Dryland River Refugia

COOPERATIVE RESEARCH CENTRE FOR
FRESHWATER ECOLOGY

Newsletter Number 1 - May 2002

What is in this Newsletter?

This is the first newsletter to be produced by the Cooperative Research Centre for Freshwater Ecology Dryland River Refugia Project. In 2001 we undertook field trips to both Cooper Creek and the Warrego River. This newsletter summarises some initial results from the 2001 Cooper Creek field work. This is an ongoing project with more field trips to be conducted in 2002 - 2003. We will be producing more newsletters summarising the ongoing results from the Cooper Creek, Warrego River and Border Rivers over the next two years. Your feedback would be greatly appreciated.

Dryland rivers such as those in the northern regions of the Murray-Darling Basin and in the Lake Eyre Basin are renowned for their episodic floods that extend over vast floodplains. However, for much of the time they exist as a network of ephemeral channels and turbid waterholes. Many of these river systems are essentially unregulated but are under increasing pressure, especially from water resource development for irrigated agriculture.

Although some aquatic organisms with desiccation resistant life stages can utilize ephemeral aquatic refugia on the floodplain (e.g. claypans), the larger waterbodies represent the only permanent aquatic habitat for much of the aquatic biota during extended periods of low or no flow. The major aim of this project is to determine the importance of waterholes as refugia for aquatic organisms in dryland river catchments. We propose to determine the relationship between biodiversity and the physical attributes of individual waterholes, and how populations are connected in space and time. We also propose to identify the biophysical processes that sustain biodiversity and ecosystem health in dryland river refugia. This information will enable us to predict the likely impacts of water resource development, as well as changed floodplain and riparian management, on biodiversity and ecosystem function in dryland river refugia. It will also assist us in identifying key environmental flow and land management criteria to restore dryland rivers where altered flow regimes and changed land management have affected connectivity and other key biophysical processes.


Photo by Jon Marshall QNRM

Collecting Samples, Top Waterhole


Photo by Jon Marshall QNRM

Top Waterhole, Thomson River

Broad Research Objectives

1. Determine the importance of waterholes as refugia for aquatic organisms in dryland river catchments.

2. Identify biophysical processes sustaining biodiversity and ecosystem health in dryland river refugia

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Further Information

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About the Project

What is a Dryland River?

Dryland rivers are those rivers flowing through semi-arid or arid landscapes.

Dryland rivers differ markedly from rivers of wetter, cooler, regions, particularly in terms of their unpredictable and highly variable nature. Australian dryland rivers have gentle gradients and, when in flood, their floodwaters spread over large and complex floodplains. Most of the time, however, they are 'dry', existing only as networks of turbid waterholes. Dryland rivers, therefore, fluctuate between being highly fragmented (with numerous disconnected waterbodies) and highly connected (with enormous tracts of inundated floodplain). During dry periods, the larger waterbodies represent the only aquatic habitat for biota requiring permanent water.

Photo by Jon Marshall QNRM

The team at Murken Waterhole, Windorah

Photo by Stuart Bunn, Griffith Uni.

Cooper Channel at Windorah

Key Project Aims

1. Identification of Refugia

Are there key low flow/no flow habitats in dryland rivers that function as refugia?
How is aquatic biodiversity partitioned in space and time among refugia?
What is the relationship between biodiversity and the physical (and chemical) attributes of individual waterholes?

2. Connectivity of Refugia and Patterns of Dispersal

Are refugia static over time in terms of location and size?
How are refugia connected in space and time?
What are the mechanisms and extent of dispersal among populations of aquatic organisms?

3. Biophysical Processes

What are the physical, chemical and biological processes that sustain refugia during dry periods?
Which taxa are able to recruit within refugia and what are the physical, chemical and biological characteristics/processes in refugia, that govern reproductive success and recruitment?

What are Refugia?

A 'Refuge' is a habitat (or place) that supports populations of plants and animals not able to live elsewhere in the surrounding landscape.

Refuges may only become important during harsh times; thus refugia are habitats where conditions are less harsh than in the surrounding area. During adverse conditions, plants and animals in refugia are more likely to survive until conditions improve. In aquatic systems, plants and animals may take refuge from drought conditions, floods and high flows, high water temperatures and predation from other animals. For the purposes of this project, we define refugia in dryland rivers (where suitable habitat expands and contracts dramatically under natural flow regimes) as places where plants and animals survive during periods when the area of their habitat contracts. These refuge areas are those areas needed to re-seed the broader region when the suitable habitat expands again. Thus, using this definition, during dry or no flow periods, refugia for the aquatic biota needing permanent water will be the larger waterbodies. It is clear that this definition of refugia is essentially species-specific. Episodic floods may be favourable (boom times) for some species whereas for others they will be adverse times to be endured and survived before returning to life during the favoured dry periods.

Photo by Jon Marshall QNRM

Homestead Waterhole, Kyabra Creek

Sampling Design

Collecting Zooplankton, Shed Waterhole, Cooper Ck.

Sampling Design

The northern rivers of the Murray-Daring Basin and the rivers of the Lake Eyre Basin provide a unique set of variables for understanding the physical and biological processes related to sustaining refugia in dryland rivers. Within the region are rivers that suffer the full range of impacts from both water resource development and intensive cropping and grazing. The sampling design of the project, therefore, covers three separate river catchments: the Cooper Creek Catchment, the Warrego River Catchment and the Border Rivers Catchment. Within each catchment there are four separate river reaches, and within each reach a number of waterholes will be sampled. Some waterholes are predicted to be less permanent than others and therefore function differently as refugia. In the more developed catchments, ring tanks and other 'artificial' floodplain waterbodies will be sampled to compare with main waterholes.

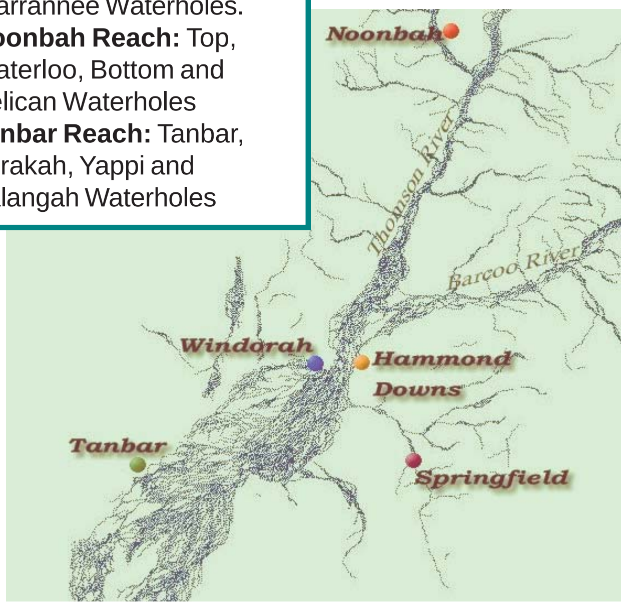
Mayfield Waterhole, Cooper Creek

Cooper Creek Study Sites

During April 2001, fifteen waterholes were sampled in the Cooper Creek region around Windorah. They were distributed among 4 "reaches" (see Table and Map of sites). The same waterholes were sampled again in September 2001. At each site samples were taken of phytoplankton, macro and microinvertebrates, fish and turtles. Samples were also taken for water quality parameters and experiments undertaken to determine the productivity of the waterholes.

Windorah Reach: Murken, Mayfield, Glen Murken and Shed Waterholes.
Springfield Reach: Homestead, One Mile and Warrannee Waterholes.
Noonbah Reach: Top, Waterloo, Bottom and Pelican Waterholes
Tanbar Reach: Tanbar, Yorakah, Yappi and Yalangah Waterholes

Sampling at Top Waterhole, Thomson River



Measuring Waterhole Features

Martin Thoms & Louisa Davis: University of Canberra

Which waterholes constitute refugia?
Are these refugia static over space and time?
How are refugia connected in space and time?

Waterholes in the Cooper and Warrego catchments are significant features of the landscape. They are the only permanent habitat for aquatic plants and animals in dry or drought times. The physical characteristics of waterholes, such as their size, shape and complexity, will effect the way in which plants and animals can utilise them. In this project to date we have been to the Cooper catchment twice and studied a total of 22 waterholes and visited the Warrego catchment once and studied 14 waterholes.

How do we study waterholes?

The data we collect can be roughly grouped into three areas. Large scale landscape variables such as the width of the floodplain, measurements of the entire waterhole such as area, volume, length and elongation and the small scale measurement of bank features and other assessments of habitat within the waterhole.
The morphology of the waterholes is studied using two methods;
1. measurements taken while we are in the field, and
2. measurements calculated from aerial photography and satellite imagery.

Using surveying equipment to take a cross section of the bank.

Field measurements

In the field we use surveying equipment to take cross sections of waterholes at intervals along the bank. This gives us a range of measurements such as the shape, width and complexity of the channel. It also enables us to calculate the amount of water that the river can hold in that section. A longitudinal depth profile is taken along the deepest section of the waterhole to see the depth changes along the channel. Habitat assessments are also made as we travel down the waterhole. These assessments help to ascertain the different structures that are present in the channel, such as bars, undercut banks, and the presence of fringing and aquatic vegetation.

Red Waterhole in the Warrego catchment: In this photo you can see small-scale features such as snags and features of the bank.

Geographic Information Systems

Geographic Information Systems (GIS) refers to a range of computer packages. We use these to measure attributes of aerial photography and satellite imagery. This method is a good way of measuring the large scale features of each waterhole and surrounding environment that would otherwise be difficult, or time consuming, to assess on the ground.

An aerial photograph of Tanbar waterhole, in the Cooper Catchment. Large-scale features such as the length of the waterhole and the width of the surrounding floodplain can be calculated using photos such as this. (Tanbar Waterhole is approximately 9km long).

What have we found?

So far our focus has been mainly on data collection. We have found that the physical character of the waterholes is quite varied. The depth of water ranges from 40cm to over 10 m. Length varies from a few hundred metres to over 20km. With the information collected we plan to link physical characteristics, such as waterhole size, bank complexity and landscape features, to ecological characteristics, which have been collected by the other teams.

Water Quality of the Waterholes

Steve Hamilton: CRCFE Visitor from Michigan State University, USA
Satish Choy & Jon Marshall: Qld Natural Resources & Mines

What are the chemical processes that sustain refugia during dry periods?

The Queensland Department of Natural Resources and Mines sampled the 15 waterhole study sites in April and September 2001 for the measurement of several water quality indicators. The results provide a preliminary portrait of waterhole water quality during the period of isolation from river flow. The most recent extensive flooding prior to the sampling trips occurred in March 2000.

Water quality measurements are of interest not only for potential human uses of the water – they also provide an indication of the suitability of the water as an environment for aquatic animals, the availability of critical nutrients to support aquatic production, and information about the hydrology of the waterholes (i.e., the sources and losses of water that determine water levels and permanence of the water bodies).

The ranges of conductance (salinity) in the table below show that the waterholes were quite fresh, and the pH was neutral to slightly basic. The waters were generally well-oxygenated at the surface. These data show good conditions for freshwater life.

Measurement	April 2001	September 2001
Conductance (uS/cm; 25°C)	95 - 365	120 - 620
pH (after sample storage)	7.05 - 7.75	7.00 - 8.15
Alkalinity (mg $CaCO_3$/L)	31 - 175	35 - 270
Sodium (mg/L)	8.5 - 34.5	9.9 - 72
Turbidity (NTU)	120 - 2000	41 - 1100
Dissolved O_2 (mg/L)	3.3 - 8.2	1.3 - 11
Total nitrogen (mg/L)	1.0 - 4.1	1.2 - 7.5
Total phosphorus (mg/L)	0.17 - 0.81	0.18 - 2.5

Table 1. Ranges in hydrochemical composition for 15 Cooper Creek waterholes, measured on samples of surface water collected during the day.

Turbidity in most waterholes was elevated due to suspended clays. As a result, light penetration was very limited and precluded photosynthesis in all but the uppermost part of the water column. Light limitation may explain the rather high concentrations of nitrogen and phosphorus. These nutrients are liberated by natural decomposition of organic matter, and in clearer waters they tend to be taken up by plants and algae, resulting in lower concentrations. Near the water surface where there is enough light, these nutrient concentrations would be expected to support high rates of algal growth.

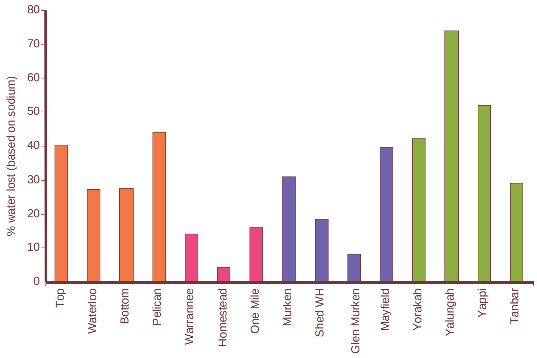
Water Quality and Hydrology

Certain dissolved substances in the water serve as tracers of water sources and losses because they remain in solution and are not affected by biological uptake. For example, sodium is often a good "conservative" tracer of hydrology. What can sodium concentrations tell us about the hydrology of these waterholes?

Previous work on soils of the Cooper Creek system has suggested that there is little exchange of water between the waterholes and underlying groundwater because the fine clays seal the basins and prevent water flow. If true, then the waterholes would receive water from occasional floods that top up their basins, then gradually lose water by evaporation until they become dry or another flood (or unusually large rainfall) occurs. Differences in evaporation losses relative to basin volumes would determine the permanence of the waterholes, a feature of paramount importance to their role as refuges for aquatic life.

We can examine the change in sodium concentrations between the two sampling dates as an indication of the relative loss of water by evaporation, assuming no groundwater exchange or rain inputs. All sites increased in concentration over the interval, but the relative increase was quite variable among the 15 waterholes. For each waterhole, the percentage of water lost by evaporation that would be necessary to produce the observed increase in sodium concentrations is depicted in the figure below.

Estimated water loss by evaporation
(April to September 2001)



The large variation is probably explained in part by differences among the waterholes in the ratio of surface area to volume; evaporation rates were probably similar across all sites. Yet some sites appeared to lose surprisingly little water, which is suggestive of river water inputs at intermediate channel flows, or groundwater or rain inputs. This topic demands further investigation, since an understanding of the hydrology of these waterholes is fundamental not only to the present-day role of the waterholes as refugia, but also to the issue of how river water extraction and flow alterations might impact these ecosystems in the future.

The Fish Community

Angela Arthington & Stephen Balcombe: Griffith University
Glenn Wilson: CRCFE, Goondiwindi Laboratory

How is fish diversity partitioned in space and time among refugia?
What are the relationships between fish diversity and the physical (and chemical) attributes of individual waterholes?

By sampling fish we can determine whether species richness, faunal composition and relative abundance can be predicted from waterhole characteristics such as geomorphic features, flow permanence and water quality.

How we sampled fish

Fish have been sampled using fyke and seine nets. Fish surveys are conducted under a General Fisheries Permit from the Department of Primary Industries (Queensland Fisheries Service). With the exception of exotic species (eg. goldfish) all individuals are returned unharmed to the waterhole. In each waterhole, three fyke nets are set parallel to the bank with the wings widely separated and staked into the mud. These nets tend to capture the large fish species/individuals moving about in the water column or along the banks and bottom. The net mesh size is too large to retain the smaller fish/individuals so these are sampled using a small-mesh seine net hauled along a set length of bank (usually about 20 metres). All fish are identified to species, counted and are returned to the waterhole after a sample of selected species has been measured and weighed. Fish counts are then adjusted to provide data on the 'catch per unit effort' or CPUE (i.e. the number of fish caught by a standard level of fishing effort). This process yields data that can then be compared between waterholes and between river reaches.

Setting a fyke net in a waterhole

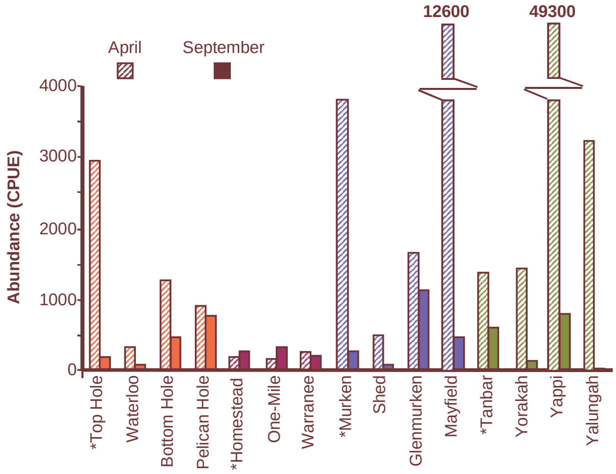


Figure 1. Total fish abundance (CPUE) for Cooper Creek, April and September 2001. The main waterhole in each reach is highlighted by an asterix.

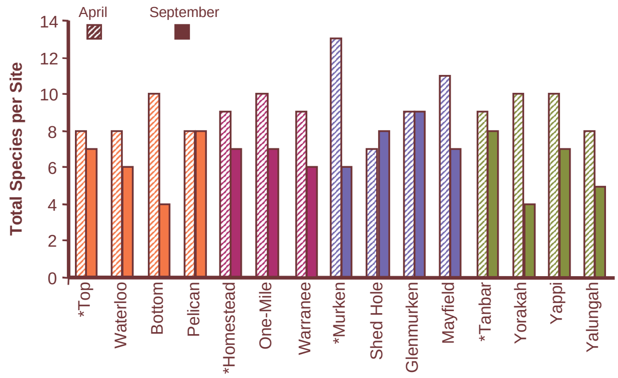
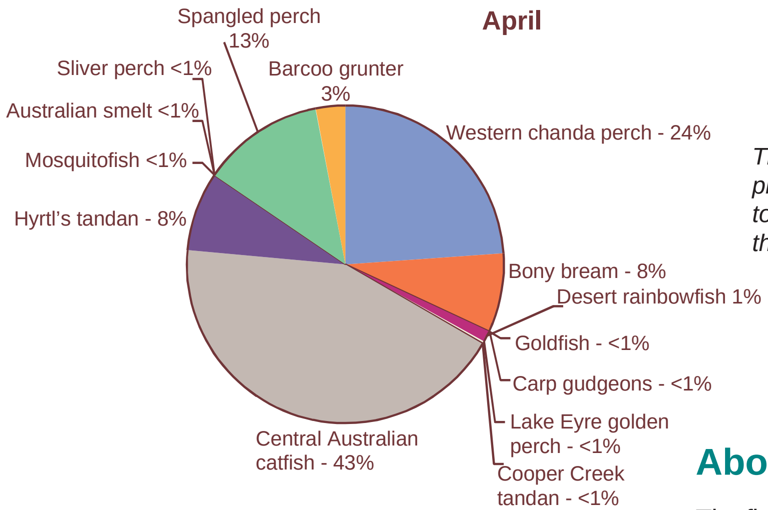
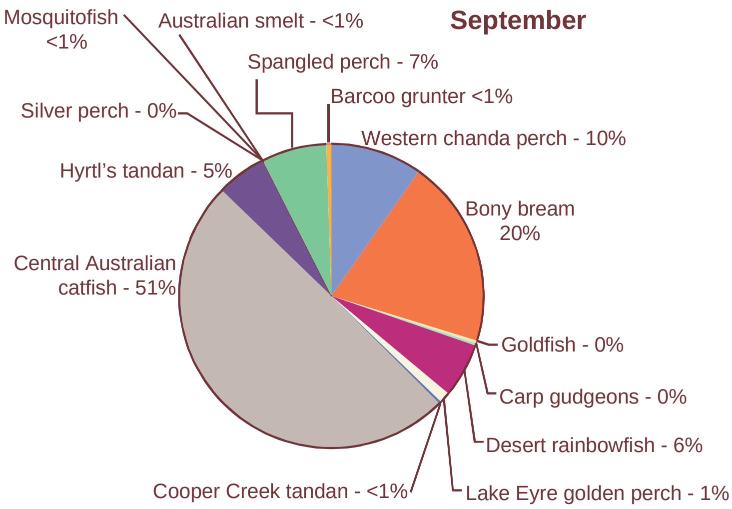


Figure 2. Total number of species per site for Cooper Creek April and September 2001. The main waterhole in each reach is highlighted by an asterix.

Figure 1 shows total fish abundance (CPUE) at each waterhole for the April and September 2001 sampling trips and Figure 2 the total number of species. Several interesting points emerge from the data collected thus far. Catch data showed wide variation among waterholes on both field trips but more so in April and catches were almost always lower in September than in April after several months of falling water levels. The total number of species collected varied from 7–13 per waterhole in April and 4-9 in September (Figure 2). Murken waterhole at Windorah had the highest species richness (13 in April 2001) and Yorakah at Tanbar had the lowest number of species (4 in September 2001).

Cooper Creek tandan - *Neosiluroides cooperensis*





These are 'pie diagrams' and the percentage of the pie represented by a particular spieces corresponds to the percentage of the whole catch across all sites for the sample period.

Figure 3. Fish species distribution across all sites Cooper Creek, April and September 2001.

Fish in the Cooper

Native species:-

Lake Eyre golden perch – *Macquaria sp.*
Barcoo grunter – *Scortum barcoo*
Spangled perch – *Leiopotherapon unicolor*
Bony bream – *Nematalosa erebi*
Central Australian catfish - *Neosilurus argenteus*
Hyrtl's tandan – *Neosilurus hyrtlii*
Cooper Ck tandan – *Neosiluroides cooperensis*
Desert rainbowfish – *Melanotaenia splendida tatei*
Australian smelt – *Retropinna semoni*
Western chanda perch – *Ambassis mulleri*
Carp gudgeons – *Hypseleotris* spp.

Introduced native species:-

Silver perch – *Bidyanus bidyanus*

Introduced exotic species:-

Goldfish – *Carassius auratus*
Mosquitofish – *Gambusia holbrooki*

About the Fish Community

The fish fauna of Cooper Creek waterholes is an interesting mix of species. The 11 native species included three catfishes, with the Cooper Creek tandan being the rarest of these and collected only in Noonbah and Windorah waterholes (i.e. the northern part of the study area). The most abundant species in April were the Central Australian catfish (moonfish), western chanda perch, spangled perch and bony bream. These patterns of abundance generally persisted to September 2001, except that we caught many less chanda perch in September (Figure 3).

Three fish species, not native to Cooper Creek, were also collected. The silver perch, *Bidyanus bidyanus*, has been introduced into this catchment from the Murray-Darling Basin. It is related to Welch's grunter or black bream, *Bidyanus welchi*, and also to the Barcoo grunter (*Scortum barcoo*).

Two exotic species (species originally from other countries), mosquitofish and goldfish, were included in our samples. The mosquitofish is quite rare (only caught in Murken, Tanbar and Yappi waterholes), whereas the goldfish is more common and apparently confined to the southern reaches of the study area. Goldifsh were found in all Springfield, Tanbar and Windorah waterholes. Both of these exotic fishes can have adverse interactions with native fishes and we will be observing their occurrence and abundance patterns closely during the study. European carp were not collected from any Cooper Creek sites during our surveys.

The next phase of the study will examine the factors determining these spatial and temporal patterns of species richness, composition and abundance.

Turtles in Waterholes

Arthur Georges & Fiorenzo Guarino: University of Canberra

Are there key refugia for turtles in dryland rivers?
What are the mechanisms and extent of dispersal among turtle populations?

To survive in Dryland Rivers, turtles must have evolved special traits allowing them to survive unpredictable flows and to sustain themselves between boom times. We are investigating the interplay between attributes of dryland river refugia and the biology of these animals that make it possible for them to inhabit these arid ecosystems. This will provide insight into the likely consequences of water resource development and changed land use on the long-term sustainability of these unusual turtle populations.

How do we sample turtles?

We capture turtles using baited hoop traps, seining and fyke netting. Upon capture, each turtle is given a permanent and unique mark, it is measured and its growth determined from annual growth rings on the scutes of its shell. We will also be taking a small sample of skin from each animal for DNA fingerprinting.

We examine all female turtles to determine if they are gravid: this involves squeezing the lower abdomen to feel for eggs in the body cavity. For gravid turtles, we use X-ray technology to determine the number and size of eggs and the stage of eggshell formation. We also use laproscopy to determine the proportion of animals breeding, their size at maturity and clutch frequency.

Rates of growth and size distribution are likely to be related to the size of turtle populations and to primary production and permanence of waterholes. We expect that past patterns of wetting and drying of waterholes, even at the time scales of many decades, will be imprinted on the populations of these very long-lived animals. Some of the largest turtles would be very old indeed, perhaps 80 or 100 years old.

What will this yield?

Turtles are long-lived taking 10-15 years to reach maturity with the largest animals over 80 years old. Waterholes that dry too frequently (every 2-5 years) will have no turtles at all. Waterholes drying every 15-25 years are unlikely to develop self-sustaining populations, and must rely on immigration during times of flood. Waterholes drying every 25-50 years will have time for some breeding, but insufficient time for mature populations to establish (Figure 1). Only permanent waterholes would have well established populations dominated by large adult turtles, with low growth rates and low rates of recruitment (Figure 1). This is our working hypothesis and if true, dryland river refugia will represent a source-sink arrangement, whereby relatively few refugia are responsible for recruitment over the broader region. DNA fingerprinting will yield estimates of the relatedness of turtles between waterholes allowing us to test our hypothesis that relatively few waterholes function as long-term refugial sites for turtles. These sites will require special attention if we are to ensure that these animals are able to persist long-term in the Cooper. However, their persistence will depend on the flooding regime and the ways in which human disturbance interferes with it through water resource development and illegal fishing practices.

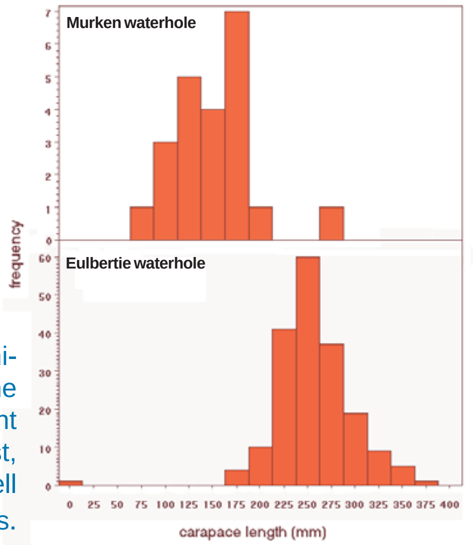


Figure 1. Murken is a good example of a semi-permanent waterhole with a turtle population on the upswing —it has some breeding but has had insufficient time for a mature population to establish. In contrast, Eulbertie is a permanent waterhole and has a well established turtle population dominated by large adults.

Progress so far

So far, the focus of the study has been on data collection. The turtles are indeed locally abundant, but their distribution is very patchy. We have identified at least two mature populations of turtles, one at Springfield and the other at Tanbar. Interestingly, these two waterholes have been protected from fishing and netting, and this opens for us the possibility of a confounding factor – illegal netting. Turtles will drown in gill nets and drum nets if not checked very frequently (every couple of hours). Death of one adult turtle is equivalent to 2,500 eggs which she would potentially lay in her lifetime.

After two intensive field trips to the Cooper we have captured only one species of turtle, the Cooper Creek short neck *Emydura macquarii.* The status of this species is contentious and further morphological and genetic work is required before we are able to determine whether we are dealing with a separate species, or a subspecies of the *Emydura macquarii* complex (Macquarie river short-necked turtle).

Diversity of Freshwater Invertebrates

Jane Hughes, Chris Bartlett, Katrina Goudkamp & Fran Sheldon: Griffith University

How is aquatic biodiversity (including invertebrate diversity) partitioned in space and time among refugia?

To measure the biodiversity of invertebrates we have sampled each waterhole using a range of techniques. Sampling and processing has been undertaken in association with the Queensland Department of Natural Resources and Mines. We have used 250 µm mesh sweep net samples from waterholes to collect macroinvertebrates and 75µm mesh plankton tows to collect zooplankton.

Photo by Jon Marshall QNRM

QNRM staff processing samples Yorakah Waterhole

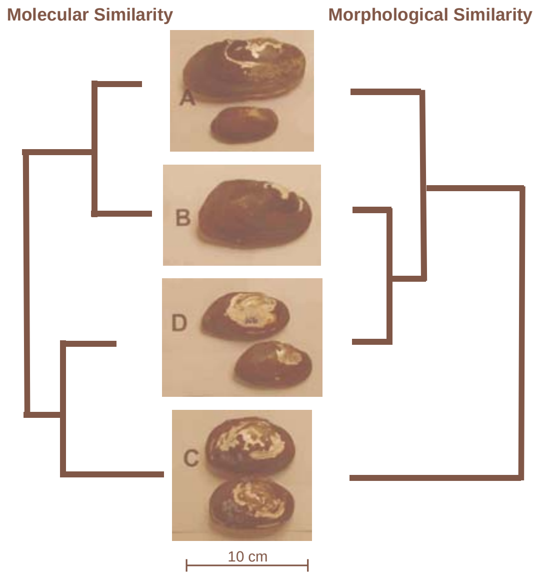
In addition, for some of the larger invertebrates, we have attempted to go further and to use genetic techniques to determine the presence of additional 'cryptic' species which cannot be identified using morphology alone. Genetic techniques can be used a) to determine whether interbreeding is occurring among different types within a waterhole (and thus the presence of multiple species) and b) to determine evolutionary relationships among the various types.

When we collected freshwater mussels, initially we thought we were sampling a single species. However, after we analysed the individuals using allozyme and mitochondrial DNA techniques, we were able to recognise four clearly distinct, non-interbreeding species. The relationships between them based on molecular data are shown by the tree opposite. Having used molecular methods to recognise the species, we then made a number of morphological measurements on the shells. The relationships between the species are similar using these two techniques, although the shell measurements could not delineate the species accurately without the DNA data.

Photo by Jon Marshall QNRM

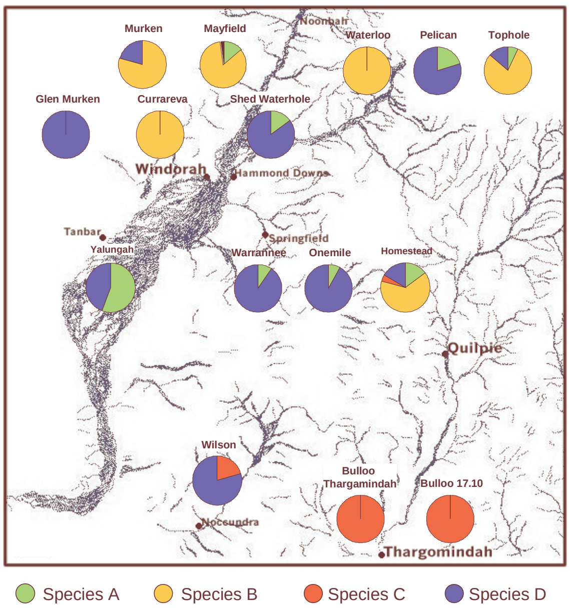
Collecting mussels

The Freshwater Mussel Story



Distribution of cryptic species of freshwater mussels

The relative abundance of each of the four species in each waterhole is shown in the pie diagrams opposite. These 'cryptic' species clearly occur throughout the Cooper system. In any particular waterhole, there may be one or more species. As these species have only just been identified, we have no idea about how their life-histories may differ. For example, it is known that the larvae attach to the gills of fish. It is possible that each species is restricted to one or a few fish species. This is likely to affect their ability to move between waterholes and to recolonise waterholes where local extinctions have occurred. We aim to use further genetic techniques to answer some of these questions.



Connectivity and Dispersal

Jane Hughes, Ben Cook & Gio Carini; Griffith University

What are the mechanisms and extent of dispersal among populations of aquatic organisms?

Genetic techniques to measure dispersal

A major question that we wish to address in this project is the role of connectivity in maintaining biodiversity in isolated waterholes. The ability of individuals of a species to move between waterholes will depend on their mechanisms of dispersal, for example whether they can fly, whether they can swim long distances etc. In many species little is known about how much dispersal occurs among sup-populations and because dispersal events may be rare, marking individuals and following movement patterns is usually not feasible.

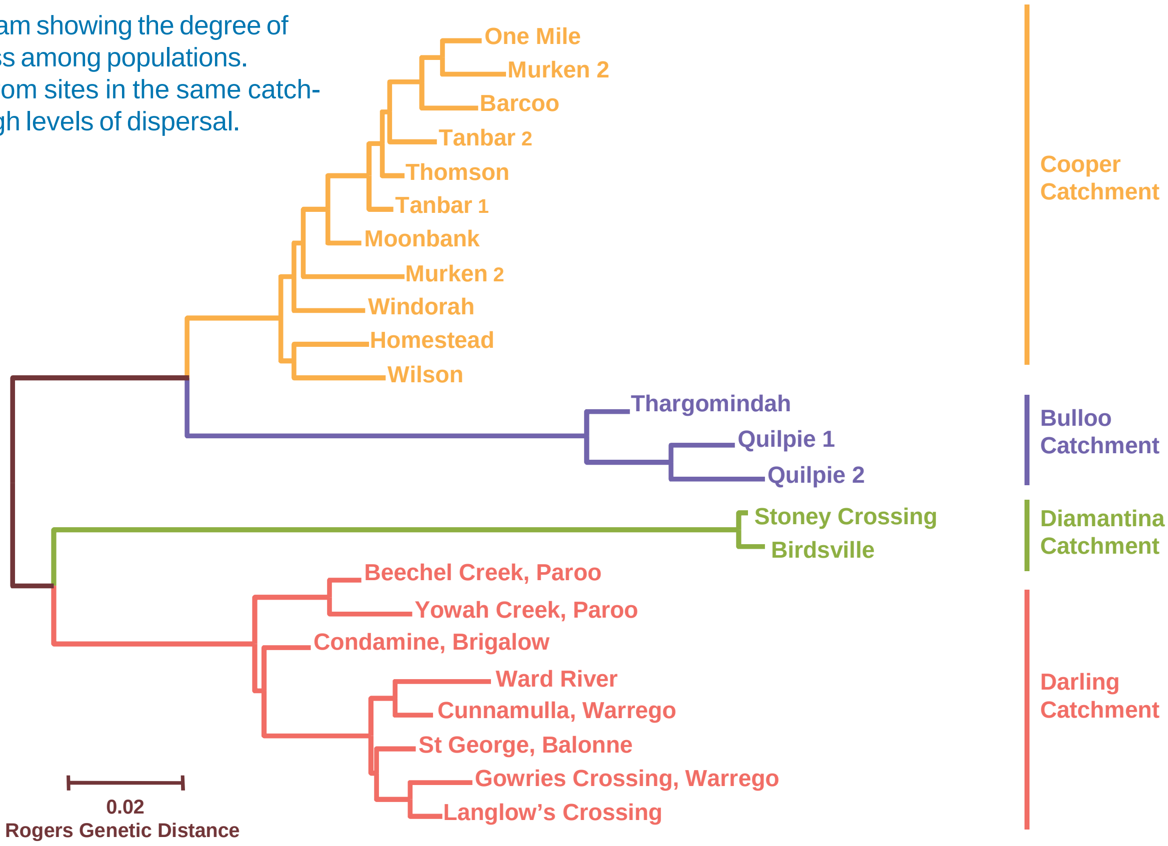
We have used genetic techniques to answer some of these questions. These techniques rely on the idea that if two populations are isolated, i.e. if dispersal between them is limited, then eventually they will become genetically different. If dispersal between them occurs regularly, then they will be genetically similar.

Dispersal in the Freshwater Prawn

We have used allozyme electrophoresis to measure genetic differentiation among populations from isolated waterholes. The freshwater prawn (*Macrobrachium australiense*) has been collected from waterholes from four drainages. Populations from within a drainage are very similar to one another, whereas populations from different drainages are clearly differentiated. This indicates that this species is capable of widespread dispersal within each drainage system, but that movement between drainages does not occur, even during peak flood times. Although capable ot overland movement, this does not occur between the major dryland river catchments.

Macrobrachium australiense (Freshwater prawn)

A 'Tree' Diagram showing the degree of connectedness among populations. Populations from sites in the same catchment show high levels of dispersal.



Dispersal in the River Snail

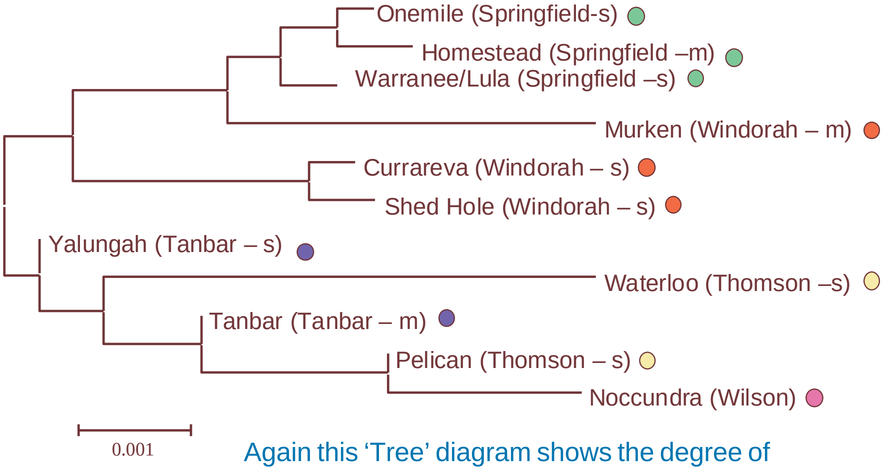
A similar analysis has been performed on the freshwater snail (*Notopala* sp.) from the Cooper System. This species is thought to brood young and to lack a planktonic larval stage. We had thus expected that dispersal among waterholes would be very limited. Surprisingly, the levels of genetic differentiation among populations from different waterholes within the catchment are similar to those observed for the prawn. Pie diagrams illustrate genetic variation for two genetic markers. Clearly there is little genetic differentiation among populations from different waterholes. For both markers, the same gene is most common in all populations and there is little variation in the relative frequencies of different genes (as indicated by the different colours in the pies) among waterholes. This indicates that this species is also capable of widespread dispersal within the Cooper system.

Photo by Stuart Bunn Griffith Uni

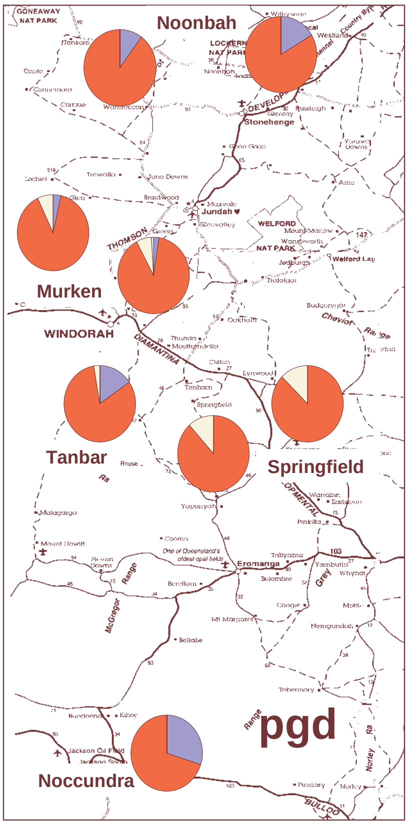
Notopala in a Cooper Waterhole

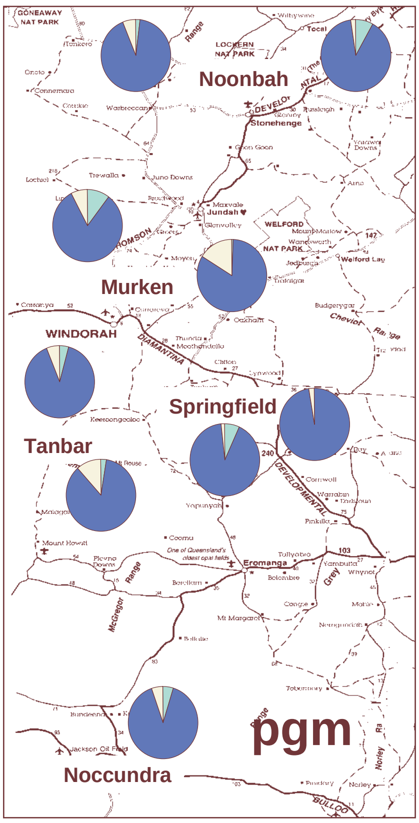
Photo by Jon Marshall QNRM

Freezing snails in liquid nitrogen

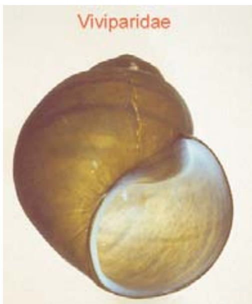


Again this 'Tree' diagram shows the degree of connectedness among populations. Populations from sites on the same branch show high levels of dispersal.





These are 'pie diagrams' showing patterns for two different loci or genetic markers (pgd & pgm). The more similar the pies, the greater the degree of dispersal between the sites.



Notopala sp.

Waterholes are Productive

Christy Fellows, Stuart Bunn & Joanne Clapcott: Griffith University

What are the chemical and biological processes that sustain refugia during dry periods?

Plants in one form or another form the energy base for most food webs. Through the process of photosynthesis, plants convert light energy, water, and carbon dioxide into organic carbon (like sugars) and oxygen. Primary production is the rate of formation of this organic carbon. Measuring primary production gives us an estimate of how much food is available for animals to consume. There are three basic types of plants that are potential food sources for the organisms living in waterholes: terrestrial plant material that enters the water, algae that live in the water column (phytoplankton) and algae that live attached to the sediment on the water hole bottoms (benthic algae). Previous work in Cooper Creek has determined that the two types of algae are the most important contributors to water hole food webs. Dryland river waterholes are very turbid (lots of sediment in the water) naturally, and therefore light does not penetrate very far into the water. Under these conditions, it might be expected that rates of photosynthesis of phytoplankton and benthic algae would be very low. However, many waterholes have a highly productive band of algae restricted to the shallow water at the edge of the waterhole. One of the goals of this project is to quantify the rates of primary production of benthic algae and determine why some waterholes may be more productive than others. Waterholes with different rates of primary production may, in turn, support different sized populations of crustaceans, fish, turtles and other animals.

Figure 2.
Bath-tub ring of algae around the edge of a Cooper Creek waterhole.

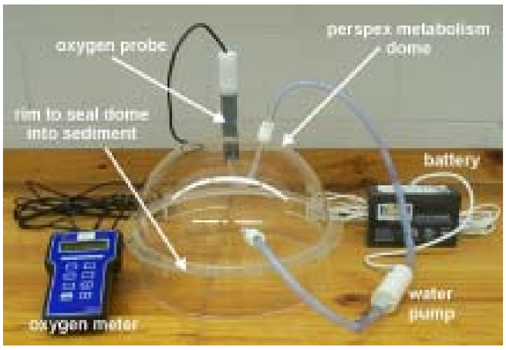


Figure 1. A benthic metabolism chamber

How is the primary production of benthic algae measured?

To measure primary production, clear domes made of Perspex are inserted into the sediment in the shallow edges of the waterholes to enclose a portion of the benthic algae (Figure 1 & 2). A meter which measures dissolved oxygen concentrations is inserted in the top of the dome, and a small pump circulates the water. The domes are left in place for 24 hours, and the meters automatically record the dissolved oxygen concentration every 15 minutes. Because photosynthesis produces oxygen, concentrations increase during the day (Figure 3). Twenty four hours a day, the algae and other organisms in the chamber are also carrying out the process of respiration, which consumes organic carbon and oxygen and produces carbon dioxide. At night, photosynthesis is not occurring, so oxygen concentrations gradually decrease due to respiration (Figure 3). From these changes in dissolved oxygen, the rates of photosynthesis and respiration can be calculated for each area of waterhole bottom where a dome has been inserted.

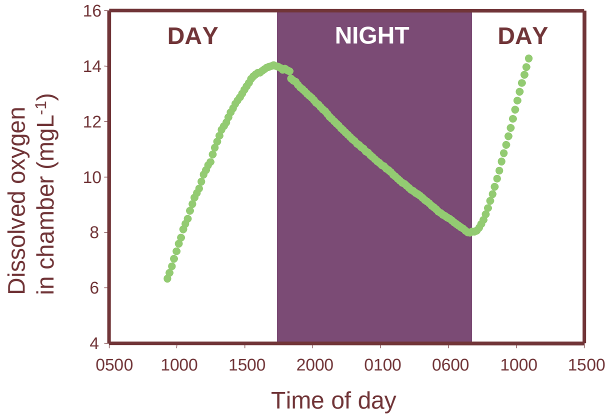


Figure 3. Photosynthesis and respiration of benthic algae result in changes in dissolved oxygen in a sealed chamber. Respiration happens continuously and consumes oxygen. Photosynthesis occurs during the day and produces oxygen.

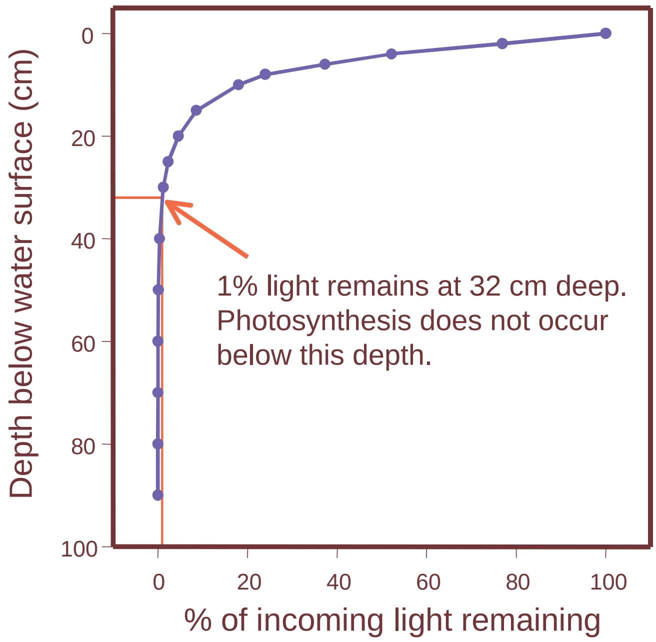


Figure 4. The amount of light available decreases sharply with depth in Cooper Creek waterholes. In this example from Glen Murken waterhole, only about 50% of the incoming light reaches a depth of 4 cm. Below 32 cm deep, there is not enough light available to support photosynthesis.

Cooper Creek - April 2001

Primary production and respiration were measured in 15 waterholes, using 4 domes per waterhole. Light penetration in the water was measured by taking readings of light intensity at different depths. The depth at which there is only 1% of the incoming light left is considered to be the deepest that algae can carry out photosynthesis (Figure 4). This depth varied from 10 cm at Yalungah waterhole to 48 at Tanbar waterhole. Rates of primary production ranged from 0.8 grams carbon produced per square meter per day at Yappi water hole to 0.1 at Homestead, One-Mile and Shed waterholes, with an average value of 0.4 for the 15 waterholes. The highest rate of respiration was also at Yappi, with a value of 0.7 grams carbon consumed per square meter per day and the lowest value was at 0.2 at Top and One Mile waterholes, and the average value was 0.4. There was a strong relationship between light penetration and rate of primary production (Figure 5), with higher primary production in waterholes with higher light penetration (lower turbidity).

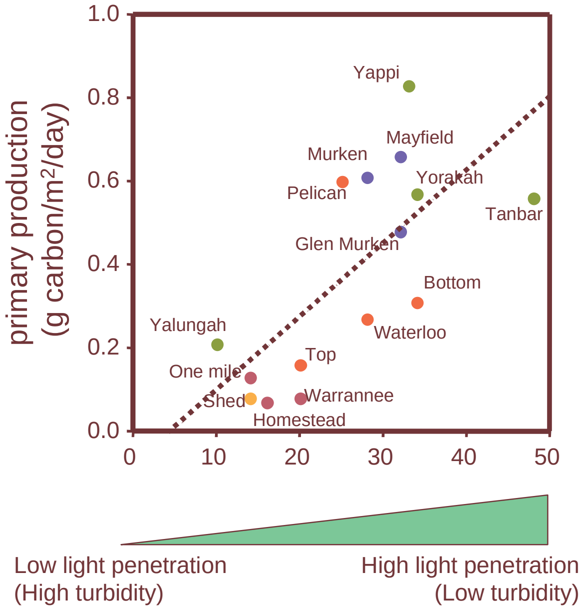


Figure 5. Rates of primary production of benthic algae decrease with decreasing light availability. In waterholes with higher turbidity, light does not penetrate as deeply, and the depth to which 1% incoming light remains is shallower. Primary production is lower in waterholes with higher turbidity.

At the waterhole scale, benthic algae primary production is a function of the surface area of the waterhole bottom that is shallow enough to receive at least 1% of the incoming light. Consequently, production will be strongly influenced by changes in water turbidity and interactions between water level changes and waterhole morphology. Waterhole perimeter and the slope of the banks are both important features of waterhole morphology.

The next step in this study is to work with the team looking at waterhole morphology, to determine the total primary production for each waterhole scaling up our chamber measurements. We will then work with the teams studying the other aquatic components to estimate what populations could be supported by the primary production in each waterhole.

Summary so far....

Photo by Jon Marshall QNRM

Sampling at Homestead Waterhole, Kyabra Creek

Photo by Jon Marshall QNRM

Setting fyke nets, Yorakah Waterhole, Tanbar

Photo by Jon Marshall QNRM

Glen Murken Waterhole, Windorah

The first 3 year phase of the Dryland River Refugia project is primarily focused on the identification and characterisation of refugia. The initial work, highlighted in this newsletter, has been undertaken in the Cooper Creek catchment. This system, together with the Warrego River, has low levels of water resource development and therefore allow us to improve our understanding of dryland rivers in a relatively undisturbed state. Comparisons between the Cooper and Warrego will also help us to determine the degree to which we can generalise predictions across major dryland river catchments.

Management Outcomes

One of the key management objectives of this project is to predict the consequences of water resource development on physical and biological processes and biodiversity in dryland rivers. In some developed catchments, floodplains and their associated waterholes may become isolated from the main channel. These natural features have been replaced by ring tanks and other on-farm storages. In developed catchments in-channel waterholes may be made more permanent by weir construction and the overall pattern of connectivity affected by modifications to the flow regime. How do these changes affect patterns of biodiversity and the key processes that sustain populations of aquatic plants and animals?

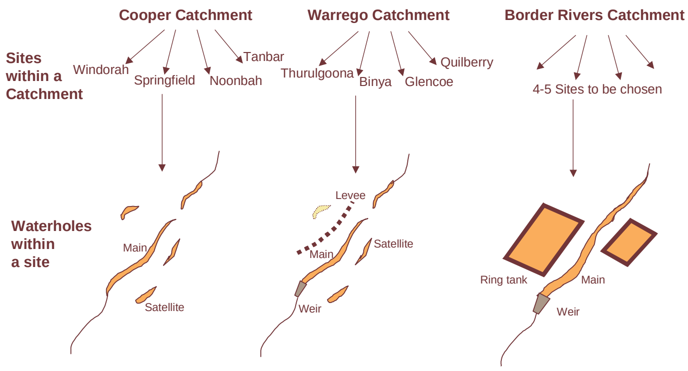
Although a key focus of the project is on impacts relating to water resource development, the project will also provide information to landowners and management agencies which will assist in the management of dryland rivers and protection of their biodiversity. Examples of some of the key issues we may address include:

- If populations are supported by a “bath-tub” ring of algae what are the management issues relating to water draw down rates and trampling of the water edge by stock?
- What are the mechanisms that keep waterholes permanent? *(i.e. the relative importance of surface water versus ground water)*
- Why are some waterholes the main sites for turtle populations?

Notostraca (tadpole shrimps) collected from Cooper floodwaters.

Future Field Work

2001 was our first year of field work and we commenced sampling in the Cooper Creek catchment and on the Warrego River. In 2002 we will continue working at sites on Cooper Creek and the Warrego River and pick up sites in the Upper Darling catchment.



Sampling design for the project. Three Dryland River catchments with different levels of water resource development. Reaches and sites within catchments. At this stage we have sampled sites within the Cooper and Warrego catchments. Sampling of the Upper Darling catchment will commence in September 2002.

Cooper Creek short neck turtle *Emydura macquarii*

Photo by Jon Marshall QNRM

Packing up camp on a Cooper Field Trip

Next Newsletter

In our next newsletter we will
(a) present initial data from the Warrego field work, our second largely undisturbed system, and,
(b) begin to explore what features of waterholes underlie the observed patterns in biodiversity. This will not only include their physical shape but also aspects of their connectivity.

Photo by Jon Marshall QNRM

Sampling Mirage Waterhole, Warrego River

Photo by Jon Marshall QNRM

Sampling Glencoe Waterhole, Warrego River

Newsletter prepared by Fran Sheldon, CRCFE Griffith University. F.Sheldon@mailbox.gu.edu.au

Cooperative Research Centre for Freshwater Ecology

Improving Australia's Rivers

Healthy rivers are essential for the future of Australia's landscape and its people. Yet many rivers are being damaged by unsustainable practices, resulting in poor water quality, degraded habitats and declining biodiversity. Understanding how our river systems work is essential if we are to manage them in a sustainable way.

The Cooperative Research Centre for Freshwater Ecology (CRCFE) is a world-class research centre specialising in river system ecology, river restoration and sustainable river management. It provides the latest ecological knowledge needed to manage rivers in a sustainable way. A core part of the CRCFE's work is to communicate this knowledge while working with other scientists, water managers, policy makers and the community.

The CRCFE's 200 staff and students are based in Adelaide, Brisbane, Canberra, Melbourne and Sydney; as well as in three regional laboratories: the Murray-Darling Freshwater Research Centre in Albury, the Lower Basin Laboratory in Mildura and the Northern Laboratory in Goondiwindi.

The CRCFE's research addresses four key themes in water resources management:

- Environmental Flows (Program A)
- Restoring River Systems (Program B)
- Conserving Biodiversity (Program C)
- Assessing River Health (Program D)

Key questions

- Can we improve river systems through better management of water releases?
- How does flood harvesting and flow regulation affect river – floodplain ecology?
- How can we best rehabilitate disturbed river systems?
- What biodiversity still remains in our river systems and how is it regulated?
- How can we best measure river condition to evaluate management actions?

The research required to address these questions is often beyond the resources and skills of individual researchers. The CRCFE brings together some of Australia's best freshwater scientists from many different disciplines and organisations to work in teams. This collaborative, multidisciplinary approach enables the CRCFE to play a leading role in water resources management as a provider and broker of knowledge.

Further information

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