internal report **342**

Description and literature review of the flora and vertebrate fauna of the Magela Creek system, Alligator Rivers Region, northern Australia

A resource for development and assessment of management strategies for the catchment, with particular reference to Swift Creek

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Acknowledgements

Special thanks go to Ms Joan Mount for conducting on-line searches and establishing the 'MAGELA SYSTEM' bibliography database, and to Guy Boggs for his assistance with the preparation of figures.

1 Introduction

The Magela Creek and floodplain is located in the Alligator Rivers Region, which encompasses Kakadu National Park, some 200 km east of Darwin, Northern Australia. Management strategies in the catchment of Magela Creek have largely been directed towards the environmental effects of uranium mining and milling at the Ranger minesite and, more recently, at the site of the proposed Jabiluka mine (see Figure 1 for map of all locations). Recent assessments have been summarised by Johnston & Prendergast (1999) and Johnston and Needham (1999). Further assessment has been anticipated with renewed emphasis on the biodiversity of the floodplain habitats. The floodplain downstream of the Ranger Uranium Mine and the Jabiluka lease area is of particular interest, as the biota of this region are considered the most susceptible to any pollutants in waste-waters released from mining operations. In support of such assessment we present two papers: a description of the Magela floodplain, and review of information on the flora and vertebrate fauna. The literature on the invertebrate fauna has been summarised in a separate report (Humphrey & Bouckaert, in draft). Literature containing baseline data on species composition, abundance, distribution and biomass were reviewed, to determine what flora and fauna occur in the Magela system, to identify any species of conservation importance and to highlight areas requiring further work.

A description of the floodplain habitats and the flora and vertebrate fauna is presented. This is in summary form and presented under the following headings: vegetation, algae, fish, amphibians, reptiles, birds and mammals and alien species. This is followed by a second paper which is an annotated review of individual articles, presented under similar headings including an additional section of general studies that encompass a range of organisms. The emphasis for this second paper was on studies of aquatic and wetland flora and fauna. However, studies on other fauna such as birds, reptiles and mammals were summarised, although not aquatic, these animals potentially utilise the Magela Creek system as a source of water and the surrounding vegetation as habitat. The studies that were reviewed ranged from having a narrow focus, such as those that sampled one section of the Magela creek system, to studies that incorporated the whole of the Alligator Rivers Region. Wider studies without survey sites in the vicinity of the Magela Creek system were not considered relevant for this report, such as *The Kakadu Fauna Survey* (Braithwaite 1985), and the *Alligator Rivers Region Fact-Finding Study* (Adams et al 1973, CSIRO 1973, Story 1973).

Given recent debate about the World Heritage values of the Park in relation to uranium mining proposed for the Jabiluka minesite special attention is given to assessing the relevance of this information to Swift Creek (Ngarradj) that flows past the minesite and into the Magela (Figure 1). The Swift Creek catchment, including the backwater floodplain confluence with the Magela and the upper catchment covers an area of 66.0 km^2. Relevance was based on the proximity of a study's sampling sites to Swift Creek, as well as the extent of site-specific data provided in a report.

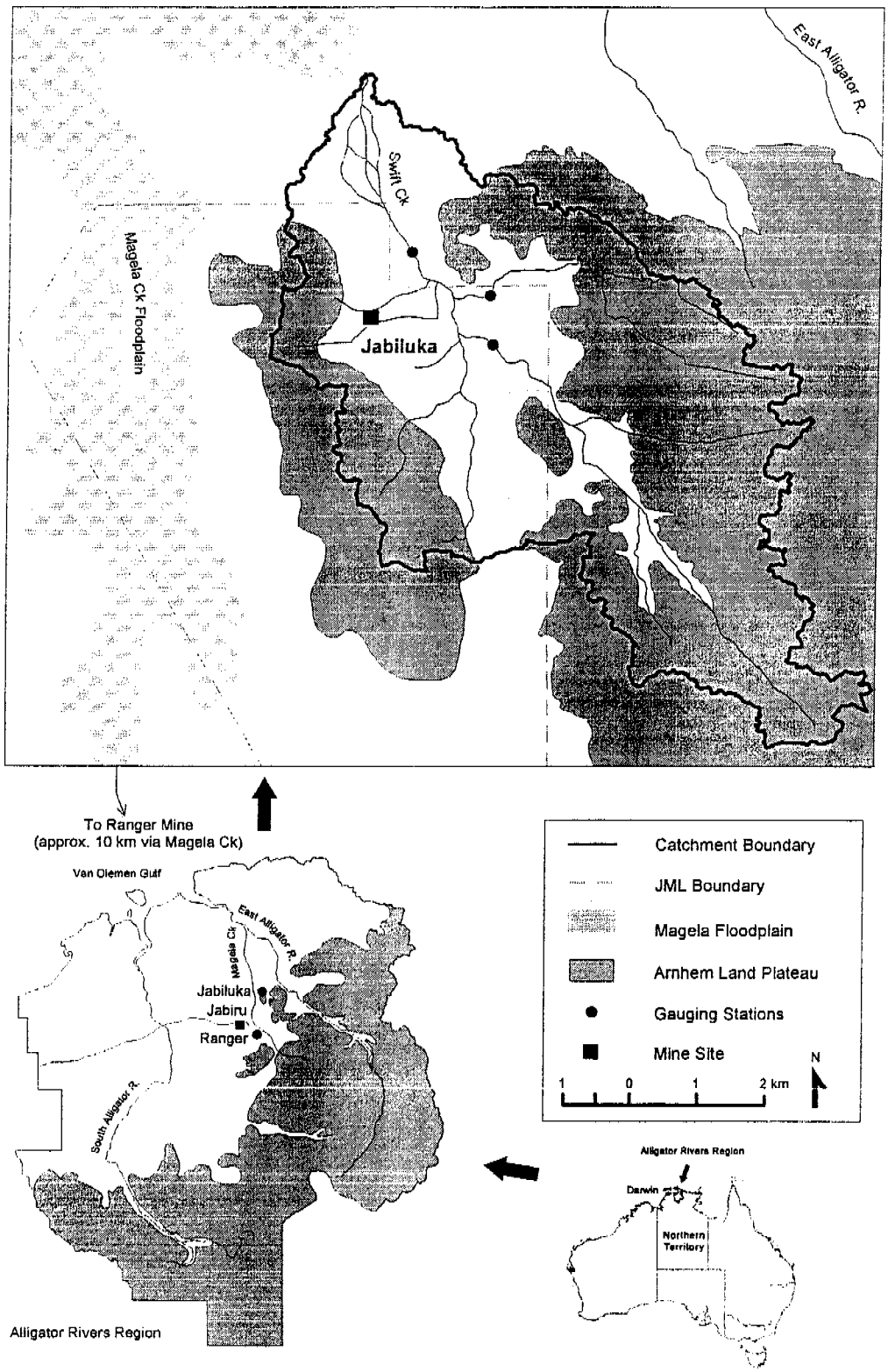

Figure 1 The Magela Creek floodplain in relation to the Swift Creek (Ngarradj) catchment (after Boggs et al 2000)

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DESCRIPTION OF THE FLORA AND VERTEBRATE FAUNA OF THE MAGELA CREEK SYSTEM, ALLIGATOR RIVERS REGION, NORTHERN AUSTRALIA

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1 Introduction

In this paper we provide a description of the flora and vertebrate fauna of the riparian, channel and wetland habitats found along Magela Creek, located in Kakadu National Park, Northern Australia. Extensive research on the creek and its wetland habitats has been undertaken as a result of concerns over the potential environmental effects of mining operations at Ranger Uranium Mine, and more recently at the Jabiluka minesite (Finlayson et al 1990a, Johnston 1990, Johnston & Needham 1999, Johnston & Prendergast 1999). The natural values of the wetland habitats have been recognised through the listing of Kakadu National Park under the World Heritage Convention and the Ramsar Wetland Convention. Components of the biota that are described include the distribution and seasonal changes in vegetation, phytoplankton diversity and productivity, and the diversity of the fish, amphibian, reptilian, bird and mammal fauna. The impacts of introduced plant and animal species are reviewed and general management considerations for the creek system are discussed. As the biota on the Ranger and Jabiluka minesites is possibly at risk from any disturbance and mining development, studies conducted specifically on these areas are also reviewed, as is the potential of species to transfer contaminants from aquatic to terrestrial environments.

2 Physical Characteristics

2.1 Location

Magela Creek is located in the Alligator Rivers Region (ARR) about 250 km east of Darwin (Figure 1) (Finlayson et al 1990a). The creek is a seasonally-flowing tributary of the East Alligator River, originating in the sandstone Arnhem-land plateau (East 1996). It is made up of five definite parts: channels that dissect the escarpment; braided sandbed channels that stretch across the lowlands; a series of billabongs and connecting channels (the Mudginberri Corridor); and a seasonally-inundated black-clay floodplain with permanent billabongs; and a single channel that flows into the East Alligator River (Finlayson 1994, Finlayson et al 1990a).

This paper examines all five areas of the creek, but focuses on the floodplain as this section, downstream of the Ranger and Jabiluka lease areas, is considered most at risk from any contaminants released in waste-waters from the minesites (see Johnston 1990, Johnston & Needham 1999 for details of steps taken to manage waste-waters). This area, referred to as the Magela floodplain, incorporates the Mudginberri corridor and the black-clay floodplain, and covers about 250 km^2 (Finlayson et al 1989). Paperbark forests, open perennial and annual swamps, billabongs and grass/sedge herbfields make up the floodplain (Williams 1979). The billabongs of the system have been categorised by Walker et al (1984) into three types: channel (depressions in flow channels), backflow (lagoons on small feeder streams) and floodplain (remnants of deep channels on the black-clay floodplain). The location of the billabongs is shown in Figure 2.

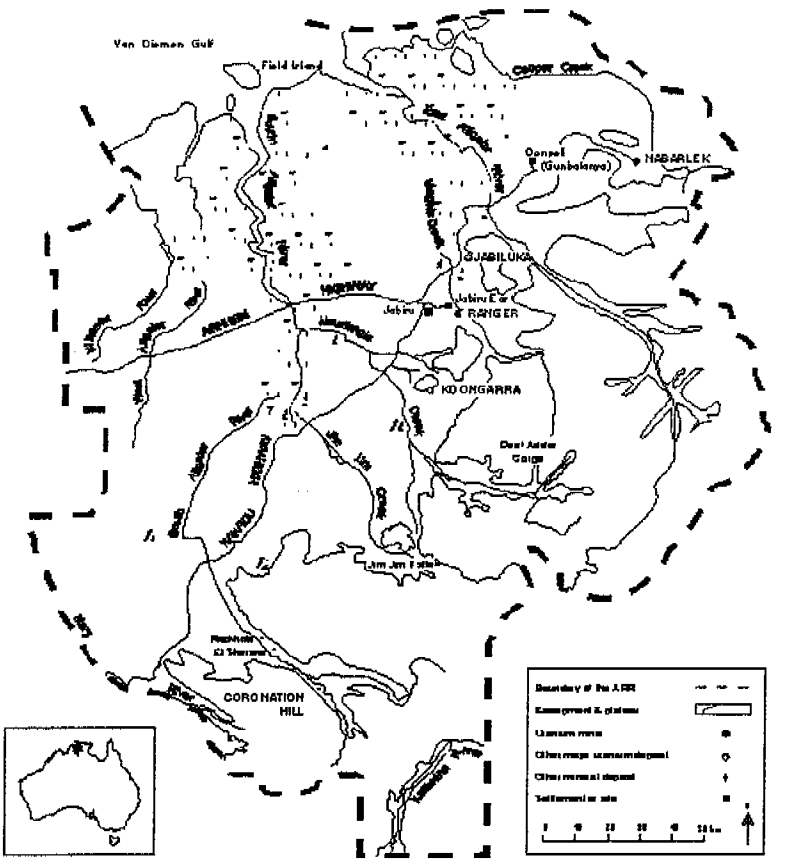

Figure 1 Location of the Magela Creek system and the main features of the Alligator Rivers Region

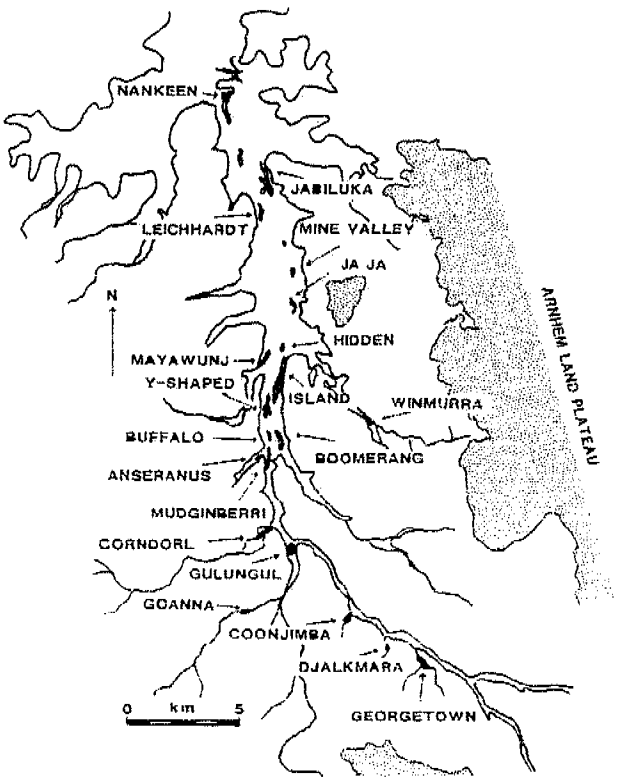

Figure 2 Magela Creek floodplain showing the main billabongs (Finlayson et al 1990a)

2.2 Climate

The Alligator Rivers Region is characterised by a monsoonal climate with two distinct seasons, the Wet and the Dry. The onset of the Wet season occurs in November-December and the season usually lasts for 3-4 months; however the start and duration of the season changes from year to year (Finlayson et al 1990a). The average annual rainfall ranges from 1300-1500 mm mostly occurring in the Wet season as a result of thunderstorms, tropical cyclones and monsoon depressions. January-March have the highest rainfall with 250-350 mm, but November-December have an average of 150-200 mm. Average maximum temperatures range between 31-37 °C, with the hottest month being October and June-July the coolest months. July has the lowest average minimum of 13 °C while the highest minimum (24 °C) occurs from November-March (McQuade et al 1996).

Local Aboriginal people recognise a calendar that includes six seasons. The calendar reflects both direct climatic changes as well as ecological changes in the flora and fauna (Stokes 1981). The six seasons include the: *Gudjewg* or monsoon season (December-March); *Banggerreng* or harvest time (March-May); *Yegge* or cool weather time (May-June); *Wurrgeng* or early dry season (June-August); *Gurrung* or hot dry season (August-October); and *Gunumeleng* or pre-monsoon season (October-December) (Morris 1996) (Figure 3).

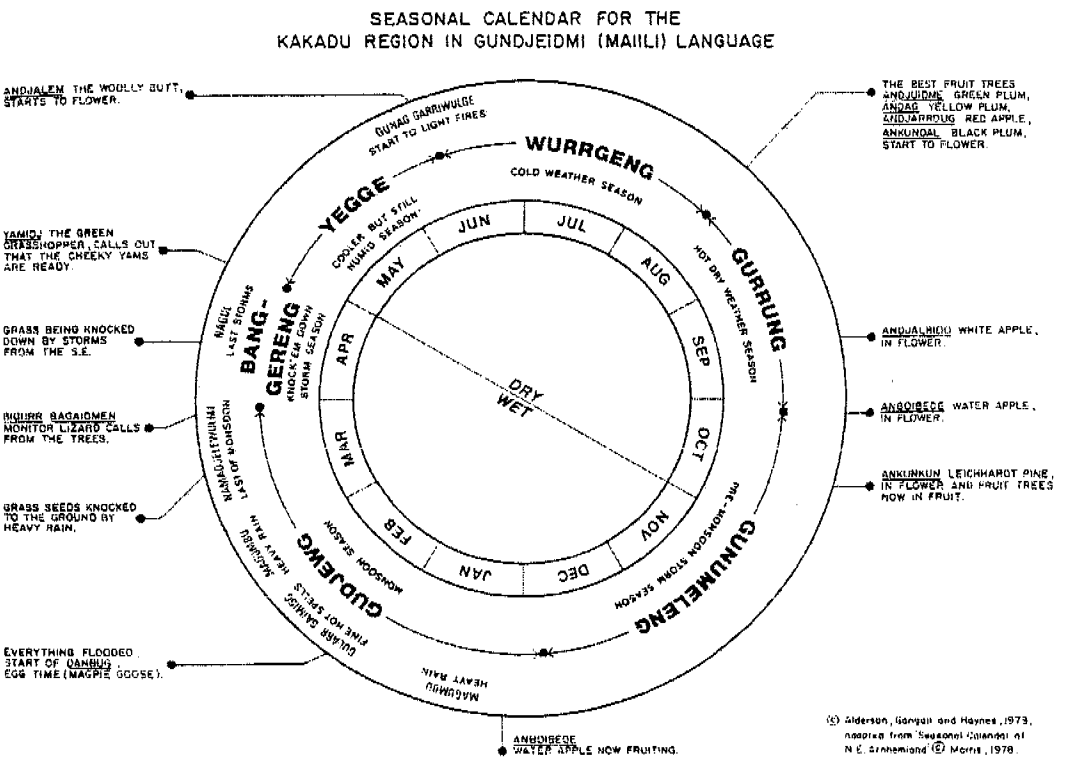

Figure 3 Aboriginal seasonal calendar (Stokes 1981)

The seasonal nature of the rainfall in the ARR causes significant fluctuations in the water regime of its creeks and rivers (Bishop et al 1986). Sanderson et al (1983) provided a generalised representation of the rainfall and waterflow cycle in Magela Creek (Figure 4) that included six phases: intermittent heavy rains which saturate the soils; more consistent rains that result in creek flow; wide-spread flooding as the rainfall continues, inundating the floodplain; cessation of the Wet season flow and falling water levels as the rains stop; and a decline in the water level due to evaporation leaving water only in a small number of permanent billabongs and swamps.

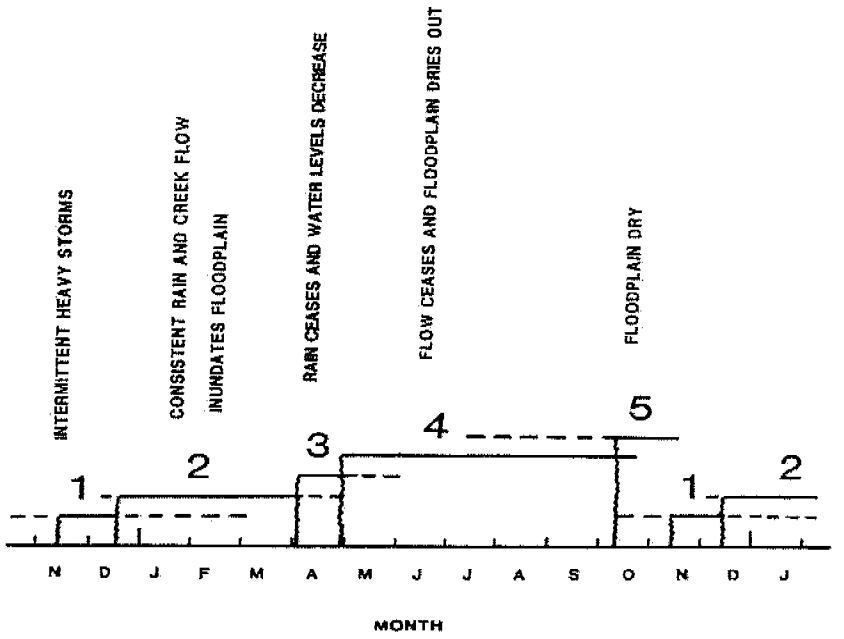

Figure 4 Seasonal cycle on the Magela Creek floodplain based on observed events from 1979-85 (adapted from Sanderson et al 1983) (Finlayson et al 1990a)

3 Biological Characteristics

3.1 Vegetation

3.1.1 Vegetation description

One of the earliest scientific descriptions of the vegetation of Magela Creek was produced by Story (1969) from a survey of the Adelaide-Alligator area. Story (1969) identified 15 communities: tall open forest; woodland; stunted woodland; mixed scrub; *Pandanus* scrub; leguminous-myrtaceous scrub; paperbark forest; mangrove scrub; rain forest; semi-decidous forest; savannah; grassland; sedgeland; herbaceous swamp vegetation and samphire-*Arthrocnemum* dominant. Williams (1979) delineated six broad vegetation communities on the Magela floodplain which were interpreted as indicators of water depth. These included: mixed herbfield; grassland; undulating annual swamp and grassland; forest; annual swamp; and perennial swamp. Morley (1981) compiled a species list of the aquatic vascular plants on the floodplain between Nankeen and Mudginberri billabongs. Sixty-one species were

recorded, comprising 36 communities, the distributions of which were dependent on flow conditions and water depth. However, as this classification was too detailed and not repeatable in subsequent years Sanderson et al (1983) produced a broader classification for the same region. Ten vegetation types were identified: *Najas-Nymphaea Pseudoraphis* herbland; *Pseudoraphis* grassland; *Eleocharis Pseudoraphis* sedgeland; *Oryza-Hygrochloa* grassland; fast flow *Blyxa* herbland; fringing closed *Hygrochloa-Nymphoides*; mixed herbland; *Hygrochloa* grassland; fringing *Majas-Blyxa* herbland; and deep water community. However, this classification only covered the area between Mudginberri and Nankeen billabongs and is only applicable to the 1980 season when the survey was conducted.

To account for the seasonal variations in the vegetation on the Magela floodplain, Finlayson et al (1989) compiled a general vegetation classification and map based on several years of peak Wet season vegetation data. The name of each vegetation unit reflected an indicator species most abundant at the time of peak biomass, or a general descriptive name was given. Ten communities were delineated: *Melaleuca* open forest and woodland (7390 ha, 34%); *Melaleuca* open woodland (1290 ha, 6%); *Nelumbo-Nymphoides* herbland (2090 ha 9%); *Oryza* grassland (2730 ha, 12%); *Hymenachne* grassland (1930 ha, 9%); *Pseudoraphis* grassland (3050 ha, 14%); *Hymenachne-Eleocharis* grass-sedgeland (1290 ha 6%); mixed grass-sedge-herbland (1120 ha, 5%), *Eleocharis* sedgeland (960 ha, 4%); and open water community (160 ha 1%). A map of these vegetation communities is given in Figure 5.

Of the 1874 species recorded in the Alligator Rivers Region (Brennan 1996), a total of 222 species occur on the Magela floodplain (Finlayson et al 1989). These species are found within 4 general habitats: seasonally inundated plain; seasonally inundated fringe zone; billabong; and permanent swamp. The first two habitat types contained 41% and 71% respectively of the 222 species, while billabongs contained 20% and permanent swamps 10%. One hundred and thirty-nine annual species were recorded, of which 102 were terrestrial and 37 aquatic. The terrestrial species were herbs, sedges and grasses, while the aquatic species were predominantly herbs. There were 68 perennial species, 50 of which were found in the fringe zone. Thirty-four perennial species were terrestrial, 26 aquatic and 8 hard to classify. As with the annuals, the majority of the aquatic perennials were classified as herbs. Fourteen species of geophytic perennials were present, 6 of which were herbs found only in the fringe zone.

The vegetation of some billabongs along Magela Creek has also been classified. Finlayson et al (1994) described the communities of three backflow (Coonjimba, Djalkmara and Georgetown) and two floodplain billabongs (Jabiluka and Leichhardt). The fringing perennial *Melaleuca* spp. trees and the geophytic perennial *Eleocharis* spp. sedges were the dominant plant species, in terms of biomass, in backflow billabongs. Due to a decline in feral water buffalo, sedges have become more abundant in backflow billabongs, which has resulted in increased siltation in these waterbodies. In general, floodplain billabongs are deeper with steeper sides and as a result the vegetation is restricted to a narrow fringe along the edge. Floating grass and sedge mats including the introduced species *Salvinia molesta* were present in the floodplain billabongs.

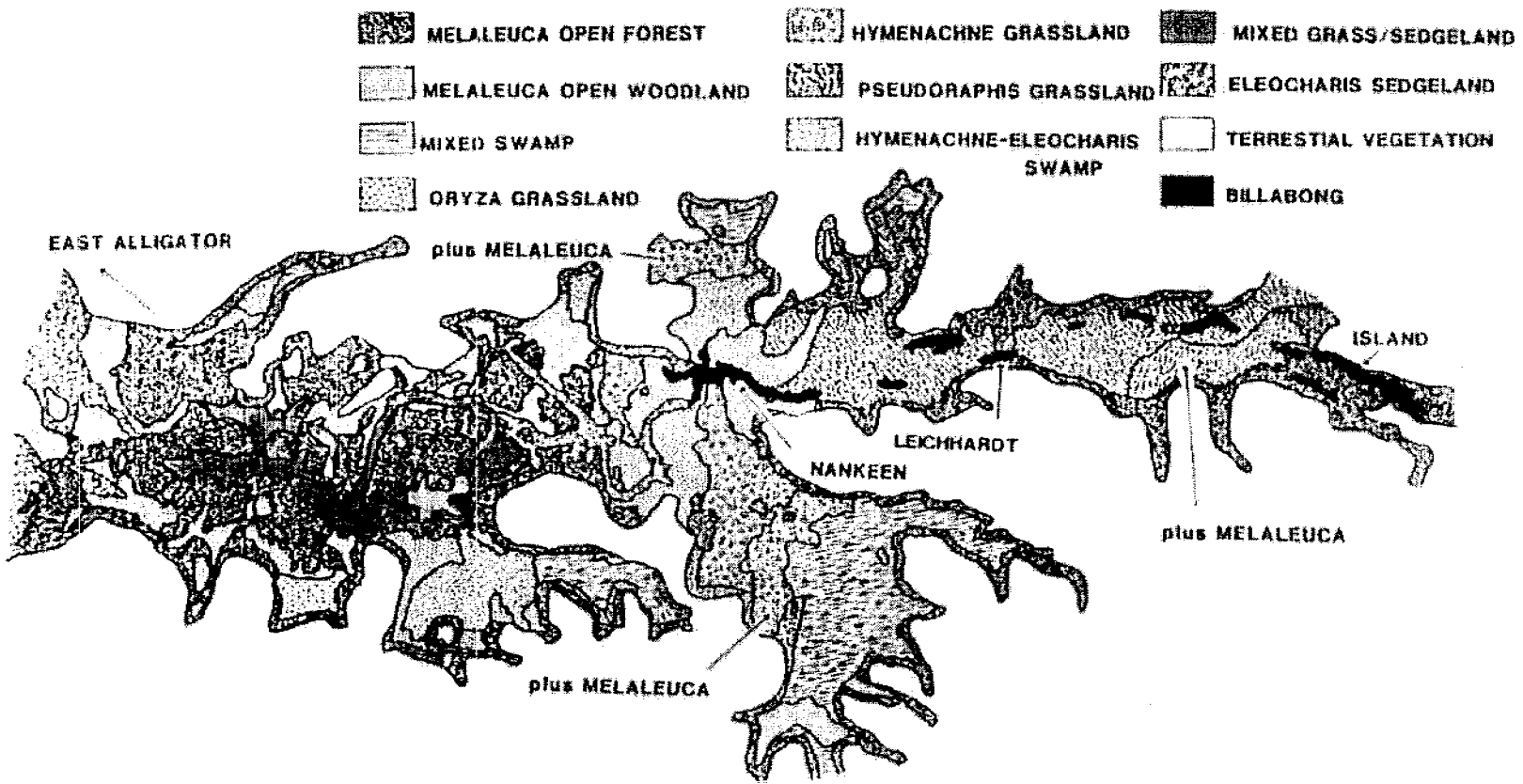

Figure 5 Vegetation map of the Magela Creek floodplain (1: 100 000) (Finlayson et al 1990a)

As part of the Jabiluka EIS (Kinhill Engineers Pty Ltd & ERA Environmental Services Pty Ltd 1996), a vegetation survey of the Jabiluka project area was undertaken. One hundred and sixty-nine species from 62 families were recorded. The vegetation was classified into two broad alliances: the Dryland Plain Alliance and the Floodplain Alliance, which were divided into 8 communities. The four floodplain communities were: *Melaleuca* channel woodland; riparian woodland; *Melaleuca* floodplain; and grassland with few emergents. A more recent study by Lane (1998) recorded 265 species from 78 families and identified 3 main vegetation associations: lowland, dryland and escarpment. The lowland associations included: *Allosyncarpia ternata* closed forest; riparian woodland/open forest; *Melaleuca leucadendra* (paperbark swamp); *Eucalyptus alba* closed forest; *Corymbia arafurica* open forest; *M. nervosa* woodland/open forest; *M. viridiflora* open forest; and mixed woodland. The vegetation of the Ranger lease area was surveyed by Corbett (1996). The aquatic and riparian vegetation in 3 Magela Creek billabongs, Rentention Pond 1 and the Jabiru Lake was sampled. A total of 69 aquatic and 154 riparian and terrestrial species were recorded. All the natural billabongs were characterised by *Caldesia oligococca* and *Maidenia rubra*, while the artificial waterbodies were characterised by *Eleocharis sundiaca* and *Vallisneria spiralis*. The aquatic vegetation of Djalkmara and Coonjimba billabongs was dissimilar to the other natural billabongs. Corbett (1996) suggests this may reflect the fact that these two billabongs receive waste-water from Ranger retention ponds. Aquatic plants are known to take up and release heavy metals and other contaminants directly from the water column and from the sediments (Hart et al 1984). The vegetation of these billabongs may potentially uptake contaminants released in the waste-water. Moreover, as plant communities form the base of food webs in the billabongs, and on the floodplain in general, they have the potential to transfer pollutants to the terrestrial environment.

3.1.2 Vegetation dynamics

A significant feature of the Magela Creek floodplain is the seasonal changes in the vegetation. The hydrological regime of the Magela floodplain, presented by Sanderson et al (1983) (Figure 4), indicates there are five periods important to the seasonal growth of floodplain plants. Finlayson et al (1989) surveyed transects along Nankeen Billabong to demonstrate the seasonal variations, and the changes are shown in Figure 6. In general, following inundation of the floodplain, development of aquatic plants is rapid and communities are well-established by the Late-wet season. The cessation of rainfall during the Late-wet to Early-dry season causes water levels to decline, and in turn aquatic plants senesce and decaying plant matter becomes abundant. By late in the Dry season there is little water remaining on the floodplain and aquatic plants are present only in billabongs, unless they have terrestrial growth forms. Terrestrial grasses and herbs are predominant during this period.

In addition, Finlayson et al (1990) examined the sediment seedbanks of 3 widespread grassland communities on the floodplain. The size and composition of plant species that developed from the seedbanks were determined under moist and flooded conditions. In terms of the species present, the *Pseudoraphis*-site seedbank had the most similar species composition to that of its community on the floodplain. In contrast, the *Hymenachne*-site and *Oryza*-site seedbanks did not as closely reflect their individual floodplain communities. The experimental data collected in these two studies have been applied to examine the effectiveness of an empirical model to predict plant succession on the floodplain. While the model is limited it does allow predicted patterns and actual successional changes to be

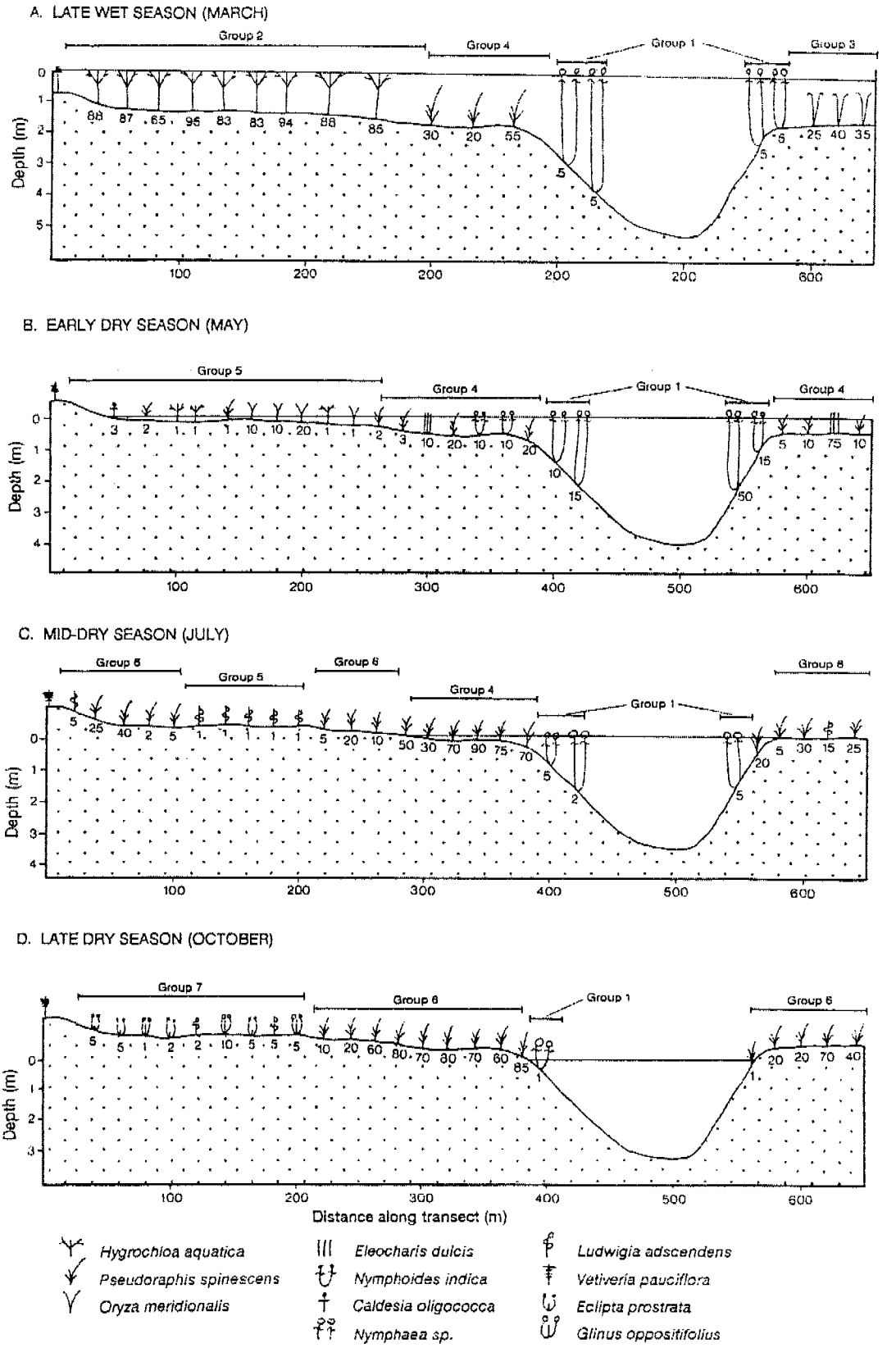

Figure 6 Seasonal changes in floodplain vegetation, percentage cover and dominant biomass along transects at Nankeen Billabong (Finlayson et al 1989, Finlayson et al 1990a)

compared. To validate the model the 1983-84 hydrological cycle was considered and the successional changes in *Pseudoraphis*, *Hymenachne* and *Oryza* grasslands were determined (Figure 7 & 8). Validation revealed that both duration of inundation and water depth influence patterns of vegetation succession.

3.1.3 Vegetation productivity

Productivity of the vegetation on the Magela floodplain was examined by Finlayson (1988, 1991a). Changes in above-ground biomass for three widespread aquatic grasses (*Pseudoraphis spinescens*, *Hymenachne acutigluma* and *Oryza meridionalis*) were measured. Water depth on the floodplain influenced the dry weight of the three species and peak dry weights (1.67 ± 0.21 kg m^{-2}, 1.41 ± 0.10 kg m^{-2}, 0.51 ± 0.10 kg m^{-2}, respectively) coincided with the end of the Wet season, when water levels were receding. The correlation between water depth and productivity was positive for *P. spinescens* and *O. meridionalis*, but negative for *H. acutigluma*. Two growth periods were evident for the perennial species *P. spinescens* and *H. acutigluma* which had an annual productivity of 1.91 ± 0.26 kg m^{-2} and 2.09 ± 0.38 kg m^{-2} respectively. Although productivity was not as high as for some large emergent aquatic species, it was high in comparison to other aquatic and wetland species. *O. meridionalis* which is an annual species had a lower annual productivity of 0.51 ± 0.10 kg m^{-2}. As these three grass species cover 35% of the floodplain and about another 220 species are present on the floodplain this ecosystem can be described as highly productive. Finlayson (1988) and Finlayson et al (1993) also measured the litterfall of *Melaleuca* forests and woodlands that cover 40% of the floodplain, as an indirect analysis of productivity. Litterfall appears to be bimodal with peaks occurring in the Wet season (January) and Mid-dry season (June-July). As wind speeds are high during these periods wind is thought to influence litterfall. The annual amount of litterfall ranged from 8 to 15 t ha^{-1} and was dominated by leaf material. The amount of litterfall varied spatially which was attributed to waterflow. As a result of transport by flowing water very little leaf litter accumulates on the floodplain. The litterfall is equal to or higher than values for many other forests in Australia, further indicating that the floodplain is highly productive.

3.2 Algae

3.2.1 Algae populations

Algae occur in all natural aquatic ecosystems and are predominant primary producers. Maintenance of healthly natural assemblages is essential to the health of the whole ecosystem (Walker & Tyler 1986). Numerous taxonomic studies of the algal flora of the Alligator Rivers Region and the Magela Creek system, including the assessment of these organisms as water quality monitors, have been conducted. Brady (1979), McBride (1983) and Thomas (1983) have examined the diatom flora while Morley (1981), Ling and Tyler (1986) and Kessell and Tyler (1982) have sampled all other groups. Broady (1984) investigated the cyanobacteria and Walker and Tyler (1983) examined the productivity of the algal populations in Magela Creek billabongs.

The diatom flora of the Alligator Rivers Region is very diverse and has much in common with the flora of South-East Asia. Thomas (1983) recorded more than 160 diatom taxa from 32 genera, with both tropical and cosmopolitan distributions. Within the Magela Creek

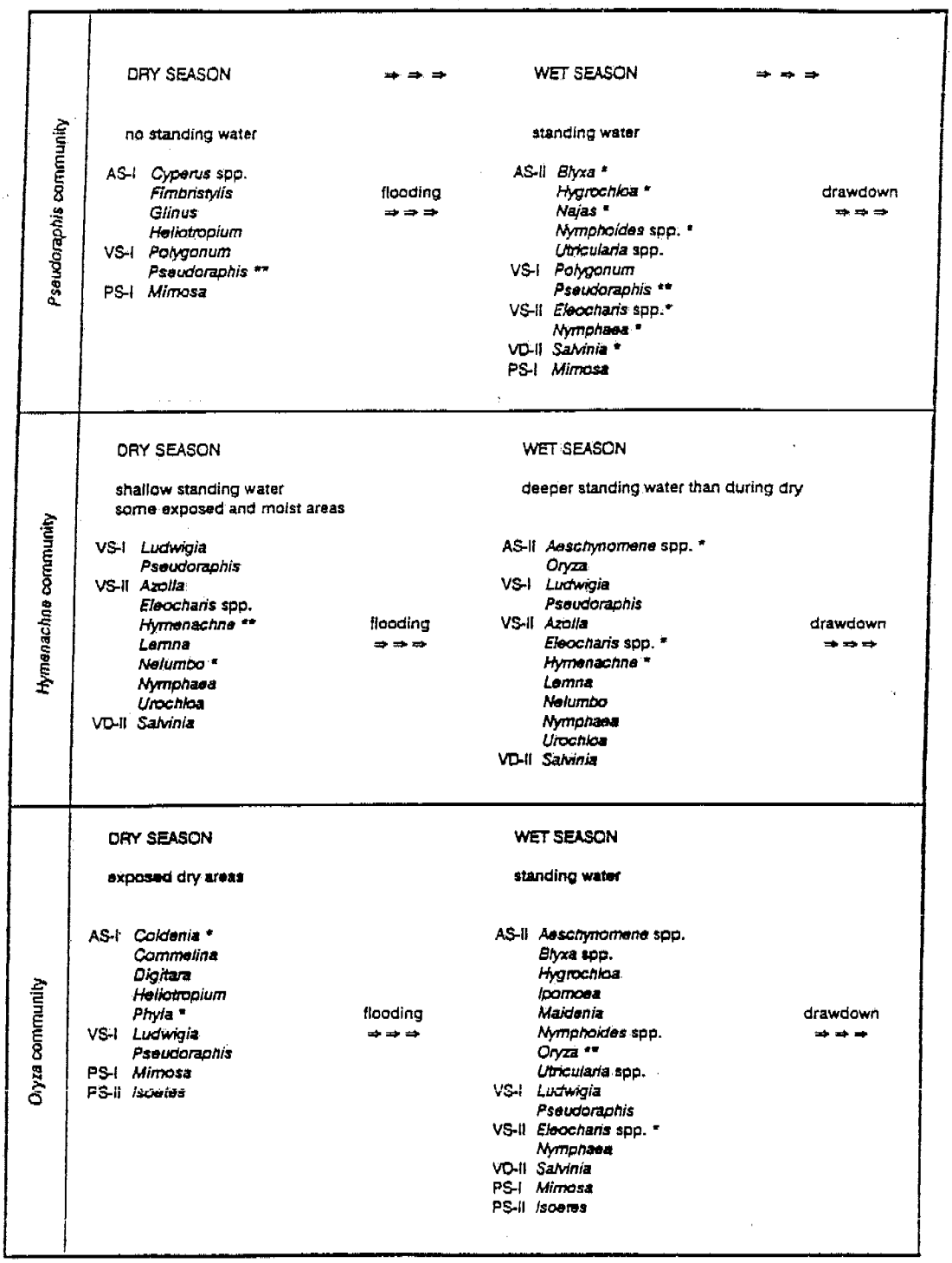

Figure 7 Predicted species succession due to water level fluctuation on the Magela floodplain during the 1983-84 Wet-Dry cycle. The dominant species in each community is indicated by ** and the next by * (A = annual, V = vegetative, P = perennial, S = short-lived propagules, D = long-lived propagules, I = propagules established in areas devoid of standing water, II = propagules established in standing water) (Finlayson 1991b)

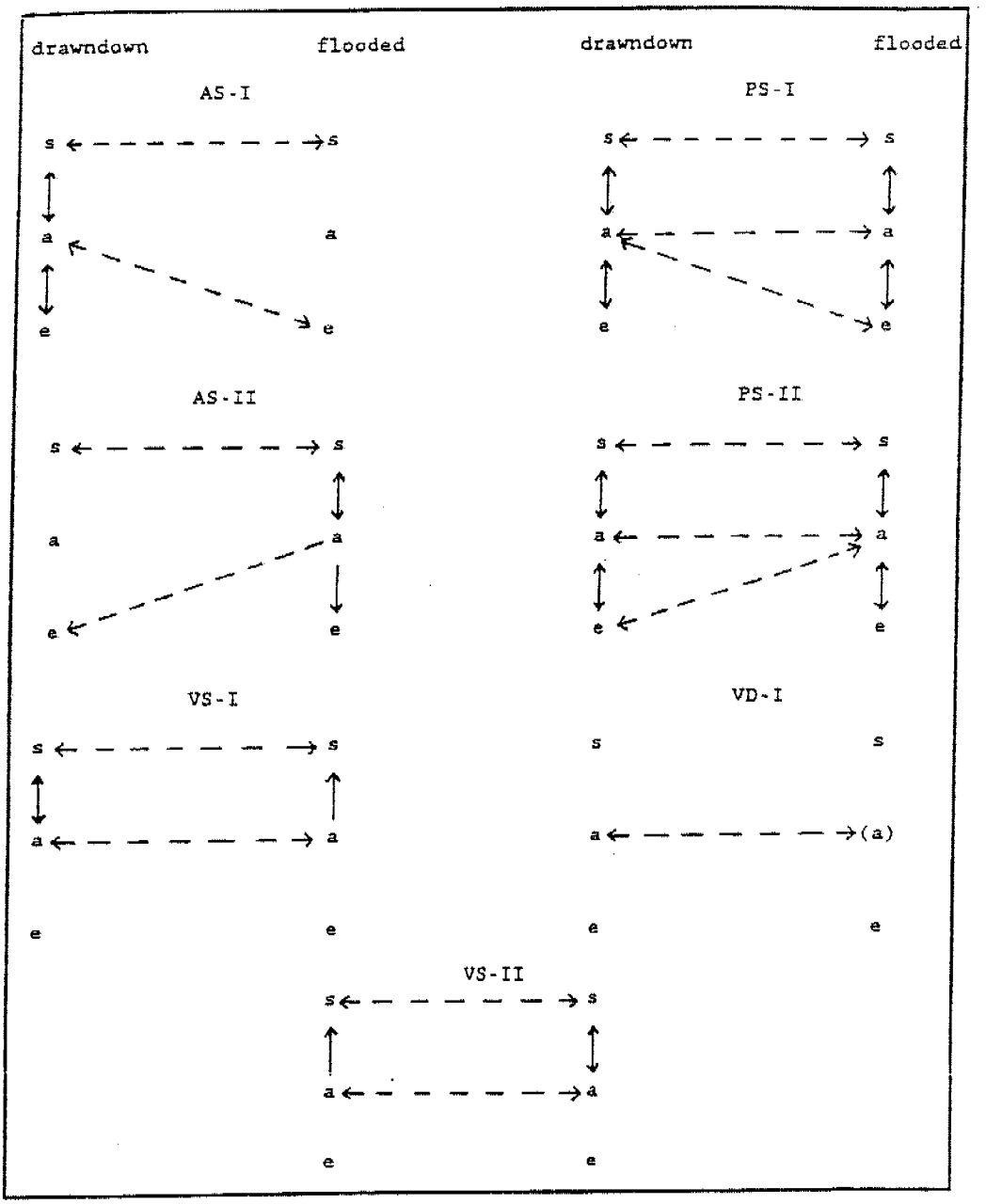

Figure 8 Potential species transitions between two 'environmental situations' – increasing (i.e. flooding) and decreasing (i.e. drawdown) periods in a wetland. Solid lines represent potential transitions within an environmental situation and dashed lines represent transitions between environmental situations. The species states are: s – present as long-lived propagules in a persistent seedbank; a – mature adults; and e – locally extinct. If establishment is dependent on dispersal from another site adult populations are indicated in parentheses (Finlayson 1991b)

system the taxa can be divided into groups: those predominantly restricted to the escarpment, others to the plains and floodplains and then a group where the bulk of taxa have no specific distribution. The seasonal variation in water quality has a minimal influence on the flora in escarpment pools, but a significant effect on communities in the floodplain billabongs.

Brady (1979) sampled the diatom flora of four Magela Creek billabongs. Two general floral types were identified that appear to define the waters in the Magela system, at least during the Dry season when the water is not flowing. These are the *Eunotia-Frustulia* flora and the *Gomphonema-Eunotia-Frustulia* flora. The significant feature of the diatom communities is that the species composition reflects a predominantly acidic environment. Similarly, McBride (1983) found that there is a common regional flora in the Mudginberri Corridor of Magela Creek, which is adapted to a low pH environment. One notable difference to the findings of Thomas (1983) is that the flora has a low species diversity, with only 20 taxa representing 97% of the total numbers. Very large diatom populations estimated at 170 g/m^2 were established on aquatic macrophytes. *Eunotia* spp. dominated the flora which is unusual, as this species is usually dominant only in acid bogs. The diatom populations varied temporally between the Wet and Dry seasons, but also spatially in the water column as a result of diurnal temperature changes. As well as pH and the seasonal cycle, water hardness and organic carbon levels were thought to influence the structure of populations.

Ling and Tyler (1986) sampled the Magela Creek system for all groups of algae excluding the diatoms, and recorded over 530 taxa, of which most were desmids. Of these 360 had not been previously recorded and 66 were either new to science or could not be identified. This high floristic diversity, particularly amongst the desmids, is common in the tropics. The algal flora recorded in this study had a strong affinity, like the diatoms, with the flora of South-East Asia, with the exception that only a few taxa of cyanobacteria were recorded. In contrast to this low total of cyanobacteria taxa, Broady (1984) found that cyanobacteria are abundant in the Magela Creek system, particularly in habitats that become desiccated during the Dry season, such as floodplain soils and the sandstone escarpment. These organisms must withstand extreme temperatures and aridity in these desiccated environments. Broady (1984) investigated the diversity and abundance of cyanobacteria in these habitats, as well as in the billabongs of Magela Creek. *Microchaete* and *Scytonema* were two species present in the billabongs that were not recorded by Ling and Tyler (1986). These two taxa, as well as *Gloetrichia*, *Anabaena* and *Hapalosiphon*, are heterocystous and can potentially fix nitrogen, although their role in the nitrogen cycle of the floodplain is not known. Filamentous cyanobacteria intertwine to produce crusts and felts over the soil on the floodplain which stabalise the soil and retain moisture. Cyanobacteria form black streaks on the sandstone rock outliers of the escarpment, whilst felts form in summit rock depressions. There is considerable scope for more detailed floristic and taxonomic surveys of these organisms. Furthermore, an investigation of the seasonal variations in abundance as a result of water quality changes is needed (Broady 1984).

3.2.2 Algae population dynamics

Morley (1981) sampled the billabongs of Magela Creek in and adjacent to the Jabiluka project area, as part of a study to describe the environmental baseline conditions of the lease area. Phytoplankton populations were found to fluctuate greatly. An increase in total abundance

was usually accompanied by an increase in species richness, which reflects a favourable growth environment. However, in general an increase in productivity from one or two species was the cause of algal blooms. Algal blooms were found to be irregular and influenced by a range of environmental variables. In particular, the blooms were thought to be phosphate limited with an increase in orthophosphate levels producing an increase in algal biomass.

Kessell and Tyler (1982) also sampled the Magela Creek billabongs and reported similar fluctuations in the algal populations. Eighty to a hundred species were recorded on all sampling occasions. Desmids, Chlorococcales and motile flagellates were the most common taxa present. Low indices of similarity (<50%) between successive samples indicated that the species composition fluctuates from hour to hour, as well as spatially on both horizontal and vertical planes. Horizontal fluctuations appeared to be random in nature, whereas vertical heterogeneity may have been due to passive sinking by non-motile species or active migration by flagellate species. Subsequently, the distribution of chlorophyll also varies greatly in the water column. Kessell and Tyler (1986) also reported that at the end of the Dry season red or green algal scums are common on the floodplain billabongs. Dense masses of phytoflagellates make up the scums but the actual species composition varies considerably; *Pyramimonas*, *Chlamydomonas*, *Chlorogonium* and *Euglena* species are common.

3.2.3 Algal productivity

Walker & Tyler (1983) examined the productivity of the phytoplankton communities in the Magela Creek system. Productivity is seasonal in the billabongs. Extensive flushing and the subsequent removal of phytoplankton during the Wet season cause a reduction in productivity. In contrast, evaporative concentration occurs during the Dry season producing high nutrient levels, which result in increased algal growth and thus productivity. However, the extent to which levels increase is determined by the nutrient chemistry, turbidity and underwater light levels of the billabongs. Comparison of the productivity of Magela Creek billabongs with billabongs elsewhere in the world indicated that levels are moderate for the tropics, but high in comparison with temperate lakes. A heavy load of triptonic turbidity, common in these billabongs during the Dry season, adds to the nutrient load, but limits the underwater light field. This occurrence is thought to restrict production.

In general, the algal flora in the Magela Creek system has a high diversity. This complexity, combined with seasonal fluctuations of populations and the spatial and temporal heterogeneity in distribution, makes the flora difficult to use in water quality monitoring programs designed to detect impacts of uranium mining operations in the area (Kessell & Tyler 1982).

3.3 Fish

3.3.1 Fish populations

Early studies of the fish fauna of the Magela Creek system were conducted by Midgley (1974) and Pollard (1974) as part of the *Alligator Rivers Region Fact-Finding Study* (Christian & Aldrick 1977); these studies recorded 24 and 28 species of freshwater fish respectively. An extensive study of the fish species of the Alligator Rivers Region was

conducted by Bishop et al (1986, 1990, in press) from 1978-1979, to provide information on the environmental requirements, life histories, general biology and interactions between species of freshwater fishes in the Region. This study, in conjunction with further investigations by Bishop & Harland (1992), aimed to design an environmental monitoring program to detect impacts on the fish communities from uranium mining in the area. The Magela Creek system was sampled intensively due to its proximity to Ranger Uranium Mine. A total of 59 species of fish, 50 of which are freshwater, have been previously recorded in the ARR (Bishop et al, in press). Thirty-four species are known to occur in the Magela Creek system. A list of these species is given in Table 1. *Pingalla midgleyi* (Midgley's grunter) and *Craterocephalus marianae* (Mariana's hardyhead) are endemic to the Top End. *P. midgleyi* is listed in the Jabiluka EIS under the IUCN classification as 'low risk-near threatened'. *C. marianae* is also thought to be 'potentially threatened', but is listed as 'data deficient' in the Jabiluka EIS (Kinhill Engineers Pty Ltd & ERA Environmental Services Pty Ltd 1996).

Table 1 Fish species of the Magela Creek system (Bishop et al, in press, Walden & Pidgeon 1998)

Family	Species	Common name
Megalopidae	*Megalops cyprinoides*	Tarpon
Clupeidae	*Nematalosa erebi*	Bony bream
Osteoglossidae	*Scleropages jardini*	Saratoga
Ariidae	*Arius leptaspis*	Salmon catfish (Fork-tailed catfish)
Plotosidae	*Neosilurus ater*	Black catfish
	Neosilurus hyrtlii	Hyrtl's catfish
	Porochilus rendahli	Rendahl's catfish
Belonidae	*Strongylura kreffti*	Longtom
Melanotaenidae	*Melanotaenia nigrans*	Black-banded rainbowfish
	Melanotaenia splendida inornata	Chequered rainbowfish
Pseudomugilidae	*Pseudomugil gertrudae*	Spotted blue-eye
	Pseudomugil tenellus	Delicate blue-eye
Atherinidae	*Craterocephalus stercusmuscarum*	Fly-specked hardyhead
	Craterocephalus marianae	Mariana's hardyhead
Synbranchidae	*Ophisternon gutterale*	One-gilled eel
Centropomidae	*Lates calcarifer*	Barramundi
Chandidae	*Ambassis agrammus*	Sailfin glassfish
	Ambassis macleayi	Reticulated glassfish
	Denariusa bandata	Penny fish
Terapontidae	*Amniataba percoides*	Banded grunter
	Hephaestus fuliginosus	Sooty grunter
	Leiopotherapon unicolor	Spangled grunter
	Syncomistes butleri	Sharp-nosed grunter
	Pingalla midgleyi	Midgley's grunter
Apogonidae	*Glossamia aprion*	Mouth almighty
Toxotidae	*Toxotes chatareus*	Common archer fish
Mugilidae	*Liza alata*	Ord River mullet (Diamond mullet)
Gobiidae	*Glossogobius aureus*	Golden goby
	Glossogobius giurus	Flathead goby
Eleotrididae	*Hypseleotris compressa*	Empire gudgeon (Carp gudgeon)
	Oxyeleotris lineolata	Sleepy cod
	Oxyeleotris nullipora	Dwarf gudgeon
	Oxyeleotris selheimi	Black-banded gudgeon
	Mogurnda mogurnda	Purple-spotted gudgeon

* Taxonomy as per Bishop et al (in press) and Walden & Pidgeon (1998)

A continuous gradient of environmental conditions occurs along the creeks systems of the ARR. As a result distinctive fish communities occur in the upper Arnhem land escarpment and lowland floodplain habitats. Escarpment communities inhabit waters with low temperatures, high dissolved oxygen and low turbidity over a rocky substrate; the environment of the lower reach areas is the opposite. These two zones provide refuge habitats for fish during the Dry season. Heterogeneity in the environment is greatest at this time and conditions are most favourable in the escarpment waterbodies. With the onset of the Wet season waterbodies are more homogeneous and fish communities are less distinct. The structure of fish communities in lowland areas is a mixture of the escarpment and lower reach floodplain communities (Bishop et al 1986, 1990).

This pattern is evident in the fish communities of the Magela Creek system. The Magela system can be divided into plateau, escarpment and lowland habitats, and within each habitat different species are dominant. *Melanotaenia nigrans*, *Mogurnda mogurnda* and *Leiopotherapon unicolor* were the most abundant species in the pot-hole pools and cascades of the plateau. The main channel waterbodies of the escarpment are very turbulent during the Wet season, but become isolated pools as flow declines. Waterbodies underneath large waterfalls from the plateau contained fewer species than pools closer to the lowland areas. *C. marianae*, *Ambassis* spp., *Amniataba percoides* and *L. unicolor* were the most abundant species in the lower reach pools. Radon Springs is a spring-fed perennial stream located in the escarpment of the Magela system; *M. nigrans*, *Neosilurus hytlii*, *L. unicolor* and *P. midgleyi* were numerically dominant in this stream. The sandy creekbeds were found to contain 21 species with *C. marianae*, *M. splendida inornata*, *C. stercusmuscarum* and *Ambassis* spp. the most abundant species. The number of fish species in the backflow billabongs of the lowland areas ranged from 13 species in Fishless Billabong to 22 species in Djalkmara and Coonjimba billabongs. The most abundant species were *Ambassis agrammus*, *A. macleayi*, *M. splendida inornata*, *Denariusa bandata*, *L. unicolor*, *Porochilus rendahli*, *Nematalosa erebi* and *Glossamia aprion*. Twenty-three to 25 species of fish were recorded in the billabongs of the Mudginberri Corridor. The most abundant species were *A. agrammus*, *A. macleayi*, *M. splendida inornata*, *C. stercusmuscarum*, *D. bandata*, *G. aprion* and *Glossogobius giurus*. In the upper floodplain billabongs 22-24 species of fish were present with *A. agrammus*, *A. macleayi*, *M. splendida inornata*, *C. stercusmuscarum*, *D. bandata*, *Arius leptaspis* and *Pseudomugil tenellus* the most abundant species (Bishop et al 1990).

3.3.2 Breeding, feeding and migration habits

The breeding, feeding and migration habits of fish species were examined as part of the study by Bishop et al (1986, 1990, in press). Lowland and floodplain habitats were observed to be important breeding and nursery areas. Thirteen of 23 species investigated in the study had a definite breeding season, while the other 10 either breed for an extended period or throughout the year. In the Magela Creek system important breeding areas were located downstream of Ranger Uranium Mine. Backflow and floodplain billabongs appeared to be significant spawning and nursery areas, as smaller juveniles of the greatest number of fish species occurred in these habitats. Similarly, the average number of species feeding vigorously (based on fullness indices of the stomach) was greatest downstream of the Ranger minesite, in backflow and floodplain billabong habitats. Feeding activity peaked in the Mid-wet season and reached a low in the Late-dry season. Nine feeding guilds were identified, however most species are opportunistic feeders. To determine if biomagnification is occurring peak

carnivores would be appropriate species to monitor; correspondingly herbivore/detritivores and/or benthic carnivores would be suitable species to examine the impact of contaminated sediments. Body condition of most species peaks following a peak in feeding. For the fish communities in the ARR best body condition was attained from Mid-wet to Mid-dry seasons, with a peak in the Late-wet–Early-dry season. Breeding activity, food resources and environmental conditions are thought to affect body condition and cause these seasonal changes.

Migration of fish in the ARR is thought to reflect temporal and spatial variation in resources. The most notable effect of fish movements in the Region is the movement into lowland sandy creekbeds and backflow billabongs with the start of flow early in the Wet season, for breeding and feeding purposes (Bishop et al, in press). A range of species also migrate upstream later in the Wet season. This is thought to be an important survival strategy to reach escarpment waterbodies as conditions in lowland areas decline with the onset of the Dry season (Bishop et al 1995).

3.3.3 Fish population dynamics

To expand on Bishop et al's (1986, 1990, in press) study, Bishop & Harland (1982) sampled sites in the lowland region of the Magela system. The aim was to collect more data to facilitate the development of a monitoring program. Annual variability in community structure was highest in the Late-dry and Early-wet season and was most prevalent in shallow muddy lagoons. Muddy channel lagoons had the lowest annual variability. Hence, these lagoons may be suitable sites to monitor fish communities, as natural fluctuations are less likely to mask the effects of mining or other development. Many species of fish demonstrated preferences to habitat-structural variables such as substrate, and to a lesser extent, physico-chemical parameters such as maximum depth. They were found to recognise and subsequently colonise microhabitats, which may allow prediction of which species are expected to occur in different microhabitats.

3.3.4 Fish populations of the Jabiluka and Ranger project areas

Surveys of the fish fauna of both the Ranger and Jabiluka project areas have been conducted. Corbett (1996) surveyed sites associated with Ranger Uranium Mine including Coonjimba, Djalkmara and Georgetown billabongs in the Magela Creek system, and Retention pond 1. The Jabiru lake (an artificial waterbody) and two Nourlangie system billabongs were sampled as comparison sites. A total of 25 species was recorded. Earlier surveys by Bishop et al (1986, 1990, in press) and Bishop & Harland (1982) of the same Magela billabongs recorded two species *Ambassis macleayi* and *Glossobius giuris* which were not recorded in this survey. Corbett & Batterham (1998) surveyed the fish fauna of the Jabiluka project area. Samples were taken from Swift Creek, 7J Creek, North Magela Creek and Magela Creek, upstream and downstream of the minesite. A total of fifteen species was recorded and species richness was higher in the larger and more persistent streams. The results of this study corresponded with an earlier study of the lease area conducted by Morley (1981). Morley surveyed Swift Creek and 7J Creek and recorded 14 species compared to the 13 species recorded at these sites by Corbett & Batterham (1998). Also Morley (1981) reported a similar variation in the richness between small and large streams.

Due to the numerous studies conducted on the fish fauna of the ARR, and more specifically the Magela Creek system, a large body of information is available to assess the extent of impacts from mining operations and other developments in the area.

3.4 Amphibians

3.4.1 Frog populations

Twenty-four species of frogs from 3 families occur in the Magela Creek system (Table 2). The 3 families represented are the Hylidae (2 genera, 16 species), Leptodactylidae (5 genera, 7 species) and Microhylidae (1 genus, 1 species) (Tyler et al 1983). Several of these species of frogs are rock-dwellers endemic to the Top End and Kimberly regions, and inhabit crevices near small perennial streams in the sandstone escarpment (Braithwaite et al 1991, Press et al 1995). These species include *Megistolotis lignarius*, *Litoria coplandi*, *L. meiriana*, and the rarely seen *L. personata* and *Uperolei arenicola*. These species are listed in the Jabiluka EIS as being species that are 'potentially threatened' (Kinhill Engineers Pty Ltd & ERA Environmental Services Pty Ltd 1996). Most of the other species are found across Northern Australia, and predominantly inhabit wetlands and the margins of floodplains (Tyler et al 1983, Press et al 1995).

Table 2 Frogs present in riparian and floodplain habitats of the Magela Creek system (Tyler & Crook 1987)

Family	Species	Common name
Myobatrachidae	*Crinia bilingua*	Bilingual frog (Ratchet frog)
	Limnodynastes convexiusculus	Marbled frog
	Limnodynastes ornatus	Ornate Burrowing frog
	Notaden melanoscaphus	Northern spadefoot toad
	Uperoleia innundata	Floodplains toadlet
Hylidae	*Cyclorana australis*	Giant frog
	Cyclorana longipes	Long-footed frog
	Litoria bicolor	Northern dwarf tree-frog
	Litoria caerulea	Green tree-frog
	Litoria dahlii	Dahl's aquatic frog
	Litoria inermis	Peter's frog
	Litoria dorsalis	Javelin frog (Dwarf rocket frog)
	Litoria nasuta	Rocket frog
	Litoria pallida	Pale frog
	Litoria rothi	Brown tree-frog (Roth's tree-frog)
	Litoria rubella	Desert tree frog (Red treefrog)
	Litoria tornieri	Tornier's frog
	Litoria wotjulumensis	Wotjulum frog
Microhylidae	*Sphenophryne adelphe*	Northern Territory frog

* Taxonomy as per Press et al (1995)

Tyler and Cappo (1983) examined the densities and abundances of frog species on the Magela floodplain. The frog fauna was more abundant and diverse in poorly drained areas with sandy soil than in areas with well-drained gravelly soil. *Cyclorana australis* was very common on the floodplain and occurred mainly in swamp grass/sedgeland and open woodland. *L. nasuta*,

L. sp. nr. *latopalmata, L. inermis, L. tornieri* and *L. wotjulumensis* were also common in these habitats. *L. bicolor, L. dahlii, L. rothii* and *Ranidella bilingua* were observed only in areas of regularly inundated grass/sedgeland. The density estimates may incorporate an element of bias as a result of sampling procedures and the behaviour of the frogs themselves.

3.4.2 Frog population dynamics

Distribution and abundances of frogs on the floodplain varies with changes in water levels (Tyler & Cappo 1983). Most species are completely inactive during the Dry season and some aestivate underground (Tyler & Crook 1987). Species such as *L. nasuta, L. inermis*, *L.* sp. nr. *latopalmata, L. wotjulumensis* and *L. tornieri* were observed around waterbodies sheltering in cracks in dried mud or under logs and leaf litter. Species hibernating underground such as *L. dahli,* are brought to the surface following heavy rains that penetrate to the depths at which they are buried. Once rains continue, temporary pools form in wallows and depressions which the frogs utilise as breeding sites. As water levels rise adult *R. bilingua* and *L. nasuta* and juvenile *L. nasuta* and *L.* sp. nr. *latopalmata* use banks around billabongs such as Nankeen Billabong as a refuge; once the banks are flooded these frogs remain in flooded vegetation. Aboreal species such as *L. rothi, L. bicolor* and *L. rubella* were common in *Pandanus aquaticus* and *Barringtonia acutangula* on the margins of Nankeen Billabong (Tyler & Cappo 1983).

3.4.3 Frogs as potential transferers of contaminants

Tyler and Crook (1987) identified several frog species (*C. australis, C. longipes, L. caerulea, L. nasuta, L. rothii, L. rubella, L. wotjulumensis* and *Limnodynastes ornatus*) which are ready colonisers of artificial environments such as the tailings dam and retention ponds associated with mining operations in the area. These species may transfer contaminants from these aquatic locations to the terrestrial environment. Cappo (1986) examined which species are most important in this transfer process through the ingestion of prey of aquatic origin. The aquatic frog *L. dahlii*, aboreal frogs (*L. rothii and L. bicolor*), ground hylids (*L. pallida, L. inermis, L. nasuta, L. tornieri, L. wotjulumensis*) and the froglet *R. bilingua* were found to feed in habitats close to waterbodies. However, all species may ingest aquatic prey during their life as juveniles exiting the larval environment and as adults breeding at waterbodies.

3.4.4 Frog populations of the Jabiluka and Ranger project areas

Corbett (1996) conducted a survey of the amphibian fauna of the Ranger lease area sampling three Magela Creek billabongs (Coonjimba, Djalkmara and Georgetown billabongs) and two billabongs in the Nourlangie system as comparison sites. Fifteen species were recorded; the richness was similar to that of nearby Nourlangie billabongs, but the abundance of individuals was higher at the Ranger billabongs. A similar survey was conducted of the Jabiluka lease area (Corbett 1999). Eighteen species were recorded which represents about 75% of the known frog species in the Magela Creek system.

3.5 Reptiles

3.5.1 Reptile populations

The reptile fauna of the Magela Creek system is one of the most diverse found in Australia. Sadlier (1981, 1990) investigated the terrestrial and semi-aquatic reptiles of this system. In general, rapid flow and changes in water levels mean the upper reaches of Magela Creek are not a suitable habitat for most reptile species, with the exception of aboreal species. Ground-dwelling species were more common in the riparian habitats of the mid-low sections of the creek. Larger reptiles were abundant during the Wet season and only present in low numbers during the Dry season (Sadlier 1990). A list of the major aquatic or floodplain species is presented in Table 3.

Sadlier (1990) recorded a total of 74 species of snakes and lizards in the Magela Creek system. Seventeen of these species are either endemic to or are found in greatest numbers on the sandstone escarpment. They also occur in this habitat further east in Arnhem land. Similarly, *Ctenotus arnhemensis, C. gagadju* and *Menetia concinna* are endemic to lowland areas. However, these three species are currently only known from the Alligator Rivers Region. The sandstone species *Morelia oenpelliensis and Ergernia arnhemensis,* and the lowland species *M. concinna* and *C. arnhemensis,* are listed as 'potentially threatened' in the Jabiluka EIS (Kinhill Engineers Pty Ltd & ERA Environmental Services Pty Ltd 1996).

Table 3 Large reptiles present in riparian and floodplain habitats of the Magela Creek system (Finlayson et al 1990)

Family	Species	Common name
Crocodylidae	*Crocodylus johnstoni*	Freshwater crocodile
	Crocodylus porosus	Estuarine crocodile
Chelidae	*Chelodina rugosa*	Northern snake-necked turtle
	Chelodina sp. nov	
	Elseya dentata	Northern snapping turtle
	Elseya latisternum	Saw-shelled turtle
	Emydura victoriae (= australis)	Northern yellow-faced turtle
Varanidae	*Varanus gouldii*	Sand goanna (Gould's goanna)
	Varanus mertensi	Merten's water monitor
	Varanus mitchelli	Mitchell's water monitor
	Varanus panoptes	Northern sand goanna
Acrochordidae	*Acrochordus arafurae*	Filesnake
Boidae	*Liasis fuscus*	Water python
	Liasis olivaceus	Olive python
Colubridae	*Enhydris polylepis*	Macleay's water snake
	Stegonotus cucullatus	Slaty-grey snake
	Tropidonophis mairii	Keelback or freshwater snake
Elapidae	*Pseudechis australis*	King brown snake

* Taxonomy as per Press et al (1995)

3.5.2 Filesnakes, goannas and pythons

Shine (1986) investigated the feeding, reproduction, habitats and use by Aboriginal people of five species of reptiles in the Magela Creek system. The species examined were filesnakes (*Acrochordus arafurae*), sand goannas (*Varanus panoptes* and *V. gouldii*) and water goannas *V. mertensi* and *V. mitchelli*).

Filesnakes are entirely aquatic and are restricted to billabongs during the Dry season. They are commonly found under or amongst *Pandanus aquaticus* and floating grass mats. With the onset of the Wet most snakes move to shallow inundated grasslands and under the roots of freshwater mangroves (*Barringtonia acutangula*) (Shine & Lambeck 1985). Filesnakes feed only on fish and eat a wide variety of species (Shine 1986). In general, filesnakes are more abundant in lower mainstream billabongs than the upper sections of the creek (Shine 1986). A mark-recapture study by Houston & Shine (1994) revealed that males are more abundant in broad-shallow backflow billabongs of the Magela Creek floodplain, whereas females are more prevalent in narrow-deep main channel billabongs. Population densities were much greater than recorded for other species of snakes; the high biomass is sustained due to large numbers of fish and the low energy requirements of filesnakes. Madsen & Shine (2000) conducted a 10-year field survey of filesnakes in Djarr Djarr (Ja Ja) Billabong on the Magela floodplain. Following Wet seasons with high rainfall and extended inundation of the floodplain, sampling during the Dry season found that fish were abundant, filesnakes obtained a good body condition and a large number of females were reproductive. Similarly, recruitment into the population was related to fish abundance and hence, to rainfall levels during the Wet season.

The large sand goanna, *Varanus panoptes*, may be found throughout the Magela Creek system, but was encountered most frequently in riparian habitats in the study by Shine (1986). This species and the other sand goanna *V. gouldii,* which was thought to favour a woodland habitat, feed predominantly on reptiles and mammals. The water goannas *V. mertensi* and *V. mitchelli* were primarily found on small creeks often near larger pools. *V. mitchelli* also inhabited areas of water flowing between the billabongs of the main channel. *V. mertensi* feeds predominantly on freshwater crabs whereas *V. mitchelli* forages on land and underwater, feeding more on fish and orthopterans (Shine 1986).

Filesnakes have the potential to transfer contaminants as they are entirely aquatic and piscivorous, and an important food source for Aboriginal people. Similarly, the sand goanna *V. panoptes* is a popular food source and a third of its prey is of aquatic origin. The water goannas *V. mitchelli* and *V. mertensi* also consume aquatic prey items and thus are potentially important transferers of pollutants from aquatic to terrestrial environments, but they are rarely eaten by Aboriginal people (Shine 1986).

Other species of snakes that occur on the floodplain include water pythons (*Liasis fuscus*) and king brown snakes (*Pseudechis australis*). During the Wet season they occur in seasonally inundated areas feeding on eggs from floating nests of magpie geese. With the onset of the Dry season, water levels drop and other species move onto the drying floodplain including the olive python (*Liasis olivaceous*) and northern death adder (*Acanthophis praelongus*). These

species follow seasonally variable resources and must tolerate daily fluctutations in temperature on the exposed floodplain (Cowie et al 2000).

3.5.3 Crocodiles

Both species of Australian crocodile occur in the Magela Creek system. The saltwater *Crocodylus porosus* occurs in both estuarine and freshwater environments and is larger (up to 7 m in length) than *Crocodylus johnstoni* (up to 3 m in length), which is restricted to freshwater habitats. *C. porosus* builds a mound nest during the Wet in floodplain grasses or on the edge of billabongs and swamps, while *C. johnstoni* nest holes in sand banks during the Dry season (Finlayson et al 1990, Webb 1991). Both species of crocodiles are nocturnal and feed on fish, crustaceans, reptiles, birds and mammals (Cogger 1996). It is important that these species, being at the top of the food chain in the floodplain habitat, be monitored to determine impacts of contaminants released into the system from uranium mining (Messel et al 1979).

Messel et al (1979) conducted the first survey of the *C. porosus* populations in the Magela Creek system. A 3 km section of the creek near where it empties into the East Alligator was surveyed and an average of 20 crocodiles was recorded. Jenkins and Forbes (1985) conducted a similar survey on the same section of the creek over a four-year period. Up to 20 individuals were recorded during one survey period. More crocodiles were recorded late in the Dry season (November) than late in the Wet (April-June). Crocodiles move from such rivers as the East Alligator to adjacent floodplains during the Wet season. Once the freshwater habitat declines crocodiles are thought to move back into the river (Jenkins & Forbes 1985). Messel et al (1979) only recorded 2 hatchlings in the Magela Creek system. Grigg and Taylor (1980) surveyed the same area of the creek and found a nest, suggesting the area is suitable for breeding, however it does flood. Due to limited access to permanent water the floodplain of the Magela provides few good nesting sites, compared to the permanent billabongs where nests were sited (Finlayson et al 1990a). There have been no recent surveys of the crocodile populations of the Magela Creek system (G Lindner *pers comm*). However, occasional surveys of the crocodiles of large Magela Creek billabongs (primarily Island Billabong) are done, mainly as training exercises for rangers (A Turner *pers comm*.).

3.5.4 Turtles

Seven species of freshwater turtles (*Carrettochelys insculpta, Emydura* sp., *Emydura victoriae (= australis), Chelodina rugosa, Chelodina* sp. nov., *Elseya dentata* and *Elseya latisternum*) occur in the Alligator Rivers Region. Legler (1980, 1982) examined turtle populations at a range of locations in the ARR as part of studies on taxonomy, distribution and feeding. Five species are present in the Magela Creek system; two species *El. latisternum* (saw-shelled turtle) and *Chelodina* sp. nov. occur in the section of the Magela Creek system flowing through the Arnhem Land Plateau, whereas *Ch. rugosa* (northern snake-necked turtle), *El. dentata* (northern snapping turtle) and *Em. victoriae* (northern yellow-faced turtle) are present in the creek below the escarpment. *Ch. rugosa* is carnivorous, feeding mainly on fish and crustaceans. *El. dentata* is herbivorus consuming leaves, flowers and fruits falling into the water. *Chelodina* sp. nov., *Em. victoriae* and *El. latisternum* are omnivorus. *Em. victoriae* is primarily herbivorous feeding on aquatic vegetation, while *El. latisternum* feeds on crustaceans and algae. *Chelodina* sp. nov. feeds on crustaceans, fish and plant material.

This species is listed in the Jabiluka EIS as 'potentially threatened'. *Ca. insculpta* is also listed as 'potentially threatened' in the EIS. Although this species occurs in the South Alligator River and has been found in the East Alligator River, there is no evidence that this species is present in the Magela Creek system. As Aboriginal people consume all of the species of turtles found in the Magela Creek system there is the potential for contaminants to be transferred from the aquatic to terrestrial environment.

3.5.5 Reptile populations of the Jabiluka and Ranger project areas

More recent surveys of the reptile fauna in the Magela Creek system have been conducted on the Ranger and Jabiluka lease areas. Corbett (1996) sampled the reptile fauna in and around 3 Magela Creek billabongs (Coonjimba, Djalkmara and Georgetown billabongs) on the lease. A total of 33 species was recorded. Species richness and abundances were markedly higher than that recorded for Nourlangie system billabongs, which were used as comparison sites. A survey of the Jabiluka project area was undertaken by Corbett (1999) and 38 species were recorded; this represents about 42% of the reptile species richness recorded from prior surveys of the Magela catchment.

3.6 Birds

3.6.1 Waterbird population dynamics

Over 270 species of birds including more than 100 species of waterbirds occur in the Alligator Rivers Region, making this region one of the most diverse in Australia (Morton et al 1991). The wetlands of the Region support a wide range of waterbird species including herons, egrets, bitterns, ibis, spoonbills, ducks, geese, darters and cormorants (Press et al 1995). Waterbirds in the ARR have been described by Morton et al (1991). Aerial and ground surveys revealed that waterbirds are uncommon in the Wet season but very abundant during the Dry season. The birds are thought to migrate to the ARR from other wetlands of the Top End, the sub-tropical belt to the south, locations well to the east and south of the Northern Territory, and from the northern hemisphere (Morton et al 1991). Approximately 35 species of migratory birds visit the Region. The more common species include the little curlew (*Numenius minutus*), oriental plover (*Charadrius veredus*), large sand plover (*C. leschenaultii*) and the Mongolian plover (*C. mongolus*). They peak in abundance just prior to and just after the wettest months (January-March). Waterfowl from Southern Australia, such as the grey teal (*Anas gracilis*), pink-eared duck (*Malacorhynchus membranaceus*), hardhead (*Aythya australis*) and purple swamphen (*Porphyrio porphyrio*) are more common as water levels drop during the Dry season (Morton & Brennan 1991). Magpie geese (*Anseranas semipalmata*) dominate the influx, but the bulk of species increase in numbers during the Dry season (Morton, Brennan & Armstrong 1991). The majority of species do not breed in large numbers in the ARR; one exception is the comb-crested jacana (*Irediparra gallinacea*) which breeds in abundance (Press et al 1995).

The Magela floodplain retains some water year round in billabongs and several large permanent swamps and thus is an important Dry season habitat for waterbirds. Species common on the Magela floodplain are listed in Table 4. Surveys found that waterbirds were uncommon during the Wet season, but by the end of the Dry were assembled in densities up

Table 4 Common and abundant waterbirds of the Magela Creek system (Finlayson et al 1990)

Family	Species	Common name
Pelecanidae	*Pelecanus conspicillatus*	Australian pelican
Anhingidae	*Anhinga melanogaster*	Darter
Phalacrocoracidae	*Phalacrocorax melanoleucos*	Little pied cormorant
	Phalacrocorax varius	Pied cormorant
	Phalacrocorax sulcirostris	Little black cormorant
Ardeidae	*Ardea pacifica*	White-necked heron (Pacific heron)
	Ardea picata	Pied heron
	Ardeola ibis	Cattle egret
	Ardea alba	Great egret
	Egretta garzetta	Little egret
	Ardea intermedia	Intermediate egret
	Nycticorax caledonicus	Nankeen night heron (Rufous night heron)
Ciconiidae	*Ephippiorhynchus asiaticus*	Black-necked stork (Jabiru)
Plataleidae	*Plegadis falcinellus*	Glossy ibis
	Threskiornis aethiopica	Sacred ibis
	Threskiornis spinicollis	Straw-necked ibis
	Platalea regia	Royal spoonbill
Anatidae	*Anseranus semipalmata*	Magpie goose
	Dendrocygna arcuata	Whandering whistling duck
	Dendrocygna eytoni	Plumed whistling duck (Grass whistling duck)
	Tadorna radjah	Radjah shelduck (Burdekin duck)
	Anas superciliosa	Pacific black duck
	Anas gracilis	Grey teal
	Malacorhynchus membranaceus	Pink-eared duck
	Nettapus pulchellus	Geen pygmy goose
Accipitridae	*Haliaeetus leucogaster*	White-bellied sea eagle
Rallidae	*Porzana pusilla*	Baillon's crake (Marsh crake)
	Porzana cinereus	White-browed crake
Gruidae	*Grus rubicundus*	Brolga
Jacanidae	*Irediparra gallinacea*	Comb-creseted jacana
Charadriidae	*Vanellus miles*	Masked lapwing (Masked plover)
	Erythrogonys cinctus	Red-kneed dotterel
	Charadrius melanops	Black-fronted plover
Recurvirostridae	*Himantopus himantopus*	Black-winged stilt
	Numenius minutus	Little curlew (Little whimbrel)
	Tringa stagnatilis	Marsh sandpiper
	Calidris acuminata	Sharp-tailed sandpiper
	Calidris ferruginea	Curlew sandpiper
Glareolidae	*Stiltia isabella*	Australian pratincole
Laridae	*Chlidonias hybrida*	Whiskered tern
	Sterna nilotica	Gull-billed tern

* Taxonomy as per Press et al (1995)

to a 100 per hectare. At its peak the aggregation of waterbirds was estimated to be almost a million birds. In general, birds preferred areas where water occurred at a range of depths, but at the end of the Dry were found in high densities where ever water was present. Such areas include the upper floodplain, the western part of the plain and channels through the *Melaleuca* swamps in the central plain (Morton et al 1991).

3.6.2 Feeding habits

Waterbirds feed on aquatic invertebrates, vertebrates such as fish and frogs, and plant material. Herbivorous magpie geese (*A. semipalmata*) and wandering whistling-ducks (*Dendrocygna arcuata*) are often most abundant on the wetlands, which reflects the expanse of vegetation present as a food source. Species feeding primarily on aquatic vertebrates utilise specific foraging zones and techniques, which in turn determine the type of prey likely to be consumed. Black-fronted plovers (*Charadrius melanops*) and masked lapwings (*Vanellus miles*) feed in the mud while the glossy-ibis (*Plegadis falcinellus*) and little egret (*Egretta garzetta*) forage in shallow water. Some species such as whiskered terns (*Chlidonias hybrida*) and comb-crested jacanas (*I. gallinacea*) are insectivorous, but also eat aquatic invertebrates. Piscivores such as the little black cormorant (*Phalacrocorax sulcirostris*), darter (*Anhinga melanogaster*), black-necked stork (*Ephippiorhynchus asiaticus*) and great egret (*Ardea alba*) feed almost entirely on fish, hunting in open water (Morton & Brennan 1991). Contaminants potentially released in waste-waters from uranium mining in the Magela Creek catchment may be transferred from the aquatic to terrestrial environment by waterbirds. Species feeding on fish and other vertebrates are more at risk as these prey items are likely to have accumulated higher concentrations of contaminants, than insects or tadpoles, as they are higher in the food chain (Recher & Holmes 1982). However, not all contaminants biomagnify and this is the case for most of the metals in Ranger waste-water (B Pidgeon *pers comm*).

3.6.3 Waterbird populations of the Jabiluka and Ranger project areas

Corbett et al (1999) conducted a 4-year study of waterbirds on the Ranger lease. Waterbirds were recorded from Georgetown, Djalkmara and Coonjimba billabongs and from five artificial waterbodies (RP1, RP2, RP3, RP4, Tailings dam and RP1 wetland filter). Combined with other studies the total list for the Ranger project area is 65 species. This represents 82% of all waterbird species found in inland waters of Kakadu National Park. Approximately half of the species recorded are listed under one or more international agreements. As most waterbirds were not observed to be feeding at 'unhealthy' waterbodies ('health' was based on electrical conductivity levels) the potential for them to transport heavy metals from the lease area was considered to be limited. Corbett (1999) conducted a similar study of the waterbirds on the Jabiluka project area. Birds were recorded from Djarr Djarr (Ja Ja), Jabiluka and Nankeen billabongs on the Magela floodplain and occasionally from 7J Swamp and Swift Creek. A total of 33 species were recorded which is 46% of all species recorded in Kakadu National Park, the majority of which were located outside of the lease area.

3.7 Mammals

Mammals have received less attention than other vertebrate fauna of the Magela Creek system. A list of the species occurring in riparian and floodplain habitats of the Magela Creek system is given in Table 5. Introduced and feral mammals are discussed in the following section on alien species.

3.7.1 Mammal populations of the Jabiluka project area

Kerle and Burgman (1984) investigated mammal species of the Jabiluka project area. Thirty native species were recorded which represents 60% of the species found in the Alligator Rivers Region. In general, the abundance of mammals in the study area was low. Three

Table 5 Mammal species present in riparian and floodplain habitats of the Magela Creek system (Corbett 1999, Kerle & Burgman 1984, D Walden, *pers comm*)

Family	Species	Common name
Dasyuridae	*Dasyurus hallucatus*	Northern quoll
	Antechinus bellus	Fawn antechinus
	Sminthopsis virginiae	Red-cheeked dunnart
	Planigale maculata	Common planigale
	Planigale ingrami	Long-tailed planigale
Peramelidae	*Isoodon macrourus*	Northern brown bandicoot
Macropodinae	*Macropus agilis*	Agile wallaby
	Macropus antilopinus	Antilopine wallaroo
Muridae	*Hydromys chrysogaster*	Water rat
	Melomys burtoni	Grassland melomys
	Pseudomys nanus	Western chestnut mouse
	Pseudomys delicatulus	Delicate mouse
	Rattus tunneyi	Pale field rat
	Rattus colleti	Dusky rat
Pteropodidae	*Pteropus alecto*	Black flying-fox
	Pteropus scapulatus	Little red flying-fox
Emballonuridae	*Saccolaimus flaviventris*	Yellow-bellied sheathtail-bat
	Saccolaimus saccolaimus	Naked-rumped sheathtail-bat
	Taphozous georgianus	Common sheathtail-bat
	Taphozous kaplagenis	White-striped sheathtail-bat
Megadermatidae	*Macroderma gigas*	Ghost bat
Hipposideridae	*Hipposiderae ater*	Dusky horseshoe-bat
	Hipposiderae diadema	Diadem horseshoe-bat (Diadem leafnosed
	Rhinonicteris aurantius	Orange horseshoe-bat (Orange leafnosed
Molossidae	*Chaerephon jobensis*	Northern mastiff-bat (Northern freetail-bat)
	Mormopterus beccarii	Beccari's mastiff-bat (Beccari's freetail-bat)
Vespertilionidae	*Miniopterus schreibersii*	Common bentwing-bat
	Nyctophilus arnhemensis	Arnhem Land long-eared bat
	Chalinolobus gouldii	Gould's wattled bat
	Chalinolobus nigrogriseus	Hoary bat
	Myotis moluccarum	Northern myotis
	Pipistrellus adamsi	Cape York pipistrelle
	Pipistrellus westralis	Western pipistrelle
	Scotorepens sanborni	Northern broad-nosed bat
	Vespadelus caurinus	Western cave bat
Canidae	*Canis familiaris dingo*	Dingo

* Taxonomy as per Press et al (1995)

groups of species were evident which corresponded with the main vegetation categories. Several of the species were associated with rocky outliers, whereas other species were more common in dryland open forest and woodland habitats. Six species occurred in riparian woodland: red-cheeked dunnart (*Sminthopsis virginiae*); antilopine wallaroo (*Macropus anitlopinus*), water rat (*Hydromys chrysogaster*), grassland melomys (*Melomys burtoni*), western chestnut mouse (*Pseudomys nanus*), and brindled bandicoot (*Isoodon macrourus*). *S. virginiae* and *H. chrysogaster* were present mainly along the Magela Creek floodplain, and also in the vicinity of waterholes on tributary creeks. *S. virginiae* feeds mainly on small insects, while *H. chrysogaster* consumes fish, crustaceans and mussels. *Me. burtoni* was found along the floodplain and minor drainage lines, but *P. nanus* occurred only along drainage lines of tributary creeks (Kerle & Burgman 1984, Strahan 1995). The latter species is listed as 'low risk – near threatened' in the IUCN Red list (Corbett 1999). *Ma. antilopinus*

was not very common in the lease area. *I. macrourus* occurred in riparian woodland associated with the floodplain, but also was present in dry woodland habitat. *P. nanus* and *Ma. antilopinus* both feed on a variety of grasses whereas *Me. burtoni* and *I. macrourus* are omnivorous, eating seeds, fruits and insects (Kerle & Burgman 1984; Strahan 1995). *Rattus colletti*, the dusky rat, which is found predominantly in flooodplain habitats, was also recorded in the survey. During the Dry season this species inhabits the black soil plains sheltering in the soil cracks. As the water levels increase with the Wet season animals move to the shallow flooded edges and levee banks of the rivers (Williams & Newsome 1991). *R. colletti* feeds on stembases of grasses and the corms of sedges that are abundant on the floodplain (Strahan 1995).

Two species common in the region that were not recorded in Kerle & Burgman's (1984) study were *Rattus tunneyi* (pale field rat) and *Antechinus bellus* (fawn antechinus). *Rattus tunneyi* inhabits tall grass around small seasonal water courses while the latter species shelters in hollows in trees and logs. However, in a more recent survey of the Jabiluka lease area conducted by Corbett (1999) these species were recorded. *Rattus tunneyi* is also listed as 'low risk-near threatened' in the IUCN Red List. In total 34 species of native mammals were recorded, 18 of which were bat species. The most widespread species were the agile wallaby (*Macropus agilis*), northern quoll (*Dasyurus hallucatus*), grassland melomys (*Melomys burtoni*), delicate mouse (*Pseudomys delicatus*) and dingo (*Canis familiaris dingo*), and all were recorded in riparian habitats. The pale field rat, northern quoll and delicate mouse are listed in the Jabiluka EIS as 'potentially threatened' species (Kinhill Engineers Pty Ltd & ERA Environmental Services Pty Ltd 1996). The species richness represents approximately 102% of mammals recorded in prior surveys of the Magela catchment. The high value reflects the high number of bat species recorded. The number of bat species is double that recorded by Kerle & Burgman (1984). The difference is due to electronic survey techniques employed by Corbett (1999). However, Corbett (1999) only recorded one species of flying-fox, *Pteropus alecto* (black flying fox), while Kerle & Burgman (1984) recorded this species, as well as *P. scapulatus* (little red flying-fox). These two species are both common on the Magela floodplain and feed on nectar and pollen, particularly from blossoms of eucalypts. The remaining species recorded were microbats which are predominantly insectivorous. Two species of microbats, the ghost bat (*Macroderma gigas*) and dusky horseshoe-bat (*Hipposideros ater*) were recorded by Kerle & Burgman (1984), but were not recorded by Corbett (1999). This was attributed to patchy distributions of these species. Several species of microbats are listed as 'potentially threatened' in the Jabiluka EIS (Kinhill Engineers & ERA Environmental Services Pty Ltd 1996). The microbat species of the Jabiluka project area were found to have a distinct pattern of habitat use. In general, bats were most active at billabongs and waterholes which was attributed to the fact that insect prey are more abundant and productive at these locations (Corbett 1999).

3.7.2 Mammal populations of the Ranger project area

Corbett (1996) also conducted a survey of the Ranger lease area sampling 3 billabongs of the Magela Creek system (Coonjimba, Djalkmara and Georgetown) and two Nourlangie system billabongs for comparative purposes. A total of 12 native species (not including bat species) were recorded. There was little variation in the species recorded to those found on the Jabiluka lease area. Ranger and Nourlangie waterbodies had similar numbers of species.

3.8 Alien Species

There are several species of alien flora and fauna that occur in the Alligator Rivers Region and in the Magela Creek system. These species have the potential to adversely impact on the environment, complicating the assessment of impacts due to mining operations in the area.

3.8.1 Alien flora

The number of alien plant species that have become naturalised (i.e. non-native species reproducing and establishing populations successfully without deliberate human assistance) in the ARR has been documented in several studies (Cowie et al 1988, Cowie & Werner 1987, 1993, Brennan 1996). Ninety-nine weed species have been recorded in the Region, which represents 5.3% of the total flora (Brennan 1996). In a 1948 survey 14 species were recorded in the Region; since then number has increased at an average of 1.6 species per annum (Cowie & Werner 1993). Cowie & Werner (1993) found that most alien species occurred in anthropogenic habitats such as settlements and roadways. In natural habitats severe infestations were recorded in riparian vegetation, particularly in areas disturbed by feral animals such as water buffalo and pigs.

The most common weed species are the annuals *Hyptis suaveolens, Sida acuta, Sida cordifolia* and the perennial vine *Passiflora foetida* (Finlayson et al 1988). However, the species which have the potential to cause the most damage are those species able to dominate relatively pristine native communities. *Pennisetum polystachion* may pose a threat to *Eucalypt* communities in the uplands while *Salvinia molesta, Mimosa pigra* and *Brachiaria mutica* are the major species invading the wetlands (Finlayson et al 1988, Cowie & Werner 1993). All three of these species occur on the Magela floodplain. *M. pigra* is a thorny woody shrub and poses the most significant threat due to its high seed production and rapid regeneration. A program of chemical and manual removal has been successful within Kakadu but is threatened by large infestations in areas adjacent to the Park (Finlayson et al 1988, Cowie & Werner 1993). *S. molesta,* an aquatic floating fern, is widespread on the Magela Creek floodplain. It occurs amongst overhanging trees and floodplain grasses, making manual and chemical control very difficult. The weevil *Cyrtobagous salviniae* was released in 1983 as a biological control agent. However, over the next 2-3 years *Salvinia* continued to spread and the weevil population did not expand as it had done previously in other areas. A three-year study by the Australian Nature Conservation Agency (ANCA) and Commonwealth Scientific and Industrial Research Organisation (CSIRO) was initiated in 1991 to identify factors influencing the biological control of the weed. The study found that repeated releases of weevils into areas where the weevil was already established provided no extra benefit. Trials were also conducted to identify suitable herbicides and the most effective timing of application. Recommended measures for longterm control of *Salvinia* on the Magela floodplain involve the continued use of weevils in conjunction with herbicides, restricted access, and mechanical harvesting (Finlayson 1994, Storrs & Julien 1996). *B. mutica* (para grass), a perennial grass, invades *Oryza* and *Eleocharis* grasslands on the Magela floodplain. This causes a reduction in the major food resource for magpie geese using the floodplain as a Dry season refuge (Cowie & Werner 1993). Following the reduction in buffalo numbers on the floodplain *B. mutica* has flourished (Finlayson et al 1988). This species is difficult to control as the only effective method involves chemical application at particular stages of the lifecycle. Research into more effective approaches is being conducted by Parks Australia (Lane 1998).

Larger sites being actively used such as settlements and minesites are most likely to be more susceptible to further invasions of alien species (Finlayson et al 1988). Mining operations at Ranger and Jabiluka lease areas have the potential to facilitate the invasion of weed species through major disturbances to the environment, as well as the introduction of soils and other materials. Alien plants colonising such areas have the potential to spread throughout the Park and the whole of the ARR.

3.8.2 Alien fauna

Introduced and feral mammals found in the Alligator Rivers Region include the water buffalo (*Bubalus bubalis*), cattle (*Bos taurus/indicus*), horse (*Equus caballus*), donkey (*Equus asinus*), pig (*Sus scrofa*), cat (*Felis catus*) and black rat (*Rattus rattus*) (Press et al 1995). The main species that occur on the Magela Creek floodplain are feral horses and cats, water buffalo and pigs. Feral cats occur mainly along water courses and around human settlement, but are thought to occur in relatively low numbers on the Magela floodplain. They pose a major threat to the native fauna. Similarly, brumbies occur in scattered herds on the floodplain, but are not overly abundant. Buffalo were recorded in the ARR in the mid-1840s and increased in numbers dramatically. They have had a severe adverse impact on the environment causing vegetation loss and acceleration of soil erosion, the creation of wallows and trails, a general decline in the diversity of wetland flora and fauna, as well the spread of diseases such as tuberculosis. A major eradication program implemented in the mid-1980s has markedly reduced the numbers in the ARR and on the Magela floodplain. Pigs damage the environment causing a reduction in regrowth of vegetation through rooting and the introduction of weeds. They are common throughout the ARR and occur on the Magela floodplain. Their numbers have seemingly increased concomitantly with the decline in buffalo populations. Despite shooting by Parks Australia and removal by local Aboriginal groups on a contract basis, pig numbers do not appear to be declining (Kinhill Engineers Pty Ltd & ERA Environmental Services Pty Ltd 1996).

Another introduced species that poses a threat to the wetland habitats of the Magela Creek system is the cane toad (*Bufo marinus*). This species is not currently present within Kakadu National Park, but has been recorded in nearby areas. Cane toads will have a detrimental impact on some species of native fauna through direct consumption, competetion for resources, and toxic effects on predators. Quolls and goannas are two species thought to be particularly at risk (Corbett 1998). Van Dam et al (2000) prepared a preliminary ecological risk assessment to predict the effects of cane toads in Kakadu National Park. The assessment examined the potential impacts of cane toads on predator and prey species, effects of competition for resources, cultural and economic impacts, and other potential impacts. From this assessment key habitats and species most at risk were identified. The assessment outlines information gaps that need to be addressed, provides recommendations for potential monitoring programs to gather pre-invasion baseline data and will assist Park managers in establishing a management strategy to control the toads.

4 Conclusion

Collection of information on the flora and vertebrate fauna of the Magela Creek system has involved describing species and habitats, measuring abundances and biomass, and determining natural variations and seasonal fluctuations. Interrelationships between species and interactions with their habitats have also been assessed. Baseline data collection and ongoing monitoring are necessary to enable detection of impacts from uranium mining operations at the Ranger minesite, and more recently at the Jabiluka minesite. Furthermore, any Magela Creek data that are applicable to the Swift Creek system may play an important role as baseline information for this system if mining operations proceed at Jabiluka. The process of predicting the effects of proposed development is complicated by natural variability within the environment and other impacts on the area such as the invasion of alien species. Although water buffalo have been controlled on the Magela floodplain, feral pig populations, weed species such as *Salvinia* and *Mimosa*, and the potential invasion by cane toads present an ongoing threat to the wetland habitats. These issues, as well as tourism and Aboriginal use, need to be considered in assessments of the impacts of uranium mining in the Magela Creek system. Biomagnification and the potential transfer of contaminants from the aquatic to terrestrial environment by different species requires further research, as the pathways are not clearly understood, due to the complex interactions present within ecosystems and food webs.

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LITERATURE REVIEW OF THE FLORA AND VERTEBRATE FAUNA OF THE MAGELA CREEK SYSTEM, ALLIGATOR RIVERS REGION, NORTHERN AUSTRALIA

Contents

1 Introduction

This paper is an annotated review of individual articles presented under the following headings: vegetation, algae, fish, amphibians, reptiles, birds, mammals and general studies that encompass a range of organisms. Each paper has been summarised to provide a brief overview of its contents. In the case where there is more than one version of a report, only the most recent report has been reviewed and a note made of earlier versions. This information is presented using a standardised format that lists the bibliographic details and describes the contents of each article. For studies with a wider scope than a description of species abundances and distributions, the remainder of the study is mentioned, but is not outlined in any detail. Direct quotes from a paper are given in quotation marks; any other text is a combination of the original author's material and the current authors' work. References in the summaries to data and tables refer to information in the original paper, not that presented in this current report. Some studies are confidential and permission to use any part of the reports should be gained from the copyright holder.

2 Database

References were collected from several sources and a database of those references was created. The ***eriss*** library database (SSAR, OSSCAT and ARRI) as well as Current Contents (1996-2000) and INIS (International Nuclear Information System) (1970-1999) were searched. An on-line search of Biosis, Enviroline and ASFA (Aquatic Sciences and Fisheries Abstracts) was also completed. The following search terms were used: Magela; Swift; Jabiluka; Ranger; Alligator Rivers Region in conjunction with flora, vegetation, plants, fauna, animals, fish, birds, waterbirds, mammals, wildlife, wetland, community(s) and ecosystem. The location of hard copies of the references is provided to facilitate retrieval of the originals, and refers to the ***eriss*** library unless otherwise stated. The database from which this report was compiled is stored on the ***eriss*** computer network and is called 'MAGELA SYSTEM'. This can be accessed through the ***eriss*** library system. This database can be searched using the same procedures as used to search other ***eriss*** library databases. References containing information on other aspects of the Magela Creek system have also been included in the database for future use. To access only the references listed in this report 'Y' can be entered into a set field called 'To identify items listed in report type a Y in this box'. These references have been edited following the ***eriss*** style guide as closely as possible. The remaining references containing information on the Magela system have been grouped into topics and are unedited. A certain topic be retrieved by entering the following headings into 'Free text keywords':

> Aboriginal Food; Biology; Biological Monitoring; Fish Kills; Geomorphology; Hydrology; Invertebrates; Jabiluka; Limnology; Ranger; Swift Creek; and Trace Metals.

VEGETATION

TITLE: Seasonal distribution and biomass of aquatic macrophytes in Corndorl Billabong (Magela Creek, Northern Territory).

AUTHOR(s): Bailey B, Clay D, Baker L & Walden D (1983).

PUBLICATION: In *Environmental protection in the Alligator Rivers Region: A scientific workshop.* Vol 1, Jabiru 17-20 May 1983, Supervising Scientist for the Alligator Rivers Region, 34.1-34.8. Unpublished paper.

LOCATION: CR SSAR 010 (Vol 1).

SUMMARY

The ecology of the plant communities in Corndorl Billabong, Magela Creek was examined over an 18 month period between 1981 and 1982. The vegetation communities were surveyed using a line transect, with 0.25 m^2 or 4 m^2 quadrats being used for biomass estimates. 'The sampling program was completed in December 1982 and at the time of writing data analysis had not commenced'. However, general features of the macrophyte communities have been described from preliminary assessments of the data. Some of this information was presented in a report prepared by Finlayson et al (1989).

On the basis of waterflow, depth and period of inundation during the Wet season, three major habitats were identified in Cordorl Billabong. They were the open floodplain, the deeper channel and the fringe zone between the floodplain and the surrounding open woodland. The main macrophyte communities occurring within these three habitats were described. A total of 31 species of aquatic macrophytes were identified and listed in a table provided in the report. The floodplain of Corndorl Billabong contained three major community types, the largest one being dominated by *Pseudoraphis spinescens*, a mat-forming grass. 'The aquatic vegetation found within the deeper slow flowing channel tended to be dominated by submerged rooted, emergent rooted and floating-leaved rooted forms'. 'Many community types consisting mainly of grasses and sedges, terrestrial herbs and facultative aquatics were identified within the fringe or transition zone that surrounds the billabong'. This zone had a high species richness and contained species tolerant of short periods of inundation. A species list for the fringe zone was also provided. Great seasonal variation of biomass was observed in nearly all plant communities. 'Plant biomasses on the floodplain during the dry season were low, usually less than 0.5 kg/m^2'. Biomasses in the channel communities were notably higher averaging 6.5 kg/m^2. 'By the end of the Wet season, biomass in the floodplain and channel communities had increased by 85% and 80% respectively, relative to end of the Dry season'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Corndorl Billabong is located in Magela Creek, well upstream of the Swift Creek confluence with the Magela floodplain. Hence the data collected on macrophyte communities are not directly relevant except for comparative purposes to similar habitats on the floodplain downstream of the confluence with Swift Creek.

TITLE: *An annotated checklist of the vascular plants of the Alligator Rivers Region, Northern Territory, Australia.*

AUTHOR(s): Brennan K 1996.

PUBLICATION: Supervising scientist report 109, Supervising Scientist for the Alligator Rivers Region, AGPS, Canberra [Incorporates Cowie & Finlayson (TM 17) and Brennan 1990 (OFR 62)].

LOCATION: SERIES SSAR SSR 109.

SUMMARY

This checklist of native and naturalised exotic plants covers the Alligator Rivers Region (ARR) including the Magela Creek system. The list includes 1899 taxa and replaces previous lists by Cowie & Finlayson (1986) and Brennan (1990). 'This comprises 1874 species, 18 of which are represented by 2 or more subspecies or varieties'. 'In the 23 years since the Alligator Rivers Fact-Finding Study (Adams et al 1973), (the first detailed survey of area), the number of known species has almost doubled'. 'Of the 174 plant families represented in the region the grass family, Poaceae, is the largest having 220 species. A summary of the flora of the ARR in terms of lifeform composition shows that almost 60% of the terrestrial plant-life either dies or is deciduous during the Dry season (May-September)'. A separate list of the species found in the region with conservation significance to the Northern Territory (364 species), and a list of the naturalised exotic flora (99 species), are provided in the report. 'For each species on the checklist, lifeform, known habitat association(s), a voucher reference, synonyms or previously misapplied scientific names, common names (where known) and a reference to recent taxonomic literature is given'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

This checklist of vascular plants covers the Alligator Rives Region. As such it lists species that could be found in Swift Creek.

TITLE: *Cluster analysis, ordination and dominance-structural classification applied to diverse tropical vegetation at Jabiluka, Northern Territory.*

AUTHOR(s): Burgman MA & Thompson EJ 1982.

PUBLICATION: *Australian Journal of Ecology* 7, 375-387.

LOCATION: ARRI File 0044.

SUMMARY

'One hundred and seven sample plots were established on a study area at Jabiluka, Northern Territory, and detailed quantitative floristic and structural data were collected. Data collection was by sampling both on aerial photographs and in the field, and both sets of data were used to describe the primary floristic types and structural sub-types'. The field survey was conducted in June/July of 1979 and covered the Jabiluka lease and surrounding areas. 'Cluster analysis, polar ordination and Specht's approach to vegetation classification were used to analyse the data. Two independent clustering techniques, one based on an information measure and the other on a measure of within group dispersion, produced very similar dendograms. The analyses consistently separated the plots into three major groups – floodplain, dryland and sandstone landscapes; within these groups 15 floristic associations and eight structural formations were identified'. The fifteen vegetation communities that were identified are described in the paper. They are: floodplain macrophyte communities; floodplain fringe; upper floodplain fringe; riparian (floodplain association); riparian (dryland association); riparian fringe; *Fabaceous-myrtaceous* open-woodland; *Eucalyptus miniata*; mature mixed type; mixed eucalypt type 1; mixed eucalypt type 2; mixed eucalypt type 3; sandstone type 1; sandstone type 2; closed forest. 'The environmental parameters associated with the various groups were substrate type, and seasonal inundation from the Magela Creek system'.

'Many species in the Jabiluka area are restricted to one of the three major landscape types, that is, areas where water is abundant, dry woodland areas, and sites where the substrate is sandstone. A few species are restricted to just one community. For example, *Dianella caerulea* occurs only in closed forest, *Hymenachne acutigluma* occurs only in floodplain macrophyte communities, and *Coldenia procumbens* is peculiar to floodplain fringe vegetation. Other species may be found largely within one community though they may occur outside it'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

The Jabiluka lease area includes Swift Creek, making the information on the vegetation communities highly relevant, particularly in relation to reference conditions and assessment of any floristic change in the area.

TITLE: Alien plant species invasive in Kakadu National Park, tropical Northern Territory

AUTHOR(s): Cowie ID & Werner PA 1993.

PUBLICATION: *Biological Conservation* 63, 127-135. [Incorporates Cowie & Werner 1987, 1988, CR ANCA 055 (a&b)].

LOCATION: ARRI File 1643.

SUMMARY

'A survey of the distribution and abundance of invasive alien plant species in Kakadu National Park in Australia's tropical Northern Territory was undertaken to provide a basis for management'. This paper overviews the findings of two previous studies conducted by Cowie & Werner (1987, 1988) which contain more detailed information on alien species.

Survey sites were located in all three stages of Kakadu National Park, including the Magela Creek system. 'Kakadu was stratified into two types of habitat: anthropogenic and natural'. A total of 406 sites were sampled between late October and mid-December 1986. The percentage of the park covered by each natural habitat is given in the report. Anthropgenic habitats covered less than 0.1% of the park and included such sites as stockyards, roadsides and campgrounds. 'Two measures of abundance: plant cover and frequency of occurrence' were used. 'At each sample site three quadrats, each approximately 10 x 10 m, were located 30 m apart'. 'Mean percentage foliar cover and frequency of occurrence were calculated for each species over all quadrats in each habitat'.

'Some 5.8 % (89 species) of the vascular flora of Kakadu were considered invasive aliens'. Only those species with a frequency of 25 % or more on any habitat are listed in the report. A complete list of alien species is available in Cowie & Werner (1987). 'Most species were widespread tropical weeds'. 'The majority of these species were either rare in distribution or widespread but with low mean cover values. Most were associated with human activities, roadways and other disturbed ground—habitats comprising a small proportion of the Park. In natural habitats, the most severe infestations occurred in riparian communities, especially those frequented by the feral Asian water buffalo, *Bubalus bubalis*. The most commonly found species were the annuals *Hyptis suaveolens*, *Sida acuta*, *Sida cordifolia*, *Alysicarpus vaginalis* and *Euphorbia hirta* and the perennial vine *Passiflora foetida*. However, the species considered most damaging to the integrity of the Park's biota were those capable of dominating relatively undisturbed native plant communities, especially the vulnerable wetlands. The most important of these perennial weeds remains *Mimosa pigra* in wetlands, under control in the Park but occurring in abundance elsewhere in the region. Also important are *Brachiaria mutica* and *Salvinia molesta* in wetlands and *Pennisetum polystachion* in the uplands. If fundamental changes to the nature and conservation status of this World Heritage Park are to be avoided, an ongoing commitment to controlling invasive alien species (especially *Mimosa*) both inside and outside the Park is required.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

The presence of alien species is given within habitat types, not at specific study site locations; similar habitats in the Swift Creek system may contain similar species of alien plants. However, Cowie & Werner (1987) provide a list of each weed species recorded at each sample site, as well as locality maps for the common alien species. Due to the proximity of Magela Creek sites to Swift Creek some of the weeds present at these locations may also be present within the Swift Creek system.

TITLE: *Alien plants in the Alligator Rivers Region, Northern Territory, Australia.*

AUTHOR(s): Cowie ID, Finlayson CM & Bailey BJ 1988.

PUBLICATION: Technical memorandum 23, Supervising Scientist for the Alligator Rivers Region, AGPS, Canberra.

LOCATION: SERIES SSAR TM 23.

SUMMARY

'This is a report on the presence, distribution and frequency of occurrence of alien plant species naturalised in the Alligator Rivers Region, Northern Territory'. The physical features, vegetation, climate, and land use of the Region are briefly described. Previous lists of alien species were consulted to document temporal changes in the number of species in the Region; a list of alien plants, the date they were first recorded in the Region, their habitat and habit is provided. 'The survey of alien species was concentrated at sites of disturbance, along the edges of floodplains and water courses and in the areas frequented by buffalo'. Descriptions of the 44 sites surveyed and their locations are given in the report. 'Some alien plants have also invaded wetlands in the Region. The presence of these species was noted although, except for the Magela Creek floodplain, this habitat type was not extensively surveyed'. Most sites were visited in the Late-wet-Early-dry season (April-June) between October 1983 and June 1986. Data analysis techniques used for the analysis of weed species presence/absence are outlined in the paper. The species and the sites at which they occurred are tabulated in the report.

'A total of 71 alien species, representing 5.3% of the flora, was recorded'. 'The alien species came from 21 families, the major ones being the Poaceae, Fabaceae, and Asteraceae'. 'Since 1948, when 14 species were recorded, the number of alien species recorded in the Region has increased exponentially. The major weed species invading wetlands are *Salvinia molesta*, *Mimosa pigra* and *Urochloa mutica*. The most successful (and generally longest resident) colonisers of disturbed sites and riparian habitats are *Hyptis suaveolens*, *Sida acuta*, *Passiflora foetida* and *Sida cordifolia*'. 'Many of the species recorded are recent arrivals and are expected to continue to spread. Species richness (and size of site) explained most of the structure in the data. The larger, comparatively species rich sites in active use (settlements and mines) are expected to be the areas most susceptible to further introduction of alien species'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

The data for alien plant species is relevant to Swift Creek especially if habitat disturbance occurs as a consequence of mining exploration and disturbance. Weed species invading the floodplain, such as *Salvinia molesta* and *Mimosa pigra,* and riparian zone, such as *Hyptis suaveolens*, have the potential to spread to Swift Creek.

TITLE: Salvinia, water hyacinth and mimosa in the Alligator Rivers Region, Northern Territory.

AUTHOR(s): Finlayson M 1984.

PUBLICATION: *Australian Weeds* 3 (2), 83.

LOCATION: ARRI File 0796.

SUMMARY

This paper briefly discusses the presence of noxious weeds in the Alligator Rivers Region. During September 1983 salvinia (*Salvinia molesta*), water hyacinth (*Eichornia crassipes*) and mimosa (*Mimosa pigra*) were found in the Magela Creek system. Water hyacinth was found close to the Oenpelli road crossing and was easily removed. Salvinia was found in several billabongs and interconnecting channels and was widespread amongst the other vegetation, making manual and chemical control very difficult. The biological control *Cyrtobagous* agent was released and more insects were to be released following the 1983-84 Wet season. Mimosa had been present elsewhere in the Region but had not occurred in the Magela system until it was found near Nankeen Billabong in 1983. The mimosa was sprayed, but remains a concern as it had seeded and it 'is well adapted to growing under seasonally flooded conditions and poses a serious threat to the floodplain environment'. Control measures have not been overly effective, though a biological control scheme has been initiated.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

This information is relevant as the exotic waterweeds have the potential to spread to Swift Creek. Salvinia in particular is found in habitats near the confluence of Swift Creek with the floodplain.

TITLE: Flowering plants and chemical turnover on the Magela floodplain.

AUTHOR(s): Finlayson M May 1989.

PUBLICATION: *Australian Science Mag* No. 2 32-34.

LOCATION: ARRI File 0589.

SUMMARY

This paper provides a description of the vegetation communities and chemical turnover of the Magela floodplain. Approximately 200 species of plants occur on the Magela floodplain and they occupy four broad habitats: the billabongs; seasonally inundated plain; fringe zone; and permanent swamps. 'The seasonally-flooded plain and the fringe zone contain 41% and 71% respectively of the total known species compared to 20% in the billabongs and 10% in the permanent swamps. The first two habitats also contain a greater proportion of annual species than the other two habitats'. 'Of the 139 annual species, 102 are terrestrial and 37 are aquatic; 89 of the terrestrial species occur in the fringe zone'. 'There are 68 perennial species, 50 of which occur in the fringe zone; 37 do not occur elsewhere on the floodplain. Thirty-four of the perennial species are terrestrial, 26 are aquatic and eight others are difficult to classify'.

'Detailed analyses of the aquatic plant distribution on the Magela floodplain shows that it is not reproducible in subsequent years. Distribution data for Wet season vegetation over several years has been used to describe and map 10 broad plant communities on the floodplain'. These are paperbark open forest and woodland; paperbark open woodland; lotis lily-*Hymenachne* grass swamp, wild rice grassland, *Hymenachne* grassland, mud grass grassland, *Hymenachne* grass-spike rush swamp, mixed grass-sedgeland, spike-rush sedgeland and open-water community.

The remainder of the paper discusses the turnover of nutrients and non-nutrient metals by the flowering plants on the Magela floodplain.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Information in this paper provides an ecological context for vegetation communities that occur near the confluence of Swift Creek and the Magela floodplain. However, site specific information is not given.

TITLE: Production and major nutrient composition of three grass species on the Magela floodplain, Northern Territory, Australia.

AUTHOR(s): Finlayson CM 1991a.

PUBLICATION: *Aquatic Botany* 41 (4), 263 - 280.

LOCATION: ARRI File 1332.

SUMMARY

Three aquatic grasses on the Magela Creek floodplain were sampled to determine dry weights and nutrient concentrations over a seasonal cycle. Three sites, each dominated by one of the grass species, were surveyed at four-week intervals between October 1983 to February 1985. A transect line was used at each site. Five quadrats were placed along the transect and the vegetation growing in each quadrat was harvested. The harvesting and laboratory procedures are described in the paper.

'The dry weight of the aquatic species *Pseudoraphis spinescens* (R. Br.) Vick., *Hymenachne acutigluma* (Steudel) Gilliland and *Oryza meridionalis* Ng varied with water depth on the floodplain. Maximum dry weights (1.67 ± 0.21 kg m^{-2}, 1.41 ± 0.10 kg m^{-2}, 0.51 ± 0.10 kg m^{-2}, respectively) occurred at the end of the Wet season when water depth was decreasing. The perennial species *P. spinescens* and *H. acutigluma* had two growth periods and an annual productivity of 1.91 ± 0.26 kg m^{-2} and 2.09 ± 0.38 kg m^{-2}, respectively, compared with 0.51 ± 0.10 kg m^{-2} for the annual *O. meridionalis*. Relative to other aquatic and wetland species, the former two grasses have high production rates'. The remainder of the paper discusses the nutrient concentrations of the three grass species and their role in the chemical turnover on the floodplain.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

As *Pseudoraphis spinescens* occurs near the confluence of Swift Creek and the Magela floodplain, it can be assumed that similar standing crop and productivity levels could occur. However, specific sampling sites were not located in this area.

TITLE: Plant ecology and management of an internationally important wetland in monsoonal Australia.

AUTHOR(s): Finlayson CM 1991b.

PUBLICATION: In *Proceedings of an international symposium on wetlands and river corridor management.* Charleston SC, eds J Kusler & S Day, Association of Wetland Managers, Berne, NY, 90-98.

LOCATION: ARRI File 2880.

SUMMARY

This paper reviews previous studies done on the macrophyte vegetation of the Magela floodplain. It provides an overview of the administration of the Alligator Rivers Region, and the plant ecology research program at the Alligator Rivers Region Institute (now the Environmental Research Institute of the Supervising Scientist). A brief description is given of the vegetation and its seasonal variation, production levels and chemical turnover. Ten vegetation communities have been identified on the floodplain, consisting of about 225 species. Seasonal variation in the macrophyte vegetation occurs as a result of the hydrological cycle; an empirical model was found to be useful to describe this vegetation succession. The nutrient and non-nutrient metal loads of substances that potentially could be released from Ranger mine were compared with the loads already being turned over by the vegetation on the floodplain. Except for the loading of uranium the loads turned over by the plant species greatly exceed those contained in the wastewater. Other studies relate this to loadings contained in floodplain sediments (**Finlayson 1994).

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Papers referred to in this review contain information on vegetation habitats found near the confluence of Magela floodplain and Swift Creek.

TITLE: Vegetation changes and biomass on an Australian monsoonal floodplain.

AUTHOR(s): Finlayson CM 1993.

PUBLICATION: In *Wetlands and ecotones: Studies on land-water interactions*, eds B Gopal, A Hillbricht-Ilkowska & RG Wetzel, National Institute of Ecology, New Delhi, 157 - 171.

LOCATION: ARRI File 1674.

SUMMARY

This paper is a review of information on the wetland vegetation of the Magela floodplain. 'Firstly, a brief description of the vegetation, including seasonal changes in species occurrence and plant biomass is presented. This is preceded by a description of climate and physical characteristics of the floodplain. Secondly, an empirical model of plant succession that relates changes in the hydrological cycles to the life histories of the plants is used to describe seasonal changes in the occurrence of plant species on the floodplain'.

Freshwater levels on the Magela floodplain reach 2-3m during the Wet season, whereas during the Dry season the floodplain almost dries out completely. 'The wetland vegetation is also highly productive with a high biomass present during the Wet season. The Wet season vegetation is diverse and floristically rich compared to that of the Dry season. Overall, about 225 species are found on the floodplain. These have been divided into 10 broad vegetation communities based on dominant species present at the end of the Wet season'. The ten vegetation types are *Melaleuca* open forest and woodland; *Melaleuca* open woodland; mixed swamp; *Oryza* grassland; *Hymenachne* grassland; *Pseudoraphis* grassland; *Hymenachne-Eleocharis* swamp; mixed grass-sedgeland; *Eleocharis* sedgeland; and open water community. A generalised map and descriptions of the 10 vegetation communities are provided in the paper. 'The species composition of these communities varies seasonally and annually with water depth and period of inundation being key determining factors'. An empirical model of plant succession for the Magela floodplain was validated using the 1983-84 hydrological cycle, and was found to be useful in describing the general changes in species composition over the Wet-Dry cycle.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

The vegetation map of the major plant community encompasses the convergence of Swift Creek with the Magela floodplain. *Melaleuca* open forest and woodland and *Pseudoraphis* grassland predominate in this area. The paper is a review of several previous studies done on plant biomass and seasonal variation of floodplain vegetation. These studies need to be examined separately, in order to identify study sites located near the confluence of Swift Creek with the floodplain.

TITLE: Wetland Vegetation.

AUTHOR(s): Finlayson CM & Woodroffe CD 1996.

PUBLICATION: In *Landscape and vegetation ecology of the Kakadu Region, Northern Australia.* Geobotany 23, eds CM Finlayson & I von Oertzen, Kluwer, Academic Publishers, Boston, 81-112.

LOCATION: 581.5 LAN.

SUMMARY

This chapter on wetland vegetation in the Kakadu region focuses on mangrove swamps and freshwater wetlands, and is an overview of available information. Freshwater wetlands are discussed in terms of their hydrological cycle, general vegetation patterns, and the South Alligator and Magela Creek floodplains are described in detail. For the purpose of this current report only the information on the Magela floodplain will be summarised.

'The freshwater wetlands are found along the major rivers and greatly influenced by the seasonal hydrological cycle. During the Wet season the floodplains are covered with 1-2 m of water and contain a multitude of plants. During the Dry, in contrast, the plains are parched and the vegetation is sparsely distributed'. A total of 222 plant species were recorded on the Magela floodplain. 'These were listed in four broad habitat categories – seasonally inundated plain, seasonally inundated fringe zone, billabong and permanent swamp'. 'The seasonally inundated plain and the fringe zone contain 41% and 71% respectively, of the 22 species, compared with 20% in the billabongs and 10% in the permanent swamps'. Overall there were 139 annual species consisting of 102 terrestrial and 37 aquatic species; and 68 perennial species of which 34 were terrestrial species, 26 aquatic and 8 hard to classify. Fourteen species were geophytic perennials, with *Nymphaea* and *Eleocharis* the more widespread species.

The distribution of plants on the Magela floodplain has been well documented; previous classifications of plant communities on the Magela plain are reviewed in the chapter. From 6 to 36 types of vegetation types have been identified depending on the classification used. The vegetation of 5 billabongs of the Magela Creek system is also briefly described, followed by a discussion of productivity and vegetation succession on the floodplain. The relative abundance and distribution of many plants varies seasonally on the floodplain. 'Seasonal changes in the distribution and biomass dominance of the vegetation are greatly affected by the flooding patterns, although feral animals and exotic weeds have also exerted an influence. The widespread grasslands are very productive with dry weight biomass values ranging from 0.5-1-1 kg m^{-2} y^{-1}. The *Melaleuca* forests are similarly productive with litterfall values of 0.7-1.5 kg m^{-2} y^{-1}'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

This chapter reviews other studies that describe the vegetation of the Magela Creek floodplain, including that which occurs in the vicinity of the confluence of the Magela floodplain and Swift Creek.

TITLE: *Macrophyte vegetation of the Magela Creek floodplain, Alligator Rivers Region, Northern Territory.*

AUTHOR(s): Finlayson CM, Bailey BJ & Cowie ID 1989.

PUBLICATION: Research report 5, Supervising Scientist for the Alligator Rivers Region, AGPS, Canberra.

LOCATION: SERIES SSAR RR 5.

SUMMARY

This paper contains a description of the macrophyte vegetation of the Magela floodplain, an area downstream of Ranger Uranium Mine covering 220km^2. 'A broad generalised vegetation classification was prepared based on Wet season data'. Major plant communities were delineated on the combined basis of interpretation of aerial photographs and field surveys. Details of species composition and indicator species for the different communities were derived from fieldwork conducted between 1983 to 1986. 'All macrophyte species known to occur on the Magela floodplain are listed and assigned to growth-strategy, growth-form and habitat categories'.

Ten major macrophyte communities were identified; *Melaleuca* open forest and woodland; *Melaleuca* open woodland; *Nelumbo-Nymphoides* herbland; *Oryza* grassland; *Hymenachne* grassland; *Pseudoraphis* grassland; *Hymenachne-Eleocharis* grass-sedgeland; mixed grass-sedge-herbland; *Eleocharis* sedgeland; and open water community. 'The *Melaleuca* open forest and woodland community covered 34% of the floodplain, and *Pseudoraphis* and *Oryza* grasslands covered 14% and 12% respectively. The 222 plant species recorded from the floodplain were categorised into four habitat types: seasonally inundated plain, seasonally inundated fringe zone, permanent swamps and permanent billabongs. One hundred and thirty-nine annual species, 69 perennials and 14 geophytic perennials were recorded on the floodplain. The seasonally inundated plain and fringe zone habitats respectively contained 41% and 71% of the plant species. The fringe zone contained 100 annual species (91 of which were terrestrial), the seasonally inundated plain 57, the permanent billabongs 19 and the permanent swamps 5. Seasonal variation of plant communities and the occurrence and extent of plant groups near billabong margins was related to the hydrological cycle on the floodplain'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

The area mapped encompasses the convergence of Swift Creek with the Magela floodplain. *Melaleuca* open forest and woodland and *Pseudoraphis* grassland predominate in this region. The vegetation transect data are also relevant, as the transect originated at Nankeen Billabong, which is located on the Magela floodplain, slightly downstream of where Swift Creek enters the floodplain. Twenty-seven species and 7 major plant communities were identified along the transect.

TITLE: Sediment seedbanks in grassland on the Magela Creek floodplain, Northern Australia.

AUTHOR(s): Finlayson CM, Cowie ID & Bailey BJ 1990.

PUBLICATION: *Aquatic Botany* 38 163-176.

LOCATION: ARRI File 1139, Journal Shelves.

SUMMARY

'The size and species composition of plant populations arising from sediment seedbanks of three communities (*Pseudoraphis*, *Hymenachne* and *Oryza* grasslands) on the Magela Creek floodplain were compared under experimental (moist and flooded) conditions'. Sediment cores were collected from each community during the Dry season (September 1984) and subjected to either a moist or flooded treatment. The number of seedlings that germinated were identified and counted every 4 weeks until June 1985. 'The mean number of seedlings produced in the moist-treatment ranged from 8 000 to 15 400 m^{-2}, and in the flooded-treatment ranged from 3 800 m^{-2} to 7 100 m^{-2}. Seed from 33 taxa germinated: 22 from the *Oryza*-, 13 from the *Pseudoraphis*- and 18 from the *Hymenachne*-site samples'. The number of seedlings of each taxa that germinated from the three sites, under each treatment, are listed in the paper. 'The *Pseudoraphis*-site seedbank was closer in species composition to that of the *Hymenachne*-site than were either to the *Oryza*-site'. 'In terms of the species present the *Pseudoraphis*-site seedbank closely reflected that of its community on the floodplain, whereas the *Hymenachne*-site and *Oryza*-site seedbanks were not as closely related to the composition of their respective floodplain communities. Indices of diversity and evenness point to the relative homogeneity of species seedbank production in the moist-treatment of *Pseudoraphis*- and *Hymenachne*-site samples, compared with that in both treatments of the *Oryza*-site samples and the flooded-treatment of *Pseudoraphis*- and *Hymenachne*-site samples. *Pseudoraphis spinescens* (R.Br.) Vick. with a relatively small, but persistent seed dominated the seedling composition of the *Pseudoraphis*- and *Hymenachne*-site samples. 'From analysis of the seedbank data it is evident that plant species, other than those that currently dominate the biomass, could establish and under certain conditions even dominate the biomass'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

A map of the Magela floodplain is provided in the report showing the dominant plant communities. *Pseudoraphis* grassland and *Melaleuca* woodland and forest predominate in the vicinity of where Swift Creek joins the Magela floodplain. Whilst none of the sample sites were located in the vicinity of the confluence point the information from the *Pseudoraphis*-site located upstream is assumed to apply across all areas dominated by this species.

TITLE: Biomass and litter dynamics in a *Melaleuca* forest on a seasonally inundated floodplain in tropical, Northern Australia.

AUTHOR(s): Finlayson CM, Cowie ID & Bailey BJ 1993.

PUBLICATION: *Wetlands Ecology and Management* 2 (4), 177-188.

LOCATION: Journal Shelves.

SUMMARY

'Litterfall from a *Melaleuca* forest was investigated as part of chemical cycling studies on the Magela Creek floodplain in tropical, Northern Australia'. The study site was located in the vicinity of Leichhardt Billabong and was sampled at various intervals between 1983 and 1986. The above-ground biomass of the trees was determined by indirectly relating tree height, trunk diameter and fresh weight. Litterfall was collected using nets and trays, and accumulated litter was measured within quadrats.

'The forest contained two species of tree, *Melaleuca cajaputi* and *Melaleuca viridiflora*, with a combined average density of 294 trees ha^{-1}. The *M. viridiflora* trees had diameter breast height measurements ranging from 11.8 to 62.0 cm, median class 25.1-30.0 cm and a mean value of 29.2 ± 1.0 cm, compared to 13.0 to 66.3 cm, 30.1-35.0 cm and 33.5 ± 1.0 cm for *M. cajaputi* trees. A regression model between tree height, diameter breast height and fresh weight was determined and used to calculate average tree weights of 775 ± 1.6 kg *for M. viridiflora* and 1009 ± 1.6 kg for *M. cajaputi*, and a total above-ground fresh weight of 263 ± 0.3 t ha^{-1}. The weight of litter recorded each month on the ground beneath the tree canopy ranged from 582 ± 103 to 2176 ± 376 g m^{-2} with a monthly mean value of 1105 ± 51 g m^{-2}. The coefficient of variation of 52% on this mean indicates the large spatial and temporal variability in litter distribution over the study site. This variability was greatly affected by the pattern of water flow and litter transport during the Wet season. Litterfall from the trees was evaluated using two techniques – nets and trays. The results from these techniques were not significantly different with annual litterfall collected in the nets being 705± 25 g m^{-2} and in the trays 716 ± 49 g m^{-2}. The maximum monthly amount of litterfall, 108± 55 g m^{-2}, occurred during the Dry season months of June-July. Leaf material comprised 70% of the total annual weight of litter, 480 ± 29 g m^{-2} in the nets and 495 ± 21 g m^{-2} in the trays. The tree density and weight of litter suggest that the *Melaleuca* forests are highly productive and contribute a large amount of material to the detrital/debris turnover cycle on the floodplain'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

The information derived from this study is assumed to be broadly applicable to all *Melaleuca* forest on the Magela floodplain, including that near the confluence of Swift Creek with the floodplain.

TITLE: *Vegetation communities of five Magela Creek billabongs, Alligator Rivers Region, Northern Territory.*

AUTHOR(s): Finlayson CM, Thompson K, Oertzen I von & Cowie ID 1994.

PUBLICATION: Technical memorandum 46, Supervising Scientist for the Alligator Rivers Region, AGPS, Canberra [Incorporates Finlayson et al 1992 (IR 54)].

LOCATION: SERIES SSAR TM 46.

SUMMARY

The major vegetation communities in three backflow (Coonjimba, Djalkmara and Georgetown) and two floodplain (Jabiluka and Leichhardt) billabongs of the Magela Creek System are described. 'Vegetation maps of the five billabongs were prepared based on information collected during the 1987-1988 Wet season'. 'Information for the maps was obtained by foot, boat and aerial reconnaissance'. 'An inventory of species was made and indicator species for different communities selected'.

'All macrophyte plant species known to occur in each billabong are listed and categorised into growth-strategy and growth-form types. The plant biomass (assessed qualitatively) in the backflow billabongs was dominated by the fringing perennial *Melaleuca* spp. trees and the geophytic perennial *Eleocharis* spp. sedges. The floodplain billabongs are deeper, have steeper banks than the backflow billabongs and have a narrower woodland fringe. A feature of the floodplain billabongs over the study period was the presence of floating mats of grass, sedge and herb species, that also contained the introduced floating fern *Salvinia molesta*'. Coonjimba and Georgetown Billabongs were divided into eight vegetation communities containing forty-five and thirty-six species respectively. The forty-four plants species recorded in Jabiluka Billabong were represented by seven vegetation communities. Six vegetation communities comprising forty species were identified in Leichhardt Billabong while nine communities and forty-three plant species were recorded in Djalkmara. 'The vegetation in the backflow billabongs has changed since buffalo numbers were reduced, with sedges becoming more widespread. This in turn appears to have led to an increase in silt deposition in these billabongs. At times, mats of *Salvinia molesta* have completely covered the surface of the floodplain billabongs'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Jabiluka Billabong is located near the confluence of Swift Creek with the Magela floodplain, hence the vegetation descriptions and map of this billabong are relevant to ecological assessment of this area.

TITLE: *Grassland community dynamics of a freshwater tropical floodplain: Invasion of Brachiaria mutica (Para grass) on the Magela floodplain, Kakadu National Park.*

AUTHOR(s): Knerr NJA 1998.

PUBLICATION: Internal report 275, Supervising Scientist for the Alligator Rivers Region, Canberra/Darwin. Unpublished paper.

LOCATION: SERIES SSAR IR 275.

SUMMARY

This study investigated the vegetation dynamics of the Magela floodplain in Kakadu National Park, with particular focus on the introduced plant species, *Brachiaria mutica*. 'The species composition and abundance of the extant vegetation in four grassland communities (*Brachiaria*, *Oryza*, *Hymenachne* and *Pseudoraphis* grasslands) were examined in the Dry and Wet seasons of 1995-1996 in order to examine spatial and temporal changes.' 'The four grassland communities on the floodplain were surveyed using a nested quadrat technique'. The area on the southern section of the floodplain covered by each grassland community was mapped using aerial photography. 'The change in distribution of *Brachiaria mutica* was estimated by detailed mapping of the most heavily infested area in 1996 and by interpreting aerial photographs of the same area taken in 1991. In addition, the spatial variation of seeds in sediments was studied through a sediment germination trial. Data generated from this experiment were compared to a previous sediment germination trial conducted in 1984'. Soil cores were collected and the seedlings were grown in trays under flooded and moist conditions, and then identified. 'The potential seed production of the grass species that dominate the floodplain was estimated (*Brachiaria mutica*, *Oryza meridionalis*, *Hymenachne acutigluma* and *Pseudoraphis spinescens*). Seed germinability and viability of these species was also assessed by a direct germination trial and tetrazolium chloride tests. The density of *Brachiaria mutica* and *Oryza meridionalis* seeds in the sediments was estimated by direct seed counts from soil cores'.

'A total of 25 taxa were recorded through the vegetation survey. Twelve taxa were found in the *Brachiaria* grassland, 16 in the *Oryza* grassland, 20 in the *Hymenachne* grassland and 11 in the *Pseudoraphis* grassland'. A list of the taxa found in each community is given in the report. 'Species richness and diversity in the extant vegetation was highest in the *Hymenachne* grassland. The *Pseudoraphis* and *Oryza* grasslands had a low species richness and diversity in the Dry season and this increased significantly in the Wet season. *Brachiaria* grassland had the lowest species richness and diversity of all grasslands. *Pseudoraphis* grassland covered the greatest area of the floodplain followed by *Oryza*, *Brachiaria* and *Hymenachne* grasslands. The *Brachiaria* grassland was found to increase in area by 290 ha in the most heavily infested area over 5 years and a corresponding decrease in the *Oryza* grassland was found'.

'Sediment samples were found to have heterogeneously distributed samples'. 'In total 34 taxa emerged from the sediment samples'. 'The *Hymenachne* grassland samples contained 25 taxa, the *Oryza* grassland samples, 24 taxa, *Brachiaria* grassland samples, 21 taxa, and *Pseudoraphis* grassland samples, 13 taxa'. The taxa emerging from samples of the four

communities are listed in the report. 'Many aquatic taxa emerged from the sediments and low numbers of grass seeds germinated. Distinct differences in the seedbanks of each community were found. *Brachiaria* and *Hymenachne* grasslands contained more species rich seedbanks than the *Pseudoraphis* and *Oryza* grasslands. This was attributed to the growth form of the species that dominate the former communities. Species composition of the *Brachiaria* grassland seedbank was more similar to that of the *Oryza* grassland than other grasslands, indicating that the latter community is being invaded. Comparisons of seedbanks between 1984 and 1996 gave varying results, indicating that the seedbanks of these grasslands are dynamic. Differences in the proportions of individual species found to emerge in each year were attributed to differences in methodology between the studies and variation in rainfall in the years leading up to sample collection for each study as this factor effects seed production'.

'*Brachiaria mutica* was found to have the greatest potential seed production followed by *Hymenachne acutigluma*, *Pseudoraphis spinescens* and *Oryza meridionalis*. These differences may be due to growth forms and habit of these species. Seeds of *Hymenachne acutigluma* had the highest germinability compared to other species. No *Pseudoraphis spinescens* seeds germinated and this species had the lowest seed viability (tetrazolium test) of all species. *Oryza meridionalis* and *Brachiaria mutica* were both found to have low germinability but high viability indicating that these species have some seed dormancy mechanism. Seed counts from soil cores indicated that *Brachiaria mutica* contains a considerable seedbank in the sediments below the community in which it occurs. Hence, the eradication of *Brachiaria mutica* from the Magela floodplain may be impossible, therefore, it is suggested that management efforts should be directed toward restricting *Brachiaria mutica* to areas already invaded'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

A vegetation map of the Magela floodplain is provided in the report. *Melaleuca* open forest woodland is the dominant community in the vicinity of the confluence of Swift Creek with the Magela floodplain. The four grassland communities (*Brachiaria*, *Oryza*, *Hymenachne* and *Pseudoraphis* grasslands) are located nearby.

TITLE: Jabiluka flora.

AUTHOR(s): Lane A (Energy Resources of Australia Environmental Services Pty Ltd) October 1998.

PUBLICATION: In *The Jabiluka project. Final six monthly progress report to the Minister for Resources and Energy: Additional environmental studies. Report prepared for ERA Ranger Mine by ERA Environmental Services Pty Ltd*, appendix 1 [Incorporates Lane April 1998 (CR RAN 337)].

LOCATION: CR RAN 346 (Vol 1).

[Commercial-in-confidence: Contact ERA Ranger Mine for approval to use any information contained in the report. Tel: (08) 89381306 and Fax: (08) 89381203]

SUMMARY

'This report discusses the results of vegetation surveys of the Jabiluka lease that were conducted in December 1997 and February 1998. The aim of these surveys was to describe and map the vegetation of the lease, and to record the occurrence of any species of conservation significance and introduced species. This information, apart from a map of vegetation associations, was contained in the first six monthly report submitted in April 1998 (Lane 1998)'. 'Forty-eight sites were selected form aerial photographs and thoroughly described in terms of species and abundance'. Lifeform and structural data were also collected. 'Two hundred and sixty five species from 78 families were positively identified from the survey, including two species of conservation significance, 56 species that have not previously been recorded on the lease, and five introduced species'. A list of species and families recorded in the lease area is provided in the report.

'One of the species of conservation significance, *Distichostemon arnhemicus*, was recorded at four sites and the other, *Trianthema megasperma*, was recorded at five sites. The significant number of opportunistic recordings of these two rare species in a relatively small area indicates that the species may lose their conservation status as the number of surveys conducted in the region increases, especially if surveys occur during the Wet season when annual species are more conspicuous. 'Two of the five introduced species, *Brachiaria mutica* (para grass) and *Salvinia molesta* (salvinia) are major weeds of conservation. Control of these species is difficult and Parks Australia North in Kakadu National Park dedicate considerable resources towards their management'.

'Based on the structure of the dominant stratum, each site was categorised as a vegetation community. Field data were used to classify the vegetation on a digital image'. A vegetation map was produced identifying 14 associations which generally occur on lowland, dryland or escarpment areas. A list of species occurring within each of the vegetation communities is tabulated in the report. The lowland vegetation associations included *Allsoyncarpia ternata* closed forest; riparian woodland/open forest; *Melaleuca leucadendra* (paperbark swamp); *Eucalyptus alba* closed forest; *Corymbia arafurica* open forest; *Melaleuca nervosa* woodland/open forest; *Melaleuca viridiflora* open forest; mixed woodland. *Eucalyptus tetrodonata* woodland/open forest; *Eucalyptus miniata* woodland; *Corymbia kombolgiensis* woodland; *Eucalyptus* mixed woodland; mixed open woodland; and closed grasslands are all

dryland associations. The two escarpment associations are *Corymbia bleeseri* woodland and mixed open woodland. 'Mixed woodland is described for its occurrence in each of lowland, dryland and escarpment areas'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

The data on the flora of the Jabiluka lease area are relevant to the Swift Creek system as part of this system falls within the lease area. Furthermore, several of the survey sites used were in proximity to Swift Creek.

TITLE: The ecology of the vegetation of the Magela Creek floodplain: upper section from Oenpelli road crossing to Nankeeen Billabong.

AUTHOR(s): Sanderson NT, Koontz DV & Morley AW 1983.

PUBLICATION: In *Environmental protection in the Alligator Rivers Region: A scientific workshop.* Vol 1, Jabiru 17-20 May 1983, Supervising Scientist for the Alligator Rivers Region, 33.1-33.9. Unpublished paper.

LOCATION: CR SSAR 010 (Vol 1).

SUMMARY

'This paper outlines some important aspects of the seasonal cycle of vegetation on the [Magela Creek floodplain] and summarises some of the early work on the classification of the aquatic vegetation on the floodplain'. 'A field study was conducted in April, 1981 at the end of the Wet season, to sample the herbaceous vegetation of the flooded Magela Creek study area and produce a classification based on floristic and physical characteristics'. A total of 165 random and transect sites were sampled between the out-flow of Mudginberri Billabong and the mid-section of Nankeen Billabong. A total of 35 vegetation types were identified; this classification 'was considered too detailed and not reproducible in subsequent Wet seasons' Using the same analysis a broader classification with fewer categories was produced. The resultant classification distinguished 10 vegetation types, which are mapped and described in the paper. The 10 plant communities are: *Najas-Nymphaea Pseudoraphis* herbland; *Pseudoraphis* grassland; *Eleocharis Pseudoraphis* sedgeland; *Oryza-Hygrochloa* grassland; fast flow *Blyxa herbland*; fringing closed *Hygrochloa-Nymphoides*; mixed herbland; *Hygrochloa* grassland; fringing *Najas-Blyxa* herbland; and deep water community.

'In April 1982, a field program, was undertaken to gather biomass data representative of the standing crops of each of the broad vegetation types'. 'The floodplain is a highly productive system during the Wet season inundation phase as evidenced by the massive standing crop estimates. The emergent aquatic grasses are the major primary producers of the system'. 'The perennial aquatic grass was the dominant species in about 70% of the floodplain area and made up 60-70% of the total biomass estimated for the same area'. 'The annual aquatic herbs, though relatively a diverse flora, are only a minor portion of the total standing crop'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

The broad vegetation communities identified in the Magela Creek floodplain study area are presented in a vegetation map in the report. The confluence point between Swift Creek and the Magela plain is shown and is characterised by *Pseudoraphis* grassland.

TITLE: Vegetation of the Adelaide-Alligator area.

AUTHOR(s): Story R 1969.

PUBLICATION: In *Lands of the Adelaide-Alligator area, Northern Territory*. Land research series No. 25, Commonwealth Scientific Research and Industrial Organisation, Australia.

LOCATION: 333.730994295 LAN.

SUMMARY

This study describes the vegetation of the Adelaide-Alligator area, including the Magela Creek system. The vegetation survey was conducted as part of a wider study assessing the land systems, soils, erosion, geology, geomorphology and climate of the region. The aim of the survey was to delineate and describe the different vegetation communities present in the area. Fifteen vegetation types were identified and described in detail: tall open forest, woodland, stunted woodland, mixed scrub, *Pandanus* scrub, Leguminous-Myrtaceous scrub, paperbark forest, mangrove scrub, rain forest, semi-deciduous forest, savannah, grassland, sedgeland, herbaceous swamp vegetation and Samphire-*Arthrocnemum* dominant. The vegetation communities are discussed in relation to their land system relationships. The dominant communities in the vicinity of the Magela Creek floodplain were grasslands, sedgelands, and herbaceous swamp vegetation.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

This report describes the vegetation of the Adelaide-Alligator area which includes the Swift Creek system.

TITLE: Vegetation and stream pattern as indicators of water movement on the Magela Floodplain, Northern Territory.

AUTHOR(s): Williams AR 1979.

PUBLICATION: *Australian Journal of Ecology* 4, 239-247.

LOCATION: ARRI File 0772.

SUMMARY

The purpose of this paper was to 'interpret the vegetation and stream patterns in terms of water flow and thereby construct a conceptual model for research and management of the [Magela floodplain]'. One step towards achieving this objective was to describe the vegetation of the floodplain. Six vegetation types were delineated from photointerpretation and ground surveys conducted during October 1975 and January-August 1976. The six types are mixed herbfield, grassland, undulating annual swamp and grassland, forest, annual swamp and perennial swamp. Descriptions of the communities and their distributions are given in the paper. The remainder of the paper discusses the stream pattern of Magela Creek, rainfall and flood observations, and the vegetation units as indicator of water depth on the floodplain.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

A map of the vegetation types on the Magela floodplain is provided in the report. This shows the area where Swift Creek joins the floodplain. The vegetation in this region is classified as 'forest'.

TITLE: Changes in the *Melaleuca* forest density on the Magela floodplain, Northern Territory, between 1950 and 1975.

AUTHOR(s): Williams AR 1984.

PUBLICATION: *Australian Journal of Ecology* 9, 199-202.

LOCATION: ARRI File 0306.

SUMMARY

'The stability of the Magela floodplain prior to the development of uranium mining at Ranger, in the Magela catchment, was estimated by comparing aerial photographs taken in 1950 and 1975, using the density of *Melaleuca* swamp forest as an index of change'. 'The photographs were examined stereoscopically and the floodplain was stratified into areas with reasonably homogeneous tree cover in either 1950 or 1975'. 'The 1975 photographs were interpreted in the light of a ground survey carried out in the Dry season of 1976'. Estimates of tree density within each stratum were made on a five-point scale and used as the index of change over the 25 year period. A map is provided in the report showing the strata boundaries on the floodplain and the tree density within each one for 1975.

'There was no increase in the area occupied by *Melaleuca* trees, indicating that infilling of perennial swamp and plant succession were not significant agents of change in this period. Thirty-eight percent of the forested area suffered a significant decrease in tree density: fire, wind and buffalo are among the probable causes, and these hazards should be taken into account in monitoring the effects of the uranium mining'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

The confluence of Swift Creek with the Magela floodplain is shown as having a *Melaleuca* tree density of between 151-1100 km^{-2} in 1975. In order to determine changes in tree density in the Swift Creek system similar photointerpretation of this area is needed.

ALGAE

TITLE: *Diatom flora of Australia. Report 1. Freshwater diatoms of the Northern Territory, especially in the Magela Creek System.*

AUTHOR(s): Brady HE (ed) 1979.

PUBLICATION: School of Biological Sciences, Macquarie University, Sydney. Unpublished paper.

LOCATION: 589.481 MAC.

SUMMARY

This report summarises an initial taxonomic survey of the diatom flora of the Magela system and contrasts the local flora with those from other sites to the south of Darwin. Samples were collected from Jabiluka, Mine Valley, Ja Ja and Island billabongs on the Magela floodplain, and from Howard Springs, Elizabeth River, Darwin River and Tumbling Waters, in August 1978 and in June 1979. Samples were taken from water grasses, aquatic macrophytes, rock scrapings, dead leaves, floating green algae, *Pandanus* stems and bottom sediment. The report describes each taxa and its distribution. A plate of each taxon is also provided in the report.

The significant feature of the Magela Creek diatom communities is that the populations reflect a predominantly acidic environment. The billabongs sampled had a pH between 4.4 to 6.8. In contrast, the waterbodies sampled from the Darwin and Elizabeth Rivers had a pH ranging from 6.75 to 8.6. 'The distribution at species level is so affected by pH that the Elizabeth River populations were inversely distributed to those of the Magela system'. Two general floral types have been identified and described that appear to define the waters in the Magela system (at least during the Dry season when the water is not flowing). These are the *Eunotia-Frustulia* flora and the *Gomphonema-Eunotia-Frustulia* flora. A floral definition of the communities outside the Magela system has not been completed. The diatom community distribution in the Magela billabongs not only reflects the pH of the system, but also the available nutrient and light levels.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Jabiluka and Nankeen billabongs were two of the billabongs sampled for diatom flora. They are located near the junction between Swift Creek and the Magela floodplain, making the taxa list for these two billabongs relevant to Swift Creek.

TITLE: *A preliminary investigation of the cyanobacteria (blue-green algae) of the Magela Creek System and nearby sites, Northern Territory.*

AUTHOR(s): Broady PA 1984.

PUBLICATION: School of Botany, University of Melbourne, Parkville, Victoria. Unpublished paper.

LOCATION: DS IDN 4371.

SUMMARY

'The primary aim of this investigation was to assess the diversity and abundance of cyanobacteria in aquatic and non-aquatic habitats in the billabongs and on the floodplains of the Magela Creek system. Sampling was also extended to the sandstone outcrops of outliers of the Arnhem Land escarpment'. The study was undertaken in the Dry season from 4-11 August 1984. Samples were collected from 7 billabongs and springs in the Magela system, from 7 sites on the floodplain from the desiccated soils, and from 5 sites on the sides and summit of the escarpment outlier, to the immediate north-east of Ja Ja Billabong. The cyanobacteria found at the various study sites are listed and described in the report. 'An appendix provides brief notes on algae from other divisions which are additional to those reported previously' in Ling & Tyler (1986).

'Cyanobacteria are abundant and widespread in the Magela Creek system and adjacent areas'. Significant populations occur in habitats where water is present for the duration of the year, but are also predominant 'in habitats which become highly desiccated during the dry season i.e. floodplain soils and sandstone rock outcrops'. There is considerable scope for more detailed analysis of the role of these algae. Detailed floristic and taxonomic surveys are needed. Spatial distribution patterns and seasonal fluctuations in abundance, as a result of water quality changes, also require investigation.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Billabong samples were not taken in the vicinity of the confluence between Swift Creek and the Magela floodplain, thus the data are not applicable to the Swift Creek system. The sites used to sample the desiccated floodplain soils are not specified in the report, so it is not possible to assess their relevance.

TITLE: *Phytoplankton populations of the Magela Creek system, Alligator Rivers Region, Northern Territory (final report).*

AUTHOR(s): Kessell JA & Tyler PA 1982.

PUBLICATION: Open file record 18, Supervising Scientist for the Alligator Rivers Region, Canberra/Darwin. Unpublished paper.

LOCATION: SERIES SSAR OFR 18.

SUMMARY

'The aim of this study was to explore the nature of phytoplankton communities of the Magela System, and to give preliminary indication of their suitability as biological monitoring systems'. Five sites were surveyed in 1980; Mudginberri, Jabiluka, Island and Leichhardt billabongs and Retention Pond No.1. Samples for the examination of the species composition were collected by towing a plankton net though the water. An index of similarity was calculated to determine the similarity between two samples. 'Temporal and spatial heterogeneity of plankton populations was also measured in the *in vivo* fluorescence of chlorophyll'. The species present at each of the sites on each of the sampling days are tabulated in the report and ranked as dominant, common or present.

Over 500 taxa of freshwater are known to occur in the Alligator Rivers Region. 'The first obvious feature of the phytoplankton of the Magela system is that it is diverse. On every occasion sampled, 80-100 species were recorded from the billabongs'. 'Passively-floating desmids and Chlorococcales, and motile flagellates are major components'. 'The other prominent feature of the plankton populations of the Magela system is their variability and dynamic nature'. 'Species composition varies greatly from hour to hour and from site to site in any one billabong, with low (<50%) indices of similarity between successive samples. The distribution of chlorophyll in the water column varies greatly in space and time, over short distances and times'.

'The taxonomic difficulties of a rich flora, the heterogeneity of the plankton, and above all its dynamism pose many problems for development of a monitoring program using algae to detect low-level metal pollution'. As the plankton are a major contributor to the food web of the billabongs they require close examination in any surveillance scheme.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Jabiluka Billabong is located in the vicinity of the junction between Swift Creek and the Magela floodplain, thus the data on the phytoplankton population of this billabong are directly relevant to any further analyses in this area.

TITLE: *A limnological survey of the Alligator Rivers Region. II. Freshwater algae, exclusive of diatoms.*

AUTHOR(s): Ling HU & Tyler PA 1986.

PUBLICATION: Research report 3, Vol 2 Supervising Scientist for the Alligator Rivers Region, AGPS, Canberra.

LOCATION: SERIES SSAR RR 3 (Vol 2).

SUMMARY

'The aim of this study was to provide a means of ready identification for most of the bewildering array of freshwater algae, exclusive of the diatoms, encountered in large numbers in the waterholes of the Magela Creek system and its near neighbours'. Twenty-two sample sites were used in the Magela Creek catchment, predominantly in the billabongs. Sites outside the Magela Creek catchment included the Nourlangie system and elsewhere in the Alligator Rivers Region. Samples were taken with a plankton net, by squeezing macrophytes, or scraping rocks, soil, buoys and sticks.

Twelve hundred samples were collected, of which 70 from 35 locations were intensively studied. From the samples 'over 530 taxa were recorded, mostly desmids, of which 66 either are new to science or cannot be identified'. 'About 360 taxa not previously recorded were encountered'. Each taxon is described and its distribution in general, and within the study area, is provided. Figures of each taxon are also presented in the report. 'Some new species, though illustrated and described, require formal taxonomic description'.

The study shows that 'the billabongs of the Alligator Rivers Region contain a rich and diverse algal flora which shows strong affinities with that of tropical South-East Asia and the Indian subcontinent'. 'Researchers designing a monitoring program, or carrying out ecological studies of the aquatic ecosystem of the Magela, will have frequent contact with this rich and diverse microflora. This paper should remove a major taxonomic hurdle from their path'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Jabiluka and Nankeen billabongs were two of the billabongs sampled for algal flora. They are located near the junction between Swift Creek and the Magela floodplain, making the taxa list for these two billabongs directly relevant to ecological investigation in this area.

TITLE: *Diatom communities of the Mudginberri Corridor, Northern Territory, Australia: Their structure, annual succession, and responses to environmental change.*

AUTHOR(s): McBride P 1983a.

PUBLICATION: PhD thesis, Macquarie University, Sydney [Incorporates McBride 1983b, CR SSAR 010 Vol 1].

LOCATION: 579.85 MCB.

SUMMARY

This study examined the diatoms of the Magela Creek floodplain. Quantitative sampling was undertaken to describe the principal floristic and physical characteristics of the diatom communities. Ordination analyses were used to determine patterns in the fluctuating populations and 'to attempt to relate particular diatom associations to the physico-chemical parameters of the water'. The suitability of diatoms to measure impacts of uranium mining on the water quality of Magela Creek was also assessed.

Six billabongs (Island, Jabiluka, Ja Ja, Leichhardt, Mine Valley and Winmurra billabongs) located in the Mudginberri Corridor of Magela Creek were sampled. Due to insufficient samples, population data for Mine Valley and Winmurra billabongs were not included in the statistical analyses. Monthly sampling was undertaken between May 1980 and July 1982, using a floating sampler called a diatometer, which was placed in each waterhole for a period of 3 weeks. The sample processing, slide preparation and population counting techniques are described in the report. 'A series of experiments [were conducted] in which diatometers were enclosed within floating tanks or plastic bags in Ja Ja Billabong, to ascertain the effects of increased concentrations of heavy metals and nutrients on the diatom communities'. 'Comprehensive data for both physical and chemical water parameters were available for most billabongs in the Mudginberri corridor as a product of routine environmental monitoring by mining companies and government bodies'.

'Luxuriant macrophyte growth during the Wet season supported very large diatom populations, estimated at 170 g/m^2. A common regional diatom flora adapted to low pH conditions inhabited the billabongs of the mid section of Magela Creek. A total of 54 diatom taxa were identified. Descriptions and photomicrographs of the taxa are provided in the report. 'This flora was characterised by a low species diversity, where 20 taxa comprised 96.7% of the total numbers, and a strong and regular seasonal pattern. The acidophilic genus *Eunotia* dominated the diatom assemblage'. The relative abundances of the 20 principal diatom taxa are presented in the paper. These taxa all belong to the Biraphidae family. 'The flora of the Mudginberri corridor is remarkable for what is rare and absent as well as for the dominant position of *Eunotia* species', which is normally predominant only in acid bogs. 'In the 150 000 or so frustules counted there were no observed occurrences of the genera: *Achnanthes, Amphora, Fragilaria, Hantzshia, Synedra*; and very few occurrences of *Cocconeis* and *Cyclotella*'.

'Comparison of the ordination axes of the monthly diatometer samples with the physico-chemical water parameters suggested that as well as the seasonal cycle, pH, alkalinity, and the concentrations of total organic carbon affected the diatom populations. The silica budget in Magela Creek indicated that extensive recycling of diatomaceous silica must take place. Phosphorus levels appeared to limit the growth of green algae suggesting that eutrification due to pollution would seriously alter the floodplain microflora and produce major changes in both the algal and macrophyte populations'. 'Heavy metals reduced the community numbers without significantly altering the species profile'. Hence, 'it was concluded that diatoms could effectively monitor eutrification effects in the region whereas their use as indicators of heavy metal pollution could be limited'.

The diatometers used were found to 'provide a practical and precise means of surveillance of these diatom communities and the possible effects of increased nutrient and heavy metal loads can be successfully studied by enclosing the diatometers within tanks in the billabongs'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Jabiluka Billabong which is located in the vicinity of the junction between Swift Creek and the Magela floodplain was surveyed. The abundance data of the 20 principle taxa for Jabiluka Billabong are relevant; however a complete list of all the species present in this billabong is not given.

TITLE: *A limnological survey of the Alligator Rivers region, Northern Territory. I. Diatoms (bacillariophyceae) of the region.*

AUTHOR(s): Thomas DP 1983.

PUBLICATION: Research report 3, Vol 1, Supervising Scientist for the Alligator Rivers Region, AGPS, Canberra.

LOCATION: SERIES SSAR RR 3 (Vol 1).

SUMMARY

This survey was conducted as part of a study of the algae of the Alligator Rivers Region, and of the Magela Creek system in particular. The study formed part of 'an investigation into the possible use of native algae as an indicator of any changes in water quality, which might occur as a result of uranium mining and milling in the Region'. 'This report deals only with the diatoms (Bacillariophyceae) found in the Alligator Rivers Region, though that flora is compared with the diatom flora of samples from other parts of tropical Australia to give some degree of regional perspective'.

The survey was conducted between 1978-1980. Fourteen sample sites were used in the Magela Creek catchment, predominantly in the billabongs. Sites outside the Magela Creek catchment 'included billabongs on Nourlangie Creek, sites associated with the lower East Alligator River including the Magela outflow and mostly single sample sets from diverse sites across tropical Australia'. Samples were collected using mesh plankton nets and a variation of the diatometer method, involving plastic strips suspended from the ropes of permanent buoys. The results are 'based on the examination of approximately one-third (477 samples) of the total number of samples collected during this study'. 'A full account of the sampling and specimen preparation methodology is included, together with a key to the genera'. Each taxon observed in the study is described and its distribution in general, and within the study area, is provided. Plates of each taxon are also presented in the report.

'The diatom flora so far observed numbers more than 160 taxa from 32 genera and contains representatives of both tropical and cosmopolitan distributions. Only two taxa are apparently new to science, though many more have been seen, though rarely, beyond the location in which they were originally collected'. The distribution of the taxa within the Magela Creek catchment is provided in the report. It appears there are taxa predominantly restricted to the escarpment, others to the plains and the floodplains and then a group where the bulk of taxa have no specific distributional pattern. There was a 'marked temporal variation in water quality between the end of the Wet season and the end of the Dry season. The effect of this variation on the diatom flora seems to vary from minimal in the escarpment pools to maximal in the floodplain billabongs'.

'The diatom flora of the Alligator Rivers Region is a very rich one by temperate and tropical freshwater standards, probably because of the very diverse nature of the environment'. The complexity of the flora makes it difficult to use in a water quality monitoring program.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Jabiluka and Nankeen billabongs were two of the billabongs sampled for diatom flora. They are located near the junction between Swift Creek and the Magela floodplain, making the taxa list for these two billabongs directly relevant to Swift Creek and nearby floodplain areas.

TITLE: Algal populations and phytoplanktonic productivity in billabongs of the Alligator Rivers Region

AUTHOR(s): Walker TD & Tyler PA 1983.

PUBLICATION: In *Environmental protection in the Alligator Rivers Region: A scientific workshop.* Vol 1, Jabiru 17-20 May 1983, Supervising Scientist for the Alligator Rivers Region, 30.1-30.9. Unpublished paper.

LOCATION: CR SSAR 010 (Vol 1).

SUMMARY

'The aim of this study was to provide a means of ready identification for most of the freshwater algae encountered in large numbers in the waterholes of the Magela Creek system and its near neighbours'. The study also aimed 'to determine natural fluctuations, seasonal or sporadic, in the structure and density of the population, and to quantify their productivity as an indication of the trophic potential of waterholes'. Ten billabongs were sampled during 1980; Bowerbird, Gulungul, Georgetown, Goanna, Mudginberri, Island, Ja Ja, Leichhardt, Jabiluka and Red Lilly billabongs. Taxonomy was determined using light and electron microscopy, and counting and chlorophyll estimation were used to measure fluctuations in population structure and density. Turbidity, the underwater light climate and nutrient concentrations were also measured. The results discussed in this paper are based on data extracted from six other detailed reports, which are referenced in the paper.

'The billabongs of the Alligator Rivers Region contain a rich and diverse plankton flora heterogeneously distributed in space and time'. A total of 700 taxa of freshwater algae from the billabongs were described and illustrated elsewhere in reports by Ling & Tyler (1983) and Thomas (1983). The diversity and heterogeneity make characterisation of the natural community structure difficult. Phytoplankton productivity in the billabongs is seasonal. 'During the Wet, the high flushing rate and consequent export of phytoplankton results in low levels of productivity. During the Dry, productivity increases, but to what extent depends entirely on the individual characteristics of the billabongs in regard to turbidity, underwater light climate and nutrient chemistry'. Comparison of productivity levels of the Magela Creek billabongs with billabongs elsewhere in the world indicated that levels are moderate for the tropics, but high in comparison with temperate lakes. 'Production may be held in check by limitation of available solar radiation by heavy tripton loads'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

The paper is essentially a review paper. The other studies that the data were extracted from need to be examined, in particular the taxonomic studies, for a record of phytoplankton taxa and productivity levels in each of the billabongs. As Jabiluka billabong is located near the confluence of Swift Creek and the Magela floodplain, the data collected for this billabong would be directly relevant to Swift Creek and nearby floodplain areas.

FISH

TITLE: Seasonal changes in composition and density of littoral fish populations in Corndorl Billabong (Magela Creek).

AUTHOR(s): Baker L, Clay D, Bailey B & Walden D 1983.

PUBLICATION: In *Environmental protection in the Alligator Rivers Region: A scientific workshop.* Vol 1, Jabiru 17-20 May 1983, Supervising Scientist for the Alligator Rivers Region, 38.1-38.9. Unpublished paper.

LOCATION: CR SSAR 010 (Vol 1).

SUMMARY

Littoral fish populations were studied in a backflow billabong of the Magela Creek system. The fish population of Corndorl Billabong was sampled from September 1981 to November 1982 using a biodegradable icthyocide, 'Rotenone'. Sample areas were defined by quadrats which were placed along transect lines. 'At the time of writing, analysis of the data had not commenced'. However, data from samples taken at one site on Transect 2 have been analysed and are presented in the report.

Ten species of fish plus frogs and one-gilled eels were collected; the fish species were classified as either planktonivorous or piscivorous according to their prey items. 'The planktonivorous fish (perchlet, penny fish, checkered rainbow fish, fly-speckled hardyhead, blue-eyes and eeltail catfish) were present in much larger numbers than the piscivorous fish (purple spotted gudgeon, spangled grunter, mouth almighty and sleepy cod), which conforms to the normal pattern of predator-prey relationships' 'Fish numbers followed a seasonal pattern with the highest occurring in the early Dry season (April to July). The lowest numbers occurred in the early Wet season after rising floodwaters diluted the depleted population, before spawning had commenced'. The dominant macrophyte communities present at the time of sampling are given in the paper; these also varied seasonally. The authors state that 'further analysis will provide information on the ecological significance and seasonality of the littoral fish population. Combination of this knowledge with information on the aquatic macrophyte communities and the pelagic fish populations (i.e. the larger the fish in the open-water billabongs), will eventually lead to a greater understanding of floodplain ecology and help anticipate the effects of possible contaminants on the system'. The macrophyte data were later included in a report by Finlayson et al (1989) on the macrophytic vegetation of the Magela floodplain.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Corndorl Billabong is located well upstream of the confluence between Swift Creek and the Magela floodplain, thus the data on littoral fish populations cannot be applied to the fish populations of Swift Creek. Further, the macrophyte billabong habitats differ greatly from the sandy channels of Swift Creek.

TITLE: *Dynamics of the freshwater fish communities of the Alligator Rivers Region, tropical Northern Australia.*

AUTHOR(s): Bishop KA 1987.

PUBLICATION: PhD thesis, Macquarie University, Sydney. Unpublished paper.

LOCATION: NS, DS IDN 4320.

SUMMARY

'This thesis presents a selection of interrelated studies on the dynamics of freshwater fish communities in the Alligator Rivers Region, tropical Northern Australia. These studies represent an initial preparation for the development of surveillance techniques which are intended to detect responses by fish communities to environmental change arising from mining operations which recently commenced within the lowlands of the Region'. The thesis is divided into three parts – the contents of each section are outlined below.

Part 1.

'The first part of this thesis is an examination of inter-seasonal and inter-habitat patterns in community data and associated environmental data collected during an extensive survey in 1978 and 1979'. The data were collected by Bishop et al (1986), as part of their report on the ecological studies on the freshwater fish of the Alligator Rivers Region. Only data from 22 sites sampled seasonally, using gillnets, were examined. Four of the sites were located in the Nourlangie Creek system, the remainder were located in the Magela Creek system. Sampling was undertaken in the following five seasons; 1978 Late-dry, 1978 Early-wet, 1979 Mid-wet, 1979 Late-wet-Early-dry and 1979 Mid dry. The sampling sites were chosen to represent five habitat types which were: escarpment mainchannel waterbodies; lowland backflow billabongs; lowland sandy creek; corridor waterbodies; and floodplain billabongs. Twenty-species of fish were collected and are listed in the thesis, along with their abundances in the different habitats and at various intervals during the sampling period. This section of the thesis 'characterises major physiographic gradients and patterns in changing environmental conditions in sampled waterbodies'. Patterns in the compositional structure of communities were determined and a biological interpretation and validation of the identified structure patterns is provided. In addition, patterns in the numerical structure of communities were identified and discussed.

Part 2.

'Year-to year patterns in the compositional structure of fish communities sampled in the lowland habitats of Magela Creek between 1978 and 1986 [were] characterised' in this section. Samples were collected 5 times a year from 10 Magela Creek billabongs; Fishless, Georgetown, Djalkmara, Indium, Coonjimba, Goanna, Gulungul and Corndorl billabongs. A total of 21 fish species were recorded and are listed in the report. The species list was very similar to the list resulting from the 1978-79 gillnet survey. Interpretations of any evident patterns were 'made using physical and chemical, habitat-structural and hydrological data collected in line with the community data'. 'Emphasis [was] placed upon determining whether any components of the year-to-year patterns were attributable to uranium mining operations which commenced in the lowlands during the study period'.

Part 3.

'Movement patterns of five fish species in the lowland creek habitat of Magela Creek during the 1985 Wet season [were] examined' in this section. 'Emphasis is placed upon determining whether any components of the patterns were attributable to the release of complex waste-waters from Retention Pond Four (RP4) of the Ranger Uranium Mine during the season'. "This part related to the previous parts in that it examined a major 'mechanism' by which fish community structures were altered in the Region". Monitoring of movement patterns and rates was achieved through creekside observation at two sites on the western channel of Magela Creek, in the vicinity of the pipe-outlet discharging waste water. During a one hour monitoring period at midday the number of fish moving upstream or downstream was recorded. Monitoring was timed to coincide with RP4 water releases. A total of 22 species were observed during the study period, which are listed in the thesis. The species list varied slightly from the 1978-1979 gillnet survey, recording 7 different species. "In line with considerations concerning the relative tolerances of fluviatile and non-fluviatile species to 'poor' water quality, results indicated that a fluviatile species avoided, and a non-fluviatile species was attracted to the plume of waste-waters in the creek".

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Two of the sites used to collect data for Part 1 of the study, Jabiluka and Nankeen billabongs, are located on the Magela Creek floodplain. These two billabongs are located in the vicinity of the confluence between the Swift Creek system and the floodplain, making the list of fish species recorded at these sites directly relevant. The sites surveyed in the other two parts of the study were located upstream of the confluence point.

TITLE: *Further ecological studies (I) on the freshwater fishes of the Alligator Rivers Region (final report).*

AUTHOR(s): Bishop KA & Harland WG 1992.

PUBLICATION: Open file record 34, Supervising Scientist for the Alligator Rivers Region, Canberra/Darwin. Unpublished paper.

LOCATION: SERIES SSAR OFR 34.

SUMMARY

This study continues on from surveys completed by Bishop et al (1986, 1990, in press) on the freshwater fishes of the Alligator Rivers Region between August 1978 and December 1979. The aim of the study was to design an environmental monitoring program to detect impacts from uranium mining and other development on the fish fauna of the Region.

The first objective of the study was 'to provide information on annual variability in the ecological characteristics of fish communities'. Fish were collected during five seasons (Late-dry, Early-wet, Mid-wet, Late-wet/Early-dry and Mid-dry) using multiple mesh-sized monofilament gillnets and a seine net. Ten sites were sampled adjacent to the Ranger project area. These were Magela bed; Gulungul downstream; Indium and Goanna billabongs (muddy channel lagoons); Fishless, Georgetown, Djalkmara, Coonjimba, Gulungul and Corndorl billabongs (muddy shallow lagoons). Descriptions of the fish communities occurring at the sites during the study period are given in the report. The numbers and abundances of the fish species are provided. Similarly, seasonal abundance, biomass, number of species, richness and Shannon diversity, and evenness indices are tabulated in the report. Highest annual variability in community structure, total abundance and biomass, occurred in the Late-dry and Early-wet seasons, and was most prevalent in shallow muddy lagoons. Annual variability was least evident in the communities of the channel muddy lagoons, and was at its lowest between the end of the Wet season and the Mid-dry season.

A second objective of the study was 'to examine the selection and recognition of microhabitats by fish'. This information will facilitate identification of the importance of various microhabitats to fish communities, and will also enable prediction of community structure at given locations and seasons for use in monitoring programs. In the 1980-81 Late-wet/Early-dry season (June) 'twelve sites were examined to represent 8 habitat types: Bowerbird (escarpment mainchannel waterbody); Radon and Baroalba Springs (escarpment perennial streams); Magela-bed (sandy lowland creekbed); Djalkmara, Georgetown, Corndorl floodplain and mouth (shallow muddy lowland lagoons); Mudginberri (sandy corridor lagoon); Island (transitional corridor/floodplain lagoon); and Jabiluka (floodplain lagoon)'. For each species recorded in the study area, its associated physico-chemical and habitat-structural parameters are given in the report.

'Many fish species showed distinct preferences to a range of habitat-structural (particularly bank incline, substrate and bank cover type) and to a lesser extent physico-chemical parameters (particularly maximum depth and visibility). Many of these parameters interact to

form complex sets of factors which control fish distribution and abundance'. 'Fish diversity increased as the number of microhabitats available increased at sites. It appears that 'predictions may be made as to which species would be expected to occur in particular microhabitats within the examined sites', which is necessary for any monitoring program aiming to detect impacts from industrial operations in the region. 'The remainder of this section details some possible mechanisms and further analyses and information which are required'.

The rest of the study encompasses two main objectives. First to examine spatial variations in fish communities due to migration in the Gulungul and Magela creek systems during the Wet season. A list of species at each of the sampling sites on each sampling occasion is given in the report. Second 'to describe fish communities which have become established in man-made ponds in the Ranger Uranium lease area'. A list of the fish species collected during the study period is provided in the report, along with details of the fish stomach contents. The final section of the report reviews the all of the surveys described above and recommends 'fish species or communities and areas of the creek system, which should be included in the monitoring programs'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

The sites used to sample the fish communities within the study area are all located upstream of the confluence of Swift Creek with the Magela floodplain. As a result the data cannot be applied to the fish communities of Swift Creek; although, the concepts pertaining to seasonal changes in fish community structure and recognition of microhabitats by fish may apply to the Swift Creek communities. This would require further studies to confirm.

TITLE: *Ecological studies on the freshwater fishes of the Alligator Rivers Region Northern Territory. Vol I. Outline of the study, summary, conclusions and recommendations.*

AUTHOR(s): Bishop KA, Allen SA, Pollard DA & Cook MG 1986.

PUBLICATION: Research report 4, Vol 1, Supervising Scientist for the Alligator Rivers Region, AGPS, Canberra [Incorporates Bishop et al 1980 (OFR 23)].

LOCATION: SERIES SSAR RR 4 (Vol 1).

SUMMARY

The present study 'aimed at developing an ecological monitoring system that would detect changes in freshwater fish communities brought about by recent uranium mining and processing in the lowlands of the [Alligator Rivers Region]. The broad objectives were:

1. to describe fish community structure at sites from a longitudinal array of habitats and show the seasonal changes in structure;
2. to collect environmental and biological information on the fish species and study sites for use in interpreting changes in community structure; and
3. to advise on the best practicable approach for detecting, predicting and minimising adverse effects on the Region's fish fauna due to uranium mining and processing operations'.

The results of the study are presented in three volumes. An overview of Volume I is presented in this summary. This volume describes the field and laboratory procedures in detail, and provides a brief overview of the study's findings and general conclusions. A brief overview of earlier ichthyological studies in the Alligator Rivers Region is given. A total of 59 species, 50 of which are freshwater, have been previously recorded in the Region. A list of these species is given in the report. The study area is described in terms of its geographical position and physiography and aquatic habitat types. Eight zones were identified in the region and each one was sampled. These zones included: plateau, escarpment (interface zone), lowlands, corridor (interface zone), upper floodplains, lower (riverine) floodplains, estuarine upper reach areas and estuarine middle and lower reach areas. The habitats within each zone are described in detail and aquatic habitat subdivisions are also discussed. The seasonal climatic cycle and artificial changes to the environment as a result of uranium mining are also briefly outlined.

The study was conducted between August 1978 and December 1979 and fish were collected during eight sampling periods. 'These regular sampling periods were timed to coincide with periods of maximum biological activity, based on the Wet-Dry seasonal cycle of events rather than on a fixed time interval approach'. The fish fauna was sampled at sites in the East Alligator River, Cooper Creek, Magela Creek and Nourlangie Creek systems. The Magela Creek system was intensively sampled due to its proximity to the Ranger Uranium Mine. The sampling sites were chosen to represent the above habitat types. Lists of all the sites sampled regularly and occasionally are given in the report. At each of the sampling sites habitat-structural and physico-chemical variables were described for the immediate fishing area. The

general environment of the whole waterbody was also recorded. A range of collecting and observation methods were used to sample fish including seine nets, gill nets, dipnets, spears, lines, a cast net, poisoning, natural fish kills and underwater observations.

'Distinctive fish communities were present in the upper reaches of the Arnhem Land escarpment and the lower reach floodplain zones. These zones were major Dry season refuge habitats for fish. Distinctiveness was most likely the result of the substrate preferences (including aquatic plants) of some species and allowed recognition of migrations of fish between the escarpment and floodplains as Wet season flows across the lowlands linked the zones. The community structure of lowland habitats in the Wet season showed a flux between the community structures of the two Dry season refuges. In the Wet season the lowlands were very important breeding and feeding areas. Fish movement in the ARR appeared to be a classic response to temporal and spatial patchiness of resources'. Recommendations are made regarding future studies on spatial and temporal patterns in fish community structure and approaches for minimising detrimental impacts to the fish fauna, as a result of uranium mining in the Region. Also fish species suitable for toxicity experiments are identified and discussed.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Fish were sampled at Nankeen and Jabiluka billabongs, which are located near the confluence of Swift creek with the Magela floodplain. Numbers and weights of fish species captured in the billabongs are provided in Volume II of the study.

TITLE: *Ecological studies on the freshwater fishes of the Alligator Rivers Region, Northern Territory. Vol II. Synecology.*

AUTHOR(s): Bishop KA, Allen SA, Pollard DA & Cook MG 1990.

PUBLICATION: Research report 4, Vol 2, Supervising Scientist for the Alligator Rivers Region, AGPS, Canberra [Incorporates Bishop et al 1980 (OFR 23)].

LOCATION: SERIES SSAR RR 4 (Vol 2).

SUMMARY

This study carried out from August 1978 to December 1979 was 'aimed at developing an ecological monitoring system that would detect any changes brought about by recent uranium mining and processing in the lowlands of the [Alligator Rivers Region]'. 'The key to this development, and the focus of the synecological studies, was a description of spatial and temporal patterns in the community structure of the fish fauna. Interpretation of these patterns was made possible by the collection of detailed environmental data from the study sites'. The results of the study are presented in three volumes. This summary overviews the results of the synecological studies presented in Volume II.

Expected environmental changes as a result of uranium mining, and the role of fish in biological monitoring, are briefly discussed. The fish fauna was sampled at sites in the East Alligator River, Cooper Creek, Magela Creek and Nourlangie Creek systems. The Magela Creek system was sampled intensively due to its proximity to the Ranger Uranium Mine. The sampling sites were chosen to represent plateau, escarpment, lowland, corridor, upper floodplain billabong, lower (riverine) floodplain billabong and artificial habitats. Number of species, total abundance and total weight were recorded for each sample. 'The concepts and related indices of richness, evenness and heterogeneity [were] used as a measure of species diversity'. Multivariate analyses were used to identify patterns in the community data.

During the study 166 freshwater samples were taken, yielding 29 254 fish of 35 species in 16 families. The numbers, weights and size ranges of the fish species, corresponding diversity indices, as well as habitat-structural and physico-chemical variables are tabulated in the report. Each habitat type is discussed in terms of its environment and the fish communities that are present within it. Seasonal changes in the major environmental characteristics and fish community structure, within the different habitats of the study area, are described.

'From the headwaters to the mouths of the creek systems, the habitat-structural and physico-chemical conditions presented a continuous gradient of conditions; cooler, clearer waters over rocky and sandy substrates moving downstream to hotter, more turbid waters over muddy and clayey substrates with hydrophytes. Distinctive fish communities were present in the upper escarpment and lower reach floodplain zones. These zones contained major refuge habitats for fish'. Seasonal changes also occurred due to fluctuations in water flow. 'During the Dry season, the conditions were generally heterogeneous between waterbodies, with the most 'favourable' conditions for fish existing in escarpment zone waterbodies and varying 'unfavourable' conditions existing downstream in the lowland and floodplain habitats'. This

was the season when communities in the upper and lower reaches were most distinctive. During the Wet season the waterbodies are more homogeneous and the communities are less distinctive.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Fish were sampled at Nankeen and Jabiluka billabongs, which are located near the confluence of Swift Creek with the Magela floodplain. Provided in the report are the numbers and weights of fish species that were captured in the billabongs.

TITLE: *Ecological studies on the freshwater fishes of the Alligator Rivers Region, Northern Territory. Vol III. Autecology.*

AUTHOR(s): Bishop KA, Allen SA, Pollard DA & Cook MG (in press).

PUBLICATION: Research report 4, Vol 3, Supervising Scientist for the Alligator Rivers Region, Unpublished paper [Incorporates Bishop et al 1980 (OFR 23)].

LOCATION: SERIES SSAR RR 4 (Vol 3).

SUMMARY

The aim of this study was to examine the ecology and biology of the freshwater fishes of the Alligator Rivers Region to enable prediction of the impacts of uranium mining on the fish fauna or any long-term effects on the aquatic ecosystems. The study was conducted from August 1978 to December 1979; the results are presented in three volumes. 'Volume III discusses the autecology of the fish species of the region'. 'The essential objective of the [autecological studies] was to identify the locations and timings of activities critical in the life cycles of each of the fish species considered. By cross-relating such knowledge to information on the location and timing of potential mining-induced physical and chemical (abiotic) impacts, the life-cycle components of species most at risk can be identified – an important task in impact risk assessment'.

The fish fauna was sampled at sites in the East Alligator River, Cooper Creek, Magela Creek and Nourlangie Creek systems. The Magela Creek system was sampled intensively due to its proximity to the Ranger Uranium Mine. The sampling sites were chosen to represent plateau, escarpment, lowland, corridor, upper floodplain billabong, lower (riverine) floodplain billabong and artificial habitats. 'During this study, 166 standard samples were taken from freshwaters, yielding 29 254 fish of 37 taxa in 18 families (The majority of the taxa were identified to the species level, however two were subspecies of *Melanotaenia splendida*). In addition, 39 sets of underwater observations were made in escarpment area sites, in which 6 276 fish of 28 taxa yielded additional information'.

'Primary biological/ecological information was obtained and analysed for each of the 37 freshwater fish taxa found in the Alligator Rivers Region in relation to the following generic species-account structure: size composition, environmental associations, reproduction and feeding habitats. Each of these components revealed complementary information on the locations and timing of activities critical in the life cycles of the fish taxa considered'. 'The extent of biological information gathered varied considerably between taxa, mainly due to their relative abundances in the Region. A list of the fish taxa ranked by the numbers of specimens examined for basic biological information is provided in the report'. 'Information on fish distributions beyond the Alligator Rivers Region is given in the introductory section for each taxa'.

'A key finding from the study is the crucial importance of lowland backflow billabongs to the ecology of the majority of the freshwater fish fauna'. 'The detailed information presented in this report constitutes a major contribution to the autecological knowledge of the freshwater

fish fauna of the Alligator Rivers Region. Importantly, the information arising from the present study will have considerable application when assessing the nature and magnitude of impacts arising from a range of fresh-water associated developments, and particularly those in the mining arena'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Fish were sampled at Nankeen and Jabiluka billabongs, which are located near the confluence of Swift creek with the Magela floodplain. Numbers and weights of fish species captured in the billabongs are provided in Volume II. Each species, its distribution, habitat and associated environmental factors, feeding habits, reproduction and size are given in this volume (Vol III).

TITLE: Studies on fish movement dynamics in a tropical floodplain river: Prerequisites for a procedure to monitor the impacts of mining.

AUTHOR(s): Bishop KA, Pidgeon RWJ & Walden DJ 1995.

PUBLICATION: *Australian Journal of Ecology* 20, 81-107.

LOCATION: ARRI File 1838.

SUMMARY

'Towards the end of the Wet season in the tropical coastlands of Northern Australia, there are dramatic upstream movements of many fish species in some seasonally flowing streams. These movements are considered to be a part of refuge-seeking migrations. Aspects of the dynamics of the movements of Magela Creek (in the 'Top End' of the Northern Territory) downstream from the Ranger Uranium Mine have been examined with a range of techniques (mainly direct observation) to facilitate the development of a possible procedure for monitoring impacts of the mine on the fish community of the creek system'. Routine daily monitoring and a range of studies commenced in 1985 at five sampling sites in the Magela Creek system. The techniques used to monitor fish movements and to calculate movement rates are outlined in the paper.

A list of species recorded in the routine monitoring and their relative abundance is provided in the paper. A total of 27 species, representing 15 families, were recorded moving in Magela Creek past the Ranger Uranium Mine, from 1985 to 1993. 'Data on diel patterns of movement validated that monitoring, for 1 h at midday at a single point adjacent to the mine, reflects day-to-day changes in total diel movements. To help identify the location of any impacts arising in the future, information on upstream progress rates, longitudinal changes in movements, and movements between the creek and lowland billabongs, were used to (i) demonstrate the creek-long continuity of movements and (ii) indicate the possible sources and destinations of fish approaching the mine. Marked differences in sources were apparent for two groups of species: terapontids originating from the lowland creek channels, and chequered rainbowfish and ambassids originating from the floodplain and lowland billabongs. Identification of the relative contributions from these habitats will require additional monitoring effort'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

The study sites in Magela Creek were located well upstream of where Swift Creek joins the Magela floodplain. Some of the species may occur in the Swift Creek system, but this would require further work to confirm.

TITLE: *Biological monitoring of fish communities in Gulungul billabong, a backflow billabong of Magela Creek.*

AUTHOR(s): Boyden J, Pidgeon RWJ & Humphrey C 1992.

PUBLICATION: Internal report 90, Supervising Scientist for the Alligator Rivers Region, Canberra/Darwin. Unpublished paper.

LOCATION: SERIES SSAR IR 90.

[***eriss*** staff only – may be made available to others with the Director's approval]

SUMMARY

'The lowland billabongs of Magela Creek are important habitats for fish'. These billabongs are located downstream of Ranger Uranium Mine and can receive and accumulate waste substances which potentially impact on the biota. 'A research project aiming to develop techniques for detection of long-term effects on fish communities in [these] billabongs has been conducted by ARRI [now ***eriss***] since 1980'. 'Included in this program has been a study of the fish community of Gulungul billabong'. 'This report describes the sampling methods, sampling sites and the data files for this project'.

Gulungul billabong was sampled using a lift-trap and water jet. 'Sampling between 1988-92 was conducted once per year, at the onset of the Dry season'. 'Ten samples were taken each year from the same fixed locations near the billabong margin water less than 0.5 m deep'. 'The basic data for the fish counts are in the form of numbers of fish of each species for each site, the total numbers of all species per site and the total number of species per site. A total of 12 species were recorded during the study and are listed in the report.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Gulungul Billabong is located upstream in Magela Creek of the point at which the Swift Creek system joins the Magela floodplain.

TITLE: Gillnet fishing in four billabongs of the Magela Creek.

AUTHOR(s): Clay D, Baker L, Bailey B & Walden D (1983).

PUBLICATION: In *Environmental Protection in the Alligator Rivers Region: A scientific Workshop.* Vol 1, Jabiru 17-20 May 1983, Supervising Scientist for the Alligator Rivers Region, 37.1-37.9. Unpublished paper.

LOCATION: CR SSAR 010 (Vol 1).

SUMMARY

'The pelagic or open-water fish communities were studied. The fish were caught by gillnetting in four billabongs of the Magela Creek system'. 'The four billabongs were chosen to represent a range of habitats: Corndol, a backflow billabong; Y-shaped, a mid-channel billabong; and both Jabiluka and Nankeen representing floodplain billabongs'. Monthly sampling was undertaken between February to December 1982; fish were caught over two consecutive 12-hour periods. The data collected during the survey had yet to be analysed in detail at the time the paper was written. 'The total catch (species combined) gives an indication of the relative abundance of fish in various parts of the Magela system. Corndorl Billabong had the lowest level of catch of the four billabongs. The other three billabongs followed a similar pattern of catch levels, which increased as the year progressed. Y-shaped Billabong appeared to have the highest catch levels until late in the dry season, after which there was a steady decline'. The four billabongs represent a range of habitats and these are reflected in the relative abundance and species composition of the fish community. Some of the fish species present included tarpon, saratoga, eeltail catfish and forktail catfish, with the forktail catfish *Hexanematichthys leptaspis* being the dominant species in all the billabongs.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Jabiluka and Nankeen billabongs are located in the vicinity of the junction of Swift Creek with the Magela floodplain. Hence, the information on the fish communities of these two billabongs is directly relevant to Swift Creek.

TITLE: *Habitat utilisation by microinvertebrates and fish and their trophic interactions in Magela Creek.*

AUTHOR(s): MacFarlane WJ 1996.

PUBLICATION: Internal report 211, Environmental Research Institute of the Supervising Scientist (Australia), Canberra/Darwin. Unpublished paper.

LOCATION: SERIES SSAR IR 211.

SUMMARY

Habitat utilisation and trophic interactions of Magela Creek fish and macroinvertebrate communities were examined during the Dry season. One of the specific objectives of the project was to describe the macroinvertebrate and fish communities occurring in different microhabitats. The study area was located upstream of Mudginberri Billabong in two channels of the creek. A total of 11 fish species was recorded, four of which comprised 78% of the fish community. The major species observed in the study area are listed in the report.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

The Magela Creek study area where the fish species were recorded was located well upstream of where Swift Creek joins the Magela floodplain.

TITLE: *Fresh water fish inventory and associated habitat information. Project 4 of Alligator Rivers Region environmental fact-finding study (A report for the Department of the Northern Territory).*

AUTHOR(s): Midgley H 1973.

PUBLICATION: Unpublished paper.

LOCATION: CR ALL 004.

SUMMARY

An investigation was conducted between September 1972 and August 1973, involving four visits to the Alligator Rivers Region, to document the freshwater fish, molluscs and crustaceans occurring in the area. Nineteen stations were sampled, four of which were located in the Magela Creek system. Fish were caught using a variety of net types during the day and at night. The species present at each station and whether they were abundant, common or rare, as well as the physical stream characteristics were recorded. Over the survey period a total of 24 fish species were recorded in the Magela Creek catchment. The species recorded at each station during each visit are listed in the paper.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

None of the four sampling stations in the Magela Creek system were located in proximity to the junction of Swift Creek with the Magela floodplain.

TITLE: *Fish migration data collected during 1991/92 Wet season.*

AUTHOR(s): Pidgeon B & Boyden 1993.

PUBLICATION: Internal report 99, Supervising Scientist for the Alligator Rivers Region, Canberra/Darwin. Unpublished paper.

LOCATION: SERIES SSAR IR 99.

[*eriss* staff only – may be made available to others with the Director's approval]

SUMMARY

'Data on the numbers of fish migrating in Magela Creek have been collected at a single station near the [Ranger Uranium Mine] since 1985. This data will be used to develop a procedure for monitoring both short term and long term effects of mining on the fish community of Magela Creek'. 'This report outlines the data collected during the 1991-1992 Wet season as part of this database and provides some summary statistics of annual migration rates and seasonal migration patterns during this season'. Visual observations from the Ranger release pipe, for a one-hour period at midday, were used to record the number of fish migrating upstream and downstream. Twenty-six species have been recorded and are listed in the paper.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

The Ranger release pipe is located upstream in Magela Creek of the confluence of Swift Creek with the Magela floodplain.

TITLE: *Biological monitoring of fish communities in Mudginberri Billabong, Magela Creek. Review of methods and data from 1988-1992 sampling.*

AUTHOR(s): Pidgeon R, Boyden J & Humphrey C 1992.

PUBLICATION: Internal report 83, Supervising Scientist for the Alligator Rivers Region, Canberra/Darwin. Unpublished paper.

LOCATION: SERIES SSAR IR 83.

SUMMARY

'The lowland billabongs of Magela Creek are important habitats for fish'. 'These billabongs can receive mine waste substances from Ranger Uranium Mine in solution during the Wet season and they are possible sites for deposition of particulate substances'. 'A research program developing strategies for long-term monitoring of the fish communities in these billabongs is being carried out by ARRRI [now ***eriss***]'. As part of this program, a study of the fish communities in Mudginberri Billabong, which is located downstream of Ranger Uranium Mine, was conducted between 1989 and 1992. Counts of fish were made visually along five 50 m transects. Since 1992, a set of habitat structure variables has also been recorded to enable interpretation of the patterns of variation in fish community structure. The abundances of the different species recorded along each transect are given in the report. Twenty-three species of fish commonly occur and have been recorded in the study area.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Mudginberri Billabong is located well upstream in Magela Creek, and is not in proximity to the confluence of Swift Creek with the Magela floodplain.

TITLE: *Procedures for routine monitoring of fish migration at the Ranger release pipe on Magela Creek.*

AUTHOR(s): Pidgeon RWJ, Boyden J & Humphrey C 1993.

PUBLICATION: Internal report 100, Supervising Scientist for the Alligator Rivers Region, Canberra/Darwin. Unpublished paper.

LOCATION: SERIES SSAR IR 100.

[***eriss*** staff only – may be made available to others with the Director's approval].

SUMMARY

The report describes the procedures for collection and storage of data on the number of fish migrating in Magela Creek. Data have been collected at a single station near the Ranger waste water release pipe, about 300 m downstream from the point where Georgetown Billabong drains into Magela Creek. The only information pertaining to species distribution or abundance is a list of 25 freshwater species commonly encountered in the lowland section of Magela Creek.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

The list of freshwater species given in the report is for an area of the Magela Creek well upstream of where Swift Creek joins the Magela floodplain.

TITLE: Report I. The Freshwater fishes of the Alligator Rivers "Uranium Province" area (top end, Northern Territory) with particular reference to the Magela Creek catchment (East Alligator River System).

AUTHOR(s): Pollard DA 1974.

PUBLICATION: *In Project 6 of Alligator Rivers Region environmental fact finding study: Four AAEC reports,* ed PJF Newton, Australian Atomic Energy Commission, Lucas Heights.

LOCATION: CR ALL 006.

SUMMARY

'This report is based on the results of a survey of the fishes of the Magela Creek catchment, and some other sections of the East Alligator River system, carried out for the Australian Atomic Energy Commission during June and July 1972'. A number of different net types and rod and line were used to collect the fish. The sample sites within the Magela Creek catchment were as follows: Magela Creek, Boggy Creek, Indium Billabong, Georgetown Billabong, Mudginberri Lagoon, Leichhardt Lagoon, Ja Ja Lagoon, Island Billabong, Lagoon on Magela Plain and Upper Magela Creek. A total of 28 species of fish were collected during the study. For each of the fish caught information was recorded on physical characteristics, distribution, size, habits, diet, suitability for eating and where specimens were collected.

The sample sites in the Magela Creek catchment fell within a 20 km radius of Mudginberri station. They have 'a fish fauna of at least 28 freshwater species compared, for instance, with a total of 27 native species present in the entire Murray-Darling system, the most extensive river system in Australia'. 'The richness and diversity, and the scientific interest of this icthyofauna, as well as its importance for food and sport to Aborigines and other residents of the area, thus warrants the most careful consideration of any proposed changes in land use in the Alligator Rivers area'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

None of the sampling locations in the Magela Creek catchment were located in proximity to the junction between Swift Creek and the Magela floodplain, thus the fish data is not applicable to Swift Creek.

TITLE: *Fish communities in sandy pools of Magela Creek, Alligator Rivers Region.*

AUTHOR(s): Woodland DJ & Ward PJ 1992.

PUBLICATION: Research report 9, Supervising Scientist for the Alligator Rivers Region, AGPS, Canberra [Incorporates Ward & Woodland 1982 (OFR 16)].

LOCATION: SERIES SSAR RR 9.

SUMMARY

'Phsico-chemical conditions, changes in fish communities and characteristics of species populations of eight permanent sandy pools along Magela Creek during the 1981 Dry season are described. Causes of mortality in each species, especially *Craterocephalus marianae* (Mariana's hardyhead), were investigated'. Eight pools of the main channel of Magela Creek were sampled monthly between August and November 1981. Pool size, temperature, pH, turbidity, suspended solids, conductivity and levels of chlorophylls a, b and c, oxygen, ammonia and heavy metals were measured. The fish communities were surveyed using seine nets to determine species composition, abundances, population biomasses, size distributions, and mortality. Data on reproduction, diet and feeding were also collected.

Details of the physico-chemical conditions of the pools, as well as species distribution, abundance and biomass in each of the pools are provided in the report. 'The fish communities of the pool were diverse considering the apparent low heterogeneity of the habitat and the small size of the pools'. Twenty species were recorded and most species appeared to be at high densities. In biomass *Leiopotherapon unicolor* (spangled grunter) and *Nematalosa erebi* (bony bream) were the dominant species, whilst *C. marianae* was the most numerically dominant. Most species were present as large juveniles or adults only, with the exception of three species present as fry and small juveniles. Most pools had a low mortality; anoxic conditions and predation by other fish were the main causes.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Data on fish species abundance and biomass were collected from sandy pools located in an area of Magela Creek well upstream of where Swift Creek joins the Magela floodplain.

AMPHIBIANS

TITLE: *Frogs as predators of organisms of aquatic origin in the Magela Creek system, Northern Territory.*

AUTHOR(s): Cappo, M 1986.

PUBLICATION: Masters thesis, University of Adelaide, Adelaide. Unpublished paper.

LOCATION: 597.89 CAP.

SUMMARY

'The patterns of distribution and diets of the anuran fauna of the Magela Creek system of the Northern Territory have been examined'. Waste-waters released from uranium mining operations at Ranger and Jabiluka, adjacent to Magela Creek, are a potential source of contaminants which may accumulate in aquatic ecosystems. 'The aim of this study was to predict which species of frogs are most important in [the transfer of pollutants from aquatic to terrestrial ecosystems] through ingestion of prey with wholly or partially aquatic life histories'. 'This objective has been addressed in two main ways. Firstly, the spatial and temporal distributions of the frog fauna were studied to determine which species forage in, or near, natural and artificial water bodies. Secondly, stomach content analyses of species collected from major natural and artificial habitats in the Magela Creek system were used to represent the ingestion of prey of aquatic origin'.

Field studies were undertaken during the periods January-April 1981, August 1981 and October 1981- May 1982. Twenty-four species of frogs comprising eight genera are found in the Magela Creek area; their distribution and abundance according to Tyler and Crook (1980) is given in the report. The sixteen of the 24 frog species studied are listed in the report. The sixteen species fall into seven faunal groupings: aquatic, aboreal, ground hylids, wide-mouth burrowing frogs, narrow-mouthed burrowing frogs, toadlets and froglets. Habitats of the lowland area of the Magela Creek floodplain were sampled: 'open sclerophyll forest', 'inundated grassland', 'fringes of billabongs', 'floodplains' and 'artificial pools, scrapes and ponds'. Frogs were collected at a wide range of locations. These included Magela and Gulungul Creeks, Magela floodplain billabongs including Nankeen Billabong, the tailings dam and retention ponds in the Ranger lease area, Jabiru townsite roads, sewerage treatment works, and the airstrip. A variety of methods were used including spot-lighting, pit-traps, counting along transects and netting in the waterbodies. The dates, locations and methods used for collection during each sampling period are given in the report. Frogs were measured, sexed, their stomach weighed and the volume estimated and any contents were removed and prey items identified.

"All sampling locations were classified broadly as being either 'waterbodies', 'ephemeral waterbodies' or 'terrestrial' according to the presence of surface water during the study period". 'The numbers of frogs captured within these classifications, by species and by faunal groupings', are shown in the report. Species and numbers recorded at each of the sampling locations are listed in the report. The Magela Creek and Gulungul Creek transects were classified into habitat types. The five habitat types recognised were open woodlands, gravelly lateritic soil; open woodland, sandy soil; sedge/grassland, sandy soil; swamp sedge/grassland, black soil; and paperbark swamp. The numbers of frogs of the 16 species

that were sighted in each of the habitat types for both the transects are given in the report. Densities of frogs recorded along the two transects also were calculated. 'Along the transects, poorly drained areas with sandy soils support a more diverse and abundant anuran fauna than do well drained areas with hard gravelly soils'.

The 'regular collections made at major waterbodies and along transects through different types of habitat showed that species comprising different faunal groups forage in different macrohabitats'. 'The spatial distribution of the frog fauna varies temporally with rising water levels at waterbodies, inundation of grassland and woodland and the onset of breeding activities'. Macrohabitats in close vicinity to waterbodies were found to be important as foraging areas for only the aquatic frogs, *Litoria dahlii*, the aboreal frogs *L. rothii* and *L. bicolor*, the ground hylids and froglets. However all species may encounter prey of aquatic origin during at least two stages of their post-metamorphic ontogeny, as juvenile frogs leaving the larval habitat and as adults visiting waterbodies for breeding purposes'.

The remainder of the paper discusses the results of the stomach content analyses. Frequency of occurrence, numbers, and volumes of prey orders present in the stomachs of the different faunal groupings of frogs were determined. The incidence of aquatic/terrestrial prey orders in the stomach contents was also quantified.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Extensive sampling was conducted at Nankeen Billabong, and to a lesser extent at Jabiluka Billabong. Both of these waterbodies are located in the vicinity of the confluence of Swift Creek with the Magela floodplain, making the information on frog abundances and temporal and spatial distributions relevant to Swift Creek.

TITLE: *Diet and feeding habits of frogs of the Magela Creek system (final report).*

AUTHOR(s): Tyler MJ & Cappo M 1983.

PUBLICATION: Open file record 10, Supervising Scientist for the Alligator Rivers Region, Canberra/Darwin. Unpublished paper.

LOCATION: SERIES SSAR OFR 10.

SUMMARY

This investigation aimed to examine the diet, feeding habits and abundances of frogs in the Magela Creek system. Particular focus was given to those species considered to be potential colonisers of the Ranger minesite following environmental disturbance resulting from the construction phase. 'Field studies were undertaken during the periods January-April 1981, August 1981 and October 1981-May 1982'. The sampling period 'included two Wet seasons when frogs are most active and abundant, together with a short (one week) period in the middle of the Dry season designed to establish the existence of any activity by frogs'. Frogs and tadpoles were collected at a wide range of locations. These included Magela and Gulungul Creeks, Magela floodplain billabongs, Nankeen billabong and its associated floodplain, the tailings dam and retention ponds in the Ranger lease area, townsite roads and airstrip of Jabiru. A variety of methods were used comprising spotlighting, pit-traps, counting along transects, and netting in the waterbodies. The dates, times, locations and methods used for collection during each sampling period are given in the report. Frogs were sexed, their stomach volume estimated and any stomach contents were removed, and prey items identified.

A total of 16 frog species were recorded during the study. Species and number of frogs recorded at each of the sampling locations are listed in the report. The Magela and Gulungul Creek transects were classified into habitat types. The four habitat types recognised were open woodlands, gravelly lateritic soil; open woodland, sandy soil; sedge/grassland, sandy soil; and swamp sedge/grassland, black soil. Densities of frogs recorded along the two transects also were calculated. The spatial and temporal distributions are discussed in terms of habitat type and breeding suitability, water levels and prey availability. Tadpole abundances and densities, and the estimated biomass of five species in different habitats, also are given in the report. The remainder of the report discusses factors affecting the nature of frog prey items, alimentary tract clearance rates of adults, tadpole feeding trials and biovolume of ingested food.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Extensive sampling was conducted at Nankeen Billabong, and to a lesser extent at Jabiluka Billabong. Both of these water bodies are located in the vicinity of the confluence of Swift Creek with the Magela floodplain, making the information on frog abundances and distributions relevant to Swift Creek.

TITLE: *Frogs of the Magela Creek system.*

AUTHOR(s): Tyler MJ & Crook GA 1987.

PUBLICATION: Technical memorandum 19, Supervising Scientist for the Alligator Rivers Region, AGPS, Canberra [Previously OFR 1, information on frog abnormality studies is excluded in TM 19].

LOCATION: SERIES SSAR TM 19.

SUMMARY

'Facets of the reproductive biology of 24 species of frogs from the Magela Creek system were examined over two Wet seasons' between 1978 and 1980. An initial objective was to review the available data on frogs of the Magela Creek system to determine the diversity and relative abundance of the fauna. Twenty-four species, representing eight genera, are known to occur in the Magela Creek system. The composition of the frog species, their distribution and their relative abundances are provided in a table in the report. Seven vegetation units have been identified in the Magela Creek system. These units are: escarpment sandstone and woodland; escarpment rainforest remnants; inundated grassland; open sclerophyll forest; billabong fringes; floodplains; and artificial pools and gravel scrapes. The distribution of the frog species within each habitat is given. Two species, *Litoria personata* and *Uperoleia arenicola* were discovered along the edge of the escarpment east of the Magela Creek. The authors state that they are still known only from those few specimens.

The rest of the paper discusses the reproductive biology of the frog fauna in terms of activity patterns, calling and breeding, which are correlated with temperature and relative humidity. Most species breed at the onset of the Wet season before the floodplain is completely inundated. For each species the eggs and form of the spawn clump are described. Vertebrate predators and the potential impacts of uranium mining on the frog populations are briefly discussed.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

The distribution of the frog species is given within habitat types such as grasslands or floodplains of the Magela Creek system. The two species discovered along the edge of the escarpment may be further distributed in similar habitats near Swift Creek. As the data are not site specific it is not possible to determine which species occur in the vicinity of the junction of Swift Creek with the Magela floodplain.

TITLE: Reproductive biology of the frogs of the Magela Creek system, Northern Territory.

AUTHOR(s): Tyler MJ, Crook GA & Davies M 1983.

PUBLICATION: *Records of the South Australian Museum* 18 (8), 415-460.

LOCATION: ARRI File 0316, PAM 597.87 TYL.

SUMMARY

The reproductive biology of the frog fauna of the Magela Creek system was examined. A study of the fauna was conducted over two Wet seasons from October 1978 to April 1979 and October 1979 and March 1980, in the vicinity of Ranger Uranium Mine. A total of 24 species were collected, representing three families; Hylidae (2 genera, 16 species), Leptodactylidae (5 genera, 7 species) and Microhylidae (1 genus, 1 species). 'Of that total only two species: *Litoria personata* Tyler Davies & Martin and *Uperoleia arenicola* Tyler Davies & Martin are currently known only from that area. Most of the remainder are widely distributed across Northern Australia'. The species composition and relative abundances are tabulated in the paper. Relative abundance is based on the frequency of which individuals of a species were observed. 'Absent' indicates no sightings; 'Rare' indicates 1-10 observations; 'Common' involves at least 25 observations, and 'Abundant' reflects large numbers of a species at any time within the study period that the species was active. Seven vegetation units have been identified in the Magela Creek system. The distribution of the frog species within each habitat is outlined.

The rest of the paper discusses the reproductive biology of the frog fauna in terms of activity patterns, calling and breeding, which are correlated with temperature and relative humidity. Fecundity and reproductive modes as well as development history are also discussed.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Distributions of the frog species are given within habitat types, such as grasslands or floodplains of the Magela Creek system. As the data are not site-specific it is not possible to determine which species occur in the vicinity of the junction of Swift Creek with the Magela floodplain. The only relevant data may be species occurring in habitats similar to those found in the Swift Creek area.

REPTILES

TITLE: Seasonal variation in abundance and distribution of *Crocodylus porosus* in the tidal East Alligator River, Northern Australia.

AUTHOR(s): Jenkins RWG & Forbes MA 1985.

PUBLICATION: In *Biology of Australasian frogs and reptiles*, eds G Grigg, R Shine & H Ehmann, Surrey Beatty & Sons Pty Limited, Chipping Norton, NSW, 63-69.

LOCATION: 597.6099 AUS.

SUMMARY

Crocodylus porosus inhabits most seasonal wetlands and all four tidal rivers in Kakadu National Park. This study examined *C. porosus* populations in the East Alligator River and along a 3 km section of Magela Creek. The aim was to determine seasonal variations in abundance and distribution of this species. Surveys were conducted from 1980-1984 primarily in the early (April/May) and late (October/November) Dry seasons. Spotlight counts were conducted at night. Crocodiles were categorised into size classes and their location recorded.

The abundance of crocodiles recorded during each survey period is given in the report. Marked seasonal variations occurred in the abundance of *C. porosus*. This was attributed to the movement of crocodiles from the river to adjacent freshwater swamps. Once the freshwater habitat declines crocodiles are thought to move back into the river. 'The annual cycle of movement appears to be confined to the upstream section of the river and to animals >1.2 m in length'. The bulk of nesting activity is confined to the mid-section of the river and 'hatchlings and yearling display very limited dispersal from the nest site'. 'Since the upstream section appears to be unsuitable for nesting, it may act as a refuge area for non-breeding animals and a dispersal corridor from suitable breeding areas'.

'Surveys undertaken in June 1983 recorded 7 crocodiles >1.2 m' in Magela Creek. 'However, in August 1983 the number of crocodiles >1.2 m recorded was 23. It seems therefore that Magela Creek is providing a similar corridor to that suggested for the upstream section of the East Alligator'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

A separate survey of the Swift Creek would be required to determine the abundances and densities of *C. porosus* populations in this system.

TITLE: *Taxonomy, distribution and ecology of freshwater turtles in the Alligator Rivers Region, Northern Territory.*

AUTHOR(s): Legler JM 1980.

PUBLICATION: Open file record 2, Supervising Scientist for the Alligator Rivers Region, Canberra/Darwin, Unpublished paper.

LOCATION: SERIES SSAR OFR 2.

SUMMARY

Populations of freshwater turtles were examined at ten locations within the Alligator Rivers Region in July and August-September 1980. Sample sites were located at the Liverpool River, East Alligator River, Mann River, Bowerbird Lagoon, Sandy Billabong, Twin Falls, and Island and Leichhardt billabongs of the Magela Creek system. The Liverpool River and the East Alligator River were both sampled at two sites. Turtles were trapped in baited drum nets, in 100-foot trammel nets and by diving in clear water. Five species of freshwater turtles were recorded in the study area: *Carrettochelys insculpta, Chelodina rugosa, Chelodina* sp. nov., *Emydura victoriae (=australis), Elseya dentata, Elseya latisternum* and *Emydura* sp. Their common names, distribution and habits are given in the report. A key to the freshwater turtles of the Alligator Rivers Region is also provided. Stomach analyses were completed on individuals of four of the species collected. Reproductive data and measurements and live weights also were recorded. The diet of the freshwater turtles is discussed and the use of turtles for Aboriginal food is reviewed.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

The information on the freshwater turtles of the Alligator Rivers Region is not directly applicable to Swift Creek, as the study sites were not located in vicinity of Swift Creek. Billabongs located near the confluence of Swift Creek and the Magela floodplain may contain similar species.

TITLE: *The ecology of freshwater turtles in the Alligator Rivers Region.*

AUTHOR(s): Legler JM 1982.

PUBLICATION: Open file record 66, Supervising Scientist for the Alligator Rivers Region, Canberra/Darwin, Unpublished paper.

LOCATION: SERIES SSAR OFR 66.

SUMMARY

Populations of freshwater turtles were examined at 30 locations within the Alligator Rivers Region from August to November 1982. Samples were taken from the South Alligator-Nourlangie system, Katherine River, Mann River, Liverpool River, Wilton River and from 12 sites on the Magela Creek system. Turtles were collected using baited hooks and traps, trammel nets and diving. The majority of population estimates were based on diving. Specimens were dissected for reproductive data and stomach contents were analysed through flushing. Data are incorporated from surveys taken in 1974 and 1980.

Seven species of freshwater turtles were recorded in the study area; *Carrettochelys insculpta, Chelodina rugosa, Chelodina* sp. nov., *Emydura victoriae (=australis), Elseya dentata, Elseya latisternum* and *Emydura* sp. The relative abundances of the 7 species at the different sample sites, based on diving and trapping, are tabulated in the report. The distribution and habitat requirements for each species are given in the report and the taxonomy and zoogeographic information on the origin and dispersal of the turtles in the region is also discussed. The seven species fall into two distinct groups: 2 species (*E. latisternum* and *Chelodina* sp. nov.) occur on the Arnhem Land Plateau and the remaining 5 occur in the river systems below the escarpment. 'Of this latter group, two of the 5 species (*E. dentata* and *Emydura* sp.) have reached the Plateau'. Both *E. latisternum* and *Chelodina* sp. nov. are present in the section of the Magela Creek system flowing through the Arnhem Land Plateau while *C. rugosa, E. dentata* and *E. victoriae* are present in the creek below the escarpment.

The diet and reproduction of the turtles are discussed and the use of turtles for Aboriginal food is reviewed. An additional detailed description of the nesting, habitat and distribution of *Carrettochelys insculpta* is given as so little is known about this species.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Turtles were collected from Jabiluka and Nankeen billabongs which are located near the confluence of Swift Creek with the Magela floodplain. The information on species occurring at these two billabongs may be relevant to Swift Creek.

TITLE: *Surveys of tidal river systems in the Northern Territory of Australia and their crocodile populations. Monograph 4: The Alligator Region river systems.*

AUTHOR(s): Messel H, Wells AG & Green WJ 1979.

PUBLICATION: Pergamon Press, Sydney.

LOCATION: 598.14045 STRS.

SUMMARY

Crocodylus porosus populations of the Alligator Rivers Region suffered a serious decline in the 1950s and 1960s the due to overharvesting. Several of the river systems in this region were surveyed in October 1977 and in July 1978. The aim was to provide baseline data for future monitoring of populations before uranium mining commenced in the area. The river systems surveyed were Murgenella Creek, Wildman River, South Alligator River, West Alligator River and the East Alligator River including Magela Creek. Aerial photographs were used to produce river maps. Daytime surveys were conducted to familiarise the researchers with the river systems and before night-time spotlight counts were undertaken. Crocodiles were categorised into size classes and their location recorded. Environmental parameters such as salinity and temperature were measured as well. 'The density of crocodiles [was] calculated by dividing the number of crocodiles seen by the surveyed length of the river and creeks'. The results are presented separately for each of the river systems that were surveyed. Only the individual data for the Magela Creek population are reviewed in this summary.

Overall 693 non-hatchling crocodiles were recorded on the 360.2 km of the river systems surveyed during the 1978 surveys, producing a density of 1.9/km. 'The estimate for the actual number of non-hatchling crocodiles present on the surveyable portions of the total system lies between 990 and 1 283. Considering the large size of the overall system, the populations are depleted and endangered'. As there was no significant difference between the estimates for non-hatchling crocodiles between the survey years it is not possible to say whether the populations are increasing or decreasing. A three kilometre section of Magela Creek was surveyed. In this section 16 crocodiles > 1.2 m in length (12 of which were > 1.8 m) were recorded during the 1977 survey. Two hatchlings were also recorded during this survey. The 1978 survey recorded 15 crocodiles > 0.9 m in length (6 of which were >1.8 m). 'Magela Creek is the only place we know of in Northern Australia where there is such a density of large crocodiles. It is important that *C. porosus*, being at the top of the estuarine food chain, should be monitored rigorously as uranium mining proceeds' in the area.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

A separate survey of the Swift Creek would be required to determine the abundances and densities of *C. porosus* populations in this system.

TITLE: *The terrestial and semiaquatic reptiles of (Lacertilia, Serpentes) of the Magela Creek region, Northern Territory.*

AUTHOR(s): Sadlier RA 1990.

PUBLICATION: Technical memorandum 32, Supervising Scientist for the Alligator Rivers Region, AGPS, Canberra [Incorporates Sadlier 1981 (OFR 5)].

LOCATION: SERIES SSAR TM 32.

SUMMARY

The terrestrial and semi-aquatic reptiles of the Magela Creek region were investigated. Surveys were conducted in two areas. 'The Jabiluka project area (August-September 1979) was concerned mainly with habitats associated with the Jabiluka outlier and with the middle reach billabongs and drainage channels flowing into Magela Creek. The survey of the Ranger project area (March-April and July 1981) was concerned mainly with lowland habitats associated with the upper reaches of Magela Creek'. Data were gathered by actively searching, morning and afternoon, in favourable areas, in conjunction with a pitfall trapping program at each site. The habitats of the project areas were broadly divided into 3 categories and described; the three categories were sandstone habitats, lowland dry habitats and lowland wetland habitats.

'From these and later surveys in the region by other consultants, a total of 74 species of snakes and lizards are now known from the Magela Creek region, making this one of the most diverse regions in Australia'. Each species is described in terms of its distribution within the two project areas and the type of habitat it was found in. 'Though in close proximity [the two project] areas vary in the range of habitats, a feature reflected in the composition of the herpetofauna recorded from each area. The most obvious difference is the absence of remnants of the sandstone escarpment from the Ranger lease. On the Jabiluka lease 17 species of reptiles are either restricted or occur in greatest abundance in sandstone habitats. Most of these species are known from similar habitats in the Alligator Rivers Region outside the Jabiluka lease'. Both leases have a similar species composition in the lowland dry habitats. Of the 74 species of snakes and lizards found to occur in the Magela Creek system, 13% appear to be endemic to the Arnhem Land Plateau. 'Several endemic lowland species are at present known only from the Alligator Rivers Region. Further survey work to the east along the northern boundary of Arnhem Land, particularly in lowland ecotones, is required to further determine the distribution of these species'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

The study area extended northwards, outside of the Jabiluka lease area, to incorporate Jabiluka Billabong, which is near the confluence of Swift Creek with the Magela floodplain. The information on species occurring at Jabiluka Billabong may be relevant to Swift Creek. Perhaps more applicable is the habitat description of where each species occurs. Similar habitats in the Swift Creek system may contain similar species of reptile fauna. Confirmation of this requires further work.

TITLE: *Ctenotus kurnbudj* and *Ctenotus gagudju*, two new lizards (Scincidae) from the Alligator Rivers Region of the Northern Territory.

AUTHOR(s): Sadlier R, Wombey JC & Braithwaite RW 1985.

PUBLICATION: *The Beagle, Occasional Papers of the Northern Territory Museum of Arts and Sciences* 2 (1), 95-103.

LOCATION: ARRI File 0245.

SUMMARY

'Two new scincid lizards, *Ctenotus kurnbudj* sp nov. and *Ctenotus gagudju* sp. nov., are described and the distribution of both species in the Northern Territory is given'. *C. kurnbudj* is known from the West Alligator-Wildman Rivers area, while *C. gagudju* is found in lowland woodland associated with the upper reaches of Magela Creek and the mid to upper reaches of Nourlangie Creek. 'Distribution by habitat preference is discussed for eight species of *Ctenotus* Storr (*C. arnhemensis* Storr, *C. coggeri* Sadlier, *C. essingtonii* (Gray), *C. gagudju*, *C. inornatus* (Gray) *C. robustus* Storr, *C. storri* Rankin, *C. vertebralis* Rankin and Gillam) in the eastern Alligator Rivers Region'. Distribution is given as a 'stylised transect from an escarpment outlier west across the Magela Creek and surrounding floodplain and lowlands to the South Alligator River'. The major habitats identified include floodplain, lowland, paperbark riverine system and sandstone outliers. 'Much of the diversity of *Ctenotus* species in the Alligator Rivers Region is explained by the diversity of habitats in the region and within habitats by the size difference between species'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

This paper is not directly relevant to the Swift Creek system as the distribution of the eight *Ctenotus* species is given within habitat types, not at specific locations. Similar habitats in the Swift Creek system may contain corresponding species of lizards, however confirmation would require further research.

TITLE: *Diets and abundances of aquatic and semi-aquatic reptiles in the Alligator Rivers Region.*

AUTHOR(s): Shine R 1986.

PUBLICATION: Technical memorandum 16, Supervising Scientist for the Alligator Rivers Region, AGPS, Canberra

LOCATION: SERIES SSAR TM 16 [Incorporates Shine 1983 (CR SSAR 010, Vol 1) & Shine 1984 (OFR 11)].

SUMMARY

'Data were gathered on habit of food consumption, habitats, reproductive cycles, general biology, and utilisation by Aboriginal people, of five reptile species on the Magela Creek system: filesnakes (*Acrochordus arafurae*), sand goannas (*Varanus panoptes and V. gouldii*) and water goannas (*V. mertensi* and *V. mitchelli*)'. Samples were collected at intervals between January 1982 and November 1983 from Magela crossing and the Buffalo-Crescent-Mudginberri-Boomerang billabong system in the upper reaches of Magela Creek, as well as from Leichhardt and Hidden billabongs which are in the lower stream. Filesnakes were collected by hand, diving or snorkeling, baited drum nets and fyke netting. 'All snakes captured were marked before release to provide data on population sizes'. Radio-transmitters were implanted in 17 filesnakes during the study. Varanids were captured using a monofilament noose on a fibreglass pole.

The mark and recapture study revealed that filesnakes are more abundant in downstream billabongs. 'During the Dry season snakes were necessarily restricted to the main billabongs. Most locations were under or among *Pandanus aquaticus* (41%) or floating grass mats (30%). This pattern changed dramatically in the Wet season, with most snakes in the shallowly inundated grassland (32%) and under the boughs of freshwater mangrove (*Barringtonia acutangula*) (41%) which are flooded during this time. The seasonal shift in habitat utilisation is extreme'. The distribution of the four species of varanid lizards within different habitats on the floodplain is given in the paper. *V. gouldii* was thought to favour a woodland habitat. The majority of sightings of the large sand goanna, *V. panoptes* were in riparian habitats. 'The aquatic *V. mertensi* was sighted almost exclusively on small creeks, generally around larger pools'. 'The small semi-aquatic *V. mitchelli* was often found sympatrically with *V. mertensi* on small creeks'. Both species were relatively uncommon in downstream areas.

The remainder of the paper discusses the food habits, morphology and reproductive biology of the filesnakes and varanid lizards.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

The information on habitat utilisation of filesnakes and varanid lizards would be relevant to the Swift Creek system given these species occur in the system and that similar habitats are present.

TITLE: A radiotelemetric study of movements, thermoregulation and habitat utilisation of arafura filesnakes (Serpentes: Acrochordidae).

AUTHOR(s): Shine R & Lambeck R 1985.

PUBLICATION: *Herpetologica* 41(3), 351-361.

LOCATION: ARRI File 0258.

SUMMARY

'Miniature temperature-sensitive radiotransmitters were attached to 15 filesnakes (*Acrochordus arafurae*) in Magela Creek in tropical Australia'. 'The telemetry work was conducted in a series of interconnected billabongs in the upstream area of Magela Creek', primarily in the vicinity of Buffalo Billabong. 'Data were gathered during the Wet season in February-March 1982, during the Dry season in July-August 1982, and at the beginning of the Wet season in January-February 1983'. 'The snakes were monitored daily, or more often, for intervals from 2-24 days ($\bar{x}$ = 14 days)'.

'Filesnakes are entirely aquatic'. 'During the Dry season snakes were necessarily restricted to the main billabongs. Most locations were under or among *Pandanus aquaticus* (41%) or floating grass mats (30%). This pattern changed dramatically in the Wet season, with most snakes in shallowly inundated grassland (32%) and under the boughs of freshwater mangrove (*Barringtonia acutangula*: 41%) which were flooded during this time'. 'The seasonal shift in habitat utilisation was extreme'. 'Overall, habitat usage of *A. arafurae* seems to be concerned primarily with the utilisation of heavily vegetated shallow-water areas whenever these are available'.

The remainder of the paper discusses the movements and thermoregulation of filesnakes.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

The information on habitat utilisation of filesnakes would be relevant to similar habitats in the vicinity of Swift Creek.

BIRDS

TITLE: *Waterbirds at Ranger Mine, 1994-98. Report prepared for ERA Ranger Mine by ERA Environmental Services Pty Ltd.*

AUTHOR(s): Corbett L, Sewell S & Cramb G (Energy Resources of Australia Environmental Services Pty Ltd) 1999.

PUBLICATION: Unpublished paper.

LOCATION: CR RAN 366 [Incorporates Corbett & Sewell 1997 (CR RAN 360)].

[Commercial-in-confidence: Contact ERA Ranger Mine for approval to use any information contained in the report. Tel: (08) 89381306 and Fax: (08) 89381203]

SUMMARY

'This 4 year study (Oct 94 - Dec 98) examined how waterbirds used three natural and five constructed waterbodies on the Ranger Mine lease. The major aims were to (1) establish patterns of waterbird usage at Ranger compared to two similar reference waterbodies in Kakadu National Park; (2) assess the potential for waterbirds to transport heavy metals and other contaminants from the lease; and (3) recommend strategies to minimise the attractiveness of constructed waterbodies to waterbirds'. The paper discusses reasons for monitoring waterbirds as well as the ecology of the waterbirds found in the lease area. 'Within the Ranger lease, waterbirds were recorded from three natural billabongs (Georgetown, Djalkmara, Coonjimba) and five constructed waterbodies (RP1, RP2, RP3, RP4, Tailings Dam, RP1 wetland filter). These waterbodies are associated with the mid to upper parts of Magela Creek in the East Alligator River catchment. The comparison sites (controls) were the geomorphically similar backflow billabongs (Sandy, Buba) associated with Nourlangie Creek in the South Alligator River catchment'. Species richness and abundance were recorded from standard observation sites and at standard times, approximately monthly. Species were classified into trophic groups and the number and composition of groups present was also used as a comparison between the Ranger waterbodies and the control sites. The surface area and the percentage of aquatic vegetation was estimated for each waterbody. "Electrical conductivity (as a measure of salinity levels) was assumed to indicate the degree of contamination or 'health' of waterbodies".

'A total of 50 species were recorded in this study and combined with earlier records, the total species list for Ranger now stands at 65 species which is 82% of all waterbird species associated with inland waters in Kakadu National Park'. The species recorded at each of the waterbodies, their listing under international agreements and their classification into trophic groups are tabulated in the report. Waterbird abundance and richness at each of the waterbodies is also given. 'Waterbird richness was similar at the Ranger billabongs (36 spp.) and Kakadu reference billabongs (33 spp.) but greater at the Ranger constructed waterbodies (44 spp.). No IUCN threatened species were recorded but about half (26 spp.) are listed under one or more international agreements (CAMBA, JAMBA, BONN). Relatively more listed species were recorded at the constructed waterbodies, including the Tailings Dam (10 spp.)'. 'More waterbirds were recorded during Dry seasons than Wet seasons. The Kakadu reference billabongs had greater abundances than Ranger waterbodies with the lowest numbers recorded at the constructed waterbodies. For billabongs, there was a trend of increasing waterbird abundance with increasing area of surface water. For all waterbodies, there was a positive logarithmic relationship between species richness and abundance'.

'That some species visited the Tailings Dam only is of concern, especially since most of the species are listed on international agreements. Ranger should continue to monitor bird visitations to the Tailings Dam and, if necessary, verify waterbird behaviour at this waterbody'. 'The attractiveness of constructed waterbodies to waterbirds can be minimised by building deep pools with steep edges and maintaining both water and peripheral edges free of vegetation. The creation of aseasonal mudflats probably cannot be avoided during Dry season water management practices at Ranger, but most waterbirds thereby attracted could be discouraged from feeding by maintaining vegetation-free areas'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Although three of the natural billabongs sampled are located in the Magela Creek catchment they are situated upstream of where the Swift Creek system joins the Magela floodplain; thus the list of waterbird species is not directly relevant. Species abundances and richness were found to be similar between the billabongs of the different catchments; if similar habitats occur in the Swift Creek system the information on waterbird diversity may be applicable.

TITLE: *OSS/ANPWS waterbird population and habitat monitoring project.*

AUTHOR(s): Dostine P & Skeat A 1993.

PUBLICATION: Internal report 111, Supervising Scientist for the Alligator Rivers Region, Canberra/Darwin. Unpublished paper.

LOCATION: SERIES SSAR IR 111.

SUMMARY

This report presents data on the abundance of waterbirds on the Magela floodplain. Data was derived from aerial surveys along fixed transects, conducted over the mid-to-late Dry season in 1990, 1991 and 1992. Estimates of the densities and numbers of waterbirds, for each of the study years, are given in the report. A total of 52 species were identified consisting primarily of egrets, herons, ibis, spoonbills, cormorants, terns, waders, raptors, waterfowl, grassland species and woodland vagrants. Densities recorded for August in 1990, 1991, 1992 were compared with the data collected for August 1981 to 1984 by Morton et al (1991). For most species the estimates for August 1990 and 1991 were within the range of estimates recorded for 1981-1984; several species for August 1992 were below the range recorded between August 1981-1984.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Estimates of waterbird numbers and densities, for the Magela floodplain, were given for the whole floodplain, not for individual transects. As data are not available relating directly to the area where Swift Creek joins the Magela floodplain, the data obtained in this study may only be loosely applied to Swift Creek and nearby habitats on the Magela floodplain.

TITLE: Birds of wetlands and riparian forests in the Alligator Rivers Region.

AUTHOR(s): Morton SR & Brennan KG 1983.

PUBLICATION: In *Environmental protection in the Alligator Rivers Region: A scientific workshop.* Vol 1, Jabiru 17-20 May 1983, Supervising Scientist for the Alligator Rivers Region, 42.1-42.23. Unpublished paper.

LOCATION: CR SSAR 010 (Vol 1).

SUMMARY

The main aim of this paper was to examine the distribution and abundances of waterbirds in the Alligator Rivers Region that may be affected by water-borne contamination, with special reference to the Magela Creek system. Data currently available on the avifauna of the Region and in the Magela Creek system were reviewed to produce a species list of the waterbirds occurring in the area. The habitat within the Magela Creek was divided into three habitats: 'channel', 'open floodplain' and 'floodplain fringe' and the species occurring within each habitat were recorded. This species list is presented in a table in the paper. This information is largely non-quantitative, but indicates the diverse nature of the avifauna in the area.

Monthly aerial surveys along fixed transects were conducted to gather quantitative data (i.e. abundances) on the waterbirds occurring on four of the major floodplains in the Region (Magela, Nourlangie, Cooper and East Alligator floodplains). Monthly ground surveys were also conducted at ten groups of sites on the southern end of the Magela floodplain. 'A point census method based on a bounded variable circle [was] used to describe quantitatively the avifauna of the creek channel and fringing forests of the Magela Creek system'. Five census areas were used; two were located in Magela Creek, one in the paperbark swamp north of Mudginberri Billabong, and two others in woodland and forest near Magela Creek.

Work commenced in 1981; at the time of writing only a preliminary analysis of the data had been conducted. Floodplains of the East Alligator and Cooper have relatively few birds, except during the Wet season. Birds on the Nourlangie floodplain reach a peak in August, but leave in October as the drying of the swamps begins. As the Dry season advances most species on the Magela floodplain appear to follow shallow water inward from the edge of the floodplain; as soon as the floodplain fills at the commencement of the Wet many birds apparently leave altogether. The point census data indicate that 'late in the Wet season and for the first half of the Dry season, the Creek supports relatively few birds while the fringing forest contains a high population of birds throughout the year, with peak densities probably occurring in the late Dry season'.

'The results from the present work, together with qualitative information available on diets, will open the way for identification of species most at risk from potential contamination in the channel and fringing forests of Magela Creek. Supplementary studies on the details of their diets and on background levels of contaminants could then begin'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Ground survey data on waterbird distributions and abundances collected from sites in the vicinity of Nankeen and Jabiluka billabongs are directly relevant to Swift Creek, as these billabongs are located near the confluence point of Swift Creek with the Magela floodplain. However, these data are not presented in the paper, as they had not been analysed at the time of writing. The species list of waterbirds on the Magela floodplain may be of some relevance, but is general and not site-specific.

TITLE: Distribution and abundance of ducks in the Alligator Rivers Region, Northern Territory.

AUTHOR(s): Morton SR, Brennan KG & Armstrong MD 1990a.

PUBLICATION: *Australian Wildlife Research* 17, 573-590.

LOCATION: ARRI File 1141, Journal Shelves.

SUMMARY

Changes in the abundance of wandering whistling-ducks (*Dendrocygna arcuata*), plumed whistling-ducks (*D. eytoni*), radjah shelducks (*Tadorna radjah*), Pacific black ducks (*Anas superciliosa*), and grey teals (*A. gibberifrons*) were surveyed on five floodplains in the Alligator Rivers Region. The five floodplains were the Magela, Nourlangie, East Alligator and Cooper floodplains, and Boggy Plain (a large backswamp of the South Alligator floodplain). Aerial surveys were conducted monthly from 1981 to 1984 along predetermined transects. Ground surveys were conducted during the same period on the Magela floodplain at 10 groups of sites, to provide more detailed distribution information.

Average monthly densities of the five species of ducks on the five floodplains, and at the ten groups of sites on the Magela floodplain, are provided in the report. 'The Magela floodplain was inhabited by few ducks during the Wet season (November to March), but numbers then increased to dramatic peaks in the late Dry season. The Nourlangie floodplain and Boggy Plain showed similar patterns, but the numbers of ducks were usually fewer. Ducks were uncommon on the shallower East Alligator and Cooper floodplains except for relatively brief periods in the Wet season. The ground surveys suggested that ducks sought out the persistent swamps that characterise the Magela floodplain in the Dry season. Ground surveys also indicated that aerial surveys underestimate densities; on the basis of correction factors calculated from the ground surveys, peak numbers on the five floodplains were roughly estimated to be 400 000 wandering whistling-ducks, 70 000 plumed whistling-ducks, 20 000 radjah shelducks, 50 000 Pacific black ducks, and 50 000 grey teal. Pink-eared ducks *Malacorhynchus membranaceus* and hardhead *Aythya australis* were recorded sporadically in low numbers. The paper suggests that 'the Alligator Rivers Region acted as a Dry refuge for large concentrations of ducks because of the atypical persistence of freshwaters on the Magela and Nourlangie floodplains and some of the backswamps of the South Alligator, such as Boggy Plain. The large aggregations appear to be unique in Australia'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Abundance data collected during the surveys of the Magela floodplain are applicable to Swift Creek. In particular, the data from the ground survey sites 4, 5 and 6 are relevant as the sites are in proximity to the confluence between Swift Creek and the Magela floodplain.

TITLE: Distribution and abundance of magpie geese, *Anseranas semipalmata*, in the Alligator Rivers Region, Northern Territory.

AUTHOR(s): Morton SR, Brennan KG & Armstrong MD 1990b.

PUBLICATION: *Australian Journal of Ecology* 15, 307-320.

LOCATION: ARRI File 1285, Journal Shelves.

SUMMARY

Changes in the abundance of magpie geese were surveyed on five floodplains in the Alligator Rivers Region. The five floodplains were the Magela, Nourlangie, East Alligator and Cooper floodplains, and Boggy Plain (a large backswamp of the South Alligator floodplain). Aerial surveys were conducted monthly from 1981 to 1984 along predetermined transects. Ground surveys were conducted during the same period on the Magela floodplain at 10 groups of sites, to provide more detailed distribution information.

Average monthly densities of magpie geese on the five floodplains, and at the ten groups of sites on the Magela floodplain, are provided in the report in the form of figures. 'The aerial surveys showed that the Magela floodplain was inhabited by few geese during the Wet season (November to March), but that numbers increased to an estimated average peak of 80 000 in the late Dry season. The Nourlangie floodplain and Boggy Plain exhibited a similar pattern, except that the peaks occurred 2-3 months before the end of the Dry season and comprised many more geese (an estimated average of 350 000 birds). In contrast, geese were uncommon on the East Alligator floodplain except during the Wet season, and densities and numbers were lower than on the three previous plains. The Cooper floodplain was occupied intermittently, and numbers and densities were always relatively low. Geese appeared to return from their breeding localities to the floodplains of the Alligator Rivers Region progressively during the Dry season, concentrating first on the extensive *Eleocharis* swamps of the Nourlangie floodplain and then waiting out the remainder of the Dry on the substantial permanent waters of the Magela floodplain and other nearby wetlands. Ground surveys on the Magela floodplain suggested that geese were highly mobile, apparently seeking suitable nesting habitat in the late Wet season, and then a sequence of feeding areas during the Dry season. Aerial surveys underestimated densities; on the basis of ground surveys, average peak numbers on the Magela plain were calculated to be 500 000'. The study estimates 'that the Alligator Rivers Region supported an average of about 1.6 million geese in the Dry season, but very many fewer during the Wet season'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Abundance data collected during the surveys of the Magela floodplain are applicable to Swift Creek. In particular, the data from the ground survey sites 4, 5 and 6 are relevant as the sites are in proximity to the confluence between Swift Creek and the Magela floodplain.

TITLE: *Distribution and abundance of waterbirds in the Alligator Rivers Region, Northern Territory.*

AUTHOR(s): Morton SR, Brennan KG & Armstrong MD 1991.

PUBLICATION: Open file record 86, Supervising Scientist for the Alligator Rivers Region, Canberra/Darwin. Unpublished paper.

LOCATION: SERIES SSAR OFR 86, CR ANCA 047.

SUMMARY

Changes in the abundance of waterbirds were surveyed on five floodplains in the Alligator Rivers Region. The five floodplains were the Magela, Nourlangie, East Alligator and Cooper floodplains, and Boggy Plain (a large backswamp of the South Alligator floodplain). Aerial surveys were conducted monthly from 1981 to 1984 along predetermined transects. Ground surveys were conducted during the same period on the Magela floodplain at 10 groups of sites, to provide more detailed distribution information. In addition, 18 billabongs along the Magela Creek system were surveyed. Aerial surveys were conducted of all channel and backflow billabongs, while the floodplain billabongs were surveyed concurrently with the ground counts.

Monthly abundances and densities were calculated for each species and for all the species combined, on each of the five floodplains. The monthly density estimates were grouped into three-yearly data sets concerning Wet and Dry seasons to give information on seasonal fluctuations. Species richness and diversity were also calculated for each floodplain. The distribution of species of waterbirds among the 18 billabongs is given, and densities for all the species combined were calculated for each billabong. Estimated maximum abundances of common species of waterbirds in the overall Alligator Rivers Region are also presented, along with the likely sources of immigrants.

A list of the species recorded in the study, with their common names, is given in the paper. Each species is discussed in detail in terms of its abundance, distribution and seasonal fluctuations. The waterbirds recorded in the study area fall into ten main classes: magpie geese; ducks; egrets and herons; ibis and storks; cormorants and grebes; rails and their relatives; waders; terns; raptors; and terrestrial birds.

The surveys of the waterbirds on the five floodplains indicated that 'waterbirds are uncommon in the Alligator Rivers Region in the Wet season but are exceedingly abundant during the Dry season. The influx is dominated numerically by magpie geese, but nearly all species become more abundant in the Dry season. Waterbirds appear to migrate into the Region from shallower floodplains to the west, from sub-tropical areas to the south, from far distant locations in southern Australia, and from the northern hemisphere. Few species breed in large numbers in the Region'.

'Two floodplains support most of the birds – the Magela and the Nourlangie – but other smaller but equally persistent wetlands such as Boggy Plain are also important refuges in the late Dry season. Ground surveys on the Magela plain showed that waterbirds aggregate on the shallow freshwaters that become scarce at this time, and that densities calculated from the air are likely to be under-estimates. The total regional population of waterbirds late in the Dry season is likely to be in excess of two and a half million individuals. These studies confirm that the Alligator Rivers Region is unique in Australia in the diversity and abundance of waterbirds that it supports. To assist with the management of this extraordinary natural resource, recommendations are given for management and research requirements concerning waterbirds in Kakadu National Park'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Abundance data collected during the surveys of the Magela floodplain are applicable to Swift Creek. In particular, the data from the ground survey sites 4, 5 and 6 are relevant as the sites are in proximity to the confluence between Swift Creek and the Magela floodplain. Similarly, the information on the distribution of species of waterbirds among the 18 billabongs of the Magela Creek system is relevant. Two of the billabongs surveyed (Jabiluka and Nankeen Billabongs) are located near the confluence point.

TITLE: Distribution and abundance of brolgas and black-necked storks in the Alligator Rivers Region, Northern Territory.

AUTHOR(s): Morton SR, Brennan KG & Armstrong MD 1993a.

PUBLICATION: *Emu* 93, 88-92.

LOCATION: ARRI File 2844.

SUMMARY

Changes in the abundance of brolgas (*Grus rubicundus*) and black-necked storks (*Ephippiorhynchus asiaticus*) were surveyed on five floodplains in the Alligator Rivers Region. The five floodplains were the Magela, Nourlangie, East Alligator and Cooper floodplains, and Boggy Plain (a large backswamp of the South Alligator floodplain). Aerial surveys were conducted monthly from 1981 to 1984 along predetermined transects. Ground surveys were conducted during the same period on the Magela floodplain at 10 groups of sites, to provide more detailed distribution information.

Average monthly densities of the brolgas and black-necked storks on the five floodplains, and at the ten groups of sites on the Magela floodplain, are provided in the report in the form of figures and a table respectively. 'Aerial surveys indicated that brolgas were significantly more abundant in the Dry season than the Wet; they congregated particularly on the Cooper floodplain, were of intermediate abundance on the Magela and Nourlangie floodplains, and occurred only sporadically on the East Alligator floodplain and Boggy Plain. Ground surveys indicated that aerial surveys under-estimated abundance; based on rough correction factors calculated from ground surveys, peak numbers on the five floodplains were estimated at about 24 000. Black-necked storks were seen in low numbers on all floodplains, and did not vary significantly in abundance throughout the year. The total population was estimated at about 1 800 birds'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Abundance data collected during the surveys of the Magela floodplain are applicable to Swift Creek. In particular, the data from the ground survey sites 4, 5 and 6 are relevant as the sites are in proximity to the confluence between Swift Creek and the Magela floodplain.

TITLE: Distribution and abundance of herons, egrets, ibises and spoonbills in the Alligator Rivers Region, Northern Territory.

AUTHOR(s): Morton SR, Brennan KG & Armstrong MD 1993b.

PUBLICATION: *Wildlife Research* 20, 23-43.

LOCATION: ARRI File 1627.

SUMMARY

Changes in the abundance of Pacific herons (*Ardea pacifica*), pied herons (*Ardea ibis*), great egrets (*Egretta alba*), little egrets (*Egretta garzetta*), intermediate egrets (*Egretta intermedia*), glossy ibis (*Plegadis falcinellus*), sacred ibis (*Threskiornis aethiopica*), straw-necked ibis (*Threskiornis spinicollis*) and royal spoonbills (*Platalea regia*) were surveyed on five floodplains in the Alligator Rivers Region. The five floodplains were the Magela, Nourlangie, East Alligator and Cooper floodplains, and Boggy Plain (a large backswamp of the South Alligator floodplain). Aerial surveys were conducted monthly from 1981 to 1984 along predetermined transects. Ground surveys were conducted during the same period on the Magela floodplain at 10 groups of sites, to provide more detailed distribution information.

Average monthly densities of herons, egrets, ibises and spoonbills on the five floodplains, and at the ten groups of sites on the Magela floodplain, are provided in the report in the form of figures. 'The aerial surveys indicated that the Magela floodplain was inhabited by few of these birds during the Wet season (November to March), but that numbers then increased substantially in the Dry season. The Nourlangie floodplain and Boggy Plain showed similar patterns, but the number of birds tended to be lower. Birds were generally uncommon on the shallower East Alligator and Cooper floodplains, except for egrets in the Wet season. Ground surveys suggested that the birds sought out the persistent swamps that characterise the Magela floodplain in the Dry season. Ground surveys also indicated that aerial surveys underestimated densities. On the basis of correction factors calculated from ground surveys, peak numbers on the five floodplains were roughly estimated to be about 4 000 pacific herons, 50 000 pied herons, 300 000 egrets (primarily intermediate egrets), 60 000 glossy ibis, 16 000 sacred ibis, 80 000 straw-necked ibis and 35 000 royal spoonbills. Great-billed herons (*Ardea sumatrana*), white-faced herons (*Ardea novaehollandiae*), striated herons (*Butorides striata*), rufous night herons (*Nycticorax caledonicus*), black bitterns (*Dupetor flavicollis*) and yellow-billed spoonbills (*Platalea flavipes*) were recorded sporadically in low numbers'. The paper suggests that 'the Alligator Rivers Region acted as a Dry-season refuge for herons, egrets, ibises and spoonbills because of the unusually persistent fresh waters of the Magela and Nourlangie floodplains and some of the backswamps of the South Alligator, such as Boggy Plain'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Abundance data collected during the surveys of the Magela floodplain are applicable to Swift Creek. In particular, the data from the ground survey sites 4, 5 and 6 are relevant as the sites are in proximity to the confluence between Swift Creek and the Magela floodplain.

MAMMALS

TITLE: Some aspects of the ecology of the mammal fauna of the Jabiluka area, Northern Territory.

AUTHOR(s): Kerle JA & Burgman MA 1984.

PUBLICATION: *Australian Wildlife Research* 11, 207-22.

LOCATION: ARRI File 0161.

SUMMARY

'A mammal survey of the Jabiluka exploration lease was undertaken from July 1979 to September 1981, in order to obtain information about the distribution, abundance, and response to disturbance of the mammal species present'. The lease area incorporates 'a large outlier of the Arnhem Land Plateau complex, a part of the Magela Creek floodplain, and some lowland country consisting of undulating plains and small rocky outcrops'. Six visits were made to the lease area and trapping was conducted on 3 consecutive nights per visit, using 3 trap types. The 18 sites sampled were 'selected to cover the entire range of floristic and structural vegetation types present'. 'Floristic lists and general structural descriptions of vegetation were used to classify each site in terms of the floristic classification of Burgman and Thompson (1982)'.

Thirty native and five introduced mammal species were recorded in the lease area, and are listed in the paper. Nineteen floristic categories were identified. The distribution of the mammal species recorded in the lease area, and their relative abundance in each of the defined floristic categories is given in the report. 'In general, mammals were not abundant in the area, with an overall trap success of 5% and an average of 1.9 animals sighted per spotlight-hour'. 'Three major groups of mammal species corresponded to the primary groupings of vegetation in the study area: riparian woodland, dryland woodland, and open forest and sandstone. This last group was subdivided into three on-site preferences. Two ungrouped species were found in a variety of habitats. The distribution of mammals was very patchy, and their abundance varied seasonally. This may result from rainfall patterns, fire occurrence and fire history, as well as from landform and edaphic factors. The species responded to the variation in environment and the consequent mosaic of habitats by three strategies: by rapid response to changes in microhabitat through increased dispersion or moving to more favourable habitats, by restriction to stable habitats, or by adaptation to a variety of habitats'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Several of the sampling sites used were located adjacent to the Swift Creek system making the information on the mammal species relevant.

GENERAL STUDIES

TITLE: *Aquatic studies at Ranger mine: A whole-ecosystem approach. Final report prepared for ERA Environmental Services Pty Ltd.*

AUTHOR(s): Corbett L (Commonwealth Scientific Research and Industrial Organisation, Division of Wildlife and Ecology) 1996.

PUBLICATION: Unpublished paper.

LOCATION: CR RAN 313.

SUMMARY

Using a whole-ecosystem approach this study examines the species richness and relative abundance of aquatic vegetation, riparian vegetation, microinvertebrates, macroinvertebrates, fishes, frogs, reptiles, bushbirds, waterbirds and mammals at waterbodies on the Ranger lease. For the purpose of this current report the invertebrates will be excluded from the summary as they are being reviewed in a separate report.

Three Magela Creek billabongs in the vicinity of Ranger Uranium Mine (Coonjimba, Djalkmara and Georgetown) and Retention Pond Nos 1, 2 and 4 were studied. Two billabongs in the Nourlangie Creek catchment (Buba and Sandy) which are located away from the mine were used as comparison sites for the near-mine billabongs. Jabiru Lake was used a comparative constructed site for the retention ponds. Sampling took place between October 1994 and May 1996; not all groups were sampled at the same intervals or frequency. Presence/absence and abundance/cover information for aquatic macrophytes was recorded using transects and floating quadrats. Mapping units were identified with aerial photographs, and within each unit, plots were sampled to measure species abundance and percentage cover of riparian vegetation. Gill and seine nets were used to survey fish. Reptiles and frogs were studied using pit-traps and transect surveys. Bushbirds and waterbirds were counted from vocalisations and observations. Traps, spotlighting and observation of tracks were used to survey the mammal fauna.

The dominant aquatic and riparian vegetation is identified for each site, and a complete species list with lifeforms is given in the report. Mean percentage cover for each waterbody is also provided. A total of 25 fish, 33 reptile, 15 frog, 15 mammal, 82 bushbird and 48 waterbird species were recorded. Species composition, as well as species richness and abundances are listed for each of the vertebrate groups. For each of the flora and fauna groups the species were classified into trophic groups. The number and structure/composition of trophic groups at the sites potentially impacted by the mine was compared with the unimpacted sites, as a method of assessing the health of the Ranger waterbodies. A high degree of similarity was recorded between the Ranger and control sites, indicating that the Ranger billabongs are healthy.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

The sites surveyed in this study are not located in the vicinity of Swift Creek.

TITLE: Environmental monitoring at Ranger Mine: a whole-ecosystem approach.

AUTHOR(s): Corbett L 1997.

PUBLICATION: In *Proceedings of the 22nd Annual Minerals Council of Australia Environmental workshop*, Adelaide, 1997, 240-254.

LOCATION: ARRI File 2858.

SUMMARY

'At ERA's Ranger Mine, the health of aquatic ecosystems was assessed by comparing trophic groups in billabongs potentially affected by mining operations with trophic groups in unimpacted billabongs elsewhere in Kakadu National Park'. Trophic groups are defined in terms of life forms and/or functional roles. 'This study was conducted in 1994-95 towards the completion of mining Ranger #1 but prior to the commencement of mining Ranger #3'. "The study sites were Coonjimba and Djalkmara billabongs (downstream of Ranger Mine) and Georgetown Billabong (upstream) which are all 'backflow' billabongs adjacent to Magela Creek, and the geomorphologically similar Buba and Sandy billabongs in the separate catchment of Nourlangie Creek about 35 km from the mine". The sampling techniques used are described in detail in Corbett (1996). Briefly, presence/absence and abundance/cover information for aquatic macrophytes was recorded using transects and floating quadrats. Mapping units were identified with aerial photographs, and within each unit, plots were sampled to measure species abundance and percentage cover of riparian vegetation. Gill and seine nets were used to survey fish. Reptiles and frogs were studied using pit-traps and transect surveys. Bushbirds and waterbirds were counted from vocalisations and observations. Traps, spotlighting and observation of tracks were used to survey the mammal fauna.

'The study recorded a total of 619 species of aquatic vegetation, microinvertebrates, macroinvertebrates, fishes, frogs, reptiles, bushbirds, waterbirds and mammals. These were categorised into 90 trophic groups of which 96% were present at the Ranger billabongs compared to 97% in the reference billabongs'. The 90 trophic groups identified within major taxa, as well as the total number of species and trophic groups at Ranger and Nourlangie billabongs, are listed in the report. 'These data indicated that Ranger billabongs were healthy and representative of backflow billabongs in Kakadu National Park after 16 years of uranium mining'.

'Overall, these data now serve as a new benchmark of biodiversity at Ranger following the removal of feral buffalo in the mid-1980's and the subsequent recovery of ecosystems in Kakadu National Park. They also imply that the environmental management programs used by Ranger Mine and the regulatory authorities have been adequate over the existing life of the mine and would be suitable templates for the management of proposed future developments'. 'Given the advantages of a whole-ecosystem approach, future ecological monitoring of Ranger and other mines elsewhere in Australia should include whole-ecosystem assessments of aquatic ecosystems in particular'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

The sites surveyed in this study are not located in the vicinity of Swift Creek. However similar trophic groups may occur in this system; confirmation of this requires further research.

TITLE: *Jabiluka baseline surveys: terrestrial, arboreal and volant vertebrates; and terrestrial invertebrates. Final report prepared for ERA Ranger Mine by ERA Environmental Services Pty Ltd.*

AUTHOR(s): Corbett L (Energy Resources of Australia Environmental Services Pty Ltd) 1999.

PUBLICATION: Unpublished paper.

LOCATION: CR RAN 364.

[Commercial-in-confidence: Contact ERA Ranger Mine for approval to use any information contained in the report. Tel: (08) 89381306 and Fax: (08) 89381203]

SUMMARY

'Baseline surveys of vertebrates, particularly endangered and internationally listed species, were required at Jabiluka by the Minister for Resources and Energy as a component of approval for the Jabiluka EIS [environmental impact statement]'. Data on frogs, reptiles, birds and mammals were collected from fourteen sites within the study area, which comprised the Ranger and Jabiluka lease areas. The surveys were conducted in November 1997 and monthly from May to December 1998. Reptiles and amphibians were studied using pit traps and field surveys. Bush birds were recorded from vocalisations and observations, while mammals were recorded in live-traps, pit traps or from their tracks. Water birds were recorded from Ja Ja, Jabiluka and Nankeen billabongs, and from billabongs on the Ranger lease, Nourlangie catchment and constructed water bodies on Ranger and Jabiluka leases, for comparison purposes.

The data from the present survey were combined with data from the 1997 Dry season and 1997-98 Wet season, presented in two previous progress reports to the Minister (Corbett 1998, Corbett & Batterham 1998). A total of 240 vertebrate species were recorded: 99 bushbird, 33 waterbird, 37 mammal, 18 frog, 38 reptile and 15 fish species. Species richness, abundance and distribution are tabulated in the report. These results were compared with the data presented in the Jabiluka EIS (Kinhill Engineers Pty Ltd & ERA Environmental Services Pty Ltd 1996). 'The baseline surveys increased the previously known fauna lists at Jabiluka by 14 frog species, 7 reptiles, 9 bushbirds and 22 mammals'. Species recorded in the survey known to be listed under international agreements, or of conservation significance, are discussed; none are likely to be impacted by mining.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Several of the fourteen sites in the study area are located in or adjacent to the Swift Creek channel, making the data on species richness and abundance pertinent. Similarly, waterbirds were recorded at Jabiluka and Nankeen billabongs, which are in the vicinity of the junction between Swift Creek and the Magela floodplain, making these data relevant.

TITLE: Jabiluka fauna – baseline surveys.

AUTHOR(s): Corbett L & Batterham R (Energy Resources of Australia Environmental Services Pty Ltd) October 1998.

PUBLICATION: In *The Jabiluka project. Final six monthly progress report to the Minister for Resources and Energy: Additional environmental studies. Report prepared for ERA Ranger Mine by ERA Environmental Services Pty Ltd*, appendix 3. Unpublished paper.

LOCATION: CR RAN 346.

[Commercial-in-confidence: Contact ERA Ranger Mine for approval to use any information contained in the report. Tel: (08) 89381306 and Fax: (08) 89381203]

SUMMARY

The aim of this report was to provide baseline data on the terrestrial and aquatic fauna of the Jabiluka lease area. 'The first 6-monthly report provided information on terrestrial vertebrates sampled at 12 sites in the Dry season in November 1997 (Corbett 1998). 'This second 6-monthly progress report provides further data on terrestrial vertebrates sampled following the 1997-98 Wet season at similar sites; data from the Wet and Dry season surveys are integrated. Additionally, data are included on benthic macroinvertebrates and fishes sampled from streams in the Jabiluka lease'. The information on the vertebrates, except for the fishes, has been combined with data collected in the 1998-99 Wet season and presented in Corbett (1999). For this reason only the data provided on the fishes will be reviewed in this current summary.

'Fishes were sampled from control sites (upstream of the mine and proposed access/haul road) and from treatment sites (downstream of the mine or proposed access/haul road) on Swift Creek, 7J Creek, North Magela Creek and Magela Creek on 5-6 May 1998'. Fish were captured using seine and hand netting. Approximately 50 chequered rainbowfishes were collected at each site for muscle and tissue analyses, and any other species collected or observed were recorded.

'Fifteen species were recorded and their abundance and distribution between sites is given' in the report. Rainbowfishes, particularly the chequered rainbowfish, were the most common species in all streams; and relatively more were captured in the smaller streams (Swift and 7J Creeks). Species richness was greater in the larger and more persistent streams (Magela and North Magela Creeks) and Mariana's hardyhead was recorded only there'. A study conducted by Morley (1981) surveyed two sites located on Swift Creek and 7J Creek close to the sites used in the current study. Morley recorded 14 species at the two sites compared to 13 recorded in this study, and found a difference in richness between small and large streams, similar to the results of this study.

The remainder of the study discusses the elements found in the liver and muscle tissues of two species of rainbowfishes.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

The list of fish species recorded in Swift Creek is relevant.

TITLE: Productivity and nutrient dynamics of seasonally inundated floodplains in the Northern Territory.

AUTHOR(s): Finlayson M 1988.

PUBLICATION: In *North Australia: progress and prospects*. Vol 2, eds D Wade-Marshall & P Loveday, Australian National University, Darwin, 58-83.

LOCATION: ARRI File 0424.

SUMMARY

This paper describes the species composition and productivity of plants and vertebrates on the seasonally inundated floodplains of the Top End of the Northern Territory. The majority of the information comes from previous studies done on floodplains in the Alligator Rivers Region, in particular the Magela floodplain.

'*Oryza meridionalis* grasslands and *Melaleuca* spp. woodlands are extensive and occur across most of the floodplains. The sedges *Eleocharis* spp. and *Fimbristylis* spp., the annual grass *Hygrochloa aquatica* and the water lillies *Nymphaea* spp. and *Nymphoides* spp. are also common'. Several detailed classifications have been produced for the vegetation of the Magela Creek floodplain and these are briefly discussed. Thirty-five perennial species occur on the Magela floodplain, including the emergent aquatic grasses *Pseudoraphis spinescens* and *Hymenachne acutigluma*, and the paperbark trees *Melaleuca* spp. These perennials collectively occupy 80% of the floodplain. Fifty-seven species of annuals occur, 15 are aquatic and 42 are terrestrial herbs, grasses and sedges. Dry weights of three aquatic grasses on the Magela floodplain were investigated and found to have high annual production rates relative to other aquatic species. The three grasses *Pseudoraphis spinescens*, *Hymenachne acutigluma* and *Oryza meridionalis* cover 18%, 15% and 13% of the floodplain respectively indicating that the floodplain is highly productive. The productivity of the floodplain vegetation is being affected by the increasing invasion of a number of weed species, including *Mimosa pigra*, *Salvinia molesta* and *Brachiaria mutica*.

The floodplains of the Northern Territory contain a large number of vertebrate animals. 'These include freshwater and saltwater crocodiles, other large reptiles such as the filesnake and freshwater turtles, freshwater fish, introduced Asian water buffalo and many species of water birds. These numbers when taken in conjunction with the sizes of the animals, convey the reality of a high standing biomass of animals'. Estimates of the abundance, size or weight of a variety of wetland animals in the Northern Territory are given in the report. 'In addition to the plants and vertebrate fauna discussed above, the floodplain ecosystems contain large and dynamic populations of the invertebrate animals and algae. These organisms add to the diversity and productivity already discussed, but very little is known about their role as primary producers or consumers'. The remainder of the paper discusses the cycling of nutrients by vegetation on the Magela floodplain

RELEVANCE AND PROXIMITY TO SWIFT CREEK

The majority of the information in the paper comes from studies done on the Magela floodplain and provides a context for floodplain habitats found near the confluence with Swift Creek. However, as it is a review paper no site-specific information is given.

TITLE: Characteristics of a seasonally flooded freshwater system in monsoonal Australia.

AUTHOR(s): Finlayson CM, Cowie ID & Bailey BJ 1990a.

PUBLICATION: In *Wetland ecology and management: Case studies,* eds DF Whigham et al, Kluwer Academic Publishers, 141-162.

LOCATION: ARRI File 1030.

SUMMARY

Physico-chemical and biological characteristics of the Magela floodplain are outlined through a review of previous studies conducted on the floodplain. 'This paper describes some of the ecological documentation that has occurred since 1978 when investigations were initiated by the Office of the Supervising Scientist for the Alligator Rivers Region and by Pancontinental Limited, the holder of the Jabiluka mining lease adjacent to the floodplain. Aspects considered are water quality and stratification of permanent waterholes, algal diversity and productivity, vegetation distribution and seasonality, and diversity of the native fauna, including aquatic invertebrates, fish, amphibians, reptiles, and birds'.

'The phytoplankton community is very diverse with more than 160 diatom taxa and 530 taxa from other groups. Chlorophyll values were not generally high except during blooms. The macrophytic flora was also diverse with 225 species, 139 of them being annuals'. A broad classification identified 10 vegetation types on the floodplain. These were *Melaleuca* open forest and woodland; *Melaleuca* open woodland; mixed swamp; *Oryza* grassland; *Hymenachne* grassland; *Pseudoraphis* grassland; *Hymenachne-Eleocharis* swamp; mixed grass-sedgeland; *Eleocharis* sedgeland; and open water community. The floristic composition and foliage cover of the 10 main macrophyte communities varied seasonally; the abundance and floristic richness of the Wet season contrasting with the sparse cover of the Dry season'. Descriptions and a map of the 10 vegetation communities are provided in the paper.

'The vertebrate and invertebrate fauna were also diverse. The invertebrates demonstrated vast temporal and spatial differences in species abundance. Species diversity was greatest during the Wet season. Similarly, the distribution and habitat selection and abundance of the fishes and amphibia were influenced by the occurrence of floodwaters during the Wet season. The water birds were also numerous and diverse. Their usage of the floodplain varied seasonally with about 200 000 occurring during the Dry season when food sources were scarce elsewhere'. The major species of fish, frogs, reptiles and birds found on the floodplain are listed in the report.

'Stimulation for this documentation came from proposals to discharge excess water from a uranium mine to Magela Creek. The biological documentation was one step in the process of determining standards and protocols to govern any releases of water. The assessment of any impact from the mining operation on the floodplain was complicated by changes brought about by other activities in the area. Control of feral animals and occurrence of aggressive alien plant species are two such activities'.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

This paper is a review paper and the study site locations are not given for each of the individual studies that were discussed. Some of the studies have collected data in the vicinity of the confluence of Swift Creek with Magela floodplain, hence these studies need to be examined separately to determine the direct relevance of the data to Swift Creek.

TITLE: Report II. Toxicity Studies on aquatic organisms and grass sedge communities in the Magela Creek area.

AUTHOR(s): Giles MS 1974.

PUBLICATION: In *Project 6 of Alligator Rivers Region environmental fact finding study: Four AAEC reports,* ed PJF Newton, Australian Atomic Energy Commission, Lucas Heights.

LOCATION: CR ALL 006.

SUMMARY

The aim of this study was to examine the sensitivities of a range of organisms from the Magela Creek system to possible pollutants released from uranium mining in the region. Fish as well as plants of the sedge community on the banks of the creek were studied between 1972 and 1973. A fish census was conducted in the Magela Creek channel and in Georgetown Billabong, using 'Chemfish' to intoxicate the fish. The number and mass of species recorded in the census are listed in the report. The remainder of the report focuses on acute toxicity testing of various organisms from the creek system.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

The sites surveyed were not in the vicinity of Swift Creek junction with the Magela floodplain.

TITLE: *The Jabiuka project: Draft environmental impact statement.* Vol 1-5.

AUTHOR(s): Kinhill Engineers & Energy Resources of Australia Environmental Services Pty Ltd 1996.

PUBLICATION: Energy Resources of Australia Limited, Sydney.

LOCATION: CR RAN 310.

SUMMARY

'The Draft Environmental Impact Statement (EIS) for the Jabiluka project describes a proposal by Energy Resources of Australia (ERA) to mine ore from the Jabiluka #2 ore body in the Alligator Rivers Region (ARR) of the Northern Territory, and its environmental consequences'. The major environmental issues addressed include: soils and erosion control; hydrology and hydrogeology; water and air quality; noise and vibration; waste management; visual issues; social infrastructure; Aboriginal community and cultural issues; radiation; World Heritage area issues; and flora and fauna. The last two issues are of primary interest for the purpose of this current report and thus have been reviewed.

Vegetation

The vegetation of the general Ranger and Jabiluka lease areas has been investigated as part of studies conducted for the greater Alligator Rivers Region, and during specific survey work associated with the Ranger and Jabiluka mine proposals'. An overview of the previous vegetation surveys and mapping that have been completed is provided in the EIS. 'A vegetation survey of the minesite and haul road corridor was also conducted for the EIS on April 15-17 1996'. Species were recorded and the plant community was given a structural form based on the dominant and/or characteristic species from each strata, combined with foliage protective cover of the major strata. 'Communities were classified as belonging to a broad alliance based on geomorphic location, and hence, moisture availability'.

A list of all terrestrial species recorded from previous surveys, and those recorded during the 1996 survey, is included in the EIS. The list contains family and species names, common names and which surveys identified the species. The type of community a species is found in, such as floodplain or riparian, is also given. One hundred and sixty-nine species from 62 families were recorded in the 1996 survey. Seventy-one tree and shrub species from 24 families were identified. 'Myrtaceae had the highest representation of tree and shrub species with 23'. 'Twenty-one grass species (Poaceae), 68 forb species from 36 families and 9 sedge species (Cyperaceae) were recorded'. 'No species of conservation significance were found in the survey conducted for the EIS. Nine species, however, were recorded during previous surveys' and these are discussed. One weed species was found which was *Passiflora foetida* (wild passionfruit). A brief overview is given of weeds in the Jabiluka lease area and Kakadu National Park.

The vegetation of the Jabiluka project area was classified into two broad alliances. '*Eucalypt* open woodland and open forest predominate in the Dryland Plain Alliance, while *Melaleuca* channel and floodplain woodland predominate in the Floodplain Alliance. Two other alliances

are found in proximity to the operations, namely the Escarpment Alliance (associated with the escarpment outliers), and the Escarpment Riparian Alliance, that is found in the local tributaries flowing from the sandstone escarpment'. A full description of the communities within both the Dryland Plain Alliance and Floodplain Alliance is presented in the EIS.

Fauna

Field surveys for fauna were not conducted for the EIS due to weather and access restrictions. Instead a literature review was conducted of all references containing information on the terrestrial and aquatic fauna in the Jabiluka area. Species recorded from the literature review for each of the Jabiluka area, the Magela Creek catchment and the Alligator Rivers Region are listed in the EIS. The number of faunal taxa recorded for each area is also given in the report. Overall the Region contains a rich vertebrate fauna: 67 fish species, 273 bird, 119 reptile, 25 frog and 36 species of native terrestrial mammals. 'The list of species actually recorded from the Jabiluka area is most likely incomplete as many species that have been recorded elsewhere in the Magela Creek catchment and even further afield in the ARR, are likely to be resident or be present in the Jabiluka area for some stages of their life cycle.'

The persistence of species/groups and their conservation status is discussed to provide an indication of those species which may be impacted on by the mine. The persistence of the major taxa was determined by examining their presence in the ARR over the last five years. A list of potentially threatened species in the ARR, their conservation status, their habitat and their likely presence in the Jabiluka area is also given the EIS. Thirteen mammal species, 11 bird, 15 reptile, 6 frog and 8 fish species were identified as being potentially threatened. Feral and introduced fauna is briefly discussed with respect to species that may be found within the lease or be inadvertently introduced.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Swift Creek runs adjacent to the Jabiluka lease area, making the data contained in the EIS relevant. In particular, the list of fauna present in the Jabiluka area is applicable. Similarly, several of the sites used in the vegetation survey were located near Swift Creek.

TITLE: *A review of Jabiluka Environmental Studies.* Vol 1-6.

AUTHOR(s): Morley AW (ed) 1981.

PUBLICATION: Pancontinental Mining Limited, Environmental Department, Jabiluka Division. Unpublished paper.

LOCATION: CR PAN 001.

SUMMARY

This report is a comprehensive account of the surveys conducted by the School of Biological Sciences, Macquarie University (as consultants to Pancontinental Mining Ltd) from 1977-1979, to describe the environmental baseline conditions of the Jabiluka project area. Studies were undertaken on a range of flora and fauna. The information on aquatic and terrestrial vegetation, phytoplankton, fish and birds is of primary interest for the purposes of this current report.

'Aquatic vasuclar plants were surveyed on the Magela floodplain between the northern end of Mudginberri Billabong and downstream to Nankeen Billabong. Over half of this area of the floodplain lies within the Jabiluka project area'. Presence/absence and cover abundance of hydrophytes was recorded along transects. Sixty-one species were recorded; 'three are restricted to shallow temporary rock pools on the sandstone escarpment, 1 species to the small ephemeral creeks, and 55 species to the floodplain and tributaries'. A list of the aquatic plants and their life forms is included in the report. Thirty-six hydrophyte communities were identified and described in the study. Terrestrial vegetation was surveyed using 107 sample plots throughout the Jabiluka project area and areas adjacent to the project boundary. Fifteen community types were recognised, four of which are associated with the floodplain. The communities are described, and a complete list of the species recorded is given in the report.

Phytoplankton species composition and abundance was described through analysis of fortnightly and monthly water samples. Eight major billabongs in the Magela Creek floodplain were examined; Nankeen, Jabiluka, Mine Valley, Ja Ja, Island, Winmurra, Buffalo and Leichhardt billabongs. A complete list of the species identified in the billabongs is given in the report. Abundance and species composition of the phytoplankton populations were found to fluctuate greatly. Algal blooms were irregular and thought to be controlled by a range of environmental parameters.

Birds were surveyed at the same sites as those examined for phytoplankton, with the exception of Buffalo and Leichhardt billabongs, which were excluded. Observations were conducted monthly giving data on species occurrence, population numbers and breeding of birds in the study area. A complete list of the bird species observed during the study is presented in the report. 'The presence of large numbers of single species in the region is a common occurrence, and the regional climate is often the most significant factor controlling the arrival and departure of these large single species populations'.

Fish were examined at 11 sites on the Magela Creek floodplain. These were Nankeen, Jabiluka, Mine Valley, Ja Ja, Ja Ja Extension, Island, Winmurra, Buffalo, Leichhardt, Kellys and 7J Creek Extension billabongs and Magela Crossing. Collection of fish was conducted monthly using nets. A list of the fish species collected, their presence in each of the billabongs, and their abundances for the duration of the study period is provided in the report. A total of 35 species of fresh water fishes were recorded from the floodplain billabongs. Nine species of fish were most abundant, while for seven species of fish only one specimen was collected. Several species of fish were found to have a restricted distribution, whilst others have been identified as having preferred habitats.

RELEVANCE AND PROXIMITY TO SWIFT CREEK

Phytoplankton, birds and fish were all surveyed in the vicinity of Jabiluka and Nankeen billabongs. Data on species composition, abundance and distribution for these billabongs are relevant to Swift Creek, as these billabongs are located in proximity of the junction between Swift Creek and the Magela floodplain. Aquatic and terrestrial vegetation was sampled at sites near the confluence point, making that data applicable.

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*** References that have been referred to but that have not been summarised as they do not contain information on species distribution and abundances.