019565

WESTERN SWAMP TORTOISE

RECOVERY TEAM

ANNUAL REPORT

1998

by Andrew Burbidge, Gerald Kuchling, Lyndon Mutter and Dean Burford

for

The Western Swamp Tortoise Recovery Team

Property and copyright of this document is vested jointly in
the Director, National Parks and Wildlife Service, Environment Australia, and
the Executive Director, Western Australian Department of Conservation and Land Management

The Commonwealth disclaims responsibility for the views expressed

Department of Conservation and Land Management
Western Australian Wildlife Research Centre
PO Box 51, Wanneroo, WA 6065

Summary

It is a pleasure to report that during the past year there has been continuing progress towards implementing the actions contained in the Western Swamp Tortoise Recovery Plan and that implementation continues to be on schedule. Highlights of the year included:

- Monitoring of the population at Ellen Brook Nature Reserve continues to suggest a gradual increase in the number of tortoises over the past decade, but most of these are juvenile animals. The increase has been sustained since the fox-proof fence was constructed around the tortoise habitat in the reserve in 1990.
- Perth Zoo currently holds 172 tortoises comprising 7 adult males, 14 adult females and 151 juveniles. Thirty-six hatchlings were obtained in 1998 from eggs laid in 1997 at a hatching rate of 84% .
- Groundwater was pumped to North West Swamp, Twin Swamps Nature Reserve early July until the third week of November. Both 1997 and 1998 winters had below average rainfall and without groundwater pumping, the Western Swamp Tortoise population at Twin Swamps would not have fared well; nor would translocations have been possible. No monitoring of invertebrates was undertaken in 1998 because of lack of funding from the Endangered Species Program.
- Twenty-two tortoises, bred and raised to about 100 g body weight at Perth Zoo, were released at North West Swamp, Twin Swamps Nature Reserve, in August 1997. Four hatchlings were also released.
- The inadequacy of raven control programs over the past few years led to a new project being designed and implemented. From 24-28 November, volunteers from CALM staff based at Perth District and the WA Wildlife Research Centre patrolled North West Swamp from first light to dark. A shotgun was used to scare ravens away. This project was successful as no predation on juvenile tortoises was recorded during 1999.

Two matters of concern are:

- The slow rate of progress in finalising a new translocation site. Negotiations with Westralia Airports Corporation slowed because of the need for them to prepare a Master Plan and Environmental Strategy. Concern has also been raised by WAC staff that future runway extension earthworks may affect the swamps proposed for translocation. This has been referred to the Waters and Rivers Commission for advice.
- The delayed response by Environment Australia to the Recovery Team's 'major project review' sent to them in October 1997 and to the Team's request for further funding assistance. Funds to contract the major project investigator (Dr Kuchling) have nearly run out and some areas of work have been cut back or not carried out.

INTRODUCTION

The Western Swamp Tortoise Recovery Team first met in December 1990. It grew from the very successful Western Swamp Tortoise Captive Breeding Management Committee, which was set up in 1987 and which was a runner-up for the IBM 1990 Conservation Award.

At the end of 1998 Team membership was:

Dr Andrew Burbidge, CALM, WA Threatened Species and Communities Unit, Chair
Professor Don Bradshaw, Zoology Department, The University of Western Australia
Mr Dean Burford, Perth Zoo
Mr Phil Fuller, CALM Science and Information Division
Dr David Groth, Department of Biomedical Science, Curtin University of Technology
Mr Colin Hyde, Perth Zoo
Dr Gerald Kuchling, Zoology Department, The University of Western Australia
Mr Lyndon Mutter, CALM Perth District
Ms Sandra McKenzie, National Threatened Species network, World Wide Fund for Nature Australia

During 1998 the Team met twice: in June and November. Although the Team works together on many projects, primary responsibilities have been established as follows:

Management of Nature Reserves and rehabilitation of habitat	Lyndon Mutter and Rod Martyn, CALM Perth District
Reserves water depth and quality and population monitoring	Phil Fuller & Andrew Burbidge, CALM Science & Information Division
Ecological studies and translocation	Gerald Kuchling, UWA Zoology Department
Captive breeding	Dean Burford, Perth Zoo, with advice from Gerald Kuchling
Conservation genetics	David Groth, Curtin University
Perth Airport proposed re-introduction	Andrew Burbidge and Gerald Kuchling

RECOVERY PLAN AND FUNDING

During 1991 a Recovery Plan for the Western Swamp Tortoise was prepared, based on the Management Program published in 1990. The Recovery Plan covers a ten year period from 1993 to 2002 and lists actions necessary to ensure the species' continued recovery. In July 1993, the Recovery Plan was formally endorsed by CALM's Corporate Executive and in December 1993 it was endorsed by the National Parks and Nature Conservation Authority, in which the three nature reserves are vested. The Plan was formally endorsed by the Minister for the Environment and was published by CALM during 1994 and has been given administrative acceptance by the Commonwealth Minister of the Environment (the Commonwealth *Endangered Species Protection Act 1992* does not allow adoption of recovery plans for species that occur on both Commonwealth and State lands).

The objective of the Recovery Plan is to decrease the chance of extinction of the Western Swamp Tortoise by creating at least two wild populations and doubling the total number of individuals. Because of the species' low fecundity, slow growth rates and long time to sexual maturity it will not be possible to achieve up-listing from Endangered (old IUCN categories) or Critically Endangered (new IUCN categories) within the 10 year time frame of the Recovery Plan.

Four actions were prescribed in the Recovery Plan:

1. Management of Ellen Brook Nature Reserve, and wild population.
2. Captive breeding.
3. Re-introduction to Twin Swamps Nature Reserve.
4. Education, publicity and sponsorship.

Implementing the actions was estimated to cost a total of $1 676 000 over the Recovery Plan's ten year period. Funding has mainly come form Environment Australia through the Endangered Species Program,

Perth Zoo and CALM. Several sponsors have assisted with various aspects.

Funding from the Endangered Species Program was for five years and this period concluded at the end of 1997. A review of the success of the Plan over the first five year period was prepared by the Recovery Team in October 1997. A revised draft Recovery Plan for 1998-2002 was prepared at the same time and attached to the review. At the time of writing this report, Environment Australia have advised that funding would be continuing in line with the revised recovery plan, but that the Commonwealth required an external review of the Recovery Plan and its implementation. Advice is still to be received concerning the proposed review. The Recovery Team has decided to finalise the revised draft Recovery Plan after the review is completed and seek its approval and adoption.

Possible future translocation sites

Perth Airport. A Western Swamp Tortoise was recorded at Perth Airport in 1970 and a search for Western Swamp Tortoises and an examination of the swamps there was conducted during 1995. No Western Swamp Tortoises were located during the 1995 survey. The report concluded, however, that the Perth Airport land contained that was suitable swamp tortoise habitat and that translocations to Perth Airport should be considered. The Team also examined four other areas as possible translocation sites - Drummond Nature Reserve near Toodyay, Austin Bay- Nature Reserve (Reserve No. 4990) on the eastern side of Peel Inlet and Dobaderry Swamp in Wandoo Conservation Park. After assessing all areas, the Recovery Team concluded that Perth Airport provided the best chances of successful translocation because it was the only remaining significant area of habitat within the species' known range and because Western Swamp Tortoises are known to have occurred there. The Team also decided to investigate whether Western Swamp Tortoises can grow and breed east of the Darling Scarp under captive conditions.

Following a recommendation from the Recovery Team, CALM wrote to Westralia Airports Corporation, the new owners of Perth Airport, seeking their endorsement of a proposal to re-introduce Western Swamp Tortoises to Airport land. It should be noted that the airport land is and will remain Commonwealth land and is subject to Commonwealth law, including the provisions of the Commonwealth Endangered Species Protection Act 1992, rather than State law. In their response Westralia Airports stated:

"It is a requirement of the Airports Act 1996 that the Westralia Airports Corporation prepare a Master Plan and Environmental Strategy, for Ministerial endorsement, detailing the proposed development and management of the Airport asset over the next twenty year period. The preparation of these documents will involve a comprehensive public consultation process prior to submission to the Minister, by 1 July 1998. The WAC Board has therefore resolved that the question of the possible translocation of the tortoise be addressed during the preparation of the above documents and that a recommendation be included in the final report.

"In the interim the Corporation will continue to manage the areas identified by the Tortoise Recovery Team in accord with previous practice."

Recent advice from Westralia Airports Corporation is that they are concerned that future runway extensions and other work may deleteriously affect the swamps. In response to this, CALM arranged for an evaluation of the groundwater in the area by the Waters and Rivers Commission, who advised that, although there is a lack of monitoring bores in the area it is unlikely that runway extension construction will have any impact on groundwater flows into the swamps. However, the Commission considered that there was a possibility of groundwater contamination from airport facilities and this needs further investigation. The Recovery Team will continue to explore this proposal with Westralia Airports.

Caversham. In November, Drs Kuchling and Burbidge inspected Commonwealth land managed by the Defence Estate Organisation, Department of Defence, near Pearce and at Caversham. The land near Pearce was judged unsuitable for re-introduction of the swamp tortoise; however, the Caversham land was judged to be possibly suitable. This land was an aerodrome during World War Two and is currently used for communications towers. Swamps in the area were drained when the runways were constructed. The Defence Estate Organisation has agreed to block the drains that currently maintain low water levels in the swamps so a more detailed evaluation of the area can be made in 1999.

RECOVERY PLAN IMPLEMENTATION

Progress with the actions laid down in the Recovery Plan is as follows.

3.1 MANAGEMENT OF ELLEN BROOK NATURE RESERVE AND WILD POPULATIONS

3.1.1 Management of fire, predators, etc.

Routine management of the nature reserve continued as in past years. Two 1080 baiting programs were undertaken. The system of strategic firebreaks was maintained. No wild fires occurred on the reserve.

Minor repairs were made to the vermin proof fence. The Ellen Brook Nature Reserve vermin proof fence, the first attempt at a vermin proof fence by CALM, is not as robust as the later Twin Swamps Nature Reserve vermin proof fence, and requires considerably more maintenance. With continued maintenance the life expectancy of this fence will certainly extend beyond the term of the current recovery plan, but will be shorter than the Twin Swamps fence.

Control of the weed Watsonia was undertaken with all plants in the vicinity of the vermin proof compound being removed. Paterson's Curse and Cape Tulip control was also undertaken. Summer control of African Lovegrass will be undertaken in areas adjoining Great Northern Highway following slashing to reduce the risk of fire entering the reserve from Great Northern Highway.

3.1.2 Removal of the "nature reserve drain"

This action was completed in 1995.

3.1.3 Rehabilitation of purchased land and creation of additional habitat on existing nature reserve

Rehabilitation
Depths of the shallow "ponds" constructed some years ago in Reserve A42126 were monitored as before.

Four hundred seedlings propagated from seed collected from the nature reserve were planted around the shallow ponds, and direct seeding was undertaken in a trial area. Significant effort was made to control weeds in areas being revegetated. This involved conducting a controlled burn in autumn to remove all standing grass and promote germination of the weed seed bank to allow effective control. Several herbicide treatments were undertaken in early winter prior to the site becoming waterlogged. This control initially appeared to be effective with low weed density during winter, however a dense growth of weeds developed in spring and early summer. As the area was still waterlogged at this time, it was not considered acceptable to use herbicides. Instead, hand weeding was undertaken around the seedlings. A good level of survival has been achieved with the plantings. The direct seeding has been of limited success because of the dense weed growth.

The revegetation prescriptions are being updated based on this year's experience, and will involve planting of seedlings rather than direct seeding, and the use of weed suppressing mats to control weeds around seedlings. Herbicides will only be used in summer to control Kikuyu, not in winter when the area is waterlogged. The density of weeds will gradually decrease as revegetated areas mature with shading and build up of leaf litter, as has been observed in Acacia regrowth areas on the reserve.

The next stage of plantings will be undertaken in 1999. Seed collection will continue this summer.

Acquisition of additional land adjacent to Ellen Brook Nature
The land swap arrangement with the owner of adjacent Lot 5 to swap an area of Lot 5, which is suitable to rehabilitate for the Western Swamp Tortoise, for a section of the nature reserve unsuitable for the Western Swamp Tortoise and that is disturbed has the necessary approvals and is still being processed by the

Department of Land Administration. An adjoining neighbour to the Nature Reserve has expressed concern at the land swap. The Shire of Swan advised CALM this neighbour had been informed of the land swap proposal with a request they contact CALM if they had any concerns. The neighbour claimed they did not receive this advice. CALM is negotiating with them to see if their concerns can be satisfied.

3.1.4 Extension of fox-proof fence

Vermin proof fencing of the new section of nature reserve to the south of the original nature reserve was completed in 1995.

Further fencing will need to be undertaken in future years to enclose other areas of habitat once acquisition is complete.

3.1.5 Population monitoring

In 1998, activities at EBNR focused on monitoring water levels, recapturing tortoises for the population estimates, and the experimental repatriation of some of the tortoises which were originally collected on the new block (when it was still privately owned) or on private property close by. During winter of 1998 the fence was removed between the old and the new, rehabilitated fox-proofed fenced areas of Ellen Brook Nature Reserve. This allowed the release of four male tortoises, which were equipped with radio transmitters, during the spring of 1998 .

Radio-tracking

Four radio-transmitter-equipped adult male *P. umbrina* were released into the new, rehabilitated part of Ellen Brook Nature Reserve during October 1998. All these males were originally found outside the then boundary of Ellen Brook Nature Reserve and have been kept for a number of years in the captive colony at Perth Zoo. Two of these individuals were originally collected in the newly rehabilitated and now reserved area, one in 1990 and one in 1996. The two other individuals were collected at neighbouring properties to the west, one in a swamp on the Midland Bricks land in 1992 and the other one in a dam about 20 m from the reserve boundary on the property of Mr Smith, also in 1992.

All four males were released on 18 October 1998 into the pool at depth gauge # 4. Two males stayed in that pool until it dried out in early November. The two other males had left the pool by late October and moved for some days along the western fence, but both returned into pools in the new, rehabilitated area by early November. Unfortunately, one of the transmitters failed by the middle of November and two more during late December. Two of the then three radio-tracked males started to aestivate in early December, one in a rabbit warren at the boundary between the old and the new reserve areas and one in an artificially constructed aestivation site (half concrete pipes buried under an earth mound) in the rehabilitated area. The third male had moved into the old, partially filled in dam in the southern portion of the new area by the middle of December. This dam had still water by the end of 1998, but by then only the transmitter of the male in the rabbit warren was still working.

Although the early failing of three of the four radio-transmitters is disappointing, the radio-tracking results do suggest that the new, rehabilitated area now offers swamps of an adequate quality for Western Swamp Tortoises. Furthermore, the fact that one of the then three radio-tracked tortoises started to aestivate in one of the two experimental, artificial aestivation sites suggests that the provision of artificial aestivation sites can be a useful strategy to restore degraded habitat areas.

Mark - Recapture

Twenty tortoises without radio transmitters were handled at Ellen Brook Nature Reserve during 1998, 14 of them during a major searching effort on 11 November. Five of the 20 tortoises were hatchlings from 1998 which, at the end of their first growing season, had body masses of 17.0, 24.0, 24.7, 27.0 and 28.0 g. Thus, four of the five hatchlings had reached body masses well over 20g, indicating good growing conditions for hatchlings at Ellen Brook Nature Reserve during 1998.

Monitoring of the only wild population at EBNR continued by mark-and-recapture methods. Unfortunately, only five tortoises were handled during 1997, fewer than during the past few years - this was due to the focus of research shifting to Twin Swamps Nature Reserve (TSNR) and to very hot weather shortly before the swamps dried, causing the animals to leave the water just before a major searching effort took place. In 1998, however, the catch at the end of the season was successful. Table 1 shows the number of tortoises in the EBNR population known to be alive since 1963 and also provides estimates of population size using the Manly & Parr method, which utilises mark and recapture data and known date of hatching. Because of the small population size, and the small sample size in most years, it is not a very reliable method of estimating total population size and the Manly & Parr estimates given in Table 1 should be viewed with caution. No more reliable method of estimating population size exists. Table 1 shows a gradual increase in the number of *P. umbrina* through the 1980s and 1990s, but most of these are juvenile animals. These data (and data for TSNR, Table 3) now represent one of the longest population monitoring data sets in Australia.

Table 1. Ellen Brook Nature Reserve, Western Swamp Tortoise Population Estimate - 1998

Year	No. captured	KTBA	Manly & Parr estimate
1963	4	21	-
1964	9	22	48
1965	3	18	48
1966	4	17	21
1967	2	16	30
1968	5	16	19
1969	1	15	15
1970	3	18	-
1971	0	17	-
1972	6	18	20
1973	0	20	-
1974	2	21	40
1975	3	21	30
1976	9	21	24
1977	3	20	20
1978	8	22	36
1979	4	22	22
1980	8	24	29

Year	No. captured	KTBA	Manly & Parr estimate
1981	8	27	30
1982	10	29	37
1983	5	32	73
1984	10	37	100
1985	7	36	58
1986	2	34	34
1987	6	35	41
1988	5	37	85
1989	17	36	39
1990	12	35	40
1991	21	33	34
1992	22	36	45
1993	25	39	48
1994	35	46	59
1995	18	29	38
1996	11	21	39
1997	6	15	20
1998	22	22	-

Notes:

1. KTBA - known to be alive
2. 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 a '-'

3.1.6 Interim Guidelines for Necessary Operations

These guidelines were completed in 1997.

3.2 CAPTIVE BREEDING

This year saw the construction of an exhibit displaying Western Swamp Tortoises for the first time in 20 years. The exhibit explains the plight of the WST, from the reasons for its decline to the current efforts in captivity and the field to prevent its extinction. Tortoises are displayed in as close to their natural habitat as possible. Graphics at the entry of the enclosure depict the unique WST lifecycle. Overall it should aid significantly in increasing public awareness of the recovery program and its achievements to date.

Extensions to the breeding facility were completed. They included the construction of newly-designed aestivation pens and additional holding ponds. The pens are now partly roofed to reduce the amount of rain entering them and have had the height increased for easier servicing. The extensions now give greater flexibility in animal management and help to avoid overcrowding.

In March-April, thirty six hatchlings emerged from 43 eggs, a hatching rate of 84%. A further 46 eggs were obtained this year from 12 females, one of which produced two clutches. Double-clutching, something not recorded in the WST prior to 1994, has now occurred with 4 females since then. Another female spontaneously aborted 4 eggs then later laid a 5th egg in the normal manner; however, it failed to go beyond several days of development in incubation. The cause of the abortion is unknown.

One small egg was laid by an eight-year-old captive-bred female. She was retained in the Zoo, instead of being released, for future breeding and marks the beginning of a second generation of breeders. Obviously this will increase the number and genetic base from which to breed and will increase at a much faster rate the overall number of WSTs. This, while being a good thing, may in the near future put pressure on resources within the captive-breeding facility. One option that is being used to address this situation is to return tortoises currently being used for breeding at the Zoo to areas from which they were acquired several years ago and which have now become part of EBNR. This was done in part this year by releasing four adult males; however, because of the unexplained abortion of the above-mentioned eggs, the planned release of four adult females and the hatchlings they may produce, will be withheld till next year.

Four eggs of a female from TSNR whose genetic input into the project has been minimal, were obtained in 1997 and incubated at the Zoo. Four hatchlings from a more common blood line were then released as a substitute for the four that would have hatched in the reserve. In addition to these, 18 captive-bred juveniles of approximately 100 grams or more were also released for a total of 22 translocations in 1998.

In 1997 growth rates were increased 50% in newly hatched tortoises. This rate continued in 1998 and should be reflected within the next 1-2 years in a higher number of tortoises ready for translocation to the wild.

Skin lesions were a significant health concern in some of this year's hatchlings. They were of the same nature as in previous years but were more persistent, often appearing to respond well to anti-bacterial treatment then re-occurring several weeks later. Results of treatment seemed to improve markedly later in the year as higher water temperatures may have boosted the tortoises' immune system. A close examination of the overall situation will need to be undertaken before any of the previously afflicted hatchlings are placed in aestivation as the health of any tortoise needs to be at a high level to ensure survival during this period. The factors causing the lesions are not entirely clear; however, they are understood to be bacterial infections. The bacteria is probably present in most ponds and attacks only the softest areas of skin and shell, perhaps only when on the odd times several elements combine to create conditions conducive to the bacteria. Only once has more than one pond been affected at any given time.

Initially, the procedure adopted to treat the infection was to withhold the affected hatchlings from water over a two week period while the prescribed antibiotic was applied. Given the time spent in aestivation and therefore being completely out of water is much longer than this (three months), the risk factor was considered virtually non-existent. Unfortunately the stress of the infection combined with no access to water resulted in one death, but this was not a direct result of the infection itself.

In total, two deaths occurred in 1998. The 2nd, also a hatchling, drowned for reasons unknown. This then leaves the number of WSTs in the Zoo at 172. Seven adult males, 14 adult females and 151 hatchlings and juveniles make up this number.

3.3 RE-INTRODUCTION TO TWIN SWAMPS NATURE RESERVE (TSNR)

3.3.1 Construction of fox-proof fence

This action has been completed.

3.3.2 Pumping groundwater to maintain swamps and monitoring of food on swamps.

The pump was used to supplement NW Swamp from early July until the third week of November.

Three of the four dams constructed on the reserve boundaries functioned well providing a water source for any tortoises walking along the fence from early winter until early summer. The fourth dam will require modification this summer.

The bunding put in place in 1997 was strengthened this year and continued to function well, redirecting the flow of water leaving NW swamp to NE swamp rather than being lost from the reserve.

No monitoring of invertebrates was undertaken in 1998 because of lack of funding from the Endangered Species Program.

3.3.3 Translocation

In 1998 the focus at TSNR was on monitoring the tortoises which were re-introduced in previous years and on further re-introductions.

Aestivation - summer 1997/98

Eleven captive-bred juvenile *Pseudemydura umbrina*, plus two adult females and one male were successfully radio-tracked at the start of 1998. On 13 January 1998, two radio-tracked juveniles which had been released during 1997 were found dead under *Regelia* bushes were they had started aestivation. The corpses were dry and, obviously, cleaned out by insects. Not all of their limb bones could be found. The most likely explanation for the cause of their death is that they were damaged by predators after they left the drying swamps and before they reached their aestivation site. Seriously damaged tortoises (e.g. a juvenile which had lost its right front leg, liver and guts in December 1996) have moved away from the swamp to hide in bushland, and two juveniles emerged from aestivation with a front leg each missing in 1996. For this reason, it is assumed that they were damaged by ravens, escaped into the bushland, but died from their injuries.

All other radio-tracked tortoises stayed in holes underground, seven juveniles and one female in *Regelia* shrubland, one juveniles, one female and one male in *Banksia* woodland, and one juvenile in *Acacia* woodland. The holes were either rabbit warrens (8) or shorter foraging holes of rabbits (3) or holes created by timber buried in the mounds at the edges of fire breaks (1). On 19 May 1998, all tortoises, except two juvenile, had left their holes and were sheltering under leaf litter or dead branches under bushes. One of the juveniles that had remained in its hole was looking out of the entry of the hole when tracked. By 15 June

the transmitter of one juvenile had stopped working and all other transmitters were being replaced.

The rains during May and June 1998 did not provide more then a few ephemeral puddles in the swamp areas at TSNR, but three of the five dams build along the fence contained some water by 19 May 1998 and all had water by the middle of June. The ground water pump was turned on in the last week of June and directed into NW Swamp. Until early August 1998, the supplemented NW Swamp and the five dams along the fence provided more or less the only permanent source of standing water (the new depression in E Swamp had also water). By the end of July, two radio-tracked juveniles were still in *Regelia* bushland, but all the other had moved into water.

Translocation 1998

On 12 August 1998, 18 juvenile, captive-bred Western Swamp Tortoises (>95 g) were released at NW Swamp, five of them equipped with radio-transmitters. In addition, four captive-bred hatchlings were released into NW Swamp on 7 October 1998, to compensate for the 1997 clutch of eggs of female #92, which was incubated at Perth Zoo to provide increased genetic diversity in the captive colony.

Radio-tracking

By early October 1998, a total of ten juveniles plus one adult female *P. umbrina* were being radio-tracked. The transmitters of the other juveniles and those of the other adult female had stopped working, the male had shed its transmitter with its carapacial scutes. All except two tracked juveniles either shed their transmitters or the transmitters stopped working during early November. Due to the recapture of nine juveniles during November, a total of 11 juveniles plus one adult female were again being radio-tracked by late November. All tracked juveniles which were released in 1998 remained in NW Swamp until the water disappeared. As discussed below, CALM's raven shooter patrol program from 23-28 November appeared very successful, as no predation by ravens or other mortalities were recorded during the spring of 1998. Most juveniles moved out of the swamp at that time or a few days earlier. By 28 November, all 11 radio-tracked juveniles had moved out of the swamp area and into *Regelia* or *Banksia* bushland where they started to aestivate.

Predation and mortality

The predation events on Western Swamp Tortoises from 1995 to 1997 at TSNR suggested that predators, presumably the Australia Raven, may attack and kill or injure tortoises that leave the water when swamps dry out. All three injured tortoises (Table 1) survived raven attacks, with two of them losing a front leg. At least two of the three recorded mortalities during aestivation seem to have been preceded by injuries, presumably caused by raven attacks when the swamps dried out. The lack of predation on juveniles due to the dawn to dusk patrols of raven shooters at NW Swamp during the critical time in 1998 supports the hypothesis that ravens are the main culprits that kill and injure Western Swamp Tortoises. Predation by ravens seems to be the single most important mortality cause for released juvenile tortoises. Table 2 summarises the recorded mortalities at Twin Swamps.

Table 2. The number of released juveniles >95g and the number of recorded mortalities and injuries per year at TSNR

year	number released	recorded mortalities, active period	recorded mortalities during aestivation	recorded injuries
1994	10	0	0	0
1995	18	3	0	1
1996	7	1	0	2
1997	25	5	1	0
1998	18	0	2	0
total	**78**	**9**	**3**	**3**

Of all recorded mortalities:

10 occurred in the same year the juveniles were released;
1 occurred 1 year after the juvenile was released;
1 occurred 3 years after the juvenile was released.

This suggests that "experienced" juveniles may be slightly less prone to predation than newly-released animals.

The 1998 breeding season

The only female radio-tracked at TSNR during spring 1998 ovulated and was gravid by late October. As happened also in 1994, 1995 and 1997, the nest of this old resident female #77 could not be found. No nests are, therefore, being monitored from the 1998 laying season.

Long-necked Tortoises at TSNR

Two *Chelodina oblonga* were radio-tracked in NW Swamp over the summer of 1997/98 and one in SW Swamp. On 1 October, the two long-necks in NW Swamp were collected and moved outside the fox-proof fence. The long-neck from SW Swamp was moved outside on 24 November. In addition, a further male *C. oblonga* (141.4 mm CL) was collected at NW Swamp on 24 November and moved out of the reserve. A further juvenile (111.1 mm CL) was found in the dam at SW Swamp on 25 November and also moved out of the reserve. Thus, the number of *C. oblonga* recorded at Twin Swamps Nature Reserve since 1994 stands at 17.

The Effect of Earthworks at Twin Swamps Nature Reserve in 1998

All five dams constructed along the fence at TSNR provided at least some water from about the middle of June until early to late November, and one (at NE Swamp) until the middle of December. These dams, thus, fulfilled their purpose during the dry winter of 1998 - to provide water from about June to November. The slight enlargement of most dams in the summer of 1998 improved their function.

The earth dam along the firebreak at the fence at NE Swamp improved the water level in that swamp, once water drained in along the modified firebreak. On 1 October, the two depth gauges showed water levels of 28.8 and 33 cm, but the water had disappeared by early November.

Population monitoring

Table 3 shows the number of tortoises in the TSNR population known to be alive since 1963 and also provides estimates of population size using the Manly & Parr method, which utilises mark and recapture data and known date of hatchling. The same cautions should be noted in interpreting these data as are described above for EBNR. The increase in the number of tortoises since 1994 is due to translocations.

3.3.4 Interim Guidelines for Necessary Operations

A final draft of the Interim Guidelines was completed in 1998.

3.3.5 Management of Fire, Predators, etc

Reserve management of the nature reserve continued as in past years.

Two 1080 fox baiting programs were conducted.

Table 3. Twin Swamps Nature Reserve, Western Swamp Tortoise Population Estimate - 1998

Year	No. captured	KTBA	Manly & Parr estimate
1963	1	53	-
1964	4	75	288
1965	9	97	273
1966	65	101	125
1967	26	76	156
1968	17	62	68
1969	8	61	93
1970	26	59	71
1971	27	52	72
1972	15	40	57
1973	13	34	59
1974	8	29	92
1975	8	24	34
1976	4	21	27
1977	9	20	26
1978	9	18	29
1979	6	13	20
1980	2	10	10

Year	No. captured	KTBA	Manly & Parr estimate
1981	3	10	10
1982	3	11	11
1983	5	11	15
1984	3	9	12
1985	2	8	-
1986	0	6	-
1987	0	7	-
1988	0	7	-
1989	0	7	-
1990	2	7	12
1991	0	6	-
1992	1	6	-
1993	0	5	-
1994	14	16	23
1995	40	45	73
1996	34	35	38
1997	39	39	39
1997	32	32	-

Notes:
1. KTBA - known to be alive
2. 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 a '-'

A raven scaring program was undertaken in 1998 in an effort to reduce mortality in juvenile swamp tortoises, which in past years has occurred when the last swamp dries. Volunteers from CALM staff from Perth District and the WA Wildlife Research Centre were rostered to be present at North West Swamp from dawn to dark each day from 23 to 28 November 1998. A shotgun was used to scare ravens away from the swamp. This project was very successful (see 3.3.3 – 'radio-tracking', and 'predation and mortality').

Prescribed fuel reduction burning was undertaken in two blocks of the reserve during spring, consistent with the Interim Management Guidelines for the reserve. Fuel reduction burning will be involve one third of the reserve, burnt on a 10 year rotational basis to establish internal low fuel areas to minimise the area of the reserve burnt in a wildfire. Burning is undertaken in spring when tortoises are located in the ponds and not threatened by the fire. No wildfires occurred on the reserve. Firebreaks were maintained.

Cape Tulip was controlled on all external and internal fire breaks and on a buffer of 5 metres adjoining breaks. Cape Tulip control is required by the Agriculture Department as part of a local control containment strategy. An infestation of pig melon was removed from the reserve.

The vermin proof fence did not require any maintenance.

3.4 EDUCATION, PUBLICITY AND SPONSORSHIP

3.4.1 Education and publicity

General publicity of the Western Swamp Tortoise Recovery Plan and its implementation continued as in past years.

The educational children's book *Yakkinn the Swamp Tortoise - Survival* (G and G Kuchling, ERA Publications) was short-listed for the Australian Children's Book Council Awards (information books) in 1998. The publicity related to the short-listing helped to disseminate the book and information on the Western Swamp Tortoise.

Papers on the biology of *P. umbrina* were presented by G. Kuchling at the International Conference on Turtles and Tortoises, California State University, 30 July – 2 August, 1998 and at the annual conference of the Australian Wildlife Management Society at the University of Queensland, Gatton College, 1-3 December, 1998.

3.4.2 Sponsorships

The Western Australian Water Corporation sponsored the Western Swamp Tortoise exhibit at Perth Zoo.

A donation of £500 (A$1,354.90) towards equipment for Western Swamp Tortoise research was received from the British Chelonia Group (BCG) in August 1998.

North Tom Price and Kambalda Primary Schools raised money for the recovery of the Western Swamp Tortoise in association with an Internet 'Book Rap' on *Yakkinn the Swamp Tortoise - Survival*, arranged by Heather Jenkins, a teacher at North Tom Price. $350 has been received so far. This donation was the subject of an article in the 'Bush Telegraph' section of *Landscope*, Spring 1998.