Eyre Peninsula NRM Board

PEST SPECIES REGIONAL MANAGEMENT PLAN

Vulpes vulpes Red Fox

Natural Resources Eyre Peninsula

Government of South Australia
Eyre Peninsula Natural Resources Management Board

INTRODUCTION

Synonyms

Fox, European red fox.

Biology

After dogs and dingos, the red fox *Vulpes vulpes* L. is the largest mammalian predator in Australia.

Red foxes are generally nocturnal **[1, 2]**, but can be active during the day when undisturbed **[3]**. During denning females are more active and their activity can become almost completely diurnal **[2]**.

Red foxes are opportunistic predators and scavengers with a very wide dietary range, being omnivorous, but predominantly carnivorous **[4-12]**. They prey on vertebrates ranging in size from small skinks (<2 g) to wallabies (15 Kg) and also feed on carrion and other scavenged materials **[13]**. Invertebrates, berries and other vegetative material may be predominantly taken during summer **[13]**, or autumn **[14]**. Foxes typically consume less than ten percent of their body mass in a day i.e. 380 to 450 g **[15]**.

Red foxes generally have well defined home ranges within spatially stable borders **[16]**. Home ranges vary with habitat type, and with food availability, terrain, and habitat complexity. In central Victorian pasture/woodland habitat home ranges have been estimated at between five and seven km^2, and in semi-urban areas from 0.6 to 1.3 km^2 over a four to eight day period **[1]**. Ranges are mutually exclusive territories, except for breeding pairs, which share a common home range **[2]**.

Red fox densities vary with season. In rural agricultural areas densities have been shown to peak in summer (3.0 foxes/km^2), with minimum winter densities (1.2 foxes / km^2) **[1]**. Densities as high as 12 foxes / km^2 have been recorded in suburban Melbourne **[16]**.

They breed only once a year, but not all females breed every year **[1]**. Mating is during winter, with a single average litter of 4-5 cubs born in late winter or spring after a gestation of 51 to 53 days **[16]**. Cubs reach independence in late summer **[3]**. Natal dens are usually extensive burrows dug by the breeding pair. Alternatively, existing rabbit or wombat burrows, or hollow logs may be used. A post weaning litter size of 3.3 cubs per den (range 2-5) has been reported in central Victoria **[1]**.

Juvenile foxes, particularly males **[16]**, disperse in autumn **[17]**. Young fox dispersal distances in central Victoria were predominantly less than two kilometres, but distances of up to 30 km have been recorded **[1]**. The 30 % of animals moving over two kilometres from point of capture (i.e. beyond home range dimensions), dispersed an average 11 km **[1]**. The longest being a straight-line distance of 300 kilometres **[18]**. The rate of dispersal over small areas can be rapid: when foxes were eradicated from a control zone of two km^2, migration occurred as quickly as animals were eliminated **[19]**.

A suite of native mammal species that weigh between 35 g and 5,500 g have been shown to be at particular risk of extinction as a result of red fox predation **[20]**. Collectively, these mammal prey species are known as Critical Weight Range (CWR) mammals. Mammals generally constitute the major food items of red foxes in Australia, but the key prey species taken may vary with locality, season, fox sex, and age, moon phase, and prey species availability **[5-7, 9, 11, 14]**. In all studies small mammals such as rabbits and house mice were taken as live prey, but larger prey such as sheep and kangaroos appear to be predominantly taken as carrion. Invertebrates appear to be an important supplementary prey **[5, 7-10]**, whereas birds, reptiles and vegetation were generally a minor diet component. Red foxes appear to actively select for rabbits despite the abundance of suitably sized native mammals **[11]**, but where rabbit numbers are low, and in natural landscapes, foxes can sustain their populations on indigenous prey alone **[2, 4, 6]**.

Origin

The red fox has a natural distribution across the continents of Europe, Asia and North America **[21]**.The subspecies in Australia is probably *Vulpes vulpes vulpes* **[22]**. They were first successfully released in southern Victoria, at Point Cook and Ballarat, probably in 1871 **[23]**. The subsequent spread across Australia was rapid, reaching South Australia by 1888 and Kalgoorlie in Western Australia by 1917 **[22]**. This spread and establishment of red foxes followed the spread of rabbits, but after a lag of several years **[16]**.

Distribution

The red fox is distributed widely across Australia excepting the far north **[24]**, occurring in most habitats from wet forests to deserts and urban areas **[3]**. They are more prolific in patchy landscapes of native bushland and agricultural land, as these fragmented environments offer a wide variety of cover, food and den sites. They are not as common in more uniform, open environments or areas that are mountainous or heavily forested. Red foxes are found at higher densities in urban areas than agricultural areas **[1, 25]**.

Severe disturbance such as clearing for grazing or agriculture appears to play a part in the distribution and abundance of red foxes. Phillips and Catling **[2]** found that they favour habitat with a high abundance of either small or medium sized mammals. Dens are generally located in thick cover, burrows or other cavities **[3]**. In urban areas around Melbourne diurnal red fox habitat use was strongly preferenced to patches of blackberry or gorse over all habitat types **[25]**, suggesting dense structure for diurnal refuge may be a limiting factor for populations in urban areas.

Red foxes inhabit all mainland areas of South Australia, being abundant and widespread south of the dingo fence (Figure 1) **[24]**.

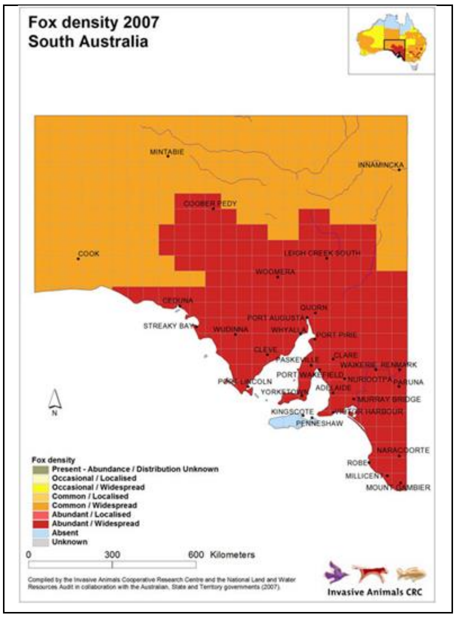

Figure 1: Red fox occurrence, abundance and distribution for South Australia in 2007. Source: [24].

RISK ASSESSMENT

Pest Risk

Red foxes have a wide dietary range, and are threatened by few natural enemies or few serious diseases in Australia. They also have high reproductive rates and high rates of cub survival, which allows them to rapidly colonise areas although they only breed once a year over a short period. These attributes are important in making the fox a significant threat to biodiversity **[26, 27]**.

The role of red foxes as a predator of livestock is not well understood **[16]**. Red fox predation has been reported on lambs, kids, piglets, calves, cows in birthing difficulties, deer, ostrich and emu chicks, and poultry including chickens, ducks, geese and turkeys **[28]**. The red fox is acknowledged as a significant predator of free-ranging poultry flocks **[29, 30]**. Until recently, predation was considered a problem only for small-scale poultry operations, as larger producers housed their birds indoors; however, with the growth of the free-range poultry industry, susceptibility to predation has increased not only bird losses but also stress-related declines in egg-laying and meat quality **[31]**. Despite this, studies in Australia show that freshly killed livestock, as distinct from carrion, are an infrequent dietary item for the red fox **[28, 32-36]**. This has been debated with some evidence to suggest that foxes may take from 10 to 30% of lambs in some areas **[16]**, but given the quality and number of previous studies this is far from resolved. In some situations red foxes and other predators can cause heavy losses. Predation is likely to be higher in some sheep breeds, for example merinos, which exhibit poor mothering ability. Predation is also higher where optimal red fox habitat occurs nearby **[37]**. There is some evidence that individual red foxes become habituated to the killing of lambs **[34]**.

In an extensive survey of neonatal lamb mortality it was demonstrated that neither disease nor predation were responsible for most lamb losses **[34]**. Most lambs die because they are starving after the relationship between mother and offspring has been broken or failed to establish. Such animals die slowly and become increasingly easy victims for a predator. Rowley **[34]** argued that it is financially insignificant whether or not a predator hastens the inevitable end of a starving lamb, as once it enters this state it is usually irreversible. Nutrition of the ewe during pregnancy and adequate shelter and supervision during parturition were identified as the key to reducing the number of lambs vulnerable to predation.

Red foxes have been linked to major regional declines of medium-sized mammals, birds and reptiles in Australia **[13, 38, 39]**, predominantly through direct predation. The ongoing effect of foxes on the abundance of many fauna is not known **[40]**. The evidence of impacts is greatest for medium sized ground-dwelling and semi-arboreal mammals, ground-nesting birds and chelid tortoises **[40]**. Of the threatened species listed under the EPBC Act, foxes are considered a threat to 14 species of birds, 48 mammals, 12 reptiles and two amphibians **[27]**. These species include the spotted quail thrush, mallee fowl, plains wanderer, two local subspecies of the southern emu-wren, and the southern brown bandicoot. This impact of red foxes on native fauna has probably been exacerbated by habitat fragmentation and modification since European settlement **[40, 41]**.

In 2004, foxes were estimated to cost the Australian economy, environment and agricultural industries more than $227 million, of which $190 million was environmental impact **[42]**. Importantly, increased densities of rabbits and cats may be a substantial environmental cost of fox control **[40]**.

Given the information presented above defining an effective protection zone around key assets is only appropriate where a baiting program has adequate frequency and spatial extent to address the dispersal ability of red foxes.

Feasibility of Control

Complete removal of foxes from Eyre Peninsula is well beyond the capacity of available techniques and resources **[26]**. Red fox populations must therefore be suppressed and managed to mitigate impacts on affected native species. Progress in control programs must be monitored to ensure that objectives are met and to allow management options to be adapted to changing circumstances **[26]**. There are insufficient resources to control red foxes effectively in all areas where they co-exist with native fauna, thus control programs need to focus on prey species for which the population level impacts of red fox predation are likely to be greatest **[40]**. Synergy between conservation authorities and the agricultural community over large areas is required for effective management of red fox populations **[16]**.

Urban and peri-urban areas, with their relatively high fox densities, are a source for fox dispersal in the NRM region. Increased food availability from human waste can have a profound effect on the reproductive success and densities of red foxes, and sound waste disposal measures are very effective in rapidly controlling these overabundant populations **[43]**. Effective red fox control across the region should address this source of fox dispersal.

A variety of red fox control techniques are used in Australia. These include hunting by trapping and shooting, poisoning, den destruction, exclusion by fencing, or changes to farming practices. These methods are described in detail in a number of references **[e.g. 16, 28]**. However, apart from broad scale baiting, the methods are expensive, labour intensive, long-term and of limited effectiveness **[28]**. There has been some research into abortifacients **[**i.e. cabergoline **44]** but it has never been registered for use on red foxes.

Wherever red foxes, feral cats, and rabbits co-occur integrated control methods enhance the decline of predator species. The general principals and strategies of integrated control are outlined in Braysher **[45]**. Williams *et al.* **[46]** and Saunders *et al.* **[16]** provide guidelines for the application of these principals and strategies to rabbits and foxes, respectively.

Effective broad-scale fox control, as a conservation or wildlife management tool, requires that the majority of foxes residing within the control area be presented with an opportunity to locate and consume poison baits. An annual kill rate of at least 65% is needed to stop growth in red fox numbers **[40]**. This is best achieved by ensuring that the majority of bait stations are established within the home ranges of the majority of individuals. Continuous control operations over large areas are more likely to suppress red fox numbers than seasonal or pulsed baiting programs, or short-term operations over small areas **[47, 48]**. The reliance on a single tactic for red fox control (poison baiting) will always have limited success in reducing populations in the long-term, with evidence indicating that resistance to 1080 can build up over time **[49]**. Consideration should be given to alternative tactics to control red foxes over large areas and long periods.

Fox control programs are evaluated by measuring the impact of baiting on red fox abundance, and in turn measuring the changes to prey species, and other species within the food web that may be subsequently affected.

Predation by the red fox is listed as a key threatening process under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act). Under the EPBC Act, the Australian Government in consultation with the states and territories has developed the Threat Abatement Plan **[26, 27]**.

Status

Within the EP NRM Board region a risk management assessment shows that red foxes merit a Manage Pest Animal Populations status in all the relevant land use types (Table 1) with the aim of reducing the overall impact of the species through targeted management.

Table 1: Regional Assessment

Land Use	Pest Risk	Feasibility of Control	Management Action
Crop/pasture rotations	409 (Very High)	588 (Negligible)	Manage Pest Animal Populations
Native vegetation	436 (Very High)	360 (Negligible)	Manage Pest Animal Populations
Non-arable grazing	409 (Very High)	309 (Negligible)	Manage Pest Animal Populations
Urban	436 (Very High)	765 (Negligible)	Manage Pest Animal Populations

REGIONAL RESPONSE

Special Considerations/Board Position

Effective red fox control is a landscape scale issue. On Eyre Peninsula district based fox baiting groups composed of agricultural landholders have been effective in implementing baiting programs on the landscape scale. Many of these programs need to be reinvigorated.

Landholders should be encouraged to bait more often in each year. Baiting in autumn and spring should be encouraged as a minimum.

All actions need to have regard to the consequences of red fox control on other species.

Integrated pest management is integral to the effective control of red foxes. Rabbit control programs in conjunction with fox control should be encouraged through district baiting groups. The potential for cat control programs needs to be investigated and where possible research encouraged and supported.

Red foxes can be a vector for disease, with potentially significant economic and social costs where disease is introduced.

An effective control and monitoring program for red foxes needs to be developed at the regional level.

Protocols for assessing the economic and environmental impact of red foxes needs to be defined at the regional level. Choice of key indicator species to assess outcomes of the red fox control program need to take into account the nature of the impact, the likely lag in recovery and the ease of monitoring any change.

Outcome

To develop and implement a monitoring program that facilitates a coordinated regional approach to best practice red fox management across Eyre Peninsula to minimise their economic and environmental impacts.

Objectives

To:

1. encourage coordinated red fox control programs that operate at an effective temporal and spatial scale;
2. assess the economic and environmental outcome of red fox control to improve practice across the region; and
3. implement effective integrated pest management programs as part of best practice.

Area/s to be protected

All regions

Actions

To:

1. identify areas (key assets) where effective red fox management programs should be implemented for productive and conservation purposes;
2. monitor red fox populations that threaten key assets;
3. monitor significant fauna species in control and experimental sites to assess impact of red fox control;
4. support and encourage landholders to adopt best-practice red fox management;
5. minimise impact of red fox control on fauna species of conservation significance;
6. establish protocols for systematic data collection and storage in a central spatial database (this will need to include a reporting mechanism at the district level for work undertaken by contractors); and
7. raise community awareness about the impact of red foxes and to improve management practices (e.g. domestic waste and food availability) to decrease populations in urban areas

Evaluation

Evaluation of success will be based on:

1. comparison of fox population estimates in baited and non-baited sites in each region based on bi annual spotlight surveys;
2. an annual review (literature review) of best practice, e.g. review outcomes of red fox control programs across the nation and globally; and
3. assessment and reporting on outcomes of landscape scale trials for key economic (lamb production) and environmental indicators (breeding shorebirds e.g. pied oyster catcher, sooty oyster catcher, hooded plover and red capped plover; small mammals e.g. common brushtail possum; and small reptiles e.g. Rosenberg's goanna).

Declarations

In South Australia the red fox is a declared pest under Schedule 1 (CLASS 6 – Provisions: 175(1)(3), 176(1), 177, 179, and 182(2) for the whole of state) of the *Natural Resources Management Act 2004* (

Table 2). Meaning that you cannot bring red foxes into the region or spread them to areas where they do not already exist. You cannot keep, sell or release red foxes in the region, and must control and keep controlled red foxes on your land.

Table 2: Red foxes – relevant sections of the *Natural Resource Management Act 2004*. Provisions for the whole of state excluding all offshore islands

Section	Description of how the section applies
175 (1) (3)	Cannot bring the animal into the region Cannot spread animals to areas where it doesn't already exist
176 (1)	Cannot keep a declared animal
177	Cannot sell the animal
179	Must not release the animal in the region
182 (2)	Landowner must control and keep controlled red foxes.

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Monitoring Program

A conditional case-control study design is proposed to identify if changes in site occupancy by native species is conditional on the presence of red foxes. One hundred km^2 + control sites that have ineffective low-level red fox control (and corresponding high red fox densities as assessed through spotlight surveys) will be compared with 100 km^2 + experimental sites that have a substantially reduced number of foxes (as assessed through spotlight surveys) through high density and repeated annual baiting programs supported by other pest control measures.

To allow assessment of the impact of landscape makeup on red fox control, and in turn economic and environmental benefits, sets of comparable control and experimental sites will situated in three types of landscape mosaics: 1. extensive cleared (<10% remnant native vegetation); 2. mixed mosaic (approximately equal areas of remnant vegetation and farmland); and 3. natural (>90% remnant vegetation). Ideally this program would be replicated across each of the three regions

Hypothesis

In areas where red foxes are effectively controlled to reduce population densities there will be a higher probability of key indicator species persisting than at sites where control is ineffective.

Fox Monitoring

SPOTLIGHT TRANSECTS

Spotlight surveys are relatively quick and simple, can sample large distances or areas and are effective across many different habitat types **[28]**. Where foxes are naïve to lethal control, they are more reliably detected using spotlights, and there is a lower level of difference in behavioural response between individuals **[50]**. Where delectability is low it is more efficient to survey additional transects less intensively **[51]**. Where population densities are moderate to high, spotlighting is the most effective means of detecting red foxes when compared with camera traps, hair traps, and scat sampling from bait stations **[52]**.

Survey transects within each landscape type need to be carefully planned, because the effective distance at which foxes may be detected each side of the road varies between habitat types. The effective survey distance should be determined along each transect within each of the habitat types monitored prior to the first survey.

Relative red fox populations will be assessed using vehicle mounted spotlights for surveys along set 10 km transects. In order to allow valid comparisons between each survey vehicles, should be driven at 15 km/hr maximum where-ever safe to do so.

A reliable index of the population at each site will require a minimum of three counts, ideally on consecutive nights. This assumes that the probability of observing a fox is high i.e. > 0.5 foxes / survey **[51]**. Where consecutive surveys are not possible, each transect should be surveyed on three separate occasions during a maximum two week period. Data from these initial surveys will need to be analysed on completion of the third survey. Where the standard error of the counts is not within 10% of the mean, additional counts should be scheduled until this is achieved **[53]**.

Possible sources of variation between counts should be minimised. For example conducted by the same people, from the same vehicle and height, travelling at the same speed, using the same light intensity, and close to the same time each night.

Each vehicle will have a driver supported by a trained and experienced observer who will handle the spotlight. Transect length will be 10 km. The relative experience and name of each observer and driver need to be recorded along with details on: survey site name, date, time of survey start and finish, weather at start of survey [temperature (ºC), wind direction (N, NE, E, SE, S, SW, W, NW) and strength (None (<3km/hr), Light (3-10 km/hr), Moderate (10-20 km/hr), Strong (20-50 km/hr), Gale (>50 km/hr)), Cloud cover (eighths), cloud type, rain], moon phase, time of rising or setting, time of sunset, and spotlight wattage. **It is critical that all data fields are completed prior to the start of the survey.**

All foxes, kangaroos, cats, rabbits observed are to be counted. To enable a valid estimate of relative density to be calculated the line transect surveys must obtain accurate estimates of distances at which each animal is observed from the road. To facilitate this, additional data for each sighting that must be recorded includes:

- Distance from start of transect to observation of animal
- Habitat type in which the animal was observe
- Angle from the road to the animal (estimated to ±5° accuracy)
- Distance from the observer to the animal (estimated to ±10 m accuracy)
- Lateral distance from the transect over which spotlighting is effective

Indicative Fauna Species for Assessing Program Effectiveness

BRUSHTAIL POSSUM (*TRICHOSURUS VULPECULA*)

Monitoring of brushtail possum population dynamics have been used as a measure of the impact of red fox control on medium sized mammals in two large-scale fox control programs in Victoria **[54, 55]**. In both studies there was evidence of a significant treatment effect for brushtail possum populations in the long-term, although the response varied across replicates.

The brushtail possum is listed as rare in South Australia. Their abundance has declined dramatically throughout much of this range and they are now considered Rare in the arid zone. The species merits an Endangered status in the Eyre Peninsula region **[56]**, with remnant populations in the Eyre Hills and Talia regions both undergoing decline. Although, despite this general trend in some localities (e.g. Tasmania, Kangaroo Island and urban areas) there are some areas where they are very common **[57]**.

Population decline has been attributed to habitat loss, competition for food **[58]**, cycles of resource poor seasons and predation **[57]**. It is hypothesised that the decline in abundance and di9stribution arises as a consequence of disturbance of refuge habitat patches critical for the survival of the species. This occurred at the same time as areas of southern Australia experienced below average rainfall. Once populations were reduced they may have fallen into a 'predator pit' through depredation by dingoes and introduced predators (E.g. cats and foxes) and have been unable to increase in numbers even with the advent of improved conditions **[57]**.

Brushtail possums are nocturnal arboreal marsupials. Home range size varies from 0.7 to 11.3 ha, with the extent of home range overlap being highly variable; some populations are apparently territorial, while others show no evidence of territoriality **[57]**. Their density is typically in the range of 0.4 to 1.4 animals / ha **[59]**. They generally live up to 11 years **[59]**. Their major breeding period is in autumn, but they also breed in spring **[57, 59]**. The young spend four to five months in the pouch, and a further one to two months suckling and on their mother's back prior to dispersal. Dispersal occurs between six and 18 months of age, during which time there is high mortality, particularly in males **[59]**.

Brushtail possums are susceptible to predation by foxes, cats and dingoes when they come to the ground to feed **[57, 60, 61]**. In areas with high red fox density possums reduce the distance travelled on ground and change their foraging habits relative to areas with low red fox density **[61]**. Predation of dispersing sub-adults appears to be a major threat **[62]**. Predation appears to be instrumental in the final demise of a population that has declined, rather than being the cause of the original decline **[63]**.

As a semi-arboreal mammal species, with a body weight within the critical weight range (CWR) **[20]**, known to be under threat from red fox predation across much of its range, and being distributed across the southern region of Eyre Peninsula , the brushtail possum is an important indicator species for monitoring the effect of red fox control on native fauna. As such, in the Eyre Peninsula region brushtail possum monitoring would allow an effective assessment of the outcome of red fox control.

GOANNAS (*VARANUS ROSENBERGI* AND *V. GOULDII*)

The heath goanna (*Varanus rosenbergi*) and sand goanna (*V. gouldii*) are found in low numbers on Eyre Peninsula. Anecdotal evidence **[64]** and research **[38]** suggests that *Varanus*, particularly the young are vulnerable to predation by red foxes.

Monitoring of goanna's can be achieved through the use of visual encounter surveys, visual signs such as tracks in sand along transects as well as photographs of animals taken by unmanned cameras **[65]**.

Heath Goanna

The heath goanna is classified as Vulnerable in South Australia and is considered to be facing a high risk of extinction in the wild. Its natural range in South Australia is the higher rainfall areas in the southern zones. It is still common on Kangaroo Island which is fox free. On Eyre Peninsula it occurs in the Eyre Hills, Talia, Yalata and Hampton regions and merits a Vulnerable rating with ongoing decline suspected **[56]**.

Habitat preference across SA includes coastal heaths, humid woodlands, and wet and dry sclerophyll forests **[66]**. They generally shelter in burrows, rock outcrops and hollow logs **[67]**. The time spent in activity by this species is highly seasonal, and is positively correlated with the daily solar radiation **[68]**. But, even during the peak activity period in summer the time spent active is not great (Mean 47.6 min / day; range 12.3 to 141.3 min / day), meaning that the animal is difficult to detect in surveys.

Green *et al.* **[69]** found that adult heath goannas would need to consume less than 5 kg of prey / year to stay in energy balance, and gravid females would require a 40% increase in food acquisition in late spring and early summer to address the extra energy needs for egg production. Given this females probably breed every two years. On Kangaroo Island heath goannas are commonly found in low lying cleared areas in the warmer months, and elevated, well-drained and more densely vegetated sites during winter **[67]**.

A wide range of prey items is acceptable to heath goannas, and they feed opportunistically. On Kangaroo Island the diet of the heath goanna comprises a large variety of invertebrates, but vertebrates form around 65% of their diet, the majority of which was probably road kill **[67]**.

Heath goannas lay eggs in active termite mounds in mid-late summer **[70]**. Clutches of three to 19 eggs are generally laid after which the female refills the excavation. Both the male and female return to the termite mound for some days after egg-laying, probably to ward off predators until the termites reconstruct the mound, completely sealing off the eggs **[67]**. Eggs hatch after eight months in the following spring and young remain in the mound for several weeks after slowly excavating an escape tunnel **[70]**. They do not emerge until warm weather arrives. Juveniles will continue to use the mound as shelter for several months **[67]**.

Sand Goanna

The sand goanna has the most widespread distribution of all Australian monitors, inhabiting much of the mainland. It does not merit a significant conservation rating.

This ground dwelling goanna shelters in burrows, hollow logs and dense litter. It is an alert, fast moving diurnal scavenger and active predator that ranges over large areas foraging for food. Home range estimates vary from an average of 20 ha (range 4-93 ha) on Kangaroo Island **[71]**, to 67.6 ha for males (s.e. 40.2) and 3.91 ha (s.e. 0.36) for females in Western Australia **[72]**. Ranges showed significant overlap with no evidence of territoriality for males of females **[72]**. In their daily movements animals often foraged in dense leaf litter near to the periphery of their activity area and retreated to burrows that were centrally located **[72]**.

Sand goannas emerge from their burrow in the morning when the ambient temperature reaches that of the burrow. They show bimodal daily activity patterns, taking refuge in the hottest part of the day.

The sand goanna strongly overlaps the red fox in food niche breadth and is itself a direct target of fox predation, in particular eggs and young **[38]**. The diet of the sand goanna includes snakes, lizards, small mammals (including mice and rabbits), birds, insects and carrion **[73]**. Sand goannas lay five to 10 eggs in an excavated tunnel or hollow in spring. Eggs take approximately 265 days to hatch.

EMU *(DROMAIUS NOVAEHOLLANDIAE)*

Emus constitute a component of the red fox diet **[74]**, although as adults they are generally taken as carrion. Young emus in particular are vulnerable to red fox predation. A negative correlation between red fox populations and emu populations was demonstrated in a red fox baiting program in the South Para Biodiversity program region (unpublished data A&MLR NRM Board 2007).

Typical habitat in South Australia includes, heath, mallee heath, open mallee and eucalypt woodlands, cutting grass swamps and chenopod plains with trees **[75]**.

The birds are resident where conditions permit, but otherwise dispersive **[75]**. In the Grampians in Victoria local movements were probably determined by the availability of food and water and to a lesser extent shelter **[76]**. Emus are generally solitary when unmated, but in pairs in the breeding season. They defend mates and hold territories for at least five months before incubation, which typically starts in May or June **[75]**. Pair bonds end when the males start incubating, and the females usually then disperse. Thus, surveys between January and May in each year are unlikely to double count birds, and records of tracks and signs may provide a useful adjunct to counts based on observations.

Typically, there are an average of nine eggs per nest (one egg laid every two days), with incubation typically taking 56 days **[75]**. Young are precocial and leave the nest shortly after hatching, with males typically brooding chicks at night for 2-3 months. Red foxes destroy nests at or about the time of hatching **[75]**.

Emu's are omnivorous taking sparsely distributed foods of high nutritional quality, typically seeds, fruit, flowers , insects and growing tips of plants **[75, 76]**. They typically feed from half an hour after sunrise until dusk.

SHEEP – LAMBING SUCCESS

Data on lambing success within individual properties are collected across the Eyre Peninsula. These data will be correlated with baiting data for regions.

BREEDING RESIDENT SHOREBIRDS (HOODED PLOVER *THINORNIS RUBRICOLLIS*, PIED OYSTERCATCHER *HAEMATOPUS LONGIROSTRIS*, SOOTY OYSTERCATCHER *H. FULIGINOSUS*, RED-CAPPED PLOVER *CHARADRIUS RUFICAPILLUS*)

There is considerable variation in the impact of red fox predation on the breeding success of beach nesting birds in Australia **[77]**. Even though urban development can encourage relatively high fox densities, it is in the relatively pristine areas that red foxes become the dominant local threat to beach-nesting birds such as hooded plovers **[78]**.

In NSW, red foxes are the most common predator of hooded plovers and oystercatchers **[79-81]**. In Western Australia the stomach contents of a single fox contained up to 30 red-capped plover chicks (R, Johnstone cited in Macguire 2008). On the Victorian coast, rates of 17% and 27% of hooded plover nest failures **[77, 78]** were attributed to red fox predation. In western Victoria, Weston and Morrow **[82]** attributed 28.6% of known hooded plover nest failures to red fox predation, and Stojanovic **[83]** found fox predation rates of experimentally deployed nests containing quail eggs to be as high as 37% along western Victorian beaches.

Fox control has the potential to reduce predation pressure on shorebird nests **[77]**, with only 2% of nests predated in areas of fox control **[84]**.