The Chuditch
(Dasyurus geoffroii)

by Melody Serena, Todd R Soderquist and Keith Morris

1991

Wildlife Management Program No 7

Department of
Conservation and
Land Management

WESTERN AUSTRALIAN WILDLIFE MANAGEMENT PROGRAM NO. 7

The Chuditch

(*Dasyurus geoffroii*)

by

Melody Serena*[1], Todd R. Soderquist*[2] and Keith Morris*

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

[1]present address: Healesville Sanctuary
P.O. Box 248, Healesville, VIC 3777

[2]present address: Department of Botany and Zoology
Monash University, Clayton, VIC 3169

1991

Published by the
Department of Conservation and Land Management
P.O. Box 104, COMO W.A. 6152

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

ISSN 0816-9713

Editor ..... Marianne Lewis
Page preparation ..... Jan Rayner and Raelene Hick
Figures ..... CALM Land Information Branch
Production and distribution ..... CALM Corporate Relations

FOREWORD

Western Australian Wildlife Management Programs are a series of publications produced by the Department of Conservation and Land Management. The programs are prepared in addition to Regional Management Plans to provide detailed information and guidance for the management and protection of certain exploited, or rare and endangered species.

This program is the seventh in the series and is concerned with one species of rare fauna, the Chuditch (*Dasyurus geoffroii* Gould 1841). It provides a description of the available biological knowledge of the species and a plan of management to ensure and enhance the survival of *D. geoffroii*.

ACKNOWLEDGEMENTS

To individually thank all the people who provided assistance in the course of this project would require a volume in its own right. We particularly would like to acknowledge the help of N. Kinal, L. Vickery and H. Warren in handling animals both in captivity and the field. Unpublished records and survey results were kindly provided by O. Nichols (Alcoa of Australia Ltd) and T. Leftwich, K. Maisey and M. Mason (Department of Conservation and Land Management). J. Gardner and D. King (Agriculture Protection Board) provided baits for captive feeding trials, and G. Bell kindly allowed us to trap Chuditch on his private land. Invaluable assistance in locating radio-collared animals was provided by the Dwellingup fire spotter pilots in the 1986-1988 seasons, especially J. Woodward. CALM operations and research staff provided constructive comments on drafts of this management program. Sue Moore provided helpful discussions on the implementation of the program. Jan Rayner and Raelene Hick typed the draft copies.

Special thanks go to A.A. Burbidge for enabling us to study Chuditch in Western Australia, and J. Bartle for originally encouraging us to do so in the vicinity of Dwellingup.

The Chuditch research program was funded in part by Alcoa of Australia Ltd, the Chicago Zoological Society, and Worsley Alumina Pty Ltd. We are indebted to the Department of Conservation and Land Management for generous special funding as well as logistical support.

CONTENTS

SUMMARY

The Chuditch (*Dasyurus geoffroii* Gould 1841) has declined drastically in range in the past 50 years or so, and is now found only in south-western Australia. The total population probably numbers c. 6000 animals. Major populations occur in the jarrah forest, and it also persists in the wheatbelt and mallee regions of W.A. Much of its present distribution is affected by activities such as cereal and sheep farming, timber production, bauxite mining and fire management activities. Because of its large home range requirements, the present conservation reserve system is not adequate to ensure the conservation of the Chuditch. Habitat management of areas outside conservation reserves is therefore essential for this species' survival. Appropriate predator control programs also need to be developed. A captive breeding and translocation program will reintroduce the Chuditch to parts of its former range. Further research, particularly on Chuditch ecology in semi-arid areas, is also required.

1. BACKGROUND

1.1 Taxonomy and Relationships

The Chuditch (*Dasyurus geoffroii*) was described in 1841 by John Gould, based on a specimen collected on the Liverpool Plains in New South Wales (Iredale and Troughton 1934).

Definition of subspecies within *D. geoffroii* has been and continues to be hampered by the fact that very few specimens were collected at sites outside south-western Western Australia. Thomas (1906) recognized two forms: *D. g. geoffroii* (based on material collected in eastern Queensland, New South Wales and South Australia), and *D. g. fortis* (based on material collected in south-western Western Australia and near Shark Bay). He distinguished the two on the basis of minor differences in belly and tail fur colour, size of the auditory bullae (larger in *fortis*), colour of the palms and undersides of the toes (blackish in *fortis* vs whitish in *geoffroii*), and overall size of the male skull (larger in *fortis*). At least one of these criteria appears to be in error: the unfurred skin of the palms and toes in *fortis* is light-coloured (pink) rather than blackish. In addition, the size variation first noted by Thomas in 1888 ('...the males of [*geoffroii*] little more than equalling in size the females of [*fortis*]...') corresponds to that observed within single populations of sexually mature *fortis*, when one-year-old males are compared with older females (Soderquist and Serena[1]).

D. geoffroii is the largest carnivorous marsupial (family Dasyuridae) found in Western Australia. Five other species have been described in the genus *Dasyurus,* of which only one occurs in W.A: the Northern Quoll (*Dasyurus hallucatus*) is found in the Pilbara and Kimberley as well as the 'Top End' of the Northern Territory and parts of Queensland (Begg 1981). Two of the remaining species (*D. viverrinus* and *D. maculatus*) are restricted to eastern mainland Australia and/or Tasmania (Caughley 1980; Godsell 1982b; Mansergh 1983). Two others (*D. albopunctatus* and *D. spartacus*) are found only in Papua New Guinea (Van Dyck 1988).

1.2 History and Status

Chuditch formerly occurred in every State and territory in mainland Australia (Fig. 1). Such information as is available suggests that at the time of European settlement they were reasonably abundant over much if not all of the very large range defined by museum records. In the mid-1800s, John Gilbert noted that Chuditch were 'very generally dispersed over the whole colony of Western Australia' (Whittell 1954). A few decades later, Collett (1887) reported that they appeared to be 'the commonest species [of *Dasyurus*] in Northern Queensland'. Finlayson (1961) characterized the species as 'formerly widely distributed and plentiful' in the central deserts; this view has been supported by later studies based on Aboriginal informants (Johnson and Roff 1982; Burbidge *et al.* 1988). Contrary to statements in Waithman (1979) and Arnold (1983), there is no evidence that *D. geoffroii* has ever occurred outside Australia. In particular, all of the large *Dasyurus* collected in Papua New Guinea are now identified as Bronze Quolls (*D. spartacus*) (Van Dyck 1988).

1 Unpublished data. Predicted vulnerability of Dasyurus geoffroii to canid poisoning programs: variation due to sex, season and bait type.

The geographical range of Chuditch contracted dramatically following European settlement. Museum specimens were last collected in New South Wales in 1841, Victoria in 1857 and in Queensland between 1884-1907. The species has also vanished from the arid zone (Burbidge and Fuller 1979; Johnson and Roff 1982; Burbidge *et al.* 1988); the last reports of Chuditch surviving in the central deserts date from the mid-1950s (Finlayson 1961). Along the western coast of Western Australia, museum specimens were collected at Shark Bay and Derby in the middle to late 1800s. By 1907, the species was still regarded as 'fairly numerous in many parts of the South-West', but was absent from coastal areas north of approximately Geraldton (Shortridge 1909).

Based on specimens lodged in the Western Australian Museum and reliable sightings and road kill records within the last 15 years, Chuditch are now restricted to south-western Western Australia (Fig. 2). Most records are associated with jarrah (*Eucalyptus marginata*) forest or woodland. Surveys undertaken since 1970 indicate that Chuditch occur at low to very low densities throughout the jarrah forest (Appendix I). At the upper end of the scale, an average of one female was caught per 1.5 km of road trapped along the Murray River valley from 1985-1987 (Serena and Soderquist 1989b). In addition, a few records are associated with the drier woodland and mallee shrubland habitats to the east of the jarrah forest. This area, commonly known as the wheatbelt, is the State's major cereal growing region and is mostly cleared. Densities of Chuditch in these areas are probably lower than in the jarrah forest. Chuditch have never been recorded in pure karri (*Eucalyptus diversicolor*) forest, and have not been recorded on

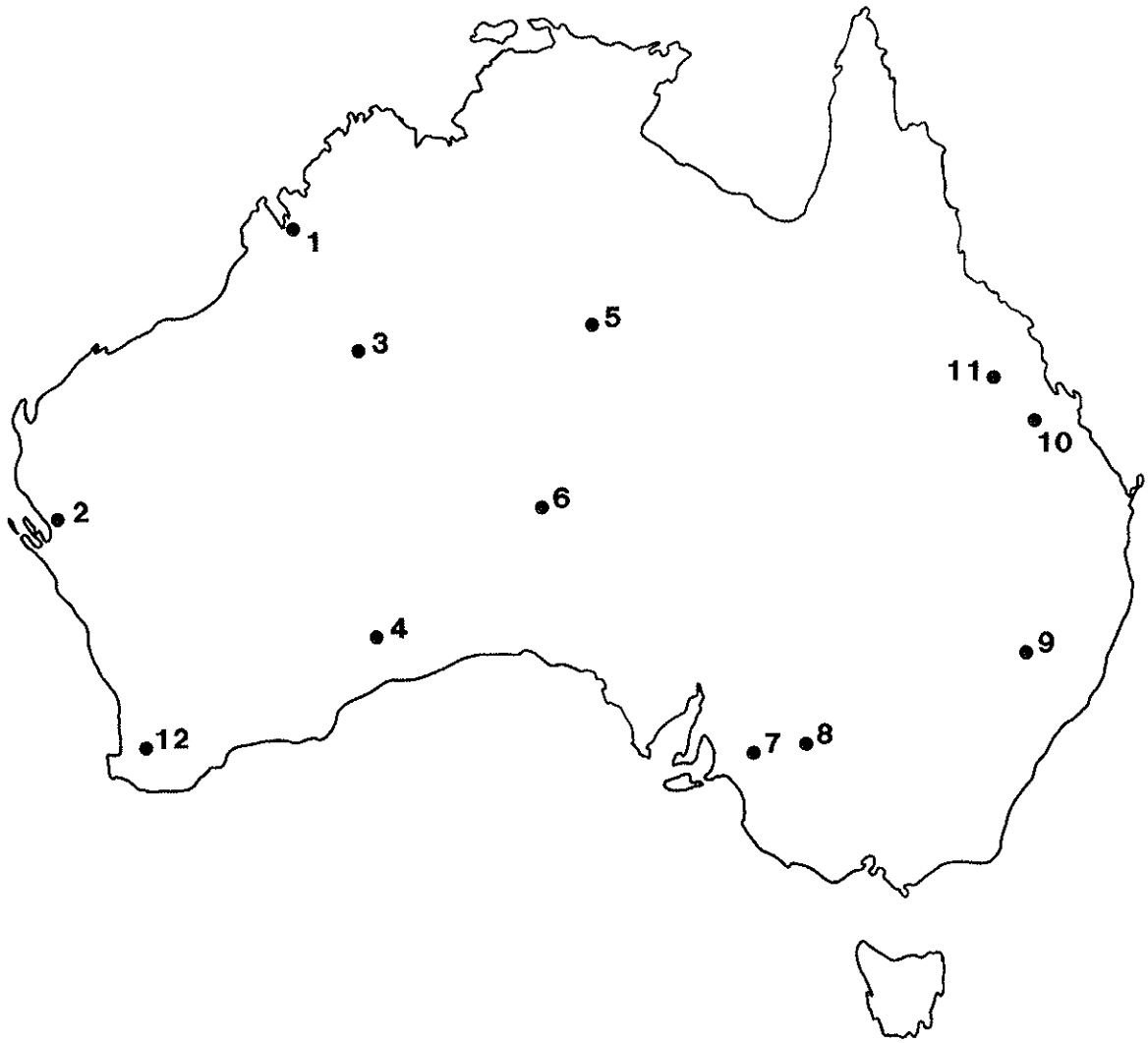

Figure 1

The distribution of Chuditch at the time of European settlement, as documented by museum specimens. 1 Derby, WA; 2 Shark Bay, W.A; 3 Kuduarra Well, W.A; 4 Rawlinna W.A; 5 Barrow Creek, N.T; 6 S of Musgrave/N of Everard Ranges, S.A; 7 Murray River, S.A; 8 Juncture of Murray/Darling Rivers, VIC; 9 Liverpool Plains, N.S.W; 10 Coomooboolaroo, Q; 11 Peak Downs, Q; 12 Arthur River, W.A.

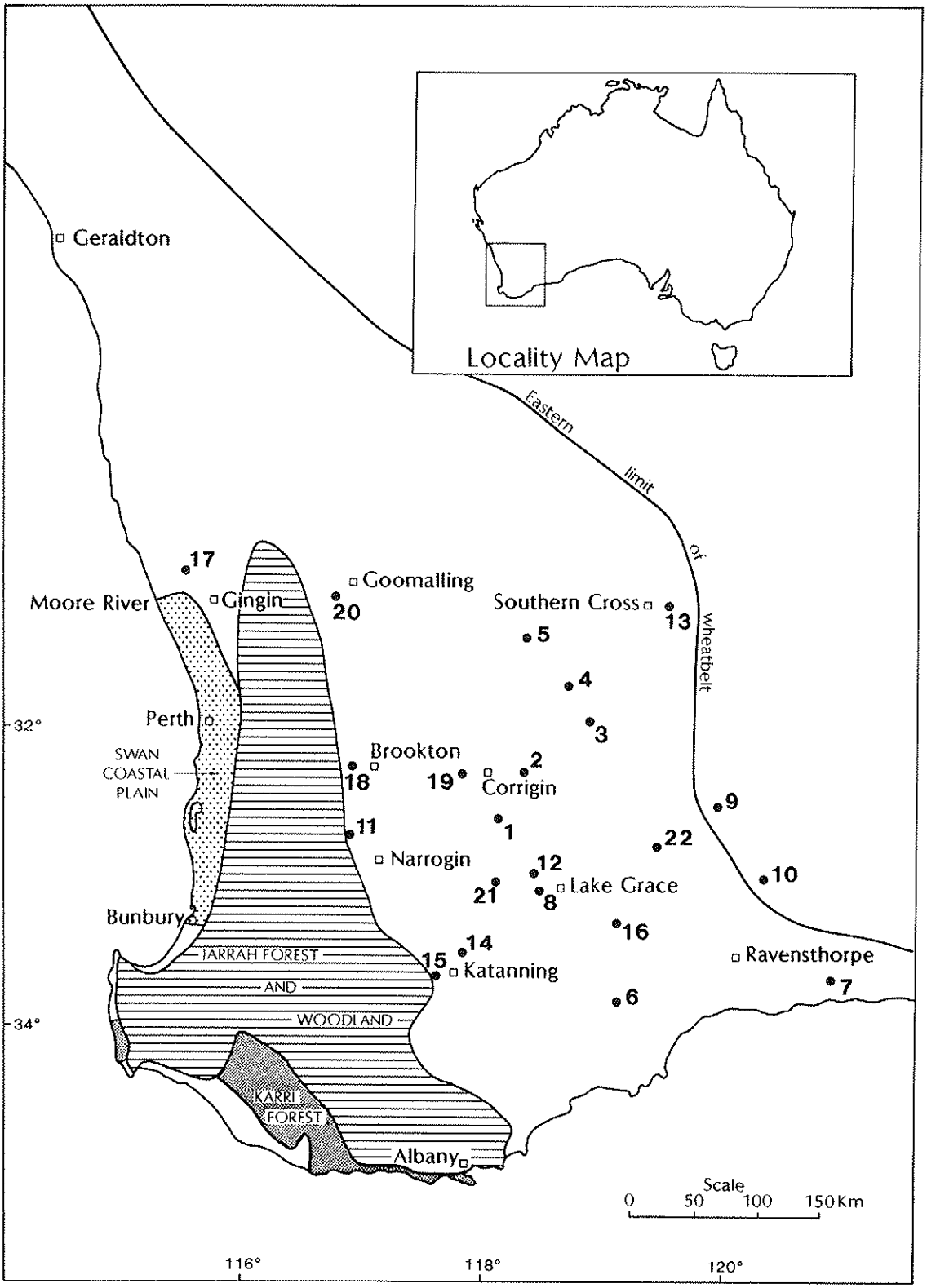

Figure 2

Present distribution of Chuditch based on museum specimens and reliable sighting and road kill records from 1975-1990. Chuditch have been recorded throughout the jarrah forest and woodlands and from the numbered sites outside the jarrah forest. 1 Kulin, 1975; 2 Bendering, 1976; 3 Welcome Hill, 1976; 4 Mt Cramphorne, 1977; 5 Merredin, 1977; 6 Fitzgerald River N.P., 1980; 7 Munglinup, 1983; 8 Lake Grace, 1983; 9 Forrestiana, 1984/85; 10 Frank Hann N.P., 1987; 11 Dryandra, 1987; 12 Lake Grace, 1989; 13 Ghooli, 1989; 14 and 15 Katanning, 1990; 16 Lake Magenta; 17 Caren Caren Brook; 18 Brookton, 1989; 19 Corrigin, 1988; 20 Goomalling, 1990; 21 Harrismith, 1990; 22 Lake Varley, 1986.

the Swan Coastal Plain (the coastal area between Moore River in the north and Bunbury/Collie River in the south) for 50 years. The present distribution of Chuditch falls within the CALM Northern Forest, Central Forest, Southern Forest, Wheatbelt and South Coast management regions.

Many factors may have contributed to the progressive decline of Chuditch populations in different areas, including habitat alteration owing to grazing by rabbits and livestock, changing fire regimes and land clearing; competition for food from foxes and feral cats; and epidemic disease (Wood Jones 1923; Marlow 1958; Finlayson 1961; Burbidge and Fuller 1979; Johnson and Roff 1982; Burbidge *et al.* 1988). Shortridge (1909) noted that the animals were 'killed off as much as possible in the agricultural and more thickly populated districts on account of being so destructive to poultry'. In addition, many undoubtedly died in the course of poisoning campaigns directed against other species, notably dingoes (Leake 1962; Rolls 1969). Fox predation may have also contributed to the decline of Chuditch.

In 1983, in recognition of its drastically reduced range, *D. geoffroii* was declared a rare species in Western Australia (W.A. Wildlife Conservation Act 1950).

1.3 Biology and Habitat Requirements

1.3.1 Description, Diet and General Habits

At maturity, Chuditch are about the size of half-grown domestic cats: males and females respectively weigh an average 1.3 and 0.9 kg (Serena and Soderquist 1988b). The species is readily distinguished from all others in its present range by the combination of a non-hopping gait, white-spotted brown pelage, large rounded ears, pointed muzzle, and large dark eyes. The tail is 17-32 cm long (70-80 per cent of the head and body length) and black-furred over the end half. Detailed physical descriptions of *D. geoffroii* are available in Thomas (1888) and Wood Jones (1923).

The diet of desert Chuditch included live mammals (e.g. hopping mice and rabbits), carrion, lizards, frogs, and invertebrates (e.g. witchetty grubs) (Johnson and Roff 1982; Burbidge *et al.* 1988). As in the closely related Eastern Quoll (*D. viverrinus*) (Blackhall 1980), the mainstay of the diet in the jarrah forest is insects, ranging in size from winged termites to large cockroaches and beetles (unpublished data collected on the Lane-Poole Conservation Reserve). Forest Chuditch also eat mammals (e.g. Mardo (*Antechinus flavipes*); Southern Brown Bandicoot (*Isoodon obesulus*); Black Rat (*Rattus rattus*)); birds (e.g. Splendid Wren (*Malurus splendens*); White-Breasted Robin (*Eopsaltria georgina*); Port Lincoln Parrot (*Barnardius zonarius*)); lizards (e.g. Napoleon's Skink (*Egernia napoleonis*)); and freshwater crustaceans (*Cherax* spp.). The only plant matter known to be consumed in the jarrah forest is the red pulp surrounding zamia (*Macrozamia riedlei*) seeds. Chuditch scats collected near campgrounds occasionally incorporate such unorthodox items as bubble gum, aluminium foil, and used sticking plasters.

Chuditch forage primarily on the ground and at night, using their manipulative forepaws, sharp teeth and claws, and keen senses of sight, hearing, and (especially) smell to locate and capture prey. The animals are sometimes active during the day, especially at the height of the breeding season or when cold, wet weather has served to restrict nocturnal foraging. Chuditch may climb trees both to obtain prey and escape from predators. In the jarrah forest, this activity normally seems to be restricted to fairly small (12-20 cm diameter at breast height (d.b.h.)) boles, which the animals can clasp effectively using the long hind foot and heel.

1.3.2 Reproduction and Mortality

Various aspects of Chuditch reproductive biology are discussed by Archer (1974), Arnold (1976), Serena and Soderquist (1988b, 1989 a and b), and Soderquist and Serena (1990).

Jarrah forest Chuditch are seasonal breeders and a summary of their breeding cycle is shown in Table 1. Nearly all wild females enter oestrus from late April to early July. Males and females are sexually mature and breed in their first year. The population sex ratio is close to parity both in the case of pouch young (52 per cent males, N = 34 litters) and breeding adults (an average 49 per cent males trapped from May-August 1986-1988). The gestation period is about 17-18 days and newborn juveniles are correspondingly poorly developed, measuring about 5 mm in length and weighing 9-15 mg. In the wild, pouch life lasts about 61 days; young are then left in a burrow while their mother forages.

When first left in a den, wild juvenile Chuditch weigh less than 15 g. They are blind, can barely crawl, are very poorly insulated by fur, and are not yet capable of shivering. Juveniles are well furred and beginning to eat solid food by 110 days of age. They are fully weaned by about 170 days of age and disperse shortly thereafter, in the period November to January.

Wild litters have been observed to include two to six young. Along the Murray River south of Dwellingup, about 80 per cent of the juveniles weaned in the period 1986-1988 were the offspring of one-year-old mothers. In part, this reflects the fact that first-year females consistently comprised more than half (overall mean = 56 per cent) of the breeding female population. First-year females also

had larger litters on average than older females (first-year mean = 5.4 pouch young, N = 40; older mean = 4.9 pouch young, N = 25) and were about three times more successful in actually weaning young.

Table 1

SUMMARY OF CHUDITCH BREEDING CYCLE

Season	*Event*
Late April - early July	Females enter oestrus mating occurs
Mid May - mid July	Birth of 2-6 young
Mid July - mid September	Young deposited in burrow
Mid October - mid December	Young are weaned
November - January	Young disperse and will breed in their first year

While Chuditch have been known to live for at least 5.5 years in captivity, wild individuals normally die before their fourth year. Many factors are known to contribute to Chuditch mortality in the jarrah forest: being hit by motor vehicles; illegal shooting near roads; predation by foxes, raptors and (probably) feral cats; injury in rabbit traps; and natural accidents (e.g. drowning) and disease. Based on the fates of radio-collared Chuditch, being hit by motor vehicles at night is a major cause of death at the Lane Poole Conservation Reserve, and probably in other areas of forest as well. This undoubtedly reflects the seasonally heavy nocturnal motor traffic in this area, as well as the animals' common use of dirt roads to traverse their large home ranges. Fox predation is also a significant cause of mortality. Interestingly, each of the three Chuditch known to be killed by foxes at Lane Poole died along or within a short distance of a walking track, suggesting that well-defined paths may act to significantly increase the frequency with which the two species encounter each other.

1.3.3 Home Range and Den Requirements

Chuditch originally utilized an extremely wide array of habitats, ranging from woodland associations and dry sclerophyll forests to beaches and deserts (Thomas 1906; Shortridge 1909; Burbidge *et al.* 1988). They were commonly found in the roofs of suburban residences around Perth at least as recently as the 1930s, and also occurred in Kings Park (Glauert 1933). Within the jarrah forest, populations are associated both with the relatively dry, open, gently sloping forest of the Perup Nature Reserve (Christensen 1980) and the relatively wet, densely vegetated, steeply sloping forest found along the Murray River valley portion of the Lane-Poole Conservation Reserve (Serena and Soderquist 1989b). On a finer scale, the population density of Chuditch has been shown to be about four times greater along the Murray River valley than on adjacent uplands and seasonal stream drainages (Serena and Soderquist 1989b). The difference is most plausibly explained by either of two (not mutually exclusive) hypotheses.

(i) The relatively well-watered and apparently productive river valley habitat may provide a better or more reliable food supply for Chuditch than surrounding areas.

(ii) The dense layer of forbs and shrubs found along the river valley may provide superior cover for Chuditch, reducing vulnerability to both aerial predators (owls) and ground predators (foxes, feral cats).

Desert Chuditch denned in earth burrows, hollow logs and tree limbs, and hollows in termitaria (Johnson and Roff 1982; Burbidge *et al.* 1988). In the jarrah forest, nearly all diurnal resting sites consist of either horizontal hollow logs or earth burrows (Table 2); over the course of a year, an average adult female dens in an estimated 66 logs and 110 burrows. Based on radio-tracking studies conducted on the Lane-Poole Conservation Reserve, critical den log dimensions are as follows:

Diameter of Hollow ~ This varied from a minimum of 7-8 cm in the case of adult females or 9-10 cm in the case of adult males to a maximum of 23 cm (N = 66 logs).

Diameter of Bole at Den ~ Logs utilized were at least 31 cm wide at the den from December-March, and at least 48 cm wide in other months. Across all months, the average bole diameter at dens = 77 cm (S.D. = 26.4, N = 123 logs).

Den-Entrance Distance ~ This varied from 0.7-7.2 m in the case of adult females, and 0.9-8.2 m in the case of adult males. Animals most typically were found resting 1.0 m or more from the nearest entrance; the average den-entrance distance was 2.65 m (S.D. = 1.85, N = 66 logs).

Den Log d.b.h. ~ The d.b.h. (under bark) of 42 den logs could be accurately determined. These values ranged from 52-191 cm; 79 per cent of den logs exceeded 70 cm d.b.h., and 62 per cent exceeded 90 cm d.b.h.

Most Chuditch burrows are associated with surface features such as trees or rock outcrops (Table 2). These are located over the den (thereby providing increased protection from predators) and/or supply pre-existing channels or cavities which facilitate den construction. Nearly 70 per cent of burrows examined in the jarrah forest were associated either with living trees or their derivatives (fallen trees, stumps, logs, and the cavities created when trees are uprooted or their stumps decompose). The minimum d.b.h. (over bark) of trees occurring over dens was respectively 38 cm in the case of standing trees (N = 60) and 49 cm in the case of uprooted trees (N = 16); 85 per cent of standing trees and

94 per cent of uprooted trees associated with dens exceeded 50 cm d.b.h.

Table 2

DIURNAL RESTING SITES OF ADULT RADIO-COLLARED CHUDITCH LIVING ALONG THE MURRAY RIVER VALLEY, SOUTH OF DWELLINGUP.

Den description	*n*	*% of dens*
Hollow Log	127	35.3
Burrow:		
Under tree or stump	67	18.6
Into side of pit left by uprooted tree or burnt/rotted stump (follows the root channel)	60	16.7
Under root mass of uprooted tree	18	5.0
Under log	11	3.1
Under rock/concrete or within granite outcrop	20	5.6
Rabbit warren	22	6.1
Simple burrow (not associated with any special surface feature)	28	7.8
Other:		
(e.g. niche under log on soil surface; bandicoot nest)	7	1.9

The spatial organization of adult Chuditch living along the Murray River has been described by Serena and Soderquist (1989b). Both sexes are essentially solitary, and have relatively large home ranges (females, 3-4 km^2; males, about 15 km^2) which include a central 'core area' defined by den locations. Male core areas comprise about 4 km^2 (range = 3.9-4.4, N = 2) and overlap substantially. Female core areas comprise an average 0.9 km^2 (range = 0.55-1.2, N = 7) and usually show little or no overlap, although some core areas may be shared by a mother and her adult daughter.

1.3.4 Fire Ecology

Much of the State forest north of the Preston River has been subject to prescribed burning for fuel reduction on a 5-7 year cycle since the late 1960s. Fires are scheduled for either the spring or autumn, and are usually of low to moderate intensity. Variation to the prescribed burning pattern occurs through some areas being deliberately left unburnt and other areas being affected by wildfires. Unfortunately, Chuditch fire ecology is difficult to investigate experimentally given the very large home ranges and low population densities of the species. At least in theory, fires may affect Chuditch positively or negatively. Fires may increase their vulnerability to predators when plant cover is removed (Newsome *et al.* 1975; Christensen 1980), and reduce the numbers of invertebrate prey for a variable length of time after burning (Abbott 1984; Majer 1984, 1985; Wooller and Calver 1988). They may also serve to benefit Chuditch in that they themselves are predators. While some data on the population consequences of fire are available for three sites, the interpretation is problematic in each case, as detailed below.

Murray River valley ~ In Plavins block, four radio-collared females successfully reared young in an area that had been burnt the previous spring (about 7-12 months previously, in 1985). However, each of the four home ranges included a substantial area along the river which was entirely protected from burning. This fire was also very mild, i.e. cooler than a typical spring fuel reduction burn (Tom Rouse, Dwellingup forester, personal communication). Chuditch have also been trapped in Park block six months after a spring fuel reduction burn (in November 1989).

Perup Nature Reserve ~ Two adult males, one adult female and one small juvenile female were trapped in 1974 on Boyicup forest block prior to an experimental autumn burn conducted in 1975. Following the fire, Chuditch continued to be caught on the 225-ha site (one male and two females, including the former juvenile) until August 1975. Thereafter, no Chuditch were trapped in the burnt area until an adult male was caught in March 1979, followed by an adult female in April 1981. The apparent reduction in use of the burnt site by Chuditch for several years following the fire cannot be attributed to differential trapping effort, since this remained high over the entire period (Appendix I). However, there is some evidence to suggest that Chuditch numbers were relatively low throughout Perup in the years following the experimental burn (Christensen *et al.* 1985).

Batalling forest block ~ Pre-burn trapping surveys conducted in 1982, 1983 and 1984 consistently resulted in 5 Chuditch being trapped on each trapping occasion along a 15 km trapping route, despite considerable turnover in individuals among years. Following an autumn fuel reduction burn, surveys over the same route in August and October 1985 resulted in 6 Chuditch being trapped; 3 of the 4 females caught were carrying pouch young (a total of 17 juveniles). When the route was again trapped in September and December 1986, only one adult (a female; also present on the site in 1985) was caught. Interpretation of these results is equivocal in that no information is available concerning mortality, reproductive success, or juvenile dispersal over the period 1985-1986. Barring such information, there is no way to determine which of many possible factors (including pure chance) may have caused the apparent population decline.

The above data are of interest in agreeing that Chuditch are fully capable of surviving a fire and its aftermath for a period of at least several months. The critical question that remains to be answered is how fire affects juvenile recruitment in the first and second breeding seasons following burning, particularly in the case of typical prescribed burns, and when the entire maternal home range has been subject to fire.

1.3.5 Vulnerability to Poisoning Programs

Captive Chuditch are highly partial to the meat baits commonly used to bait dingoes and foxes. Chuditch are also potentially at risk from cereal- and fruit-based baits intended for pigs: Mollison (1961) reported mortalities among Eastern Quolls (*D. viverrinus*) that had eaten poisoned baits of carrot, apple, and bran-pollard mix. Factors that must be taken into account when designing baiting programs that spare Chuditch include all of the following.

Type of poison ~ Marsupials in south-western Australia tend to be more resistant (per kg of body weight) to the toxic effects of Compound 1080 (sodium fluoroacetate) than are introduced species (King *et al.* 1989; McIlroy 1986). Conversely, strychnine and cyanide are extremely toxic to native and non-native species alike.

Sensitivity to compound 1080 ~ The median lethal dose (LD_{50}) of 1080 that will theoretically kill one half of a baited Chuditch population is about 7.5 mg/kg body weight (King *et al.* 1989). The estimated maximum 'safe' dose for adult Chuditch (i.e. one which may make them sick but probably will not kill them) is 5 mg/kg (King *et al.* 1989). Present fox baiting programs in W.A. use 4.5 mg 1080 injected into a 120 g fresh meat bait, which is then dried to 40 g before being distributed. Recent research suggests that levels of 2.5 mg 1080 per bait may be able to be used in the future (McIlroy and King 1990).

High or low environmental temperatures greatly increase the relative sensitivity of mammals to 1080 (Oliver and King 1983; Eastland and Beasom 1986). For example, Brush-tailed Possums (*Trichosurus vulpecula*) can tolerate on average about 2.5 times more 1080 at 23.5°C than at 10.5°C (Oliver and King 1983). Both the LD_{50} and the maximum non-lethal dose reported for Chuditch above were determined at 23°C, and so probably underestimate the vulnerability of Chuditch during winter in the jarrah forest.

Doses of 1080 that are not fatal to adult Chuditch can still be very harmful on a population basis. Toxins passed through milk can kill the pouch young of females that survive being fed sublethal doses of 1080; this has been demonstrated to occur in Tammar wallabies (*Macropus eugenii*), Brush-tailed Possums, and the Northern Quoll (*Dasyurus hallucatus*) (McIlroy 1981). Sub-lethal doses of 1080 can also potentially cause sterility in males, as has been demonstrated in rats (Sullivan *et al.* 1979).

Type of bait ~ Overnight feeding trials with captive Chuditch indicate that moist meat baits are eaten in larger amounts and more rapidly than dry meat baits.

Chuditch will eat any bait acceptable to a canid or feral cat, including a wide range of non-meat baits. Crackle baits (as manufactured by the W.A. Agricultural Protection Board) are eaten more rapidly than 70 per cent dried meat but in similar quantities. Whole fowl eggs are readily cracked open by both juveniles and adults and then quickly consumed. Captive feeding trials involving imitation cyanide baits (wax capsules covered with condensed milk/sugar syrup) invariably resulted in these being eaten, with the capsule often being carried to a secluded location before being chewed.

Amount of bait eaten ~ Average overnight consumption of fresh meat by captive Chuditch is equivalent to about 20 per cent of the individual's body weight. The maximum observed overnight consumption was over twice this amount.

The increased metabolic demands associated with activity mean that free-roaming Chuditch are expected to eat more bait than captives (Nagy 1987). This difference has been demonstrated for three dasyurids: wild *Antechinus stuartii* were found to consume 160 per cent of that of captive individuals (Nagy *et al.* 1978); wild *Sminthopsis crassicaudata* about 260 per cent (Morton 1980); and wild *Dasyurus viverrinus* about 250-300 per cent (Green and Eberhard 1983). Thus the values obtained for captive Chuditch must be considered conservative estimates (perhaps half) of the expected bait consumption by wild Chuditch.

Animal size and condition ~ Because the toxicity of Compound 1080 is weight-specific, seasonal variation in the size of Chuditch influences their vulnerability. Thus juveniles are the most susceptible group because they are small, usually thin, and eat relatively large amounts in order to meet the demands of growth. Winter, when Chuditch are typically under energetic stress (i.e. thin and hungry) because of low prey availability (Majer 1984; Postle *et al.* 1986), is also a period of increased vulnerability.

1.4 The Need for Management

While the total population of Chuditch in Western Australia is unknown, the jarrah forest population (which certainly comprises a major fraction of the whole) is estimated to comprise between 2500 and 4400 individuals[2]. These animals are distributed patchily and at low densities, suggesting that they continue to be highly vulnerable to extinction when considered at the local population level. No island populations are known. The need for active management arises not only because the animals are scarce, but because their forest habitat is currently affected by a wide variety of human activities and management practices. In the jarrah forest Chuditch prefer the denser vegetation along the river systems. In peripheral forest areas these relatively moist and fertile valleys have been selectively cleared for agriculture. Bauxite mining, timber production, prescription burning, recreational activities and natural factors such as wildfire and plant diseases also affect the forest habitat. At present, no single land use appears to pose an imminent threat to the survival of *D. geoffroii*, and it has survived in the jarrah forest while declining elsewhere. However, the jarrah forest represents only approximately 3 per cent of the former habitat occupied by Chuditch and the conservation of this species will be significantly benefited if its habitat needs are taken into account when designing and implementing programs of forest use. Future research may suggest that some areas be managed primarily for Chuditch. The low absolute numbers of Chuditch also suggest that it would be prudent to prepare for a program whereby the species is progressively reintroduced to areas of historic habitat. The following management program addresses these areas of concern in more detail. The program also refers to management in areas other than the jarrah forest where Chuditch are still known to occur i.e. the drier areas to the east of the jarrah forest, but where less is known of this rare marsupial.

2. THE MANAGEMENT PROGRAM

2.1 Aim

The aim of the management program for the Chuditch is to ensure that

(a) the species persists within its present range;

(b) population numbers increase through expansion into its former range.

2 This estimate assumes that the density of Chuditch throughout jarrah production forest, conservation areas and privately-owned forest (19 500 km^2) is equivalent to 40-70 per cent of the average density of the unusually high quality population occupying the Perup Nature Reserve. The Perup density estimate was calculated based on the results of trapping surveys undertaken in Boyicup and Yendicup blocks in the period 1974-1988, excluding years in which no animals were caught in a given area (i.e. years in which Chuditch numbers may have been unusually or atypically low) (See Appendix I).

2.2 Strategies

Six primary strategies will be pursued during the term of this program.

(i) Habitat management in the jarrah forest (including both multiple use and conservation areas).

(ii) Development and application of appropriate predator control programs.

(iii) Development of a captive breeding program at the Perth Zoo.

(iv) Development of techniques for successfully translocating animals into areas of vacant, suitable habitat in the jarrah forest and elsewhere.

(v) Monitoring the number of breeding individuals present in a representative sample of populations both in the jarrah forest and elsewhere.

(vi) Undertaking further research into Chuditch distribution and requirements.

2.3 Habitat Management

2.3.1 Management in multiple use forest

The availability of adequate den sites (logs and burrows) is essential for the continued survival of Chuditch in the jarrah forest. Most forest conservation reserves probably offer adequate den sites for Chuditch. In forest which has previously been logged on long rotations there are greater numbers of logs on the ground, a proportion of which are suitable Chuditch den sites. However, in forests used for timber production and which are managed on rotations less than the biological rotation, there will eventually be a reduction in the number of large trees which are useful in facilitating burrow channels into the soil. More intensive utilisation (e.g. firewood collecting) also has the potential to reduce log dens.

Direct management can ameliorate these affects by retaining adequate den logs in logged areas, maintaining mature forests along streams, retaining large trees throughout the logged areas, and if necessary generating burrow sites around stumps and building artificial dens. The first three approaches are already routine practice (see Appendix II) the last two require further research to determine their necessity and effectiveness.

Prescriptions

(i) Adequate numbers of refuge and den logs will be maintained in multiple use forest areas. During logging and regeneration or thinning, hollow logs will be selected and retained for Chuditch. Although any hollow log may

potentially provide a refuge from predators and therefore should be saved, logs suitable to serve as diurnal resting sites and dens will meet the following criteria

(a) the diameter of the hollow should be 8-20 cm;

(b) the diameter of the bole at the den should be at least 30 cm and preferably more than 50 cm;

(c) the length of the hollow (excluding very wide or flared sections at the entrance) should be at least 150 cm if there is a single entrance (allowing a 100 cm distance between the entrance and the animal, plus 50 cm for the animal's body) or 250 cm if both ends are open;

(d) den logs should be distributed at a density of at least 1/ha, and preferably 5/ha to provide adequate choice.

(ii) Following tests to determine their effectiveness, burrow sites may be generated around stumps in areas where timber harvest and regeneration is occurring if there is a need to do so. This involves pushing stumps over so that their root mass is pulled partly out of the ground. The root mass should also remain partly anchored. Stumps should measure at least 30 cm d.b.h., and preferably more than 50 cm d.b.h. to generate a substantial root mass and provide multiple large exposed root channels. Preferably 3-5 stumps/ha should be manipulated.

(iii) If necessary, artificial dens may be provided for Chuditch in areas where the number of den logs and stumps is inadequate, if trials indicate that they are effective. These can be constructed by piling up branches and small logs along with sizeable rocks to create a 'honeycombed' mound about 5 m by 3 m by 2 m high. Soil is then spread over the mound to provide insulation; it is desirable that some branches and/or logs protrude from the finished mound to facilitate and encourage initial burrowing by the animals. The goal is to provide numerous protected channels and chambers that can serve as secure dens until tree growth again promotes the development of natural burrows. Between one and five artificial mounds/ha should be created if trials indicate they are effective.

2.3.2 Rehabilitation after surface mining

Surface mining for gravel and bauxite involves the removal of all vegetation. At present bauxite mining companies undertake extensive rehabilitation programs to encourage the recolonization of mined areas by native flora and fauna. Rehabilitation of gravel pits has not always been as rigorously pursued. Correct rehabilitation of all mined areas is important for the conservation of Chuditch in the jarrah forest.

Prescriptions

(i) To enhance recolonization by Chuditch, den sites will be provided in rehabilitated minesite areas, including gravel pits. Both hollow logs (1-5/ha) and artificial burrow mounds (1-5/ha) as described above should be provided.

(ii) Vegetative cover in rehabilitated areas should be moderately dense in the 0.5-2.0 m layer; the early development of deep ground litter should also be encouraged.

(iii) Minesite rehabilitation techniques that encourage rapid development of prey biomass (particularly litter arthropods) are preferred.

2.3.3 Fire management

The effect of prescribed burning patterns and wildfires on Chuditch is poorly understood. This is a matter of concern because jarrah forest populations may often be inhabiting 'islands' of suitable habitat (Serena and Soderquist 1989b), which in turn may make it difficult for areas to be recolonized if drastic post-fire population declines occur. Management prescriptions with respect to fire are based on the following informed assumptions.

(i) Chuditch appear to regularly survive wide-scale fires, but recruitment may be reduced unless home ranges contain a minimum amount of currently unburnt habitat (perhaps 25 per cent of the total area).

(ii) Litter invertebrates (the mainstay of the Chuditch diet) probably recover faster after cool than hot fires, when considered on a season by season basis (Majer 1985). Cool spring fires are also less likely to destroy den logs, and more likely to leave unburnt patches.

(iii) Riparian areas, especially those bordering rivers and their first order tributaries, appear to constitute exceptionally good foraging habitat for Chuditch. In the Lane Poole Conservation Reserve, Chuditch activity is concentrated in a 2 km wide band running along both banks of the Murray River (i.e. 4 km wide in all).

(iv) Hot summer wildfires consume all vegetation and many den logs and are therefore undesirable.

Prescriptions

(i) To reduce disruption of Chuditch populations, the riparian vegetation along rivers and their first order tributaries will be protected from fire whenever feasible. If it is necessary to carry out fuel reduction burns for wildfire mitigation along

streams and rivers, schedule the fires on a longer rotation than in adjacent areas, with a minimum of one year (ideally, two or more years) separating riparian and contiguous non-riparian fires. In all cases, riparian vegetation should be burnt under cool moist conditions, or in limited sections, so that a substantial proportion (a minimum of 50 per cent, and ideally 80 per cent or more) of any given stream drainage remains unburnt in a given year.

(ii) In areas where high density Chuditch populations are known to occur, burn non-riparian forest habitat as patchily as possible (ideally in blocks of 5 km^2 or less). If more extensive burns are necessary, a high perimeter: area ratio is desirable (excepting always high quality linear habitats, such as stream banks or wet gullies). In addition, prescribed fires should be scheduled for spring in such areas to coincide primarily with cool, moist burning conditions.

(iii) Undertake research into the effect of different burning regimes on Chuditch diet, determine the most appropriate fire regimes from this aspect, and incorporate this information into forest burning prescriptions. This study would necessarily involve a wider ranging examination of the diet of the Chuditch. The population monitoring sites (Section 2.7.1) would provide suitable sites for this study.

2.3.4 Forest Traffic Management

Road kills are a major source of Chuditch mortality in the jarrah forest, and elsewhere. Motorists need to be informed of the likely presence of Chuditch in certain areas.

Prescriptions

(i) Chuditch warning signs need to be placed along roads that

  (a) carry frequent night traffic (e.g. Brookton Highway, Albany Highway);

  (b) traverse localities known to support Chuditch populations, particularly in the vicinity of rivers (e.g. Lane Poole Reserve, Wellington Mills).

(ii) Nocturnal use of roads in such areas for road rallies or other motorized racing events is inappropriate.

(iii) CALM staff and the public should be encouraged to report and collect Chuditch road kills or report sightings to either District offices or Wildlife Research, so that distribution patterns can be determined (see Research Requirements).

2.3.5 Clearing of habitat

It is known that in the jarrah forest, Chuditch require large areas of suitable (uncleared) habitat to survive. The same is probably true for populations in the woodlands and mallee shrubland to the east of the jarrah forest. Loss and fragmentation of these large areas for agriculture or residential development contributes significantly to the decline of Chuditch populations. Clearing removes den sites, protective cover and typically reduces the availability of prey. At the same time, direct mortality from poisoned baits, rabbit traps, possible predation by domestic dogs and cats, and motor vehicle collisions is expected to increase. In addition, the proliferation of rabbits and domestic stock on cleared land results in increased local densities of foxes, which in turn may both compete with and prey upon Chuditch. Clearing is particularly deleterious where

  (a) the affected land includes or adjoins riparian habitat;

  (b) it creates new gaps in otherwise homogeneous habitat;

  (c) it leads to progressive fragmentation of habitat; or

  (d) it necessitates the construction of roads (especially sealed roads) through or adjacent to uncleared habitat.

Prescriptions

(i) Further extensive clearing of jarrah forest and mallee for residential developments and agriculture will be discouraged through appropriate channels. In particular, clearing of land adjacent to or including riparian habitats will be discouraged.

(ii) Where clearing is proposed, (e.g. for hydrological purposes) the potential of the area as Chuditch habitat needs to be assessed. Standard fauna survey techniques are not adequate to detect Chuditch. Specialized trapping techniques are required and the assistance of trained CALM staff should be sought.

(iii) On the fringes of jarrah forest, woodlands and mallee shrublands where residential and agricultural clearing has occurred, corridors of uncleared vegetation connecting smaller reserves with the larger areas of uncleared land need to be maintained.

2.4 Predator Control

Foxes and feral cats can potentially affect Chuditch through both competition for food and direct

predation, however, the impact of these on Chuditch populations has not been clearly demonstrated. Fox predation may be more significant in the more open woodland and mallee shrubland habitats than in the jarrah forest. However, present poison baiting programs for introduced predators may also have the potential to detrimentally affect Chuditch populations and baiting to protect Chuditch should be conducted only where evidence indicates the benefit is substantial.

Research into the impact of introduced predators on Chuditch population, and into the effect of current baiting programs on Chuditch are required. From this research, appropriate predator control programs need to be implemented in areas also known to support Chuditch populations.

Prescriptions

(i) Further research is required into

  (a) the impact of introduced predators on Chuditch populations; and

  (b) the effect of present baiting programs on Chuditch.

(ii) With present knowledge, baiting programs to control introduced predators in areas known to also support Chuditch populations should use a fresh meat bait injected with 1080 and then dried to 30 per cent of its original weight. Present baiting regimes use 120 g fresh meat baits injected with 4.5 mg 1080, and dried to 40 g. Where Chuditch are present the size of the fresh meat bait needs to be increased to at least 200 g and then dried to 60 g. As further research is undertaken on the actual availability to a fox of 1080 within a meat bait, and environmental effects on 1080 concentrations, 1080 levels may be able to be lowered without losing effectiveness against foxes. This will be of further benefit to Chuditch and should be implemented as soon as possible.

(iii) Strychnine and cyanide are not acceptable poisons for use in or near Chuditch habitat. Baits incorporating strychnine, which continue to be used on farms bordering State Forest and in the woodland habitats east of Lake Grace, may be harming Chuditch populations (e.g. How *et al.* 1988, p. 79). Compound 1080 should be substituted in such areas.

(iv) Seasonal constraints narrow the period of relatively safe baiting in the jarrah forest from January to March. Poison baits are most dangerous when distributed during breeding (April-July) and lactation (May-December) and winter months generally.

(v) Crackle baits are an acceptable alternative to dried meat baits if the poison dosage is maintained at a safe level (i.e. 1 mg of poison/20 g of crackle bait, or any multiple thereof). Polony (processed luncheon meat) is a poor bait because the granular texture allows it to be eaten extremely rapidly, even when dried. When conducted in potential Chuditch habitat, poisoning programs for pigs should use compressed-grain pellets rather than fruit.

2.5 Captive Breeding

Captive breeding of Chuditch will provide a source of animals for display and education purposes, and for translocation programs. The characteristically low density of Chuditch populations means that taking individuals from the wild for display and translocations will be both time-consuming and potentially problematic to the parent population. The only feasible alternative is to generate surplus animals through a program of captive breeding. This option is particularly attractive in that Chuditch are relatively fecund (litters of 5 or 6 are most common), with both sexes capable of breeding at one year of age. Techniques of captive husbandry and breeding are discussed in Arnold (1976) and this document (Appendix III).

Prescriptions

(i) In collaboration with the Perth Zoo, undertake a captive breeding program.

(ii) This program will utilize existing captive Chuditch (presently 3 adult males, 5 adult females and 12 young from 2 litters born in 1990), and be supplemented by obtaining juveniles in December (i.e. prior to dispersal) from relatively dense wild populations. To reduce inbreeding within captive lines, a wild caught male (either juvenile or adult) will be supplied to the Zoo on an annual or every second year basis, depending on how many captive animals are being maintained and bred.

(iii) Once the captive breeding program has been successful, develop in collaboration with the Perth Zoo, an appropriate exhibit and public information program.

(iv) Juveniles that are surplus to the breeding program requirements will primarily be used for release into the wild in the autumn following their birth, as part of the translocation program. Chuditch surplus to this requirement will be sent to other zoos for breeding and display purposes. Juveniles destined for translocation will be supplied with hollow logs and artificial burrows in their cages to facilitate their search image for suitable den sites after release.

(v) Adult Chuditch surplus to the captive breeding program will be primarily used to stock other zoos, rather than used in the translocation program. Adults over three years of age are probably of little use to a captive breeding program.

(vi) All Chuditch taken from the Perth Zoo for either translocation to the wild or transfer to another zoo will be screened for parasites and disease by qualified veterinary personnel.

2.6 Translocation

Chuditch are presently restricted to a small fraction of their former range. Within the jarrah forest, known populations are sparsely distributed even in apparently high quality habitat. This low density, in conjunction with a short average life span, means that Chuditch populations are susceptible to extinction purely owing to chance events or normal environmental fluctuations, as well as more obvious causes such as natural catastrophes or habitat destruction (Shaffer 1981; Soule 1988).

The aim of translocations is to counter the post-European settlement pattern of Chuditch decline by re-establishing animals in suitable areas of vacant habitat, specifically where these appear to have no potential for ready recolonization from other areas. An experimental translocation conducted in the summer of 1987-1988 demonstrated that captive-reared females typically establish home ranges near their point of release, and quickly learn to obtain the normal range of prey items consumed by forest Chuditch (Appendix IV).

Prescriptions

(i) An initial translocation will be attempted, on an experimental basis. Subsequent operational translocations will be undertaken depending upon

(a) the success of the initial translocation;

(b) the supply of captive bred juvenile animals.

(ii) Translocations will be attempted only in areas lacking resident Chuditch populations. Possible translocation sites are shown in Figure 3, and in the jarrah forest include Julimar State Forest and suitable Alcoa bauxite mining rehabilitation sites at Jarrahdale and Willowdale. Other west coast locations such as Moore River National Park and Kalbarri National Park will also be considered. Fitzgerald River National Park may be a suitable semi-arid release location, although the effect of Chuditch on the rare mammals and Ground Parrot in the Park needs to be determined first. The effect of the proposed fox baiting program on translocated Chuditch also needs to be considered.

(iii) Selection criteria for translocation sites will include

(a) land that is managed by CALM or land that is subject to an agreement with CALM;

(b) a large continuous area of land (at least 20 000 ha);

(c) the presence of hollow logs and pre-existing burrows;

(d) the occurrence of moderate to dense understorey vegetation and moderate to deep leaf litter;

(e) the absence of high numbers of foxes and illegal shooting activity;

(f) the absence of major and frequently used roads.

(iv) Translocations will use only surplus young animals from the captive breeding program and will occur in March or April when the juveniles are approximately 10 months old. At this stage juveniles have essentially reached adult size. Food is also predicted to be relatively abundant at this time.

(v) Trial translocations will include 5-10 males and 5-10 females (comprising 2-4 litters). All animals will be fattened to Fat Index level 3 (Serena and Soderquist 1988b) and fitted with radio collars prior to release. Animals should be acclimatized on site for at least 48 hours in medium sized cages prior to release.

(vi) During the trial translocation, Chuditch will be located by radio tracking at least twice a week for the first two months following release. This is the most difficult period for captive reared animals. The effect of food supplementation should be tested during this period. Food (100 g fresh meat, dried with skin) should be left at the entrance to the den of half the released animals whenever they are located. The Chuditch will be trapped and the condition (weight and tail fat index) of the supplemented and non-supplemented groups compared at one- and two-month intervals after release. Survival rate of both groups will also be compared.

(vii) Additional experimental work required before subsequent translocations occur includes

(a) the determination of survivorship and reproductive success of translocated Chuditch;

(b) the recording of behavioural responses of translocated males;

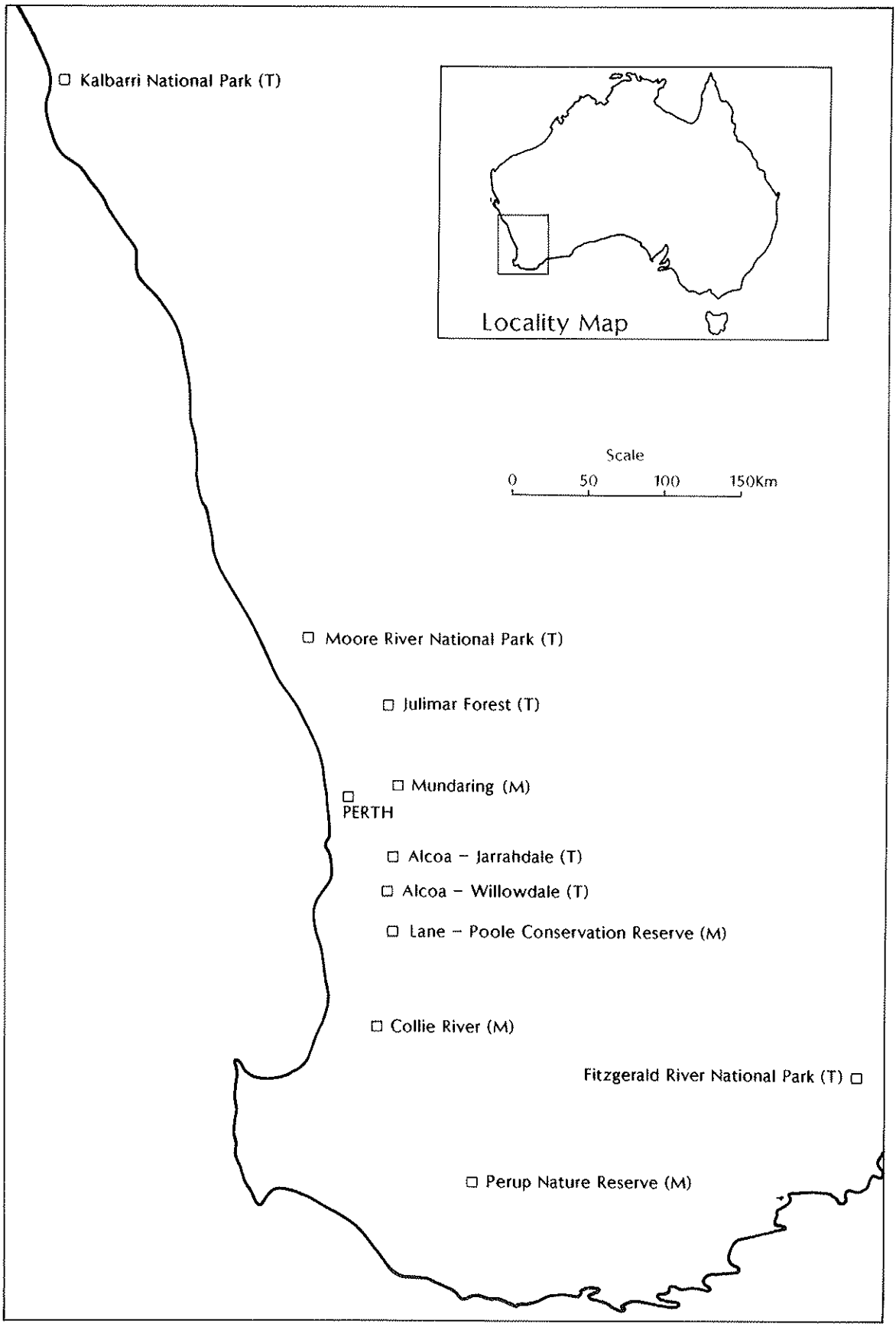

Figure 3

The location of proposed Chuditch monitoring (M) and translocation sites (T) in the south-west of Western Australia.

(c) the determination of the value of predator control to Chuditch conservation.

(viii) Experimental translocation is an expensive operation and will require the assistance and cooperation of CALM research and operations personnel and staff from the Perth Zoo. In particular CALM regional personnel will be involved in this program. External funding will be sought to employ staff to execute and monitor the experimental translocation.

(ix) Once satisfactory translocation procedures have been established, translocations to other suitable areas may occur with less rigorous monitoring. Operational translocations to semi-arid habitats may also need to be preceeded by a trial translocation.

2.7 Population and Habitat Monitoring

2.7.1 Population Monitoring

The monitoring of Chuditch populations at several selected sites in the jarrah forest enables the effect of forest management practices and forest diseases to be assessed. It also provides regular information on the condition, breeding biology, diet and population densities of Chuditch throughout the jarrah forest. Widespread changes to the status of Chuditch can also be detected. Three populations suitable for this occur in the jarrah forest at (a) the Murray River Valley (Lane-Poole Reserve); (b) the Wellington Mill camp and Collie River Valley; and (c) the Perup Nature Reserve (Fig. 3). These areas have been trapped for Chuditch for the past 2-10 years. It would also be appropriate to establish a fourth monitoring site in the northern jarrah forest near Mundaring, and another in a semi-arid location when a suitable population was found. A Chuditch field data sheet for recording population monitoring (and habitat monitoring) data is shown at Appendix V.

Prescriptions

(i) Continue monitoring the Chuditch populations at Lane-Poole Reserve, Wellington Mill and Collie River, and Perup Nature Reserve. A fourth monitoring site will be established near the northern limit of the Chuditch's present range in the jarrah forest, probably in the Mundaring district. Additional population monitoring sites will be established if suitable Chuditch populations are found in the drier parts of its range.

(ii) Population monitoring through trapping will be undertaken by CALM research staff initially and later by CALM regional staff. Some assistance from qualified volunteers (e.g. W.A. Naturalists Club) may also be sought.

(iii) Standardized trapping procedures will be used (Serena and Soderquist 1988a). Trapping will be

(a) undertaken annually along predetermined, mapped routes (minimum length 15 km);

(b) conducted preferably in June/July so that information on population density at breeding and on pouch young, can be obtained. Furthermore Chuditch are most easily trapped in winter when natural prey is relatively scarce. Trapping will not be scheduled from mid-August to early October when juveniles are first deposited in dens and in the absence of their mothers are vulnerable to cold and predation;

(c) undertaken along the edges of paths and dirt roads (at 250-300 m trap intervals), near bridges (including natural log crossings) and saddles between hills, along gullies and streams, and near camp grounds;

(d) undertaken for a maximum of 3 consecutive nights. This is usually sufficient to trap most, if not all, resident females in an area. Longer trap sessions are inadvisable if Chuditch are being repeatedly trapped, especially in winter, unless large baits (80-100 g) are provided to maintain body weight.

2.7.2 Habitat Monitoring

The distribution of Chuditch in the jarrah forest depends on the quality of the habitat. The correlation of various habitat variables with the presence or absence of Chuditch will provide a better understanding of their requirements and assist in their management.

Prescriptions

(i) At each of the population monitoring sites, the following habitat variables will be monitored (Appendix V)

(a) the presence or absence of *Phytophthora cinammomi*;

(b) changes in the forest fuel loads;

(c) fire history;

(d) logging and regeneration or thinning activity;

(e) den log formation and disappearance;

(f) abundance of dietary invertebrates.

(ii) Habitat monitoring will be extended to other areas of known Chuditch occurrence in the jarrah forest and to semi-arid areas when appropriate.

2.8 Research Requirements

Three areas requiring further research have been alluded to above. These are

(a) section 2.3.1 - Management in multiple use forest - examining the effectiveness of pushed stumps and artificial dens in providing suitable refuge areas for Chuditch in production forest;

(b) section 2.3.3 - Fire management - examining the effect of prescribed burning practices on Chuditch diet. This study would also include a wider ranging examination of Chuditch diet;

(c) section 2.4 - Predator control - examining the impact of introduced predators on Chuditch and the effect of current predator control programs on Chuditch.

Additional research requirements are listed below.

2.8.1 Chuditch Distribution

Through a combination of trapping surveys and the reporting of road kills and sightings, a more accurate indication of Chuditch distribution is being obtained. This information will also provide information on the habitat requirements and status of Chuditch. This knowledge of Chuditch distribution is not yet complete.

Jarrah Forest ~ Many parts of the jarrah forest have not been adequately surveyed for Chuditch. Trapping surveys will be based on at least 150 box-trap nights (e.g. 50 traps set for 3 nights along a 15 km section of dirt road) and follow standardized methods (e.g. Serena and Soderquist 1988a). First priority will be given to areas where Chuditch populations are suspected to be present, particularly areas of jarrah forest habitat along the major river systems of the south-west. Volunteer participation in these surveys will be encouraged, especially by university students (e.g. as part of a class project) and naturalist groups.

Wheatbelt and Semi-arid Woodland ~ Surveys of large (10 000 ha) reserves in the wheatbelt (including west coast locations), and semi-arid woodlands east of the wheatbelt are essential, in order to identify remaining populations of Chuditch and assess their population densities and conservation status.

2.8.2 Ecology of Chuditch in Semi-arid Habitat

Although the basic ecology of Chuditch in the jarrah forest has been examined, Chuditch adapted to semi-arid habitats may demonstrate a markedly different natural history. There is some suggestion that individuals in these areas may be smaller than jarrah forest Chuditch. Appropriate management of Chuditch in semi-arid habitats will require knowledge of their diet, denning habits, patterns of home range use, and reproductive success. Once surveys locate a population which is sizeable enough (and accessible enough) for a reasonable study, research will be undertaken over a minimum 12-month period, based on outside funding to employ a consultant for the field work.

2.8.3 Monitoring of Parasites and Disease

The limited distribution of viable Chuditch populations in the jarrah forest leaves the species vulnerable to decline owing to disease. It is therefore important to begin the process of identifying diseases and parasites that affect Chuditch so that any future changes in population health can more readily be diagnosed. Road-killed animals provide an ideal source for such analyses since they are (presumably) randomly selected throughout the year. Pathologists at the Murdoch University Veterinary School have expressed an interest in disease/endoparasite analysis, and entomologists at the Western Australian Museum are willing to identify ectoparasites. Information will be disseminated to CALM employees on the need for road-killed Chuditch and the collection techniques required to facilitate these studies.

2.8.4 Arthropod Recovery in Rehabilitated Minesites

Little is known about the suitability of rehabilitated bauxite minesites for Chuditch. Preliminary data are available on the recovery of some arthropods in revegetated bauxite minesites (e.g. Majer *et al.* 1984). The suitability of rehabilitated minesites as habitat needs to be assessed through a comparison of Chuditch dietary information with analyses of arthropod biomass in rehabilitated areas of different age and floristics.

2.9 Staff Training

To undertake many of the prescriptions outlined in this management program, staff from CALM, other government departments and relevant mining companies will require some training in Chuditch field techniques. This is necessary because

(a) Chuditch occur in low densities and standard fauna trapping techniques will not necessarily detect Chuditch;

(b) The Chuditch is a medium sized carnivore/insectivore and requires special handling to avoid injury to handler and animal.

The Chuditch is a declared rare species and as such its requirements need to be considered when undertaking management operations on CALM lands (CALM Policy Statement Number 33: Conservation of Endangered and Specially Protected Fauna in the Wild). This management program presents all available knowledge on the Chuditch and should be

read by all CALM staff concerned with operational duties in the southern areas of the State, particularly the forest regions. Operations staff will be informed of new information relating to Chuditch management as it becomes available through workshops, seminars and departmental publications such as Silviculture Specifications.

2.10 Public Education Program

The support of the public is essential if the Chuditch is to be conserved, since the program described here is expensive in terms of both staff and finance.

The Department of Conservation and Land Management and Perth Zoo, in cooperation with other relevant organizations, will coordinate a public education program on the Chuditch and on the measures being undertaken to prevent its extinction.

2.11 Term and Implementation of Management Program

2.11.1 Chuditch Recovery Team

Coordination of research and management of the Chuditch and of the education program will be carried out by a Chuditch Recovery Team. This will comprise representatives from the Department of Conservation and Land Management (Research Division-Chair, Nature Conservation Division and relevant regions), Perth Zoo, and any other organizations that become involved in this program in the future.

2.11.2 Term of the Management Program

Unless superseded the term of this program will be ten years.

2.11.3 Implementation of Management Program

The successful implementation of this management program will require the cooperation and assistance of several sections of the Department of Conservation and Land Management, predominantly in the Research and Operations Divisions. Within Operations Division, staff in the Northern, Central and Southern Forest Regions will have most responsibility towards implementation of this management program. Some external agencies will also have some involvement with the implementation of this program, in particular the Perth Zoo and Agriculture Protection Board.

A plan for implementation is shown in Table 3. It includes

(a) a brief description of the strategy and prescription;

(b) the implementation mechanism;

(c) an indication of responsibility for implementation;

(d) a timetable for implementation;

(e) the expected outcome of the prescription implementation.

Table 3

IMPLEMENTATION OF CHUDITCH WILDLIFE MANAGEMENT PROGRAM

Strategy	Prescription	Implementation Mechanism	Responsibility	Timetable	Expected Outcome
2.3 Habitat Mgt					
2.3.1 Mgt in multiple use forest	(i) Maintenance of adequate refuge and den logs	Silvicultural Specification 5/89	Silviculture Branch Regional Ops. Officer	Effective immediately. Ongoing	1-5 logs/ha left on ground
	(ii) Generation of stump burrow sites - trials	Silvicultural Specifications if successful	Silviculture Branch Regional Ops. Officer	Effective as soon as trials completed. Ongoing	3-5 stump site dens/ha if trials are successful
	(iii) Provision of artificial den sites - trials	Silvicultural Specifications if successful	Silviculture Branch Regional Ops. Officer	Effective as soon as trials completed. Ongoing	1-5 mound/ha where there are no suitable logs or dens if trials are successful
2.3.2 Rehabilitation after surface mining	(i) Provision of den sites in rehabilitated sites and gravel pits	Alcoa rehabilitation prescriptions	Protection Branch Regional Operations Off.	Effective immediately. Ongoing	1-5 logs/ha and 1-5 mounds/ha
	(ii) Development of moderately dense vegetation and deep ground litter in rehabilitated areas	Alcoa rehabilitation prescriptions	Protection Branch Regional Operations Off.	Effective immediately. Ongoing	a. 30-70% conopy cover in 0.5- 2.0m layer b. Deep ground litter
	(iii) Use of rehabilitation techniques that encourage rapid development of prey biomass	Alcoa rehabilitation presciptions	Protection Branch Regional Ops. Officer	Effective immediately. Ongoing	Rapid development of Chuditch prey
2.3.3 Fire management	(i) Protection of riparian vegetation	Regional master burning plan	Fire Branch / Regional Operations Officer	Effective immediately. Ongoing	a. 7 year + rotation for streams b. 1 year + difference in fuel age between riparian and non-riparian c. 50%+ streams unburnt in any year
	(ii) Protection of non-riparian vegetation	Regional master burning plan	Fire Branch / Regional Operations Officer	Effective immediately. Ongoing	a. block burns 5 km^2 or less b. spring burning
	(iii) Undertake research into effect of burning regimes on Chuditch diet.	Research project plan	Research Division	Commence as soon as possible	Incorporate research findings into burning prescriptions
2.3.4 Forest traffic mgt	(i) Erection of warning signs	Regional directive	Regional Operations Off. District Managers		Signs on MRD[(a)] and CALM lands

[(a)]MRD Main Roads Department

Table 3 (*continued*)

Strategy	Prescription	Implementation Mechanism	Responsibility	Timetable	Expected Outcome
	(ii) Restrict nocturnal use of roads for car rallies	CALM rally policy (draft 5/90)	Regional Planning Officer	Liaison with rally organisers on application to hold event	No rallies at night on roads in known Chuditch habitat
	(iii) Reporting of road kills and sightings	road kill/sighting report forms	Regional Ecologist Research Division	Ongoing	Additional distribution data, use carcasses for diet analysis
2.3.5 Clearing of habitat	(i) Discourage further extensive clearing of forest and mallee particularly riparian habitat	Regional recommendations	Regional Planning Officer and Ecologist	Effective immediately. Ongoing	No (minimal) clearing of riparian and adjacent habitat
	(ii) Appropriate assessments of areas to be cleared	a. Guidelines provided by Research Division b. Regional recommendations	a. Research Division b. Regional Planning Off	As required	No (minimal) clearing of riparian and adjacent habitat
	(iii) Maintenance of uncleared corridors on fringes of forest and mallee	Regional recommendations	Regional Planning Officer	Effective immediately. Ongoing	Retention of suitable corridors
2.4 Predator control	(i) Undertake research into impact of introduced predators and effect of baiting programs on Chuditch	Research project plan	Research Division	Initiate as soon as possible	Recommendations on: a. placement of meat baits b. need to bait foxes c. 1080 dose levels
	(ii) Use of appropriate baits and dose of 1080	Letter to APB[(b)] Protection Branch circular	Protection Branch / APB/ District Managers	Initiate as soon as possible	Use 4.5 mg 1080/200 g meatbait. Use lower levels of 1080 if these are found to be effective against foxes.
	(iii) Use of appropriate poisons	Letter to APB Protection Branch circular	Protection Branch / APB/ District Managers	Effective immediately. Ongoing	Use 1080, not strychnine or cyanide in Chuditch areas
	(iv) Seasonal constraints	Letter to APB Protection Branch circular	Protection Branch / APB/ District Managers	Effective immediately. Ongoing	Baiting undertaken Jan-March not during breeding period
	(v) Alternative baits				crackle baits 1 mg 1080/20 g crackle compressed grain pig baits
2.5 Captive breeding	(i) Undertake a captive breeding program	Zoo breeding program	Zoo	Underway. Ongoing	Provision of Chuditch for display and translocation

[(b)] APB - Agriculture Protection Board

Table 3 (*continued*)

Strategy	Prescription	Implementation Mechanism	Responsibility	Timetable	Expected Outcome
	(ii) Reduction of inbreeding	Zoo breeding program	Research Division Regional Ecologist	Underway. Ongoing	Provide 'new' wild male to Zoo every 1-2 years
	(iii) Development of appropriate exhibit and public information program	Zoo Education Branch	Zoo/CALM	Instigate once breeding program established	Public display and exhibit
	(iv) Use of surplus juveniles	Zoo / CALM agreement	Zoo / Research Division	Undertake when appropriate	Juveniles released or given to other zoos
	(v) Use of surplus adults	Zoo / CALM agreement	Zoo / Research Division	Undertake when appropriate	Adults released
	(vi) Screening for parasites and disease	Zoo veterinarian	Zoo	Undertake as required	Release of disease-free animals
2.6 Translocation	(i) Undertake trial translocation prior to subsequent operation translocation	Research	Research Division Regional Staff	Implement as soon as captive breeding program is successful	Develop guidelines for subsequent translocations
	(ii) Translocations sites	Research project plan	Research Division Regional Staff	Assess prior to translocation	Translocation only to areas with no Chuditch
	(iii) Selection criteria for translocation sites	Research project plan Survey of suitable sites	Research Division Regional Ecologists	Assess prior to translocation	Identification of suitable translocation sites
	(iv) Use young Chuditch only for translocations	Research project plan	Research Division Regional Ecologists / Zoo	Use animals when available	Higher survival of translocated animals
	(v) Numbers and condition of Chuditch used in trial location	Research project plan	Research Division Regional Ecologist / Zoo	As available	Higher survival of translocated animals
	(vi) Monitoring of translocated Chuditch	Research project plan	Research Division Regional Ecologists District Managers	Immediately after release	Assess success of translocation program
	(vii) Additional experimental work before subsequent translocation is carried out	Research	Research Division	Undertake during trial translocation	Determine success of translocation, determine effect of foxes and baiting on Chuditch
	(viii) Personnel involved	Consultancy administered by Research Division	Research Division	Commence when Chuditch become available	Successful translocation
	(ix) Subsequent translocations to other areas	Research project plan	Research Division Regional staff	Undertake when appropriate following successful trials	Successful translocations to other areas of previous distribution

Table 3 (*continued*)

Strategy	Prescription	Implementation Mechanism	Responsibility	Timetable	Expected Outcome
2.7 Population and habitat monitoring					
2.7.1 Population monitoring	(i) Continue monitoring at Perup, Wellington Mills and Lane-Poole, establish additional site at Mundaring	District works program Chuditch field data sheet	District Managers Wildlife Branch	Ongoing. Once per year	Assess effects of management practices and status of Chuditch
	(ii) Staff involved	District works program	Regional Ecologists District Managers		Commitment to Chuditch monitoring
	(iii) Use of standardised trapping techniques	Chuditch field techniques	Regional Ecologists District Manager		Standard data collected
2.7.2 Habitat monitoring	(i) Monitoring of habitat variable	a. Chuditch field data sheet b. District works program	Regional Ecologist District Managers	Implement when resources become available	Provides data on Chuditch habitat requirements
	(ii) Habitat monitoring in other areas	Chuditch field data sheet	District Managers	Subject to finding of other Chuditch populations elsewhere	Provides data on Chuditch habitat requirements in semi-arid areas
2.8 Research Requirements					
2.8.1 Distribution	(i) Jarrah forest	Research project plan	Research Division Regional Ecologists	Ongoing	a. info. on new populations (better distribution maps) b. management recommendations
	(ii) Wheatbelt and semi-arid areas	Research project plan	Research Division Regional Ecologists	Ongoing	a info. on new populations (better distribution maps) b. management recommendations
2.8.2 Ecology in semi-arid areas		Research project plan	Research Division	Subject to finding suitable population	a. information on Chuditch in semi-arid b. management recommendations
2.8.3 Parasites and disease			Research Division Regional Ecologists tertiary institutions		a. information b. management recommendations
2.8.4 Arthropod recover in rehabilitated minesites		Research project plan	Research Division / Alcoa	Recommendations added to Alcoa rehabilitation prescriptions	

REFERENCES

Abbott, I. (1984). Changes in the abundance and activity of certain soil and litter fauna in the Jarrah forest of Western Australia after a moderate intensity fire. *Australian Journal of Soil Research* **22**, 463-469.

Archer, M. (1974). Some aspects of reproductive behaviour and the male erectile organs of *Dasyurus geoffroii* and *D. hallucatus* (Dasyuridae: Marsupialia). *Memoirs of the Queensland Museum* **17**, 63-67.

Arnold, J.M. (1976). Growth and bioenergetics of the Chuditch, *Dasyurus geoffroii*. Ph.D. Thesis, University of Western Australia Perth.

Arnold, J.M. (1983). Western Quoll. IN: R. Strahan (Ed). *Complete Book of Australian Mammals*, Angus and Robertson, Sydney p. 22.

Begg, R.J. (1981). The small mammals of Little Nourlangie Rock, N.T. III. Ecology of *Dasyurus hallucatus*, the northern quoll (Marsupialia: Dasyuridae). *Australian Wildlife Research* **8**, 73-85.

Blackhall, S. (1980). Diet of the Eastern Native-Cat, *Dasyurus viverrinus* (Shaw), in southern Tasmania. *Australian Wildlife Research* **7**, 191-197.

Burbidge, A.A. and Fuller, P.J. (1979). Mammals of the Warburton region, Western Australia *Records of the Western Australian Museum* **8**, 57-73.

Burbidge, A.A., Johnson, K.A., Fuller, P.J. and Southgate, R.I. (1988). Aboriginal knowledge of the mammals of the central deserts of Australia. *Australian Wildlife Research* **15**, 9-39.

Caughley, J. (1980). Native quolls and tiger quolls. IN: C. Haigh (Ed). *Endangered Animals of New South Wales*, New South Wales National Parks and Wildlife Service, Sydney pp. 45-48.

Collett, R. (1887). On a collection of mammals from central and northern Queensland. Zoologischen Jahrbuchen. Zeitschrift fur Systematik, Geographie und Biologie der Thiere. Gustav Fischer, Jena.

Christensen, P.E.S. (1980). The biology of *Bettongia penicillata* Gray, 1837, and *Macropus eugenii* (Desmarest, 1817) in relation to fire. Forests Department of Western Australia, Bulletin 91.

Eastland, W.G. and Beasom, S.L. (1986). Effects of ambient temperature on the 1080-LD_{50} of raccoons. *Wildlife Society Bulletin* **14**, 234-235.

Finlayson, H.H. (1961). On central Australian mammals. IV. The distribution and status of central Australian species. *Records of the South Australian Museum* **41**, 141-191.

Glauert, L. (1933). The distribution of the marsupials in Western Australia. *Journal of the Royal Society of Western Australia* **19**, 17-32.

Godsell, J. (1982b). The population ecology of the eastern quoll *Dasyurus viverrinus* (Dasyuridae: Marsupialia) in southern Tasmania. IN: M. Archer (Ed). *Carnivorous Marsupials* pp. 199-207. Royal Zoological Society of New South Wales, Mosman.

Green, B. and Eberhard, I. (1983). Water and sodium intake, and estimated food consumption, in free-living Eastern Quolls, *Dasyurus viverrinus*. *Australian Journal of Zoology* **31**, 871-880.

How, R.A., Newby, K.R., Dell, J., Muir, B.G. and Hnatiuk, R.J. (1988). Biological survey of the eastern goldfields of Western Australia, Part 4, Lake Johnston-Hyden study area. *Records of the Western Australian Museum Suppl.* 30.

How, R.A., Dell, J. and Humphreys, W.F. (1987). The ground vertebrate fauna of coastal areas between Busselton and Albany, Western Australia. *Records of the Western Australian Museum* **13**, 553-574.

Iredale, T. and Troughton, E. le G. (1934). A check-list of the mammals recorded from Australia. *Australian Museum Memoirs* **6**, 1-122.

Johnson, K.A. and Roff, A.D. (1982). The Western Quoll, *Dasyurus geoffroii* (Dasyuridae, Marsupialia) in the Northern Territory: historical records from venerable sources. IN: M. Archer (Ed). *Carnivorous Marsupials*, pp. 221-226. Royal Zoological Society of New South Wales, Mosman.

King, D.R., Oliver, A.J. and Mead, R.J. (1981). *Bettongia* and fluoroacetate: a role for 1080 in fauna management. *Australian Wildlife Research* **8**, 529-536.

King, D.R., Twigg, L.E. and Gardner, J.L. (1989). Tolerance to sodium monofluoroacetate in dasyurids from Western Australia. *Australian Wildlife Research* **16**, 131-140.

Leake, B.W. (1962). *Eastern Wheatbelt Wildlife*. Docket Book Co., Perth.

McIlroy, J.C. (1981). The sensitivity of Australian animals to 1080 poison I. Intraspecific variation and factors affecting acute toxicity. *Australian Wildlife Research* **8**, 369-83.

McIlroy, J.C. (1986). The sensitivity of Australian animals to 1080 poison IX. Comparisons between major groups of animals, and the potential danger non-target species face from 1080-poisoning campaigns. *Australian Wildlife Research* **13**, 39-48.

McIlroy, J.C. and King, D.R. (1990). Appropriate amounts of 1080 poison in baits to control foxes, *Vulpes vulpes*. *Australian Wildlife Research* **17** 11-13.

Majer, J.D. (1984). Short-term responses of soil and litter invertebrates to a cool autumn burn in Jarrah (*Eucalyptus marginata*) forest in Western Australia. *Pedobiologia* **26**, 229-247.

Majer, J.D. (1985). Fire effects on invertebrate fauna of forest and woodland. IN: J.R. Ford (Ed). 'Fire Ecology and Management of Western Australian Ecosystems', pp. 103-106. Proceedings of Symposium, held in Perth, May 1985. WAIT Environmental Studies Group Report 14.

Majer, J.D., Day, J.E., Kabay, E.D. and Perriman, W.S. (1984). Recolonization by ants in bauxite mines rehabilitated by a number of different methods. *Journal of Applied Ecology* **21**, 355-375.

Mansergh, I. (1983). The status, distribution and abundance of *Dasyurus maculatus* (Tiger Quoll) in Australia, with particular reference to Victoria. *Australian Zoologist* **21**, 109-122.

Marlow, B.J. (1958). A survey of the marsupials of New South Wales. *CSIRO Journal of Wildlife Research* **3**, 71-114.

Mollison, B.C. (1961). Florentine Valley investigation. A special report to the Animals and Birds Protection Board. Tasmanian Region. Laboratories, Division of Wildlife Research, CSIRO.

Morton, S.R. (1980). Field and laboratory studies of water metabolism in *Sminthopsis crassicaudata* (Marsupialia: Dasyuridae). *Australian Journal of Zoology* **28**, 213-27.

Nagy, K.A. (1987). Field metabolic rate and food requirement scaling in mammals and birds. *Ecological Monographs* **57**, 111-28.

Nagy K.A., Seymour, R.S., Lee, A.K. and Braithwaite, R. (1978). Energy and water budgets in free-living *Antechinus stuartii (Marsupialia:Dasyuridae) Journal of Mammalogy* **59**, 60-68.

Newsome, A., McIlroy, J. and Catling, P. (1975). The effects of an extensive wildfire on populations of twenty ground vertebrates in south-east Australia. *Proceedings of the Ecological Society of Australia* **9**, 107-123.

Oliver, A.J. and King, D.R. (1983). The influence of ambient temperatures on the susceptibility of mice, guinea-pigs and possums to Compound 1080. *Australian Wildlife Research* **10**, 297-301.

Postle, A.C., Majer, J.D. and Bell, D.T. (1986). Soil and litter invertebrates and decomposition in Jarrah (*Eucalyptus marginata*) forest affected by Jarrah dieback fungus *(Phytophthora cinnamomi)*. *Pedobiologia* **29**, 47-69.

Rolls, E.C. (1969). *They All Ran Wild*. Angus and Robertson, Sydney.

Serena, M. and Soderquist, T.R. (1988a). Field techniques for working with Chuditch (*Dasyurus geoffroii*). Unpublished Report, Western Australian Department of Conservation and Land Management, 8pp.

Serena, M. and Soderquist, T.R. (1988b). Growth and development of pouch young of wild and captive *Dasyurus geoffroii* (Marsupialia:Dasyuridae). *Australian Journal of Zoology* **36**, 533-543.

Serena, M. and Soderquist, T.R. (1989a). Nursery dens of *Dasyurus geoffroii* (Marsupialia: Dasyuridae), with notes on nest building behaviour. *Australian Mammalogy* **12**, 35-36.

Serena, M. and Soderquist, T.R. (1989b). Spatial organization of a riparian population of the carnivorous marsupial *Dasyurus geoffroii. Journal of Zoology, London* **219**, 373-383.

Shaffer, M.L. (1981). Minimum population sizes for species conservation. *BioScience* **31**, 331-338.

Shortridge, G.C. (1909). An account of the geographical distribution of the marsupials and monotremes of southwest Australia having special reference to the specimens collected during the Balston expedition of 1904-1907. *Proceedings of the Zoological Society of London* **55**, 803-848.

Soderquist, T.R. and Serena, M. (1990). Occurrence and outcome of polyoestry in wild Western Quolls, *Dasyurus geoffroii* (Marsupialia:Dasyuridae). *Australian Mammalogy* **13**, 205-208.

Soule, M.E. (1985). *Viable Populations for Conservation*. Cambridge University Press. Cambridge, United Kingdom.

Sullivan, J.L., Smith, F.A. and Garman, R.H. (1979). Effects of fluoroacetate on the testis of the rat. *Journal of Reproduction and Fertility* **56**, 201-7.

Thomas, O. (1888). *Catalogue of the Marsupialia and Monotremata in the Collection of the British Museum (Natural History)*. Taylor and Francis, London.

Thomas, O. (1906). On mammals collected in south-west Australia for Mr. W.E. Balston. *Proceedings of the Zoological Society of London* 1906, 468-478.

Van Dyck, S. (1988). The Bronze Quoll, *Dasyurus spartacus* (Marsupialia: Dasyuridae), a new species from the savannahs of Papua New Guinea. *Australian Mammalogy* **11**, 145-156.

Waithman, J. (1979). A report on a collection of mammals from southwest Papua, 1972-1973. *Australian Zoology* **20**, 313-326.

Whittell, H.M. (1954). John Gilbert's notebook on marsupials. *Western Australian Naturalist* 4, 104-114.

Wood Jones, F. (1923). *The Mammals of South Australia*. Government Printer, Adelaide.

Wooller, R.D. and Calver, M.C. (1988). Changes in an assemblage of small birds in the understorey of dry sclerophyll forest in south-western Australia after fire. *Australian Wildlife Research* **15**, 331-338.

APPENDIX I

Number of male and female Chuditch trapped in jarrah forest surveys 1971-1988 exclusive of small juveniles trapped in November/December. Number of trap nights based on the use of weldmesh cage traps and/or the largest version of Elliott traps. MONTHS: 1, Jan-March; 2, April-June; 3, July-Sept; 4, Oct-Dec. SOURCE: 1, CALM files; 2, authors' unpub. data; 3, Alcoa files; 4, Nichols *et al.* 1981. For additional survey results see Christensen *et al.* 1985 and Worsley Alumina Pty Ltd 1985.

AREA OR FOREST BLOCK	MONTHS	YEAR	NO. TRAP-NIGHTS	NO. CHUDITCH M	NO. CHUDITCH F	SOURCE
Batalling	3	1982	304	2	3	1
	1,3	1983	350	3	2	1
	1	1984	400	3	2	1
	3,4	1985	993	2	4	1,2
	3,4	1986	322	-	1	1,2
Boyicup	2,3,4	1974	1801	3	1	1
	1,2,3,4	1975	2442	1	2	1
	1,2,3,4	1976	3321	2	-	1
	2,3	1977	816	-	-	1
	2,4	1978	1140	-	-	1
	2,4	1979	912	1	-	1
	2,4	1980	1044	-	-	1
	1,2,4	1981	1695	1	1	1
	4	1982	90	-	1	1
	1,2,4	1983	300	-	1	1
	1,2,3,4	1984	332	-	1	1
	1,2,3,4	1985	322	-	-	1
Collie River	3	1987	18	2	-	2
	4	1988	28	1	2	2
Del Park	3,4	1979	192	2	1	3
	1	1980	64	1	-	3
Federal[a]	1,2,3	1980	ca.565	-	-	4
	3	1985	210	1	-	2
George	3	1985	432	-	1	2
Holyoake	3	1971	140	-	-	1
Inglehope	2	1971	170	-	-	1
Jarrahdale[b]	3	1978	64	-	1	3
	1	1980	112	2	1	3
	4	1981	225	-	-	1
Julimar	2,4	1983	300	-	-	1
Marrinup						
Moore's Swamp	2,3	1971	289	-	-	1
	1	1972	100	-	1	1
Scarp Road	2	1971	293	-	-	1
Nalyerin	1	1982	175	-	-	1
Nanga, Yarragil,	3,4	1985	596	4	9	2
Plavins & Park[a]	1,2,3,4	1986	2162	27	35	2

Appendix I (*continued*)

AREA OR FOREST BLOCK	MONTHS	YEAR	NO. TRAP-NIGHTS	NO. CHUDITCH M	NO. CHUDITCH F	SOURCE
	1,2,3,4	1987	1931	25	31	2
	1,2,3,4	1988	699	20	13	2
Scott	2	1971	243	-	-	1
Serpentine[c]	4	1980	ca.200	-	-	4
	3	1981	ca.200	-	-	4
Wandering Mission	3	1986	201	1	-	2
Wellington Mill	3	1987	22	3	1	2
	1,4	1988	65	6	4	2
Yendicup	3,4	1977	1032	-	-	1
	1,2,3,4	1978	2144	-	-	1
	1,2,3,4	1979	2304	2	1	1
	1,2,3,4	1980	2468	7	5	1
	1,2,3,4	1981	2320	1	3	1
	1,2,3,4	1982	2198	5	4	1
	4	1983	304	-	-	1
	1,4	1984	397	-	-	1
	4	1986	144	2	3	2
	3	1987	138	4	2	2
	1	1988	108	2	1	2

(a) Trapped areas are within or adjacent to the Lane-Poole Conservation Reserve.

(b) 1979 Alcoa data omitted because animals not marked (recaptures not assessed).

(c) One Chuditch seen while spotlighting.

REFERENCES

Christensen, P., Annels, A., Liddelow, G. and Skinner, P. (1985). Vertebrate fauna in the southern forests of Western Australia. Forests Department of Western Australia Bulletin 94.

Nichols, O.G., Glossop, B.L. and Smurthwaite, A.J. (1981). A method for assessing the likely effects of bauxite mining on conservation of flora and fauna management priority areas. Alcoa of Australia Ltd, *Environmental Research Bulletin 12*.

Worsley Alumina Pty Ltd. (1985). 'Worsley Alumina Project. Flora and Fauna Studies, Phase Two'. Worsley Alumina Pty Ltd, Perth.

DEPARTMENT OF CONSERVATION
AND LAND MANAGEMENT

SILVICULTURE SPECIFICATION 5/89

MAINTENANCE OF HABITAT FOR HOLE NESTERS IN TIMBER PRODUCTION AREAS OF THE JARRAH FOREST

PREAMBLE

The jarrah forest provides habitat for many fauna species, including some birds and mammals which were once more widely distributed through the woodlands of the coastal plain and wheatbelt. This fauna value has been maintained in a forest managed for multiple uses (including timber production) for the past 100 years, with no species known to have become extinct since European settlement.

The type of forest management which has maintained suitable habitat within the jarrah forest has varied from heavy cutting and intensive regeneration treatment to light selective cutting. Conditions common to these systems have been the survival of mature non-commercial trees, creation of considerable quantities of woody debris and the rapid regeneration of forest cover. The potential now exists to commercially remove low-grade timber and large quantities of accumulated debris. This specification retains some of these components of the fauna habitat which can be lost through intensive harvesting and regeneration operations, and which would take many years to replace.

The retention of unmerchantable trees in the forest reduces the growth of crop trees and therefore represents a trade-off between wildlife and timber values. Variation from this specification may be at the cost of one of these values.

As detailed requirements of particular fauna species become known it may be necessary to vary this specification. Note that timber harvesting and regeneration operations affect only about 1.5% of the jarrah forest each year. This specification is therefore only a subset of the wider approach to CALM's fauna management in the jarrah forest.

2. OBJECTIVE

To retain the essential components of habitat for hole nesting fauna which cannot be readily replaced through post-harvest forest manipulation.

3. STANDING TREES AS HABITAT

3.1 Characteristics of habitat trees

- Mature and likely to live for many years. It is essential that these trees have the capacity to provide fauna habitat until regrowth trees can replace them at some time in the future.
- Contain holes, or broken branch stubs below the live crown with the potential to develop into holes.

- Average sized crown. Excessively vigorous trees will affect regrowth over a wide area.
- Marri in preference to jarrah.
- Contain low value in preference to high value products.

3.2. Rate of Retention

Trees, as defined above, are to be retained for fauna habitat at a rate of 15 trees per 5 hectares. A clump of 3-4 trees is preferred to an even distribution. If insufficient trees with these characteristics are available retain mature trees as potential habitat.

Habitat trees must be deliberately marked for retention.

Do not retain habitat trees in regeneration gaps of one hectare or less, as they will provide excessive competition for regrowth.

4. GROUND HABITAT

4.1 Characteristics

Logs
Diameter 30-100 cm
Pipe 6-15 cm diameter extending into log
Length - pipe at one end - 1.5 metres minimum
- pipe at both ends - 3 metres minimum

Stumps and Leaning Trees
Stumps which have been lifted creating a protected underground cavity due to a leaning tree or some other agency.

4.2 Rate of retention

Logs and stumps with these characteristics are not common in the forest. Operators should be trained to recognise and retain them. If necessary they should be marked by the treemarker. Where available retain at least one per hectare. All marked logs must be retained undisturbed.

5. FAUNA HABITAT PROTECTION

As for protection of crop trees, tops and other residues larger than 7.5 cm diameter are to be removed 1 metres from the bole of habitat trees to ensure subsequent protection from fire.

F J BRADSHAW
MANAGER, SILVICULTURE BRANCH

APPENDIX III

Captive breeding of Chuditch (*Dasyurus geoffroii*): some methods and guidelines

General Husbandry

Details of cage and nest box dimensions and design and the feeding routine associated with breeding captive *D. geoffroii* over the period 1986-1988 at Dwellingup are provided in Serena and Soderquist (1988b, 1989a). Additional recent information on captive husbandry of this and other species of *Dasyurus* is available in Nelson and Smith (1973), Arnold (1976), Settle (1978), Godsell (1982a), Merchant *et al.* (1984), Fletcher (1985), Bryant (1988) and Conway (1988).

It has recently been suggested that ambient noise may play a role in restricting the success of captive breeding in *D. geoffroii*. However, at least in the case of moderately loud diurnal noise, the Dwellingup captive colony bred prolifically within 400 m of a commercial sawmill. Nocturnal noise may be more problematic, however, particularly in the case of newly caught individuals, and should be minimised whenever possible.

Timing of Red Pouch Secretion

A yellowish-brown, rather waxy exudate sometimes collects at the base of *D. geoffroii* teats in the nonbreeding season. As females approach breeding condition, the same physical area begins to secrete a reddish, slightly sticky fluid which adheres to and stains the pouch hairs. This reddish secretion was first observed in the pouches of captive females from 45-70 days before birth (mean = 56, S.D. = 10, N = 8; females checked every three days beginning in late March). It was consistently present (though sometimes only as a few dried flakes) through the onset of oestrus, and then disappeared by late oestrus or during gestation.

Captive Breeding Protocol

D. geoffroii is a promiscuously breeding species; no enduring pair bond is established between mates. In our captive breeding work we tried to parallel the wild system as much as possible, through the following protocol:

(a) Males and females were caged separately (males singly; females singly or in pairs) beginning in late March;

(b) Beginning in May, each female was individually introduced to a male's cage at intervals of three days (1600-1730 hours);

(c) Females were returned to their home cage the following morning;

(d) Once copulation occurred (as confirmed by direct observation or the presence of a damp, matted patch of fur on one side of the female's tail base at dawn), females were placed with a male every or every other night until mating failed to occur twice in a row. Our observations suggest that males and females both prefer mating with individuals with which they have not previously (or at least recently) copulated. To increase the total number of matings, females were paired with different males on consecutive occasions.

The only problem we encountered was in trying to mate smaller first-year males with older (second-year) females. When introduced to a male, the demeanor of oestrous females initially tends to be excitable and somewhat aggressive; the size difference between first-year males and older females is sufficient for the male to be intimidated and not mate.

Length of Behavioural Oestrus

Females were observed to copulate over intervals of 4-10 days.

Physical and Behavioural Correlates of Oestrus

(a) *Pouch and cloaca* ~ At oestrus, the region immediately surrounding the cloaca became moderately to markedly swollen in 5 of the 8 females monitored for this trait. Behavioural oestrus could not be predicted on the basis of a change in pouch appearance. Oestrous pouches were characterized by the following: skin light pink; pouch hairs sparse to quite dense; reddish stain heavily present to absent; pouch dry to fairly moist.

(b) *Female vocalization* ~ Females that have entered (or, occasionally, are only close to) oestrus produce a characteristic call: a short, rather low-pitched 'tok' or 'chok'. The call may be uttered singly or repeated (sometimes in prolonged stanzas) at the rate of one vocalization/1-2 seconds. It was often elicited when females were placed with males, and is presumed to signal sexual receptivity. Oestrous females also 'tokked' when apart from males, especially in response to hearing other females make the call, but also sometimes spontaneously.

(c) *Female sexual behaviour* ~ A receptive female signals her interest in a male by crouching with rump slightly raised and oriented towards him. Once he mounts her, she typically crouches passively for at least the first hours of copulation. Anoestrous (e.g. pregnant) females may allow themselves to be mounted on occasion, but typically remain in a standing position and quickly become restless.

Length of Copulation

The first copulation of a female's oestrus was sometimes relatively brief, taking less than an hour. Copulations otherwise lasted 3-7 hours.

Gestation and Birth

The interval from last copulation to birth ranged from 15-19 days. Although some females will give birth successfully after being handled within the previous 24 hours, the safest procedure is to leave females strictly undisturbed around the expected time of parturition. Once established in the pouch, litters may be examined without risk to their continued well-being.

The appearance of the pouch changes through the course of gestation:

(a) *About ten days before birth* ~ Pouch dry to moderately moist. Pouch skin light pink, speckled with fine, white, slightly raised sebaceous glands.

(b) *About one day before birth* ~ Pouch moist to very moist. Pouch skin flushed deep pink. White or cream-coloured sebaceous glands very conspicuous, distributed more or less densely to approximately the pouch rim.

REFERENCES

Bryant, S. (1988). Maintenance and captive breeding of the Eastern Quoll. *International Zoo Yearbook* **27**, *119-124.*

Conway, K. (1988). Captive management and breeding of the Tiger Quoll. *International Zoo Yearbook* **27**, *108-119.*

Fletcher, T.P. (1985). Aspects of reproduction in the male Eastern Quoll, *Dasyurus viverrinus* (Shaw) (Marsupialia: Dasyuridae), with notes on polyoestry in the female. *Australian Journal of Zoology* **33**, 101-110.

Godsell, J. (1982a). Notes on housing the Eastern Quoll *Dasyurus viverrinus* in outdoor enclosures. IN: D.D. Evans (Ed). *The Management of Australian Mammals in Captivity*, p. 45. Zoological Board of Victoria, Melbourne.

Godsell, J. (1982b). The population ecology of the eastern quoll *Dasyurus viverrinus* (Dasyuridae : Marsupialia), in southern Tasmania. IN: M. Archer (Ed). *Carnivorous Marsupials*, pp. 199-207. Royal Zoological Society New South Wales, Mosman.

Merchant, J.C., Newgrain, K. and Green, B. (1984). Growth of the Eastern Quoll, *Dasyurus viverrinus* (Shaw), (Marsupialia) in captivity. *Australian Wildlife Research* **11**, 21-29.

Nelson, J.E. and Smith, G. (1973). Notes on growth rates in native cats of the family Dasyuridae. *International Zoo Yearbook* **13**, 38-41.

Settle, G.A. (1978). The quiddity of tiger quolls. *Australian Natural History* **19**, 164-169.

Serena, M. and Soderquist, T.R. (1989a). Nursery dens of *Dasyurus geoffroii* (Marsupialia : Dasyuridae), with notes on nest building behaviour. *Australian Mammalogy* **12**, 35-36.

APPENDIX IV

Results and conclusions from an experimental translocation of Chuditch (*Dasyurus geoffroii*) in the jarrah forest

Many areas of apparently suitable habitat within the jarrah forest lack populations of Chuditch (*Dasyurus geoffroii*). Previous research has indicated that juveniles commonly disperse widely and theoretically should recolonize these vacant areas. An experimental translocation of captive Chuditch into vacant habitat adjacent to a viable population was designed to answer two questions: (i) What factors are causing the habitat to remain vacant? (ii) What techniques are necessary to translocate Chuditch?

Methods

In late December 1987, nine captive-reared female Chuditch were released along the Murray River 25 km south-east of Dwellingup in the Lane-Poole Conservation Reserve (Keats forest block). Seven animals were 7 months old (juveniles) and two were 18 months old (adults). All animals were judged to be very fat (Fat Index level 3, Serena and Soderquist 1988b) prior to release. Chuditch were radio-collared before being familiarized on-site for three days in large cages. Puppy chow and water were provided at the release site for several days after the cage doors were opened.

Results

(i) Most Chuditch left the vicinity of the cages immediately, and then dispersed slowly in various directions. The rate of linear travel from the release site averaged less than 1 km over the first three days. By ten days, most Chuditch had moved 2-3 km; the exception was a juvenile which moved relatively rapidly, covering 7 km (straight line distance) in the first 9 days. After about 10 days, movement patterns suggested that animals had settled in areas and were establishing home ranges.

(ii) No puppy chow was eaten after release, nor were the den boxes within the cages used for sleeping.

(iii) Den sites were often relatively insecure during the first two weeks (e.g. under raised logs and in exposed hollows). Selection gradually improved with experience. No animals ever denned together.

(iv) The diet of released animals, based on scat analyses, was very similar to that of wild Chuditch (i.e. primarily insects with some small mammals and lizards). Nonetheless, juveniles lost weight rapidly under the dual pressures of learning to forage and continued growth. Adult Chuditch declined in weight for the first three weeks and then slowly increased again.

(v) One radio-collar failed prematurely, and another was lost when the collar band separated. Information on mortality was available for the remaining seven animals.

  (a) Two juveniles were shot within a fortnight. Both deaths occurred within 15 m of a major dirt road running through the area (South Junction Form).

  (b) One juvenile probably died of starvation. Another was on the verge of starvation when her radio signal failed.

  (c) One juvenile was found, partly eaten, along a dirt road. The head, shoulders and one front leg were intact, and the tail was nearby. No loose fur was found near the body, nor was there any sign of a struggle or fight. Toothmarks on the collar suggested she may have been killed by a feral cat.

  (d) One juvenile's radio-collar was found without bodily remains or loose fur nearby. The transmitter case was partly crushed as if by a large tooth, but in a manner not observed in known fox kills of radio-collared Chuditch. A dog or pig is implicated, and may have consumed the Chuditch as carrion.

  (e) The remains of one adult were found on top of a large log, along with a substantial quantity of fur that had been plucked from the body. Feathers found on the log were identified as belonging to an owl (species not determined) by ornithologists at the Western Australian Museum.

  (f) One adult died away from shelter while apparently in good condition. Her body was intact and unburied.

Conclusions

(i) The prompt loss of two animals to illegal shooters, combined with the frequent observation of shooters in the release site, suggests one important reason why this area previously lacked Chuditch. (Wild Chuditch commonly forage and travel along roads, and are consequently highly vulnerable to spotlighting.)

(ii) The relatively limited exploratory movements demonstrated by most Chuditch in this translocation indicate that future reintroductions will not be hampered by extensive dispersal and are feasible as a management technique.

(iii) The main suggested improvement in translocation technique is to release older juveniles (i.e. in late March or April) so that the energetic stresses of growth are less severe. Other improvements are outlined in the body of this Plan.

REFERENCE

Serena, M. and Soderquist, T.R. (1988b). Growth and development of pouch young of wild and captive *Dasyurus geoffroii* (Marsupialia : Dasyuridae). *Australian Journal of Zoology* **36**, 533-543.

APPENDIX V

Chuditch Field Data Sheet

DATE _____

AREA _____
(e.g. forest block, national park, nature reserve)

TRAP LOCATION _____
_____
_____
(e.g. map coordinates, latitude & longitude, distance to nearest town)

ANIMAL NUMBER L _____ R _____

RECAPTURE YES/NO

SEX MALE/FEMALE

BODY WEIGHT (animal + bag - bag wt)

ANIMAL CONDITION (fat at base of tail) _____
_____
_____
_____
_____
_____

INJURIES _____
_____
_____

ECTOPARASITES _____
_____

BREEDING CONDITION _____
_____
_____
(e.g. pouch young, extended teats, in oestrus)

AGE OF POUCH YOUNG _____

SCATS COLLECTED YES/NO

HABITAT COMMENTS (e.g. fire history, dieback, logging history, litter etc.) _____
_____
_____
_____
_____