

WESTERN SWAMP TORTOISE (*Pseudemydura umbrina*) RECOVERY PLAN

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Lyndon Mutter for the Western Swamp Tortoise Recovery
Team



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WESTERN SWAMP TORTOISE **(*PSEUDEMYDURA UMBRINA*)** **RECOVERY PLAN**

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Cover photo: adult male *Pseudemydura umbrina* at Ellen Brook Nature Reserve by Gerald Kuchling

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FOREWORD

The Western Australian Department of Environment and Conservation (DEC) publishes Wildlife Management Programs to provide detailed information and management actions for the conservation of threatened species of flora and fauna or of ecological communities, as well as harvested species of flora and fauna. This Western Swamp Tortoise Recovery Plan is the 4th edition of Wildlife Management Program No. 11, published in 1994, which in turn was based on Wildlife Management Program No. 6, published in 1990. The 2nd edition covered work from January 1998 to December 2002 and the 3rd edition covered 2003 to 2007.

Recovery Plans delineate, justify and schedule management actions necessary to support the recovery of threatened species and ecological communities. The attainment of objectives and the provision of funds necessary to implement actions are subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery Plans do not necessarily represent the views nor the official position of individuals or organisations represented on the Recovery Team.

Approved Recovery Plans are subject to modification as dictated by new findings, changes in species' status and completion of recovery actions.

Implementation of this Recovery Plan has been funded by the Western Australian Government through DEC and Perth Zoo and previously recovery plans had been funded by the Commonwealth Government through the Natural Heritage Trust. Additional funds and resources have been provided by The University of Western Australia's Zoology Department, The School of Biomedical Sciences at Curtin University of Technology, the Western Australian Water Corporation, the World Wide Fund for Nature Australia, the Friends of the Western Swamp Tortoise and several companies, conservation groups and schools. Without this support, the recovery of the Western Swamp Tortoise would not be as advanced as it is.

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SUMMARY

Current Species Status: Threatened (WA *Wildlife Conservation Act 1950*), Critically Endangered (ranking by WA Threatened Species Scientific Committee), Critically Endangered (Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*), Critical (Action Plan for Australian Reptiles, 1993), Critically Endangered under IUCN (2001) Red List Criteria A2c and D, listed as Critically Endangered in the IUCN 2010 Red List of Threatened Species.

Habitat requirements and Limiting Factors: *Pseudemydura umbrina* inhabits shallow, ephemeral, winter-wet swamps on clay or sand-over-clay soils with nearby suitable aestivating refuges. Clearing and drainage have destroyed most original habitat within its very small former range. Existing protected habitat marginal.

Recovery Plan Objective: To decrease the chance of extinction of the Western Swamp Tortoise (WST) by creating at least three wild naturally recruiting populations, increasing the total number of mature individuals in the wild to more than 50 and conducting a translocation at a fourth site.

Recovery Criteria: Criteria for successful achievement of the Objective are:

1. Complete extension of the Ellen Brook Nature Reserve to the west to include Western Swamp Tortoise habitat currently within private properties.
2. An increase in the number of adult, sub-adult and juvenile (non-hatchling) tortoises at Ellen Brook Nature Reserve by 2012 and 2013 as indicated by Manly and Parr population estimates, to more than 110.
3. Persistence of a population of more than 50 adult, sub-adult and juvenile tortoises at Twin Swamps Nature Reserve by 2012 and 2013 as indicated by Manly and Parr population estimates, and recruitment of non-hatchling juveniles demonstrated by 2014.
4. Persistence of a population of more than 50 adult, sub-adult and juvenile tortoises at Mogumber Nature Reserve by 2012 and 2013 as indicated by Manly and Parr population estimates, and recruitment of non-hatchling juveniles from re-introduced tortoises demonstrated by 2014.
5. The total number of adult wild *Pseudemydura umbrina* being >50 as indicated by KTBA numbers for 2011 and 2012.
6. The maintenance of a captive population of an average of 12 breeding adults producing at least 20 two-year-old animals each year.
7. The creation of a population from captive-bred animals at Moore River Nature Reserve of more than 50 adult, sub-adult and juvenile (>2 years old) tortoises by 2012 and 2013 as indicated by Manly and Parr population estimates.
8. The selection by the recovery team and the endorsement by relevant authorities of a fifth suitable translocation site and the start of a trial translocation

The criteria for failure to achieve the objective are:

1. A continuing decline in numbers of adult Western Swamp Tortoise in the wild.
2. Cessation or significant reduction (to less than 20 hatchlings per year) in captive breeding.
3. The maintenance of more than 50% of the non-hatchling world population of *P. umbrina* in a single captive colony.

Recovery Actions: The Western Swamp Tortoise Recovery Team will coordinate implementation of the following actions.

1. Coordination and administration of recovery team and recovery program.
2. Employment of Chief Investigator
3. Management of Ellen Brook, Twin Swamps, Mogumber, and part of Moore River Nature Reserves
4. Tortoise population monitoring
5. Captive breeding
6. Translocations
7. Education, publicity and sponsorship.

Cost of Recovery Actions (\$000)		2010	2011	2012	2013	2014	Total
1	Administration of recovery program	\$59,500	\$61,000	\$62,500	\$64,000	\$65,500	\$312,500
2	Employment of Chief Investigator	\$87,300	\$90,700	\$94,200	\$97,700	\$101,200	\$471,100
3	Management of Ellen Brook, Twin Swamps, Mogumber & Moore River Nature Reserve	\$227,900	279,700	\$233,500	\$265,000	\$233,000	\$1,239,100
4	Tortoise population monitoring (assistance to chief investigator)	\$17,500	\$18,000	\$18,500	\$19,000	\$19,500	\$92,500
5	Captive breeding	\$352,563	\$174,948	\$182,710	\$192,086	\$200,712	\$1,103,019
6	Translocations	\$16,500	\$17,500	\$15,500	\$15,500	\$15,500	\$80,500
5	Education, publicity and sponsorship	\$25,500	\$26,000	\$26,500	\$27,000	\$27,500	\$132,500
TOTAL		\$786,763	\$677,848	\$633,410	\$680,286	\$662,912	\$3,431,219

Biodiversity benefits: The Western Swamp Tortoise represents the subfamily Pseudemydurinae monotypically and is little changed from fossils from the early Miocene at Riversleigh in Queensland. Ellen Brook, Twin Swamps and Moore River Nature Reserves protect wetland ecological communities that are now threatened because of clearing and drainage. Twin Swamps, Ellen Brook and Moore River Nature Reserves protect threatened ecological communities and Mogumber Nature Reserve protects species of threatened plants.

1 SPECIES INFORMATION

1.1 Species description

The Western Swamp Tortoise (*Pseudemydura umbrina* Siebenrock, 1901) (also known as the Western Swamp Turtle, or Short-necked Tortoise) is a short-necked freshwater tortoise that monotypically represents the sub-family Pseudemydurinae (family Chelidae, sub-order Pleurodira) (Gaffney and Meylan 1988). The Western Swamp Tortoise represents an ancient lineage of Australian chelids, with modern animals little changed from fossils from the early Miocene at Riversleigh in Queensland (Gaffney *et al.* 1989). *P. umbrina* is the smallest of the Australian chelids (Burbidge 1967, Burbidge *et al.* 1974). Adult males do not exceed a carapace length of 155 mm or a weight of 550 g. Females are smaller, not growing beyond 135 mm carapace length or a weight of 410 g. Hatchlings have a carapace length of 24-29 mm and weigh between 3.2 and 6.6 g. Sex in adults can be distinguished by the shape of the plastron and the length of the tail.

The Western Swamp Tortoise can be readily distinguished from the only other freshwater tortoise (or turtle) occurring in the south-west of Western Australia by its short neck; the Oblong Tortoise (*Chelodina oblonga*) has a neck that is equal to or longer than the length of its shell.

1.2 Biology and ecological relationships

Perth and nearby areas have a Mediterranean climate with cool, wet winters and hot, dry summers. The long-term (since 1938) mean annual rainfall at Pearce, the closest weather station to Ellen Brook and Twin Swamps Nature Reserves, is 680 mm, 575 mm of which falls in May through September. The closest weather station to Mogumber is at Wannamal, which has records from most years since 1905. The mean annual rainfall is 596 mm of which 462 mm falls in May through September.

P. umbrina inhabits shallow, ephemeral, winter- and spring-wet swamps on clay or sand over clay soils with nearby suitable aestivation refuges. After the swamps fill in June or July the tortoises can be found in water, feeding when water temperatures are above 14°C. They are carnivorous, eating only living food such as insect larvae, small crustaceans and small tadpoles. As the swamps warm in spring and swamp life becomes plentiful, the tortoises' food intake increases, eggs develop and fat supplies are laid down for the forthcoming summer. When the swamps are nearly dry and water temperatures rise above 28°C, usually in November, the tortoises leave the water to aestivate during the summer and autumn. Aestivation refuges vary with the soil type. At Ellen Brook Nature Reserve they are naturally-occurring holes in the gilgai clay. During the 1960s and 70s at Twin Swamps Nature Reserve most aestivated under *Banksia* leaf litter or fallen branches, but a few found holes in the ground dug by other animals or left by a rotting tree root (Burbidge 1967, 1981). Radio tracking data from 1994 to 2001 showed that nearly all individuals at Twin Swamps Nature Reserve spent the hot summer months (December to March/April) underground in rabbit burrows, but emerged during April/May and spent the latter part of the autumn under leaf litter, fallen branches or dense, low bushes (Kuchling unpublished). At Mogumber Nature Reserve since 2002 the majority of released, captive-bred tortoises have aestivated under *Eucalyptus* leaf litter or under trunks and branches of fallen trees. Early aestivation experience in captivity shapes future aestivation behaviour of released tortoises: in 2003 Perth Zoo changed the aestivation management of juveniles to 'train' them again to use holes for aestivation. Since 2007 released juveniles again preferentially choose underground holes, including artificial aestivation tunnels, for aestivation. This increases their chance of survival in a wildfire (Kuchling unpublished).

P. umbrina is not territorial and individuals use all suitable habitat in the nature reserves. Homing behaviour suggests that *P. umbrina* do have home ranges, but that individual home ranges may potentially be larger than the nature reserves. At Twin Swamps Nature Reserve movements of up to 600 m have been recorded in two days. At Ellen Brook Nature Reserve the area of suitable habitat is much smaller and most movements are correspondingly shorter (Burbidge 1981); however, one animal was recorded moving 450 m in 24 hours. Twin Swamps animals have been found up to 1 km outside the nature reserve boundary, especially in dry years, suggesting that there may have been movements between swamps some distance apart. At Mogumber some released tortoises dispersed up to 1.5 km outside the nature reserve boundary (Kuchling unpublished). At Moore River Nature Reserve some tortoises moved from the release site about 1 km to the eastern reserve boundary, but dispersed only temporarily to the neighbouring cleared farming property. Long-range

movements (>500 m) may primarily take place when tortoises search for suitable or optimal habitat, e.g. in dry years.

Females lay three to five hard-shelled eggs of *ca* 35 x 20 mm in an underground nest in November or early December (Burbidge 1981). The nesting behaviour of *P. umbrina* is unique because the nest cavity is constructed with the forelegs, contrary to all other chelonians, which dig the nest chamber with the hind legs (Kuchling 1993). Only one clutch per year is produced in the wild; in most other Australian chelids multiple clutching is the norm. Eggs may be predated by native predators such as bandicoots and varanids, as well as exotic predators. They may also be dug out by rabbits. Pigs are known predators of tortoise eggs and aestivating tortoises in northern Australia (Fordham *et al.* 2006) and with feral pigs being observed within Moore River Nature Reserve may be additional predators of eggs.

Eggs hatch only after early winter rains cause a drop in incubation temperature. Hatchlings emerge from the nest from late April to June. Hatchlings, being small, are prone to predation by birds, mammals and reptiles. Growth in juveniles is slow and varies considerably from year to year as well as within age-classes. Consequently, age to sexual maturity (which occurs in females at about 112 mm carapace length, Kuchling and Bradshaw 1993) varies from animal to animal and depends on seasonal conditions - the lower the annual rainfall the shorter the swamp life and the slower the growth rate. Age to sexual maturity at Twin Swamps Nature Reserve has varied from 6.5 to 14 years, with a mean of about 11 years (Burbidge 1981), while at Ellen Brook Nature Reserve it varies between 8 to 18 years, with a mean of around 13 years (Kuchling, unpublished). Sex is determined genetically; incubation temperature does not seem to have an influence on hatchling sex ratios (Kuchling, unpublished).

1.3 Species conservation status

The Western Swamp Tortoise has been declared as fauna 'likely to become extinct or is rare' pursuant to Section 14(2)(ba) of the Western Australian *Wildlife Conservation Act 1950* and is ranked as 'Critically Endangered' by the Department of Environment and Conservation's (DEC) Threatened Species Scientific Committee, a ranking that has been endorsed by the Minister for the Environment. It is included in the category 'critically endangered' in the list of threatened species established pursuant to section 178 of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Under IUCN (2001) Red List Categories, *P. umbrina* meets 'Critically Endangered' (CR) under Criteria A2; D. It is listed as CR in the *2010 IUCN Red List of Threatened Species*.

2 DISTRIBUTION

Western Swamp Tortoises have been recorded only from scattered localities in a narrow strip of the Swan Coastal Plain with largely alluvial soils, roughly parallel with the Darling Scarp, running from Perth Airport at Guildford to near Pearce Royal Australian Air Force Base at Bullsbrook. Anecdotal information (Burbidge 1967, 1981) suggests that their stronghold was the clay soils of the Swan Valley, the first part of Western Australia developed for agriculture. Almost all this land is now cleared and either urbanised, used for intensive agriculture, viticulture and horticulture, or mined for clay for brick and tile manufacture. Burbidge (1967) reported unsubstantiated sightings from near Mogumber (75 km north of Upper Swan), Pinjarra (95 km south) and Donnybrook (200 km south).

3 POPULATIONS

3.1 Location

From the 1960s until 2000 there were two known and monitored wild populations, in each of Ellen Brook (Class A Reserve 27620) and Twin Swamps (Class A Reserve No. 27621) Nature Reserves, which were created to protect the tortoise's habitat in 1962. By 1985 the population at Twin Swamps was nearly extinct, although a few individuals remained in the area and a few more had been taken into captivity. A juvenile specimen of *P. umbrina* was found in 1970 in the southern part of Perth Airport. This record and anecdotal information suggest that the Five Mile Swamp area in the southern part of Perth Airport harboured a Western Swamp Tortoise population at least until the early 1970s. This population was not monitored and no specimens were found during a survey in 1995 (Kuchling and Burbidge 1996).

In 2000 DEC commenced the translocation (introduction) of captive-bred tortoises to Mogumber Nature Reserve, 100 km north of Perth. Translocation (introduction) commenced at Moore River Nature Reserve with the release of captive-bred tortoises in August 2007.

3.2 Population estimates

Mark and recapture studies have been carried out since 1963 at Ellen Brook and Twin Swamps Nature Reserves and since 2000 at Mogumber Nature Reserve. Two estimates of population size are provided: known to be alive (KTBA) and the Manly and Parr method (Manly and Parr 1968, Manly 1969, Manly *et al.* 2003) (Tables 1 and 2, Figures 1 and 2). The Manly and Parr method, which uses known age data, is the best available population estimate; however, it may not provide high quality estimates, due to the small population and low sampling success rates.

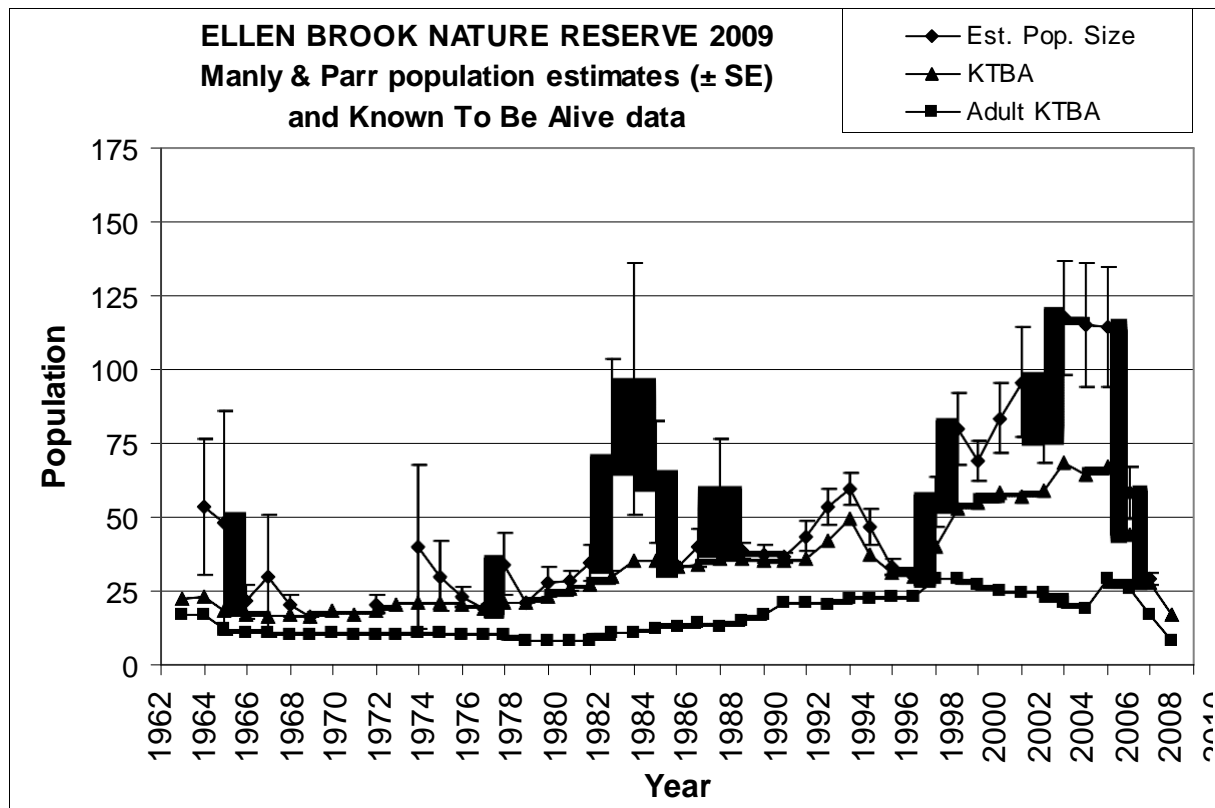


Figure 1. Ellen Brook Nature Reserve: adult KTBA and estimated population size using Manly & Parr (1968) with standard error bars.

Notes:

1. KTBA - known to be alive. KTBA is significantly lower than actual for at least the most recent five (or so) years because of low sample size. The figures for recent years are not a reliable estimate of actual population size.
2. Animals with carapace length >110 mm are assumed to be adults.
3. Juveniles are one or more years old, but <110 mm carapace length.
4. Manly & Parr estimates are not possible in the first and last year of sampling and in some other years due to small number of animals captured. Accuracy of these estimates depends on the proportion of a population captured each year—the larger the better.

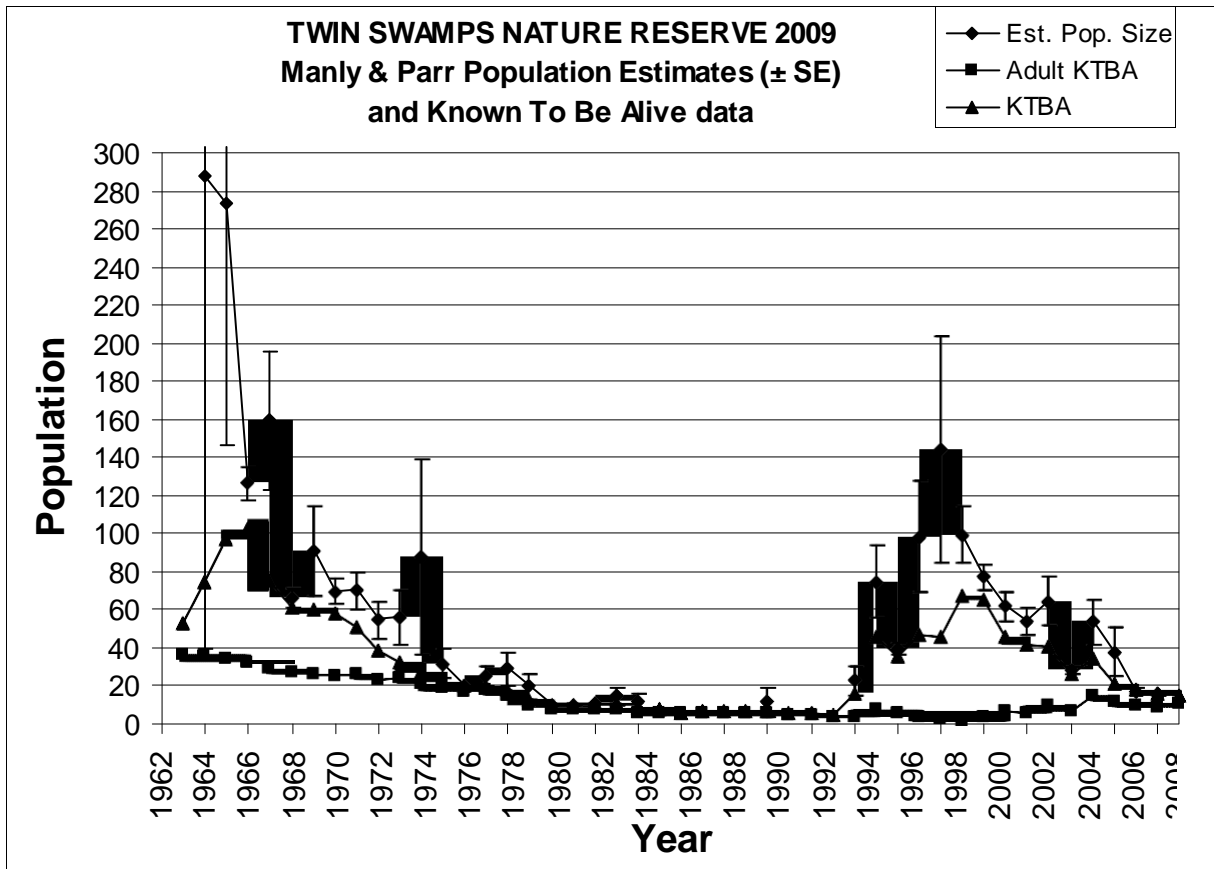


Figure 2. Twin Swamps Nature Reserve: adult KTBA and estimated population size using Manly & Parr (1968) with standard error bars (Manly 1969).

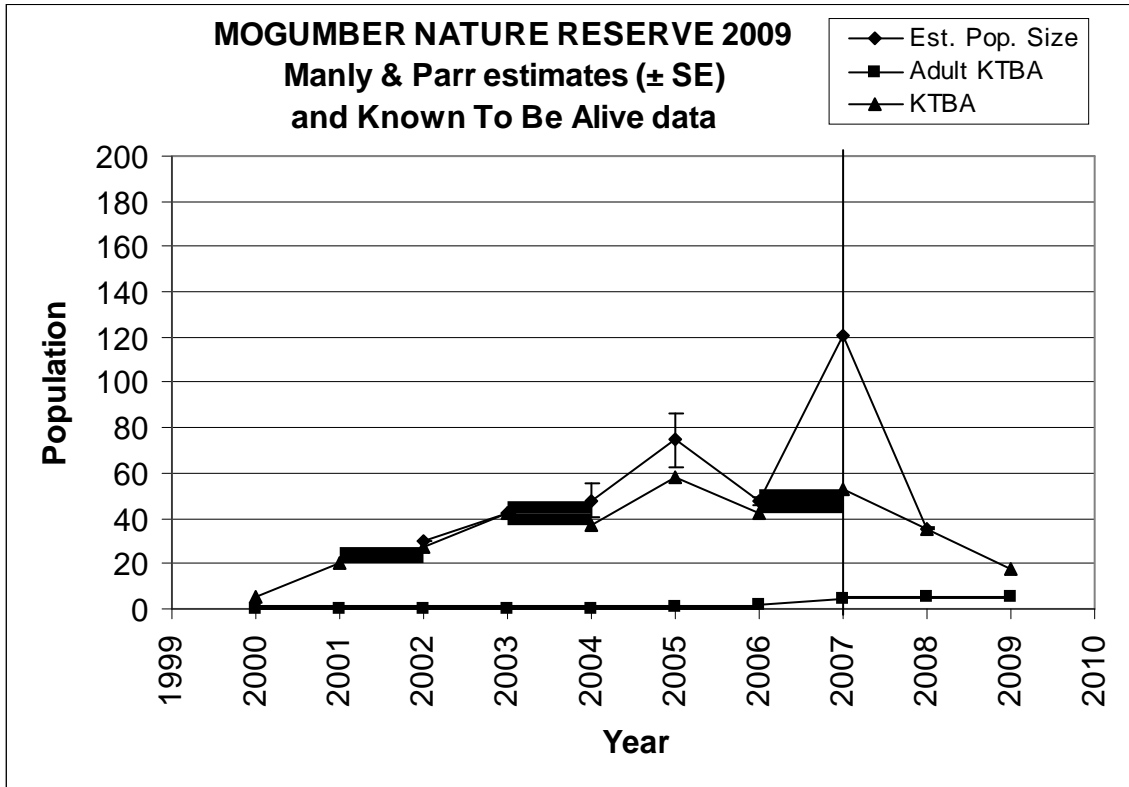


Figure 3. Mogumber Nature Reserve: KTBA, adult KTBA and estimated population size using Manly & Parr (1968) with standard error bars.

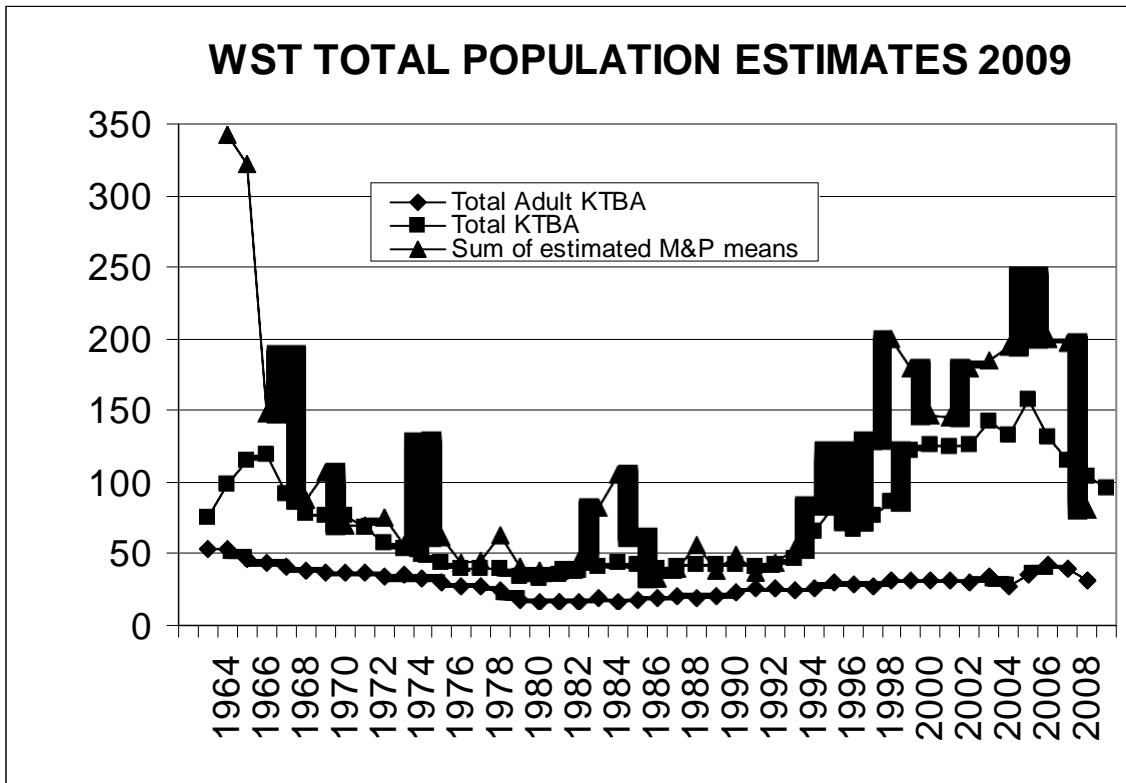


Figure 4. Western Swamp Tortoise total population estimate from all four nature reserves: adult KTBA, total KTBA and sum of estimated population size using Manly & Parr means(1968).

4 HABITAT CRITICAL TO SURVIVAL OF THE SPECIES

Critical habitat is habitat identified as being critical to the survival of a listed threatened species. Habitat critical to the survival of a listed species is identified pursuant to Environment Protection and Biodiversity Conservation Regulation 7.09 (Cmlth).

As the Western Swamp Tortoise is critically endangered, all known habitat and areas designated for translocations should be considered to be habitat critical to the survival of the species. This includes the following:

- all land within the 'fox-proof' fences at Twin Swamps Nature Reserve (Reserve number A27621, centroid coordinates 31°43'18"S, 116°00'58"E) and Ellen Brook Nature Reserve (Reserves A27620 and A42126, centroid coordinates 31°45'19"S, 116°02'04"E) and all land within Mogumber Nature Reserve (centroid coordinates approximately 31°05'45"S, 116°01'45"E) (digitised boundaries are available from DEC) and the south-east portion of Moore River Nature Reserve where clay soils occur (centroid approximately 31°11'48"S, 115°40'20"E),
- land to the west of Ellen Brook Nature Reserve that contains Western Swamp Tortoise habitat and which is earmarked for purchase for inclusion into the reserve; this includes Lot 505 and the eastern part of Lot 15,
- land within surface water catchments extending outside the three above nature reserves,
- any land where a wild population (not scattered individuals) of *P. umbrina* is detected in the future, and
- land targeted in this recovery plan for Western Swamp Tortoise reintroduction, namely land at the northern end of Perth Airport (centroid coordinates approximately 31°55'34"S, 115°58'53"E), which is Commonwealth land leased to Westralia Airports Corporation, zoned for conservation in the Perth International Airport Master Plan and Environmental Strategy.

5 THREATS

There are a number of compounding reasons for the current critically endangered status of the Western Swamp Tortoise:

- (i) a very small geographic range, most of which has been converted to agricultural, industrial or urban use,
- (ii) protection of habitat in the known natural range solely in two small nature reserves that include only marginal habitat,
- (iii) a specialised biology that includes dependence on a rare habitat, a wholly carnivorous diet, low fecundity and slow growth rates, mitigated to some extent by great longevity,
- (iv) a drying climate, a factor compounded by the marginal nature of the remaining habitat and which could become worse if the climate becomes more arid,
- (v) the presence of exotic predators, particularly the European Red Fox, and
- (vi) susceptibility of tortoises aestivating under leaf litter, shrubs or logs to summer wildfire at Twin Swamps and Mogumber Nature Reserves and susceptibility of tortoises at all reserves to late autumn wildfires or controlled burns.

Thus the major threatening processes are: land clearing and clay mining, predation by exotics, wildfire or inappropriate fire regimes and climate change. Urbanisation of land surrounding Ellen Brook and Twin Swamps Nature Reserves is a potential threatening process, but is currently restricted via an Environmental Protection Policy.

6 EXISTING CONSERVATION MEASURES

Detailed information up to 2002 can be found in Burbidge and Kuchling (2004). A brief summary and updates are provided here.

6.1 Creation of Nature Reserves

Two Class A nature reserves, Ellen Brook (now 79.7 ha) and Twin Swamps (now 141 ha), were declared in the 1962. Both have been enlarged by purchase of adjacent land. In 2006, an additional 6.4 ha immediately west of Ellen Brook Nature reserve, mostly acquired from Midland Brick (a division of Boral) as part of an agreement with WA government that permitted them to mine clay in another area, and partly purchased from another landowner, were added to the reserve.

An area of private property south of Mogumber Nature Reserve that contained three clay swamps was purchased in 2000, partly to protect potential swamp tortoise habitat, and added to the reserve. An additional property linking Mogumber and Lake Wannamal Nature Reserve was purchased and added to the nature reserve in 2008-9

6.2 Management of nature reserves

The management of Ellen Brook, Twin Swamps, Mogumber, and Moore River Nature Reserves is the responsibility of DEC via its Swan Coastal District and the reserves have been managed since their declaration. Management has included general protection, the monitoring of water quantity and quality, fire management, predator control, weed control and revegetation. Dieback disease caused by *Phytophthora cinnamomi* occurs in Twin Swamps Nature Reserve, where it is seriously degrading *Banksia* woodland vegetation, and hygiene rules are in place to minimise its spread.

6.2.1 Water quantity and quality

DEC maintains water depth gauges at all four reserves and has had water samples taken from immediately adjacent to each gauge analysed by the W.A. Chemistry Centre annually since 1972. Automated data loggers were installed in 2007 to continuously record water levels during winter and spring.

At Ellen Brook Nature Reserve water levels are not greatly affected by drought and the swamps contain water from June to November during most years. The water quality in the swamps to the north of the drainage line in the old part of Ellen Brook Nature Reserve is excellent and there is no evidence of pollution entering these wetlands. However, the old reserve part south of the drainage line and the new reserve additions have water catchments on surrounding land and receive run-off from areas with horse (Lot 505) and sheep paddocks (Lot 504), and from a transport depot and expanding salvage yard (Lot 14). Since these areas are now

preferentially used by Western Swamp Tortoises a more rigorous sampling regime to detect any changes in water quality will be implemented.

The wetlands at Twin Swamps Nature Reserve are greatly affected by drought and the drying climate. Now, only in high rainfall years do they contain water for long enough to enable females to produce eggs and hatchling Western Swamp Tortoises to feed sufficiently to survive the summer aestivation period. The water quality varies between the wetlands with some areas receiving run-off from surrounding land that has relatively high levels of phosphates and nitrogen; others have good quality water. There is no evidence that suggests that Western Swamp Tortoises have been affected by changing water quality.

In 1994, the Western Australian Water Corporation installed a bore and pipelines in Twin Swamps Nature Reserve as sponsorship of the Recovery Plan. Pumping of groundwater into North West Swamp has taken place every year since 1994; in many recent years rather than supplementing water late in the season as intended, pumping has had to occur throughout the winter and spring. In 2006, the Department of Environment and Conservation contracted hydrological consultants to investigate the hydrology of Twin Swamps Nature Reserve and report on options for improving swamp depth and swamp longevity. The study found individual swamps vary considerably in relation to their hydraulic mechanisms and have variable responses to rainfall and artificial supplementation. It recommended upgrading the bore and flow rates to supplement additional habitat areas. The nutrient concentrations in the water pumped from the bore were tested and is considered acceptable. Water samples from pump tests following installation will determine whether minor treatment (polishing) for iron is required. An upgrade of the bore and pump system to sustain key swamps, if dry climatic conditions continue, will be completed in 2010 with funding from DEC.

The wetlands at Mogumber Nature Reserve are filled by rain and have good water quality, but can be greatly affected by severe drought. The swamps remained virtually dry in 2006 and some tortoises moved into adjacent farm dams and wetlands on private land. Increasing salinity on adjacent land is of concern and groundwater in Mogumber Nature Reserve is continually monitored.

The wetlands at Moore River Nature Reserve have an excellent water quality. This is a result of the catchment for the wetlands being located inside the reserve.

6.2.2 Predator control

European Red Foxes (*Vulpes vulpes*) are known to predate western swamp tortoises, mainly during aestivation. At Ellen Brook Nature Reserve, a fox-proof fence surrounds all high quality tortoise habitat and Twin Swamps Nature Reserve has a fox-proof fence that surrounds the entire reserve. Fox control via baiting is conducted within the fenced reserves on a quarterly basis as foxes occasionally breach the fences.

The fences also prevent most emigration or immigration of adult Western Swamp Tortoises from or to the reserves. Problems have occasionally occurred when a few individual tortoises persistently tried to get through the fence, which mainly happened in spring and early summer when swamps inside the reserves are drying and water outside (e.g. in farm dams) attracts tortoises. Some tortoises have managed to negotiate the fence, possibly by climbing it. To alleviate the problem of tortoises trying to enter the reserves from the outside, one way tortoise gates were developed, tested and built into the fence at Ellen Brook Nature Reserve (Guyot and Kuchling 1998).

From 1994 to 2006, eight recorded mortalities at Twin Swamps Nature Reserve were attributed to Australian ravens (*Corvus coronoides*), 11 to Black Rats (*Rattus rattus*) and two to either rats or Quenda (*Isodon obesulus fusciventer*). In addition, three tortoises that survived had injuries thought to be due to raven attacks and three others thought to be due to rat attacks. At Ellen Brook Nature Reserve five recorded mortalities in 2005 and 2006 were attributed to raven predation, three to rat predation, while in one mortality due to predation the predator was unclear. One injury due to rat predation in a surviving tortoise was observed in 2001.

Interestingly, all 13 mortalities at Twin Swamps Nature Reserve in which rats can be implicated took place during the aestivation period, whereas all three rat-caused mortalities at Ellen Brook Nature Reserve took place towards the end of the activity period when tortoises were still in shallow water. This suggests that black rats and possibly brown rats (*Rattus norvegicus*) could be the predators at Twin Swamps Nature Reserve, whereas at Ellen Brook Nature Reserve water-rats (*Hydromys chrysogaster*) could be the problem (Kuchling, unpublished).

Control of Black Rats commenced in 1999 at Twin Swamps Nature Reserve and in 2005 at Ellen Brook Nature Reserve, and is now routine. Rat baiting is conducted in accord with a protocol agreed by the Recovery Team. Raven numbers have greatly increased in the Perth metropolitan area over recent decades. Ravens will be controlled when necessary.

Methods to control feral pigs within Moore River Nature Reserve are currently being investigated and the most appropriate methods of control will be implemented as required.

6.2.3 Fire

Summer wildfire has limited effects on Western Swamp Tortoises at Ellen Brook Nature Reserve because aestivation sites are underground. However, late autumn fires can affect them as at that time tortoises are on the ground's surface waiting for the swamps to fill. Three summer wildfires have occurred at Ellen Brook Nature Reserve since 1963 and in no case were any tortoise deaths recorded. At Twin Swamps Nature Reserve fire is thought to have some detrimental effects on Western Swamp Tortoises because aestivation sites are often in leaf litter or under fallen branches. DEC's fire procedures for Ellen Brook and Twin Swamps Natures Reserves are:

- (i) to meet its responsibilities under the Bush Fires Act by maintaining a perimeter and internal fire break,
- (ii) to immediately respond with DEC fire-fighting forces when a fire is reported,
- (iii) to fight any fires on or threatening the nature reserves, including providing assistance to neighbours and the local Bush Fire Brigade where possible,
- (iv) at Ellen Brook Nature Reserve, once a fire has entered the main part of the tortoise habitat to allow it to burn to the other side or fight it using hose-lay techniques so fire-control machinery does not damage the gilgai aestivating tunnels,
- (v) at Twin Swamps Nature Reserve, to allow fire-fighting machinery off constructed fire-breaks only with the permission of the District Nature Conservation Program Leader, Regional Ecologist or a senior Research Scientist, and
- (vi) at Twin Swamps Nature Reserve to maintain a system of strategic low fuel internal buffers by winter/spring prescribed burning to ensure the total area burnt in any one wildfire is minimised.

A severe summer wildfire at Mogumber Nature Reserve in December 2002 resulted in the death of several tortoises (see below). Mogumber is more distant from DEC fire fighting resources, but DEC will assist with fire control at Mogumber Nature Reserve and on surrounding properties as a matter of priority.

6.2.4 Effects of adjacent land use

Clay mining for brick manufacture near Ellen Brook Nature Reserve has been assessed by the Environmental Protection Authority (EPA). Ministerial conditions prohibit mining within 100 m of the reserve's boundary and ongoing hydrological studies will be used to assess whether this buffer can be amended.

Urbanisation nearby would threatened the integrity of the reserves due to human pressure, pollution and possibly, calls to reduce the impact of nuisance biting insects on nearby residents. Industrial use of nearby land could also impact the nature reserves. In 1993, the EPA decided to prepare an Environmental Protection Policy (EPP) for land adjacent to the tortoise reserves. The Policy was aimed at implementing Recommendation M17.1 of the System Six Report (DCE 1983) that "ways and means of providing protective buffers around Reserves A27620 and A27621 be sought through planning procedures ...". In 1994, following widespread public concern at provisions in the draft EPP, the EPA decided to investigate other means of protecting the nature reserves from adverse impacts of adjacent land use. In 2001 the EPA released a revised EPP for public comment and after considering the comments, it was forwarded to the Minister for the Environment and Heritage who endorsed it.

In 2010, the Office of the EPA (OEPA) released a review of the EPP. The EPA has recommended as part of this review that two new Special Control Areas (SCA) be created within the Shire of Gingin and City of Swan which will be incorporated into the local planning scheme. The intention of these SCAs will be to assist in ensuring WST habitat protection as a priority when considering development applications.

Several farm dams adjacent to Twin Swamps Nature Reserve are of concern. Firstly, it is possible that they may lower the water table of adjacent swamps in the eastern part of the reserve with which they have a

hydraulic connection through the sand layer covering the clay. Secondly, they seem to attract tortoises to the fence when swamps inside the reserve do not contain much water or are dry. In this way dams adjacent to the fences are potential death traps for *P. umbrina* which are prone to perish at fences through over-heating. Tortoises have to be occasionally removed from the fence line adjacent to dams. From early 1997 several small 'dams' were constructed inside the nature reserve opposite major farm dams with the aim of minimising undesirable tortoise movements.

Development activities involving fill and storage of salvage goods associated with a Transport depot on Lot 14 adjoining Ellen Brook Nature Reserve can potentially have detrimental effects on the Ellen Brook Nature Reserve population. This population is currently the only breeding, self sustaining population. The State and Local Government planning and environmental protection mechanisms have not been able to satisfactorily address these activities to date. DEC will continue its discussion with OEPA, Local Governments in relation to the review of the EPP and proposed SCA with a view to improving planning outcomes in the WST reserve catchments.

6.3 Ecological studies

Studies on the Western Swamp Tortoise commenced shortly after it was rediscovered and have continued since (Lucas 1963, Burbidge 1967, 1981, 1984, 1987a, 1987b, Burbidge and Friend 1988, Kuchling 1993, 1995, 1997, 2000, King *et al.* 1998). Recently, work has concentrated on monitoring the three populations, the effects of drought and the translocations to Mogumber Nature Reserve.

6.4 Captive breeding

Captive breeding was attempted from 1964 (Spence *et al.* 1979), but until 1987 with little success. Since then, work by Kuchling and Perth Zoo has achieved significant egg and hatchling production and rapid growth rates in captivity (Kuchling 1988, 1989; Ladyman *et al.* 1998). From 1989 to January 2010 the captive breeding operation has produced a total of 723 hatchlings with 500 juveniles being released to the wild, and has a rearing success of over 70%.

Recently the hatchling pond facilities have been upgraded.

The facilities for juvenile and adult tortoises need upgrading to address the following issues.

1. Additional ponds are required to accommodate the number of tortoises being held in captivity. While this can be alleviated to some degree through the release of additional tortoises, there is no flexibility to accommodate tortoises much beyond their planned release date should drought preclude a release going ahead.
2. The ponds need to be built up in height (with brickwork similar to the hatchling ponds) so that the water level (and hence the tortoises) are within easy reach of keeping staff.
The current ponds are set into the ground (ie below ground level) and keeping staff reach the tortoises by balancing on planks that straddle the ponds and bending to reach into the water. This presents an Occupational Health and Safety risk.
3. There is a requirement for a footpath between the tortoise enclosures. This will require additional space within the zoo and a significant extension of the current external perimeter fencing and roof meshing.
4. During the breeding season, males who are not paired with females aggressively mount and harass other males they are housed with. This causes abrasions and other injuries. It would preferable to house the males individually during the breeding season however this is not possible without a significant increase in the number of ponds available. This is currently managed by ensuring that males of similar size are housed together and that particularly aggressive individuals are removed from enclosures with more submissive animals.

The new facilities have been designed and costed with detailed planning and construction design commencing in the 2009- 2010 financial year. The facility will be built on a new site so that all tortoises currently in the collection can continue to be housed during construction. As the new facility is close to the existing one there may be some disturbance and as a result, some impact on breeding success during the construction year. The new facility will include a separate set of quarantine ponds, and additional breeding, housing and adult male ponds. All ponds will be raised similar to a prototype that has been trialled over the last 18 months.

In April 2010, Perth Zoo held 168 tortoises comprising 19 adult males, 13 adult females and 136 other tortoises comprising hatchlings, juveniles, sub-adults and non-breeding adults. This number is currently within design capacity, however improved husbandry and welfare would result through increasing the number of ponds available and thus the ability to separate males during the breeding season.

6.5 Genetic management

The captive breeding stock of *P. umbrina* still consists overwhelmingly of a small number of wild-caught individuals and DNA. Joint Australian Research Council small grants to Curtin University of Technology's School of Biomedical Sciences and the UWA Department of Zoology in 1995 and 1996 allowed the identification and sequencing of microsatellite loci in *P. umbrina*, the development of a PCR-based assay for the genetic analysis of the *P. umbrina* population and the determination of pedigrees. By July 1996, this DNA assay was successfully established and provided microsatellites with variable alleles which showed relatively high levels of heterozygosity. These results have been used to set up breeding pairs. A complication for genetic management is the ability of females to store sperm over several years (Kuchling *et al.* 1992).

Each year a female is paired with a particular male and the resulting young, for the purposes of the studbook, are assumed to be the result of that pairing. But with sperm storage the young could well be the result of any number of the previous few years' pairings. While this was not of great concern at the commencement of the recovery program when the main objective was to get breeding occurring, we are now in a position where we have a significant number of young and some F1 generation at breeding age. It is now important to know the true parentage of these animals in order to best manage the genetic diversity of the captive breeding for release program.

Each year the allantoic sacs of all hatchlings have been kept and stored frozen for future DNA analysis and parentage checking. A PhD project by Danielle Giustiniano started in 2009 to investigate the genetic health of the captive and released populations, using stored allantoic sacs from all captive bred WST and genetic material stored from wild tortoises for analysis. The genetic analysis is of significant interest as the exact heritage of all captive bred tortoises is unknown.

6.6 Translocations

6.6.1 Twin Swamps Nature Reserve

Restocking of Twin Swamps Nature Reserve with captive-bred *P. umbrina* commenced in September 1994 with annual translocations of around 30 to 40 tortoises taking place each year until 1999. Smaller numbers have been released since.

The majority of recorded mortalities occurred in the same year the juveniles were released, at the time when the swamps dry and the tortoises have to move overland to search for aestivation sites. These mortalities are mainly attributed to attacks by ravens *Corvus coronoides*. Some mortality also occurred during aestivation and are believed to have been mainly caused by introduced rats *Rattus rattus* and/or *R. norvegicus*. There is a possibility that bandicoots *Isodon obesulus* also predate juvenile tortoises. In regard to ravens, "experienced" juveniles (those that have already spent over a year in the reserve) are slightly less prone to predation than newly-released animals, but rat predation does not depend on 'experience'. In addition to the mortalities, three tortoises survived injuries by ravens and recovered (with one missing front limb) and three tortoises survived attacks by rats (with scars on neck, shell and feet).

The oldest of the released tortoises, which hatched in the early 1990s, have reached sexual maturity and oviducal eggs have been detected by ultrasound since 2002. Although one nest of a captive-bred female monitored in 2008 produced hatchlings, to date no recruitment of juveniles from captive-bred females into the population has been recorded.

6.6.2 Mogumber Nature Reserve

Introduction of captive-bred juvenile *P. umbrina* started in August 2000 with six tortoises and a further 120 tortoises were released between 2001 and 2005 and a further 25 in 2007. In 2006, the swamps remained dry and there was no release. Several of the radio-tracked tortoises have moved to private land adjacent to the nature reserve, particularly in 2006 when the only available water in the area was outside the reserve. In

December 2002, a severe wildfire swept through the entire reserve. All radio-tracked tortoises aestivating in artificial aestivating tunnels installed to promote underground aestivation survived, but tortoises aestivating on the surface were killed. However, because of the lack of shade these 10 surviving animals were returned temporarily to Perth Zoo on 23 December 2002 and released again on 11 August 2003. The last release of juveniles in Mogumber Nature reserve took place in 2008. By 2007, some animals of earlier releases had reached adult size and the first oviducal eggs have been detected in the spring of 2009.

6.6.3 Moore River Nature Reserve

Introduction of tortoises into Moore River Nature Reserve started on 08 August 2007 when ten juvenile, captive-bred *P. umbrina* equipped with radio-transmitters were released into NW Swamp to the west of the threatened ecological community (TEC) area. A further 17 were released in 2008 and 30 in 2009. The spring of 2008 was relatively dry and between August and November 2008 about a third of the radio-tracked tortoises moved from the release area at NW Swamp about 1 km to SE Swamp TEC. The SE swamp is lower than NW Swamp and water naturally drains from NW Swamp into SE Swamp before it drains out of the reserve to the east. In early 2008, a bund was constructed along the eastern boundary of SE Swamp that increases the water depth and the period of standing water in SE Swamp. Although some radio-tracked tortoises crossed over to the adjacent cattle paddock in 2008 and 2009, they moved back again into the reserve. Additional deepening and bunding work in 2009 increased the duration of standing water at Moore River NR, but further construction of bunds may be necessary for the long term viability of this translocation site for Western Swamp Tortoises.

6.7 Management Program, Recovery Plan and Recovery Team

A management program was developed in 1990 (Burbidge *et al.* 1990). Its aim was to ensure that the Western Swamp Tortoise persists by creating at least two viable populations in the wild. The Management Program provided for the establishment of a Recovery Team and this first met in December 1990. In 1992 the management program was rewritten as a Recovery Plan, and following further minor revisions this was published in 1994 (Burbidge and Kuchling 1994). A second edition of the Recovery Plan, covering the period 1998-2002 inclusive, was prepared in 1998, while the third edition for 2003-2007 inclusive was published in 2004 (Burbidge and Kuchling 2004).

The Recovery Team currently meets every six months, with a management sub-team meeting as required between full team meetings. At the end of 2006 Team membership came from DEC, Perth Zoo, UWA's School of Animal Biology, Curtin University of Technology's School of Biomedical Sciences, the World Wide Fund for Nature Australia and the Friends of the Western Swamp Tortoise. The Recovery Team reports annually on the implementation of the Plan to DEC's Corporate Executive and funding agencies.

Over the past four years the funding opportunities to undertake the actions outlined in the recovery plan have been obtained on a yearly basis. This has resulted in the program being unfunded at the start of a number of past financial years and the ability to undertake long term project budgeting and planning being limited. A longer term fund arrangement for the recovery program is a major goal for the recovery team to ensure the works within this recovery plan can be completed.

7 EVALUATION OF 3RD EDITION OF THIS RECOVERY PLAN

7.1 3rd Edition Recovery Objective

The recovery objective was “to decrease the chance of extinction of the Western Swamp Tortoise by creating at least three wild populations and increasing the total number of mature individuals to >50”.

Three wild populations. There are three places where Western Swamp Tortoises exist in the wild—Ellen Brook Nature Reserve, Twin Swamps Nature Reserve and Mogumber Nature Reserve. However, only the Ellen Brook Nature Reserve population could be considered self-sustaining, albeit with habitat management. There is no evidence of recruitment from reintroduced captive-bred tortoises at Twin Swamps Nature Reserve and it is too early to say whether the Mogumber translocation will be successful.

>50 mature individuals. There are probably less than 50 mature individuals in the wild. The adult KTBA for all three populations in 2006 was 43 (including 12 adults returned from Perth Zoo to newly acquired land at

Ellen Brook Nature Reserve), and was 32 in 2001 (because of the low annual catch rate, KTBA for past years is corrected every time an animal is captured that is known to have been alive in previous years). A Manly & Parr estimate of adults at Ellen Brook Nature Reserve suggests there were 42 ± 8 in 1998, 23 ± 2 in 2001 and 30 ± 9 in 2004. The reason for the decline between 1998 and 2001, if real, is unknown. Manly and Parr estimates of adult numbers are not possible at the other two reserves.

7.2 3rd Edition Recovery Criteria

The assessment of performance against the recovery criteria has been assessed against the information available in 2007 at the expiry of the recovery plan.

1. *Complete extension of the Ellen Brook Nature Reserve to the west to include Western Swamp Tortoise habitat currently within private properties.*

In 2006, DEC acquired a further 6.4 ha of land adjacent to Ellen Brook Nature Reserve, which has now been added to it. Negotiations continue with Midland Brick with the aim of acquiring more land, especially an area to the west of Ellen Brook Nature Reserve where Western Swamp Tortoises still occur. The land acquired so far has been fenced, rehabilitation is underway and some animals originally from the area have been returned to the wild after being kept for some years at Perth Zoo. Further land needs to be acquired. **This criterion has been partially met.**

2. *An increase in the number of adult, sub-adult and juvenile (>2 years old) tortoises at Ellen Brook Nature Reserve to more than 50 by 2007.*

The 2006 non-hatchling 'known to be alive' (KTBA) for Ellen Brook Nature Reserve was 38. Because we do not catch all tortoises present in the population every year, we assume that the KTBA five years previously is a fairly accurate figure, as KTBA is corrected backwards every time an animal of known age is captured. The non-hatchling KTBA in 2001 was 50. The 2001 population estimate using mark and recapture data and the Manly & Parr method was 74 ± 10 (SE). **This criterion has been met.**

3. *Persistence of a population of more than 40 adult sub-adult and juvenile (>2 years old) tortoises at Twin Swamps Nature Reserve and reproduction (egg laying) of reintroduced tortoises demonstrated by 2007.*

Between 1994 and 2006 more than 160 juvenile and 20 hatchling captive-bred Western Swamp Tortoises were translocated to Twin Swamps Nature Reserve. KTBA in 2006 was nine animals of which eight were of adult size. KTBA in 2001 was 42. Adult females are known to have produced eggs. However, no hatchlings or wild-bred juveniles have been located. **This criterion has been met.**

4. *The creation of a population from captive-bred animals at Mogumber Nature Reserve of more than 35 adult, sub-adult and juvenile (>2 years old) tortoises by 2007.*

A total of 126 captive-bred Western Swamp Tortoises were translocated to MNR between 2000 and 2005 and a further 25 were introduced in 2007. The KTBA in 2006 was 38 of which three were of adult size. Translocations are ongoing. **This criterion has been met in 2007.**

5. *The total number of adult wild Pseudemydura umbrina being >50.*

As discussed above, there are less than 50 adult Western Swamp Tortoises in the wild and the number is unlikely to reach 50 in 2008. **This criterion has not been met.**

6. *The maintenance of a captive population of at least 12 breeding adults producing at least 20 two-year-old animals each year.*

In December 2007, the Perth Zoo captive breeding colony consisted of 21 adults and 55 two-year-old tortoises. **This criterion has been met.**

7. *The creation of a second captive colony at another accredited Zoo in Australia.*

A captive colony is now established at Adelaide Zoo. **This criterion has been met.**

8. *The creation of a semi-captive 'insurance' colony of at least 20 tortoises at the Harry Waring Reserve of UWA or some other site.*

An experimental introduction to artificial wetlands in Harry Waring Reserve was conducted in 2003 (Durell 2003). The study demonstrated that juveniles grew and maintained condition, but some tortoises were lost to unknown causes and the Recovery Team decided not to proceed further. **This criterion has not been met.**

9. *The selection by the Recovery Team and endorsement by relevant authorities of a third suitable translocation site.*

Despite considerable work, approval of a new translocation site was limited to a trial introduction at Moore River Nature Reserve in 2007. Final approval of the new site at Moore River Nature Reserve occurred in 2008. **This criterion has been met.**

Of the nine criteria laid down in the 3rd edition of the Recovery Plan, six have been met and one has been partially met. The major reason for failure to meet the important criterion of >50 wild adults has been the drying local climate leading to lack of water in swamps.

The criteria for failure to achieve the objective were:

1. *A decline in numbers of the Western Swamp Tortoise in the wild.* Numbers are increasing slowly. **Not met.**
2. *Cessation or significant reduction (to less than 20 hatchlings per year) in captive breeding.* The captive colony continues to produce >30 hatchlings each year. **Not met.**
3. *The maintenance of more than 50% of the non-hatchling world population of *P. umbrina* in a single captive colony.* In 2006 there were 231 non-hatchling Western Swamp Tortoises at Perth Zoo. Estimates of numbers in the wild are Ellen Brook 100, Twin Swamps 60, Mogumber 60, total 220. The number of Western Swamp Tortoises in Perth Zoo was higher than usual in 2006 because a translocation was not possible due to drought. Numbers at the end of 2007 (assuming adequate winter rainfall in 2007) will be lower. **Not met.**

8 RECOVERY OBJECTIVE

The objective of this 4th edition of the Western Swamp Tortoise recovery plan between 2010 to 2015 (or until replaced by a new version) is:

To decrease the chance of extinction of the Western Swamp Tortoise by creating at least three wild naturally recruiting populations, increasing the total number of mature individuals in the wild to more than 50 and conducting translocations at a fourth site.

It is not possible to upgrade the species to 'Endangered' until there have been >50 mature individuals in the wild for more than five years. This cannot be achieved by 2015.

9 RECOVERY CRITERIA

Preamble

As discussed in section 3.2 estimating the numbers of animals in wild populations of the Western Swamp Tortoise is difficult because of the small size of the populations and the ability to capture only a small proportion of each population each year. This means that the two population estimates used (Known To Be Alive (KTBA) and Manly & Parr estimates) for the most recent year and for about three years previously are underestimates of actual population size. Captures in each year allow updating of past year's estimates, so estimates gradually become of higher quality. Accordingly, it is not possible to set population size criteria for 2014, but population size criteria can be set for three years prior to 2014, ie, 2011.

Criteria for success

Criteria for the successful achievement of the objective of this 4th edition of the Western Swamp Tortoise Recovery Plan are:

1. Complete extension of the Ellen Brook Nature Reserve to the west to include Western Swamp Tortoise habitat currently within private properties.
2. An increase in the number of adult, sub-adult and juvenile non-hatchling tortoises at Ellen Brook Nature Reserve by 2011 as indicated by Manly and Parr population estimates, to more than 110.
3. Presence of a population of more than 50 adult, sub-adult and juvenile tortoises at Twin Swamps Nature Reserve by 2011 as indicated by Manly and Parr population estimates, and recruitment of non-hatchling juveniles from re-introduced tortoises demonstrated by 2014.

4. Presence of a population of more than 50 adult, sub-adult and juvenile tortoises at Mogumber Nature Reserve by 2011 as indicated by Manly and Parr population estimates, and recruitment of non-hatchling juveniles from re-introduced tortoises demonstrated by 2014.
5. The total number of adult wild *Pseudemydura umbrina* being >50 as indicated by KTBA data for 2011.
6. The maintenance of a captive population of an average of 12 breeding adults producing at least 20 two-year-old animals each year.
7. The creation of a population from captive-bred animals at Moore River Nature Reserve of more than 50 adult, sub-adult and juvenile (>2 years old) tortoises by 2012 and/or 2013 as indicated by Manly and Parr population estimates.
8. The selection by the recovery team and the endorsement by relevant authorities of a fifth suitable translocation site and the start of a trial translocation.

Criteria for Failure

The criteria for failure to achieve the objective are:

1. A continuing decline in numbers of adult Western Swamp Tortoise in the wild.
2. Cessation or significant reduction (to less than 20 hatchlings per year) in captive breeding.
3. The maintenance of more than 50% of the non-hatchling world population of *P. umbrina* in a single captive colony.

10 RECOVERY ACTIONS

The Western Swamp Tortoise Recovery Team described in section 10.1 will continue to meet regularly to coordinate the implementation of this Recovery Plan. Recovery Action costs presented below are shown by calendar year.

10.1 COORDINATION AND ADMINISTRATION OF RECOVERY TEAM AND RECOVERY PROGRAM

The recovery team meets formally twice per year. In 2010 members came from the Department of Environment and Conservation (WA), Perth Zoo, The University of Western Australia, Curtin University's School of Biomedical Sciences, WWF-Australia, a private conservation consultant and the Friends of the Western Swamp Tortoise. There are an additional three to five meetings held with a subgroup of the Recovery Team between Recovery Team meetings. Formal minutes of the Recovery Team meetings are prepared, along with various issues papers and briefing notes.

Cost:	2010	2011	2012	2013	2014
Total	\$59,500	\$61,000	\$62,500	\$64,000	\$65,000

Responsibility: DEC (Swan Coastal District)

10.2 EMPLOYMENT OF CHIEF INVESTIGATOR

The successful implementation of this plan is dependent on the continuing employment of the Chief Investigator, currently Dr Gerald Kuchling. Previously a Research Fellow at The University of Western Australia (UWA), Dr Kuchling moved to part-time employment with DEC in mid-2007. Because Dr Kuchling's tasks vary from year to year, his salary, travel, equipment and administration support costs are provided here rather than under several recovery actions. Dr Kuchling is currently employed half-time, however given the increase in the number of released tortoises, release sites and the location where tortoise need to be monitoring this role now requires 0.7 FTE worth of time and salary.

Cost:	2010	2011	2012	2013	2014
Total	\$87,300	\$90,700	\$94,200	\$97,700	101,200

Responsibility: DEC (Swan Coastal District)

10.3 MANAGEMENT OF ELLEN BROOK, TWIN SWAMPS, MOGUMBER AND MOORE RIVER NATURE RESERVES

Management of the four nature reserves where Western Swamp Tortoises occur is the responsibility of DEC's Swan Coastal District. Some management activities, including rehabilitation and installation of artificial aestivating tunnels, are assisted by 'Friends of the Western Swamp Tortoise'.

10.3.1 Management of Ellen Brook Nature Reserve

Routine reserve management

Patrols and maintenance of the fox-proof fence, the ponds along the fence and the boundary fences will continue. Fire management will continue as laid down in section 6.2.3. Rabbit, fox, rat and raven control and duck breeding control within the fenced area will take place as required. Selective weed control will be undertaken as required to protect the Western Swamp Tortoise habitat and to fulfil requirements of Agriculture Western Australia in relation to noxious weeds. An extension of the fox-proof fence northwards to include a further 10 ha of habitat, together with limited deepening of wetlands will take place. A targeted weed control program will be undertaken to remove invasive weeds from the nature reserve to preserve native habitat for estivation and nesting of the western swamp tortoise. This will be in addition to the general reserve management activities budget.

Cost:	2010	2011	2012	2013	2014
Reserve management	\$57,500	\$60,000	\$62,500	\$65,000	\$67,500
Targeted Weed Control	\$5000	\$15,000	\$0	\$0	\$0
Fence replacement	11,000	11,500	12,000	12,000	12,500
Fence new habitat acquisitions	\$0	\$0	\$0	\$40,000	\$0
Total	\$73,500	\$86,500	\$74,500	\$117,00	\$80,000

Responsibility: DEC (Swan Coastal District). Costs are salaries, overheads, labour and materials.

Rehabilitation of purchased land

Rehabilitation commenced in 1996 and is ongoing. Land acquired over the past decade still requires limited rehabilitation. Land acquired in 2006 requires intensive rehabilitation. The creation of small swamps by mechanical deepening and bunding occurred in early 2007. Planting of suitable native plant species also began in 2007. Further work is necessary. Some work will be carried out voluntarily by the Friends of the Western Swamp Tortoise.

Cost:	2010	2011	2012	2013	2014
Total	\$30,000	\$31,500	\$33,000	\$34,500	\$36,000

Responsibility: DEC (Swan Coastal District). Costs are salaries, overheads, labour and materials.

10.3.2 Management of Twin Swamps Nature Reserve

Routine reserve management

Active, ongoing management is required for Twin Swamps Nature Reserve. Management needs to ensure that sufficient leaf litter and sufficient aestivation holes for tortoise aestivation are present in some of the reserve at all times. It also needs to ensure that fuel levels are maintained at a relatively low level so that wildfires can be controlled and so that neighbours feel that the reserve does not impose an unnecessarily high fire risk. Therefore cool fuel reduction patch burning will be carried out during winter when the tortoises are occupying the swamps. Additional artificial aestivating tunnels will be installed to minimise the risk of tortoise death during wildfires. Fox, rabbit, rat, raven and other predator control will be implemented within the fenced area as required. Management also needs to ensure that water is available for tortoises along the

eastern and western fence lines from early June to late December. Selective weed control will be undertaken as required to protect the Western Swamp Tortoise habitat and to fulfil legal requirements. Some work will be carried out voluntarily by the Friends of the Western Swamp Tortoise.

Additional ponds will be constructed closer to hatchling sites to assist with the recruitment of hatchlings. A pattern of later winter rains has been observed in recent years and is resulting in a longer dry period after the emergence of the hatchlings and may effect survival. Given the lack of recruitment being observed within the reserve, providing standing water in autumn and early winter will assist hatchling survival.

Cost:	2010	2011	2012	2013	2014
Reserve Management	\$46,000	\$48,000	\$50,000	\$52,000	\$54,000
Pond Construction	\$0	\$5,000	\$5,000	\$0	\$0
Total	\$46,000	\$53,000	\$55,000	\$52,000	\$54,000

Responsibility: DEC (Swan Coastal District). Costs are salaries, overheads, labour and materials.

Pumping groundwater to maintain swamps

The groundwater bore has become increasingly important in recent years under drying climate conditions. The Recovery Team has prepared a pumping protocol to guide the DEC operations staff as to when to turn the pump on and off. The Recovery Team will review this protocol regularly.

The desirable period of swamp life is from early- to mid-June to the end of November, with at least 20 cm and preferably 30 cm depth from early-July to early-November. Water will be added only when rainfall does not provide sufficient water naturally. North West Swamp overflows at about 20 cm depth; thus depths of 30 cm are not achievable. At East Swamp, however, depths of well above 30 cm have been reached naturally, but only very infrequently over the past two decades.

A hydrological study was commissioned from consultants in 2006 with a final report being received in 2008. The consultants concluded that:

- individual swamps vary considerably in relation to their hydraulic mechanisms and have variable responses to rainfall and artificial supplementation,
- the bore should be upgraded and flow rates increased to supplement additional habitat areas, and
- the nutrient concentrations from the new bore are considered acceptable. Water samples from pump tests following installation will determine whether minor treatment (polishing) for iron is required.

An upgrade of the bore and pump system to sustain key swamps if dry climatic conditions continue, will be completed in 2010 with funding from DEC.

Studies on the effects of groundwater pumping will continue to find out whether there is any increase in dissolved salts and to ensure that any increase does not have any deleterious impact on the tortoises' food. Analysis of water samples from the swamps will continue, with costs being met by DEC.

Cost:	2010	2011	2012	2013	2014
Supplementation of swamps and maintenance	\$13,000	\$1,500	\$1,500	\$2,000	\$2,000
Bore and pump system upgrade	\$32,000	\$0	\$0	\$0	\$0
Total	\$45,000	\$1,500	\$1,500	\$2,000	\$2,000

Responsibility: DEC (Swan Coastal District). Costs are for running the bore and invertebrate sampling (\$15,000 every five years).

10.3.3 Management of Mogumber Nature Reserve

Several management actions are required at Mogumber Nature Reserve: weed control, fence maintenance, fire break maintenance, and fire control, as well as monthly fox baiting (there is no fox-proof fence). Despite

a creek running south through the eastern edge of the nature reserve becoming salt in the last decade or so, hydrological studies suggest there will be no impact on the perched clay-based swamps inhabited by the tortoise.

A significant proportion of tortoises released at Mogumber leave the reserve and spend at least part of the year on adjacent private property. In 2006, when the nature reserve swamps contained no water, 13 Western Swamp Tortoises were found in a swamp within pasture on private property. Ideally, this swamp should be included in the nature reserve, and negotiations with the owner will take place. Because some tortoises are aestivating on private property, autumn prescribed burns or the burning of ‘windrows’ could threaten these animals. Ongoing consultation with adjacent landowners will help alleviate this possibility.

In 19 January 2009 DEC acquired a 20 hectare parcel of farmland immediately north of the Mogumber Nature Reserve that was being utilised by the WST. Since 2009 DEC has been working to improve the habitat within this property through pond creation and revegetation works. In addition to providing habitat to the WST, this property also forms an important ecological corridor between Mogumber and Lake Wannamal Nature Reserves.

Cost:	2010	2011	2012	2013	2014
Reserve Management	\$42,000	\$44,000	\$46,000	\$48,000	\$50,000
Install new ponds	\$10,000	\$0	\$0	\$0	\$0
Rehabilitation	\$5,000	\$50,000	\$10,000	\$5,000	\$5,000
Total	\$57,000	\$94,000	\$56,000	\$53,000	\$55,000

Responsibility: DEC (Swan Coastal District). Costs are salaries, overheads, labour and materials.

10.3.4 Management of Moore River Nature Reserve

A GIS project undertaken in 2000-2002 indicated that an area of clay soils at the south east corner of Moore River Nature Reserve (85 km north of Perth) might provide suitable Western Swamp Tortoise habitat. Investigations since have shown that, while the area is largely suitable, it does not hold water for long enough to support Western Swamp Tortoises. The area drains into private property to the east. Bunding along the boundary firebreak, together with limited mechanical deepening of several areas may extend the period of inundation. Detailed investigations have been undertaken to ensure the modifications proposed do not adversely impact existing plant communities including the ‘Herb rich saline shrublands in clay pans’, which is listed in the Western Australian threatened ecological community database as ‘Vulnerable’. Approval has been granted by the Conservation Commission of WA, and the works commenced in 2008.

Cost:	2010	2011	2012	2013	2014
Reserve Management	\$39,400	\$41,200	43,000	\$43,000	\$44,000
Bunding and associated works	\$0		\$0	\$0	\$0
Hydrology & TEC Monitoring	\$12,000	\$5,000	\$5,000	\$0	\$0
Total	\$51,400	\$46,200	\$48,000	\$43,000	\$44,000

10.3.5 Monitoring of water depths, water chemistry and macro-invertebrates (tortoise food)

Water depths are measured at depth gauges in five swamps in Twin Swamps Nature Reserve, seven sites within Ellen Brook Nature Reserve, and two sites in Mogumber Nature Reserve. In the past, measurements were taken only when staff or scientists visit the reserves. This led to some significant data gaps and the installation of automatic depth gauges linked to data loggers took place in early 2007. Water chemistry analyses are carried out annually of samples taken at five of the depth gauges at Ellen Brook Nature Reserve, four at Twin Swamps Nature Reserve and two at Moore River and Mogumber. This work will continue.

Collections of invertebrates from the swamps commenced at Twin Swamps Nature Reserve in 1991. A sampling program for invertebrates has been designed by DEC Science Division and invertebrate sampling was repeated in the Ellen Brook, Twin Swamps and Mogumber Nature Reserves in 2003 and in all four Western Swamp Tortoise reserves (including Moore River) in 2004. These samples have been sorted and identified. For comparative reasons invertebrate sampling is best done in all reserves at the same time and should be repeated once every five years. Funds are required for the sorting and identification of the samples and report writing.

Cost:	2010	2011	2012	2013	2014
Water depth and chemistry	\$18,500	\$19,500	\$20,000	\$20,500	\$21,000
Invertebrate sampling	\$0	\$30,000	\$0	\$0	\$0
Total	\$18,50	\$49,500	\$20,000	\$20,500	\$21,000

Responsibility: DEC (Swan Coastal District). Costs are for water chemistry analysis and purchase of data loggers.

10.4 TORTOISE POPULATION MONITORING

Western Swamp Tortoises are captured at all four sites during radio-tracking, on an *ad hoc* basis during patrols and during intensive searches when water levels are drying at the start of summer. Data on tortoises captured are maintained in a micro-computer database. Population estimates are calculated annually.

Given that the wild tortoise populations are now distributed over four locations, with two being larger unfenced habitat the amount of time required to adequately monitor these populations being significantly increased.

Cost:	2010	2011	2012	2013	2014
Total	\$17,500	\$18,000	\$18,500	\$19,000	\$19,500

10.5 CAPTIVE BREEDING

10.5.1 Existing captive breeding colony

The extremely small size of the wild population means that captive breeding is essential to provide animals for translocations. Responsibility for captive breeding passed from the Western Swamp Tortoise Captive Breeding Project Management Committee to Perth Zoo in July 1991, but the tortoises remain the property of DEC. The Captive Breeding Program will operate to meet, to the greatest extent practicable, the objectives laid down in the IUCN Policy Statement on Captive Breeding (IUCN 1987a). The selection of mating pairs is guided by results of studies on genotypes of the captives.

The facilities at Perth Zoo were upgraded and increased in size in 1998 in order to produce sufficient animals of greater than two years old for translocations. Since its inception in 1988/89 the western swamp tortoise breeding project has increased steadily in size and numbers to the point where the area for the facility had reached its limit.

Technical advice on captive breeding will continue to be provided by Dr Kuchling during the period 2008-2012. Perth Zoo will continue to provide keeper time to maintain the captive colony and incubation facilities.

Cost:	2010	2011	2012	2013	2014
Employment of WST keeper	\$65,265	\$68,385	\$71,674	\$75,738	\$79,419
Back-up keeper time	\$35,006	\$36,679	\$38,444	\$40,623	\$42,598
Supervisor and Veterinary time	\$33,192	\$34,779	\$36,452	\$38,518	\$40,390
Food	\$2,500	\$2,575	\$2,652	\$2,732	\$2,814
Water and power costs	\$31,000	\$31,930	\$32,888	\$33,875	\$34,891
Interpretation costs	\$600	\$600	\$600	\$600	\$600
Employment of WST keeper, subtotal	\$167,563	\$174,948	\$182,710	\$192,086	\$200,712

Upgrade of tortoise keeping facilities	\$185,000	\$0	\$0	\$0	\$0
Total	\$352,563	\$174,948	\$182,710	\$192,086	\$200,712

Responsibility: Perth Zoo with advice from Dr Kuchling. A Memorandum of Understanding between the Zoo and DEC detail this funding arrangements. Costs are keeper employment, overheads and planned upgrades.

10.5.2 Establishment of additional captive colonies

The Recovery Team decided to establish a second captive Western Swamp Tortoise colony in Australia at a location some distance from Perth. Its purpose would be to safeguard against sudden loss or significant decline of Perth Zoo's existing population.

Adelaide Zoo indicated its willingness to set up the second colony and four Western Swamp Tortoises were moved to Adelaide in 2003. Following the successful husbandry of these animals, a further four were moved in 2006.

Cost:	2010	2011	2012	2013	2014
Total	\$13,700	\$14,500	\$15,000	\$15,500	\$16,000

Responsibility: Adelaide Zoo in consultation with Perth Zoo and the Recovery Team. Adelaide Zoo will meet all costs.

10.6 TRANSLOCATIONS

10.6.1 Re-introduction to Twin Swamps Nature Reserve, and Introduction to Mogumber Nature Reserve and Moore River Nature Reserve

Release of *P. umbrina* at Twin Swamps Nature Reserve commenced in September 1994. Translocations to Twin Swamps Nature Reserve between 1994 and 2001 and in 2005 have been successful insofar as captive-raised tortoises have adapted to the natural environment, survived and grown. Their movements, growth and aestivation patterns are generally comparable to wild individuals. However, the drying climate has limited growth and reproduction, and without groundwater pumping and deepening of some areas (ponds), the population would be under severe stress. The population requires monitoring, with some animals being fitted with radio transmitters in order to monitor growth and reproduction and, in particular, locate nests and measure hatching success.

Release of *P. umbrina* at Mogumber Nature Reserve took place from 2000 to 2008. For the duration of this edition of the Recovery Plan the emphasis is on monitoring growth, maturity, reproduction and recruitment.

A trial release of ten sub-adult tortoises was undertaken at the site in Moore River Nature Reserve in 2007 prior to proposed habitat modifications. A five year translocation program started in 2008 and bunding to increase the duration of standing water in spring took place in 2008 and 2009. During the duration of this recovery plan further releases will be undertaken at Moore River and additional habitat modifications are planned, guided by monitoring movements, survival and growth of the translocated tortoises. About 20 to 40 sub-adult tortoises of about 100 g will be released in each of 2010, to 2012. After 2012, if another translocation site becomes available most tortoises will be released there. A proportion of animals released will be fitted with miniature radio-transmitters and their fate monitored closely for at least one year. A few animals will be radio-tracked for several years.

Cost:	2010	2011	2012	2013	2014
Total	\$12,500	\$13,500	\$14,500	\$15,500	\$16,500

Responsibility: DEC (Swan Coastal District). Costs include vehicle running and purchase of radio transmitters.

10.6.2 Translocation to additional sites

While of high quality, the extent of habitat in Ellen Brook Nature reserve is too small to contain a large Western Swamp Tortoise population. Twin Swamps Nature Reserves is judged to be marginal and requires intensive management for the population there to persist. Both nature reserves lie within the Perth metropolitan area and although measures are being planned to control land use near the reserves, it can be anticipated that there will be increasing pressure on the reserves from an escalating human population in the area. It still has to be seen if Western Swamp Tortoise populations can be successfully established at Mogumber Nature Reserve and Moore River Nature Reserve, in particular under future climate change scenarios. It is desirable, therefore, that additional wild populations of the Western Swamp Tortoise be established in more secure areas that will not be under pressure from increasing urbanisation.

10.6.3 Selection of suitable translocation sites

The 3rd edition of the Recovery Plan outlined investigations undertaken up to 2002. Some sites investigated were eliminated after investigation. The only site that currently remains under active consideration is the Perth Airport. A Western Swamp Tortoise was recorded in a swamp in the southern part of Perth Airport in September 1970. During 1995, a search for swamp tortoises was carried out in swamps at Perth Airport on land vested, at that time, in the Federal Airports Corporation (FAC) on behalf of the Commonwealth of Australia. This search was funded jointly by the FAC and the then Australian Nature Conservation Agency (ANCA) and was conducted by Chelonia Enterprises assisted by the then Department of Conservation and Land Management (Kuchling and Burbidge 1996). No tortoises were located. The report concluded that several swamps had the potential to be good Western Swamp Tortoise habitat. Some of these are within areas where development is planned, mainly for the construction of new runways. Three swamps located within the 'northern conservation zone' were considered suitable and negotiations with the current Airport lessees, Westralia Airports Corporation (WAC), for use of these swamps for reintroducing tortoises are continuing.

The WAC have agreed to monitoring water levels within the northern wetlands during winter 2010. Following analysis of the results from this monitoring the recovery team will determine if a proposed experimental translocation of a limited number of tortoises equipped with transmitters should take place. If water levels are suitable and approval is obtained from WAC, DEC will undertake an experimental translocation in winter 2011 or winter 2012.

Following monitoring of any experimental translocation of these animals, further discussions will be needed on a formal translocation, and the final area proposed to be used, fenced managed.

10.6.4 Selection of additional suitable translocation sites

An ARC-linkage application lodged in 2008 (Animals on the move – an integrated approach to selecting conservation reserves under climate change) involving researchers from UWA, DEC, Perth Zoo, Melbourne University and the United States of America was successful and funding for the project became available in March 2010. The aim of the project is to develop a multi-disciplinary, mechanistic approach to predict future habitat suitability for threatened species.

The Western Swamp Tortoise was considered the ideal model to develop this approach as the species has a restricted natural range and correlative modelling approaches cannot be used to predict future habitats. Further, the tortoises will not be able to disperse at the pace required by contemporary climate change, and the climate of south-west WA has already become significantly drier over the past three decades, which has impacted on available tortoise habitat.

The approach being taken is to model the physiological constraints affecting the tortoise and to independently model the hydrology of the wetland habitat on which it depends. These models will be integrated using a GIS framework and run under future climate restraints to identify ideal long-term translocation sites.

The specific aims of the project are to:

- Model the physiological constraints on the niche of the *P. umbrina* and to map the niche onto the Australian continent;

- Develop high-resolution hydrological models of Ellen Brook and Twin Swamps Nature Reserves and test the predictive powers of the integrated model against historical datasets;
- Develop high-resolution, synthetic climate data for future climate scenarios;
- Identify potential translocation sites given projected changes in climate and hydrology;
- Develop high-resolution hydrological models of potential translocation sites under different climate futures and use the predictions to estimate tortoise survival probabilities;
- Advise the recovery team on optimum translocation sites, so that DEC can engage stakeholders and work towards site acquisition and management.

Cost:	2010	2011	2012	2013	2014
ARC funding	48,000	89,000	58,500	17,500	\$0
DEC cash contribution	21,000*	11,000*	11,000*	\$0	\$0
Total	\$69,000	\$100,000	\$69,500	\$17,500	\$0

*) These cash contributions will be partly used for parts of the data collection and monitoring costs shown under sections 10.2., 10.3.5., 10.4., and 10.6.1. In kind contributions by DEC and Perth Zoo include many costs shown under the other recovery actions. UWA in kind contribution for year 1-3 are \$33,138, \$34,222, and \$35,126.

Responsibility: The Recovery Team.

Preparation of new translocation site(s)

Once additional translocation sites have been selected and approved by the necessary authorities, work will be needed to make them suitable for Western Swamp Tortoises. This will include fox control, either by the construction and maintenance of fox-proof fences or via regular fox-baiting, water management and fire management. It is not possible to quantify these costs or allocate costs to organisations at this stage; however, it should be noted that these costs may be substantial, depending on the site.

Responsibility: DEC (Swan Coastal District). Costs will be estimated once a site is approved.

10.6.5 Release and post-release monitoring

Once a new translocation site is chosen and prepared, translocated tortoises will have to be released and monitored via radio-tracking. It is not possible to quantify these costs or allocate costs to organisations at this stage

Responsibility: DEC (Swan Coastal District).

10.7 EDUCATION, PUBLICITY AND SPONSORSHIP

10.7.1 Education and publicity

The Recovery Plan described here is relatively expensive in terms of both staff and finance and the support of the public is essential if the Western Swamp Tortoise is to be conserved.

DEC, Perth Zoo and the Friends of the Western Swamp Tortoise, in cooperation with other relevant organisations, will continue to implement a public education program concerning the Western Swamp Tortoise and the measures being undertaken to prevent its extinction and to lead to its recovery. Press releases, pamphlets, 'open days' at the reserves and other appropriate publicity and education materials will be employed as appropriate.

The information panels at the Gull Service Station in Upper Swan have been upgraded and the superseded panels moved to the park on the corner of Great Northern Highway and Chittering Rd in Bullsbrook, with support from the Friends Group and the City of Swan. A DEC display unit was erected by DEC staff and Friends members at Edgecombe Brothers Winery in Ellenbrook.

Friends Group used a 2006 Lotterywest grant to fund a website www.westernswamptortoise.com.au and prepare publicity brochures and an education package, which has been successfully used by several primary school teachers.

Cost:	2010	2011	2012	2013	2014
Total	\$26,500	\$27,500	\$28,500	\$29,500	\$30,500

Responsibility: DEC Strategic Development and Corporate Affairs Division, Perth Zoo, Friends of the Western Swamp Tortoise. Costs are salaries and in-kind contributions.

10.7.2 Sponsorships

The amount of money raised by sponsorships and public appeals has been a feature of the research into and management of the Western Swamp Tortoise. Since 1988, in addition to the provision of funds and staff time from the DEC and Perth Zoo, and grants from the Natural Heritage Trust via the Swan Catchment Council and Community Conservation Grants, money, equipment, substantial discounts on purchases or direct assistance have come from:

The Natural Heritage Trust via the Swan Catchment Council
World Wide Fund for Nature-Australia
Threatened Species Network
TiWest
ANZ Bank
Lotterywest
Midland Brick Co Ltd
Minerva Airconditioning
School of Biomedical Sciences, Curtin University of Technology
Unidata Australia Pty Ltd
WA Nature Conservation and National Parks Trust Account
Western Australian Water Corporation
Zoology Department, The University of Western Australia.
Toshiba Medical
Gull Service Station, Upper Swan
Edgecombe Brothers
British Chenonia Society

Because of its high public profile the Western Swamp Tortoise Recovery Plan lends itself to further sponsorships and other methods of fund-raising. Costs consist entirely of existing salaries and are included in 'Education and publicity (above).

Responsibility: Recovery Team. Costs are salaries.

11. MANAGEMENT PRACTICES

Land use adjacent to and close by the nature reserves can lead to detrimental impact on the Western Swamp Tortoise and its habitat. The Environmental Protection Policy (EPP, see section 6.2.4) is the major policy tool in place to control development. In addition town planning provisions administered by the City of Swan and State government need to be administered in sympathy with Western Swamp Tortoise conservation. The EPA has also recommended a Special Control Area within the City of Swan and Shire of Gingin's local planning schemes to assist in securing the WST habitat protection as a priority when considering development applications.

Possible future actions that may lead to significant impact on the Western Swamp Tortoise or its habitat include:

- any action, including changes in land use within catchments, that affected the quantity or quality of water flowing into swamps utilised by the species, including drainage or land-use in the catchments that caused pollution or eutrophication,
- any nearby industrial development that affected air quality to the extent that rainfall quality changed causing water quality in the swamps to be detrimentally affected,
- subdivision of the land near Twin Swamps and Ellen Brook Nature Reserves to levels that significantly

increase population density, with subsequent increasing people pressure on the habitat and leading to increased risk of frequent fire, increased damage to the fox-proof fences, and increased demand that nuisance insects emanating from within the reserves be controlled, and/or

- developments or actions that increase the number of ravens and black rats in the area of the reserves.

Beyond the direct scope of this Recovery Plan is the issue of climate change, but it will be addressed by ARC Linkage Project 0990428. Winter and spring rainfall in the south west of Western Australia has declined significantly since the mid-1970s and it is predicted that it will decline further. Swamp life and depth are critical factors in maintaining Western Swamp Tortoise habitat. The drought year of 2006 showed clearly that under significantly reduced winter rainfall, of the three areas where Western Swamp Tortoises occurred, only Ellen Brook Nature Reserve maintained sufficient water for Western Swamp Tortoises to feed and breed in that year. However, an unusually high mortality of females occurred at Ellen Brook Nature Reserve over the summer of 2006/07 following this drought.

12. SOCIAL AND ECONOMIC IMPACT

The implementation of this recovery plan is unlikely to cause direct significant adverse social and economic impacts as all populations are within nature reserves. The Western Swamp Tortoise Environmental Protection Policy developed by the Environmental Protection Authority and endorsed by State government limits the types of development that can be approved in land adjacent to the Ellen Brook and Twin Swamps Nature Reserves.

Westralia Airports Corporation are concerned that, if they permitted a critically endangered species to be reintroduced to land they lease, it might limit their development options.

The draft recovery plan has been referred to the Swan Coastal Plain Native title claimant groups for their input. DEC will facilitate the involvement of indigenous community members who wish to be involved in the Recovery Program. Any operations will comply with the requirements of the Commonwealth *Native Title Act 1993* and the Western Australian *Aboriginal Heritage Act 1972*, and appropriate consultation will be undertaken as required.

13. AFFECTED INTERESTS

The Swan Catchment Council is the responsible NRM regional group for the area where Ellen Brook, Twin Swamps and Mogumber Nature Reserves occur. Perth Airport also occurs within the same area.

The Friends of the Western Swamp Tortoise (Inc.) is a group of volunteers formed to support the work of the Recovery Team by assisting DEC in maintenance and revegetation of the Reserves, the Zoo where appropriate, and assisting in public education and publicity for the Western Swamp Tortoise.

14. BENEFITS TO OTHER SPECIES AND ECOLOGICAL COMMUNITIES

The threatened ecological community 'Forests and woodlands of deep seasonal wetlands of the Swan Coastal Plain (floristic community type 15)' occurs in Twin Swamps Nature Reserve and is listed in the Western Australian threatened ecological community database as Vulnerable. The threatened ecological community '*Eucalyptus calophylla* - *Xanthorrhoea preisii* woodlands and shrublands, Swan Coastal Plain (floristic community type 3c)' occurs in Ellen Brook Nature Reserve and is listed in the Western Australian threatened ecological community database as Critically Endangered. It is listed under the Commonwealth Environment Protection and Biodiversity Conservation Act as Endangered. The threatened ecological community 'Herb rich shrublands in clay pans (floristic community type 8)' also occurs on Ellen Brook Nature Reserve and is listed in the Western Australian threatened ecological community database as Vulnerable. Mogumber Nature Reserve protects the listed threatened plant *Eleocharis keigheryi*. Priority Flora species *Anigozanthos humilis* ssp. *chrysanthus* and *Villarsia submersa* also occur in Mogumber Nature Reserve. The claypan community on Mogumber Nature Reserve is currently being nominated for listing as a TEC. These threatened species and ecological communities will benefit from management of the nature reserves as prescribed in this recovery plan.

The area of Moore River Nature Reserve where the Western Swamp Tortoise has been re-introduced contains the threatened ecological community 'Herb rich saline shrublands in clay pans' (floristic community type 8), which is listed in the Western Australian threatened ecological community database as 'Vulnerable'. This TEC is currently being monitored to ensure no negative impacts have occurred from the water management and will benefit more regular patrols.

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17. GLOSSARY

aestivation, dormancy during the summer.

carapace, the upper part of the shell of tortoises and turtles.

Chelidae, the family of pleurodiran Testudines to which the Western Swamp Tortoise belongs.

chelid, a member of the Chelidae.

chelonians, members of the reptilian order Testudines or Chelonia (tortoises and turtles).

Cryptodira, the sub-order of Testudines containing the hidden-necked families; families where most species (but not marine turtles) are able to withdraw their necks into the shell by bending the neck in a vertical plane.

ephemeral, temporary, short-lived.

fecundity, the capacity to produce young.

gilgai, a clay soil containing natural hollows.

Gondwanan, originating in Gondwana, the southern "super-continent" that split up to form Australia, Antarctica, South America, Africa, Madagascar, New Zealand and India. Australia remained joined to Antarctica until between 45 and 38 million years ago.

home range, the area that an animal traverses in the scope of normal activities.

husbandry (of animals), careful management of animals in captivity: the provision of appropriate food, habitat, space and shelter to promote natural behaviours, including breeding.

Miocene, a geological epoch lasting from about 4.5 to 24.6 million years ago.

monotypic, a genus, family or some other higher taxonomic group with a single species.

plastron, the under part of the shell of tortoises and turtles.

Pleurodira, the sub-order of Testudines containing the side-necked families; families where species are unable to withdraw their necks into the shell but are able to gain some protection for the head by bending the neck in a horizontal plane (side-ways) between the carapace and plastron.

scutes, dermal plates covering shells of tortoises and turtles

taxonomy, study of the classification of organisms according to their similarities and differences.

Testudines, the order of Reptiles to which tortoises and turtles belong.

testudinid, a tortoise or turtle.

translocation, the movement of living organisms from one area with free release in another. Translocation includes introductions, re-introductions and re-stocking.

UWA, The University of Western Australia.

WWF, The World Wide Fund for Nature (formerly the World Wildlife Fund).