Introduction

Over fifty different definitions of wetlands are currently in use world wide (Dugan 1990). The broadest of these has been provided by the Ramsar convention (1971), defining wetlands as:

"Areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres"

The above definition classes a vast area as wetlands. This study deals with a small sub-set of wetlands in Australia, termed freshwater tropical floodplains. Floodplains are low lying areas subject to periodic inundation. These commonly occur between river channels and raised land on the edge of valleys. In many areas they occur in coastal lowlands ending in estuarine deltas. Floodplains are also found far inland making up parts of large river systems. Freshwater tropical floodplains, therefore, are floodplains occurring in tropical climates that, when inundated, are flooded from a fresh water source.

Tropical floodplains serve many functions and are highly productive ecosystems (Finlayson 1988). They recharge and discharge groundwater, act as buffers controlling floods and retain nutrients, sediments and toxicants (Dugan 1990). Floodplains also provide valuable resources such as wildlife, fisheries, forests and agricultural products, and have both biological diversity and cultural heritage values (Dugan 1990).

The climate of tropical regions make these floodplains highly variable ecosystems. Tropical northern Australia is characterised by two distinct seasons, the wet and the dry (Lee and Neal 1984). The wet season occurs in summer, when a large volume of rain ($\approx$ 1500mm) falls over a 3-4 month period (December - March) causing floodplains to be inundated by several metres of water. This cyclic fluctuation is very predictable, with flooding occurring every year and plays a major role in determining the vegetation of such systems. However, the timing of onset and duration of flooding varies from year to year and it has been suggested that this variation among years largely determines the relative abundance of many plant species on tropical floodplains in Australia (Finlayson *et al.* 1989).

In recent years increasing recognition of the importance of tropical floodplains has instigated the development of conservation and management strategies for these systems (Finlayson 1995a). Before such strategies can be devised substantial baseline data is required in order to assess changes and identify threats to these systems. The Montreux Record guidelines outline mechanisms by which such information should be collected (Finlayson 1996). Degradation of ecosystems can be caused by many factors ranging from changes in the physical and chemical environment, both within and surrounding a system, to overutilisation of its products and resources or invasion from introduced fauna and flora.

Few floodplains in the world are free of invasions from introduced species. The impact that an introduced species has is largely determined by its ability to survive and reproduce in its new environment and the range of environmental conditions under which it can persist (Amor and Piggin 1977). Several introduced species have had major impacts on freshwater tropical floodplains in Australia. Examples include *Mimosa pigra* (Giant Sensitive Plant) which has invaded vast areas of northern Australia converting diverse communities into impenetrable vine thickets thereby excluding native flora and containing little habitat for wildlife (Lonsdale and Segura 1987). Similarly, *Salvinia molesta* a floating weed that reproduces rapidly has been found to completely cover areas of open water blocking out light and reducing dissolved oxygen, subsequently killing fish and submerged macrophytes in natural ecosystems (Storrs and Julien 1996).

Feral buffalo (*Bubalus bubalis*) introduced into northern Australia last century, have also been recorded to dramatically change floodplains by stirring up sediments and creating wallows and swim channels thus causing considerable destruction to vegetation cover (Letts *et al.* 1979; Fogarty 1982; Friend and Taylor 1984; Corbett *et al.* 1996).

The introduction of more than four hundred pasture species to northern Australia since the 1940's poses a significant threat to Australian tropical floodplains. Lonsdale (1994) noted that 13% of introductions have become weeds. *Brachiaria mutica* is one such species. Native to Africa and South America, it was introduced into Australia late last century (Wesley-Smith 1973) and since the 1960's has been extensively planted in Queensland and the Northern Territory (Clarkson 1995). It is now a widespread weed in coastal Queensland (Clarkson 1995). The rapid expansion of this species in natural ecosystems is only now being recognised and conflicting interests between conservationists and pastoralists makes management of this species difficult (Lonsdale 1994).

Mimosa pigra, Salvinia molesta, Bubalus bubalis and *Brachiaria mutica* have all been recorded on the Magela floodplain. The floodplain has been the subject of ongoing research since the discovery of two large uranium deposits within its catchment (Christian and Aldrick 1977; Fox *et al.* 1977). Physio - chemical characteristics of the water in the Magela Creek (which feeds the floodplain) and billabongs of the floodplain have been well documented (Walker and Tyler 1982; Walker *et al.* 1984; Brown *et al.* 1985; Noller and Hunt 1985). Research has been conducted into the formation of the floodplain sediments (Wasson 1992), as well as heavy metal and radionuclide distribution within sediments (Finlayson *et al.* 1985; Finlayson 1994). Studies on the fishes, frogs, birds, crocodiles and macroinvertebrates of the floodplain have also been conducted (Grigg and Taylor 1980; Bishop *et al.* 1981; Marchant 1982; Tyler and Cappo 1983; Tyler *et al.* 1983; Morton *et al.* 1984; Humphrey 1985; Jenkins and Forbes 1985; Julli 1985). In addition, algae found on the floodplain are well documented (Brady 1979; McBride 1983; Thomas 1983; Broady 1984; Ling and Tyler 1986).

Several inventory studies of vegetation on the floodplain have been conducted (Williams 1979; Sanderson *et al.* 1983; Finlayson *et al.* 1989) including specific research on vegetation of billabongs on the floodplain (Walker and Tyler 1983; Finlayson *et al.* 1993b). Vegetation surveys of the floodplain including wider areas have also been undertaken to assess alien plant species (Cowie *et al.* 1986; Cowie and Werner 1993) and more specific research has been conducted on the biomass and litter dynamics of *Melaleuca* forest (Finlayson *et al.* 1993a) as well as primary production and nutrient composition of dominant grasses in three communities on the floodplain (Finlayson 1991). A sediment germination trial assessing the species composition of the soil seed banks of these grassland communities has also been conducted (Finlayson *et al.* 1990). Sediment samples were germinated with the objective of comparing the size and species composition of plant populations arising from seed banks of these communities (*Oryza*, *Hymenachne* and *Pseudoraphis* grasslands) with the dominant vegetation of each community. Thus providing a more complete description of the vegetation of these communities than was available previously (Finlayson *et al.* 1990).

The importance of seed banks in aquatic plant communities has long been recognised (Darwin 1859) and recently emphasis has been placed on understanding the role of seed banks in vegetation regeneration within wetland habitats (Van der Valk and Davis 1978; Smith and Kadlec 1983; Brock *et al.* 1994).

The wetting / drying cycles in tropical floodplain ecosystems make seed banks a particularly important feature of these systems. Many species have adapted to survival in tropical floodplains and seeds or oospores commonly serve as a resting stage while conditions are not suitable for growth and reproduction (Gopal 1986) For example, aquatic species that require standing water for growth (eg, *Nymphoides* spp., *Nymphaea* spp. and Charophytes) may use seeds to ensure survival over the dry season. Conversely, mudflat or terrestrial species which cannot grow when inundated for long periods (eg. *Glinus oppositifolius*) rely on seeds to allow re-establishment or regeneration after drawdown (Leck 1989). Seeds also act as effective dispersal agents allowing species to gain access to potentially inhabitable sites. Due to their function seed banks can supply information about changes that may occur in vegetation over time including what vegetation may have been present in an area in the past (Roberts 1981). Such information is particularly useful if detailed knowledge of the life histories of species occurring in the community are available (Pederson and Van der Valk 1984). In any case seed bank data add to current knowledge about life histories of the species that they contain.

Most seed bank studies in tropical systems have focussed on forests or farmlands (Garwood 1989). Hence, little quantitative data on tropical wetland seed banks exists (Gopal 1986), with the study by Finlayson *et al.* (1990) being the only seed bank experiment conducted on a freshwater tropical floodplain ecosystem in northern Australia. A recent workshop identified key issues and priority research areas for this region (Finlayson 1995b) and highlighted the need for focussed research on freshwater tropical floodplains in Australia. This created an opportunity for this study to be conducted. Therefore the information gathered by this study fits into a national context as part of a holistic research program on tropical wetlands currently run by the Research Institute of the Supervising Scientist (***eriss***).

The invasion by *Brachiaria mutica* on the Magela floodplain has been recognised (Finlayson *et al.* 1989) but not quantified. In addition, limited information on the seed production capacity of grass species that dominate large areas of the floodplain exists.

Objectives

This study examined both extant vegetation and seed bank vegetation, of the Magela floodplain to help understand aspects of the dynamics of this floodplain. The objectives of the study were:

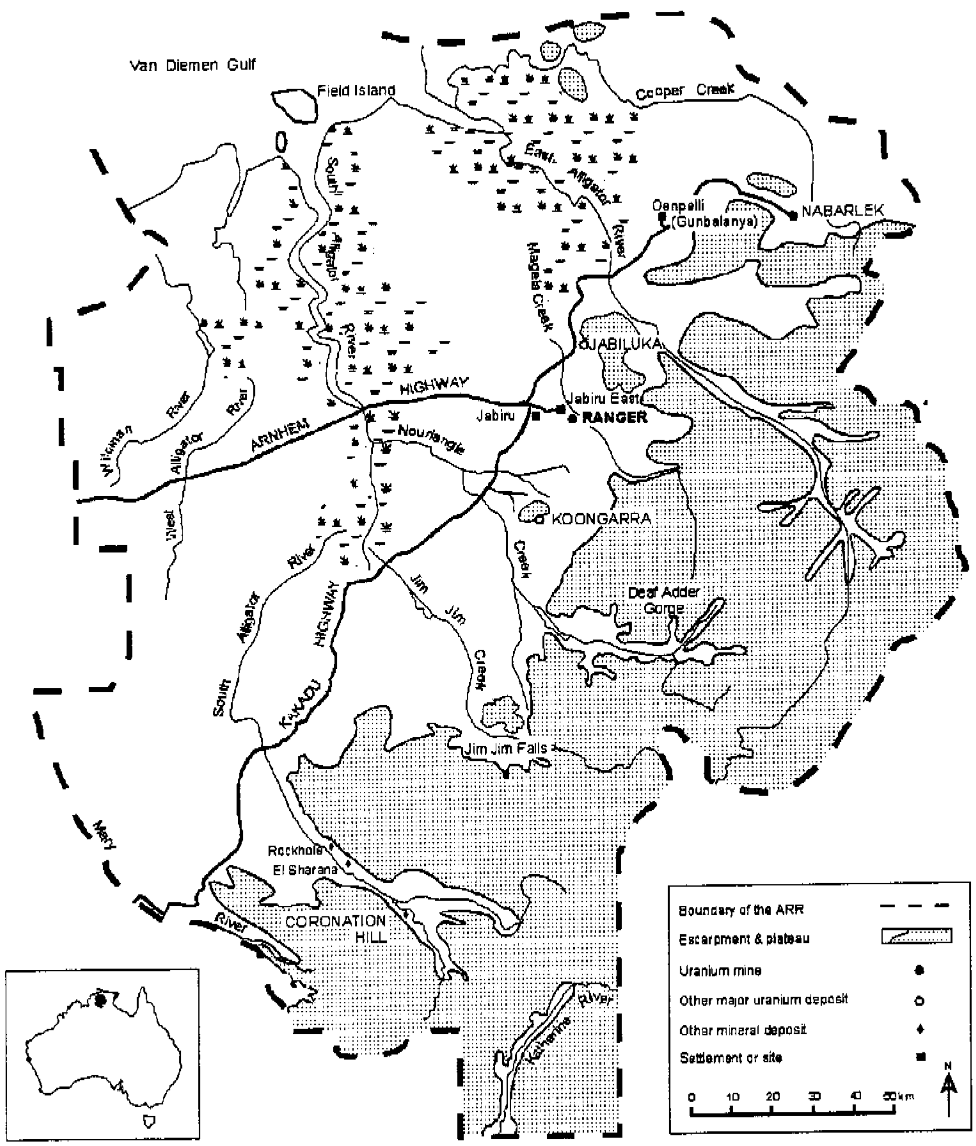
- To compare the extant vegetation of four grassland communities in wet and dry seasons.
- To determine change in the distribution of *Brachiaria mutica* (Para Grass) between 1991 and 1996 in extant vegetation over the study area.
- To assess germination from the seed banks of four grassland communities on the Magela floodplain in Kakadu National Park during 1995/96.
- To compare germination from the seed bank in 1995/96 with that in 1984.
- To examine the relationships between extant vegetation and seed banks of these communities.
- To determine if *Brachiaria mutica* seeds are present within grassland seed banks of the Magela floodplain.
- To estimate the potential seed production and seed viability of the dominant grass species in each community.

A vegetation survey identified extant vegetation communities on the floodplain which were subsequently mapped. Four communities were selected for investigation of seed banks (*Brachiaria, Oryza, Hymenachne* and *Pseudoraphis* grasslands). A study on seed production and viability of the dominant grass species in each community (*Brachiaria mutica, Oryza meridionalis, Hymenachne acutigluma* and *Pseudoraphis spinescens* was undertaken. This assists by placing survey and seed bank results into perspective through providing information on seed input into the soil. Additional information on the seed banks of *Brachiaria mutica* and *Oryza meridionalis* was attained by conducting soil seed counts, thus allowing the size of the seed bank of these two species to be estimated.

Chapter 2 The Study Site: Magela Floodplain

Site Selection & Description

The Alligator Rivers Region (ARR) lies approximately 200km east of Darwin and comprises the catchments of the East Alligator, West Alligator and South Alligator rivers (Map 2.1). A large proportion (80%) of this area is Kakadu National Park, Australia's largest National Park. Kakadu is one of seventeen places in the world listed as a world heritage area having both significant conservation and cultural value (UNESCO 1992) and the Magela floodplain which feeds into the East Alligator river is currently listed as a Ramsar site of international importance (Ramsar 1990).



Map 2.1 Alligator Rivers Region (ARR) the majority of which is now Kakadu National Park.(Map courtesy of ***eriss***)

The climate of the area is monsoonal having distinct wet and dry seasons. Annual rainfall varies from 1500 to 3500mm with most rainfall occurring during the wet season in summer (Dec-March). High temperatures (≈35C°) during the wet season are accompanied by relative humidities of about 80%. Both temperature and relative humidity drop to around 25C° and 50% respectively during the dry season (May-October). Most of the water inundating the Magela floodplain during the wet season is runoff from the surrounding sandstone plateaus.

Four different grassland communities were selected for detailed study (Map 2.2). Each is characterised by a different dominant grass species (*Brachiaria mutica, Oryza meridionalis, Hymenachne acutigluma* and *Pseudoraphis spinescens*). Vegetation on the study sites were previously described by Finlayson *et al.* (1989; 1990), as *Oryza*, *Hymenachne* and *Pseudoraphis* grassland communities. The *Brachiaria* grassland examined in this study occupies a large area that was *Oryza* grassland prior to 1989.

The same locations as those used by Finlayson *et al.* (1990) were sampled. Each sample area was determined by visual inspection of extant vegetation to select areas where dominant species were most uniform (specific sample sites were randomly located within these areas). Characteristics of the dominant species in each community and species that occur with them are:

Brachiaria grassland

Brachiaria mutica grows in dense clumps and dominates this community throughout the year. It reproduces vegetatively from stolons and no other species were found on initial inspection of this community.

Oryza grassland

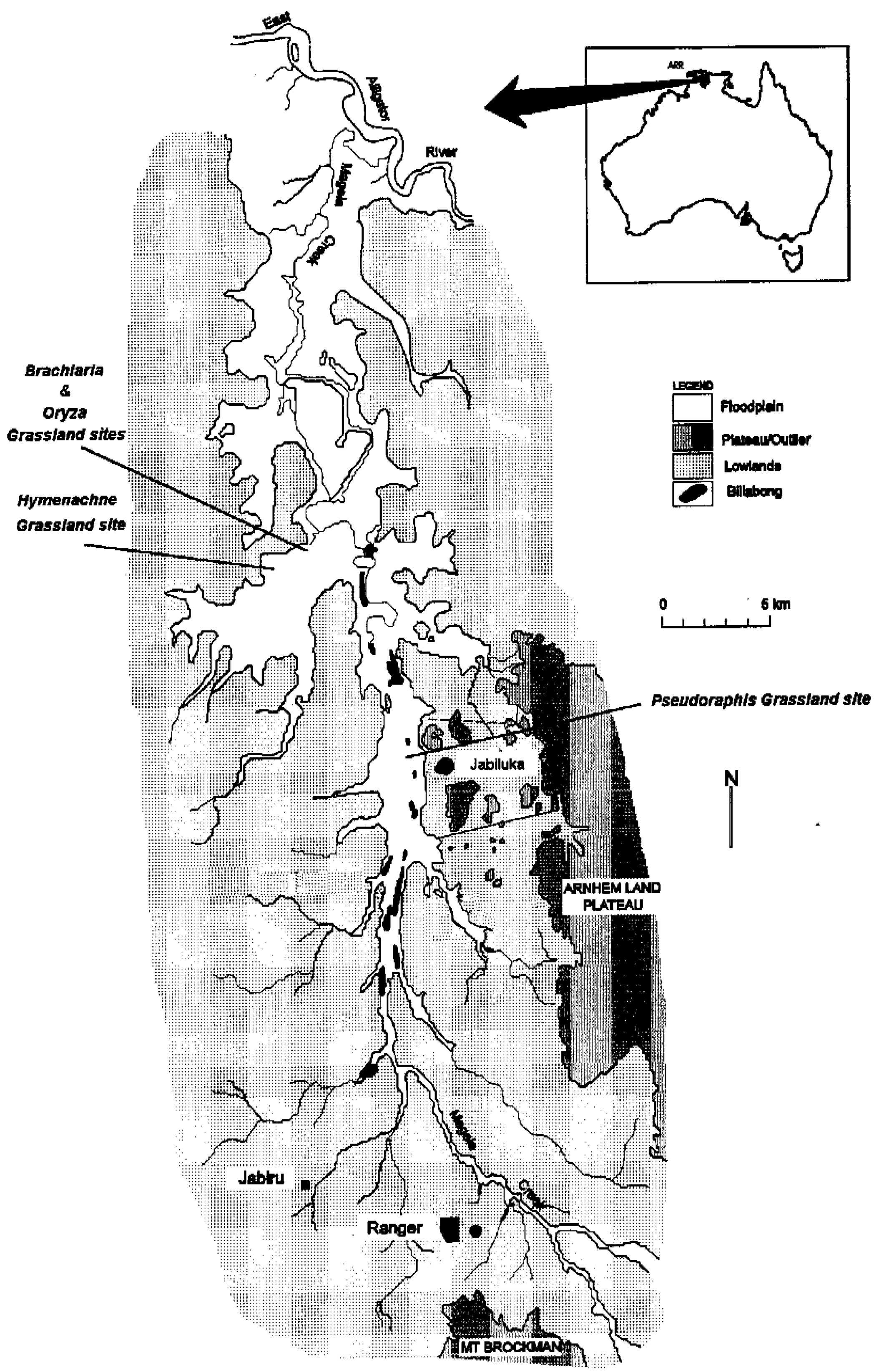
This community is dominated by *Oryza meridionalis,* an annual grass, during the wet season. In the dry season it consists of bare ground and dead *Oryza meridionalis* stems with *Pseudoraphis spinescens, Phyla nodiflora* and *Ludwigia adscendens* commonly occurring. During inundation aquatic species such as *Maidenia rubra, Isoetes* spp., *Nymphaea* spp., *Nymphoides* spp. and *Eleocharis* spp. can be found (Finlayson *et al.* 1989).

Hymenachne grassland

Hymenachne acutigluma dominates this community throughout the year with species such as *Ludwigia adscendens*, *Nymphaea* spp., *Oryza meridionalis* and *Pseudoraphis spinescens* also present. *Nelumbo nucifera* forms dense patches in this vegetation type (Finlayson *et al.* 1989).

Pseudoraphis grassland

Pseudoraphis spinescens grows in two forms depending on season and it dominates this community. During the dry season it grows as a turf and when inundated its stems elongate to reach the water surface. During the wet season *Nymphaea* spp. and *Nymphoides* spp. are extremely common and other aquatics such as *Utricularia* spp. and *Najas* spp. can also be found (Finlayson *et al.* 1989).



Map 2.2 showing the study area and locations of the four grassland communities sampled (the two uranium deposits, Jabiluka and Ranger are marked, Ranger is currently being mined; map courtesy of ***eriss***)