WESTERN SWAMP TORTOISE

RECOVERY TEAM

ANNUAL REPORT

1994

by

Andrew Burbidge, Gerald Kuchling, Stuart Halse, Lyndon Mutter and Dean Burford

for

The Western Swamp Tortoise Recovery Team

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

SUMMARY

The past year has been a most significant one for the recovery of the Western Swamp Tortoise with the first release of captive-bred animals at Twin Swamps Nature Reserve. Monitoring of radio-tracked captive-bred tortoises has shown that they are surviving and behaving in a manner similar to wild animals. The release was made possible by the success of the captive breeding project at Perth Zoo, in cooperation with the Zoology Department, The University of Western Australia. It was also made possible by the completion by CALM of a predator-proof fence around the reserve (paid for by the Australian Nature Conservation Agency' Feral Pests Program) and the supplementation from groundwater of swamps, provided as a sponsorship by the Western Australian Water Authority.

Implementation of the Recovery Plan is proceeding on schedule. A total of 35 tortoises, a record, were handled during 1994 at Ellen Brook Nature Reserve, some captures being due to the successful trialing of a new capture-technique. Thirteen of these were hatchlings. Six females and four males were radio-tracked at Ellen Brook NR until June 1994. In late 1993, 36 eggs were obtained from captive stock and nests from Ellen Brook Nature Reserve. From these, 30 hatchlings were produced; two of which were returned to EBNR, leaving 28 to be reared at the Zoo. In late 1994 a record number of eggs was produced; 47 eggs being obtained from 10 of 12 captive females. Thirty-nine were developing normally in December. The total number of Western Swamp Tortoises at Perth Zoo on 13 January 1995 was 112, consisting of 14 males, 12 females and 86 un-sexed juveniles.

A significant event was the finding of two resident adult female swamp tortoises inside the newly fenced Twin Swamps nature Reserve, where the population had been assumed to be extinct. Monitoring of invertebrates in swamps at Twin Swamps continued. Some effects of groundwater pumping at North West Swamp were observed.

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 1990 IBM Conservation Award.

At the end of 1994 Team membership was:

Dr Andrew Burbidge	CALM 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 Graham Hall	Perth Zoo
Dr Gerald Kuchling	Zoology Department, The University of Western Australia
Mr Lyndon Mutter	CALM Perth District
Dr Ray Nias	World Wide Fund for Nature Australia
Mr Terry Sargent	Shire of Swan
Ms Sally Stephens	Endangered Species Unit, Australian Nature Conservation Agency

During the year, the Team welcomed Dean Burford (Perth Zoo), and Terry Sargent, who replaced John Erceg (Shire of Swan). The Team wishes to thank the many people who have helped with various aspects of the Recovery Plan, including Rod Martyn (CALM Perth District), Chris Marmion (CALM Land Administration Branch), Stuart Halse and Alan Clarke (CALM Science and Information Division. We gratefully acknowledge the assistance of the Western Australian Water Authority for the maintenance of a bore and pipelines at Twin Swamps Nature Reserve (see below).

During 1994 the Team met twice: in July and December.

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, CALM Perth District
Reserves water depth and quality, and tortoise population monitoring	Phil Fuller & Andrew Burbidge, CALM Science & Information Division
Ecological studies and translocation	Gerald Kuchling, UWA Zoology Department
Captive breeding	Perth Zoo, with advice from Gerald Kuchling
Conservation genetics	David Groth, Gerald Kuchling, UWA Zoology Curtin University, and Graham Hall, Perth Zoo

RECOVERY PLAN STATUS 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 nature reserves are vested. The Recovery Plan was published by CALM in 1994.

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 uplisting from Endangered (old IUCN categories) or Critical (new IUCN categories) within the 10 year time frame of the Recovery Plan.

Four actions have been 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 is estimated to cost a total of $1 714 100 over the Recovery Plan's ten year period, with $200 100 being spent in 1994 and $174 500 being required for 1995. It is a pleasure to report that most of the 1995 funding has been obtained and that there are strong indications that funds will be available in future years. 1995 funding will come from CALM ($36 200), Perth Zoo ($31 500), and The National Endangered Species Program and The Feral Pests Program, Australian Nature Conservation Agency ($99 300), World Wide Fund for Nature Australia ($7 500), with additional funds coming from reptile societies and other sponsors.

Progress with the actions laid down in the Recovery Plan is as follows. Numbers of Recovery Actions follow those in the Recovery Plan.

3.1 MANAGEMENT OF ELLEN BROOK NATURE RESERVE AND WILD POPULATIONS

3.1.1 Management of fire predators etc

Rabbit control and fox baiting continued in 1994. Rabbits continue to persist at low levels. The reserve is believed still to be fox and cat free.

Fire breaks were maintained. No fires occured on the reserve, although there was one wildfire in close proximity.

3.1.2 Removal of the Nature Reserve Drain.

CALM liaised with the clay mining companies during the design of drainage rediversion (to satisfy their environmental conditions of adjacent development). The design work was completed late in 1994 with the works to be undertaken in January 1995. All drainage from the clay mining areas, Great northern Highway and the major agricultural catchment to the east of the highway will be rediverted around the Western Swamp Tortoise habitat, and the drain through the reserve will be closed.

The clay mining companies will be submitting a regional drainage strategy early in 1995 which makes recommendations on the management of other surface water flows which enter the habitat area from private farmland to the south and south east of the reserve.

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

Rehabilitation

Depths of the shallow 'dams' constructed over the past two years were monitored and analyses of samples were carried out during winter 1994.

A contract was let to I.R. and P.M. Lantzke, Environmental Consultants, to:

(I) Collate existing information on the food chain and the invertebrates of the existing wetlands of Ellen Brook Nature Reserve (Reserve 27620). Recommend methods for developing additional tortoise habitat in Reserve 42126 in terms of shape and depth of wetlands to be excavated and methods for enhancing the rapid development of a food chain that will provide abundant invertebrates of the type eaten by the tortoises. Recommend additional research requirements relating to the development of additional tortoise swamps.

(ii) Prepare a revegetation program for Reserve 42126, encompassing both the wetlands and adjacent drier areas, including weed control methods as appropriate.

(iii) Report on the likely influence on the functioning of rehabilitated areas of water and soil / sediment qualities. Recommend what monitoring should be undertaken of the chemical properties of the newly constructed and rehabilitated wetlands.

The report was received in late November 1994 and is being reviewed by the Recovery Team before the preparation of a works program and cost estimates. Sponsorship of the rehabilitation project via World Wide Fund for Nature Australia is being investigated.

Acquisition of additional land adjacent to Ellen Brook Nature Reserve

The owners of Lot 5 advised CALM that they wished to swap an area of approx. 1 ha in the south east corner of their property for a strip of land at the northern edge of Ellen Brook Nature Reserve, which would allow them better access to the northern part of their land, situated to the north of Ellen Brook. This proposal was judged to be favourable to the conservation of the Western Swamp Tortoise and arrangements are proceeding. Parliamentary approval will be required.

Further negotiations were held with the owners of Lot 15, with the aim of acquiring the eastern half of the block. A boundary was agreed between CALM and the owners. At present it is up to the owners to finalise their plans for the area.

3.1.4 Extension of fox-proof fence

Extension of the fox proof fence will commence in the coming year. Preparation and earthworks have been completed with the assistance of Midland Brick Ltd.

3.1.5 Population monitoring

Monitoring of the wild population at Ellen Brook Nature Reserve continued by mark and recapture methods. A total of 35 tortoises, a record, were handled during 1994. Table 1 shows the number of tortoises in the Ellen Brook Nature Reserve population known to be alive since 1963 and also provides estimates of population size using the Manley & Parr method, which utilises mark and recapture data and known date of hatching. Estimates presented this year differ somewhat from those of last year - this is due to a re-appraisal of the year of hatching of some animals in the data set. Because of the small population size, and the small sample size in many years, the Manley and Parr method is not a very reliable way of estimating total

population size and the estimates given in Table 1 should be viewed with caution. However, no more reliable method of estimating population size exists.

Searches of areas outside reserves for additional tortoise populations

In 1994 searches for Western Swamp Tortoises were conducted in a the claypan area east of Twin Swamps Nature Reserve (the Sproxton property), at a property at Cranleigh Street, West Swan (Norm Gianetti), and at Perth Airport.

Two *P. umbrina* individuals were observed and photographed basking on disposed car tyres in a claypan in the Sproxton property. One of them (now #340) was caught with a cast net on 7 September and translocated to Twin Swamps Nature Reserve. The second individual could not be caught.

The property of Norm Gianetti was inspected on 30 November 1994. The Gianettis knew Western Swamp Tortoises as well as Long-necked Tortoises and reported that they have not seen Western Swamp Tortoises for about ten years on their property. Since then, some areas have been subdivided, drained and cleared. Two small dams in a former (now drained) swamp area were netted three times with a seine net. Two *Chelodina oblonga* were caught in each dam. Although most Western Swamp Tortoise habitat has disappeared on this land, some searches should continue next season. This area is about 15 km south of Ellen Brook Nature Reserve; any individual from there would be significant to broaden the genetic basis of the species.

The whole Perth airport land was inspected on 16 July 1994. Many of the seasonal swamp areas were dry or had very little standing water because of the very dry summer which was followed by a dry winter. The water level of many swamps is further reduced by drainage channels, many of which were deepened and cleaned during the summer of 1994. The water level in the seasonal swamps at Perth Airport was much lower in winter and spring 1994 than in the three previous years. In the most interesting swamp areas, therefore, it was not possible to build aquatic trap lines with drift fences.

A trap line was built in a semi-artificial swamp east of the long runway in early September, just north of the area which is now proposed for development as a business and recreational park. From 16 September until 1 November 1994 several Long-necked Tortoises *Chelodina oblonga* were caught, but no Western Swamp Tortoises. From 5 November until 7 December 1994 one trap with a short drift fence was set in the Link Road Swamp in the area which is now proposed for development. Again, a few *Chelodina oblonga* were caught, but no Western Swamp Tortoises. Both locations which were trapped at the Perth Airport were not typical Western Swamp Tortoise habitat, rather Long-necked Tortoise habitat. The trapping trials at Perth Airport started too late in this very dry season for trapping to be conducted in Swamp Tortoise habitat.

Table 1. Ellen Brook Nature Reserve, Western Swamp Tortoise Population Estimate - 1994

Year	No. captured	KTBA	Manley & 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	20	23
1977	3	19	19
1978	8	21	34
1979	4	21	21
1980	8	23	28
1981	8	25	27
1982	10	27	34
1983	5	30	67
1984	10	35	93
1985	7	34	54
1986	2	32	32
1987	6	33	38
1988	5	35	80
1989	17	34	36
1990	12	33	37
1991	21	31	33
1992	21	32	42
1993	25	34	48
1994	35	35	-

Notes:
1. KTBA - known to be alive
2. Manley & Parr estimates not possible in some years due to small number of animals captured

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Ecological studies

The ecological studies of *P. umbrina* during 1994 focused on recruitment into the population and on efficient methods of population monitoring. In accordance with the prescriptions of the Recovery Plan, the intensive three year ecological study program at Ellen Brook Nature Reserve was phased out during the winter of 1994, concomitant with the start of the translocation program at Twin Swamps Nature Reserve. The investigative methods were the same as outlined in the 1992 annual report, plus a new method of an aquatic drift fence with traps which is described under monitoring of tortoises.

Results of the 1993 breeding season

Six nests were located at Ellen Brook Nature Reserve during spring 1993 and the nest temperatures were recorded with data loggers. A further female is known to have layed eggs, but her nest was not located. Of the six nests, one contained four eggs (one of which broke), three contained three eggs, and two had two eggs. Three eggs from two nests were transferred to Perth Zoo for artificial incubation because the nests were assumed to be in danger of getting too hot. Pursuant to the Recovery Team's Policy, one egg was left in each of those two nests. Three eggs of a further female (#191) were incubated at Perth Zoo because the female had problems laying the eggs and did not nest properly (see annual report 1993).

Of the thirteen undamaged eggs which were left in the six natural nests, eleven hatchlings emerged between 23 and 30 May 1994. All were marked with small stainless steel wire rings which were inserted through holes of posterior marginal scutes. The hatchlings were immediately released above the nest.

The recovery of the two remaining eggs revealed that both were dead. One of them was decomposed. It was from a nest with three eggs, two of which had hatched successfully. The other one was from a nest from which the remaining eggs had been removed for artificial incubation. This egg contained a dead embryo which possibly died after two and a half months of incubation. This was obviously related to an incident when an animal, presumably a rabbit, dug out the nest and exposed the egg to the sun. When this was detected on 15 January 1994 the nest was covered again with earth.

Since the other nest in which a single egg was left produced a hatchling, its two siblings which had hatched at Perth Zoo after artificial incubation were marked and released near the nest. Therefore, by May/June 1994, thirteen hatchlings were marked at Ellen Brook Nature Reserve.

Four 1994 hatchlings from the unsuccessful nests of the Ellen Brook population will be reared at Perth Zoo.

To summarise, the results of the twelve natural nests which were monitored at Ellen Brook Nature Reserve over the last three years were: from a total of 27 undamaged eggs, 17 hatchlings emerged on their own from the nests; one hatchling was found alive in the nest, but had not emerged; and nine embryos had died during development. The overall hatching success rate, therefore, was 66.7% ; 94.4% of those hatchlings emerged successfully. One hundred per cent of eggs were dead in three nests; in one nest with three eggs, two hatched and one was dead; in another one with three eggs, one hatched and two were dead; seven nests had a hatching success of 100% of undamaged eggs.

Monitoring of tortoises

Six females and four males were radio-tracked until June 1994 when, in accordance with the recovery plan, radio-tracking was terminated at Ellen Brook Nature Reserve. These animals emerged from their aestivation holes in the second half of May 1994, about one month later then in previous years. This may be related to the particular long and dry summer of 1994.

During August/September, a 80 m long drift fence of black plastic mesh was built in the water through the main swamp area near depth gauge 1 at Ellen Brook Nature Reserve. From 13 September until 20 October 1994 five traps, built of an aluminium frame with netting, were set into the fence. During these five weeks of trapping, ten *Pseudemydura umbrina* individuals were caught in the traps. All of them were released beside the trap in which they were found. Three of them were again caught in traps a few days later. They were then released on the other side of the fence and not trapped again.

Terrestrial drift fences with pit-falls were successfully used from the 1960s to the early 1980s at Twin Swamps Nature Reserve to trap and monitor *Pseudemydura umbrina*. But these terrestrial drift fences have two major draw backs: first, many animals are caught and subjected to stress during critical times of their active phase, eg, when gravid females move out of the swamps to lay eggs or when animals search for aestivation sites; second, in the pits the animals are exposed to predators, which results in increased losses of

animals (a serious problem not only in the case of *P. umbrina*, but in all freshwater turtle studies using terrestrial drift fences and pit falls). Because of these two major problems trapping was discontinued at Twin Swamps Nature Reserve in the early 1970s.

This new aquatic drift fence with traps avoids both these draw backs: first, the tortoises are caught when active in the water and, inside the trap, remain in the water. Although confined, they stay in their environment, experience the normal temperature conditions, and even can find their usual food inside the trap. Second, most predators cannot enter the traps (with the possible exception of snakes which could eat hatchlings or juveniles; but no snake has ever been found in a trap).

The ten individuals trapped in five weeks represent about one third of the population at Ellen Brook Nature Reserve. The method, therefore, seems to work successfully. The method may even be better than indicated by the ten individuals caught: in six instances, holes in the net had to be repaired which were obviously ripped by escaping tortoises. The trap design will be improved accordingly. A further improvement will be to use separate traps on both sides of the fence, in order to know from which side of the fence the tortoise entered a trap.

3.1.6 Interim Management Guidelines

The Interim Guidelines were not revised during the year due to pressure of other work. It is proposed that they will be completed in 1995.

3.2 CAPTIVE BREEDING

Facilities

Carrying capacity of current facilities at Perth Zoo has been reached and the remaining space will be required for aestivation pens. Five additional aestivation pens were erected in 1994 together with five holding ponds. Another rearing pond may be required in addition to the existing six to accommodate hatchings from eggs currently in incubators. Two more aestivation pens will be built in early 1995. The release of 15 to 20 juveniles into Twin Swamps Nature Reserve in 1995 will reduce the risk of overcrowding. At present there are 22 holding/breeding ponds, 18 aestivation ponds, 6 to 7 rearing ponds.

Egg production and hatching

In late 1993, 36 eggs were obtained from captive stock and nests from Ellen Brook Nature Reserve. From these, 30 hatchlings were produced; two of which were returned to Ellen Brook NR, leaving 28 to be reared at the Zoo. Of the six eggs which did not hatch, four were either infertile or death of the embryo occurred very early after incubation commenced. One animal attempted to hatch prematurely and died in the process and the remaining egg was found to contain a grossly deformed tortoise, which had to be euthanased.

In late 1994 a record number of eggs was produced. Forty-seven eggs were obtained from 10 of 12 captive females. Thirty-nine were developing normally in December. For the first time one female produced a clutch of six eggs (previous record was five) and one female laid two clutches in a single season totalling seven eggs.

Translocation

Eleven tortoises were released into TSNR (see section 3.3.3). One was an adult male brought in from the reserve several years ago and ten were captive-bred juveniles.

Animal health

The four surviving hatchlings produced in 1989 have undergone a dramatic change in health after undergoing treatment with antibiotics. No longer evident are the lesions, drab appearance of shell, broken claws and

general listlessness which became apparent soon after hatching. Their body weights are also increasing rapidly. A short period of aestivation is being considered for them, something that was previously not possible due to a high risk of death.

One 1993 hatchling grew very little during the year, but all other hatchlings and juveniles grew normally. Nineteen juveniles attained a weight of 100 g or more, with two other slightly under 100 g. All these should be available for release to the wild in 1995.

Several adults developed minor shell infections and digital abscesses which were treated successfully prior to them beginning aestivation in late December. Apart from the two related to hatching (see above) no deaths were recorded in 1994.

Aestivation

The 21 juveniles that are eligible for release in 1995 will undergo a period of three months in aestivation during the 1994/95 summer, one month more than usually undertaken by Zoo hatchlings and juveniles. This is to bring them more into line with animals in the wild, where aestivation usually lasts at least five months.

Status of breeding stock

The total number of Western Swamp Tortoises at Perth Zoo on 13 January 1995 was 112, consisting of 14 males, 12 females and 86 un-sexed juveniles.

3.3 RE-INTRODUCTION TO TWIN SWAMPS NATURE RESERVE.

3.3.1 Construction of fox proof fence

The second half of the Twin Swamps vermin proof fence was completed early in 1994. The entire reserve is now enclosed by the five kilometre fence.

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

The Recovery Plan provides for the pumping of groundwater to supplement swamps in Twin Swamps Nature Reserve. The Western Australian Water Authority (WAWA) constructed a bore near the north west corner of the reserve and installed a pump and pipelines to North West and East Swamps during 1993. WAWA have agreed to maintain the bore and pump in coming years.

The Recovery Team developed a protocol for pumping groundwater, which is managed by CALM Perth District staff. The protocol will be reviewed in 1995 in the light of 1994 experience.

Groundwater was pumped to both the East and North West Swamps between August and November to supplement their levels. During August and September most of the water pumped was directed to East swamp to try and increase its depth to satisfy preliminary management criteria. During this period the depth of NW Swamp met the designated criteria and therefore did not require additional water.

During October water was directed to both East and North West Swamps as both their levels were below that required by the interim management criteria. By late October it was apparent that it would not be possible to maintain the levels prescribed by the management criteria in both swamps. The water was directed to North West Swamp as the released tortoises all remained in that swamp. East Swamp was allowed to dry. NW Swamp was supplemented until the end of November, and an acceptable depth was maintained.

Some 8 553 kL of water was pumped to East Swamp between August and October and 13 440 kL was pumped to North West Swamp between September and November.

Analyses of a sample of groundwater collected in September 1994 were carried out by the WA Chemistry Centre. The analyses showed it to be of high quality for the area, with 220 mg/L total dissolved solids. Because groundwater has a greater concentration of dissolved solids than rain water, monitoring of aquatic invertebrates in the swamps has been commenced by CALM's Science and Information Division staff.

Invertebrate research

Invertebrates and water chemistry were sampled at Twin Swamps NR and Ellen Brook NR as part of the Western Swamp Tortoise Recovery Plan. The objectives were to determine (1) whether there are sufficient food resources in the Twin Swamps wetlands to support tortoises, and (2) whether prolonging the period of inundation in some wetlands affects their water chemistry, the amount of food available for tortoises or the structure of their invertebrate communities. Ellen Brook currently supports a self-perpetuating population of tortoises and is being used as a control site and an indicator of suitable conditions for the Western Swamp Tortoise.

Sampling began in 1991 and will continue until 2000. After three years of collecting baseline data on invertebrates and water chemistry, water was pumped into two Twin Swamps wetlands (North West and East) in 1994 to prolong the period of flooding and tortoises were re-introduced to North West swamp. There was some preliminary pumping into North West swamp in October 1993 to test the pump.

Methods

Wetlands sampled

Three wetlands at Twins Swamps were sampled: (1) East Swamp, (2) North West Swamp, and (3) South West Swamp. The main waterbody at Ellen Brook was also sampled.

Sampling dates

The wetlands were nominally sampled in July, September and November. Water was not present in all wetlands in each scheduled sampling period, however, and the actual dates each site was sampled are shown below. Previous years sampling are also shown.

Wetland	1991			1992			1993		1994		
	25.vii	25.ix	7.xi	17.viii	24.ix	3.xi	29.ix	20.x	26.vii	23.ix	31.x
East	x	x		x	x		x		x	x	
North West	x	x		x	x		x	x	x	x	x
South West	x	x	x	x	x	x	x	x	x	x	
Ellen Brook	x	x	x	x	x		x	x	x	x	

Habitat and water measurements

Measurements were taken from three sites (replicates) in each wetland on each sampling occasion for all parameters except depth, which was measured at a permanent gauge in the deepest part of the wetland. The parameters and methods of measurement are listed below.

Parameter	Units	Method of measurement
Depth	m	Permanent gauge
Salinity	ppt TDS	Conductivity
pH		Meter
Colour	TCU	Absorbance at 465 nm
Turbidity	NTU	Nephelometric turbidity meter
Total soluble persulphate nitrogen	mg/L	Persulphate digestion and colorimetric determination
Total soluble persulphate phosphorus	mg/L	Persulphate digestion and colorimetric determination
Chlorophyll	mg/L	Acetone extraction, spectrophotomic determination at 664 nm with HCl acidification
Phaeophytin	mg/L	Acetone extraction, spectrophotomic determination at 665 nm with HCl acidification
Temperature	°C	Meter
Dissolved oxygen	%	Meter
Macrophyte cover	%	Estimated visually
Macrophyte biomass	gDW/m^2	harvesting 3 1/16 m^2 random quadrats per site in areas with typical macrophyte density

Invertebrate sampling

Invertebrate samples were collected from five sites (replicates) in each wetland during the first two sampling periods. In October, only North West Swamp contained water and the water level and inundated area were so low that only three samples were taken Each sample consisted of a 50 m tow with an FBA-type pond net using 110 μm mesh. The net was kept just above the substrate to reduce the amount of detritus collected. This meant that invertebrates in the water column and on submerged aquatic vegetation were sampled better than truly benthic species.

Because most of the wetlands contained large quantities of submerged macrophytes and litter, plant material accumulated rapidly in the net during sampling and reduced the flow of water through it, which reduced the efficiency of sampling. A pressure wave could sometimes be seen in front of the net. The person sampling stopped approximately every 15 m and 'cleaned' the net, removing plant material after animals had been washed free, to improve water flow through the net. The volume of water that was sampled in each 50 m sweep if the net offered no resistance was 5.4 m^3 but it is likely that only c.1.5 m^3 was sampled per sweep at most sites.

Invertebrate samples were sorted into commonly recognised invertebrate groups (usually Order or Family level) in the laboratory and dry weight of each group was determined by oven-drying at 60°C.

Results

Incomplete results for 1994 are summarised below. Results from 1993 and 1991-92 combined are also presented. More details of 1991-92 results were given in the 1993 annual report.

Habitat and water quality

No field measurements other than salinity are available for July 1994 because the field data sheet was lost. No dissolved oxygen measurements are available for October 1994 because the meter malfunctioned and October results are not yet available for laboratory measurements. Nevertheless, several habitat and water chemistry parameters appeared to show differences between 1994 and earlier years. Some differences were probably the result of variation in rainfall but changes in North West swamp are more likely to be related to the pumping of groundwater into the wetland to maintain water levels.

In particular, the increase in biomass of macrophytes in North West swamp, the less coloured water, and the lower levels of phosphorus are probably the result of the input of clear groundwater. The increase in macrophyte biomass was partly attributable to a bloom of the filamentous alga *Spirogyra* as a result of better light penetration. The data below show a trend towards less coloured water from 1991-92 to 1994, which is partly because of a session of preliminary pumping prior to the October 1993 sampling. It seems likely that the lower phosphorus levels are a result of uptake of phosphorus by the extra macrophytes. The phosphorus will be released when the macrophytes die.

Parameter	1991-92				1993				1994			
	E	NW	SW	EB	E	NW	SW	EB	E	NW	SW	EB
Salinity (ppt)	0.06	0.15	0.36	0.04	0.03	0.20	0.61	0.05	0.16	0.13	0.67	0.05
pH	6.4	7.0	5.2	7.4	6.4	7.4	5.3	6.8	8.0	8.1	6.7	8.1
Colour (TCU)	380	1180	4580	100	187	802	5867	52	134	460	3983	56
Turbidity (NTU)	1.0	1.1	1.5	14.8	1.3	1.3	1.5	17.9	0.8	0.6	0.8	18.5
Total N (mg/L)	2.5	4.6	6.6	0.6	0.8	3.4	8.7	0.7	0.9	7.3	6.5	0.8
Total P (mg/L)	0.10	5.16	0.12	0.05	0.01	3.1	0.09	0.01	0.02	1.1	0.11	0.01
Dissolved oxygen (%)	94	92	60	115	79	105	65	105	-	-	-	-
Macrophyte (gDW/m^2)	13.2	140.0	73.1	50.2	40.6	281.2	64.4	187.0	59.2	827.2	67.2	147.2

* Macrophyte biomasses in the 1993 annual report were wrong

There were three categories of ionic composition among the wetlands. East swamp was dominated by calcium bicarbonate; Ellen Brook and North West were dominated by sodium bicarbonate; whereas South West was more saline and dominated by sodium chloride. The different chemistries probably reflected different sources of water and biological processes at the sediment-water interface.

Invertebrates

The invertebrate sampling in 1993 showed similar patterns to those from 1991-92. North West and South West were the most productive wetlands. Ostracods and isopods, respectively, were the groups contributing most biomass. Preliminary indications from 1994 are that the biomass was generally lower than previous years, probably a result of 1994 being a dry year, but that more taxa were recorded per site.

Parameter	1991-92				1993			
	E	NW	SW	EB	E	NW	SW	EB
Total biomass (gDW)	0.20	1.40	0.85	0.30	0.11	0.89	0.89	0.55
Ostracoda (gDW)	<0.01	1.00	0.11	0.06	0.03	0.51	0.17	0.04
Isopoda (gDW)	-	0.02	0.22	<0.01	-	0.02	0.35	0.01
Amphipoda (gDW)	-	-	0.08	<0.01	-	<0.01	0.04	-
Tadpoles (gDW)	0.06	0.13	0.14	0.08	<0.01	0.15	0.06	<0.01

Parameter	1991-92				1993			
	E	NW	SW	EB	E	NW	SW	EB
Total biomass (gDW)	0.20	1.40	0.85	0.30	0.11	0.89	0.89	0.55
Ostracoda (gDW)	<0.01	1.00	0.11	0.06	0.03	0.51	0.17	0.04
Isopoda (gDW)	-	0.02	0.22	<0.01	-	0.02	0.35	0.01
Amphipoda (gDW)	-	-	0.08	<0.01	-	<0.01	0.04	-
Tadpoles (gDW)	0.06	0.13	0.14	0.08	<0.01	0.15	0.06	<0.01

Conclusions

There appears to be ample food for Western Swamp Tortoises in the wetlands of Twin Swamps when they contain water. East and North West Swamps dry much earlier than Ellen Brook, however. Supplementing the water supply of North West swamp to prolong the period of inundation for tortoises may lead to problems with algal blooms if the water continues to lose colour. At present the macrophytes are abundant and the system seems comparatively healthy but, because nitrogen is often the limiting nutrient in this eutrophic wetland, there is potential for blue-green algal blooms.

3.3.3 Translocation

Ecological studies at Twin Swamps Nature Reserve commenced in winter 1994. A significant result was the finding of two resident adult *Pseudemydura umbrina* females inside the fenced reserve: #77 which had been recorded at the reserve in the 1960s and a formerly unmarked female (now #338). Both females were equipped with radio transmitters. These findings challenge the assumption in the recovery plan that, at Twin Swamps Nature Reserve, the species was "virtually extinct" by 1985.

Population monitoring

Table 2 shows the number of tortoises in the Twin Swamps population known to be alive since 1963 and also provides estimates of population size using the Manley & Parr method, which utilises mark and recapture data and known date of hatching. The same cautions should be noted in interpreting these data as are described above for EBNR. The increase in numbers of tortoises in 1994 is due to translocation (see below).

Translocation and monitoring of individual tortoises

The translocation program, as prescribed in the recovery plan, commenced in September 1994 with the release of ten captive bred tortoises from Perth Zoo. They were just over three or four years old and all had a body mass >100 g. All were equipped with radio transmitters. Three transmitters failed within three weeks due to battery failure and one failed after three

Table 2. Twin Swamps Nature Reserve, Western Swamp Tortoise Population Estimate - 1994

Year	No. captured	KTBA	Manley & Parr estimate
1963	1	52	-
1964	4	74	284
1965	9	96	270
1966	65	100	123
1967	26	75	153
1968	17	61	67
1969	8	60	91
1970	26	58	70
1971	27	51	70
1972	15	39	55
1973	13	33	56
1974	8	28	88
1975	8	23	32
1976	4	20	25
1977	9	19	24
1978	9	17	33
1979	6	11	16
1980	2	8	8
1981	3	8	11
1982	3	8	8
1983	4	8	9
1984	3	7	15
1985	1	5	-
1986	0	4	-
1987	0	5	-
1988	0	5	-
1989	0	5	-
1990	1	5	5
1991	0	5	-
1992	1	5	-
1993	0	4	-
1994	14	14	-

Notes:

1. KTBA - known to be alive
2. Manley & Parr estimates not possible in some years due to small number of animals captured (denoted by -)

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months. Most tortoises shed their horny scutes until the end of November, but most transmitter were either re-glued before they were shed or animals which lost transmitters were re-captured and provided with new transmitters. By the end of 1994 six of the ten captive bred tortoises were equipped with working and re-batteried transmitters and were being tracked.

In addition to the ten captive bred tortoises, the adult male #63 and the sub-adult male #340 also were released during September 1994 and radio-tracked. Both were captured in a privately owned claypan about 800 m east of the reserve boundary, #63 in August 1990 (it had been marked at Twin Swamps Nature Reserve during the

1960s and spent 1990-1994 at Perth Zoo) and #340 in September 1994. After about two weeks of tracking #340 lost its transmitter and has not been located since.

Therefore, by the end of September 1994, 14 P. umbrina were known to live at Twin Swamps Nature Reserve.

Due to the dry winter of 1994, one of the four major swamp areas (South East Swamp) remained completely dry and two (East Swamp and South West Swamp) had only shallow water for a relatively short period. Due to the swamp supplementation scheme, North West Swamp offered by far the best habitat and food supply. All translocated tortoises were released into NW Swamp and female #77 was captured there.

Female #338 was found in East Swamp in early July. When released at the site of capture, she kept moving to the fox-proof fence at the eastern boundary and walking along the fence, trying to get through. Three times she was moved back to East Swamp, but when she was picked up for the fourth time at the fence on 13 August she was moved to NW Swamp, where she stayed in the water until the middle of October.

On 20 October #338 and #63 both were found walking along the eastern fence, trying to get through. Because tortoises easily overheat in the sun when trying to get through a fence, both were moved back to NW swamp where they remained until late November. Two dead *Chelodina oblonga* were picked up along the western fence on 27 and on 31 October, respectively (even several *Tiliqua rugosa* died along the fence, obviously due to over heating in the sun). Because of these findings and to avoid losses of *P. umbrina*, three plastic-lined ponds were built at the fence on the east side and two on the west side of the reserve. These were similar in construction to those already in place at Ellen Brook Nature Reserve.

North West Swamp was supplemented with water until 1 December and dried out between 3 and 5 December. #77 left the water between 9 and 17 November and started to aestivate, #338 and #63 left the water between 24 and 30 November. One of the six radio-tracked juveniles from Perth Zoo aestivated on 30 November, a further one on 2 December, and the other four on 6 December. They moved between 60m and 300 m from the water in different directions into bushland (*Regelia* association). Three of them had moved another 5 - 50m before the end of December. By the end of the year, five of the juveniles were aestivating in holes under dense bushes and one may either have been in a hole or under a dead branch on the ground under dense bushes. Only one of the juveniles had moved into Banksia woodland, five stayed in the *Regelia* association. None of the tortoises was handled after leaving the water in order not to disturb aestivating animals.

Of the adults, #77 aestivated under the dense dry leaves of a blackboy, possibly also in a small hole, about 170 m away from NW swamp (*Regelia* association). #338 stayed in a hole at the base of a paper bark tree 300 m east of NW Swamp, about 30 cm from the entry of the hole; it is an open area without dense bushes, on the margin of *Banksia* woodland. #63 was in a hole on 6 December, about 150 m inside the reserve from the eastern boundary, in a paper bark and eucalypt area. The animal was seen digging itself into the soil at the end of the hole. The hole, presumably a rabbit hole, was in a relatively open area, without good shading from bushes or trees. It was about 30 cm long, with the end about 20 cm under the soil surface. On 6 December, tortoise tracks were seen along the eastern fence in the area where the male started to aestivated.

Therefore, during December 1994, seven of nine radio-tracked tortoises aestivated in holes in the ground (carapace under the ground, not above soil). For two animals, the exact aestivation location was not known, because they stayed under dense ground cover which was not disturbed. Six stayed in *Regelia* association, two in or at the margin of *Banksia* woodland, and one in *Eucalyptus - Melaleuca* woodland.

At an inspection on 5 January 1995, the empty shell of #63 was found 3 m from his aestivation hole on open ground. Carapace and plastron were separated and lay, inside down, side by side in the sun. No scratches or tooth imprints could be detected, and no other bones or remains of the animal were found. All the flesh was cleaned out of the shell. The male may possibly have died ten days earlier, in late December 1994. It is unlikely that he died from over heating, the hole was occupied by a live and relatively cool *Tiliqua rugosa* when the shell was discovered. The cause of the death of #63 is unknown. If the male had tried to get through

the fence before starting aestivation (tortoise tracks were found at that time at the fence), he may have been exhausted and desiccated when going into aestivation.

The 1994 breeding season

Both resident adult females (#77 and #338) showed a normal vitellogenic cycle when they were found and both layed eggs in 1994. Female #77 nested between 23 October and 09 November, but the nest was not located. Female #338 nested in the afternoon of 17 November, about 25 m from the margin of the water in NW Swamp (a sandy area which is flooded in winter) and layed four eggs. The nest temperatures are being monitored with a data logger.

On 23 November an aborted, putrid soft-shelled egg was found in the water of NW Swamp. It is not known which female aborted this egg, but it is possible that it was #338, after she was returned to NW swamp from the eastern fence on 20 October. The abortion may have been caused by the stress of sun exposure at the fence.

3.3.4 Interim Management Guidelines

The Interim Guidelines were not revised during the year due to pressure of other work. It is proposed that they will be completed in 1995.

3.3.5 Management of Fire Predators, etc

The reserve was intensively baited for predators following completion of the vermin proof fence. Firebreaks were inspected for fox and cat tracks by CALM staff prior to the tortoises being released, and following the release. The reserve is believed to be free of predators. An ongoing program of periodical baiting for predators and rabbit control is being undertaken.

External firebreaks were maintained for fire protection. No fires occurred on the reserve during 1994.

3.4 EDUCATION, PUBLICITY AND SPONSORSHIP

3.4.1 Education and publicity

General educational and publicity procedures continued as in past years. The release of captive-bred tortoises at Twin Swamps Nature Reserve in September received widespread publicity, with all Perth TV channels carrying the story in their major evening news. Print media stories were published in Western Australia, some other Australian States and in several overseas countries.

International activities

In March/April 1994 Dr G. Kuchling went on a trip to New Zealand and the USA and gave lectures on the Western Swamp Tortoise Recovery Program at the Victoria University of Wellington, as an invited featured speaker at the 19th Annual Desert Tortoise Meeting in Tucson, Arizona (the Desert Tortoise Council funded the trip), and at Chapman University in California.

The Western Swamp Tortoise recovery program featured prominently in the May issue of the French journal *La Tortue* which is published by SOPTOM, a society for the protection of Hermann's Tortoise in southern France.

3.4.2 Sponsorships

In 1994 the British Chelonia Group made a conservation appeal to their members on behalf of the Western Swamp Tortoise Program and raised over £2500. Members of the California Turtle and Tortoise Club donated US$800.00 towards the Western Swamp Tortoise Program. The Zoology Club of the University of Western Australia organised a Quiz Night and raised A$1000.00 for the Western Swamp Tortoise program. These donations were used for drift fence and trap material and for radio tracking equipment.