

WESTERN SWAMP TORTOISE (*Pseudemydura umbrina*) RECOVERY PLAN)

by Andrew A. Burbidge and Gerald Kuchling
for the Western Swamp Tortoise Recovery Team



2004

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THE UNIVERSITY OF
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WESTERN SWAMP TORTOISE
(*PSEUDEMYDURA UMBRINA*)

RECOVERY PLAN

3RD EDITION

JANUARY 2003 - DECEMBER 2007

by

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2004

FOREWORD

The Western Australian Department of Conservation and Land Management 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 3rd 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.

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 is 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. The Executive Director, Department of Conservation and Land Management, the Conservation Commission of Western Australia and the Minister for the Environment and Heritage have approved this Recovery Plan.

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 the Department and Perth Zoo and by the Commonwealth Government through the Endangered Species Program (now part of 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, 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.

CONTENTS

FOREWORD	5
SUMMARY	9
1. INTRODUCTION	10
1.1 Description and history of species	10
1.2 Distribution and abundance	10
1.2.1 Distribution	10
1.2.2 Population estimates	11
1.2.3 Habitat critical to the survival of the species	11
1.2.4 Important populations	11
1.3 Life history and ecological relationships	12
1.5 Reasons for threatened status	16
1.5.1 Geographic range and habitat	16
1.5.2 Biology	16
1.5.3 Effects of drought	17
1.5.4 Exotic predators	17
1.6 Existing conservation measures	17
1.6.1 Conservation status	17
1.6.2 Creation of nature reserves	17
1.6.3 Extension of nature reserves	17
1.6.4 Ecological studies	17
1.6.5 Management of nature reserves	18
1.6.6 Captive breeding	20
1.6.7 Genetic management	21
1.6.8 Translocations	22
1.6.9 Management Program, Recovery Plan and Recovery Team	22
1.7 Strategy for recovery	23
2. RECOVERY OBJECTIVE AND CRITERIA	23
2.1 Objective	23
2.2 Criteria	23
3. RELATED MATTERS	24
3.1 International obligations	24
3.2 Affected interests	24
3.3 Indigenous people	24
3.4 Benefits to other species and ecological communities	24
3.5 Social and economic impacts	25
4. GUIDE FOR DECISION-MAKERS	25
5. RECOVERY ACTIONS	25

5.1	Employment of Chief Investigator	25
5.2	Management of Ellen Brook, Twin Swamps and MOGUMBER Nature Reserves	25
5.2.1	Management of Ellen Brook Nature Reserve	25
5.2.2	Management of Twin Swamps Nature Reserve	26
5.2.3	Management of Mogumber Nature Reserve	27
5.2.4	Monitoring of water depths and water chemistry	27
5.3	TORTOISE POPULATION MONITORING	28
5.4	Captive breeding	28
5.4.1	Existing captive breeding colony	28
5.4.2	Establishment of additional captive colonies	28
5.5	Translocations	29
5.5.1	Re-introduction to Twin Swamps Nature Reserve and to Mogumber	29
5.5.2	Translocation to additional sites	29
5.6	Education, publicity and sponsorship	32
5.6.1	Education and publicity	32
5.6.2	Sponsorships	32
	EVALUATION	33
	ACKNOWLEDGMENTS	33
	REFERENCES	33
	GLOSSARY	36

SUMMARY

Current Species Status: Threatened (WA *Wildlife Conservation Act 1950*), Critically Endangered (ranking by WA Threatened Species Scientific Committee), Endangered (Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*), Critical (Action Plan for Australian Reptiles, 1993), Critically Endangered under IUCN (2000) Red List Criteria A2c and D, listed as Critically Endangered in the IUCN 2000 Red List of threatened animals.

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 by creating at least three wild populations and increasing the total number of mature individuals in the wild to >50.

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 (> 2 years old) tortoises at Ellen Brook Nature Reserve to more than 50 by 2007.
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 re-introduced tortoises demonstrated by 2007.
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.
5. The maintenance of a captive population of at least 12 breeding adults producing at least 20 two-year-old animals each year.
6. The creation of a second captive colony at another accredited Zoo in Australia.
7. The creation of a semi-captive 'insurance' colony of at least 20 tortoises at the Harry Waring Reserve of UWA or some other site.
8. The selection by the Recovery Team and endorsement by relevant authorities of a third suitable translocation site.

The criteria for failure to achieve the objective are:

1. A decline in numbers of the Western Swamp Tortoise in the wild.
2. Cessation or significant reduction (to less than 10 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. Employment of Chief Investigator
2. Management of Ellen Brook, Twin Swamps and Mogumber Nature Reserves
3. Tortoise population monitoring
4. Captive breeding
5. Translocations
6. Education, publicity and sponsorship.

Cost of Recovery Actions (\$000):

		2003	2004	2005	2006	2007	Total
1	Employment of Chief Investigator	49.9	51.0	52.5	54.0	55.5	262.9
2	Management of Ellen Brook, Twin Swamps and Mogumber Nature Reserves	94.2	74.4	88.8	81.6	84.1	423.1
3	Tortoise population monitoring	5.0	5.0	5.0	5.0	5.0	25.0
4	Captive breeding	99.5	104.5	109.5	115.0	121.0	549.5
5	Translocations	8.2	8.2	9.0	9.0	9.0	43.4
6	Education, publicity and sponsorship	4.0	4.0	4.0	4.0	4.0	20.0
	TOTAL	260.8	247.1	268.8	268.6	278.6	1323.9

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 and Twin Swamps Nature Reserves protect wetland ecological communities that are now threatened because of clearing and drainage. Twin Swamps and Ellen Brook Nature Reserves protect threatened ecological communities and Mogumber Nature Reserve protects species of threatened plants.

1. INTRODUCTION

1.1 DESCRIPTION AND HISTORY OF SPECIES

The Western Swamp Tortoise (*Pseudemydura umbrina* Siebenrock, 1901) is a short-necked freshwater tortoise that monotypically represents the sub-family Pseudemydurinae (family Chelidae, sub-order Pleurodira) (Gaffney and Meylan 1988). *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.

The colour of living *P. umbrina* varies with age and swamp type. The shell of hatchlings is grey above and bright cream and black below. The carapace in adults is usually similar in colour to the swamp water and varies from medium yellow-brown in clay swamps to almost black with a maroon tinge in the black coffee-coloured water of sandy swamps. Plastron colour is variable, from yellow to brown or occasionally black; often there are black spots on a yellow background with black edges to the scutes. The legs are short and covered in scale-like scutes and the feet have well-developed claws. The short neck is covered with horny tubercles and on the top of the head is a large single scute. There are two small barbels.

The Western Swamp Tortoise can be easily 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.

The Austrian J.A. Ludwig Preiss, who collected in Western Australia from 1839 to 1841, sent the first Western Swamp Tortoise known to science to the Vienna Museum in 1839. The specimen, which was labeled "New Holland", was named by Siebenrock (1901), who provided further details and comments on the species in 1907. No further specimens were collected until 1953 when two were found near Warbrook, only 30 km north-east of the centre of the city of Perth. Glauert (1954) described these as a new species, *Emydura inspectata*, but this was shown to be a synonym of *P. umbrina* by Ernest Williams (1958) of Harvard University.

A relict species, apparently little changed since the Miocene, *P. umbrina* is the only member of its genus and has no close relatives among other members of the Chelidae (Burbidge 1967; Burbidge *et al.* 1974; Gaffney 1977). *P. umbrina* is so different from other members of the family that a separate sub-family, the Pseudemydurinae, has been proposed for it (Gaffney 1977, Gaffney and Meylan 1988). The only fossil records of *Pseudemydura* are a portion of a skull and a pygal bone from the early Miocene Riversleigh deposits of north-west Queensland, which show only slight differences from modern specimens (Gaffney *et al.* 1989, Archer *et al.* 1991).

1.2 DISTRIBUTION AND ABUNDANCE

1.2.1 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 or mined for clay for brick and tile manufacture. Burbidge (1967) reports unsubstantiated sightings from near Mogumber (60 km north of Upper Swan), Pinjarra (100 km south) and Donnybrook (200 km south).

From the 1960s to the early 1980s there were two known and monitored wild populations, in each of Twin Swamps (Class A Reserve No. 27621) and Ellen Brook Nature Reserves (Class A Reserve 27620), which were created to protect the tortoises' habitat in 1962. By 1985 the population at Twin Swamps was nearly extinct, although a few individuals remained in the area. 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).

1.2.2 Population estimates

Mark and recapture studies have been carried out since 1963 in both Nature Reserves. Two estimates of population size are provided: known to be alive (KTBA) and the Manly and Parr method (Manly and Parr 1968) (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 does not provide high quality estimates, due to the small population and low sampling success rates. Jolly-Seber estimates (Jolly 1965, Seber 1982, Krebs 1989) are not provided as the method does not provide useful population estimates for the Western Swamp Tortoise.

At Ellen Brook Nature Reserve (Table 1) KTBA data show that numbers of breeding adults dropped from about 15 in the 1960s to only eight in 1979-1982 and then increased slowly to about 20 in the 1990s. Increased total KTBA in recent years largely reflects an increased number of hatchlings and small juveniles in the population; however, numbers of adults at Ellen Brook are now increasing slowly following the construction of the fox-proof fence in 1990. Data from Twin Swamps (Table 2) suggest that the population dropped from a high of over 100 (perhaps as much as 200) in the mid-1960s, to about 50 in the early 1970s, to less than 10 in 1985. Increased numbers since 1994 are the result of translocations. Note that KTBA figures are significantly lower than actual for at least the most recent four to five years because of low sample size due to the difficulty in capturing animals, which will not enter baited traps.

Thus total numbers in the wild dropped from about 200 in the mid-1960s to about 30 in the mid-1980s and have increased slowly, mainly due to translocations, since 1990. Total wild KTBA in 2001 was probably about 110 tortoises; however, only about 25 of these were adults.

1.2.3 Habitat critical to the survival of the species

Critical habitat is habitat identified as being critical to the survival of a listed threatened species or community. Habitat means the biophysical medium or media: (a) occupied (continuously, periodically or occasionally) by an organism or group of organisms; or (b) once occupied (continuously, periodically or occasionally) by an organism, or group of organisms, and into which organisms of that kind have the potential to be reintroduced (*Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)). Additions to the Register of Critical Habitat are determined by the Commonwealth Minister from information in recovery plans.

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 (including land purchased for addition) (centroid coordinates approximately 31°05'45"S, 116°01'45"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 the eastern parts of Lots 12 and 15.
- land within surface water catchments extending outside the three above nature reserves,
- any land where a wild population of *P. umbrina* might be detected in the future, and
- land targeted in this recovery plan for Western Swamp Tortoise reintroduction or introduction, including 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.

1.2.4 Important populations

As the Western Swamp Tortoise is critically endangered, all existing and future populations are 'important populations'.

1.3 LIFE HISTORY AND ECOLOGICAL RELATIONSHIPS

Perth has a Mediterranean climate with cool, wet winters and hot, dry summers. The mean annual rainfall is about 800 mm. *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 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).

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 (Kuchling unpublished).

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.

Lowering incubation temperature triggers hatching and hatchlings emerge the following autumn or winter during or after heavy rain, about 180 days after laying. Hatching success of wild nests varies due to excessive summer heat or unseasonable flooding. Between 1991 and 1994, twelve wild nests monitored with temperature probes at Ellen Brook Nature Reserve had a mean hatching success of 66.7% (Kuchling 1995).

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. Age to sexual maturity at Twin Swamps Nature Reserve has varied from 6.5 to 14 years, with a mean of about 11 years while at Ellen Brook Nature Reserve the mean is probably around 15 years (Burbidge 1981).

There is little information relating to sex determination in Australian chelid tortoises, but available data from both laboratory and field studies indicate that sex is genetically-determined rather than being determined by incubation temperature (Thompson 1988, Palmer-Allen and Beynon 1990). Histological examination of Western Swamp Tortoise hatchlings from the captive colony that died in 1989 also suggests that sex is genetically determined (Kuchling, unpublished). Longevity is unknown, but captive animals estimated to be at least 20 years old in the late 1950s are still producing eggs, suggesting longevity exceeds 60 years. An adult female captured at Ellen Brook Nature Reserve in 1963 (carapace length 122 mm, age probably about 20 years) was recaptured in 1990 (carapace length 135 mm) with oviducal eggs.

Predation of native animals by introduced carnivores, especially the European Red Fox, has been shown to be a significant conservation concern in Australia in recent years (Kinneer *et al.* 1988, 1998, in press). There is a little direct evidence (Burbidge 1967) but much circumstantial evidence that predators, particularly the fox, kill Western Swamp Tortoises. They may also destroy eggs, as has been documented for other Australian

Table 1. Ellen Brook Nature Reserve, Western Swamp Tortoise Population Estimates 1963 - 2001.

Year	No. captured	Manly & Parr estimate	KTBA Adults	KTBA juveniles	KTBA hatchlings	Total KTBA
1963	4	-	16	6	0	22
1964	10	57	17	6	0	23
1965	3	51	12	4	2	18
1966	4	23	11	5	1	17
1967	2	32	11	5	0	16
1968	5	21	10	6	1	17
1969	1	17	10	6	0	16
1970	3	-	11	6	1	18
1971	0	-	10	6	1	17
1972	6	22	10	7	1	18
1973	0	-	10	7	3	20
1974	2	42	11	9	1	21
1975	3	32	11	9	1	21
1976	9	26	10	10	0	20
1977	3	21	10	8	1	19
1978	8	38	10	9	2	21
1979	4	23	8	10	3	21
1980	8	31	8	13	2	23
1981	8	31	8	13	5	26
1982	10	37	8	17	2	27
1983	5	73	11	13	6	30
1984	10	100	11	17	7	35
1985	7	58	12	19	3	34
1986	2	34	13	18	1	32
1987	6	41	14	18	1	33
1988	5	58	13	19	3	35
1989	17	40	15	18	2	35
1990	11	40	17	17	0	34
1991	21	38	20	13	0	33
1992	23	46	20	11	3	34
1993	25	52	19	11	10	40
1994	35	58	21	13	13	47
1995	18	45	21	12	2	35
1996	11	41	22	7	0	29
1997	5	26	20	5	0	25
1998	22	48	23	5	6	34
1999	32	72	22	9	15	46
2000	38	61	19	16	11	46
2001	37	-	10	26	1	37

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 those 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.
4. Manly & Parr estimates not possible in the first and last year of sampling and in some other years due to small number of animals captured, estimate shown as '-'

Table 2. Twin Swamps Nature Reserve, Western Swamp Tortoise Population Estimates 1963 – 2000.

Year	No. captured	Manly & Parr estimate	KTBA adults	KTBA juveniles	KTBA hatchlings	Total KTBA
1963	1	-	38	10	5	53
1964	4	288	37	15	23	75
1965	9	273	36	36	25	97
1966	65	127	34	58	10	102
1967	27	159	30	46	0	76
1968	17	67	28	31	2	61
1969	8	91	27	32	1	60
1970	26	70	26	31	1	58
1971	27	70	27	24	0	51
1972	15	55	24	15	0	39
1973	13	56	26	7	0	33
1974	8	88	22	4	2	28
1975	8	32	19	3	1	23
1976	3	20	17	3	0	20
1977	9	26	18	2	0	20
1978	9	29	15	2	1	18
1979	6	20	10	3	0	13
1980	2	10	8	2	0	10
1981	3	10	8	2	0	10
1982	3	11	8	2	1	11
1983	5	15	8	3	0	11
1984	3	12	6	3	0	9
1985	2	-	6	2	0	8
1986	0	-	6	0	0	6
1987	0	-	6	0	1	7
1988	0	-	6	1	0	7
1989	0	-	6	1	0	7
1990	2	12	6	1	0	7
1991	0	-	5	1	0	6
1992	1	-	5	1	0	6
1993	0	-	4	1	0	5
1994	14	23	4	12	0	16
1995	41	75	8	26	12	46
1996	33	41	6	27	3	36
1997	37	93	4	40	2	46
1998	32	149	3	36	4	43
1999	58	83	1	63	0	64
2000	56	64	3	57	0	60
2001	30	-	6	24	0	30

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 those 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.
4. Manly & Parr estimates not possible in the first and last year of sampling and in some other years due to small number of animals captured, estimate shown as '-'

Figure 1. Western Swamp Tortoise, Ellen Brook Nature Reserve, 2001

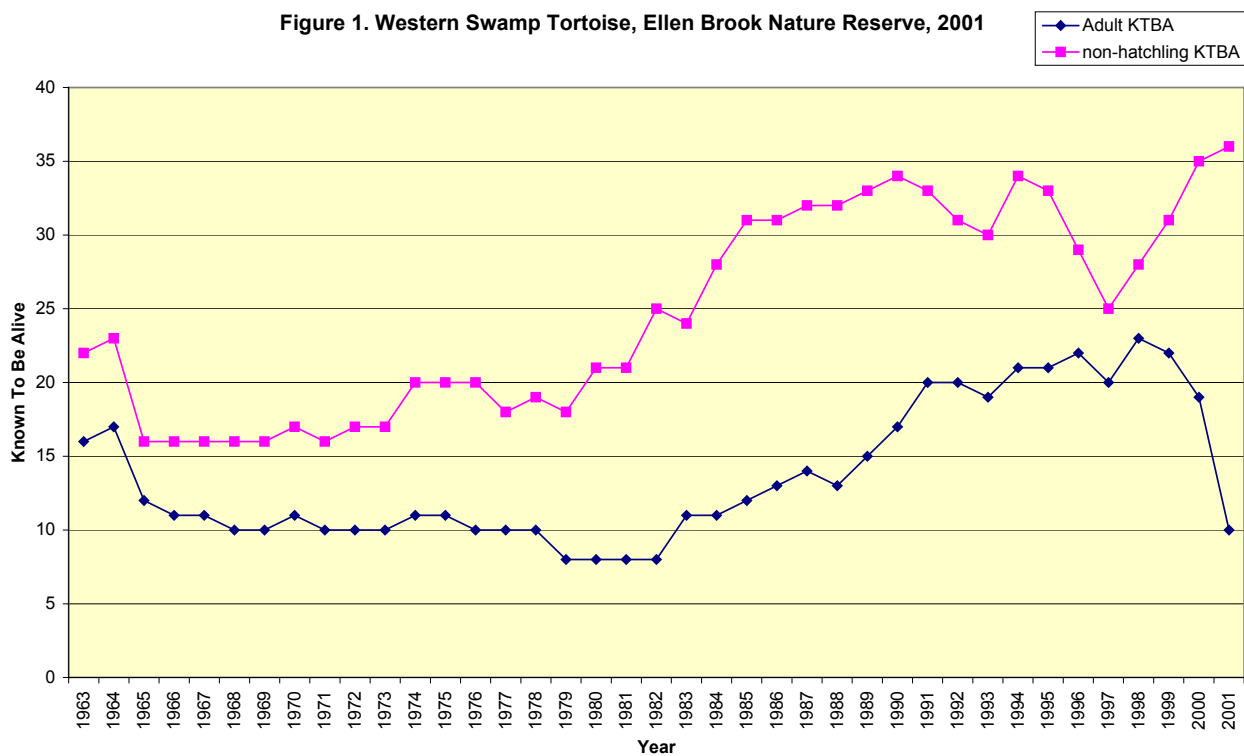
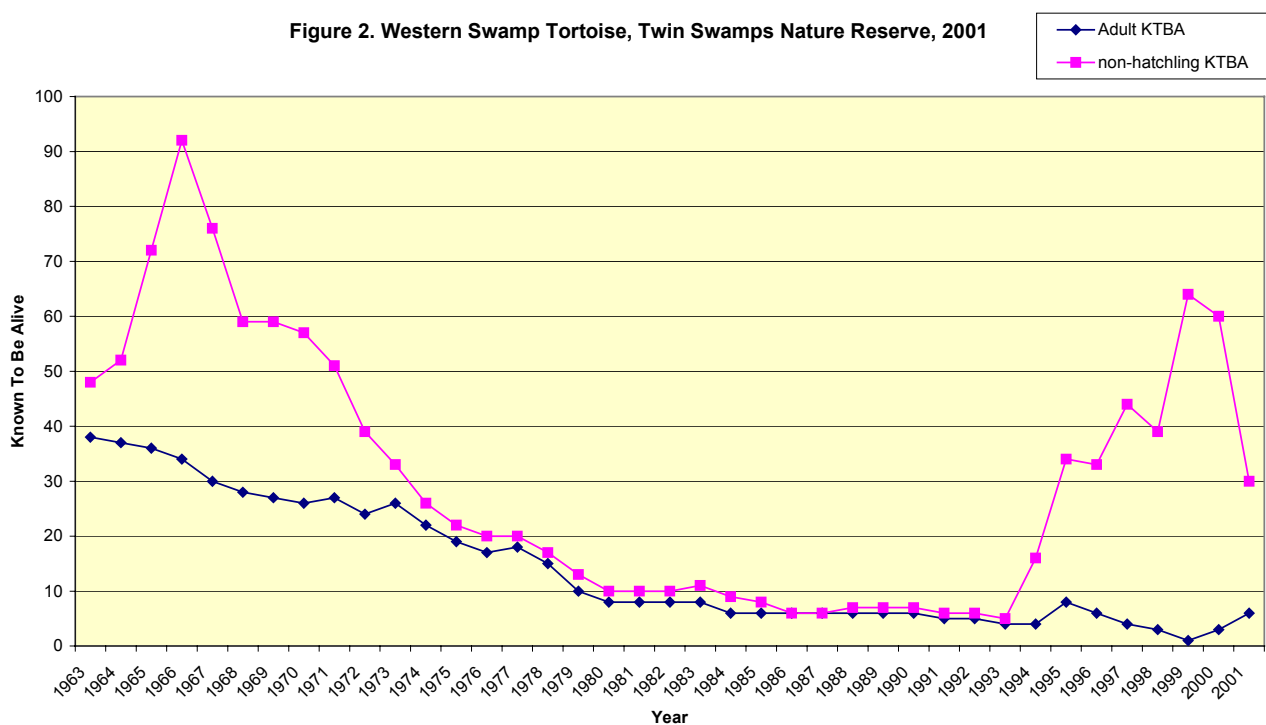


Figure 2. Western Swamp Tortoise, Twin Swamps Nature Reserve, 2001



tortoises (Clay 1981, Thompson 1983). Foxes were abundant in both nature reserves and there is no other plausible explanation for the rapid decline in numbers at Twin Swamps Nature Reserve, where aestivation refuges are mostly on the surface or underground in loose sand. At Ellen Brook Nature Reserve, where aestivation occurs underground in extremely hard clay, the species is better protected, but the very small population size means that even low levels of predation can have a significant effect.

Radio-tracking of juvenile Western Swamp Tortoises from 1995 at Twin Swamps Nature Reserve shows that the Australia Raven (*Corvus coronoides*) may attack and kill or injure tortoises that leave the water when swamps dry out. Before 1995 ravens were not recorded as predators of *P. umbrina*, but other species of ravens are well known for their disastrous impact on survival of juvenile Desert Tortoises *Gopherus agassizii* in the United States of America (Boarman 1993b, 1995) and of *Testudo kleinmanni* in Israel (Geffen and Mendelssohn 1993). Raven control was instigated by permitting local landholders to shoot ravens on and near the reserve. However, although there was a reduction in predation in 1996, the number of juveniles killed in 1997 was unacceptably high. Since 1998 a dawn to dusk patrol of the last remaining swamp has been carried out at the critical time—when the last swamp is drying and tortoises are moving to aestivation sites. A significant lowering of predation since 1998 supports the hypothesis that ravens are the main predator that kill and injure juvenile Western Swamp Tortoises at Twin Swamps Nature Reserve. Predation of juvenile tortoises by introduced rats *Rattus rattus* and/or *Rattus norvegicus* was first noted during summer/autumn 1998/99 and since spring 1999 rat bait stations have been maintained in the northern half of Twin Swamps Nature Reserve (most tortoise inhabit the northern half) during summer and autumn.

1.5 REASONS FOR THREATENED STATUS

There are a number of compounding reasons for the current critically endangered status of the Western Swamp Tortoise; these are discussed in more detail below:

- (i) a very small geographic range, most of which has been converted to agricultural, industrial or urban use
- (ii) protection of habitat 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) increasing aridity, a factor compounded by the marginal nature of the remaining habitat and which could become worse if the climate becomes more arid; and
- (v) the presence of exotic predators, particularly the European Red Fox.

1.5.1 Geographic range and habitat

Because of the rediscovery of the Western Swamp Tortoise within the Perth metropolitan area as late as 1953, little is known of its pre-European geographic range. There are no confirmed indications, however, that it had a range in the recent past significantly different from its recent one, ie, an area of about 100-150 km². Within this very small range the species is restricted to winter-wet ephemeral swamps with suitable aestivating refuges nearby. Western Swamp Tortoises do not occur in the many permanent swamps or lakes on the Swan Coastal Plain, so presumably they cannot survive in this habitat. Most of the original range of the Western Swamp Tortoise has been greatly modified in the past 170 years. What we know now of breeding and hatchling survival in the two nature reserves suggests that the habitat in them must be considered as marginal. Additionally, both reserves, especially Ellen Brook Nature Reserve, are small.

1.5.2 Biology

P. umbrina is the smallest Australian chelid. It is also the only species in which the female is smaller than the male, and the only known species in the world that digs the nest chamber with the front feet (Kuchling 1993). Egg size is similar to other species in the family and, accordingly, it has very low fecundity: wild females produce a maximum of one clutch of three to six eggs per annum. Captive females may sporadically produce a second clutch of two eggs (Kuchling and Burford unpublished). This compares unfavourably with other Australian chelids, e.g. the Oblong Tortoise *Chelodina oblonga*, which can produce two or three clutches per year each of 8-15 eggs (Burbidge 1967, Clay 1981, Kuchling 1989). Only live food is eaten; other species eat a greater variety of food including carrion and vegetable matter. Growth is slow, food being available for only a short time each year, and sexual maturity is not usually reached until 10-15 years or more.

1.5.3 Effects of drought

Aestivating tortoises desiccate during the summer. Measurements of desiccation rates of radio transmitter-equipped animals at Twin Swamps Nature Reserve have shown that hatchlings must achieve a body weight of about 25 g in their first six months in order to survive the following summer. This is not achievable in years of below average rainfall because the swamps retain water for only a short time. Furthermore, there is evidence that females are not able to produce eggs in low rainfall years; thus two successive years of average or above average rainfall are required for effective recruitment to take place at Twin Swamps (Burbidge 1967, 1981; Kuchling unpublished). Since the mid-1960s Perth has had many years of below average rainfall.

1.5.4 Exotic predators

The European Red Fox was abundant in both nature reserves and predated *P. umbrina*. Foxes are now excluded from both nature reserves by fox-proof fences. Laughing Kookaburras may predate hatchling and juvenile tortoises at Twin Swamps Nature Reserve. Introduced rats *Rattus rattus* and *R. norvegicus* may be predated juvenile tortoises at Twin Swamps Nature Reserve (see Table 5). An experimental rat control program, utilising bait stations that exclude access by Quenda *Isodon obesulus* commenced in late 1999.

1.6 EXISTING CONSERVATION MEASURES

1.6.1 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 Conservation and Land Management's (The Department) Threatened Species Scientific Committee. The Minister for the Environment and Heritage has endorsed this ranking. It is included in the category 'endangered' in the list of threatened species established pursuant to section 178 of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and is listed as critically endangered on the former Australian and New Zealand Environment and Conservation Council List of Australian Threatened Fauna. It listed as 'critically endangered' in the IUCN 2000 Red List of threatened species (Hilton-Taylor 2000), is on Appendix I of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) and was given a priority rating of '1' in the Action Plan for Tortoises and Freshwater Turtles (IUCN/SSC 1989).

Under IUCN (2000) Red List Categories, *P. umbrina* meets 'Critically Endangered' under Criteria A2; D.

1.6.2 Creation of nature reserves

Following the interest generated by the rediscovery of a presumed extinct species so close to Perth, the Government of the day, aided by a public appeal for funds, created two Class A (ie, can not be cancelled, reduced in area or used for any other purpose except by Act of Parliament) nature reserves that protected much of its remaining habitat. These were Ellen Brook Nature Reserve of 67 ha, located two kilometres north of Upper Swan, and Twin Swamps Nature Reserve of 141 ha, located about 5 km north-north-west of Ellen Brook Nature Reserve. Both reserves were created in 1966 and are vested in the National Parks and Nature Conservation Authority and managed by the Western Australian Department of Conservation and Land Management.

1.6.3 Extension of nature reserves

Land was purchased and added to Twin Swamps Nature Reserve in 1965, increasing its area to 155 ha. Negotiations to add land to Ellen Brook Nature Reserve have proceeded since 1990. An area of 5.6 ha immediately south of the reserve was purchased in December 1991 and is now contained within Class A Reserve 42126, increasing the area of Ellen Brook Nature Reserve to 73 ha. Negotiations are taking place to acquire additional parcels of land to the west of the reserve.

1.6.4 Ecological studies

Studies on *P. umbrina* commenced shortly after it was rediscovered. Initially, Dr David Ride, then Director of the Western Australian Museum, coordinated field searches and kept a captive colony at his home. (This colony was transferred to Perth Zoo in 1964.) Then, in 1963, Professor A.R. Main of The University of Western Australia

(UWA) initiated and supervised a project by several Zoology Honours Degree students, one of whom was the senior author (Lucas 1963). In 1964 the senior author commenced his Ph.D. studies with Professor Main on *P. umbrina* and, for comparison, two other southern Western Australian long-necked tortoises, *Chelodina oblonga* and *C. steindachneri*. In 1968 the senior author started work as a Research Scientist with the Western Australian Government and has conducted and coordinated less intensive studies of *P. umbrina* since, with research studies becoming more intensive through the 1980s as it became clear that the species was declining in numbers. Results of these studies can be found in Burbidge 1967, 1981, 1984, 1987a, 1987b and Burbidge and Friend 1988. Ecological studies re-commenced in 1991 under the first edition of this Recovery Plan when Kuchling radio-tracked animals on Ellen Brook Nature Reserve and located nests in the wild for the first time. Between 1991 and 1994 studies at Ellen Brook focused on the reproductive performance of females, the nest environment, hatching success and hatchling survival and growth (Kuchling 1993, 1995) and temperature and micro habitat selection (King *et al.* 1998).

Since 1994 the emphasis of Kuchling's studies shifted to Twin Swamps Nature Reserve to investigate and define the critical ecological parameters for the re-establishment of a viable Western Swamp Tortoise population and monitor re-introduced tortoises (Kuchling 1996, 1997, 2000). He has also investigated possible additional translocation sites. In 1999 Kuchling commenced studies at Mogumber, the latest translocation site (see below).

1.6.5 Management of nature reserves

The management of Ellen Brook and Twin Swamps Nature Reserves is the responsibility of the Department 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 and work to mitigate deleterious effects from surrounding land. 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.

1.6.5.1 Water quantity and quality

The Department has maintained water depth records at two depth gauges at Ellen Brook Nature Reserve and four gauges at Twin Swamps Nature Reserve and has had water samples taken from immediately adjacent to each gauge analysed by the W.A. Chemistry Centre annually since 1972. Additional gauges in Reserve A42126 and in Midland Brick land to the west of Ellen Brook Nature Reserve have been maintained since 1992. Data are held on a Departmental file and in a micro-computer database. 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. Water quality at Ellen Brook Nature Reserve is excellent and there is no evidence of pollution entering the swamps on the reserve. At Twin Swamps Nature Reserve the swamps are greatly affected by drought. 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. Water quality varies between swamps. Some areas receive run-off from surrounding land and have relatively high levels of phosphates and nitrogen; others have excellent quality water. There is no evidence that suggests that Western Swamp Tortoises have been affected by changing water quality.

Swamps at Twin Swamps Nature Reserve are greatly affected by the amount of rainfall. Only in high rainfall years do the swamps contain water for long enough to enable Western Swamp Tortoises to feed sufficiently to survive the summer aestivation period and breed successfully.

The Western Australian Water Corporation has conducted limited hydrological studies of the area with advice from the Geological Survey of Western Australia. These studies showed that it was feasible to pump from groundwater to maintain swamp life in years of average to below average rainfall. In 1992/93 the Western Australian Water Corporation drilled a bore near the north-western corner of the reserve, where the best quality water and electricity were both available, and installed pipelines take the water to North West and East Swamps. The Western Australian Water Corporation installed the bore and pipelines by way of sponsorship of the Recovery Plan. Pumping of groundwater into North West Swamp has taken place every year since 1994.

1.6.5.2 *Predator control*

Fox control has been carried out on both nature reserves sporadically since 1979, but the technique available at that time (laying of strychnine baits in meat crackle) proved to be inadequate. Predator control was stepped up at Ellen Brook Nature Reserve in 1988 by the Department using new fox control techniques (regular laying of Compound 1080 in fresh meat or fowl egg baits) developed by Dr Jack Kinnear and colleagues from the Department (Kinnear *et al.* 1988).

However, two significant problems arose with respect to control by the use of poison baits. Much of Ellen Brook Nature Reserve is under water for up to six months of the year. The use of Compound 1080 under such conditions can be ineffective, because it is highly soluble in water. This can be obviated to a degree by the use of chicken eggs rather than dried meat baits. Also the reserves are small and re-invasion of them by foxes from surrounding land is rapid. The tortoises are most likely to be eaten by foxes during the wet months when they are not aestivating.

It was considered that these problems could be largely solved by the construction of a fox-proof fence. In 1989 the Department applied for and received \$24 000 (50% of the funds required for the construction of a fence) from the then Australian National Parks and Wildlife Service (now incorporated into Environment Australia) under their Endangered Species Program for the construction of a fence around the tortoise habitat in Ellen Brook Nature Reserve. The Department met the other half of the cost. Construction commenced late in 1989, but was delayed because of unseasonable heavy rains during the 1989/90 summer. The fence was completed in December 1990. Adjoining Reserve A42126 was fenced in 1995. Twin Swamps Nature Reserve was fenced in 1993 and 1994 under the first edition of this Recovery Plan.

The Department's Swan Region staff carry out regular patrols of the fences. Although the fence is termed 'fox-proof', experience shows that foxes are capable of finding any weak links in a fence so regular poisoning inside the fence is carried out as necessary to eliminate any foxes that are able to negotiate it. Theoretically, the fences also prevent emigration or immigration of adult Western Swamp Tortoises from or to the reserves. Problems have occurred when tortoises persistently tried to get through the fence, which mainly happens in spring when swamps inside the reserves are drying and water (e.g. farm dams) outside attracts tortoises. To alleviate the problem of tortoises trying to enter the reserves from the outside, one way tortoise gates were developed and tested and built into the fence at Ellen Brook Nature Reserve (Guyot and Kuchling, 1998).

1.6.5.3 *Fire*

Fire has limited effects on Western Swamp Tortoises at Ellen Brook Nature Reserve because aestivation sites are underground. 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. The Department's fire procedures at present are:

- (i) to meet its responsibilities under the Bush Fires Act by maintaining a perimeter and internal fire break
- (ii) to continue to classify the reserves as "Red Action" areas requiring priority response from Departmental 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 so fire-control machinery does not damage the gilgai aestivating tunnels; and
- (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.
- (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.

1.6.5.4 *Effects of adjacent land use*

There have been several proposals to mine clay from private land near Ellen Brook Nature Reserve and these have been the subject of assessment by the Environmental Protection Authority (EPA) and the application of conditions by the Minister for the Environment. Future mining may not come within 100 m of the nature reserve, drainage waters are not permitted to enter the reserve, and the companies concerned committed

themselves to contributing towards the cost of relocating the 'nature reserve' drain (see below). Midland Brick has also offered to help with rehabilitation of land being added to Ellen Brook Nature Reserve.

In the 1992 Recovery Plan, provision was made for the removal of the 'nature reserve drain' that ran through Ellen Brook Nature Reserve. This action was completed in 1995. This was a major achievement that has been proposed for more than 20 years. Now all waters draining from Great Northern Highway and from land to the south of the reserve will drain into Ellen Brook via a new channel outside the fenced tortoise habitat, rather than draining through areas occupied by the last remaining wild population.

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.

Several farm dams adjacent to Twin Swamps Nature Reserve are of concern. Firstly, it is likely that they lower the water table of adjacent swamps in the eastern part of the reserve with which they have an 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 now have to be frequently removed from the fence line adjacent to dams. During early 1997 small 'dams' were constructed inside the nature reserve opposite major farm dams. These were monitored during the 1997 and 1998 winters and some modifications have been made.

1.6.6 Captive breeding

At Perth Zoo captive breeding was attempted in a low key, non-interventionist way from 1964, when Western Swamp Tortoises were first kept, until 1979 (Spence *et al.* 1979). Success was, however, very low with only four animals still being alive from the 26 that hatched between 1966 and 1977.

In 1979, the three remaining adult females from the Zoo population were transferred to the Western Australian Wildlife Research Centre for more intensive husbandry and the use of interventionist techniques in obtaining and incubating eggs. During the first year three eggs were obtained by oxytocin inducement and incubated artificially. Two hatchlings were produced, but one died in its first year and the other in its second. In 1980, 14 eggs were obtained and artificially incubated; six of these hatched, but the hatchlings did not survive for more than a few months. Although unsuccessful in raising hatchlings, this work did show that eggs could still be produced by the captives and demonstrated that the hatching of *P. umbrina* eggs is triggered by a drop in incubation temperatures; if the incubation continues at a constant temperature most embryos develop to hatchling size but do not hatch and eventually die. This adaptation, unusual in chelonians, presumably prevents hatchlings emerging before winter. The captive animals produced no further eggs until 1987.

In 1987 Dr G. Kuchling arrived at UWA from Austria to work with Professor S.D. Bradshaw on the hormonal control of reproduction in the Oblong Tortoise *Chelodina oblonga*. Later he asked the Department if he could help with captive breeding in *P. umbrina*, a suggestion that was welcomed. The development of techniques for the examination of the female reproductive tract using ultra-sound scanners (in collaboration with Dr Bruno Colomb) was a breakthrough, enabling measurements to be made of egg follicle development in live tortoises for the first time (Kuchling 1988, 1989).

In 1987 seven eggs were obtained from two captive females. These eggs were incubated artificially, but none hatched, the embryos dying at an early stage of development. The reasons for this are not clear: recent research suggests that the most likely explanation is poor quality eggs due to inadequate nutrition of the females that produced them.

Also in 1987 the Department and the UWA Zoology Department developed a budget for a two and a half year captive breeding project and sought and obtained funds from the World Wide Fund for Nature Australia, the

Australian National Parks and Wildlife Service, the Western Australian Nature Conservation and National Parks Trust Account and the Department. The project was carried out by Dr Kuchling, now a Research Fellow at Zoology Department, UWA, utilising tortoises kept at Perth Zoo and at the Department's Wildlife Research Centre. Perth Zoo and the Department have supported the project with staff and with additional funds and UWA has provided facilities and financial administration. Perth Zoo has obtained external sponsorship for the construction of new facilities for the captive tortoises and hatchlings, husbandry was greatly improved (Kuchling and DeJose 1989) and the captive colony was increased by addition of tortoises captured outside Ellen Brook and Twin Swamps Nature Reserves. From 1987 to 1992, the project was supervised and coordinated by the Western Swamp Tortoise Captive Breeding Project Management Committee.

After some initial health problems during the rearing of hatchlings were solved (Ladyman *et al.* 1998), captive breeding has become increasingly successful: since 1989 the captive breeding operation has produced a total of 423 hatchlings (up to May 2002) and has a rearing success of over 90%. In 1990, the captive breeding project team was a finalist for the IBM Australia Conservation Award. In mid-1991 responsibility for the project was transferred to Perth Zoo, with Dr Kuchling continuing to provide advice and help, and overall coordination was taken over by the Recovery Team.

In December 2001, Perth Zoo held 165 tortoises comprising 16 breeding males, 14 breeding females and 135 other tortoises comprising hatchlings, juveniles, sub-adults and non-breeding adults.

1.6.7 Genetic management

P. umbrina is in a severe genetic bottleneck. In 1985 there were about 30 animals of breeding age for the whole species (wild and captive), a number that increased to about 50 by 2001. Genetic management focuses on optimising the maintenance of genetic variability in the captive breeding stock as well as in the translocated population. Genetic management based on pedigree analysis (equalising founder contribution, or maximising founder genome equivalents, or maximising allelic diversity) produces the most genetically diverse release populations (Haig *et al.* 1990). The captive breeding stock of *P. umbrina* still consists overwhelmingly of wild-caught individuals (Table 3). A continuation of the present captive breeding success should lead to a rapid population expansion. The use of F1 offspring to re-establish populations in the wild reduces any potentially detrimental genetic drift during the time the species has to be bred in captivity (Kuchling 1997).

In the past all captive females were kept together with some of the males in a random mating situation. Since 1988 males and females have been kept in separate enclosures and individually introduced to each other for mating purposes in a rotation scheme so that every female mates with a different male in consecutive years and all captive adults have the potential to contribute their genes. This is an attempt to equalise founder contributions as much as possible without, however, diminishing the breeding output of the best breeding females. As long as the world population is at such a low level, this cannot be justified and the breeding output has to be maximised. A complication for genetic management is the ability of females to store sperm over several years (Kuchling *et al.* 1992).

Since 1988 chromosome banding, plasma enzyme gel electrophoresis and DNA analysis have been carried out, but only DNA research was able to detect limited variability between individuals. All captive and some wild adults have been bled for DNA extraction. A constraint is the necessity to sample living tissues (blood) from tortoises that are so small, rare, endangered and difficult to breed. Since 1991, the allantoic sacs of the captive bred hatchlings have been collected for DNA extraction (Hall *et al.* 1992).

During 1990 and 1991 all adult, captive *P. umbrina* and 10 hatchlings were DNA fingerprinted by the School of Biomedical Sciences, Curtin University of Technology. The costs for this study were met from the prize money of the IBM Australia Conservation Award (\$1 000) and from a grant from the Commonwealth's Endangered Species Program (\$2 000). However, due to low levels of detectable variability (an average 26 scorable bands showed 80% band sharing), fingerprinting with DNA minisatellites did not facilitate the reconstruction of patrilineages in *P. umbrina* and was discontinued.

Joint Australian Research Council small grants to Curtin University of Technology's School of Biomedical Sciences and the UWA Department of Zoology in 1995 (\$7 000) and 1996 (\$7 000) 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. DNA analyses of additional samples now in storage is desirable, and will be attempted via a University student project.

1.6.8 Translocations

1.6.8.1 Twin Swamps Nature Reserve

Release of *P. umbrina* at Twin Swamps Nature Reserve commenced in September 1994 and continued until August 2001. A total of 148 captive-bred juvenile *P. umbrina* of more than 100 g body mass and 20 hatchlings have been released. Of these, 28 tortoises are confirmed to be dead (the carcasses were found).

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 native ravens *Corvus coronoides*. Some mortalities also occurred during aestivation and may have been caused by introduced rats *Rattus rattus* and/or *R. norvegicus*. 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 hatched in 1990 and are now approaching sexual maturity. Although vitellogenic follicles have been found by ultrasound scanning in several females, no egg production has yet been recorded.

1.6.8.2 Mogumber Nature Reserve

Release of captive bred juvenile *P. umbrina* started in August 2000 with six tortoises and a further 20 tortoises were released in August 2001. Three of the radio-tracked tortoises moved to private land adjacent to the nature reserve in 2000 and another three did the same in 2001. So far no mortality has been recorded inside the nature reserve. The only recorded mortality is a tortoise that had moved about 1.2 km over cleared private land to the south. Only small shell fragments attached to the transmitter were found. Of a second tortoise that moved into the same area in 2001, only the transmitter with damaged encasing was recovered in early 2002. Fox predation is suspected as possible cause in both instances.

1.6.9 Management Program, Recovery Plan and Recovery Team

A management program was developed in 1990 (Burbidge *et al.* 1990) and was launched by the World President of World Wide Fund for Nature, the Prince Philip, in November 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, covering the period 1998-2002 inclusive, was prepared in 1998 and has been updated as unpublished draft since.

The Recovery Team currently meets every six months. At the end of 2001 Team membership came from the Department, Perth Zoo, UWA’s Zoology Department, Curtin University of Technology’s School of Biomedical Sciences, and the World Wide Fund for Nature. A representative from the Brockman/Ellen Brook Integrated Catchment Group will join the team in 2003. The Shire of Swan has been a member of the Team in the past, but has allowed its membership to lapse. The Recovery Team reports annually on the implementation of the Plan to the Department's Corporate Executive and funding agencies.

1.7 STRATEGY FOR RECOVERY

This Recovery Plan will run for a term of five years from 2003 to 2007 inclusive. Six primary strategies will be pursued during this period and are presented below. These strategies will be implemented concurrently:

- (i) implement Management Guidelines for Ellen Brook and Twin Swamps Nature Reserves and acquire additional land to extend Ellen Brook Nature Reserve;
- (ii) monitor the tortoise populations on Ellen Brook and Twin Swamps Nature Reserve and monitor water depths and water chemistry in selected swamps in both reserves;
- (iii) continue with the captive breeding project to produce tortoises for re-introduction to Twin Swamps Nature Reserve, Mogumber and other sites;
- (iv) continue to re-introduce tortoises to Mogumber Nature Reserve utilising partly grown tortoises produced by the captive breeding project and commence translocations to other suitable sites;
- (v) continue to rehabilitate the land within Reserve A42126 to render it suitable for occupation by Western Swamp Tortoises; and
- (vi) continue to disseminate educational and publicity material about the Western Swamp tortoise and continue to raise funds for its conservation.

2. RECOVERY OBJECTIVE AND CRITERIA

2.1 OBJECTIVE

The Western Swamp Tortoise currently meets 'Critically Endangered' under IUCN 2000 Red List Criteria A2c; D. The species will no longer qualify as CR under Criterion D once there have been more than 50 mature individuals in the wild for five years, so long as the species is not declining. (It will then meet EN under criterion D.) Even though tortoises have been successfully translocated to Twin Swamps Nature Reserve, the long time to maturity in this species means that there will not be more than 50 mature individuals in the wild for some years. Criterion A2 required that a taxon suffer a population size reduction of at least 90% over the last three generations (ie, for this species about 120 years), where the causes of the reduction are demonstrably reversible AND understood AND unlikely to recur. It is not possible for the recovery plan to achieve recovery to the extent that this criterion is no longer applicable within the foreseeable future.

Thus it is not possible to move the Western Swamp Tortoise from Critically Endangered to Endangered under IUCN Criteria within the life of this recovery plan.

The results of seven years of reintroduction to Twin Swamps Nature Reserve demonstrate that the establishment of a viable wild population is not straightforward and that several complex ecological and biological questions and management problems still have to be answered and solved. However, the good captive breeding success of the past seven years allows the expansion of the objective of this Recovery Plan compared to that of ten years ago.

The objectives of the third edition of this Recovery Plan are 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.

2.2 CRITERIA

The criteria for successfully achieving 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 (> 2 years old) tortoises at Ellen Brook Nature Reserve to more than 50 by 2007.
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 re-introduced tortoises demonstrated by 2007.
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.
5. The total number of adult wild *Pseudemydura umbrina* being >50.

6. The maintenance of a captive population of at least 12 breeding adults producing at least 20 two-year-old animals each year.
7. The creation of a second captive colony at another accredited Zoo in Australia.
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.
9. The selection by the Recovery Team and endorsement by relevant authorities of a third suitable translocation site.

The criteria for failure to achieve the objective are:

1. A decline in numbers of the 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.

3. RELATED MATTERS

3.1 International obligations

Although the Western Swamp Tortoise is listed under the Convention on International Trade in Endangered Species (CITES), this recovery plan does not affect Australia's obligations under international agreements.

3.2 Affected interests

All wild populations of the Western Swamp Tortoise are within nature reserves vested in the Conservation Commission of Western Australia and managed by the Department of Conservation and Land Management. One identified translocation site is on Commonwealth land within Perth Airport. Privately-owned land proposed for addition to Ellen Brook Nature Reserve will be purchased or swapped for other land on terms agreed by the owners.

3.3 Indigenous people

No indigenous communities have been involved in the development and implementation of earlier editions of this recovery plan and no indigenous community has shown any interest in the conservation of the Western Swamp Tortoise. Should any indigenous community express a wish to be involved, every consideration will be given to facilitating that involvement. 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.

3.4 Benefits to other species and ecological communities

The threatened ecological community 'Forests and woodlands of deep seasonal wetlands of the Swan Coastal Plain (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 (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 (community type 8)' 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 *Anigothanthos humilis ssp. chrysanthus* and *Villarsia submersa* also occur in Mogumber Nature Reserve. These threatened species and ecological communities will be benefit from management of the nature reserves as prescribed in this recovery plan.

3.5 Social and economic impacts

The implementation of this recovery plan is unlikely to cause significant adverse social and economic impacts. All populations are within nature reserves. One translocation area identified is on Commonwealth land within Perth Airport, but the area in question has been zoned for conservation in the Perth International Airport Master Plan and Environmental Strategy.

4. GUIDE FOR DECISION-MAKERS

Possible future actions that may constitute '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 and 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 to the extent that water quality in the swamps was lowered,
- subdivision of the land near Twin Swamps and Ellen Brook Nature Reserves to urban or near urban levels, thus 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 within the reserves be controlled, and/or
- developments or actions that increase the number of ravens and rats in the area of the reserves.

5. RECOVERY ACTIONS

The Western Swamp Tortoise Recovery Team described in 1.6.9 will continue to meet regularly to coordinate the implementation of this Recovery Plan. Recovery Action costs presented below are shown by calendar year.

5.1 EMPLOYMENT OF CHIEF INVESTIGATOR

The successful implementation of this plan is dependent on the continuing employment of the Chief Investigator, currently Dr Gerald Kuchling, Research Fellow at The University of Western Australia (UWA). Because Dr Kuchling's tasks vary from year to year, his salary and travel costs are provided here rather than under several recovery actions. Dr Kuchling is employed half-time on this project and UWA charges a 15% overhead.

Cost:	2003	2004	2005	2006	2007
	\$ 49,990	\$ 51,000	\$ 52,500	\$ 54,000	\$ 55,500

Responsibility: The Department (WA Threatened Species and Communities Unit) and UWA.

5.2 MANAGEMENT OF ELLEN BROOK, TWIN SWAMPS AND MOGUMBER NATURE RESERVES

5.2.1 Management of Ellen Brook Nature Reserve

5.2.1.1 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 1.6.4.3 above. Rabbit control, fox 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 fulfill requirements of Agriculture Western Australia in relation to noxious weeds. The fox-proof fence is deteriorating and requires progressive replacement.

Cost:	2003	2004	2005	2006	2007
Reserve management	\$18,900	\$19,700	\$20,400	\$21,300	\$22,100
Fence replacement	\$10,000	\$10,000	\$10,000	\$10,000	\$10,000
Total	\$28,900	\$29,700	\$30,400	\$31,300	\$32,100

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

5.2.1.2 Rehabilitation of purchased land

The land already purchased (Reserve A42126) for addition to Ellen Brook Nature Reserve, while retaining some native vegetation, is only marginally suitable for the Western Swamp Tortoise. The remaining swamps are small and shallow and there are no aestivating tunnels (leaf litter is also largely absent and is considered to be unsuitable aestivating habitat on this soil type).

Since the land was purchased, several small 'swamps' have been constructed within it (using machinery supplied as a sponsorship by Midland Brick Pty Ltd) and depth gauges installed and monitored. As well, the Recovery Team commissioned a report on rehabilitation options from consultants I.R. and P.M. Lantzke. They reported (I.R. and P.M. Lantzke 1994) that rehabilitation would require extensive input, especially of labour, over a long period of time and made 14 recommendations concerning procedures to be followed.

Rehabilitation commenced in 1996, with seed collection, the raising of

Cost:	2003	2004	2005	2006	2007
	\$5,000	\$5,000	\$5,200	\$5,200	\$5,400

Responsibility: The Department (Swan Coastal District). Costs are salaries, overheads, labour and materials. Increased costs in 2000 are for major fence maintenance.

5.2.2 Management of Twin Swamps Nature Reserve

5.2.2.1 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. Artificial aestivating tunnels will be installed to minimise the risk of tortoise death during wildfires. Fox, rabbit, rat, raven and kookaburra 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 requirements of Agriculture Western Australia in relation to noxious weeds.

Cost:	2003	2004	2005	2006	2007
	\$20,100	\$20,900	\$21,800	\$22,600	\$23,500

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

5.2.2.2 Pumping groundwater to maintain swamps and monitoring of food in swamps

The Western Australian Water Corporation installed a bore and pipelines by way of sponsorship of the Recovery Plan; the Corporation also agreed to maintain the bore. The Recovery Team has prepared a pumping protocol to guide the Department 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.

Studies on the effects of groundwater pumping have commenced 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 the Department. Collections of invertebrates from the swamps commenced in 1991, and the samples have been sorted and identified. A sampling program for invertebrates has been designed and has been implemented by Dr Stuart Halse, Science Division. Funds are required to pay for the sorting and identification of the samples. Sampling was carried out annually during 1992, 1993 and 1994, and thereafter will be carried out every second year.

Cost:	2003	2004	2005	2006	2007
	\$2,000	\$2,000	\$12,000	\$2,000	\$2,000

Responsibility: The Department (Swan Coastal District and Science Division). Costs are for running the bore (electricity) \$2000 per year and invertebrate sampling (\$10,000 every three years).

5.2.3 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 regular fox baiting. A creek running south through the eastern edge of the nature reserve has become salt in the last decade or so. This is believed to be due to saline run-off from the Darling Scarp; however, if it affects local groundwater it may threaten the long-term viability of the swamps into which western swamp tortoises have been introduced. A consult was contracted in 2001 to provide a preliminary report on salinity issues and in 2002 a more comprehensive study involving groundwater monitoring was commissioned.

Cost:	2003	2004	2005	2006	2007
	\$34,200	\$14,800	\$15,400	\$16,000	\$16,600

Responsibility: The Department (Swan Coastal District).

5.2.4 Monitoring of water depths and water chemistry

Water depths are measured at depth gauges in five swamps in Twin Swamps Nature Reserve, two sites within Ellen Brook Nature Reserve, five sites with Reserve A42126, one site on land owned by Midland Brick and two sites in Mogumber Nature Reserve. Measurements are taken whenever people visit the reserves. Water chemistry analyses are carried out annually of samples taken at five of the depth gauges at Ellen Brook Nature Reserve (one is on Midland Brick land to the west), four at Twin Swamps Nature Reserve and two at Mogumber. This work will continue.

No additional funds are required for water depth measurements as this is carried out during other work. The cost of water chemistry analyses averages \$4000 per annum.

Cost:	2003	2004	2005	2006	2007
	\$4,000	\$4,000	\$4,000	\$4,500	\$4,500

Responsibility: The Department (Swan Coastal District), all staff visiting reserves. Costs are for water chemistry analysis.

5.3 TORTOISE POPULATION MONITORING

Western Swamp Tortoises are captured at all three 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 on a card index and a computer database. Population estimates are calculated annually.

Cost:	2003	2004	2005	2006	2007
	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000

Responsibility: The Department (Science Division). Costs are salaries.

5.4 CAPTIVE BREEDING

5.4.1 Existing captive breeding colony

The extremely small size of the 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 the Department. 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 will be guided by results of continuing 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 2003-2007. Perth Zoo will continue to provide keeper time to maintain the captive colony and incubation facilities.

Cost:	2003	2004	2005	2006	2007
	\$99,500	\$104,500	109,500\$	\$115,000	\$121,000

Responsibility: Perth Zoo with advice from UWA Zoology Department. Costs are keeper employment and overheads.

5.4.2 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 has decided to host the second colony and preparations are underway to allow a transfer of animals from Perth. The establishment of this second breeding colony will be at no cost to the Recovery Team.

Now that Perth Zoo can produce significant numbers of juvenile tortoise each year, the Recovery Team sees merit in establishing a third captive colony at a zoo in another country as this would provide further safeguards and also, perhaps, additional financial support for the recovery plan.

A further action will be to trial the experimental establishment of a semi-captive ‘insurance’ colony of at the Harry Waring Reserve managed by UWA or some other site. The Harry Waring Reserve already has fox-proof fencing and a caretaker onsite. A swamp area (“Melaleuca Swamp”) in the eastern part of the reserve will be fenced with a low, tortoise-proof fence. Some artificial swamp areas will be sealed with plastic sheets in order to provide standing water from June to November. Artificial aestivation holes will be provided. This area will be stocked with captive-bred hatchlings to monitor if hatchlings and juveniles can be raised under these extensive conditions (as opposed to the intensive management at Perth Zoo).

Costs to be determined.

Responsibility: UWA Zoology Department. Costs are material and maintenance costs.

5.5 TRANSLOCATIONS

5.5.1 Re-introduction to Twin Swamps Nature Reserve and to Mogumber

Release of *P. umbrina* at Twin Swamps Nature Reserve commenced in September 1994. Translocations to Twin Swamps Nature Reserve between 1994 and 2001 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.

Release of *P. umbrina* at Mogumber Nature Reserve commenced in 2000 and will continue under this edition of the Recovery Plan. The area of private property purchased by the Western Australian government as a conservation reserve contains three clay swamps, which are relatively similar to those at Ellen Brook Nature Reserve and are surrounded by Banksia woodland. During 1999, the swamps held water until early December—longer than those at Twin Swamps Nature Reserve; however, rainfall at Mogumber was well above average in 1999. The Department concluded negotiations to purchase the land in mid-2000. In 1999, the Recovery Team decided that, if the purchase went ahead, the area will be fox-baited and a trial translocation utilising sub-adult captive-bred tortoise should proceed in 2000 or 2001, subject to the necessary approvals. After approval of a Translocation Proposal, six captive-bred tortoises were released at Mogumber in winter 2000 as a trial translocation to evaluate the site’s suitability. Three of these animals were known to have survived the first summer. In 2001, 20 tortoises were released; nine of these were radio-tracked and six were known to have survived the 2001/02 summer.

Translocations will continue. About 30 sub-adult tortoises of about 100 g will be released in each of 2003, to 2007, with most animals being translocated to Mogumber. If another translocation site becomes available (see 5.5.2.1) some tortoises will be released there. A proportion of animals released will be fitted with miniature radio-transmitters and their fate monitored closely for about one year. A few animals will be radio-tracked for several years.

Cost:	2003	2004	2005	2006	2007
	\$ 8200	\$ 8200	\$ 9000	\$ 9000	\$ 9000

Responsibility: UWA Zoology Department and the Department. UWA costs are \$4200 vehicle. Department costs are \$4000 per year for radio transmitters.

5.5.2 Translocation to additional sites

The habitat in both Ellen Brook and Twin Swamps Nature Reserves is judged to be marginal and both require intensive management for the populations 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 a Western Swamp Tortoise population can be successfully established at Mogumber Nature Reserve. 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.

5.5.2.1 Selection of suitable translocation sites

Investigations have been made of possible translocation sites. The status of these is as follows:

Perth Airport. The Recovery Team's preferred site for a translocation is the northern edge of Perth Airport.

A Western Swamp Tortoise was recorded in a swamp at Perth Airport in September 1970. During 1995, an intensive 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 Department (Kuchling and Burbidge 1996). The report concluded:

1. The Western Swamp Tortoise has inhabited swamps and associated vegetation at Perth Airport within the past few decades, which equates to only one or two generations of this long-lived, slow-growing species.
2. No Western Swamp Tortoises were detected during the 1995 survey. However, the species is very difficult to detect when it is in low numbers. Based on the present level of information the species can not be considered locally extinct at the airport.
3. Some swamps within Perth Airport land provide suitable habitat for the Western Swamp Tortoise, a Critically Endangered Species specially protected under Commonwealth and Western Australian legislation. Western Swamp Tortoises could survive and breed in these swamps with minor changes to land management practices (mainly the exclusion of foxes) and they constitute 'habitat' as defined in the Endangered Species Protection Act.
4. Additional swamps and adjacent areas could be made suitable as Western Swamp tortoise habitat with modification to the drainage system and current land management practices. These area, also, are 'habitat' as defined in the ESP Act.
5. Areas within Perth Airport proposed as a Business Park do not contain swamps currently suitable as habitat for the Western Swamp Tortoise, with the exception of one swamp, FMC8, which should be excluded from the Business Park and added to the proposed Five Mile Swamp centre group conservation area. It may be possible to rehabilitate Swamps FMS2 and FMS3 so they become suitable habitat for the Western Swamp tortoise (see Discussion), but further investigations of the flooding regime and groundwater levels are required.

The report recommended that areas within Perth Airport be set aside for the conservation of the Western Swamp Tortoise and that once this had been done, translocations of captive-bred animals occur. Representatives of the Recovery Team met with the General Manager, Perth Airport in November 1996. He indicated that the FAC would support translocations as long as they did not conflict with the FAC's Plans for Perth Airport as shown in *Perth Airport Draft Planning Strategy (1996)*. In 1997, the Recovery Team prepared a proposal for consideration by Westralia Airports (the new owners of Perth Airport), Environment Australia and the Department. Also in 1997, the Department wrote to Westralia Airports seeking their approval for the plan to reintroduce tortoises to airport land. Westralia Airports' reply stated that they were required to prepare a Master Plan and Environmental Strategy, for Ministerial endorsement and that the proposal would be considered as part of the Plan. The draft Plan was released for public comment in early 1998, sent to the Commonwealth Minister for Transport in mid-1998 and approved in May, 1999. The plan proposed that reintroduction would be the subject of further studies and negotiation. In 1999, the Department, the WA Water and Rivers Commission and Westralia Airports Corporation agreed to investigate groundwater levels and the possible effects of runway extension in order to assist Westralia Airports reach a decision.

In July 2000, Westralia Airports advised that hydrological investigations had shown that the target swamps would be affected by the extension of runway 06/24 and the associated relocation of the Perth Airport Northern Main Drain and that they were not prepared to support the translocation. The Water and Rivers Commission reviewed this work and reported to the Department that the 'Commission is of the opinion that while there will be an impact on the wetlands because of altered groundwater flows by the proposed drain, the level of impact may not be as high as that estimated by PPK. The magnitude of decline in groundwater levels around the wetlands and the suitability of the Western Swamp tortoise to survive under such modified conditions will need to be assessed.' The Recovery Team decided that, even though there may be detrimental effects on the swamps if the runway extension was constructed, an experimental translocation should proceed. The Department has asked

Westralia Airports to review its decision, but no reply has been forthcoming. No estimated costs of translocation to Perth Airport are included in this plan at present, as it is unclear whether the translocation will proceed.

Swamps on the east side of Peel Inlet (nature reserve): These are considered unsuitable and no further work will be carried out.

RAAF land west of Pearce: Although a photograph of a Western Swamp Tortoise from this site has been given to the Department, this land is considered to be unsuitable for translocation and no further work will be carried out.

Caversham RAAF land: Arrangements were made with the Defence Estates Organisation to block drains within the Caversham land so additional assessment could be made during the 1999 winter and spring. In late 1999, the Recovery Team decided that the northern half of this land was suitable as a translocation site for the Western Swamp Tortoise and advised the Defence Estates Organisation accordingly. Translocations to this land will be expensive, as a fox-proof fence would be needed. The Department of Defence is considering selling this land for housing. In December 2000, the Recovery Team decided to ask the Department to approach the Department of Defence seeking the reservation of the northern half of this land for the conservation of the Western Swamp Tortoise. The Department has sought this land via the 'Bush Forever' planning process.

Drummond Nature Reserve: Translocations to this reserve will be expensive, as a fox-proof fence would be needed. The site is considered to be marginal at best and no further work is proposed in the immediate future.

Dobaderry Swamp: This area is within Wandoo Conservation Park and fox control is already carried out under the Department's 'Western Shield' program. However, it is well outside the species' natural range and winters are colder and summers hotter than on the Swan Coastal Plain. Water depths and temperature were monitored during 1999. After considering available information, the Recovery Team decided that the area is not a suitable translocation site.

Additional sites. A project was initiated in 2000 to be completed in 2002 to use GIS data and other remote sensing information to attempt to identify other areas between Mogumber and Pinjarra that may be suitable for translocation. Any areas identified will be then examined on the ground.

Responsibility: UWA Zoology Department and the Department (WA Threatened Species and Communities Unit, Information Management Branch). Costs are covered under 5.1.

5.5.2.2 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: The Department (Swan Coastal District). Costs will be estimated once a site is approved.

5.5.2.3 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: UWA Zoology Department and the Department (Science Division).

5.6 EDUCATION, PUBLICITY AND SPONSORSHIP

5.6.1 Education and publicity

The Recovery Plan described here is 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.

The Department and Perth Zoo, in cooperation with other relevant organisations, will coordinate a public education program on the Western Swamp Tortoise and on the measures being undertaken to prevent its extinction. Press releases, pamphlets, 'open days' at the reserves and other appropriate publicity and education materials will be employed as appropriate.

Cost:	2003	2004	2005	2006	2007
The Department	\$1,500	\$1,500	\$1,500	\$1,500	\$1,500
Perth Zoo	500	500	500	500	500
Total Cost	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000

Responsibility: Corporate Relations Division, Perth Zoo, UWA Zoology Department. Costs are salaries.

5.6.2 Sponsorships

In recent years 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 Department and Perth Zoo, and grants from the Natural Heritage Trust, money, equipment, substantial discounts on purchases or direct assistance have come from:

Aherns Pty Ltd
British Chelonia Group
Bundesverband für fachgerechten Natur-und Artenschutz (Germany)
Chelonia Institute
Deutsche Gesellschaft für Herpetologie und Terrarienkunde (DGHT)
East-West Veterinary Supplies
Endangered Species Program, Environment Australia
Kailis Brothers
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
World Wide Fund for Nature Australia
Zoology Department, The University of Western Australia.

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.

Cost:	2003	2004	2005	2006	2007
The Department	\$1,500	\$1,500	\$1,500	\$1,500	\$1,500
Perth Zoo	500	500	500	500	500
Total	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000

Responsibility: Recovery Team. Costs are salaries.

EVALUATION

The Western Swamp Tortoise Recovery Team will evaluate implementation of this Recovery Plan annually. The Recovery Team reports annually on the implementation of the Plan to the Department's Corporate Executive and funding agencies. As the species will still be critically endangered at the end of term of the current plan in 2007, the Western Swamp Tortoise Recovery Team will prepare a further edition of the Plan before it expires.

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GLOSSARY

aestivation, dormancy during the summer.

allantois, sac-like outgrowth of gut that grows during embryonic development outside the embryo proper to lie in wall of yolk sac in birds and reptiles. Respiration takes place via blood vessels in the allantoic membrane. Allantoic – adjective.

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.

husbandry (of animals), careful management.

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.

oviposition, egg-laying

palpation, examination by the sense of touch.

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.

pygal, a bone forming part of the carapace of a testudinid.

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).