjimup had a network link to Kensington. The Fauna File was installed on the network making it accessible to designated staff in the District, Region and Science Division as well as Wildlife Branch in Kensington. The easier access has facilitated faster data transfer and better maintenance of the database.

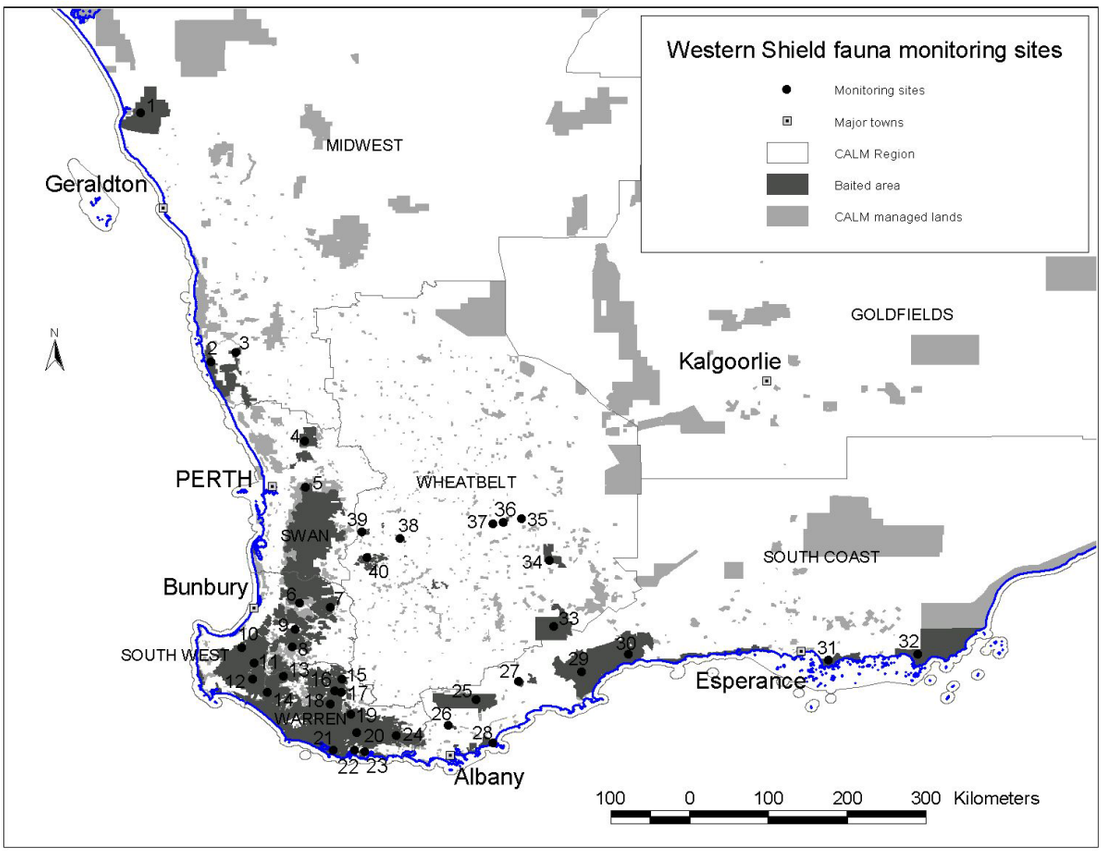

Figure 1. Map showing the location of Western Shield *fauna monitoring sites and the extent of fox baiting in the south west of Western Australia. The number shown with each monitoring site correlates with the site ID number in Table 3.*

As the CALM intranet has improved and expanded a number of districts have or are having the Fauna File transferred from PCs to the network. This will greatly improve the management of the Fauna File and the data recorded. Currently, the speed of data transfers via the network is too slow to allow the use of the Fauna File on-line from one central station, hence local databases are still required.

Improvements and significant changes to the Fauna File have been continually made since it was first distributed. Developing improvements and making changes is very time consuming and it has therefore been a slow process to distribute upgrades of the database. Bugs in the new versions often do not become apparent until the new version has been installed and used in a district. Debugging creates more delays in distributing the new versions to other districts. This has been a problem in the last two years since significant changes to the structure and front end of the database began in 1999 to improve the efficiency of the database and to allow for easier future expansion and improvement of the overall design. The current status of the Fauna File in CALM districts is summarised in Table 4.

Keeping abreast with upgrades in Microsoft Access has also been a problem as these upgrades have become more sophisticated and include some small but significant changes in programming code. Since the author's level of programming knowledge has been limited, the causes of compiling errors during upgrades of the Fauna File have been difficult to find and has lead to significant delays in upgrading to later versions of Access. The current practice is to retain the version currently in use by the Western Shield Zoologist as the current standard version for operating the Fauna File, but upgrades with future versions of the operating software is unavoidable.

Functionality

The currently used version accommodates survey data from trapping, nest box surveys, spotlighting surveys and track count surveys. Other survey methods may be added in future versions. It also accommodates details of translocations and uses the same format as the CALM Threatened and Priority Fauna Database (TPFD) for recording incidental observations of fauna. This has greatly facilitated the collection of data from some CALM districts to add to the TPFD, providing a framework for the better management of threatened and priority fauna. It features standard reference data including a master species list with currently recognised nomenclature for nearly all terrestrial vertebrate taxa. This list is not yet complete for reptile taxa and only includes fish taxa that have been listed as threatened species or priority taxa. Data manipulations and graphic report generation include calculations of trap

TABLE 3

Western Shield fauna monitoring sites indicating site type, survey design and trap types used. NP = National Park; NR = Nature Reserve; SF = State Forest; FB = Forest block. ID = site identification number used in Fig 1. Type: ● = fauna reconstruction site, ❍ = species recovery site (Burbidge *et al* 1995); ▲ = fauna reconstruction site (CALM 2000). Transect/Grid: sc = small cage traps, me = medium elliot traps, p = pit traps, nb = nest box, & = same transect or grid. Trap spacing on transects indicated by * is 100m, all other transects with sc have 200m trap spacing.

CALM REGION	SITE	ID	TYPE	TRANSECT	GRID
Midwest	Kalbarri NP	1	● ▲	100sc & 100me	(2x5p) x2
	Nambung NP	2	●	50sc & 50me	(2x5p) x2
	Badgingarra NP	3	▲	50sc & 50me	(2x5p) x2
Swan	Hills Forest	4	● ▲	55sc x2	
	Julimar SF	5	● ▲	125sc, 20nb	
South West	Centaur FB	6		100sc	
	Batalling Forest	7	●	120sc	
	Noggerup FB	8	●	173sc	
	Catterick FB	9	▲	200sc	
	Wicher FB	10		98sc & 98me	3x5p
	St John FB	11	● ▲	192sc	
	Milyeannup FB	12		106sc	
Warren	Wheatley FB	13	▲	50sc & 50me, 50nb	
	Gray FB	14		50sc & 50me, 50nb	
	Moopinup FB	15	●	50sc & 50me, 50nb	
	Boyicup FB	16	●	50sc & 50me, 50nb	
	Chariup FB	17	●	50sc & 50me, 50nb	
	Tone FB	18	●	50sc & 50me, 50nb	
	Lake Muir NR	19	●	50sc & 50me, 50nb	
	Mt Frankland NP	20	● ▲	100sc & 100me	
	Woolbales Track, D'Entrecasteaux NP	21	● ▲	100sc & 100me	
	Hilltop, Walpole-Nornalup NP	22		100sc & 100me	
	Valley of the Giants	23	▲	100sc & 100me	
	Denmark FB	24	● ▲	100sc & 100me	
South Coast	Stirling Range NP	25	●	50sc & 50me	
	Porongorup NP	26		50sc & 50me	
	Corackerup NR	27	▲	50sc & 50me	
	Waychinicup NP	28	❍ ▲	50sc & 50me *	
	Twertup, Fitzgerald River NP	29	● ▲	50sc & 50me *	9sc & 15me & 15p
	Moir Track, Fitzgerald River NP	30	● ▲	50sc & 50me *	
	Cape Le Grand NP	31	▲	50sc & 50me	
	Cape Arid NP	32	● ▲	50sc & 50me	
Wheatbelt	Lake Magenta NR	33	● ▲	100sc, 10me x10	(5x5p) x6
	Dragon Rocks NR	34	● ▲	100sc & 100me	
	Roe NR	35		25sc, 20me x2	
	North Karlgarin NR	36			(9sc&16me&16p) x5
	Bendering NR	37		25sc, 20me x2	
	Tutanning NR	38	❍	50sc	
	Boyagin NR	39	❍ ▲	50sc x2	
	Dryandra Woodlands	40	● ▲	50sc	

success and sighting rates. The Fauna File can be linked to GIS software such as ArcView, allowing spatial viewing and interrogation of data.

To date development has focused mostly on designing the front end to facilitate data entry with as many error-reducing features as possible. It has taken a long time to identify sources of error and how to rectify them as some of these errors originate from the recording of data in the field. The database has also had to be flexible enough to accommodate a range of possibilities for various types of data and thus cannot screen for all possible errors. When errors have occurred it has taken time to clean up data to enable proper function of the database.

The development of data manipulation features has been slow as these are difficult to develop without clean and complete data sets to test the prototype features. Most of the current features relate to trapping data because this data is the most complete and useable. Data manipulations for other survey methods are deficient due to the lack of useable data. Districts have also been slow to record geographic coordinates of trap locations or other survey points at *Western Shield* monitoring sites thus the development of GIS functionality has also been delayed. The recording of survey point locations has been further confused by an initial lack of awareness of the new geodetic datum, GDA94. Most existing data sets will need to be converted to the new datum.

Future development

Despite the problems associated with improving the functionality, the Fauna File has proven itself to be a valuable data collection and management tool. The collation of monitoring data on the scale of *Western Shield* and the generation of the figures presented in the following section detailing the results of monitoring has

TABLE 4

CALM district and regional offices in which *The Fauna File* software has been installed along with a summary of the status of fauna monitoring data input and type of installation (PC or N=network, (N)=network available) at each location.

DISTRICT/REGION (R)	FAUNA FILE VERSION	TRAPPING DATA	SPOTLIGHTING DATA	FAUNA RECORDS	PC OR NETWORK
Swan Coastal	2.1				PC
Swan Coastal, Mandurah	2.2	Yes			PC
Perth Hills	2.1	Yes			PC
Wellington	2.2	Yes			PC
Blackwood	2.1	Yes			PC
Donnelly	2.1	Yes	Yes	Yes	N
Frankland	2.1	Yes		Yes	N
Albany	2.1	Yes		Yes	N
Esperance	2.2	Yes			N
Merredin	2.1				PC (N)
Narrogin	2.2	Yes		Yes	N
Katanning	2.1	Yes	Yes	Yes	PC (N)
Geraldton	1.2	?		?	PC
Gascoyne	1.2				PC
Moora	2.1	Yes		Yes	PC
Goldfields (R)					
Pilbara (R)					
Exmouth					
East Kimberley	2.1				PC
West Kimberley					

been made considerably easier by its use. It has given district staff a sense of ownership and responsibility for their monitoring programs and the data they collect. It is becoming recognised as an important management tool and further investment in its development is warranted. The development of GIS functionality is a priority.

Its usefulness would be increased significantly if research data on all species could be included as this data is generally inaccessible in digital format and might otherwise be lost. Research data could significantly enhance the value of data collected by districts (and *vice versa*) and could help to generate long term monitoring data for the better management of threatened and priority fauna. There are issues of data ownership and data formatting to be resolved and there would also be an increased burden on the database custodian.

Currently, the Western Shield Zoologist is both the custodian and author of the Fauna File. The maintenance and development of the database program requires skills in database design and application as well as sound knowledge of fauna and fauna survey methodology. The combination of these skills within CALM is currently very limited and therefore the continued maintenance and development of the Fauna File is dependent on the skills and expertise of one person. Time constraints and the possibility of future staff changes leaves the database vulnerable and steps should be taken to ensure better security for its future. Consideration should also be given to migrating the Fauna File to a mainframe environment once the data set becomes too large for a PC or for Access, however this is not likely to be required within the next five years.

The creation of an additional dedicated position within the *Western Shield* program to provide support for the Western Shield Zoologist is warranted. By directing less skilled tasks such as data validation and basic user support to this position, the Zoologist could direct more time to further develop the database and provide better quality of service and support to district and regional staff within the *Western Shield* program. The skills required to carry on the custodianship would gradually be passed on to the new position, thereby providing longer term security.

RESULTS OF MONITORING OPERATIONS

A summary of species recorded in each designated *Western Shield* monitoring site by CALM Region is presented in Table 5 with an indication of whether significant recovery has been observed or no recovery has occurred and the species has declined to non-detectable levels. There have been no clear criteria established to determine successful recovery of fauna populations. For the purposes of this review data are only presented from sites that have been monitored for at least three years. Where species recovery plans have provided criteria for successful recovery, in the form of minimum capture rates, these have been used to assess recovery. More detailed results are presented below.

Recovery sites established pre-1996

Seven key fauna recovery sites were established by the implementation of fox baiting before *Western Shield* was launched in 1996. Monitoring of these sites has been undertaken in various forms since the commencement of baiting, however earlier monitoring data from sites where fox baiting was first implemented for research purposes has been unavailable for this review. While all of these

TABLE 5 (Part A)

Summary of monitoring results from *Western Shield* monitoring sites indicating mammal species recorded, whether recovery has been observed and major declines. C=Caught on monitoring transect; Co=Caught on other survey transects; S=Seen on monitoring transect; So=Seen at other locations; T=Translocated; R=Release of derelicts; dark shading=never recovered and declined to undetectable levels; light shading=recovered, may have subsequently declined.

SPECIES	MIDWEST REGION MONITORING SITES			SWAN REGION MONITORING SITES	
	Kalbarri NP	Badgingarra NP	Nambung NP	Julimar CP	Hills Forest
Echidna (*Tachyglossus aculeatus*)	S			C S	
Chuditch (*Dasyurus geoffroii*)	T C			T C	C
Mardo (*Antechinus flavipes leucogaster*)					C
Dibbler (*Parantechinus apicalis*)					
Brush-tailed phascogale (*Phascogale tapoatafa*)					
Red-tailed phascogale (*P. calura*)					
Dunnart (*Sminthopsis* spp)	C	C			
Numbat (*Myrmecobius fasciatus*)					
Bibly (*Macrotis lagotis*)					
Quenda (*Isoodon obesulus fusciventer*)				T C	C
Western barred bandicoot (*Perameles bougainville bougainville*)					
Woylie (*Bettongia penicillata ogilbyi*)	T			T C	T C
Boodie (*B. lesueur lesueur*)					
Mala or rufous hare-wallaby (*Lagorchestes hirsutus hirsutus*)					
Banded hare-wallaby (*Lagostrophus fasciatus fasciatus*)					
Black-flanked rock-wallaby (*Petrogale lateralis lateralis*)					
Quokka (*Setonix brachyurus*)					
Tammar wallaby (*Macropus eugenii derbianus*)				T S	
Western brush wallaby (*M. irma*)			S	S	
Brushtail possum (*Trichosurus vulpecula*)				T C	R C
Western ringtail possum (*Pseudocheirus occidentalis*)					
Western pygmy possum (*Cercatetus concinnus*)					
Honey possum (*Tarsipes rostratus*)	C	C	C		
Water rat (*Hydromys chrysogaster*)					
Greater stick-nest rat (*Leporillus conditor*)					
Shark Bay mouse (*Pseudomys fieldi*)					
Ash-grey mouse (*P. albocinereus*)	C	C	C		
Western mouse (*P. occidentalis*)					
Heath mouse (*P. shortridgei*)					
Mitchell's hopping mouse (*Notomys mitchelli*)					
Spinifex hopping mouse (*Notomys alexis*)	C				
Southern bush rat (*Rattus fuscipes*)		C	C		
Black rat (*R. rattus*)	C				C
Brown rat (*R. norvegicus*)					
House mouse (*Mus musculus*)	C			C	C

sites have supported recovery of at least one species, declines have occurred in at least one species in each site. All sites have been retained as monitoring sites under the *Western Shield* program and are important reference sites for other recovery and fauna reconstruction sites as fauna recovery and trends in populations can take years to manifest.

Data below are presented from Dryandra Woodland, Boyagin Nature Reserve, Tutanning Nature Reserve, Perup Forest, Batalling Forest, Hills Forest and Julimar State Forest.

Dryandra Woodland

Fox control using dried meat baits containing 1080 was first implemented in part of the main block of Dryandra Woodland in 1982 to investigate the response of the numbat to the removal of foxes (Friend 1990). Substantial increases in the number of sightings along standard transects were observed within three years. Dramatic increases in numbers of woylies and brushtail possums were also observed (Friend 1996). Fox control was extended in 1989 to the whole of the main block and Montague block, and in 1998 to all nine 'satellite' blocks under *Western Shield*.

Trapping has been undertaken in Dryandra Woodland since the early 1990s for various purposes including translocation and assessment of abundance of woylies. Regular monitoring along a designated transect was implemented by Narrogin District in 1995 and results are presented in Fig 2. Whilst five different mammal species have been trapped along this transect only woylies and brushtail possums have been trapped consistently in sufficient numbers to show changes in abundance.

TABLE 5 (Part B)

Summary of monitoring results from *Western Shield* monitoring sites indicating mammal species recorded, whether recovery has been observed and major declines. C=Caught on monitoring transect; Co=Caught on other survey transects; S=Seen on monitoring transect; So=Seen at other locations; T=Translocated; R=Release of derelicts; dark shading=never recovered and declined to undetectable levels; light shading=recovered, may have subsequently declined.

SPECIES	SOUTH WEST REGION MONITORING SITES						
	Batalling	Centaur	Catterick	Milyeannup	Noggerup	St John	Wicher
Echidna	C						
Chuditch	C	C	C	C	C	C	C
Mardo	C			C	C	C	
Dibbler							
Brush-tailed phascogale	C	C	C	C	C	C	
Red-tailed phascogale							
Dunnart (*Sminthopsis* spp)			C		C	C	
Numbat	T S						
Bibly							
Quenda	C	C		C		C	
Western barred bandicoot							
Woylie	T C	T C				T C	
Boodie							
Mala or rufous hare-wallaby							
Banded hare-wallaby							
Black-flanked rock-wallaby							
Quokka							
Tammar wallaby	T C						
Western brush wallaby	S						
Brushtail possum	C	C	C	C	C	C	C
Western ringtail possum							
Western pygmy possum				C			
Honey possum							
Water rat							
Greater stick-nest rat							
Shark Bay mouse							
Ash-grey mouse							
Western mouse							
Heath mouse							
Mitchell's hopping mouse							
Spinifex hopping mouse							
Southern bush rat			C	C		C	C
Black rat		C		C	C	C	
Brown rat		C				C	
House mouse		C				C	

Woylies recovered quickly following the implementation of fox baiting in the 1980s and had become the most abundant medium-size mammal in Dryandra Woodland by the time District monitoring commenced in 1995. Brushtail possums were consistently trapped but in comparatively low numbers. This pattern changed dramatically in 2001 when brushtail possums were trapped in higher numbers than woylies and the trapping figures for the two species were completely inversed by the following year. An additional trapping survey was undertaken on this transect shortly after the April 2002 survey using two traps at each trap point with similar results. The number of woylies known to be alive (KTBA) presented in Fig. 2 suggest that removal of animals for translocation may not be sustainable under the current population density.

Rainfall data from the Bureau of Meteorology for Narrogin and Pingelly indicate below average winter rainfall for the last three years, a trend evident in most of the south-west of WA including Perth (see Figs 24 and 25) and Albany (see Figs 26 and 27). The decline in winter rainfall, suggesting a period of drought, appears to correlate with the decline in woylie numbers. Brushtail possums appear to have become more abundant with the onset of drought. An increase in foraging activity on the ground due to changes in quality and abundance of food supply as a result of drought may have contributed to the increase in possum captures. Woylie capture rates are still higher than the 7.5% trap success stipulated in the *Woylie Recovery Plan* (Start *et al.*1995) as a criteria for successful recovery.

Boyagin Nature Reserve

Boyagin Nature Reserve consists of two disjunct blocks separated by a gap of approximately 500m. Fox baiting in the east block was first implemented in 1985 in preparation for a translocation of numbats from Dryandra Woodland. Baiting commenced in the west block in 1989 and has been maintained at a frequency of once monthly in both blocks. Woylies were reintroduced into both blocks from Dryandra in 1992. Results of monitoring by Science Division staff in Boyagin in the early years since fox control

TABLE 5 (Part C)

Summary of monitoring results from *Western Shield* monitoring sites indicating mammal species recorded, whether recovery has been observed and major declines. C=Caught on monitoring transect; Co=Caught on other survey transects; S=Seen on monitoring transect; So=Seen at other locations; T=Translocated; R=Release of derelicts; dark shading=never recovered and declined to undetectable levels; light shading=recovered, may have subsequently declined.

SPECIES	WARREN MONITORING SITES											
	Gray	Wheatley	Tone	Moopinup	Chariup	Boyicup	Lake Muir	Hill Top	Giants	Mt Lindesay	Mt Frankland	D'Entre -castaux
Echidna									C			
Chuditch			C	C	C		C			T C		
Mardo	C	C						C	C	C		C
Dibbler												
Brush-tailed phascogale						C						
Red-tailed phascogale												
Dunnart (*Sminthopsis* spp)								C			C	
Numbat												
Bibly												
Quenda		C	C	C	C	C		C	C	C	C	C
Western barred bandicoot												
Woylie	T C		C	C	C	C	T C		T C	T C		
Boodie												
Mala or rufous hare-wallaby												
Banded hare-wallaby												
Black-flanked rock-wallaby												
Quokka								C	C			
Tammar wallaby						S						
Western brush wallaby				S		S						
Brushtail possum	C	C	C	C S	C S	C	C	C	C	C	C	C
Western ringtail possum				C S	C S	C						
Western pygmy possum								C				
Honey possum											C	
Water rat								C				
Greater stick-nest rat												
Shark Bay mouse												
Ash-grey mouse												
Western mouse												
Heath mouse												
Mitchell's hopping mouse												
Spinifex hopping mouse												
Southern bush rat		C	C				C	C	C	C	C	C
Black rat	C	C					C	C	C	C		C
Brown rat		C										
House mouse		C	C	C	C		C	C	C	C	C	C

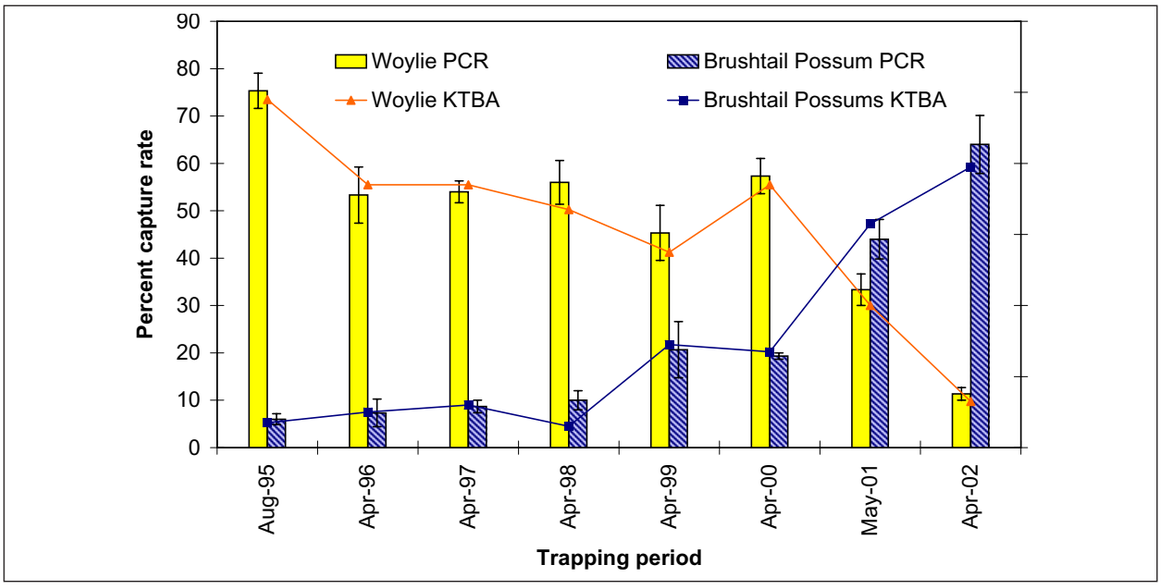

Figure 2. Mean daily percent capture rate (PCR, bars denote standard error) and number of individuals known to be alive (KTBA) for woylie and brushtail possum in Dryandra Woodland using small cage traps.

TABLE 5 (Part D)

Summary of monitoring results from *Western Shield* monitoring sites indicating mammal species recorded, whether recovery has been observed and major declines. C=Caught on monitoring transect; Co=Caught on other survey transects; S=Seen on monitoring transect; So=Seen at other locations; T=Translocated; R=Release of derelicts; dark shading=never recovered and declined to undetectable levels; light shading=recovered, may have subsequently declined.

SPECIES	SOUTH COAST REGION MONITORING SITES						
	Stirling Range	Porongorup	Waychinnicup	Twertup	Moir Track	Cape Le Grand	Cape Arid
Echidna					C		
Chuditch				C	C		T C
Mardo	C	C	C				
Dibbler				C	C		
Brush-tailed phascogale							
Red-tailed phascogale				C			
Dunnart (*Sminthopsis* spp)	C				C	C	C
Numbat	T So						
Bibly							
Quenda	C	C	C	C	C	C	C
Western barred bandicoot							
Woylie							
Boodie							
Mala or rufous hare-wallaby							
Banded hare-wallaby							
Black-flanked rock-wallaby						T	
Quokka	C						
Tammar wallaby							
Western brush wallaby							
Brushtail possum	C	C S		C	C		
Western ringtail possum		S					
Western pygmy possum				C			C
Honey possum			C	C	C	C	C
Water rat							
Greater stick-nest rat							
Shark Bay mouse							
Ash-grey mouse	C			C	C		
Western mouse	C			C	C		
Heath mouse					C		
Mitchell's hopping mouse				C	C		
Spinifex hopping mouse							
Southern bush rat	C	C	C	C	C	C	C
Black rat		C					
Brown rat							
House mouse	C	C	C	C	C	C	C

commenced have been published (Kinnear *et al.* 2002). A monitoring transect was established by Narrogin District in the east block in 1995, extended to the west block in 1996, and trapped annually as part of *Western Shield*. The results are presented in Fig 3 (the 1996 data shown were included in Kinnear *et al.* 2002).

Although woylies were reintroduced to both blocks at the same time there is a predominance of woylie captures (well above 7.5% trap success) on the west block with substantially fewer brushtail possums and the inverse pattern on the east block. Reasons for this difference are not known but possible contributing factors include baiting history, differences in carrying capacity or competition for traps (Kinnear *et al.* 2002). Numbers of both species on both blocks appear to be fluctuating about a mean though there is some indication of a decline in woylies on the west block and an increase in brushtail possums on both blocks. Such trends would be consistent with those observed in Dryandra Woodland. Quenda were reintroduced in 1995 from development sites on the Swan Coastal Plain and appear to be establishing very slowly. The trapping transect may not traverse the best habitat for quenda and the monitoring results may therefore not be indicative of the success of the translocation.

Tutanning Nature Reserve

Fox baiting was implemented in this reserve in 1984. At this time the numbat, quenda and western ringtail possum had disappeared from the reserve and tammar wallabies and brushtail possums were seldom seen and woylies were not seen at all (Kinnear *et al.* 2002). Substantial recovery of woylies, brushtail possums and tammar wallabies was demonstrated within eight years. Quenda were reintroduced between 1991 and 1995 and numbats were reintroduced between 1987 and 1996.

A monitoring transect was established by Narrogin District in 1995 and has been trapped annually as part of *Western Sheild* up until 2000 and from then on once every two years. The results are presented in Fig. 4.

The brushtail possum population is thriving and appears stable with capture rates ranging from 34.7% to

TABLE 5 (Part E)

Summary of monitoring results from *Western Shield* monitoring sites indicating mammal species recorded, whether recovery has been observed and major declines. C=Caught on monitoring transect; Co=Caught on other survey transects; S=Seen on monitoring transect; So=Seen at other locations; T=Translocated; R=Release of derelicts; dark shading=never recovered and declined to undetectable levels; light shading=recovered, may have subsequently declined.

SPECIES	WHEATBELT REGION MONITORING SITES							
	Dryandra	Tutanning	Boyagin	Bendering	North Kalgarin	Roe	Lake Magenta	Dragon Rocks
Echidna	C	C	C				C	
Chuditch	Co						T C	
Mardo								
Dibbler								
Brush-tailed phascogale								
Red-tailed phascogale	Co						C	
Dunnart (*Sminthopsis* spp)				C	C		C	
Numbat	So	T	T So					
Bibly	T Co							
Quenda		T C S	T C				C	
Western barred bandicoot								
Woylie	C	C	T C				T C	
Boodie								
Mala or rufous hare-wallaby								
Banded hare-wallaby								
Black-flanked rock-wallaby								
Quokka								
Tammar wallaby	C	S Co	S					
Western brush wallaby	S		S				S	
Brushtail possum	C	C S	C	C	C	C	C	C
Western ringtail possum								
Western pygmy possum					C		C	
Honey possum					C		C	C
Water rat								
Greater stick-nest rat								
Shark Bay mouse								
Ash-grey mouse					C	C	C	
Western mouse				C	C		C	C
Heath mouse							C	
Mitchell's hopping mouse				C	C	C	C	C
Spinifex hopping mouse								
Southern bush rat							C	
Black rat								
Brown rat								
House mouse	C			C	C	C		C

47.3%. Woylie numbers appear to have declined since the earlier recovery recorded by Kinnear *et al.* (2002) and the average capture rate from 1996 to 2000 has fallen below 7.5%. Quenda have established very well and appear to have been more abundant than woylies up to 2002 when capture rates declined to 2.7%. Capture rates of 3% or more along standard *Western Shield* transects is considered high for quenda. The changes in abundance may be a function of vegetation succession since the last fire as well as drought effects.

Perup Forest

The area of state forest about 35 km east of Manjimup is generally known as 'the Perup' and has been a proposed nature reserve for many years and is now a proposed national park. The area has long been known as 'special' since it supports populations of nearly all the species of medium-size mammals that were known to occur in the wider jarrah forests of the south-west of WA, including numbats, woylies and chuditch. The area has had a varied history of 1080 baiting. Dog baiting was carried out in the 1980s and regular fox baiting first commenced in 1994. The area has been trapped and monitored for research purposes since the 1970s. Donnelly District (formerly Manjimup District) has undertaken regular monitoring in the area since 1998 as part of Western Shield and have two established transects: one in Chariup Forest Block and the other in Boyicup Forest Block.

Woylie, quenda, brushtail possum and western ringtail possum (*Pseudocheirus occidentalis*) have been trapped on both transects and chuditch have been trapped on the Chariup transect. Woylie captures at both sites have shown an increase to near saturation levels (about 70% capture rate coupled with additional trap disturbance), reducing or excluding other species from traps. This makes it difficult to interpret data for other species. Trials comparing standard universal bait and a meat-meal-based bait less attractive to woylies have shown that high capture rates of woylies significantly exclude chuditch from traps baited with universal bait (Wayne *et al.* in prep; Morris *et al.* 2003).

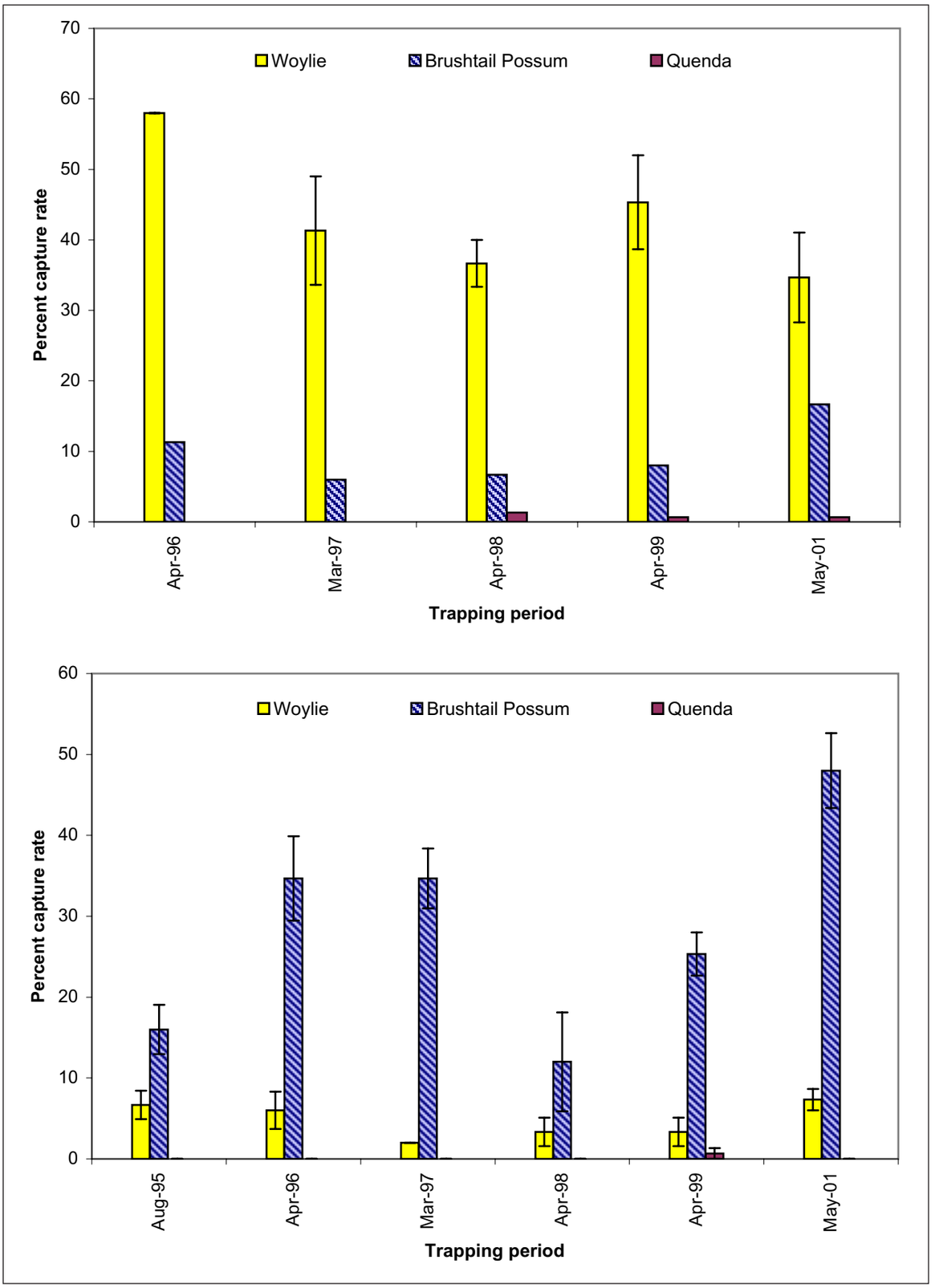

Figure 3. Mean daily percent capture rate (bars denote standard error) for medium-size mammals in (a) west and (b) east Boyagin Nature Reserve using small cage traps.

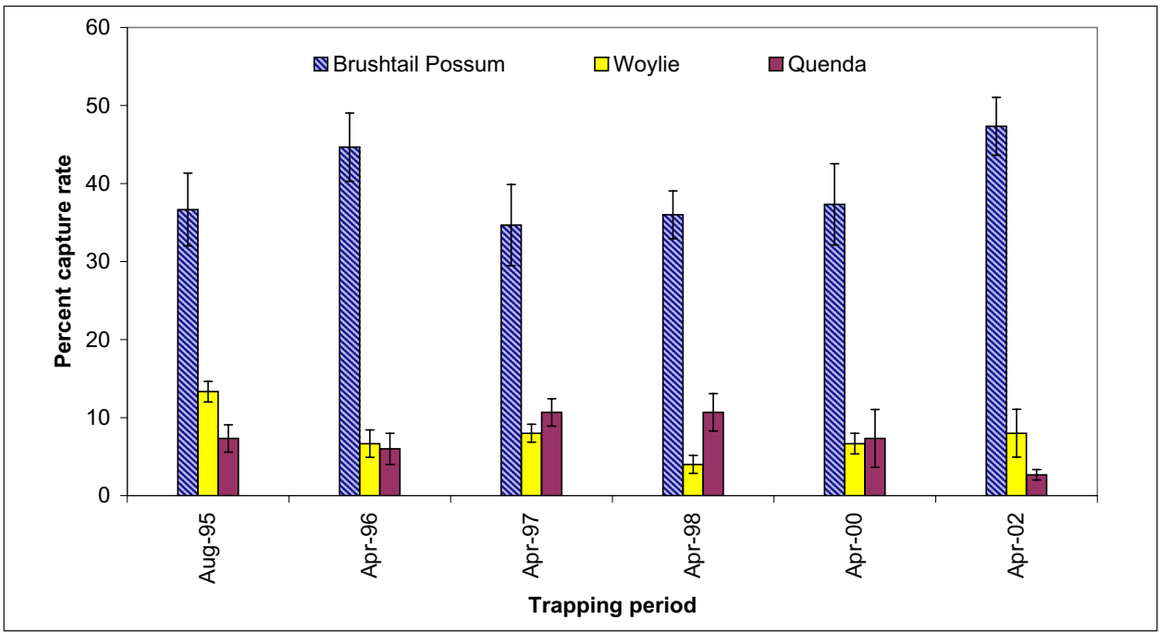

Figure 4. Mean daily percent capture rate (bars denote standard error) for medium-size mammals in Tutanning Nature Reserve using small cage traps.

Batalling Forest

This area on the eastern edge of the forest belt west of Darkan was the site of a woylie reintroduction in 1983. Some fox baiting was undertaken in the first two years after the release of woylies but it appeared that the population failed to establish. Surveys were undertaken in 1990 and found evidence that woylies were still present. Fox baiting at a frequency of four times a year was then implemented east of Don Road in February 1991. Aerial fox baiting west as well as east of Don Road was later implemented in 1994 as part of Operation Foxglove (a precursor to *Western Shield* that included aerially baiting 400,000ha of northern jarrah forest).

Extensive trapping was undertaken in the area to catch chuditch to monitor the impact of baiting on this species (see Morris *et al.* 2003). This necessitated trapping over different areas to catch sufficient animals for the study hence there was no consistently repeated trapping effort for several years. A woylie monitoring transect was established in 1995 which was then repeated annually as part of the department's Fauna Management Course and as part of Western Shield. This transect ran both east and west of Don Road.

Percent capture rates for medium-size mammals on the woylie monitoring transect east and west of Don Road are shown in Fig. 5.

Recovery of woylies is evident on both sides of Don Road, however recovery was faster on the east side than on the west side, presumably because the population was first established there and regular baiting started earlier. Recovery is more evident in Fig. 6 showing woylies known to be alive (KTBA). These figures also show that the population is large enough to sustain the removal of animals for translocation. There appears to be little influence from low rainfall trends from 2000 (see rainfall data for Perth, Figs 24 and 25, and Albany, Figs 26 and 27).

Recovery of chuditch, brushtail possums and quenda is also apparent up until 1996. Chuditch capture rates on the east side of DonRoad peaked at 21.8% in May 1995 and have been consistently higher than the minimum 1% given in the Chuditch Recovery Plan (Orell and Morris 1994) as one of the criteria for successful recovery. Capture rates for brushtail possums doubled within the first four years and quenda began to appear on the transect and peaked at 3.5% by 1996. It appears that when woylie capture rates reach about 40% there is a very noticeable decline in the capture rates of other species. Trap disturbance in addition to captures can further exclude other species from traps, and from the trapping data it is not possible to interpret population patterns in these species.

Hills Forest

This area of state forest was first baited with 1080 fox baits in 1993 and aerial baiting was later implemented over a wider area in 1994 as part of *Operation Foxglove*.

A monitoring transect was first established in February 1993. This was later modified slightly to become the *Western Shield* monitoring transect for Hills Forest with a section of 55 traps on the northern side of Mundaring Reservoir and another section of 55 traps on the south side of the reservoir. The results of the monitoring are shown in Fig. 7.

Only the northern transect has shown recovery (Fig. 7a). Chuditch and quenda have both recovered remarkably well. Capture rates for chuditch peaked at 14.1% in March 1999 and have remained well above 6%

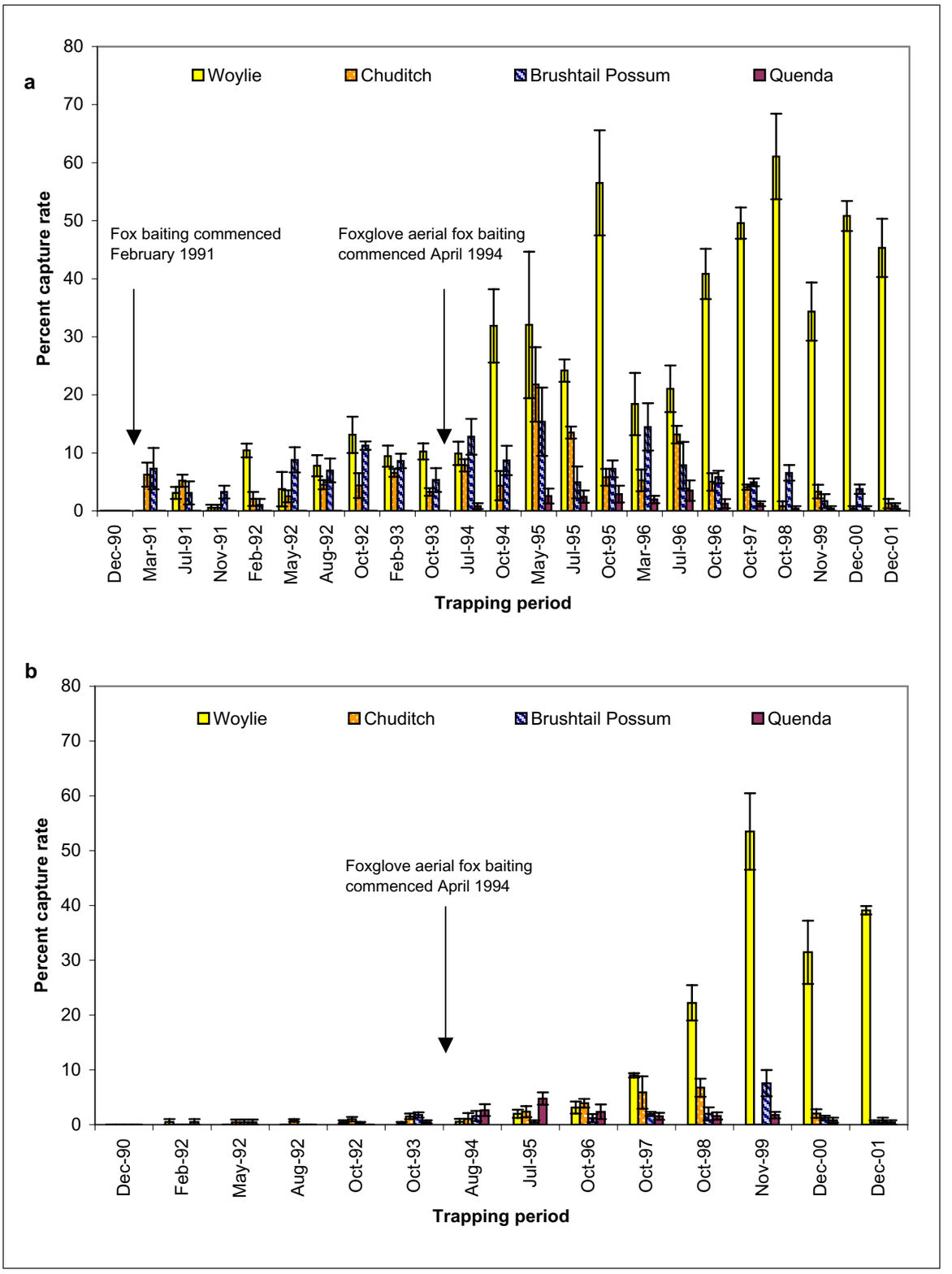

Figure 5. Mean daily percent capture rate (bars denote standard error) for medium-size mammals in Batalling Forest on the woylie monitoring transect (a) east and (b) west of Don Road using small cage traps.

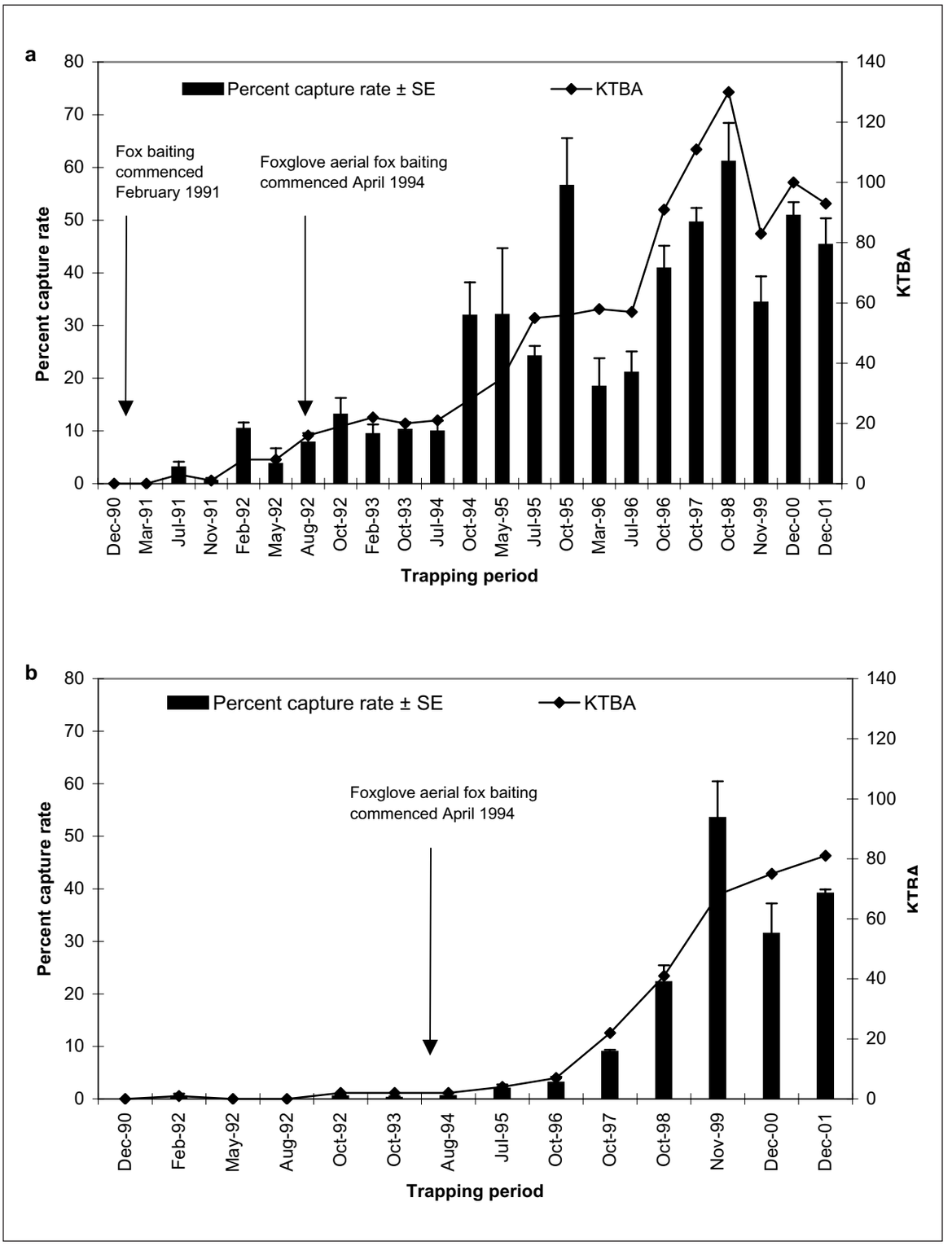

Figure 6. Mean daily percent capture rate (bars denote standard error) and the number of individuals known to be alive (KTBA) for woylies in Batalling Forest on the woylie monitoring transect (a) east and (b) west of Don Road using small cage traps.

since 1998. Quenda capture rates peaked at 6.8% in March 2000 and have remained above 1%.

Brushtail possums, mostly individuals removed from house roofs, have been released into Hills Forest by Perth Hills District staff over many years. The species has been very slow to establish but capture rates over the last three years suggest that establishment may be occurring.

Woylies were reintroduced to Hills Forest with the first release of 20 in 1996 and a second release of 17 in 1998. The population appeared to be establishing but went into decline in 1998 and had collapsed by 2001. There are three factors that may be responsible for this collapse. Firstly there was a small founder size only slightly augmented two years later with a second release. Secondly, the chuditch population was climbing rapidly possibly beyond the carrying capacity of the area at the same time that the woylie population was establishing. Chuditch are known predators on woylies and may have had a significant impact on the population in this situation. Thirdly, rainfall figures for Perth show that winter rainfall has been below average since 2000 (Figs 24 and 25) and this may have reduced the capacity of the area to support woylies.

The southern transect is only 5-11 km from the northern transect and yet capture rates for medium-size mammals have remained below 1.5% and have declined to no captures since March 2000 (Fig. 7b). As there has been no difference in the baiting regime between the two transects, the results suggest that population levels on the southern transect have been too low to sustain recovery without being supplemented by immigration or translocation. The Mundaring Reservoir represents a physical barrier to immediate expansion of the northern population into the area of the southern transect.

Julimar State Forest

This area of state forest is isolated from the main forest belt and has been a proposed Conservation Park since 1994. It was first baited with 1080 fox baits in 1992 in preparation for a translocation of captive-bred chuditch from Perth Zoo (Morris *et al.* 2003). A pre-baiting trapping survey resulted in the capture of one feral cat and many House Mice.

The recovery of native fauna in Julimar has been entirely through translocation. Most releases of zoo-bred chuditch occurred in September 1992 and March 1993 (Morris *et al.* 2003). A translocation of brushtail possums began in May 1993 using derelict and displaced animals from the Perth metropolitan area and surrounding localities. Quenda were first reintroduced in 1994 using displaced animals from development sites and a second release of quenda from a captive colony held at the University of Western Australia occurred in 1998. A reintroduction of wild-caught woylies from Dryandra Woodland occurred in 1995. Brushtail possums, quenda and woylies were all released at more than one release site.

Trapping transects have been set up to monitor the establishment primarily of the chuditch in earlier years but also of the other reintroduced species. Although trapping has concentrated mostly along the main tracks in the southwestern part of Julimar (the core monitoring area), trapping has extended beyond this area but the trapping effort has not been consistent. There have been varying efforts to monitor the spread of animals in each trapping period. To standardise the monitoring results the trapping data has been trimmed to include only the core monitoring area, which represents transects totalling about 125 traps. Results are presented in Fig. 8.

The establishment of the chuditch population is evident with a peak capture rate of 14.2% in 1998. Capture rates have subsequently dropped and stabilised around 4%, considerably higher than the 1% prescribed in the *Chuditch Recovery Plan*. While chuditch captures were initially concentrated in the core monitoring area, captures are now occurring more frequently beyond this area indicating that chuditch are now not only established but more widespread.

Woylies appeared to be establishing successfully up until 1999 when the capture rate dropped by 65%. No woylies have been trapped since 2000. There is a similarity with the pattern observed in Hills Forest and the same three factors may be responsible for the collapse in the Julimar population. Small founder size (the forty woylies released were split between two release sites separated by about 8 km thereby effectively halving the founder size), abnormally high chuditch predation and drought effects.

While quenda and brushtail possums have persisted they have not shown successful establishment or recovery in that there has been no detectable increase or expansion in the populations. The number of founders may have been insufficient to achieve this within the observed time frame. Habitat may be a factor for quenda as there are limited areas supporting dense cover of low vegetation. Julimar supports open woodland of jarrah and marri as well as wandoo and mature trees with hollows appear to be plentiful. Thus it would appear suitable for possums although they would need to spend time on the ground due to the open nature of the woodland. Competition for tree hollows by feral bees may be a possibility. The area has been regularly used by apiarists and feral bees would be well established.

Western Shield monitoring sites showing recovery of mammal fauna

These monitoring sites have been established subsequent to the implementation of fox control via aerial baiting with 1080 dried meat baits. Except where indicated, the sites have been baited by aircraft four times annually. They are presented by CALM regions.

South West Region

Centaur, Noggerup and Catterick forest blocks

Recovery of at least one species has been observed in Centaur , Noggerup and Catterick forest blocks. Data for Catterick Forest Block are presented in Fig. 9.

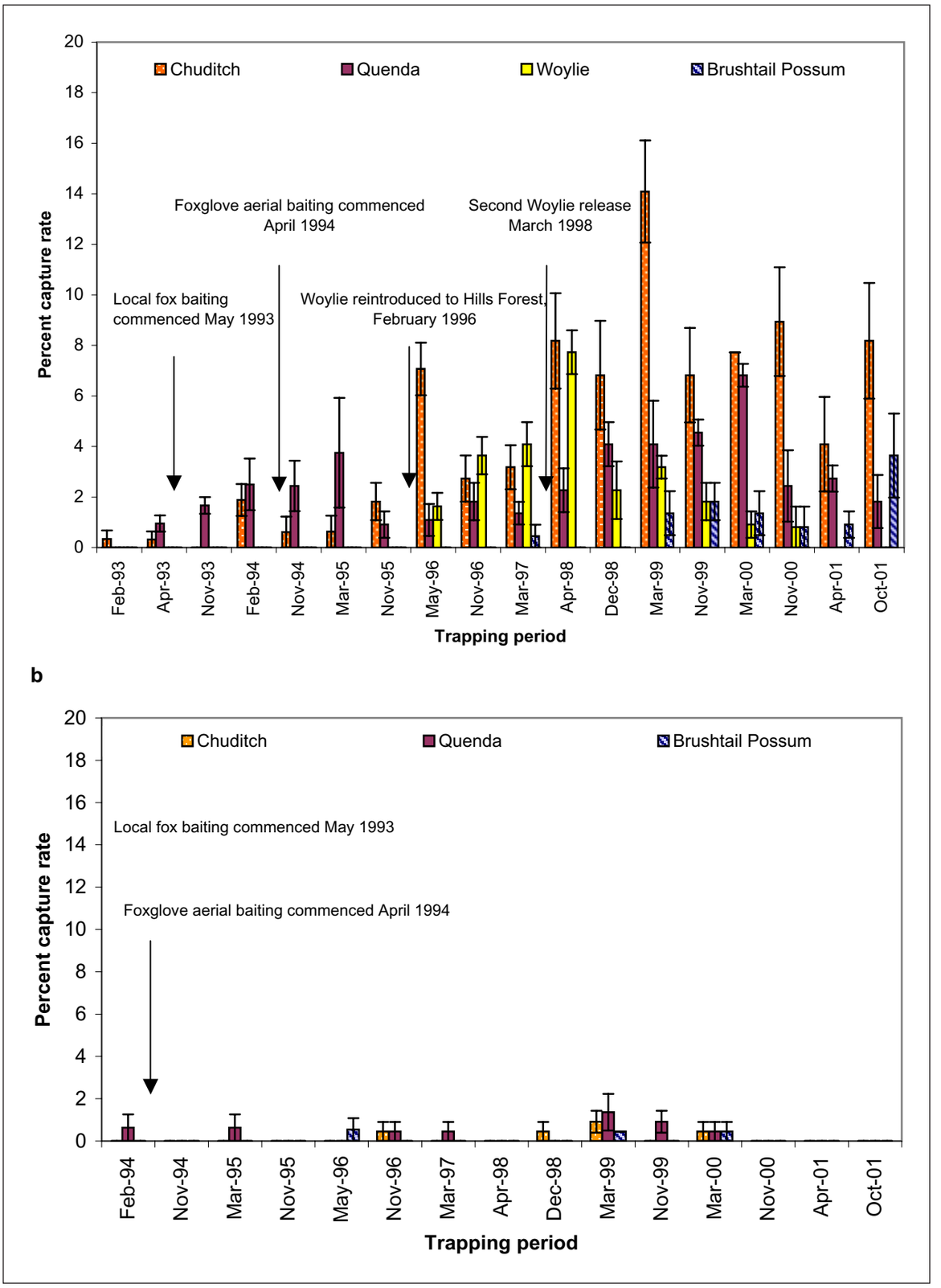

Figure 7. Mean daily percent capture rate (bars denote standard error) for medium-size mammals on (a) the northern transect and (b) the southern transect, Hills Forest, using small cage traps.

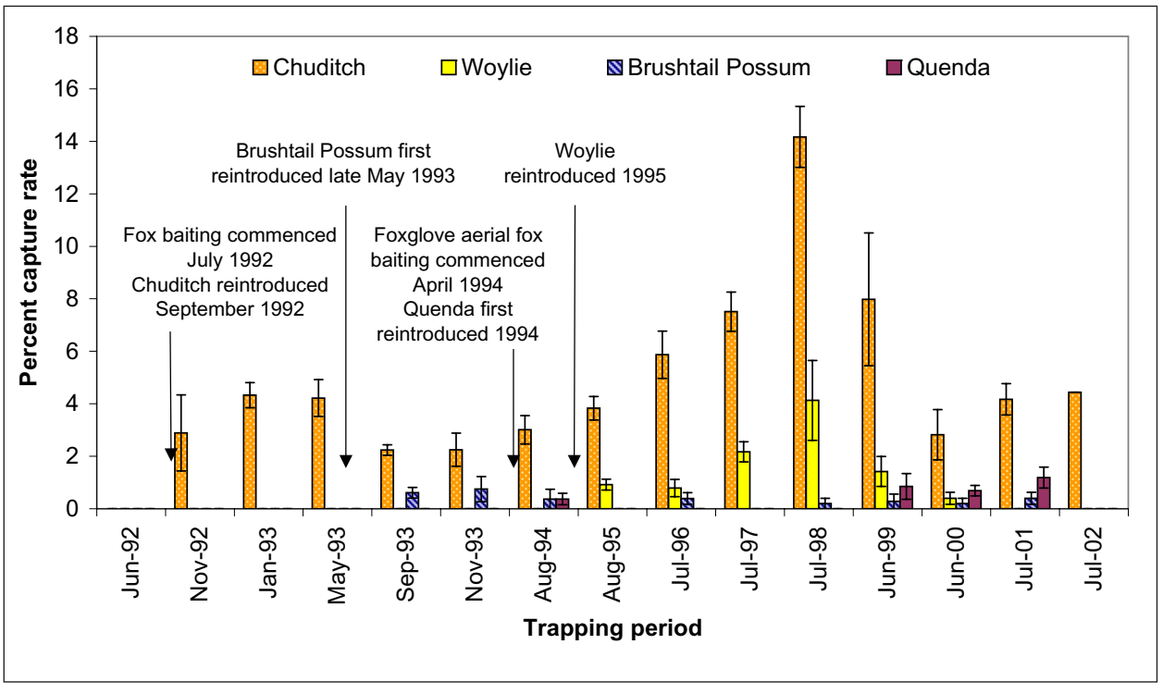

Figure 8. Mean daily percent capture rate (bars denote standard error) for medium-size mammals in the core monitoring area of Julimar State Forest.

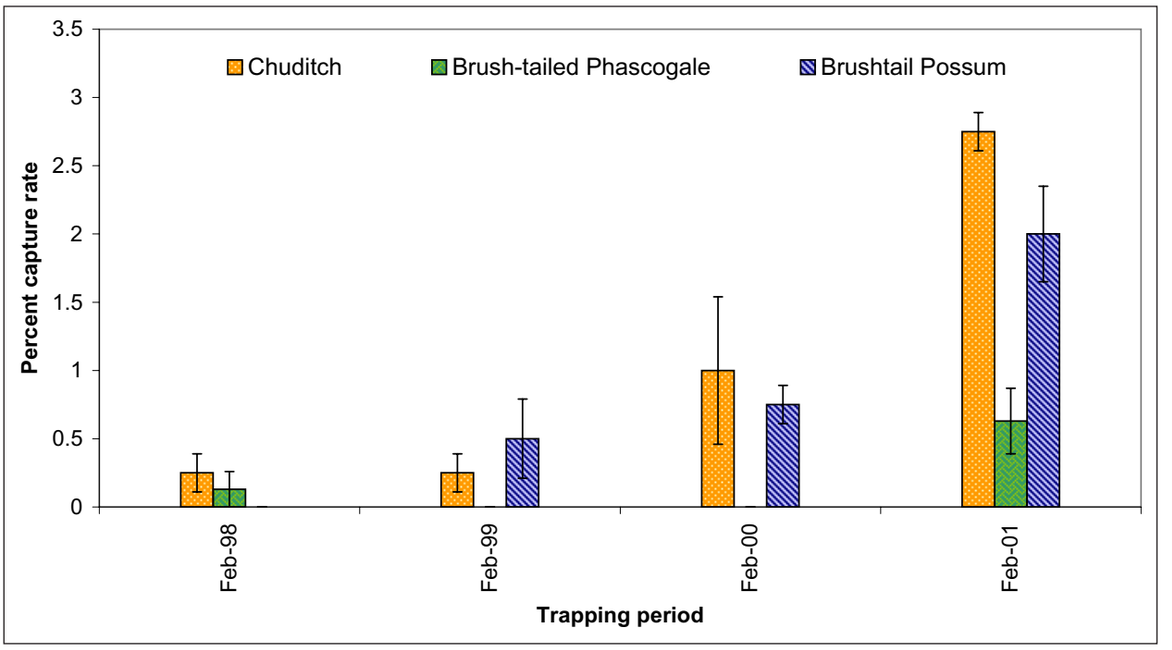

Figure 9. Mean daily percent capture rate (bars denote standard error) for medium-size mammals, including Brush-tailed Phascogale, in Catterick Forest Block using small cage traps.

Chuditch have shown recovery in all three sites with peak capture rates from 2% to 4.2%. Brushtail possums have shown a strong recovery in Centaur and Catterick. Although capture rates have shown no obvious trend in Noggerup, possums have been trapped with increasing regularity.

Woylies were reintroduced to Centaur Forest Block in 1998. Capture rates appear to be on the increase but the latest capture rate of 5.4% is still less than the capture rate of 7.5% prescribed in the Woylie Recovery Plan as a criteria for successful recovery.

St John Forest Block
The monitoring site established in the formerly proposed St John Conservation Park has consisted of a total of 170 small cage traps which has now been reduced to conserve logistics. Monitoring results have been input to the Fauna File database however a substantial portion of this data was lost during a computer upgrade as no backup had been made. This data set has not yet been rectified but earlier extractions of data indicated a strong recovery of brushtail possum though a reintroduction of woylies has failed.

Warren Region

Moopinup and Tone Forest Blocks
Although not baited for fox control until 1996, Moopinup and Tone forest blocks can be regarded as extensions of 'the Perup'. Monitoring results at Moopinup (Figs 10 and 11) have indicated a rapid recovery of the woylie suggesting that this species was well established but at low density. Capture rates are now high enough to significantly exclude captures of other species though chuditch, quenda, brushtail possums and western ringtail possums are all present. KTBA analysis indicates that the woylie population is large enough to sustain removal of animals for translocation (Fig. 11). Chuditch capture rates have been relatively high and have largely remained at or above 1%. Quenda and brushtail possum capture rates are also reasonably high in view of the high capture rates of woylies.

Recovery of brushtail possums has been evident in Tone Forest Block though there has been a decline in the last year. Chuditch persist but are not showing any discernable pattern. Quenda and woylie have been trapped but not for the last three years. Tone Forest Block appears to be only marginally influenced by the recovery patterns in the main Perup area.

Valley of the Giants
Slow recovery of quenda is apparent in the Valley of the Giants with capture rates starting at 0.5% and peaking at 3.3% in April 2001 but remaining above 1% since October 1999 (Fig. 12). Brushtail possum captures have remained below 1% except for an isolated peak of 2.5% in April 2001. Woylies were released in the Valley of the Giants in 1999 from Perup and are persisting and appear to be establishing. Woylies have now been sighted during walking tours by torchlight around the Tree Top Walk (G. Freebury, CALM, Albany, pers. comm.). Capture rates for all three species are still below 3.5% but this may be influenced by the high capture rates of southern bush rat possibly excluding them from traps.

South Coast Region

Stirling Range National Park
The monitoring results for Stirling Range National Park show a recovery in the quenda population though there was an apparent decline in November 2000. Brushtail possums made a late appearance on the transect but are increasing slowly. Interestingly, one individual quokka has been trapped on the transect (in a small Sheffield cage trap) in April 2001 and again in November 2001.

Four species of native small mammal have also been trapped on the transect. One, the western mouse, is currently listed as Priority Four species on the CALM Priority Fauna List. Captures of this species (using cage traps and type A Elliott traps) have been very low. The only species that have been caught in reasonable numbers are the mardo and the southern bush rat. There appears to be a pattern of increasing capture rates of southern bush rat up until 2001 but none of the other species show any discernable patterns. All species declined by 2001.

Porongorup National Park
Quenda and brushtail possums have both shown a strong recovery in Porongorup National Park (Fig. 13) although quenda began to decline in 2000. Capture rates for southern bush rat have been very high up until 2000 (Fig. 14) and may have suppressed capture rates of quenda and brushtail possums but then declined to less than 5%.

Waychinicup National Park
Quenda is the only medium-size mammal trapped on this transect and capture rates and KTBA analysis suggest a recovery and then a subsequent decline in 2001. Rainfall data from Albany (see Figs 26 and 27) show below average winter rainfall for the last six years. However, winter and spring 2000, summer 2000–2001 and autumn 2001 were particularly dry and the following winter (2001) rainfall may have been insufficient to compensate for these drought conditions.

Small mammal captures have consisted of mardo, southern bush rat and house mouse. Southern bush rats have been trapped consistently but show no discernable pattern. The two peaks in capture rates coincide with low capture rates in quenda suggesting that bush rat captures at these times may have excluded potential quenda captures.

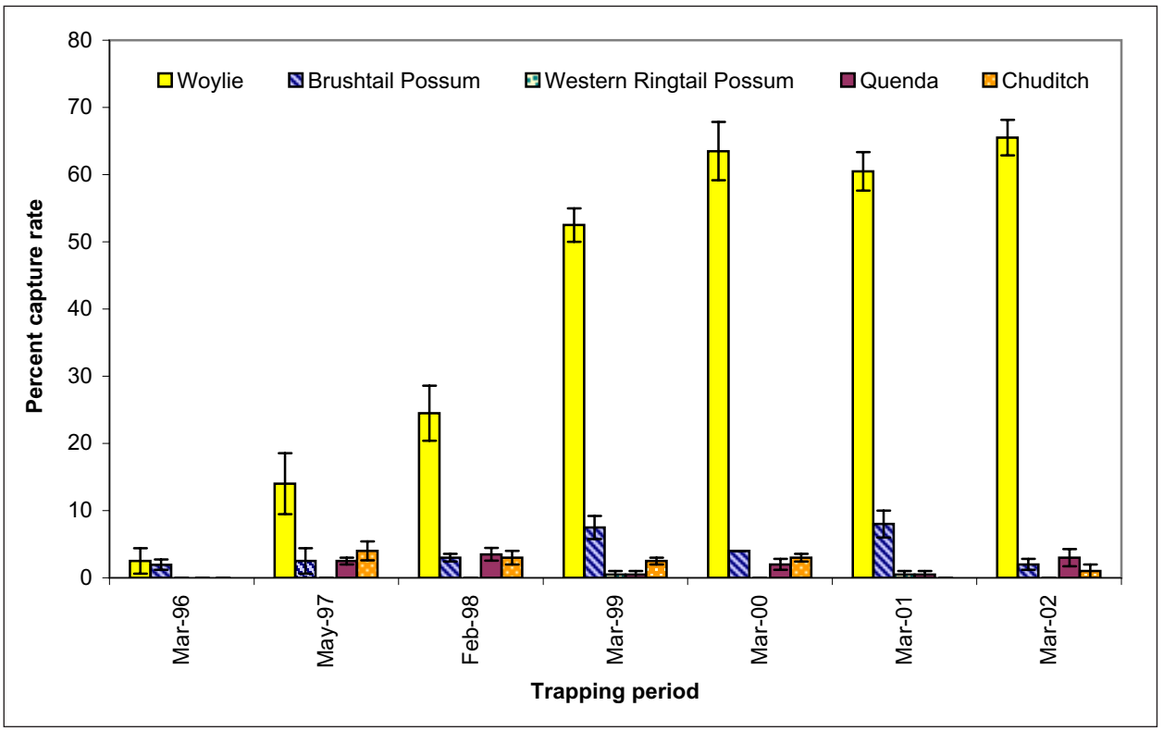

Figure 10. Mean daily percent capture rate (bars denote standard error) for medium-size mammals in Moopinup Forest Block using small cage traps.

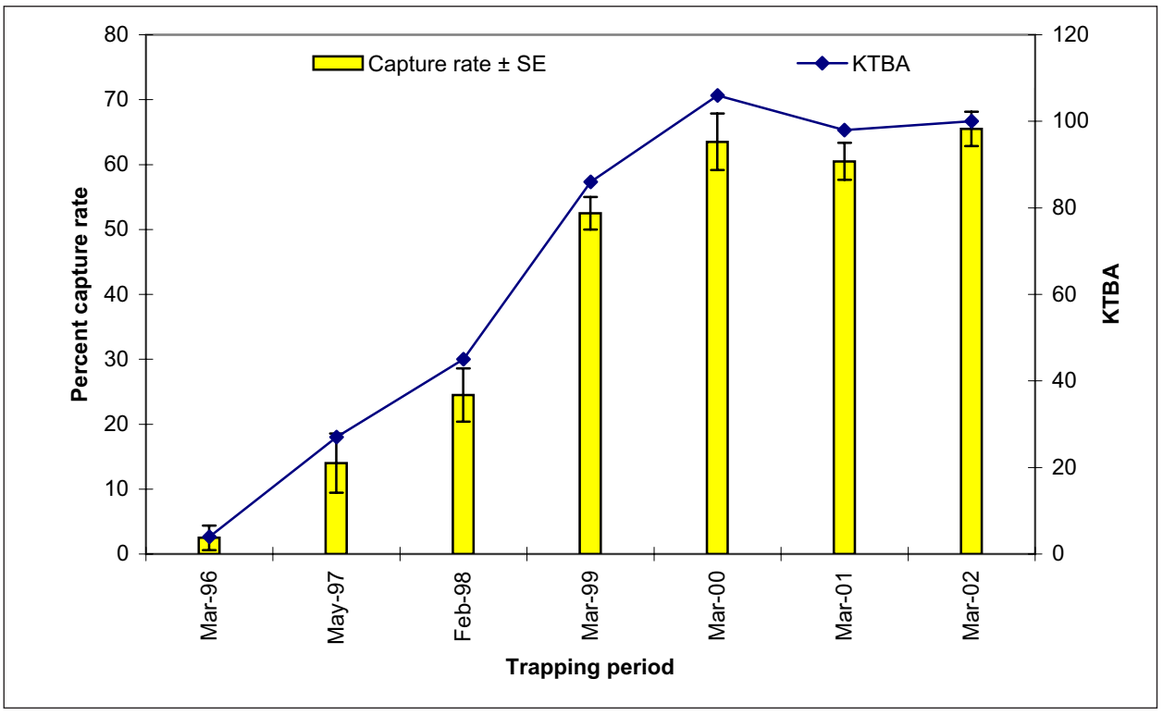

Figure 11. Mean daily percent capture rate (bars denote standard error) and the number of individuals known to be alive (KTBA) for woylies in Moopinup Forest Block using small cage traps.

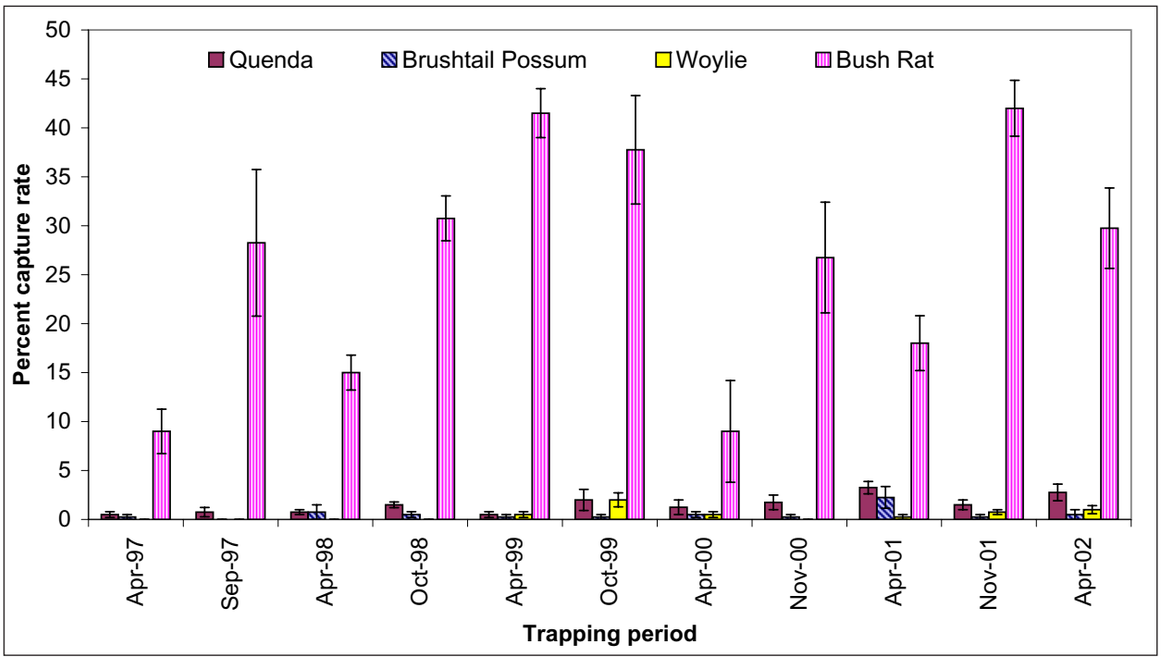

Figure 12. Mean daily percent capture rate (bars denote standard error) for medium-size mammals and southern bush rat in the Valley of the Giants using small cage traps.

Fitzgerald River National Park

Aerial baiting twice yearly for fox control was implemented in the western portion of the park between February 1991 and September 1995 (followed by two supplementary ground baitings) to assess whether fauna recovery could be achieved under this baiting regime (Kinnear *et al.* 2002). Aerial baiting four times yearly under the *Western Shield* program commenced in October 1996.

Two monitoring transects were established in the Fitzgerald River National Park in 1997 by CALM Albany District– one at Twertup in the western end of the park and the other on Moir Track in the eastern end of the park.

With the exception of white-tailed dunnart (*Sminthopsis granulipes*) all other native mammals trapped during a biological survey of the Fitzgerald River National Park in 1987 (Chapman 1995) have been trapped at either one or both of the above monitoring transects. Not recorded in 1987, chuditch have also been trapped on both of the above transects. Chapman (1995) reported observations of woylies near Twertup but trapping efforts failed to confirm their presence. Current trapping efforts have also failed to confirm the presence of this species. Tammar Wallabies were also recorded by Chapman (1995) but appeared to be scarce. Kinnear *et al.* (2002) reported increases in tammar wallaby following baiting twice yearly for fox control.

Recovery of brushtail possums has been evident on both the Twertup and Moir Track transects. The capture rates of brushtail possums at Twertup quickly rose from 14% up to 38% and the decision was made to shift the transect to accommodate captures of other species. Many of the possums caught had ear tags fitted during the earlier study by Kinnear *et al.* (2002) that also demonstrated recovery of possums following fox control. The transect was shifted further along Twertup Track and the results still show a good recovery of brushtail possums but at lower capture rates, though there is a slight decline from 2001. Quenda also appeared to be recovering but capture rates declined from October 2000. Other than House Mice, small mammals also declined from 2000 (Fig. 15). The rainfall figures (January 1997 to October 2002 from Bureau of Meteorology) for Jacup (west) and Ravensthorpe (east) show extended periods of low rainfall from September 2000 to June 2001 and again from January to October 2002 that may have contributed to the observed declines. No patterns in small mammals that may relate to the effects of fox control is evident.

Recovery has been less dramatic and the declines more dramatic on the Moir Track transect. Brushtail possums appeared to be making good recovery and then crashed in 2001. Quenda also appeared to be recovering but crashed earlier in 2000. Declines in the small mammals also occurred in 2001. Again no patterns in small mammals that may relate to fox control are evident.

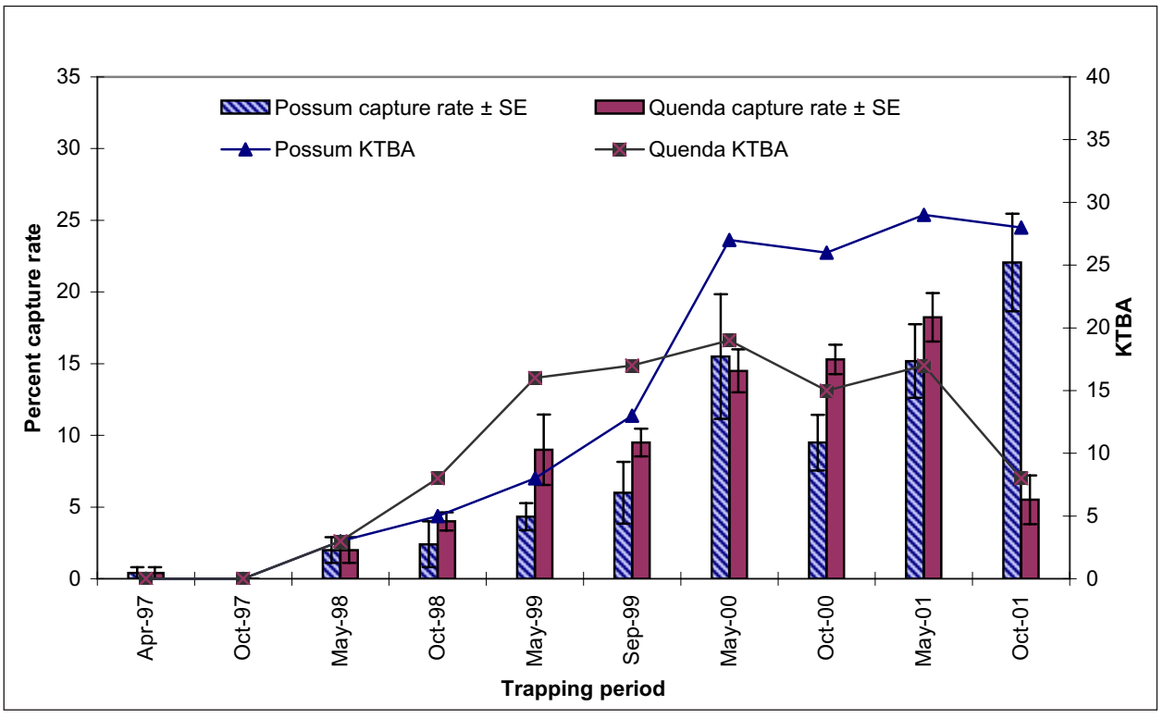

Figure 13. Mean daily percent capture rate (bars denote standard error) and the number of individuals known to be alive (KTBA) for brushtail possum and quenda in Porongorup National Park using small cage traps.

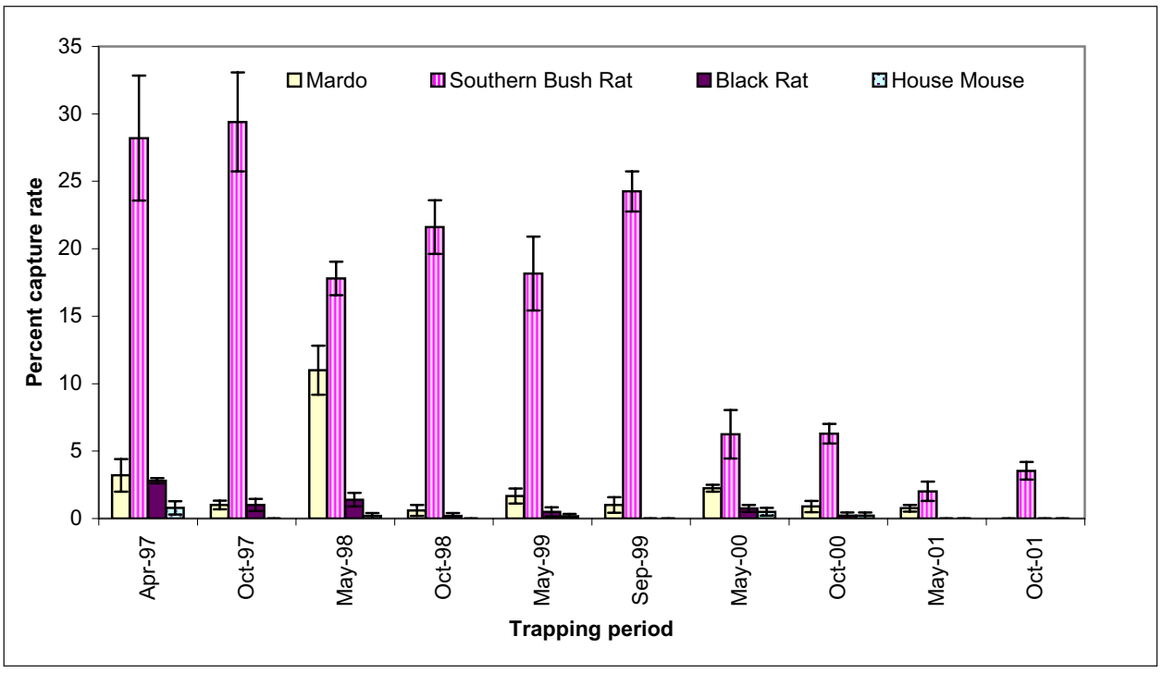

Figure 14. Mean daily percent capture rate (bars denote standard error) for small mammals in Porongorup National Park using small cage traps and type A Elliott traps.

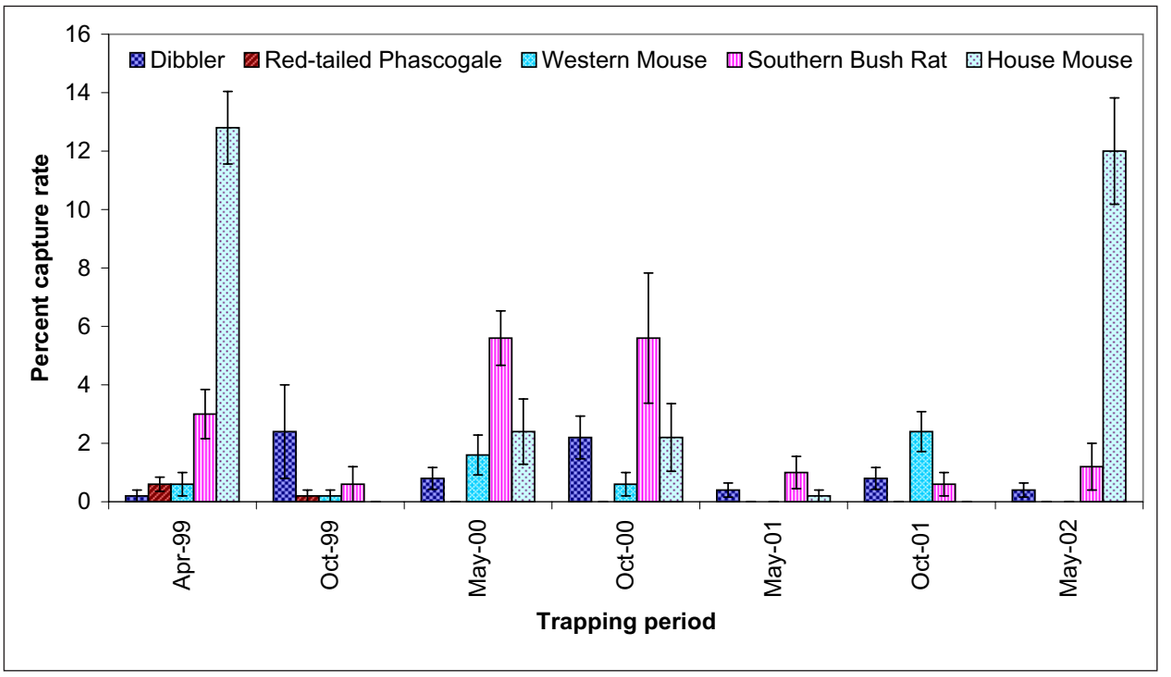

Figure 15. Mean daily percent capture rate (bars denote standard error) for small mammals in Twertup, Fitzgerald River National Park, using small cage traps and type A Elliott traps.

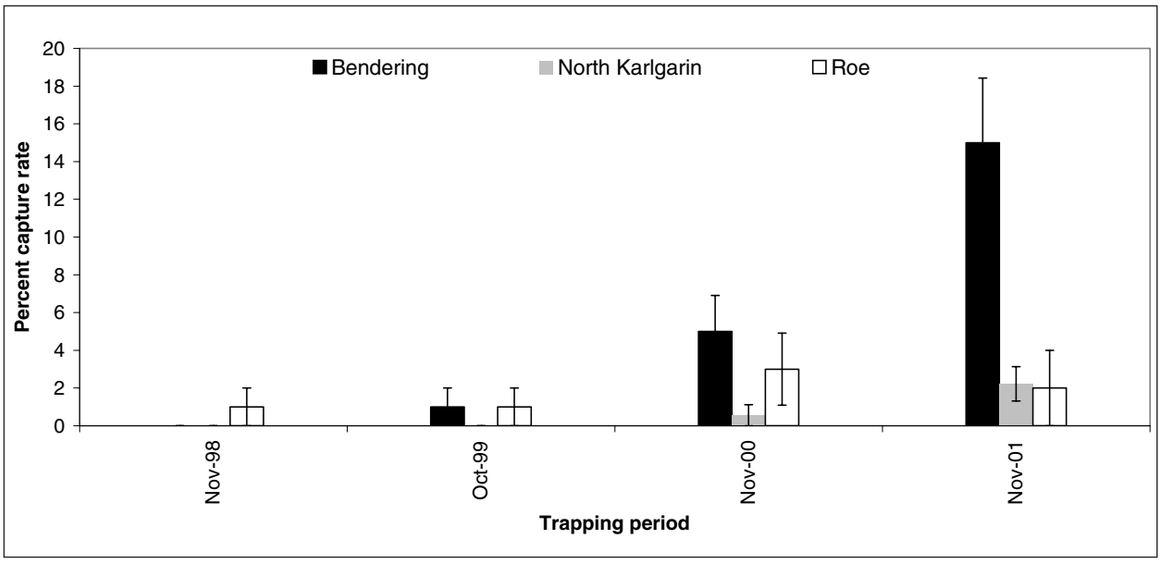

Figure 16. Mean daily percent capture rates (bars denote standard error) of brushtail possums using small cage traps at Bendering, North Karlgarin and Roe nature reserves.

Wheatbelt Region

Dryandra satellite blocks
A transect of 50 small cage traps through Bald Rock and Montague blocks has been monitored since two monthly baiting with 1080 baits for fox control was first implemented in 1996. Capture rates indicate recovery of brushtail possums whereas woylies, though present, have not recovered. The below average winter rainfall since 1999 may be responsible for inhibiting recovery of woylies.

Bendering, North Karlgarin and Roe nature reserves
These three nature reserves are monitored concurrently as they are located close together. Five grids of sixteen pitfall traps were established in North Karlgarin Nature Reserve and have been monitored since October 1993. Fox control in all three reserves by baiting four times a year commenced in 1998. The monitoring was expanded to include Bendering and Roe nature reserves and incorporated the use of Elliott traps and small cage traps to monitor the recovery of medium-size mammals. One transect of 25 small cage traps was established in each of Bendering and Roe nature reserves and nine small cage traps were added to each of the five grids in North Kalgarin Nature Reserve.

Kitchener and Chapman (1977) surveyed the mammal fauna of Bendering (formerly West Bendering) and North Karlgarin (formerly Bendering) nature reserves from 1972 to 1976. Chuditch and red-tailed phascogale were recorded during these surveys but neither species has been recorded since. With the exception of the macropods and bats, all other native mammals recorded by Kitchener and Chapman (1977) have been trapped since monitoring commenced in these reserves in 1993. In addition, western pygmy possum and ash-grey mouse have also been trapped.

The brushtail possum is the only medium-size mammal that has been trapped in these reserves since 1998. Though recorded as present in North Karlgarin Nature Reserve and very common in Bendering Nature Reserve in the 1970s (Kitchener and Chapman 1977) it was initially not detected in either reserve in 1998. It has since shown very good recovery in Bendering Nature Reserve and moderate signs of recovery in North Kalgarin and Roe nature reserves (Fig. 16). Bendering Nature Reserve includes a larger portion of mallee woodland that provides a more favourable habitat for possums (Kitchener and Chapman 1977).

Lake Magenta Nature Reserve
Before fox control was first implemented in 1996 trapping surveys had failed to catch any medium-size mammals (Crook and Burbidge 1982) except for one chuditch in 1994 (Morris *et al.* 2003). Aerial fox baiting four times a year commenced in May 1996 and has been supplemented by six weekly ground baiting around the perimeter and a few internal firebreaks. A monitoring transect of 200 small cage traps set at 100m intervals was established in 1996 to monitor fauna recovery and the establishment of translocated populations. This transect was reduced to 100 small cage traps set at 200m intervals in 1999 to economise on logistics but still covered the same area.

Captive bred chuditch were first released into the reserve in October 1996 (Fig. 17). Capture rates of chuditch have reached 5.1% and, except for May 1998 and November 2001, have remained at or above 1% up till May 2002 though there has been a noticeable decline since May 2000. No chuditch were captured in November 2002. Woylies were first reintroduced in January 1997 and capture rates have remained low but steady up to November 1999. Capture rates fell and no woylies have been trapped since May 2000 suggesting that the population has failed to establish.

After less than 12 months of baiting foxes, quenda and brushtail possums appeared on the transect (Fig. 17) though neither species had previously been recorded in the reserve. Capture rates indicate a strong recovery of both species, particularly possums, followed by a dramatic crash in quenda captures in 2000 and possum captures in 2001. Rainfall data for Lake Grace show below average winter rainfall over the last three winters with the 2002 winter rainfall being less than half of the average winter rainfall. The drought conditions appear to be the trigger, but may not be solely responsible for the observed population crashes. Other factors such as feral cat activity need to be investigated.

Monitoring data for some of the small mammals have also shown evidence of recovery related to fox control. In addition to the transect of small cage traps, ten lines of ten Elliott traps and six grids of 25 pitfall traps have also been used to survey and monitor smaller ground dwelling fauna. The heath mouse has been trapped more regularly since fox control commenced though capture rates do not reflect an increase in the population (Fig. 18). Interestingly, heath mouse was caught in Dragon Rocks Nature Reserve in 1993 after two years of fox baiting (Morris *et al.* 1993). Capture rates for western pygmy possum in pitfall traps (Fig. 19), though a little inconsistent, appear to reflect an increase in population since fox control commenced followed by a decline in 2000, coinciding with the declines in other species and the drop in rainfall. This pattern in western pygmy possum capture rates has not been recorded at other sites.

Western Shield monitoring sites showing poor recovery or no recovery of mammal fauna

The following sites, established since the implementation of *Western Shield*, have shown poor recovery or no recovery of either extant or translocated fauna. The sites are presented by CALM regions.

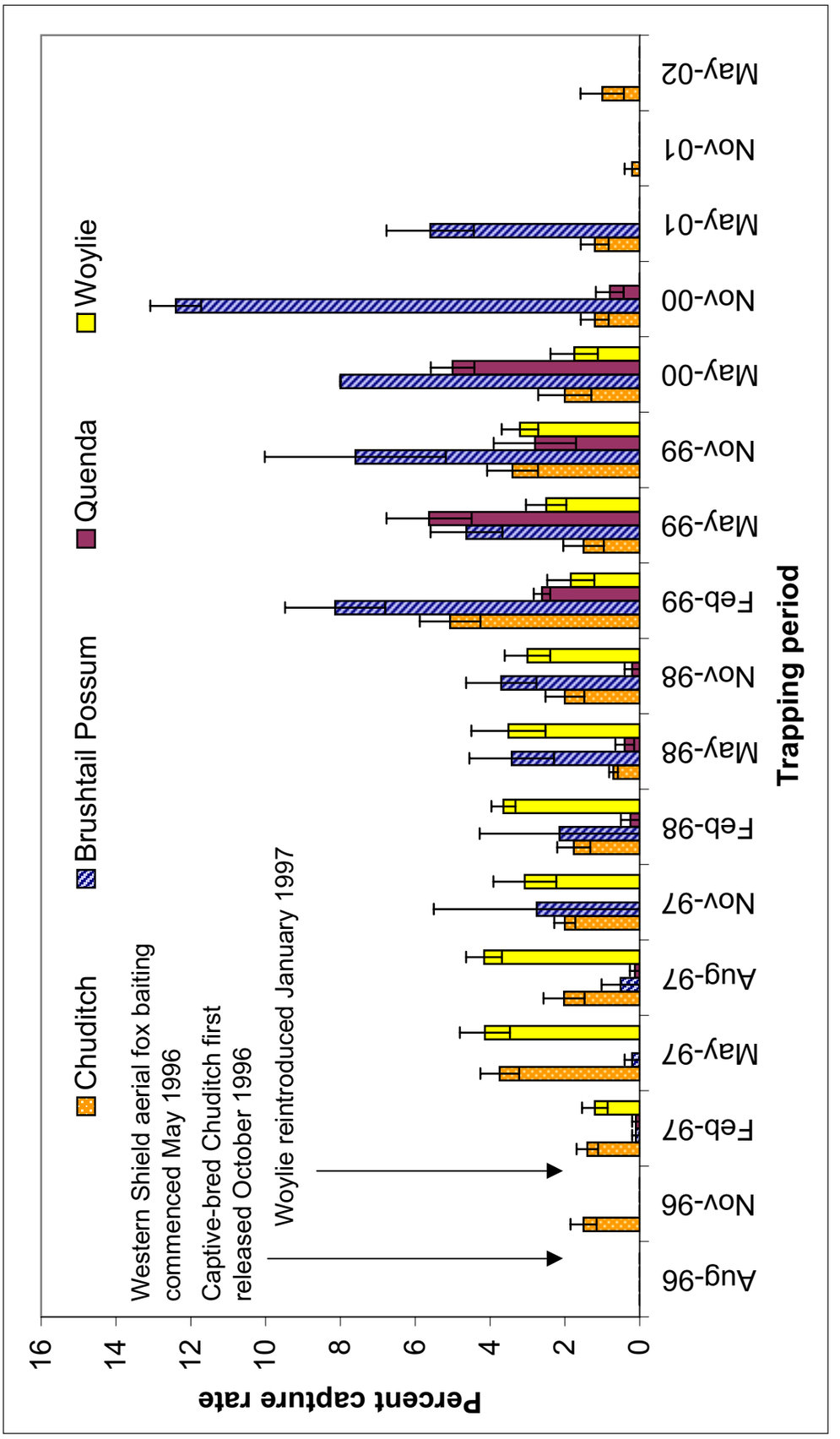

Figure 17. Mean daily percent capture rate (bars denote standard error) for medium-size mammals in Lake Magenta Nature Reserve, using small cage traps.

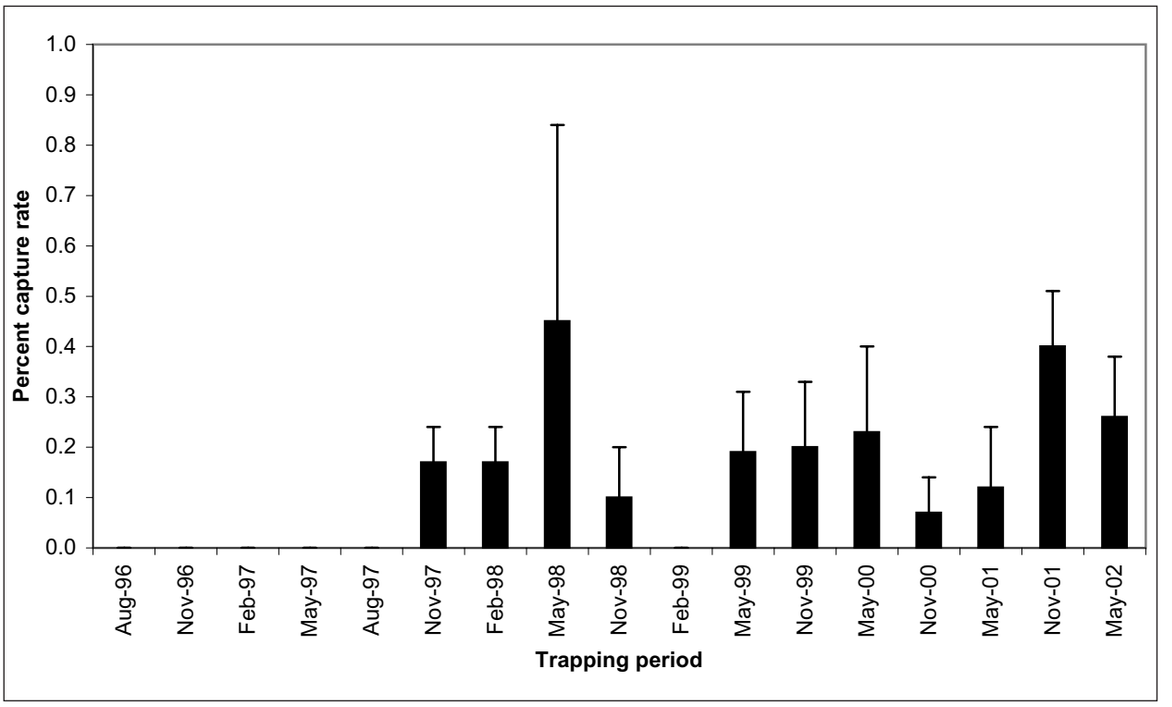

Figure 18. Mean daily percent capture rate (bars denote standard error) for heath mouse in Lake Magenta Nature Reserve, using small cage traps, elliott traps and pitfall traps.

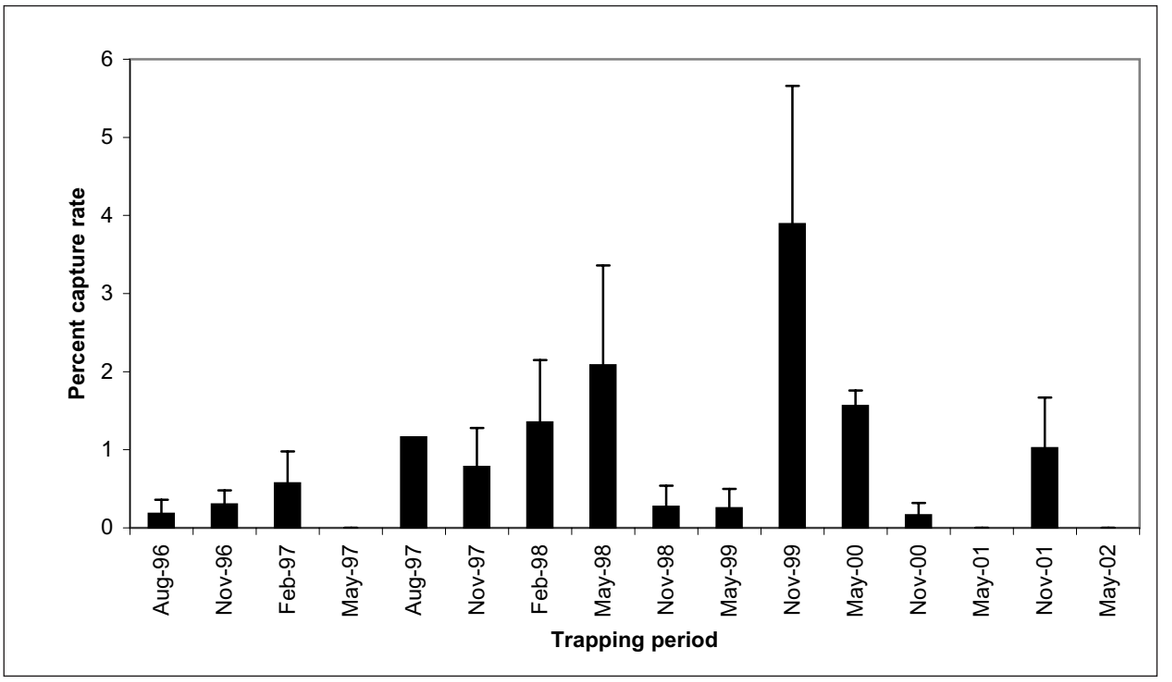

Figure 19. Mean daily percent capture rate (bars denote standard error) for western pygmy possum in Lake Magenta Nature Reserve, using pitfall traps.

South West Region

Milyeannup Forest Block
Chuditch, quenda, and brushtail possums have been caught but at very low capture rates and none show evidence of recovery. Brush-tailed phascogale, mardo and southern bush rat have also been caught, the bush rats being the most abundant species. None of these species exhibit any pattern that may relate to a response to fox control.

Warren Region

Wheatley Forest Block
Karri forest is the dominant vegetation type in this forest block. Brushtail possums, quenda, mardo, southern bush rat and Black Rat have been trapped. With the exception of bush rats in September 1996 capture rates have been very low (0.4% to 2.5%) with no discernable trends.

Gray Forest Block
This is another karri forest site. Southern bush rats are abundant but capture rates of other species have been very low, generally less than 2.5%. Brushtail possums are present apparently at very low density (only two individuals have been caught) but they may be less active on the ground in this habitat and therefore less likely to encounter traps. Woylies were reintroduced to neighbouring Strickland Forest Block in 2000 and have appeared on the transect in 2001 with a capture rate of 3%.

Lake Muir Nature Reserve
The monitoring transect is located in the eastern part of the reserve. Woylies are present in very low numbers and a restocking of woylies in neighbouring Poorginup and Chitelup forest blocks occurred in 1998. Captures of woylies have been sporadic and capture rates have remained low. Chuditch and brushtail possums have made a late appearance on the transect and appear to be showing some indication of recovery, particularly chuditch with a capture rate of 2% in March 2002.

Mt Frankland
Monitoring results show that southern bush rats are the most frequently trapped species and brushtail possums and quenda are the only medium-sized mammals trapped. Capture rates for possums and quenda are less than 1% and insufficient to determine trends.

D'Entrecasteaux National Park, Woolbales site
This monitoring transect has yielded very poor results. Southern bush rats are very abundant but capture rates of the only medium-size mammals trapped, quenda and brushtail possums, have been insignificant.

Walpole-Nornalup National Park, Hilltop site
Slightly better results have been recorded on this transect. Again southern bush rats are very abundant and dominate trap captures. Capture rates of brushtail possums suggest the beginnings of a recovery followed by a decline in 2001. Capture rates for quenda were less than 1% and show no discernable pattern.

Denmark and Denbarker forest blocks (Mt Lindesay)
This area was the site of a woylie reintroduction in 1998 and a chuditch restocking in 1999. A monitoring transect of 100 small cage traps has been established and monitoring results are presented in Fig. 20. Quenda are present but the low capture rates suggest low density along the transect. Woylies appeared to be surviving well until chuditch were released and no further captures were recorded after December 1999. Chuditch appeared to be establishing but declined in 2001 and capture rates have remained below 1%. Southern bush rats were abundant but capture rates were not high enough to significantly impact on the captures of other species.

Wheatbelt Region

Dragon Rocks Nature Reserve
An extensive fauna survey was undertaken in Dragon Rocks Nature Reserve in 1972 (McKenzie *et al.* 1973). The brushtail possum was the only medium-size mammal trapped during the survey with two individuals trapped in 909 trap-nights. One red-tailed phascogale and one western mouse (*Pseudomys occidentalis*) were captured in Elliott traps (1206 trap-nights).

Fox control was undertaken in the southern half of the reserve in 1991 for two years as part of an experiment to investigate the effect of predation by foxes on populations of the western mouse (Morris *et al.* 1993). The results suggested that factors other than fox predation were responsible for regulating abundance in this species. Fox control over the entire reserve under Western Shield began in May 1996.

Fauna monitoring under *Western Shield* using cage traps and Elliott traps commenced in 1999. The intention was to monitor twice a year but limited resources led to a decision to cease monitoring in 2001. Again, the only medium-size mammal trapped was the brushtail possum but there were signs of recovery. One individual was caught in May 2000 and four individuals were caught in May 2001 (mean daily capture rate of 1.25%). Western mouse has also been trapped and the mean daily capture rate, using both cage traps and Elliott traps, in May 2001 (2.38%) was more than double that of May 2000 (0.88%). This is not a sustained increase and it may be due to factors other than fox control. There have been no captures of red-tailed phascogale. Monitoring in Dragon Rocks Nature Reserve will be resumed in 2003 and will be continued on an annual basis.

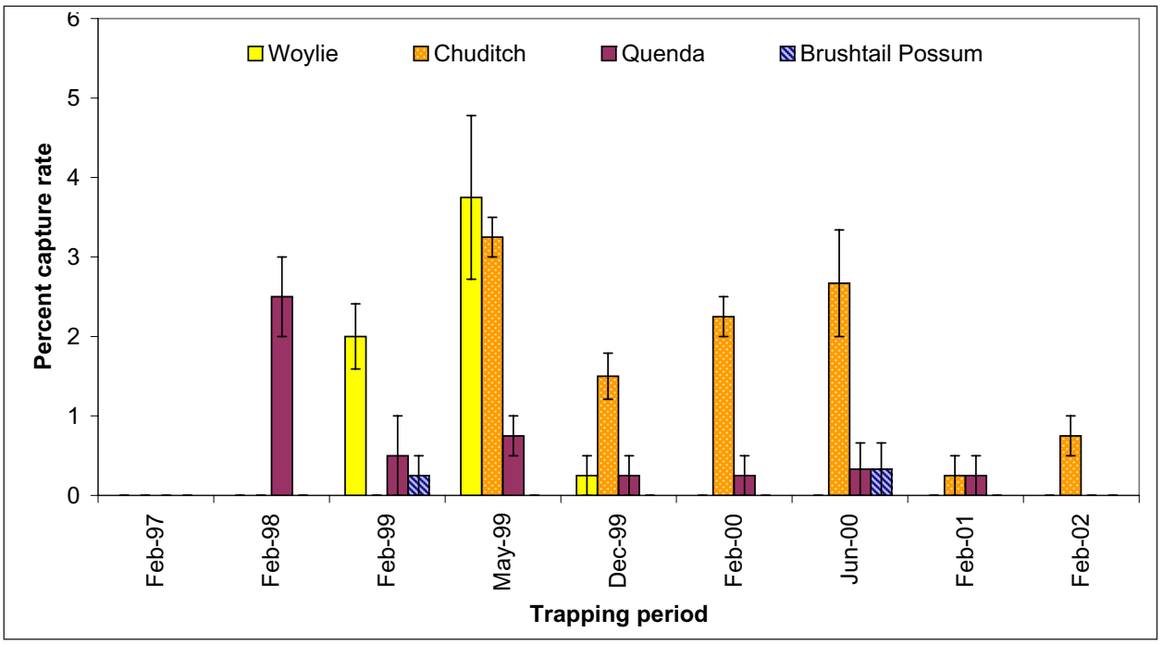

Figure 20. Mean daily percent capture rate (bars denote standard error) for medium-size mammals in Denmark and Denbarker forest blocks using small cage traps.

Spotlighting results

Very few spotlighting transects have been established to monitor fauna recovery due to limited resources for overtime allowances for district staff. Those that have been established show much greater variability in abundance estimates than data from trapping transects and trends in abundance are less evident. The sighting surveys have been done as single events rather than the recommended minimum of two consecutive nights.

Warren Region

Perup forest areas

Spotlighting surveys have been undertaken in Chariup, Moopinup and Kenninup forest blocks. These surveys have recorded brushtail possums, western ringtail possums and small numbers of Western Brush Wallabies.

The data on brushtail possums suggest a decline in Chariup since the sighting rates dropped from 8.4 per 10 km to zero sightings. The monitoring results from trapping in this forest block suggest a stable population during the same period thus the difference in results is probably an indicator of changes in possum activity. The brushtail possum data from Moopinup is consistent with the trapping data from the same period and shows little change in abundance except a temporary drop in March 2000. In Kenninup there appears to have been a general decline though the fluctuation in sightings makes this a subjective interpretation.

Data on western ringtail possums is very scant from trapping data but the spotlighting data suggest an increase in numbers at Moopinup and Kenninup. The spotlighting data does not reveal much about trends in western brush wallaby numbers since sightings were few and infrequent.

Wheatbelt Region

Dongolocking Nature Reserve

The spotlighting data from this nature reserve shows little change in the abundance of brushtail possums but a large apparent increase in western brush wallaby (Fig. 21a). Rabbits appeared to have increased substantially in 1999 (Fig. 21b) and this may have been due to the above average winter rainfall observed in that year in this area of the wheatbelt (rainfall trends similar to Perth, Figs 24 and 25). The above average winter rainfall may also have assisted the apparent increase in western brush wallaby after 1999. Foxes and feral cats have been observed infrequently indicating low-level presence.

'Jaloran' Nature Reserve

Local volunteers under the guidance of CALM staff from Katanning have undertaken the spotlighting surveys in this unnamed nature reserve, formerly known as Jaloran Timber Reserve. The data show a recovery of brushtail possums and western brush wallaby (Fig. 22a). There appears to have been a decline in western grey kangaroos during the same period. Tammar Wallabies are present but are infrequently observed and show no sign of recovery.

Rabbit numbers appear to fluctuate on a three to four year cycle which may be indicative of myxomatosis outbreaks (Fig. 22b). Foxes and feral cats have been observed infrequently indicating low-level presence.

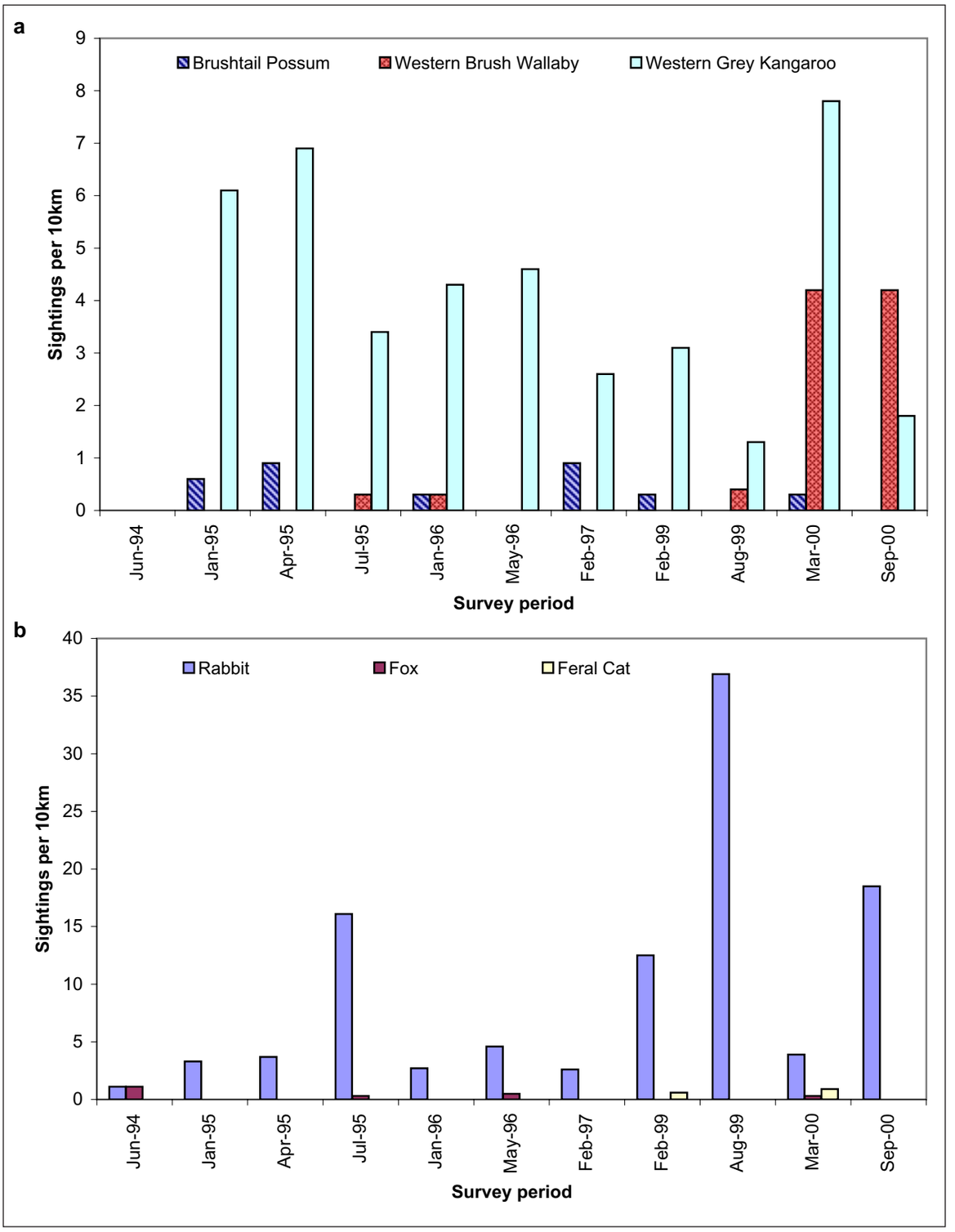

Figure 21. Spotlighting results, presented as the number of sightings per 10km, for (a) native mammals and (b) introduced mammals in Dongolocking Nature Reserve.

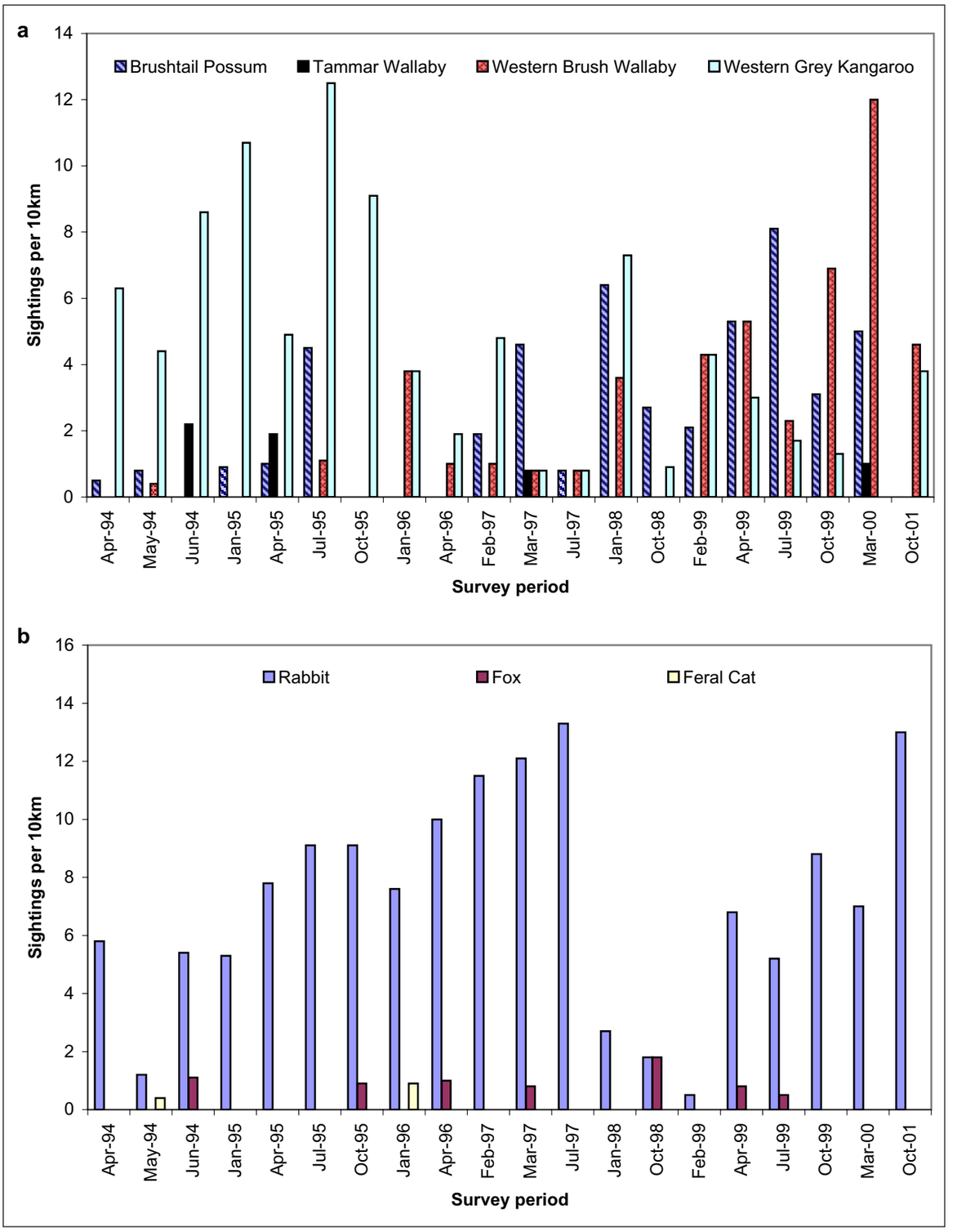

Figure 22. Spotlighting results, presented as the number of sightings per 10km, for (a) native mammals and (b) introduced mammals in 'Jaloran' Nature Reserve.

TABLE 6

Numbers of Rothschild's Rock-wallabies and Euros seen during spotlighting surveys 1992-present (Data from F. Stanley, CALM Karratha). R-w = rock-wallabies; Eu = Euro; - = no survey; and * = species not present.

DATE	BURRUP, VEHICLE		BURRUP, WALKING		DOLPHIN IS		ENDERBY IS	
	R-w	Eu	R-w	Eu	R-w	Eu	R-w	Eu
Jun 92	0	64	-	-	-	-	-	*
Nov/Dec 95	0	26	0	0	21	1	45	*
May 96	0	10	0	2	17	0	9	*
Nov 96	2	17	-	-	-	-	-	*
Sep 97	0	27	-	-	-	-	-	*
Feb 98	-	-	-	-	7	9	41	*
Sep 99	-	-	-	-	19	1	50	*
Nov 00	-	-	-	-	23	6	49	*
Mean (± SD)	0.4 (± 0.9)	28.8 (± 20.8)	0	1 (± 1)	17.4 (± 6.2)	3.4 (± 3.9)	38.8 (± 17)	*

Pilbara Region

Burrup Peninsula, Dolphin and Enderby islands

Fox baiting was implemented on Dolphin Island in the Dampier Archipelago in 1980 to protect and recover the population of Rothschild's Rock-wallaby (*Petrogale rothschildi*). Foxes are able to reach the island from the Burrup Peninsula but another population of rock-wallabies has remained isolated from foxes on Enderby Island. Spotlighting surveys have been undertaken on both Dolphin and Enderby islands since 1979 and results up to 1990 showing clear recovery on Dolphin Island have been published (Kinnear *et al.* 2002). The monitoring of these populations as well as the Burrup Peninsula has been maintained by Pilbara Regional staff and results are provided in Table 6. Results show stable populations on both Dolphin and Enderby islands. The Burrup Peninsula has had a varied baiting history since 1980 with both large temporal and spatial gaps in the distribution of baits. There has been no observable recovery of rock-wallabies on the Burrup Peninsula, although rock-wallabies have persisted at low numbers. Presumably the baiting has not been effective in controlling foxes sufficiently to facilitate recovery.

Monitoring sites showing increases in reptile fauna

The recovery of medium-size mammals has been an expected outcome of broadscale fox control under *Western Shield*. A less expected outcome has been the apparent increase of some reptile populations. Trapping results from at least three monitoring sites show increases of reptile species.

Reptile activity is very temperature dependent and capture rates of reptiles will vary at least partly in response to changes in ambient temperatures. While daily temperatures have not been recorded at monitoring sites, examination of temperature data from the nearest Australian Bureau of Meteorology recording stations show that the observed increases in reptile captures at the sites discussed below have occurred in spite of changes in ambient temperatures (see Fig. 23).

Hills Forest and Fitzgerald River National Park

Increasing capture rates of bobtail skinks (*Tiliqua rugosa*) have been recorded on the Hills Forest northern transect and on the Twertup transect in Fitzgerald River National Park. Activity of bobtails is highest in spring and thus capture rates recorded in spring months are the best indication of population trends.

Waychinnicup National Park

Not only has there been an increase in the capture rates of some species in this national park but there has also been an increase in the number of species that are consistently trapped (Fig. 23). Seven species of reptile have now been recorded on the monitoring transect. Increases appear evident in four of these: *T. rugosa*, *Egernia luctuosa*, *E. napoleonis*, and *E. pulchra*.

Records of feral cats on fauna monitoring transects

Earlier studies have shown that cats replace foxes as a key threat to fauna recovery in arid areas where foxes have been controlled or excluded (Christensen and Burrows 1994; Risbey *et al.* 2000; Morris *et al.* 2004, this issue). It could therefore be expected that the fauna recovery sites in the drier northern and eastern wheatbelt and south coast would be the most likely sites to show increases in feral cat numbers since the commencement of fox control. Feral cats are generally difficult to trap but occasionally they are caught in small cage traps during fauna surveys. Captures of cats have been recorded for all Western Shield fauna monitoring sites (Table 7).

Although capture rates are very low (less than 1%), several sites stand out as having recorded noticeably more cats than most other sites. At Hill Top site in Walpole-Nornalup National Park cats have been trapped during every survey period and the overall capture rate is the highest recorded at 0.63%. Nearby Valley of the Giants has the next highest capture rate at 0.3%. At Porongorup National Park the capture rate is 0.26%.

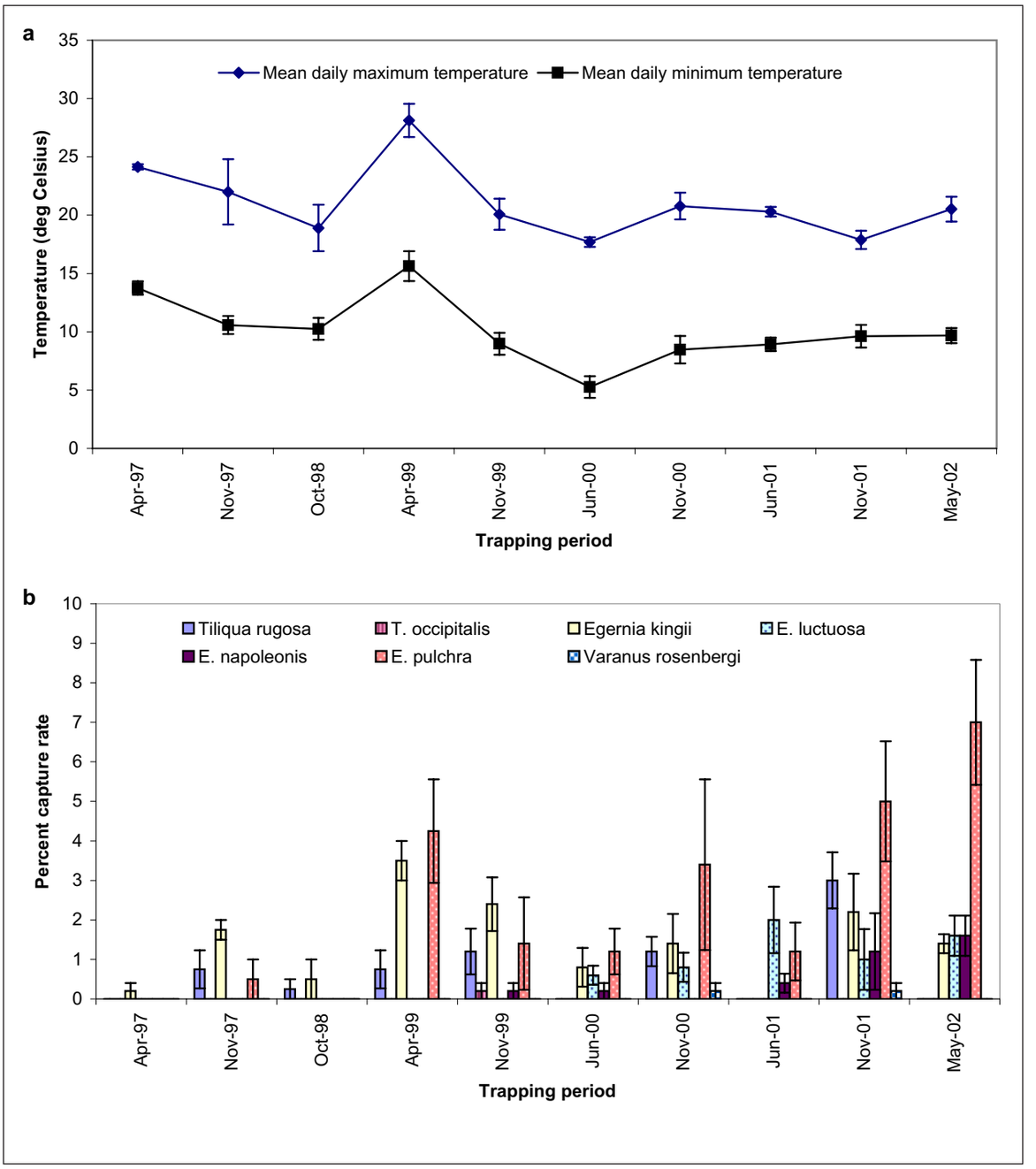

Figure 23. *(a)* *Mean daily temperatures (bars denote standard errors) recorded at Albany Airport during the trapping periods at Waychinicup National Park (data from Australian Bureau of Meteorology).*
(b) *Mean daily percent capture rate (bars denote standard errors) for reptiles in Waychinicup National Park, using small cage traps and elliott traps.*

TABLE 7
The number of feral cats caught, total number of trapnights, percent capture rate, number of survey periods and the proportion of survey periods during which cats were trapped.

MONITORING SITE	# CATS CAUGHT	TRAPNIGHTS	% CAPTURE RATE	NO SURVEY PERIODS	PROPORTION OF SURVEY PERIODS WHEN CATS WERE CAUGHT (%)
Kalbarri NP	1	2397	0.04	4	25
Badgingarra NP	0	600	0.00	3	0
Nambung NP	1	580	0.17	3	33.3
Julimar CP	5	10 056	0.05	14	28.6
Hills Forest	2	6986	0.03	18	11.1
Batalling	1	12 401	0.01	24	4.2
Centaur	0	1496	0.00	4	0
Catterick	0	4000	0.00	5	0
Milyeannup	1	2120	0.05	5	20
Noggerup	1	5709	0.02	8	12.5
Gray	0	752	0.00	4	0
Wheatley	0	904	0.00	4	0
Tone	0	1392	0.00	8	0
Moopinup	0	1376	0.00	7	0
Chariup	0	1100	0.00	5	0
Boyicup	1	800	0.13	4	25
Lake Muir NR	0	1300	0.00	7	0
Hill Top	15	2400	0.63	6	100
Valley of the Giants	13	4400	0.30	11	63.6
Mt Lindesay	2	3500	0.06	9	22.2
Mt Frankland	2	2400	0.08	6	33.3
D'Entrecastaux NP	3	2500	0.12	6	50
Stirling Range NP	0	2100	0.00	8	0
Porongorup NP	6	2318	0.26	10	40
Waychinnicup NP	0	2350	0.00	10	0
Twertup	1	1750	0.06	7	14.3
Moir Track	0	2150	0.00	10	0
Dryandra Woodland	0	1050	0.00	7	0
Tutanning NR	0	900	0.00	6	0
Boyagin NR	0	1650	0.00	6	0
Bendering NR	0	275	0.00	3	0
North Kalgarin NR	0	531	0.00	3	0
Roe NR	0	300	0.00	3	0
Lake Magenta NR	1	11 461	0.01	17	5.9
Dragon Rocks NR	1	1500	0.07	4	25

These sites are high rainfall sites supporting forests of karri or tingle. Low rainfall sites such as Dragon Rocks and Lake Magenta nature reserves have had very low capture rates of cats. An assessment of cat numbers in Dragon Rocks Nature Reserve in 2000 showed that there was a high number of cats present (Angus and Thomas, 2000). Anecdotal observations from Katanning District staff suggest that cat numbers may be high in Lake Magenta Nature Reserve. Clearly the data from fauna monitoring surveys do not accurately reflect feral cat densities. However, the data from Hill Top, Valley of the Giants and Porongorup suggest that there are unusually high cat numbers and that cats are less trap shy at these sites. Fauna recovery has been poor at Hill Top, very slow at Valley of the Giants but recovery of brushtail possums and quenda has been good at Porongorup.

Rainfall data

Rainfall data from Perth, Bridgetown, Pemberton, Albany, Lake Grace, Narrogin, Pingelly, Jacup and Ravensthorpe were obtained from the Bureau of Meterology to examine rainfall patterns in the south west of WA. The figures for Perth (Figs 24 and 25) and Albany (Figs 26 and 27) are shown as representative of the patterns from 1997 to 2002.

The figures indicate below average rainfall for most years except 1999, but particularly for 2000 through to 2002. The low rainfall in the last three years is least pronounced in the extreme south west (Bridgetown, Pemberton) and most pronounced in the eastern wheatbelt and south coast (Albany, Narrogin, Pingelly and Lake Grace).

The south-west of WA has a mediterranean-type climate with most rainfall occurring in the months of winter and early spring. Occasional cyclone events bring high rainfall events into the south west during summer months and this occurred in January 2000. For the purposes of simplifying the rainfall data it is assumed that the winter rainfall is the most important for sustaining the natural growth of the native vegetation. Winter rainfall has been presented as the combined total for the months

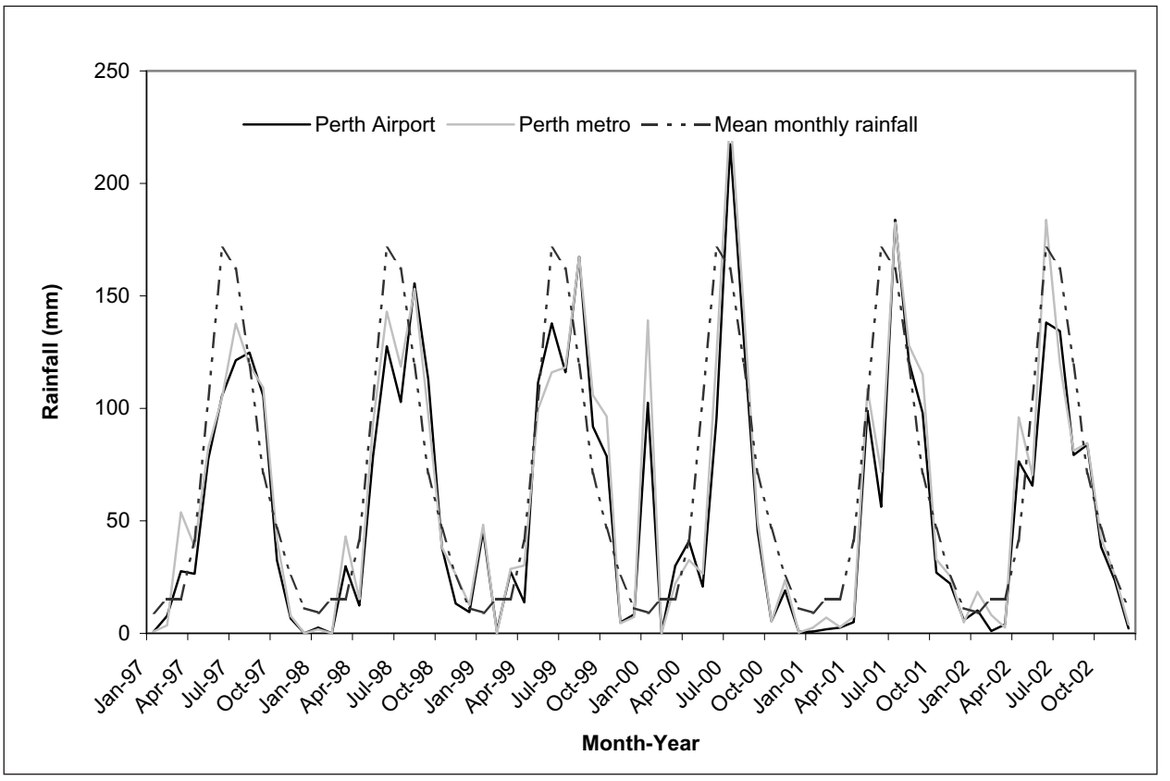

Figure 24. Monthly rainfall for Perth Airport and metropolitan area January 1997–June 2002 compared with the mean monthly rainfall for Perth metropolitan area.

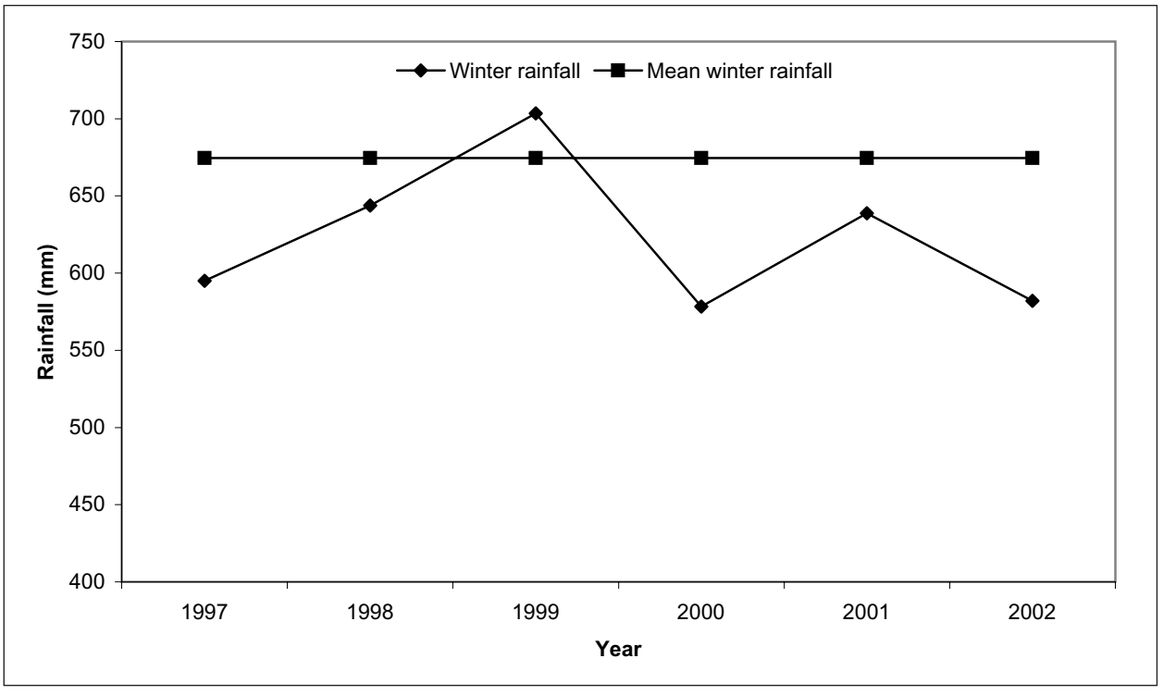

Figure 25. Total winter (May-Oct) rainfall for Perth, 1997–2002, compared with the mean winter rainfall for Perth.

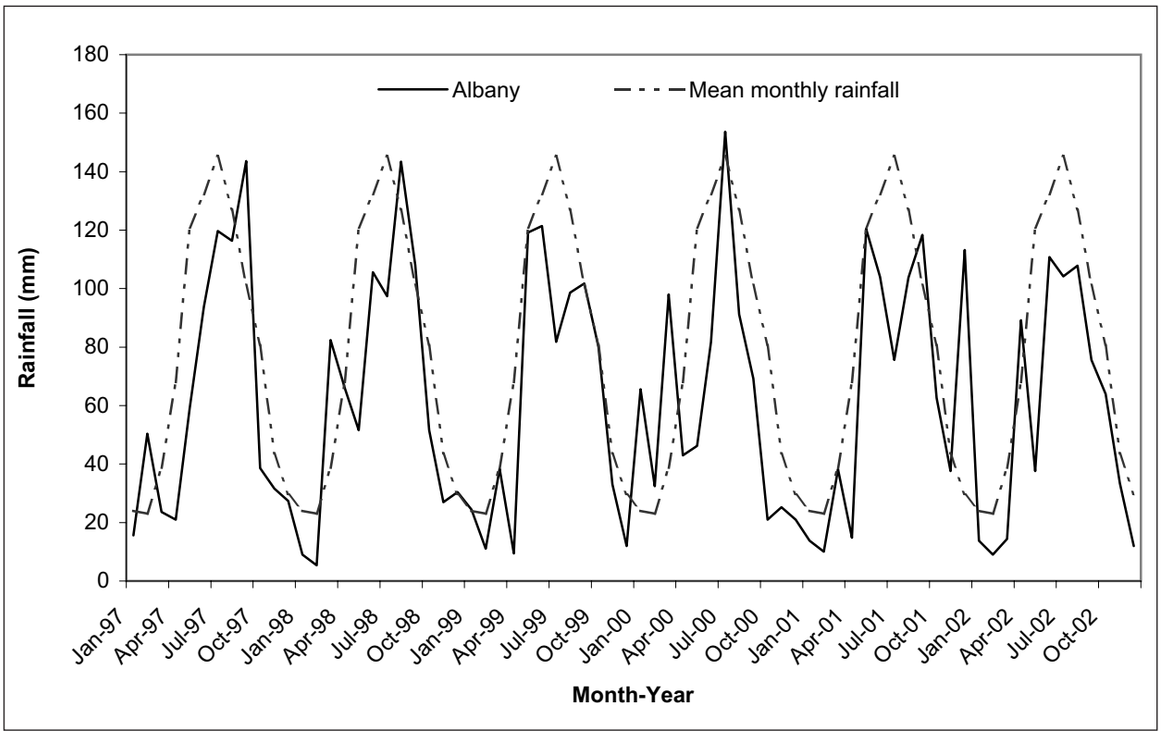

Figure 26. Monthly rainfall for Albany, January 1997–June 2002, compared with the mean monthly rainfall for Albany.

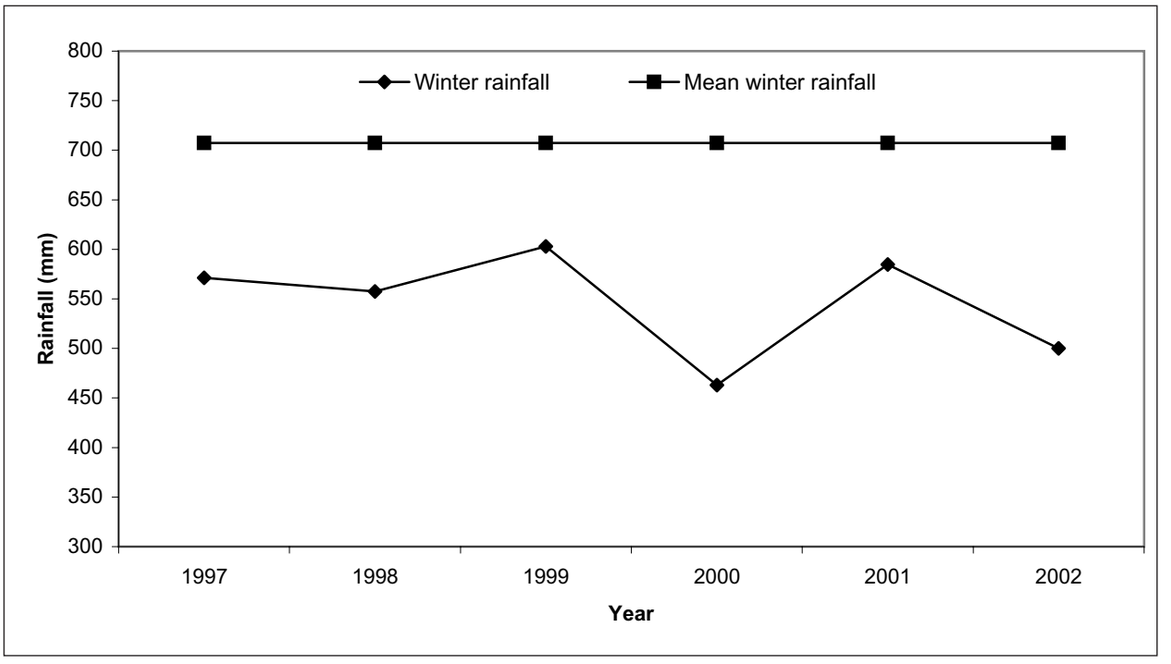

Figure 27. Total winter (May-Oct) rainfall for Albany, 1997–2002, compared with the mean winter rainfall for Albany.

of May through to October (Figs 25 and 27). Albany's winter rainfall has been well below the long term average in all years from 1997 to 2002 (Fig. 27). The impact of the drop in winter rainfall has been most pronounced in the eastern wheatbelt where the winter rainfall in some areas (e.g. Lake Grace) in 2002 was less than half of the long-term average. Clearly, these figures reflect at least mild drought conditions for most of the south-west of WA.

Deficiencies in monitoring

Monitoring of fauna recovery under *Western Shield* has largely focused on the south west of the State from Kalbarri to Fitzgerald River National Park. However, there are some key sites in the Pilbara Region and other remote areas which are currently baited but there is no formal commitment to monitoring the recovery of fauna. Cape Range National Park is baited to protect Black-flanked Rock-wallabies and sea turtles but no resources have been put into monitoring by *Western Shield*. Some monitoring of rock-wallabies in Yardie Creek has been undertaken by tour operators, but this was limited, biased, and is no longer done at all (P. Kendrick, pers comm). The monitoring of the Dampier Archipelago is undertaken using regional resources with no contribution from Western Shield. There has been some survey work done in the Esperance District in Cape Arid and Cape Le Grande national parks but there has been no formal establishment of a monitoring program. Some monitoring work was done by CALM Science Division to monitor the establishment of a tranlsocated population of chuditch.

The establishment of monitoring programs for isolated areas is essential to justify the benefits of maintaining fox control and priority needs to be given to identifying monitoring and resource requirements for these areas.

Using monitoring data for adaptive management

Monitoring of fauna under *Western Shield* has been implemented for the purpose of assessing whether fauna recovery is occurring in areas subject to fox control. The results of the monitoring and the manner in which the data are interpreted could have implications for the management of fox control or other fauna and land management practices.

If the data indicate that there has been a sustained increase in fauna abundance it is assumed that fox control is effective and the fauna are recovering. If the data indicate that fauna abundance is high with regular recruitment but has not changed significantly then it is assumed that fox control is effective and fauna abundance reflects the carrying capacity of the site. Other factors may be responsible, or partly responsible, but the desired results have been achieved and no change to the baiting regime is required.

If the data indicate that fauna abundance is very low and not increasing, or it has declined significantly, it may indicate that the level of fox control is not sufficient to facilitate recovery or perhaps predation by feral cats is significant. It may also indicate that the existing populations are too small to facilitate recovery. Or it may indicate that any number of environmental factors such as rainfall may have made conditions unsuitable for recovery. The response to this scenario may include intensifying the baiting regime, examination of other data relevant to the site or other investigations involving experimental research to identify the cause (e.g. cat predation or increased salinisation reducing habitat suitability).

Formal processes for reviewing baiting regimes and fauna management activities in light of trends in monitoring data have not yet been developed within the *Western Shield* program. Most of the efforts towards this end have been directed at developing and refining the data collection and management system structured around the Fauna File. This process in itself has necessitated the review of data from monitoring sites on a district by district basis. Data from sites showing recovery of one or more species have been used in unpublished reports to corporate sponsors, in media advertisements and in the CALM Annual Report.

With six or more years of data for most sites and a functional data collection and management system in place, development of a formal process for reviewing monitoring data, baiting and fauna management activities is recommended as a priority.

An annual review of monitoring data is suggested with the first stage being the collation of the following information within CALM districts or regions with assistance from the Western Shield Zoologist:

- Survey effort at all sites, indicating whether effort has increased, declined or remained consistent;
- Abundance estimates (percent capture rate, KTBA or other) of individual species and faunal suites (e.g. all medium-size mammals) for all survey periods;
- Data on environmental changes such as rainfall, fire and disease (dieback or zoonoses); and
- Any changes in survey methods, bait types (trapping), or other relevant variables.

The second stage of the review will be the collation of the above information across CALM regions by the Western Shield Zoologist. This will include comparisons of abundance data from all sites by species and by faunal suites, integration of environmental data and identification of any changes to survey methods, bait types, etc.

A draft report of the collated information will form the basis for any recommendations for changes to baiting regimes and other fauna management activities. This report will be circulated to all CALM district and regional Nature Conservation Program Leaders and tabled at Western Shield regional management committees for discussion and recommendations. The revised report will then be submitted to the Western Shield Steering Committee and/or the Western Shield Program Coordinator (if appointed). Final reporting of the review

and recommendations will be made to the CALM Corporate Executive and made available to CALM Strategic Development and Corporate Affairs Division for use in media and educational programs.

EXPENDITURE ON FAUNA MONITORING

Under the CALM accounting system set up for *Western Shield* all expenditure on fauna monitoring activities should be recorded against the 'WSB' tenure code. Table 8 shows all the figures recorded against this code across all CALM regions and districts where *Western Shield* activities have occurred. Amalgamation of forest districts occurred in 2001/02 and this has led to some changes in the management of accounting procedures in the affected districts. Table 8 is based on the new district names with former district names in brackets. It is apparent from Table 8 that some districts have not been using the appropriate *Western Shield* codes and hence expenditure figures cannot be tracked via the 'WSB' tenure code. This has made it difficult to identify total expenditure on Western Shield fauna monitoring activities. This problem became apparent in 2000 when an attempt was made to extract expenditure figures from all CALM districts. A review of the department's accounting system was in progress at the time and it was anticipated that the new system would solve the problem and make it easier for districts and regions to set up appropriate account codes to record expenditure for all *Western Shield* fauna monitoring activities. The new system appears to be working better but not as well as anticipated. The current review of finances associated with the development of service provider agreements should provide an ideal opportunity to bring this matter to the attention of the districts and regions and to achieve consensus on the use of account codes.

Also shown in Table 8 are the estimated costs of fauna monitoring within CALM districts provided by Burbidge *et al* (1995). A comparison of these figures with the expenditure recorded against the 'WSB' tenure code show that the costs of fauna monitoring activities have significantly exceeded the initial estimates. Some of this difference may be due to the monitoring of some sites that were not included in Burbidge *et al* (1995) but were later included in the *Western Shield* strategic plan (CALM 1999).

Wildlife Branch has purchased basic fauna monitoring equipment for the districts and regions (e.g. cage traps, Elliot traps, balances, tagging gear and tags, and bulk supplies of bait material). Four significant items in the form of custom-built trailers have been purchased to facilitate the transport of cage traps within the southwest. The expenditure breakdown for fauna monitoring equipment is shown in Tables 9 and 10. The bulk of the expenditure to date occurred in 1996/1997, with ongoing costs being largely restricted to consumable items such as peanut butter (bait ingredient) and ear tags that are purchased in bulk to effect discounts for bulk orders.

STAFF TRAINING

History

Prior to 1992 fauna surveys were performed predominantly by research personnel within the Fisheries and Wildlife Service, Forests Department, and subsequently within CALM's Research Division (now Science Division), as well as the Western Australian Museum. It became apparent that more of the responsibilities for the surveying, monitoring and management of threatened fauna needed to be shared with the regions and districts within CALM who were responsible for managing the areas where the fauna occurred. The skills to implement this strategy were generally not available within districts and regions at this time.

Since no commercial courses were available outside of CALM to train staff, an in-house course was developed jointly by Science Division and Central Forest Region in 1992 which was focused entirely on mammals. The *Mammal Conservation Course* was run at the Batalling Field Study Centre up to 1995. In 1996 this course was redeveloped by Science Division and the Pilbara Region to suit the needs of the northern areas and was held in Millstream National Park. It had a broader focus on other fauna groups as well as mammals. Central Forest Region also ran a similar course at Batalling in 1996 and included some other nature conservation issues.

The department's Wildlife Branch became the custodian of the fauna training course in 1997. With the Western Shield Zoologist appointed as course coordinator, the course has been further developed with assistance from Science Division, Nature Conservation Division, districts and regions. The course has been designed so that it is equally applicable to wages and salary staff, and is presented in a format that can be successfully completed by people without tertiary qualifications. The main focus of the course is to ensure that course graduates can design and safely implement fauna monitoring programs and obtain consistent and valid results.

Course participants each receive a course manual with detailed notes that they can refer to at any time in the future. They also have the opportunity to establish important networks with professional biologists from both within CALM and other government agencies such as the WA Museum and the Department of Environmental Protection.

Accreditation

The course has been revised a number of times over the years and has been conducted as an accredited training program. Formal accreditation however requires that the course content be compiled into a formatted presenter's manual. This stage of the accreditation process has not

TABLE 8

Summary of *Western Shield* expenditure ($) on fauna monitoring (WSB tenure code) from January 1997 to November 2002.

CALM REGION	CALM DISTRICT	EXPENDITURE							ESTIMATED COST P.A. (Burbidge *et al* 1995)
		1997	1998	1999	2000	2001	2002	**TOTAL**	
Midwest	Midwest Region								
	(Geraldton)			98	4,932	3,466	4,918	**13,414**	5,500
	Moora								
	Shark Bay				135,303	124,280	138,929	**398,512**	7,000
	TOTAL			98	140,235	127,746	143,847	411,926	12,500
Swan	Perth Hills District								
	(Mundaring)	9,550	17,033	21,196	16,554	14,059	11,444	**89,835**	3,700
	Dwellingup								7,700
	Swan Coastal District								
	(Perth)	326		348	3,040	462		**4,176**	4,550
	TOTAL	9,876	17,033	21,543	19,594	14,522	11,444	94,011	15,950
South West	Black wood District								
	(Kirup)					17,038		**17,038**	2,950
	Black wood District								
	(Busselton)	457	5,016	3,391	277		34,775		1,100
	Wellington District								
	(Mornington)	3,003	15,733	33,194	43,281	47,400		**142,611**	5,300
	TOTAL	3,461	20,749	36,585	43,558	64,438	34,775	203,566	9,350
Warren	Warren Region						475	**475**	
	Donnelly District								
	(Manjimup)					10,134		**10,134**	6,050
	Donnelly District								
	(Pemberton)	4,738	7,244	5,032	13,151	29,004		**59,169**	4,500
	Frankland District								
	(Walpole)	2,577	9,569	13,821	12,251	8,187		**46,404**	2,050
	TOTAL	7,315	16,812	18,853	25,402	47,324	475	116,182	12,600
South Coast	Esperance	0	4,270	10,318	6,584	2,712	12,656	**36,540**	12,000
	South Coast Region								
	(Albany)	15,021	26,087	27,892	32,635	31,973	34,312	**167,919**	14,850
	TOTAL	15,021	30,357	38,210	39,219	34,684	46,968	204,459	26,850
Wheatbelt	Katanning	60,402	46,563	30,585	46,138	37,668	19,495	**240,852**	8,400
	Merredin								4,000
	Narrogin	22,739	9,302	60,038	68,689	63,071	81,152	**304,990**	20,450
	TOTAL	83,141	55,865	90,623	114,827	100,739	100,647	545,842	29,250
Pilbara	Exmouth			254				**254**	1,500
	Karratha								8,850
	TOTAL			254				254	10,350
Goldfields	Kalgoorlie	1,250,184	17,875	16,698	2,111			**1,286,868**	4,000
	TOTAL	1,250,184	17,875	16,698	2,111			1,286,868	4,000
Nature Conservation	Wildlife Administration	158,439	76,962	25,871	129,064	139,450	91,765	**621,551**	
	Annual Expenditure Total	1,527,435	235,653	248,735	514,010	528,904	429,921		
	TOTAL EXPENDITURE							3,484,658	124,450

yet been achieved due to other competing priorities. Assistance is required to either address competing priorities or undertake the compilation of the manual and again the creation of a dedicated position to assist the Western Shield Zoologist is recommended.

With accreditation, the course has genuine potential for sale to other State agencies wishing to develop similar training courses as many of the sections are generic to these conservation agencies. The course also has considerable application to university students and ecological management staff from larger mining companies.

Accreditation of the course will only cover accreditation in fauna management and not accreditation for fauna capturing and handling skills. The five-day course is not long enough to allow most participants time to acquire and develop the skills to a competent standard. This needs to be addressed by a subsequent assessment in the field when candidates have had time and opportunities to practice and develop their skills and feel ready to have their competency assessed. Assessment and accreditation of these skills will ensure that standards and correct procedures are maintained within the Department. The competency standards and protocols for assessment still need to be developed. Issues to be resolved include the selection and appointment of competent assessors and how widely the assessment and accreditation should be imposed within and outside the Department (e.g. should experienced research staff have to be assessed and accredited?).

TABLE 9

Summary of *Western Shield* expenditure ($) on fauna monitoring equipment by CALM District/Region. (PB=Peanut butter). *4 WS trailers manufactured by Albany Regional Prison for $2798 each.

COST CENTRE	COST ($) OF EQUIPMENT SUPPLIED						TOTALS
	TRAPS	TAGS	KITS	BAGS	PB	MISC.	
Perth		73	275				**348**
Mundaring	325	222	437	220	276	*2,798	**4,278**
Dwellingup		62	272				**334**
Central Forest (R)		231					**231**
Mornington		296	39		184		**519**
Blackwood		322	489				**811**
Manjimup	1,136	363	1,339		374	*2,798	**6,010**
Pemberton		73	275				**348**
Walpole	4,762	212	924	132	327		**6,357**
South Coast (R)	8,890	87	718	132			**9,827**
Albany		145	174		282		**601**
Esperance	1,626						**1,626**
Narrogin	3,415	145	35		184	*2,798	**6,577**
Katanning	5,152	162	68		558	300	**6,240**
Midwest (R)	1,000	58	359	12		300	**1,729**
Moora	4,600	300	700	120	70	*3,000	**8,790**
Gascoyne	2,813	107	616		95	397	**4,028**
Exmouth	2,473						**2,473**
Hills Forest Ed.	422						**422**
Woodvale	1,473	394	156				**2,023**
Wildlife Admin.	3,018	152	776	744	285	1,890	**6,865**
Totals	**41,105**	**3,404**	**7,652**	**1,360**	**2,635**	**14,281**	**70,437**

Table 10

Summary of total expenditure ($) on fauna monitoring equipment (*Western Shield* budget allocations plus District contributions) 1996-97–1999-00 inclusive.

COST	96–97		97–98		98–99		99–00	
CENTRE	TOTAL	WS	TOTAL	WS	TOTAL	WS	TOTAL	WS
Perth	99		249					
Mundaring	431		448		3,399	2,798		
Dwellingup	89		244					
Central Forest (R)	231							
Mornington					223	223		
Blackwood			634					
Manjimup	1,136	1,136	1,654	80	3,036	2,798	184	
Pemberton	695	695						
Walpole	4,151	4,151			2,207			
South Coast (R)	9,827	9,827						
Albany			424		187			
Esperance					1,626			
Narrogin	180		1,951	1,951	4,261	2,798	184	
Katanning	5,593	5,452	190		184		184	
Midwest (R)	1,729	1,729						
Gascoyne			217		3,810			
Exmouth	2,473	2,473						
Hills Forest Ed.					422			
Woodvale	1,545				477			
Wildlife Admin.	1,348	1,348	305	305	3,618	3,618	1,502	1,502
Totals	29,527	26,811	6,316	2,336	23,450	12,235	2,054	1,502

Course participation

The higher participation rate of women in the course since 1997 (27%) is notable, along with the high retention rate (75.8%) of staff who have completed the course (Table 11). Most Districts in the southwest now have at least four trained staff (Figure 28) though not all of these staff may have responsibilities in fauna monitoring or nature conservation duties. Most of the trained staff are located in the south-west of WA.

Consideration has been given to running a second Fauna Training course in May of each year. A second course would allow CALM to cater for the staff (e.g. Land for Wildlife, Bushcare Facilitators) on the waiting list for fauna training, and to also provide opportunities to full fee paying 'students' from other government agencies, universities (e.g. Ph.D. students) and professionals from mining companies. The profits derived from the full fee paying students could then be used to off set the costs of CALM staff attending the courses each year.

It is envisaged that the course will continue to be refined and amended to reflect the needs of CALM staff.

Costs of the course

The course is run as a five-day live-in course and has been held at several different venues. The cost of running the course includes the cost of accommodation and catering for about 24 to 26 people, stationery, student manuals, field equipment, vehicle running costs and staff time. Costs incurred have varied with the venue. The course held at the Perup Forest Ecology Centre in 2001 cost approximately $10 900 excluding staff time and student transportation to the course venue compared with an approximate cost of $9 500 for the course held in 2002 at Rylington Park (about 20 km north of the Perup Forest Ecology Centre). The main difference in cost was due to Rylington Park being a cheaper venue in terms of accommodation.

To date the course has not been run at a cost recovery basis. Attendance fees currently are $250 per person for CALM staff and volunteers and $500 per person for non-CALM persons. The logistics of running the course are such that the course can only accommodate 16 participants comfortably and the demand from within the Department has excluded external participation for the last two years. The return from attendance fees therefore equates to $4000 which is less than half of the cost of running the course. It is anticipated that once the course fully meets national accreditation requirements that the fees will be increased to more closely reflect the actual cost of conducting the course.

Staff commitment and competency in monitoring

Interest in fauna recovery and management has become widespread and CALM district personnel have generally shown enthusiasm and commitment to *Western Shield* fauna monitoring activities. However, the level of commitment and competency within each district has been partly determined by the skills, abilities and attitudes of the personnel directly involved. The Fauna Management Course has been very important in helping to shape attitudes as well as teaching the basic skills to these personnel to provide the foundation for implementing fauna monitoring programs under *Western Shield*. However, individual competencies need to develop through on-the-job practice and involvement and the extent to which this has been accomplished has varied across districts for several reasons.

As shown in the previous section on fauna monitoring results, the size and density of fauna populations and the extent of recovery has varied greatly across monitoring sites. In those districts where fauna populations have been low or only a few different species are present in trappable numbers, district personnel have had limited opportunities to develop their competency in fauna survey skills. Flexibility in the sharing of personnel and resources across district boundaries would help to provide opportunities to improve and develop competencies as well as promoting enthusiasm. The benefits of this approach has already been recognised at the operational level and needs to be recognised and encouraged by managers.

Traditionally, staff positions that are given the responsibility of coordinating district fauna monitoring programs are also encumbered with other duties, some of which may be seen as more important within the management of the district or may offer better career opportunities.

Staff turnover through movements due to career development or resignations can cause disruptions in any program and necessitate recruitment and training of replacement staff. The development of competencies in fauna management and survey skills that can be retained within the *Western Shield* program is therefore limited by the length of time that individual staff remain involved in the program. Figure 27 shows that many CALM personnel located in south west districts have been through the Fauna Management Course, but it does not show that only a portion of these personnel are currently involved in Western Shield. The development of career structures and opportunities within the Nature Conservation Division may be needed to encourage staff to remain or move to positions where their skills in fauna management can be utilised and further developed.

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TABLE 11

Breakdown of graduates from the CALM fauna training courses conducted at Batalling Forest, Millstream National Park, Perup Forest Ecology Centre and Rylington Park 1992–2002. The number of female participants in each course is shown in parentheses. [Bat=Batalling Forest, Mls=Millstream NP, Per=Perup, Ryl=Rylington Park, CFR=Central Forest Region, SD=Science Division, PR=Pilbara Region, NCD=Nature Conservation Division, WD=Wellington District, DD=Donnelly District].

YEAR	VENUE	FACILITATION	CURRENT CALM EMPLOYEES	LEFT CALM	EXTERNAL PARTICIPANTS	TOTAL
1992	Bat	CFR,SD,WD	8 (0)	5 (0)	0	13 (0)
1993	Bat	CFR,SD,WD	5 (0)	11 (0)	0	16 (0)
1994	Bat	CFR,SD,WD	8 (0)	3 (0)	2 (1)	13 (1)
1995	Bat	CFR,SD,WD	9 (0)	2 (0)	1 (1)	12 (1)
1996	Bat	CFR,WD	12 (0)	0	1 (0)	13 (0)
1996	Mls	SD,PR	6 (2)	1 (0)	4 (1)	11 (3)
1997	Bat	NCD,SD,WD	12 (4)	4 (0)	0	16 (4)
1998	Bat	NCD,SD,WD	18 (4)	2 (0)	1 (0)	21 (4)
1999	Bat	NCD,SD,WD	12 (7)	3 (0)	1 (0)	16 (7)
2000	Per	NCD,SD,DD	14 (6)	0	1 (0)	15 (6)
2001	Per	NCD,SD,DD	15 (4)	1 (0)	0	16 (4)
2002	Ryl	NCD,SD,DD	16 (2)	0	0 16	(2)
Total			135 (29)	32 (0)	11 (3)	178 (32)

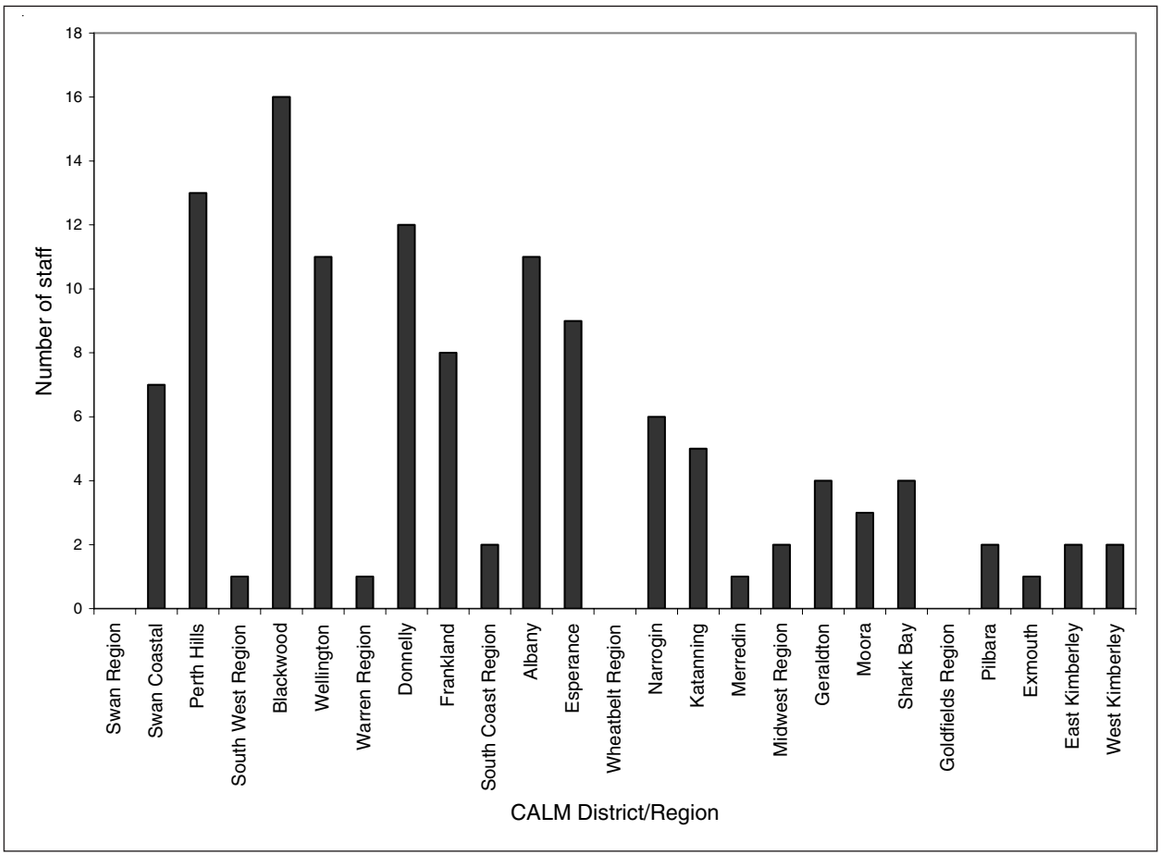

Figure 28. Number of CALM staff, in each region and district, that have attended fauna training courses since 1992.

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