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Seasonal habitat use by feral pigs (*Sus scrofa*) in the Arafura Wetlands and their impact on contemporary Aboriginal bush food resources

By Anthea Dee

A thesis submitted for the degree of Doctor of Philosophy of The Australian National University.

STATEMENT OF RESPONSIBILITY

This thesis is my own original work, except where specifically acknowledged.

Anthea Dee

August 2004

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ABSTRACT

Feral pigs (*Sus scrofa)* are a major environmental problem in many parts of Australia. As habitat generalists they have successfully colonised and continue to spread across a very wide range of environments. The environmental damage pigs cause has only recently begun to be quantified and our understanding of the impacts they have on habitats and biodiversity remains limited. Feral pigs are threatening the environmental integrity (see page 16 for definition) of the Arafura Swamp and catchment in north central Arnhem Land, Northern Territory. They are also impacting on local bushfood resources and other aspects of the lives of Yolngu, the local Aboriginal people. Without control, feral pigs are likely to continue to thrive in the Arafura area and cause further changes to the country that is so important to Yolngu people.

A broad, holistic approach to feral pig management has been adopted here by engaging two systems of knowledge - western scientific and traditional Aboriginal ecological knowledge - and their interactions with one another and the unique study area. This study focussed on feral pigs, as their impacts on Yolngu way of life are a current issue to these people. In addition, preliminary research into the impacts of Asian water buffalo (*Bubalus bubalis)* was undertaken, given the probable (and significant) future effects of this species on the land and its people.

A key objective of this thesis was to determine and quantify the seasonal use of habitats by feral pigs and buffalo in the northern Arafura Swamp and the key environmental attributes that drive their activity. Signs of presence and activity of feral pigs and buffalo were recorded in a range of habitats over a 12-month period together with potential environmental correlates. These data were used to develop a predictive model

of seasonal feral pig activity that would enable optimisation of control measures through knowing which locations to target at particular times in the seasonal cycle.

The results from this study suggest that pigs are widely distributed in the northern Arafura wetlands and immediate surrounds and are using a broad range of habitats throughout the year, which often vary with season. Some habitats are used all year round but serve different functions according to season. Seasonal variation in habitat use by pigs was largely in response to annual flooding and drying and the consequent influence of this on resource distribution and abundance, and then by a series of other environmental variables. Intense productivity and the distribution patterns of permanent water throughout the area may explain the preference pigs show for wetland habitats throughout much of the year. While detailed modelling of buffalo activity patterns was not undertaken, activity was widespread across the study area in the late and mid dry seasons and was restricted during the wet season by the presence of extensive floodwaters. It is probable that the broadest criteria (in a landscape sense) for seasonal variation in pig habitat use would also apply to buffalo.

Before feral animal management can be considered, it is essential that there is an understanding of stakeholder perceptions and aspirations regarding these animals and the effects that they have on the natural environment. These views can play a significant role in the success or failure of a pest control program. The cultural and local political environment of the Arafura wetlands also plays an enormous role in determining appropriate management strategies for this area.

Thus, a second objective of this thesis was to determine Yolngu perceptions of feral pigs and buffalo and their impacts on custodial lands and to understand Yolngu aspirations regarding the management of these animals. Qualitative methods were primarily used in this part of the research. A combination of participant observation and semi-structured interviews was used to collect information about individual and community perceptions of feral pigs and buffalo.

There was a diversity of both views and of understanding about feral pigs and buffalo and their management. A range of social (by way of relationships) and external factors have influenced the perceptions held by Yolngu in the northern part of the swamp. While there were different views about the degree of impact feral pigs have on land and resources amongst those Yolngu involved in this study, most expressed some concern about the effect pigs were having on land and bushfood resources. All were keen to implement some degree of control and most expressed a desire for complete eradication of feral pigs. However, less concern was expressed about the effects of buffalo and fewer people thought that they should be controlled. The reasons for this included the value of buffalo as a food source and the length of time that buffalo have been present in the area.

Bush foods and subsistence activities are still very important to Yolngu both in a dietary sense and for maintaining culture. Yolngu were concerned about the effects of pigs on bushfood resources and believed that increased competition for these food resources has led to a reduction in their availability. These concerns were documented as part of this study. In addition, analysis of the overlap of seasonal pig activity with key areas for resource production was undertaken.

My findings are that feral pigs and buffalo have disrupted some of the certainty about bush food availability that Yolngu have depended on over their many years of occupation of the area. People are justifiably concerned about the effects of these feral animals. There is spatial overlap in the places where people and pigs obtain many of their seasonal food resources and pigs do appear to consume many resources that are important foods for Yolngu. Consequently there is increased pressure on resources in these areas.

Feral animal management strategies must have local context and ownership and as such, Yolngu representatives need to play a key role in development of these strategies in the northern Arafura Swamp to ensure that outcomes are consistent with the social, political and cultural aims of the community. Management recommendations were developed based on the seasonal models of feral pig activity and community-based management was suggested as a key element of feral pig control.

In conclusion, this study demonstrated that feral pigs are active across a broad range of wetland and surrounding habitats and are having a significant effect on Yolngu. It would appear that feral pigs may fundamentally alter people's relationships with the land; most outwardly by affecting the subsistence economy, but also by affecting other relationships to the land including comprehension of the physical landscape and responsibility for maintaining healthy country. The results suggest, and Yolngu custodians involved in this research agree, that the significant effect that pigs are having on this landscape and its people warrants the implementation of strong and effective control measures.

The findings from this study are important for the Yolngu people and their local environment, but also provide a benchmark for other areas and other problems by showing the value of collaborative engagement. This research demonstrates the benefits of working closely with Aboriginal people to determine management strategies that are appropriate to local context. It highlights the need for a robust understanding of the complexity of the situation and diversity of opinion, which requires an in-depth understanding of the local social and political arena.

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CHAPTER 1: Introduction and thesis aims

1.1 Introduction

Australia has undergone many broad scale environmental changes since Europeans colonised it 215 years ago. Inappropriate land use and management have been behind much of the degradation, which has included loss of habitat and species, increased salinity, erosion and altered quality and flows in rivers. Exotic invasive organisms are a major reason behind many land degradation problems that exist across Australia. These currently represent a huge management challenge, are difficult to control, and are almost certainly impossible to eradicate. Their impact on the environment is largely undocumented.

These changes have and indeed continue to affect biodiversity, possibly in ways and with consequences that are unforseen. What is often not acknowledged is that these changes have also affected Australia's indigenous people in ways that are often complex. Rarely are these effects appropriately assessed. Assessment of environmental impacts has often been narrow and one dimensional, focussing on the tangible; and this has typically involved overlooking the perceptions of Aboriginal people and the effects on them. Some changes (such as the introduction of certain exotic organisms) may have been both beneficial and inimical to indigenous way of life. Beneficial in that they may offer significant new resources and opportunities for development of enterprises; and destructive in their subversion of traditional and contemporary life. These potentially conflicting factors add considerable complexity both to assessments of damage and to management decision making.

The introduction of new organisms may seriously disrupt Aboriginal cosmology (see for example Altman 1982b re buffalo; Rose 1995 re feral cats). As exotics, these plants and animals fall outside of traditional systems and their ways of dealing with issues and problems. As such, there may be a period of uncertainty before appropriate responses to these invaders can be formulated. In addition, control mechanisms for managing the environmental impacts of exotic species are inevitably going to be expensive, so it is necessary to provide as precise an estimate of costs (both environmental and cultural) as possible, in order to assess whether resource allocation to control is justified. Without structured and well-developed impact assessment, any management response will be at best weak and at worst completely inappropriate (Walsh and Mitchell 2002).

Feral pigs are causing environmental damage in the Northern Territory's Arafura Swamp and surrounds (Figure 1.1) and are impacting on local food resources and other aspects of the lives of the local Aboriginal population. As pigs are a relatively new problem in this part of Arnhem Land little control action has been considered to date. Defining and understanding an animal's pest status is fundamental to developing control strategies - as Olsen (1998) explains 'assessing the extent of the damage – deciding when and where it occurs and how severe it is - and identifying who is affected or has an interest'.

This thesis considers both of these elements by spanning the disciplines of ecology and anthropology. Necessarily this comes at the expense of not delving deeply into any one discipline. A singular focus to the problem of feral pig management in this area is inappropriate. Thus, this thesis does not report autecological research on feral pigs or an in-depth exploration of the anthropology of a group of people; nor is it the consideration of the economics of control, nor consideration of the efficacy of different possible management options. A broad, holistic approach has been adopted by engaging two systems of knowledge - western scientific and traditional Aboriginal ecological knowledge - and their interactions with one another and the unique study area to address the management of feral pigs in this natural and cultural environment.

This introductory chapter reviews basic aspects of feral pig ecology and the current state of knowledge about feral pig management. It also looks at the role of traditional ecological knowledge and collaboration in contemporary land management. The chapter concludes with the aims and context of the thesis.

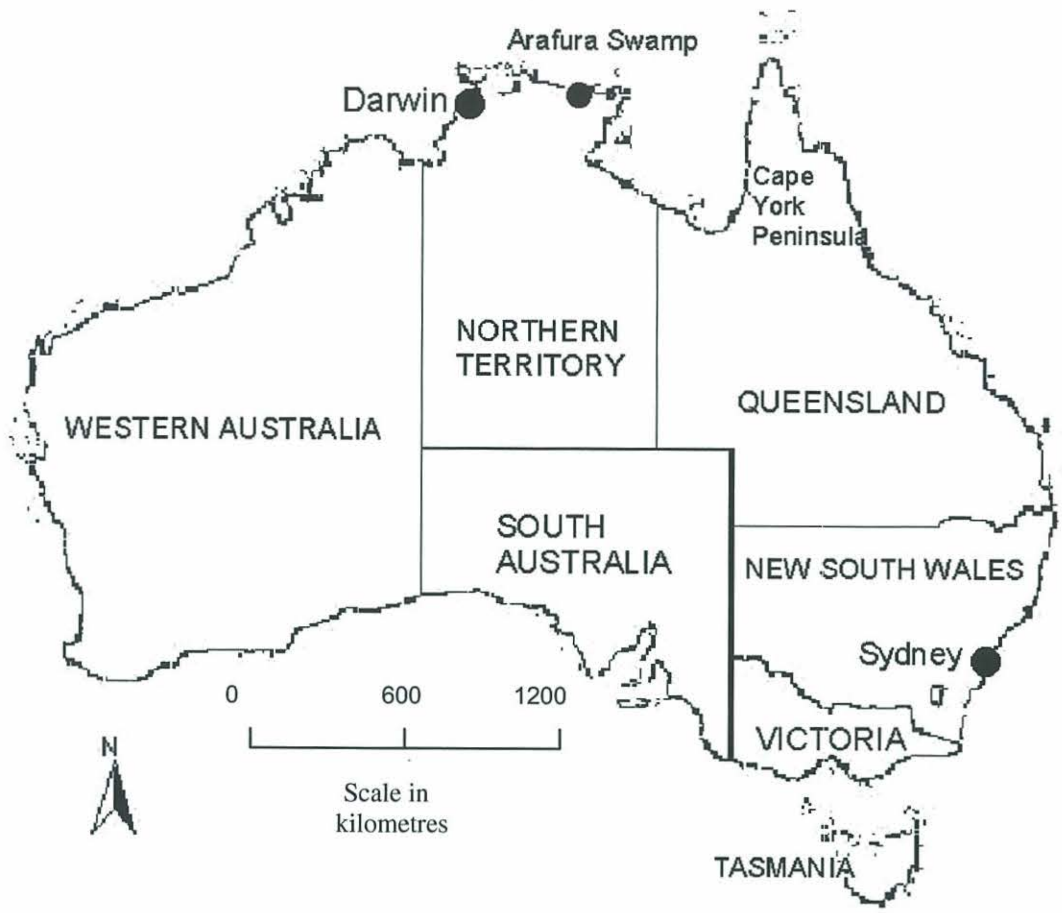


Figure 1.1: Map of Australia

1.2 Feral pigs

Introduced into Australia by early settlers more than 200 years ago (Tisdell 1982), feral pigs (*Sus scrofa*) now inhabit 38% of Australia and hence are the most abundant and widespread of feral ungulates (Hone 1990b, Choquenot et al. 1996). They have become a major pest problem with numbers estimated to exceed 13.5 million (Hone 1990b). As habitat generalists they have successfully colonised and continue to spread across a very wide range of environments. Feral pigs have poor eyesight and thus they rely on their acute senses of smell and hearing to find food and avoid danger. As daily access to water is critical to their survival, pigs are usually found in areas where there is medium to high rainfall or in areas with permanent water supplies (Wilson et al. 1992a). Feral pigs are also vulnerable to high temperatures and thus prefer thick cover in hotter environments. Over much of their range they are restricted to the immediate vicinity of watercourses or swamps, where water is available and vegetation is thickest (Choquenot et al. 1996). They tend to be most active after dusk and around dawn, thereby avoiding exposure to high diurnal temperatures and minimising contact with humans.

Feral pigs have an undesirable impact on agriculture, forests, native wildlife and natural ecosystems and have only limited benefit for recreational hunting and commercial use (Auld and Tisdell 1986). They cause economic damage to crops and pastures (Hone 1980, Tisdell 1982), prey on livestock (Pavlov et al. 1981), and cause considerable damage to watering points, roads and fences. This agricultural damage is estimated to cost more than 70 million Australian dollars annually (Tisdell 1982).

Feral pigs can harbour and transmit diseases of domestic livestock at present exotic to Australia such as foot-and-mouth disease, trichinosis, Aujeszky's disease, screw-worm fly and classical swine fever (Choquenot et al. 1996). The risk of exotic disease introduction is particularly high in northern Australia (Northern Territory and north Queensland especially) due to the proximity to Southeast Asia, where foot-and-mouth disease is endemic. The rapidly growing tourism industry in northern Australia has added a new dimension to this risk, as has the possibility of foreign boats landing on Australian shores without being subject to quarantine measures (Pavlov et al. 1992, Caley 1993). If any of these diseases enter Australia, feral pigs have the potential to distribute them widely, complicating eradication procedures. The meat export trade in this country would be brought to a standstill in the event of an outbreak and serious public and animal health issues would arise. Feral pigs also carry a range of major endemic diseases and parasites that are transmissible to both humans and livestock. The major endemic diseases are leptospirosis (*Leptospira* spp.), brucellosis (*Brucella suis*), meliodosis (*Pseudomonas pseudomallei*), tuberculosis (*Mycobacterium* spp.) and sparganosis (*Spirometra erinacei*) (Tisdell 1982, Choquenot et al. 1996). Barrett (1975) also found that pigs in the Northern Territory carried antibodies to arboviruses, parvoviruses and megalocytosis.

1.2.1 Environmental damage caused by feral pigs

Much of the research on feral pigs has focused on those adverse issues with direct economic impact. The environmental damage caused by pigs has only recently begun to be quantified and our understanding of the impacts they have on habitats and biodiversity remains limited. However, in 2001 feral pigs were officially recognised as a threatening process under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act 1999). Feral pigs were identified as known or perceived threats to sixteen listed threatened species. Feral pigs affect native ecosystems and flora and fauna via predation, habitat loss and competition as well as destructive behavior (digging, trampling, tusking or rubbing trees) and disease transmission. Ecological parameters affected include species composition, succession, and nutrient and water cycles. Impacts can be direct or indirect, acute or chronic, periodic or constant, and may be seasonally influenced (EPBC Act 1999).

The extent of environmental damage caused by feral pigs is significant. Ecological effects of feral pig populations can vary greatly depending on both pig density and ecosystem sensitivity (Bratton 1974, 1975, Baker 1979, Singer 1981). Pigs often congregate near billabongs and watercourses, where they cause erosion and silting (Wilson et al. 1992a). Feral pigs severely disturb the ground as they hunt for edible roots and invertebrates in the soil. Their digging disturbs soil, leaving it vulnerable to the introduction and spread of weeds; and causes erosion. It also damages the roots of native plants, leaving them susceptible to fungal infection (McIlroy 2001). This destructive digging is most intense when the ground is moist, so coinciding with seed germination. The new seedlings are often destroyed and there is a serious adverse effect on plant regeneration (Alexiou 1983, Pavlov and Graham 1985). Mitchell (2001a, 2001b) found that feral pig digging had a significant impact on seedlings of rainforest tree species, decreasing seedling survival rates in moist habitats by 36%.

Although the effect of digging by pigs on soil ecology is unknown in Australia, research overseas has suggested that diggings may influence soil invertebrate populations and decomposition rates (Vtorov 1993) as well as soil surface temperatures and the amount of mineral nitrogen in the soil (Kotanen 1994). It is also thought that disturbance by pigs may affect the quantity of organic matter and the capacity for cation exchange in the soil (Lackie and Lancia 1983).

It is not known to what extent pigs act as seed predators or dispersers (Choquenot et al. 1996). Chewing probably destroys most of the larger softer seeds of some tree families whilst smaller and/or harder seeds may escape destruction (Pavlov et al. 1992). In southern France, survival of seeds in pig faeces increases with a decrease in seed size (Genard and Lesourret 1985). Feral pigs on Maui (Hawaii) are excellent dispersers of the introduced woody weed, strawberry guava (*Psidium cattleianum*) as the passage through the gut increases seed viability and accelerates germination (Diong 1982).

Pig activity has been linked to changes in vegetation type and structure in some places. Alexiou (1983) reported that pig rooting in Namadgi National Park (ACT, Australia) led to an increase in shrubs such as *Leptospermum* spp. in eucalypt forests and a decrease in some herbaceous species, especially the vanilla lily (*Arthropodium milleflorum*). Hone (1980) found that a reduction in various types of native pasture was associated with pig rooting.

Feral pigs are opportunistic omnivores. Succulent green vegetation makes up the bulk of their diet but they also show preference for a variety of animal material, fruits and grain (Giles 1980). As opportunists, pigs are able to take advantage of temporarily abundant foods including corms, seeds, bulbs and tubers. They have been observed to destroy nests and feed on the eggs of marine and freshwater turtles, freshwater crocodiles, ground nesting birds, waterfowl, megapodes (Tisdell 1982, Choquenot et al. 1996) and cassowaries (Crome and Moore 1988). Puller (1950) reported that pigs eat crabs, fish and clams from the coast and yabbies, fish and freshwater mussels from inland waters. They also eat frogs, insects, earthworms, small reptiles and mammals, fledgling birds, freshwater turtles, fungi and carrion (Tisdell 1982, Crome and Moore 1990, Mitchell

1993, Choquenot et al. 1996). Feral pigs may also compete with native fauna for food resources, particularly fruits and seeds (Pavlov et al. 1992, Wilson et al. 1992a).

1.2.2 Population density

The density of feral pig populations varies considerably from habitat to habitat, depending on the available resources. In wetland habitats in eastern Australia densities of up to 20 pigs per square kilometre have been recorded (Giles 1980, Saunders and Bryant 1988, Dexter 1990). In the Northern Territory, densities in paperbark swamps and open floodplains have been recorded at between 2 and 11 pigs per square kilometre (Hone 1990a, 1990b) and densities lower than this have been recorded in woodland habitats (Ridpath 1991, Caley 1993).

Extrinsic factors such as resource limitations, weather, predation or disease are expected to regulate populations of large mammalian herbivores such as feral pigs (Caughley and Krebs 1983). Caley (1993) confirmed that food availability (as indicated by antecedent rainfall) did indeed influence the population density of these animals. Resource availability can also impact on feral pig population density via the survival rates of juveniles, as sows whose protein intake drops below a certain level cease to lactate, resulting in high mortality of piglets (Caley 1993). Although survival of young pigs is often poor, in a good year a feral pig population can easily double in size enabling rapid recovery from the effects of control programs or other setbacks (Choquenot et al. 1996).

1.2.3 Distribution and population in the Northern Territory

Feral pigs of Asian descent were brought to Melville Island and Cobourg Peninsula (see Figure 1.2) from Timor in 1827 as a food source for settlers (Letts et al. 1979, Tisdell 1982). Escaped domestic pigs probably spread from many separate foci, possibly including livestock experiment farms at Daly River, Batchelor and Oenpelli (see Figure 1.2). An extensive aerial survey of feral livestock undertaken across the Top End of the Northern Territory in 1985 found that pigs were most commonly observed in areas of higher rainfall, particularly on extensive floodplains and adjacent woodland close to the coast (Bayliss and Yeomans 1989). At this time, it was thought that pigs were mainly distributed west of the eastern edge of the Arnhem Land escarpment (Bayliss and Yeomans 1989).

Feral pigs were first observed in eastern Arnhem Land near the Liverpool River (just west of Maningrida) during the mid 1980s (Caley 1993). If these pigs were descendants of the original releases at the Cobourg Peninsula this would suggest a mean dispersal rate of around 2km per year (Caley 1997). Altman (1984) also noted the presence of feral pigs at Momega (an outstation approximately 40km south of Maningrida) during 1979-1980.

There is very little recorded information about early sightings of pigs in the Arafura Swamp area, but reports in the late 1980's and early 1990's suggested that pigs had not been seen (Bayliss and Yeomans 1989, Brocklehurst and Wilson 1992). However, at around this time, Russell-Smith (1991) noted evidence of pigs at Gatji billabong about 10km west of the Arafura Swamp (Figure 2.1). By 1992 pigs had reached the swamp but activity was minor at that stage (Brocklehurst and Wilson 1992).

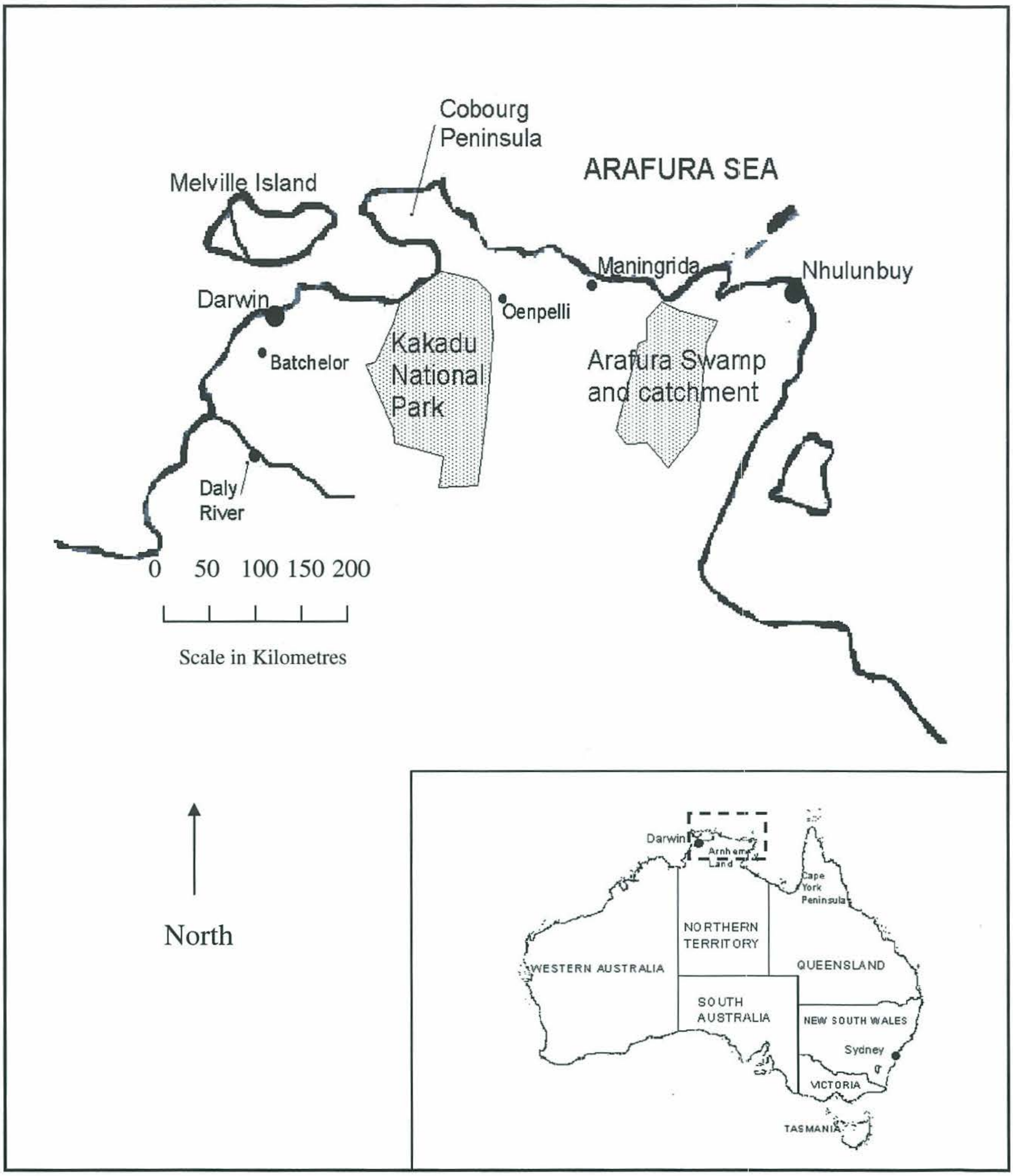


Figure 1.2: Map of Top End, Northern Territory

1.2.4 Impacts in Northern Territory

One of the main concerns regarding pigs in the Top End of the Northern Territory is the impacts they are having on local vegetation types, especially monsoon forests. Russell-Smith and Bowman (1992) recorded that 10% of Top End monsoon forest had been severely disturbed by pigs. Pigs have been responsible for the selective removal of many ground species in these areas. There has also been a decline of large herbs and vines (*Amorphophallus* spp., *Ampellocissus acetosa* and *Dioscorea* spp.) from monsoon forest southwest of Darwin which has been attributed to feral pigs (Fensham 1993). These species bear yams and fruits, which are important components of traditional Aboriginal food supply at certain times of year. Feral pigs affect these and many other resources that indigenous people depend on (see Chapter 6). In addition, changes in vegetation (and consequently bushfire fuel loads) and the spread of weeds associated with introduced herbivores such as pigs, cattle, and buffalo, have resulted in many rainforests being damaged by fire (Russell-Smith 1985, Russell-Smith and Bowman 1992).

Aside from the environmental impacts, pig diggings are aesthetically displeasing. This can be a problem for tourist destinations like Kakadu National Park where visitors expect to see pristine, unspoiled country. Obvious and extensive areas of pig digging can create impressions of mismanagement.

1.2.5 Management of feral pigs and stakeholder attitudes towards management

Despite a well-researched understanding of pig population ecology in Australia and overseas, eradication of feral pigs once they have become established across large areas has never been achieved. Effective pest control must focus on reduction of damage, which does not always result from a reduction in pest numbers. Informed management decisions rely on being able to quantify pest damage and relate it to pest density, but very little is understood about this to date (Olsen 1998). On Aboriginal land, quantifying feral animal damage in economic terms is more difficult as subsistence and cultural activities are not straightforward to value.

Control of feral animals is expensive, is not always effective, and is often only carried out where the threat of economic loss (usually to crops) is high. The common methods used to control pigs include trapping, shooting, hunting with dogs, and the use of poison baits (Choquenot et al. 1996). Controlling a pest species requires a thorough understanding of its population dynamics so that control can be targeted at the most vulnerable stages in the life cycle of the animal and at the most effective point in the dynamics of the pest population (Olsen 1998). Feral pigs have high population growth rates, which lead to rapid recovery if control is not maintained (Choquenot et al. 1996), and the fact that they are active mainly at dawn and dusk increases the difficulty of many control measures (Letts et al. 1979).

Community attitudes can also determine the success or failure of a pest control program (Braysher 1993). What is a pest animal to some people may be a valuable resource to others (Harris 1989). Conservationists, landowners, hunters and other stakeholders may all hold different opinions about the pest status of particular feral animals. Attitudes towards feral animals are as varied amongst Aboriginal peoples as they are amongst non-indigenous people (Olsen 1998) and are influenced by cultural beliefs and practices, social and political agendas, and exposure to western views.

It is inappropriate to assume that indigenous people will share the same views and control agenda about feral animals as conservationists and scientists whose perspective is that these pests have no value and threaten both agriculture and biodiversity (Davies et al. 1999). Some Aboriginal groups variously depend on feral animals whereas others see them predominantly as a threat to culture and subsistence. Certain feral animals are economically important as food resources or sources of income and some are culturally significant. For example, some Aboriginal groups in central Australia consider certain feral animals such as rabbits and cats to be good to eat, and as such do not want them to be controlled (Rose 1995). However, many Aboriginal people do recognise that feral animals are having a deleterious effect on their environment and are aware that culturally significant sites, bush food resources and habitats of native species are being affected (Baker 1999, White 2001a).

Where management of pest species is desired on Aboriginal land there are a number of factors that complicate the process. The act of controlling feral animals may be relatively easy on Aboriginal land because comparatively many people engaged in management on the lands may make the job easier. However, this is counter-balanced by a significant lack of resources to combat the threats. Aboriginal communities are usually extremely under-resourced with regard to conservation and land management issues and exotic species control may not always be a top priority (Davies et al. 1999). The remoteness of many areas increases the costs and difficulties associated with monitoring and control. Further, there is little direct economic return from implementing control (Bomford and Caughley 1996b) and where cultural benefits may result these are usually not obvious in the short term.

Feral pigs represent a difficult management challenge on Aboriginal lands. While traditional knowledge and management techniques do not encompass feral animals, indigenous people can offer the most detailed understanding of their local environment and resources and they can provide valuable insight into how these respond to various pressures such as feral pigs. Nevertheless, new concepts and techniques are needed to effectively manage these animals. Many Aboriginal people in the Top End have observed the changes wrought on their land by feral animals, especially pigs. Certainly, during the course of this work traditional owners made suggestions regarding potential management practices that may be effective on these exotic animals. Given the complexities involved, a useful approach to the management of pest animals on Aboriginal land may be to use an appropriate mix of traditional, scientific and technical knowledge (McNee et al. 1992).

1.3 Aboriginal ecological knowledge and collaborative management

In Australia in recent years, alongside a growing Aboriginal land rights and reconciliation movement, there has been increasing awareness of indigenous rights to involvement in land management. Rights regarding land and natural resources, and the knowledge Aboriginal people possess of their country, must also be recognised by supporting Aboriginal management of land and resources (Davis 1998).

Mounting global recognition of indigenous rights and practices has enhanced domestic support and recognition of indigenous rights to, and management of, land and resources in Australia (Baker et al. 2001a). Much of this support exists within numerous federal policy commitments and recommendations as well as obligations under international agreements. Sutherland and Muir (2001) provide an overview of current legal and policy developments relevant to indigenous land and resource management. The National Strategy for the Conservation of Australia's Biological Diversity (ANZECC 1996) for example, recognises the value of Aboriginal and Torres Strait Islander peoples' ethnobiological knowledge and encourages its use in biodiversity research and conservation programs. Recommended actions to facilitate this include provision of information, informed consent and equitable benefit-sharing, species recovery plans, cooperative arrangements, sustainable harvesting of wildlife, and community education (Environment Australia 1998).

In the Northern Territory, Aboriginal people have had significant areas of land returned to their ownership, including over 85% of the coastline (Storrs and Finlayson 1997). Much Aboriginal freehold land in the Top End of the Northern Territory has high biodiversity value, being largely undeveloped, although changes to land use and the invasion of exotic species have occurred in many places, affecting the environmental integrity of the landscape (Storrs and Finlayson 1997). Environmental Integrity is defined here as a balanced, integrated, adaptive system capable of supporting and maintaining basic functions (including but not confined to nutrient cycling, water capture, provision of food and shelter for fauna) at all spatial scales and a viable community of organisms having species composition and diversity appropriate to the region and is satisfactory to and able to reliably meet the long-term needs of society (adapted from De Leo and Levin 1997 and Whitehead et al. 2000).

Responsibility for managing land and resources is an integral part of life for Yolngu people living in the north east Arnhem Land region (Williams 1981), as it is for other Aboriginal people in Australia. Fundamental to this management is traditional ecological knowledge (TEK), a body of knowledge held by local communities about the environment gained through experience and built on over many generations (Suchet 2001). This knowledge encompasses indigenous people's understanding and classification of the natural world including species and processes or functional relationships between elements of the natural world (Lewis 1993).

Aboriginal knowledge and practices have previously been undervalued in the western natural resource management arena (Williams and Baines 1993) despite their relevance to the management of land and resources today, especially in areas that have remained relatively unaffected by European colonisation (Figgis and Donald 1986). Dwyer (1994) has suggested that the recognition of the value of traditional ecological knowledge has increased because of the conjunction of conservationist aims and indigenous needs. However, Deborah Bird Rose (pers. comm.2002) has suggested that this recognition is at least in part because of the apparent sustainability of indigenous human-environment relationships.

Societies, including those of indigenous people, are dynamic and able to adapt to new and changing circumstances. Many environmental and social changes have been thrust upon Aboriginal and Torres Strait Islander peoples over their time in Australia, not least the drastic consequences of European invasion. These significant changes to the environment are new to Aboriginal people and have taken place very quickly, making it difficult, if not impossible, for traditional knowledge systems, which characteristically develop slowly, to contend with such issues. To adequately value indigenous people's knowledge and contributions, there is a need to recognise Aboriginal people as contemporary land managers whose interests and aspirations in this area are focused in today's world (Smyth 1994).

As western scientific knowledge is limited in this region and many of the local land management issues being faced are new to Aboriginal people and knowledge systems, many Indigenous groups are becoming aware of the value of collaboration with non-indigenous land managers and scientists with whom they often share similar interests and concerns. These partnerships enables Aboriginal people to explore the possibilities of using traditional and western knowledge bases to find appropriate solutions and the new information that is required to manage their land.

Cross-cultural knowledge sharing and equality are essential in these partnerships to enable indigenous people to fulfill their land and resource management objectives, which typically include active participation in the management process (Robinson and Munungguritj 2001, White 2001a). However, collaboration between stakeholders can be a difficult process in any situation and when indigenous people are involved the fundamental differences in belief systems and ethics, as well as social organisation and complex local politics, can make the process even more challenging. Collaborative management processes must acknowledge that land and resources are integral to Aboriginal economic and cultural identity and incorporate the rights and responsibilities that arise from these unique relationships with the environment (Robinson and Munungguritj 2001).

From an indigenous perspective, undertaking collaborative partnerships may be most effective when there is a community-based management system in place. In the context of natural and cultural resource management, White (2001a) defines the term 'community' as the 'locus of decision making chosen by Yolngu'. He argues that 'the most effective decision-making location is that which is closest to family and clan networks' (White 2001a). From this definition, it follows that community-based management is an approach that is premised on the practical and ongoing involvement of relevant landowners and community members in decision-making.

Community-based management systems enable indigenous people to work within their own principles of law, social organisation and political institution (Robinson and Munungguritj 2001, Baker et al. 2001b), while facilitating a coordinated response to government and other external forms of management (Feit 1988). Local political context is 'the politics of ongoing and dynamic negotiation of land ownership and ceremonial and management responsibilities. Clans routinely negotiate religious, cultural and economic matters. These negotiations can involve considerable disputation' (White 2001a).

The terms decolonise and localise have been used by Robinson and Munungguritj (2001) to emphasise the need to empower indigenous values and interests and accommodate regional realities, such as political context. By working within a local community framework, these requirements can be fulfilled and collaborative management will be culturally appropriate and relevant to each situation.

The value of working together is reflected in the recent increase in the use of both traditional and western scientific knowledge as well as collaborative projects in the natural resource management arena on Aboriginal land. Aboriginal community organisations, such as the Land and Natural Resource Management Office of Kowanyama on Cape York (Dale 1991, Smyth 1994, Davies et al. 1999, Davies and Drewien 2001) and Dhimirru Land Management Corporation based in Nhulunbuy in the Northern Territory (Davies et al. 1999, Robinson and Mununggurtj 2001), have incorporated western scientific principles of resource management into their operations. They work with local indigenous community rangers and government conservation and resource management organisations and support the process that aims to maintain (or re-establish where necessary) traditional values and methods as part of land management practice (Smyth 1994). Each organisation operates differently according to local needs. Dhimurru, for example, broadly manages resources and land belonging to a number of clan groups, whereas other places have indigenous community rangers who are responsible for certain areas based on clan estates and appropriate affiliations.

Indigenous communities are not the only stakeholders to benefit from collaborative partnerships. Conservation programs including flora and fauna surveys and rehabilitation programs for threatened species have benefited from Aboriginal knowledge on species ecology (Burbidge et al. 1988, Young et al. 1991, Baker et al. 1992, Reid et al. 1992). In addition, Aboriginal communities on Cape York (Dale 1991) and in the Top End of the Northern Territory, including Maningrida (Davies et al. 1999, Bawinanga Aboriginal Corporation 2000) and Donydji (N.White pers. comm. 2000), have been involved in collaborative projects which aim to control feral animals. These projects also benefit the broader community.

1.4 The aims of this thesis

This thesis explores the seasonal use of habitats and resources by the feral pig (*Sus scrofa*) in the northern Arafura wetlands in north central Arnhem Land. The main community in the northern section of the swamp is called Ramingining and the people living in this area (and throughout north eastern Arnhem Land) are known as Yolngu (local word for Aboriginal person/people). These people have recently become concerned about the effect pigs are having on the land and have requested assistance in 'getting rid of these pigs'. There was also some concern expressed about the effects of Asian water buffalo (*Bubalus bubalis*) on their custodial lands, which along with cattle have been present in the area for many decades (see Chapter 2). This study focusses on feral pigs, as their impacts on Yolngu way of life are a current issue to these people. In addition, preliminary research into Yolngu perceptions of buffalo, given the probable (and significant) future effects of this species on the land and people, is presented. The importance of the issue of feral animals to these people cannot be overstated. Local Yolngu explained to me that damage from these animals had begun to cover large areas of land in this region. It was interfering with people's ability to travel in 4WD drive vehicles across the floodplains for hunting and was preventing people chasing wallabies and other game animals on foot in some areas due to the uneven ground surface.

This research was based on a working partnership with Yolngu, and the concerns that were raised during preliminary fieldwork shaped the collaborative process that evolved throughout the study. Considerable importance was placed on gaining the support of the local Aboriginal community and ensuring that the project goals corresponded to the goals of the Aboriginal collaborators whose involvement was fundamental to the project's success. Inherent in this approach was the desire to ensure that community gain, participation and education resulted from the work.

It became apparent that understanding Aboriginal perceptions of feral pigs and the effects they have on the local Aboriginal resource base and the custodial responsibility of caring for their land was very important. As an ecologist, it was neither possible nor practical given time and conceptual constraints for me to fully explore Yolngu culture and kinship organisation, as well as local politics, to adequately understand how these factors influence people's perceptions of feral animals. Nevertheless, I have obtained a preliminary understanding of a range of local Yolngu perceptions of feral pigs and buffalo, including the apparently disparate nature of many of these views. This understanding has provided some context and insight to the current situation and has provided a catalyst for further detailed research into the social elements that may influence feral animal management.

It is crucial to acknowledge that Yolngu people already possessed significant awareness of feral pigs before this study began. As such, it was not possible for me to obtain perceptions of these animals prior to damage occurring. In addition, education about contemporary land management issues and possible solutions was already being undertaken as a part of a land management program that was based at Ramingining. This information, along with individual experiences, will certainly have influenced people's views about feral pigs and must be acknowledged when considering the views presented by Yolngu in this thesis.

This study is part of a broader research program regarding management of the natural and cultural resources of the Arafura wetlands and catchment. A number of researchers are involved in this program, initiated by Dr Neville White (LaTrobe University). Dr White has undertaken long-term research into the human ecology of the Yolngu people of this region, which has included a detailed investigation of local ethnoecology. Within this program, research into the socio-political influences on land management decision making is being explored (Lim in preparation). This research will improve the capacity of collaborators to understand Yolngu perceptions and aspirations regarding land management issues in more detail. A biological inventory of the Arafura Swamp and catchment was undertaken by the Parks and Wildlife Commission, Northern Territory, in collaboration with local indigenous rangers, during 1998-2000, which has provided much needed baseline data about the region's flora and fauna (Brennan et al. 2003).

The basic problem being addressed by this thesis is the impact of feral pigs in the Arafura Swamp both on the natural environment and on elements of Yolngu people's way of life and how this impact could be managed. A key objective was to determine and quantify seasonal use of habitat by feral pigs and the key environmental attributes that drive their activity in order to optimise control measures by knowing the best areas to target at different times of year. The success of a control program depends on the awareness of stakeholder perceptions and integration of stakeholder aspirations into the program. Management strategies must encompass Yolngu perceptions and work towards achieving Yolngu aspirations. There must be acknowledgement of the seamless nature of the natural, cultural and spiritual worlds to Yolngu and the place, if any, of feral animals in this system. Therefore, establishing a clear understanding of what Yolngu think about these animals on their land and whether they see them as a problem and what actions, if any, they would like to see happen, is necessary. As such, a second objective of the thesis was to determine Yolgnu perceptions of feral pigs and their impacts on custodial lands and to understand Yolngu aspirations regarding the management of these animals. Managing contemporary issues on Aboriginal land may be best achieved through the integration of traditional knowledge with western ecological understanding and practices to provide the most appropriate local solutions, for this reason a holistic approach to understanding the feral pig problem is taken in this thesis. Thus, the key research questions addressed by this thesis are:

How does feral pig habitat use vary with season?

What are Yolngu perceptions of feral pigs and buffalo and aspirations regarding their management and how does this influence possible control efforts?

What is the role of traditional ecological knowledge in understanding the problem and the solutions?

Yolngu are familiar with many of the issues broached in this study and have provided a great deal of the material that is reported. Thus, this thesis predominantly seeks to present information to western land managers who will be involved in facilitating the management of feral pigs in this or comparable areas by documenting the current state of pig damage in the northern Arafura wetlands and surrounds for future reference, and recommending management strategies that may be used to control feral pigs in this area. The thesis also illustrates a range of views that Yolngu have with regard to feral animals and their management, with the aim of increasing the knowledge base regarding feral animal management on Aboriginal land and improving the efficiency of control where it is desired. However, it is important to note that the situation is dynamic and people's views, priorities and aspirations are subject to change as the situation evolves.

1.4.1 Limitations

The adoption of a holistic approach to understanding the feral pig problem, while benefiting overall understanding, also created some inevitable difficulties. These tended to be amplified in the complex and often unpredictable environment of Ramingining. The most significant limitation was inadequate time to become immersed in local culture and language, which was in part due to the intensity of the ecological survey work. The size and composition of the Ramingining community, where many clan groups live in one place with varying historical, social and political backgrounds and agendas, further complicated the situation. In addition, local Aboriginal assistants often had a variety of social commitments that reduced the time they had available to work on the project. Unexpected events such as funerals and other ceremonies also prevented people from assisting for unspecified and sometimes long periods of time.

1.4.2 Overview and structure of the thesis

In summary, the main focus of this thesis is the seasonal use of habitat by feral pigs (*Sus scrofa*) in the northern part of the Arafura Swamp and surrounds in north central Arnhem Land, including environmental correlates of pig activity. In addition, a preliminary exploration of Yolngu perceptions of feral pigs and buffalo is presented which includes the effect of these animals on contemporary Aboriginal bush foods. Yolngu aspirations for management of these animals are also considered.

The thesis is structured as follows. Chapter 2 provides a concise background to the physical and natural features of the study area. It also aims to give some understanding of the Aboriginal people living in the area and their culture and way of thinking. Finally, this chapter considers some of the threats facing the environmental and cultural integrity of the area.

The next two chapters form the basis of the ecological study into habitat use by feral pigs and to a lesser extent, buffalo. Chapter 3 describes the methods used to undertake the study and follows with a series of exploratory data summaries. In Chapter 4 the statistical analyses of the pig survey data and environmental correlates are described and the results discussed for each season.

Local Yolngu perceptions of feral pigs and feral buffalo are explored in Chapter 5. This chapter considers the beliefs Yolngu have about the origins and belonging of these animals and their impact on Yolngu custodial lands. The effect of various influences on Yolngu perceptions is also discussed.

The effects that Yolngu believe feral pigs are having on their seasonal bushfood resources are discussed in Chapter 6. This chapter also considers the overlap of habitat use by feral pigs (as determined by the scientific component of this study) and that of Yolngu hunting grounds.

Chapter 7 draws together the various elements of the thesis to provide a holistic perspective of the natural and cultural effects of feral pigs in the study area. This chapter also discusses potential culturally appropriate feral pig management strategies that are based on the results from this study.

CHAPTER 2: Environments and people of the Arafura Wetlands and surrounds

2.1 Introduction

This chapter provides a brief background to the natural and physical attributes of the Arafura Swamp and its surrounds. It also gives an introduction to the local Aboriginal people who are the traditional owners of this region. Elements that threaten the environmental and cultural integrity of this area are also considered. I draw on a range of literature as well as personal experience and observations from various times spent in the northern part of the Arafura Swamp during the period 1995 to 2000 to provide this background. A number of issues are identified in this chapter that are returned to for discussion in other parts of this thesis.

2.2 The physical landscape

Across the coastal zone of the Northern Territory, seasonally inundated freshwater wetlands occur in association with major river floodplains (Brocklehurst and Wilson 1992). These Top End wetlands are of Recent origin (Finlayson et al. 1988) and their development has been described by Chappell & Grindrod (1983) and Woodroffe et al. (1985a, 1985b). They are extremely dynamic and resilient ecosystems that undergo large annual changes in water depth (Finlayson et al. 1991). Local and regional variability in storm and cyclone activity creates a high degree of variability within and between floodplains. This leads to local and yearly variation in aquatic plant communities (Fleming 1991).

The floodplains, being relatively unweathered alluvial/colluvial clay soils, are fertile compared to other environments in northern Australia. These rich and productive environments are the source of abundant and generally reliable resources for the traditional owners. But they also have the potential to support high densities of livestock and feral animals. In addition, some Top End floodplains have been targeted for large-scale agricultural and/or improved pasture programs (e.g. rice at Humpty Doo; ponded pastures at Legune). Thus, the floodplains on Aboriginal lands and in National Parks are especially significant for the maintenance of biodiversity. Ecologically they are important because they support rich and diverse plant and animal communities that are unique to this area. In order to maintain wetlands, the ecological processes that underpin their products, functions and attributes need to be maintained and the habitats managed in a sustainable manner (Storrs and Finlayson 1997).

The Arafura Swamp is one of the largest freshwater ecosystems in the Top End of the Northern Territory (Figure 2.1). Plates 1, 2 and 3 show various views of the Arafura Swamp. Together with its catchment it covers an area of 10,365 km^2 (Brennan et al. 2003). Located some 450km east of Darwin, it is remote from main population centres and consequently is one of the least affected by European development. Nevertheless it is crucial to appreciate that this area is a 'peopled landscape' (White 2001a). The traditional Aboriginal landowners of the area are the Yolngu people. They have continuously managed the area according to their traditions and still maintain strong links to their country. The importance of the natural and cultural values of the area has been recognised by the Federal Government through the inclusion of a significant area of the swamp and catchment on the full list (gazetted) of the Register of the National Estate in March 2001 (see Brennan et al.2003 for a map of the area registered).

Some 800 Yolngu live in Ramingining township, which is located on the northwestern edge of the Arafura Swamp in north central Arnhem Land, about 30km inland (by road) from the Arafura Sea (Figure 2.1). Ramingining is a small town, with basic housing, electric power, piped water and sewerage system and is supplied with essential materials by barge and seasonally by road. Many Yolngu live at outstations or homeland centres in the area as shown in Figure 2.1. These may be permanently or seasonally occupied. Outstations usually have only a small number of basic houses and are often occupied by family groups. Water is supplied by tank and electricity, if it exists, is solar powered.

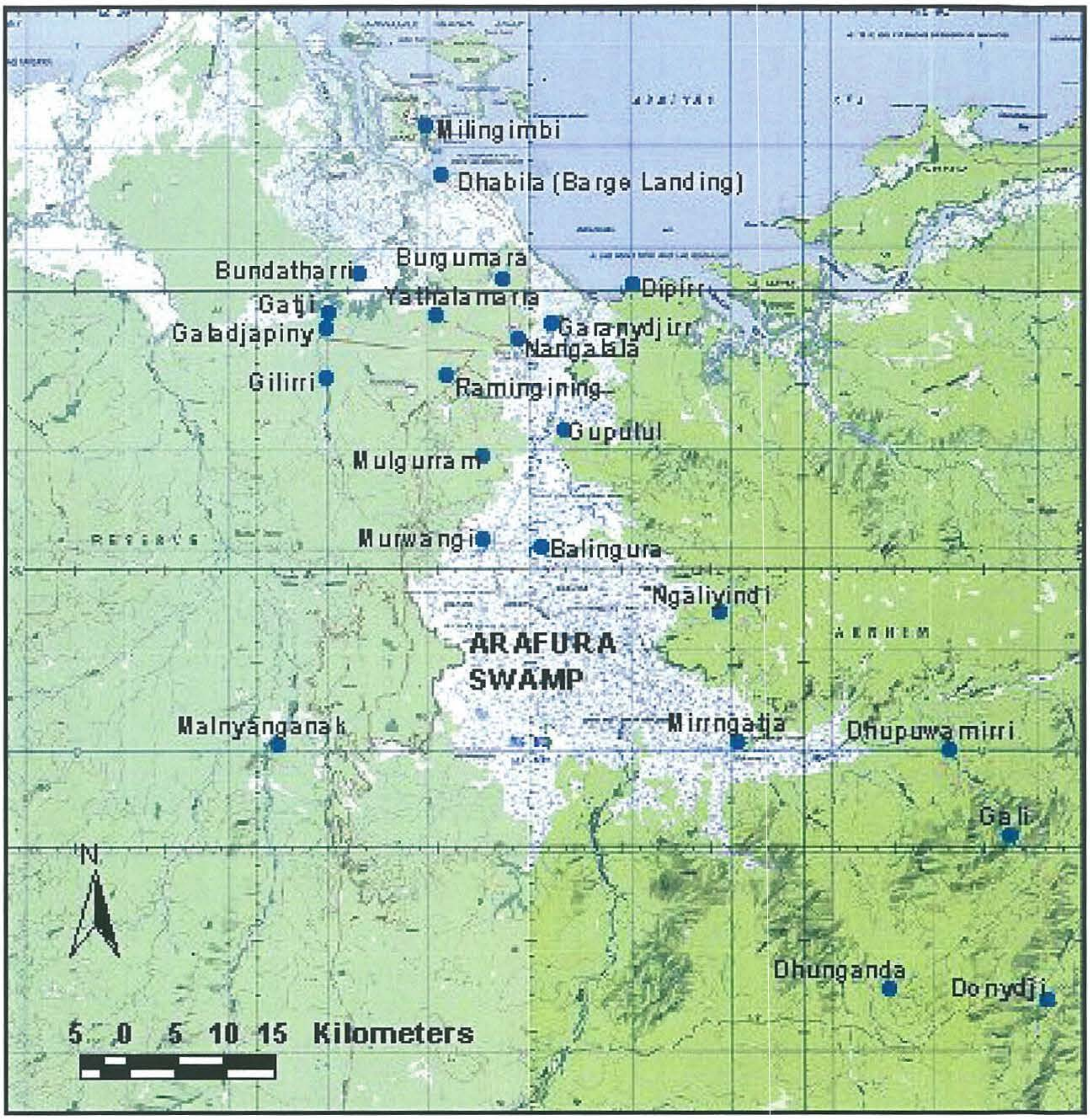


Figure 2.1: Arafura Swamp communities and outstations

Plate 1: View over Crossing showing partial inundation of this section of the Arafura Swamp.

Plate 2: Aerial view of a wooded area of the Arafura Swamp.

Plate 3: Aerial view of a permanent billabong in the Arafura Swamp.

2.2.1 Seasons and climate

The climate of the Top End is monsoonal, having annual wet and dry seasons. Temperature and rainfall data for the Arafura Swamp region are shown in Figure 2.2. Thunderstorms and localised heavy rains in November herald the beginning of the wet season. There are five 'wet' months where rainfall is greater than 200mm each month. Over 90% of the region's total rainfall (of around 1500mm annually) occurs during this time; tropical cyclones, strong winds and flooding are also common features of the wet season (McDonald and McAlpine 1991). The time of the onset of the wet season is variable, as is its duration. Temperatures are high and are accompanied by very high humidity of around 80% (Finlayson et al. 1988).

The early dry season begins around late March-April. There are still thunderstorms occurring at this time but rainfall is greatly reduced. The nights become cooler and humidity drops during the main dry season. Dry southeast trade winds are dominant and there is very little rainfall throughout this four-month period (Finlayson et al. 1988). Temperatures and humidity increase as the dry season progresses and from late September until December conditions are uncomfortable. This time is known as the 'build up' to the wet season. The early dry season and the build up to the wet season are the transitional periods in the seasonal cycle.

A small range in day length occurs at this latitude, the shortest day (11.2h) occurring on June 21, and the longest (12.7h) on December 21 (Christian and Aldrick 1977). The mean hours of sunshine during the dry season are between 9.7 and 10.2 hours per day, and in the wet season, which is often overcast, the number drops to between 4.5 and 7.5 hours per day (Christian and Aldrick 1977).

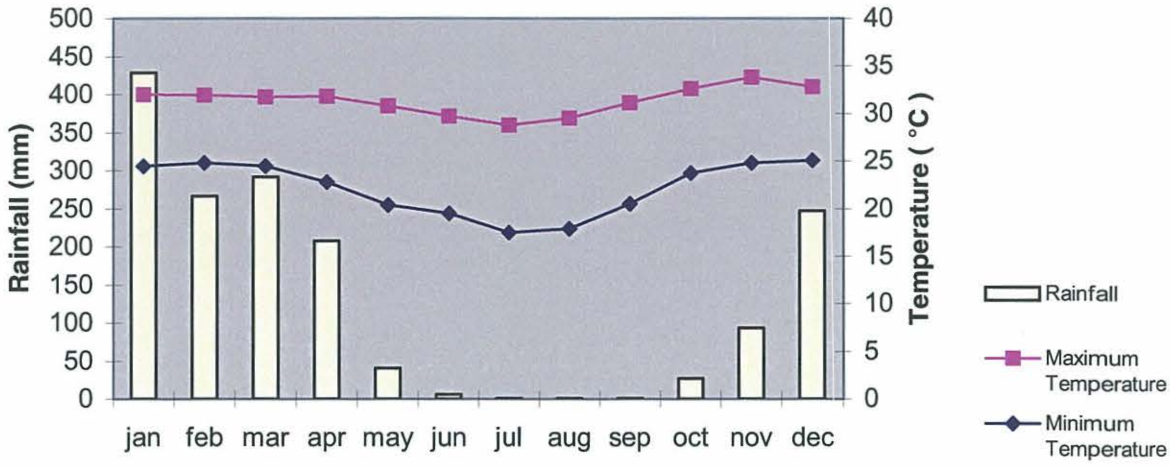


Figure 2.2: Climate data for the Arafura Wetlands area averaged over 5 years (1996-2001).

NB: Rainfall data were recorded from Ramingining (and are only available for the last 5 years) and temperature was recorded on the nearby island of Millingimbi (Bureau of Meteorology).

Yolngu have a more detailed working knowledge of the local climate and the people living in the northern Arafura Swamp area recognise five main seasons occurring throughout the year. These are *'Dhuluḏur'* - the time of the first rains (late Nov- Dec); *'Guṉmul'* - mid wet season (Jan-Feb) which includes *'Bärra'mirriy'* – time of very strong west winds; *'Miḏawarr'* (Mar-May) – early to mid dry season; *'Dharratharramirri'* (late May-July) – mid dry season and *'Rrarrandharr'* – late dry season (Aug-Nov) (Rudder 1978/79, White 1985, Davis 1989, Rudder 1999). The orthography used here is after Rudder (1999).

Seasons are named and identified by the qualities they possess and the way they affect people and other living things (White 1985, Rudder 1999). For example, the word *'dharratharramirri'* means 'having shivering' and it is the name for the coldest part of the dry season (Rudder 1999). The presence or actions of various species can also signal the timing or progress of seasons (White 1985). For example, the blooming of the redflowered kurrajong (*Brachychiton paradoxus*) and the birth of young sharks signal the start of the season *'Rharrandharr'* (Rudder 1999).

2.2.2 Physical features

The coastline of the Arafura catchment comprises dense mangrove flats broken only by sandy beaches, tidal rivers and creeks. Beyond the coast lie extensive salty floodplains that have been forming progressively over the last 5000 years (Chappell 1997). These floodplains are known by Yolngu as *gurrpulu* and are carved into by the same tidal rivers and creek channels that cross the coast. Across the coastal plains are series of chenier ridges running parallel to the present shore. Williams (1969) has suggested that such features may represent the approximate position of former coastlines.

The Arafura Swamp is a permanent wooded freshwater swamp, which during wet-season flood peaks can cover an area of approximately 700km^2 (Brennan et al. 2003). Dates from freshwater sediment deposits indicate that the swamp is approximately 3000 years old (Chappell 1997). A steep, rocky escarpment rises from the eastern and western edges of the swamp to the low plateau (60-100m) that almost entirely surrounds it. Inland of the coastal floodplains, the ground rises slightly and is gently undulating; this country is dominated by savanna woodland on infertile soils.

2.2.2.1 Hydrological features

Surface and spring water drains into the swamp, mainly from the Goyder River in the south and the Gulbuwangay River in the southeast. Freshwater moves downstream through palaeo-channels and across floodplains and eventually meets with saline water at Murwangi billabong ('Murwangi' in Figure 2.1), which marks the upstream limit of tidal penetration, some 50km from the coast (Messel et al. 1980, Brennan et al. 2003). The Glyde River and various creeks act as annual drainage outlets and along with flow across floodplains, carry huge volumes of water from the swamp to the Arafura Sea at Castlereagh Bay.

During drainage and also after the very high 'king' tides, the rivers and creeks overflow and the floodplains become covered with water and are extremely muddy. As the floodwaters recede the water passing along the rivers is greatly reduced and the plains dry out and become very hard and cracked. Water remains in low sections of the plains as semi-permanent swamps and also in channels and deep holes as billabongs and permanent waterbodies. The availability of this remaining water on the floodplains at the end of the dry season can vary annually depending on the length and intensity of the wet season. Variations in the depth of water in the swamp also occur seasonally and annually, with the average annual increase in water depth following the wet season being 1.94m (Brocklehurst and Wilson 1992). The swamp is usually at its fullest around April with water dropping to a relatively static level by October and beginning to fill again by seasonal monsoonal rains in January (Brocklehurst and Wilson 1992).

2.2.2.2 Vegetation

The vegetation of the Arafura Swamp and surrounds has been mapped on a broad scale (1:1,000,000) by Wilson et al. (1990) and described by Brocklehurst and Wilson (1992). The land systems (1:250,000) have been mapped (Lynch and Wilson 1998) as have the monsoon forests in the area (Russell-Smith 1991). A more detailed description of the area's vegetation has been reported as part of a recent biological inventory of the

Arafura Swamp and catchment (Brennan et al. 2003). These studies and my own observations have been used to derive the following vegetation descriptions.

The swamp (i.e. the area subject to annual inundation) can be considered as three major areas based on physiography. Beyond the mangrove lined coast the **Coastal plains region** is dominated by *Cyperus scariosus* sedgeland (*Cyperus scariosus/Panicum decompositum*), samphire (*Sporobolus virginicus/Halosarcia indica* subsp. *leiostachya*) and mixed sedge and grassland (*Eleocharis dulcis/Pseudoraphis spinescens*). The vegetation on these floodplains varies seasonally and is associated with water depth and amount of rainfall as well as fire regimes. After dry season fires vegetation is very sparse or non-existent in the coastal plains region compared to the abundance and diversity of flora that is found there in the wet season (Finlayson et al. 1988). The **Middle plains region** is restricted by low hills and plateaus in the north and runs into the paperbark swamp regions in the south, with widespread areas of *Melaleuca cajaputi* swamp woodland/open forest (Canopy: *Melaleuca cajaputi;* Ground cover: *Eleocharis sphacelata/Oryza rufipogon*). The **Swampy plains region** forms the main part of the swamp into which the Goyder River discharges. It is dominated by paperbark open forests (Canopy: *Melaleuca viridiflora;* Ground cover: *Pseudoraphis spinescens/Cyperus scariosus*) known by Yolngu as *gulungulun,* and woodlands and billabongs with some grassland areas. Paperbark open woodland/open forest communities dominate the wooded area of the swamp. *Melaleuca leucadendra* forests were mostly restricted to near-permanent 'back swamps' around the margins of the swamp (Brennan et al. 2003).

Various forms of open woodland, woodland and open forest occur on the fringes of swamps and creeks as well as footslopes of the adjacent escarpments and in surrounding upland country. Yolngu call these woodlands *diltji*. The riparian communities, generally associated with floodplain and creek channel wetland/upland interfaces, are variously dominated by *Melaleuca viridiflora, Corymbia bella, Lophostemon lactifluus* and *Syzygium suborbiculare* in the canopy; *Pandanus spiralis,* in the mid-layer and *Mnesithea rottboellioides, Heteropogon triticeus* and *Imperata cylindrica* ground covers. The most widespread upland community is the *Eucalyptus tetrodonta/Eucalyptus miniata* woodland/open forest dominated by *Eucalyptus tetrodonta, Eucalyptus miniata and Erythrophleum chlorostachys* in the canopy; *Buchanania obovata, Cycas arnhemica* and *Livisona humilis* in the mid-layer and *Petalostigma quadriloculare* and *Heteropogon triticeus* ground covers.

Fragments of monsoon forest or *retja* are found throughout the area on sandy or lateritic soils. These rainforests can take a number of forms including wet monsoon forests occurring on lowland areas, usually in association with small creeks or springs, or seasonally dry semi-deciduous rainforest occurring on well drained substrates in coastal areas and amongst rocky outcrops on similarly dry substrates in higher country (Russell-Smith 1991). The latter are the most extensive in this area, forming a great deal of the closed forest on footslopes surrounding the Arafura Swamp (Brennan et al. 2003).
Environment Australia (2001) report that the vegetation of the Arafura Swamp differs from other Top End floodplains in that it has larger areas of contiguous paperbark forest and of *Melaleuca leucadendra* open forest, greater abundance of the grasses *Echinochloa praestens* and *Hymenochaeta grossa*, and less wild rice, *Oryza rufipogon*.

The flora of the Arafura area is most closely related to that of Kakadu National Park, although is considerably less diverse (Brennan et al. 2003). However, it is one of the most species rich regions in the northern Top End and has a strong floristic identity (Brennan et al. 2003).

2.2.2.3 Fauna

The Arafura Swamp is a significant breeding area for many species including both saltwater crocodiles (*Crocodylus porosus*) and freshwater crocodiles (*Crocodylus johnstoni*). Saltwater crocodiles are known by Yolngu as *baru* and occur in very high densities of up to 30 animals per kilometer of billabong length, especially in the northern part of the swamp (Environment Australia 2001). Arafura File Snakes (*Acrochordus arafurae*), Water Pythons (*Liasis fuscus*), Olive Pythons (*Liasis olivaceus*) and Long-necked Turtles (*Chelodina rugosa*) inhabit the swamps and billabongs. Large varanids and many species of other lizards live in surrounding woodlands.

The Northern Territory wetlands are a vital end point or stop over point for migratory birds (Braithwaite and Werner 1987). At least 68 bird species inhabit the Top End floodplains including the Magpie Goose (*Anseranas semipalmata*), Wandering Whistling-duck (*Dendrocygna arcuata*), Glossy Ibis (*Plegadis falcinellus*), Pacific Black Duck (*Anas superciliosa*) and Green Pygmy Goose (*Nettapus pulchellus*) (Morton and Brennan 1986). The Arafura Swamp is an important breeding area for a number of waterfowl species including Great Egret (*Ardea alba*), Intermediate Egret (*Ardea intermedia*), Little Egret (*Egretta garzetta*), Royal Spoonbill (*Platalea regia*), Darter (*Anhinga melanogaster*), Little Pied Cormorant (*Phalacrocorax melanoleucos*), Little Black Cormorant (*Phalacrocorax sulcirostris*), Australian White Ibis (*Threskiornis molucca*) (Chatto 2000) and Magpie Goose (Brennan et al. 2003).

The diversity of freshwater fish in the Northern Territory's floodplains is much higher than in temperate Australia and in floodplains elsewhere (Finlayson et al. 1988). Little research has been undertaken on the freshwater fish assemblages of the Arafura Swamp and catchment, although 15 species of freshwater fish were recorded in local river and creek systems during an opportunistic survey of waterbodies around the Ramingining area in 1994 (Dee 1995). One of these species, the Banded Rainbowfish (*Melanotaenia trifasciata*), is endemic to the Northern Territory and totally restricted to the Arafura catchment (Brennan et al. 2003). The rare and spectacular Threadfin Rainbowfish (*Iriatherina werneri*), previously known only from Cape York and New Guinea, has also been recorded in the area (Environment Australia 2001).

Overall, in terms of fauna, the Arafura area appears to be less species rich compared to other northern Top End regions, especially in terms of upland reptiles and mammals (Brennan et al. 2003). However, it is an important centre of abundance (at least 25% of Northern Territory records from the Arafura area) for 10 animal species, including the NT endemic Black-spotted Ridge-tailed Monitor (*Varanus baritji*) and Scant-striped Ctenotus (*Ctenotus vertebralis*) (Brennan et al. 2003). During a recent survey of a coastal floodplain near Dhabila (see Figure 2.1) in the northern Arafura Swamp area, the rare False Water-rat (*Xeromys myoides*) was recorded. Prior to these records, this species had only been recorded in four locations in the Northern Territory, all at least 20 years ago (Woinarski et al. 2000). The Spectacled Hare-wallaby (*Lagorchestes conspicillatus*), which is not commonly seen in the northern Top End was also recorded in the eastern and southern parts of the Arafura area (Brennan et al. 2003).

2.3 The cultural landscape of the Arafura Wetlands and surrounds

Archaeological studies have shown that northern Australia has been occupied by people practising a hunter-gatherer form of subsistence for at least 50,000 years (Roberts and Jones 1994). According to Jones (1985), humans have exploited present day coastal plains for the last 5000-6000 years. Wetland and upland areas were used as hunting and foraging grounds with large groups of people living seasonally on wetland fringes (Peterson 1973, Jones 1985).

The Arafura Swamp has great cultural and economic significance to Yolngu groups inhabiting the area. Although no systematic archaeological work has been carried out in this region there is a great deal of evidence suggesting prehistoric exploitation of this wetland, including campsites and large middens (Meehan 1988). Peterson (1976) recorded the presence of large and small mounds and sites containing stone tools in the southeast corner of the swamp. The area also contains many important rock art sites, stone artefact quarry sites, stone arrangements and fish traps, and has great religious significance for the local Aboriginal people and for Aboriginal communities throughout all of eastern Arnhem Land (White 1974).

The Yolngu are a group of genetically and linguistically diverse hunter-gatherers whose identity is linked to the resource rich country from north central to northeast Arnhem Land in the Northern Territory. Yolngu social organisation is based on a complex kinship system that is divided into two patrilineal moieties, *dua* and *yirritja,* a division which extends beyond the realm of humans into the natural and spiritual worlds where creation began.

Considerable research has been directed towards understanding Aboriginal Law and the following overview has been derived from Rose (1992), White (1995b), Robinson and Munungguritj (2001) and Davies et al. (1999). Throughout time, *dua* and *yirritja* ancestral spirit beings moved across the land and sea creating pathways and features that marked their journeys. These beings also created people and gave Yolngu their language and their Law to live by. When their journeys were finished many of the ancestral beings transformed themselves into physical features such as rocks, or species of plant or animal. Others remained as spirits dwelling at various places in the landscape where they remain today. These ancestral pathways (often called dreaming pathways) and the languages and Laws delivered gave 'boundaries' or non-uniformity to country (Rose 1992). Dreaming pathways connect points on the landscape forming links between places and between people. As Rose (1992:52) explains, 'these are the boundaries that unite'. Yolngu kinship relationships structure the way people negotiate these 'boundaries' in their social, conceptual and geographical forms (Williams 1986, Keen 1994).

Within each moiety are exogamic clans, generally comprising a number of family units whom own local territories or estates that were assigned to them by their spiritual ancestors. The patrilineal clan has primary rights to the estate, which encompasses rights to the resources of the land, including the right to permit others to share resources. Managerial rights to the same estate are determined through matrilineal links and include land use and management amongst other responsibilities (Williams 1986, Keen 1994). Further information about Yolngu kinship structure can be found in Warner (1958), Williams (1986), Keen (1994) and White (1995b).

Some clans are almost entirely associated with coastal areas, having a predominantly marine environment from which to obtain resources. These people call themselves salt-water people (*mo_ukpuy mala* Yolngu). Other clans are primarily connected with inland areas, have a hunting environment associated with freshwater swamps and streams, and call themselves freshwater people (*diltjipuy mala* Yolngu) (Rudder 1978/79).

The Glyde River is the western most point of the eastern Arnhem Land language block and it is here that the linguistically distinct *Djinang* speakers live. Around the Ramingining area are the *Djinang*-speaking *Djadawitjibi, Marrangu, Wulaki, Mildjingi, Balmbi* and *Murrungun* clans (land owning groups). In the surrounding area are the traditional lands of the *Burarra, Rembarrnga, Wudamin, Ganalbingu* and *Mayarringu* peoples. Other groups reside in the area because of ceremonial or familial connections, including the *Gupapuyngu, Djambarrpuyngu, Wagilag, Liyagalawumirr* and *Liya-gawumirr* (Mundine 1999). As adjacent clan groups may speak quite distinct languages, most Yolngu are multilingual; nevertheless, many groups use the eastern *Gupapuyngu* and *Djambarrpuyngu* languages as a common vernacular (Mundine 1999).

2.3.1 Pre-contact life

Yolngu, like other Aboriginal groups pre European invasion were semi-nomadic hunter-gatherers. Hunting, gathering and fishing using traditional methods was the foundation of their subsistence economy. Some trade activities with other Aboriginal tribes and overseas visitors were also an important part of life. Warner (1958) and Thomson (1949) provide detailed descriptions of Yolngu subsistence economics and exchange practices for early post contact times. Yolngu found useful resources throughout much of their natural environment and maximised production through traditional management practices such as burning. Various practical and cultural methods were employed that helped to ensure the long-term reliability of these resources including replanting yam beds and the imposition of taboos which prevented the consumption of certain foods by particular people at various times.

Thomson (1949) noted that seasonal influence on travel and food supply were key factors in regulating people's movements. Ceremonial obligations also required people to be at certain places at specific times (Altman 1987) but these would usually coincide with the availability of an abundant food resource at the same location. These people possessed a unique and valuable knowledge about their natural environment as Donald Thomson, working with Aboriginal people in the 1930's, recognised.

> The natives (sic) are familiar with the various botanical (ecological) associations, which characterise this territory, and distinguish these by special terms. They can name, without hesitation, the characteristic trees, shrubs, and herbaceous plants in every association, as well as the food, plants and animals, and the raw materials used in technology, which at any season of the year they obtain from each of these associations. In this we see a system and orderliness which is very far removed from the general picture of the Australian Aborigine. (Donald Thomson, 1935 in Mundine 1999:93).

This knowledge was no doubt a major factor in their highly successful exploitation and maintenance of country.

2.3.2 History of contact

Before European invasion, Macassan traders from southern Sulawesi had regularly visited Yolngu lands, arriving with the annual northwest winds. Their trade was based on trepang (sea cucumber) but other items including pearls and turtle shells were also traded (Thomson 1949). In return, Yolngu obtained rice, tobacco, alcohol, fishing line and hooks, blankets, steel scraps and numerous other items (Thomson 1949). The Macassans respected Yolngu dominion and this international trading relationship was strong and enduring until the South Australian government curtailed the visits in the early 1900's (MacKnight 1976).

While European sailors and explorers had passed by Yolngu country before, it was not until 1803 when Matthew Flinders in his ship the 'Investigator' landed at Blue Mud Bay that Yolngu had any real contact with white men (Trudgen 2000). By 1885, when European colonies were well established in southern Australia, cattle leases were established in Arnhem Land (Berndt and Berndt 1954). Yolngu were strongly opposed to the establishment of cattle stations and expressed this opposition by killing cattle (Berndt and Berndt 1954). This was the beginning of a series of violent clashes where many Aboriginal people were killed. In the Arafura Swamp, the Florida cattle-lease was established in 1885 at a place Yolngu call Murwangi (see Figure 2.1). This and many subsequent ventures folded after a number of years due to opposition by Yolngu, distances to markets and unsuitable conditions, but not before a great majority of the indigenous population including entire clans were exterminated (Mundine 1999). Further altercations followed in subsequent years with Balanda (non-indigenous people) including Japanese trepangers leading to several Yolngu men being jailed (Trudgen 2000).

In 1923 a Methodist mission was established at Millingimbi on a nearshore island (McKenzie 1976). Many Yolngu were attracted to the mission where medical attention, tobacco and foods were available usually in exchange for labour and Christian teachings (Mundine 1999). During the war the island was a military base and many Yolngu worked in construction and various other jobs as part of the war effort (Mundine 1999). The mission persisted until the late 1960's (Mundine 1999). During the mid 1960's a subsidiary store/trading post of Millingimbi mission had been established on the mainland at Nangalala on the edge of the Glyde River (Figure 2.1) (Douglas and Oldmeadow 1972, Mundine 1999). On hundred and fifty head of cattle were mustered by Yolngu and brought to newly constructed cattle yards at Nangalala (Douglas and Oldmeadow 1972, Mundine 1999). A pastoral company was established in 1973 under the control of Yolngu directors and a missionary supervisor was employed to run the business, which was to be relocated south of Nangalala to Murwangi where the Florida cattle lease had once been (Mundine 1999). This business operated with a Balanda supervisor until recently. Later in the 1970's concerns about the proximity of Nangalala to several sacred sites led to a new town being developed. The new town site was on *Djadawitjibi* land at Ramingining (Mundine 1999). Nangalala remained a large outstation and many Yolngu families live there today. Many Yolngu who had settled in Darwin or Maningrida after the war returned to the new town and have adopted a more settled lifestyle in Ramingining and in homeland centres or outstations (often only seasonally inhabited) in surrounding country.

2.3.3 Land use – past and present

Arnhem Land was declared an Aboriginal reserve in 1931, but it was not until the passing of the Aboriginal Land Rights (Northern Territory) Act in 1976 that Arnhem Land became tenured as inalienable freehold land held by the Arnhem Land Aboriginal Land Trust (Keen 1994). Activity that could cause land or resource degradation in the area throughout the years has been limited. The Arafura area was formerly a major area for commercial saltwater crocodile hunting until legislation to protect the species was enacted (Brocklehurst and Wilson 1992). Currently, the main land use is based on

Aboriginal requirements and includes community housing, harvest of flora and fauna for food and other needs. Low intensity commercial pastoralism also exists in the area and has a history extending back over the last century (Cole 1979). Small-scale crocodile egg harvest and safari style tourism are also carried out in this area today.

2.3.4 Contemporary Yolngu life

Today, Yolngu people participate in the mainstream economic system whilst continuing traditional practices. This enables them to affirm and maintain their cultural identity whilst working towards achieving broader social and economic aspirations. Yolngu at Ramingining work as teachers, health-care staff, mechanics and various other roles. Many are on pensions and unemployment benefits.

Overall, Yolngu are now much more sedentary; spending their time in and around Ramingining, especially during the wet season. Even people who spend much of the dry season at outstations prefer to live in town during the wet season so as to be close to a reliable food supply at the store. The availability of store foods and other services in town (e.g. school, health clinic, banking facilities), as well as social enticements such as card playing, have also influenced traditional seasonal movements. With a majority of people now living in larger, centralised settlements, motor vehicles and in some cases boats have become essential in enabling people to access traditional estates (Young et al. 1991). Motor vehicles also give people a degree of choice about where they reside (in town or at outstations) without compromising their needs. Associated with these modern technologies is an increased dependence on the cash economy for fuel and maintenance of these vehicles (Young et al. 1991).

In terms of contemporary resource use, modern technologies have extended the accessibility of bush foods and other resources and increased the efficiency of procurement. The efficiency of the hunting economy has also improved with the introduction of non-indigenous game into the region (Altman 1987). These issues are discussed in more detail in Chapter 6.

2.3.5 People's relationship to country and Aboriginal land management

The significance of the relationship between the environment and Aboriginal culture has been well documented (see for example Warner 1958, Berndt and Berndt 1964, Rose 1992, Smyth 1994). Aboriginal identity and customary Law come from the land, and are inseparable from it. The origins of the natural world are explained in creation stories. As Smyth (1994) explains, these stories form the basis of the Law and of relations between people, and between people and their environment. For Aboriginal people, the natural world (plants and animals, including humans) is an integral part of their spirituality and social systems.

The Law stipulates Aboriginal life practice including interaction with the environment and other beings and confers on people a moral responsibility to look after their country (Rose 1992). The Law is not confined to humans as all species have their own Law that shapes the specific behavior of that species (Rose 1992). Yet humans and non-human entities were created together and as such share a bond, often referred to as totemism, that links them and their Law (Bennett 1983, Rose 1996). Thus, a reverence or 'land ethic' based on Law exists for the natural world and unites people with their community and their environment in a way that is virtually unknown in western society (Robertson et al. 1992).

Human beings as a part of the natural world have a responsibility to care for it and in turn nature is expected to provide physical, emotional and spiritual nourishment (Rose 1992, Strang 1997). This connection helps us to understand the meaning and importance behind country to Yolngu and their innate philosophy of caring for their land. Failure to properly look after country, or follow the Law, has consequences often manifested as unusual events or catastrophes and the breakdown of the systems that support people (Rose 1992, Davies et al. 1999). Bradley (2001:299) explains with reference to the Yanyuwa people from the Borroloola area in the Northern Territory:

> ...people operate within an ecological system in which human agencies, special knowledge, and power are significant components to the way in which the land is managed; that is, they negotiate their relationship to their country.

Similarly, White (2001a:3) explains with respect to Yolngu relationships to country:

> The relationships among these (human and non-human) actors is maintained by a variety of means including dialogue, ceremony, song and dance. Maintaining these relations is a political affair.

These relationships must not be ignored when discussing land management.

Western culture uses the term 'land management' to refer to concepts and actions that involve exerting some control over land and its processes. On Aboriginal land, the term 'caring for country' is often used. Bradley (2001) explains that caring for country involves negotiating with country, interpreting and responding to signs made by country. It is a more balanced relationship of reciprocity and interdependence between people and their country.

Caring for country is about people's relationships to the land and to each other; it is integral to culture and is not viewed as a separate activity that must be 'carried out' (Rose 1995). Country encompasses much more than just land; marine environments, fauna and other natural resources are also a part of country as are ancestral spirit beings and other less tangible things. Thus whilst caring for country involves some activities that are akin to western land management, this is only the surface of responsibility (Rose 1995, Davies et al. 1999). The maintenance of healthy country (including people and animal species), having its origins in indigenous Law, is also an essential component of the spiritual aspect of life. It is understood and passed on through song and ceremony and involves both rights and responsibilities towards country and resources. Great importance is placed on ensuring that younger generations learn this knowledge, as they must pass it on to future generations (Rose 1995, Davies et al. 1999).

2.3.5.1 *Wanga Djakamirr* community rangers

A network of kin connections drove the growing awareness of land management issues and formed the basis for the development of community ranger programs in this area. Local historical and political context influenced the development process, effectively resulting in separate programs for the northern and southern Arafura Swamp communtities. Yolngu in Ramingining and nearby outstations established the *Wanga Djakamirr* community ranger scheme early in 1998 with support from the Northern Land Council's Caring for Country Unit. Rangers from several outstations (including Donydji and Mirrngadja) that have close social ties, look after much of the southern part of the swamp and catchment. The discovery of the invasive weed *Mimosa pigra* in the area was one of the main incentives for the development of the ranger program (Smith 2001). Other factors involved, particularly for communities in the southern swamp and catchment area, included a feeling of limited control over many of the recent developments in roads, tourism and mining exploration (White 2001a). The nomination, and now placement, of the Arafura wetlands and surrounds for inclusion on the 'Register of the National Estate' (White 2001a) also provided incentive to these groups.

Community-based ranger programs are operating in a number of other Aboriginal communities across the Top End including Maningrida and Yirrkala. A community-based approach (as defined in Chapter 1) aims to ensure that indigenous people maintain control over land management activities and can incorporate western techniques with traditional management practices where they deem necessary. As land management is of direct cultural importance to Aboriginal people, many Yolngu have an interest in being involved and developing any additional skills that may be required. The ranger program provides employment opportunities within the community and fosters the passing on of traditional knowledge to younger generations. Further, it ensures that younger generations see the importance of traditional knowledge and the value placed upon it by western scientists seeking to work with the community rangers. At the time the fieldwork was undertaken for this study, the rangers were all men, but by the time of writing the ranger program had broadened and there were also women rangers involved in land management activities.

The Northern Land Council is the statutory support body for assisting Top End indigenous people to manage their land. The specialised 'Caring for Country Unit' (CFCU) assists landowners with the environmental issues concerning management of their land. A land management co-ordinator based at Ramingining facilitates land management planning for the northern two-thirds of the Arafura Swamp and related catchment (Storrs 1997). The land management activities undertaken by the *Wanga*

Djakamirr community rangers around Ramingining include weed and feral animal management (Plate 4), sacred site protection, participation in workshops and conferences regarding indigenous land management, monitoring the area for illegal fishing vessels and gravel pit revegetation. The ranger unit has also been involved in researching the logistics of a variety of small business aspirations within the community.

Various training and education initiatives have been delivered to Yolngu when land management work has involved dealing with new issues and/or techniques. The ranger office acts as a point of contact for relevant parties regarding land management issues and is a place where collaborative relationships, especially with the scientific community, can be fostered in a mutually educative and beneficial fashion. The rangers have worked with collaborating researchers undertaking biological surveys (Plate 5), hydrological surveys, weed management and, as part of this study, feral animal management.

Plate 4: Rangers after a successful pig control exercise.

Plate 5: Rangers checking a mammal trap as part of a flora and fauna survey undertaken in collaboration with the Parks and Wildlife Commission, Northern Territory.

Whilst the activities of the *Wanga Djakamirr* ranger unit have mainly been based on a western land management approach, Yolngu culture by way of its Law, knowledge and kinship networks informs and characterises the ideals and function of the unit. Ranger work is much admired as a form of employment that benefits the community and traditional Yolngu requirements to look after the land. The rangers are perceived by the community to be general caretakers, especially for management issues that are new or are general issues for many clan estates (such as weeds and feral animals). If work is to be undertaken on particular country, the rangers themselves ensure that an appropriate ranger (i.e. one that belongs to or has close associations to the place) participates in the management activity or has given permission for the work to be done. To the outside observer the importance of this may not be obvious, as it is often an unspoken delegation or is attenuated by the pretext that this ranger 'knows more about that place so they should go along'.

2.4 Threats

There is a range of actual and potential threats to the environment of the Arafura Wetlands and surrounds. Many of these threats are common across Top End wetlands and other ecosystems. These threatening processes may also affect local Aboriginal subsistence and other aspects of their culture. The biggest threats are exotic invasive organisms such as weeds and feral animals.

2.4.1 Weeds

The Top End is fortunate to have most of its natural vegetation intact with alien weed species comprising less than 5% of the flora (Whitehead et al. 1990, Cowie and Werner 1993). However, wetland and riparian areas are especially under threat from various weed species that can affect the structure and function of these very important, species rich and diverse ecosystems (Smith 2001). Their effect is amplified by the presence of large numbers of feral pigs, buffalo and cattle that are known to increase the spread of many weed species. In the Arafura region, 98 weed species (7.2% of total flora) have been identified (Brennan et al. 2003). One of these weeds is Mimosa (*Mimosa pigra*), which is considered a significant threat in the Northern Territory and has become a prominent feature of some Top End floodplains. Mimosa is an aggressive prickly shrub, native to Central America, which forms dense monospecific stands. It is a prolific producer of seeds that are readily dispersed by water, vehicles and animals (Finlayson et al. 1988, Smith 2001). In the Arafura Swamp region, outbreaks of Mimosa have been small and localised, and control, which has been by physical removal along with regular monitoring for new plants, has been successful to date.

2.4.2 Feral animals

Exotic animals can cause significant changes to ecosystems and threaten the environmental integrity of an area. In the Top End, ecological changes have been widespread in association with the introduction of the feral pig. Asian water buffalo (*Bubalus bubalis*) have also caused habitat degradation, which has impacted on a wide range of fauna and flora species. Buffalo are thought to have first become feral in northern Australia in the late 1820's (Letts 1962) and by 1885 were common as far east as the Liverpool River in Arnhem Land (Lindsay 1884). Further west in the Arafura Swamp region, several Yolngu recall that buffaloes were not seen until the 1940's (Yolngu assistants pers. comm. 2000).

Buffalo are the most abundant large introduced mammal in the Northern Territory and are considered responsible for extensive ecosystem destruction caused by their grazing, trampling and wallowing behavior (Ridpath 1991). They destroy levee banks and create swim channels across floodplains which contributes to premature drainage of freshwaters as well as saltwater intrusion into freshwater environments (Finlayson et al. 1988, Skeat et al. 1996). Buffalo can reach far higher local densities than pigs, and their wallowing and creation of channels can alter water flow through extensive hydrological systems. High densities of buffalo have been the cause of saltwater intrusion in many Top End hydrological systems through breaking up chenier ridges, development of swim channels, and devegetation of floodplains. High numbers of buffalo will almost certainly accelerate saltwater intrusion into the Arafura Swamp, to the marked detriment of biodiversity and Yolngu way of life. Although the feral herds to the west of Arnhem Land were almost eradicated as part of a national program to prevent diseases being transferred to domestic stock in the 1980's, buffalo still exist in large numbers in

Arnhem Land today (Storrs and Finlayson 1997). While the buffalo population is widespread in the Arafura Swamp area, they are concentrated in the northern part of the swamp and across the coastal plains (Brennan et al. 2003).

Feral cattle also occur in the Arafura Swamp area, as well as approximately 5500 head of domestic cattle, which are mainly grazed in partially fenced areas along the western edge of the swamp and along fringes of paperbark areas to the south of Murwangi (Brennan et al. 2003). While this is a relatively low number of animals, the extent to which the cattle use or damage the wetland has not been assessed. Plate 6 shows a small group of cows at Crossing.

Plate 6: Cattle on the floodplain at Crossing.

Overall, very little is known about the specific effects of grazing in the Arafura Swamp, however cattle are grazed in the most important part of the wetland system. Disturbance in this area where freshwater from the swamp drains into the tidal channel of the Glyde River may have a significant impact on the ecological and cultural values of the area (Brennan et al. 2003). Grazing along drainage lines can cause changes to run-off patterns and increased sediment loads (Storrs and Finlayson 1997). Heavily grazed wetland communities have also been found to converge floristically, with introduced pasture species being capable of replacing the native grasses (Whitehead et al. 1992). Griffin (1995) has suggested that change in the primary production cycles that can occur as a result of grazing may be having an adverse effect on fisheries production in the estuaries.

Feral cats (*Felis catus*) were observed during this study in the Arafura area, although their relative abundance is unknown. Cats were probably introduced to the Top End at the time of European settlement, although there are some beliefs that they may have been introduced earlier than this (Abbott 2002). In the 1930's, Donald Thomson described feral cats as numerous across northeast Arnhem Land and a food source to the natives (Dixon and Huxley 1985). Today, the domestic cat is a popular pet among many Yolngu people, however, I did not observe it being used as a food source. Cats hunt on the floodplains and in other habitats at night and it is likely that they have had a significant impact on small mammal and reptile populations in the area.

Cane toads (*Bufo marinus*) are a very recent arrival to the Arafura Swamp region. They were first sighted in the very southern parts of the catchment in 1998 and gradually moved north to Ramingining by the 2000/2001 wet season (Brennan et al. 2003). The effect of this poisonous toad in this environment is as yet unknown. However, some (Freeland 1984, Catling et al. 1999) argue that cane toads have not yet demonstrated that they have serious short or long-term adverse impacts on native fauna. It is thought that cane toads may initially kill some individuals of various species and that this may threaten the regional survival of vulnerable species (Brennan et al. 2003). Populations of most native predators of frogs are expected to recover as they learn either to not eat toads or to eat them in a safe manner (Brennan et al. 2003).

2.4.3 Other threats

Coastal wetlands in the Top End are potentially threatened by destructive changes that are a consequence of climate change, sea level rise and saltwater intrusion (Bayliss et al. 1997). Saltwater intrusion has the potential to cause the destruction of freshwater vegetation communities, including the dieback of paperbark swamps (Finlayson et al. 1988). Given the very flat topography of the Arafura floodplains, saltwater intrusion could progress rapidly with only a very minor global sea level rise (Storrs 1997).There is evidence to suggest that buffalo grazing and trampling have contributed significantly to the processes that result in saltwater intrusion (Finlayson et al. 1988). Certainly, overgrazing along drainage lines and elsewhere by cattle and feral animals can lead to significant changes in run-off patterns and to increased sediment loads (Storrs and Finlayson 1997).

Altered settlement patterns and the availability of modern technologies have had some significant effects on the local environment. A greater number of people sourcing foods from a concentrated area around settlements has increased pressure on flora and fauna populations in these areas, as has the improved hunting efficiency gained by the use of guns (White and Meehan 1993). Increased vehicle use may also be damaging native vegetation, sensitive habitats such as coastal dunes, and important archaeological sites (White and Meehan 1993). Road works resulting in increased vehicle traffic into the area are a threat predominantly in terms of the transmission of new weeds on car tyres. Increased ease of access to the area may facilitate increased tourism and consequent pressure to develop further infrastructure and facilities (White and Meehan 1993).

Changed fire regimes as a result of altered occupancy and visitation of many clan estates pose a further threat to the area. Reduction or cessation of early dry season burning and mosaic burning patterns can lead to an increase in the occurrence of hot wildfires that are damaging to relict plant communities, especially the rainforest communities that fringe the swamp (White and Meehan 1993, Storrs 1997, Environment Australia 2001). The Arafura Swamp was extensively burnt by late season fires on several occasions between 1986 and 1992 and during recent surveys of the area contracting rainforest patches were recorded as well as widespread deterioration of stands of the native pine, *Callitris intratropica* (Brennan et al. 2003).

This chapter highlights the complexities of the physical, cultural and political environment of the Arafura Swamp which add to the challenge of understanding the threats facing the area and determining the best approach to its management. Many of the issues that must be considered when developing a feral animal management strategy for the area are identified and given explanation and context here and are considered further in later parts of this thesis.

The next chapter describes the methods used and types of data collected on seasonal use of habitat by pigs and buffalo and the potential environmental correlates to this activity. The results are explored, prior to detailed analysis, to provide an overview of the data and summaries of data distribution.

CHAPTER 3: Feral pig surveys - methods and exploratory data summaries

3.1 Introduction

This study of habitat use by feral pigs, and to a lesser extent Asian water buffalo, was initiated in response to perceptions and concerns held by local Aboriginal people that these animals may be having a deleterious effect on the environment of the northern Arafura Swamp. These perceptions will be explored in Chapter 5. By undertaking feral pig and buffalo surveys, this study aimed to assess and quantify the impact feral pigs and buffalo have in the swamp and determine the key environmental attributes that drive their activity. This chapter describes the type and extent of pig and buffalo activity in different habitats each season and describes a range of potential environmental correlates for which data was collected. It also aims to determine whether measuring different parameters of pig and buffalo activity was necessary by analysing interrelationships between pig and buffalo activity indices each season. As the impact of pigs was of greatest concern to local people, the data collected (for feral pigs) was analysed using statistical modelling methods to explain the relationships between pig activity, season and other environmental variables in order to develop a predictive model of seasonal habitat use by pigs which could be used to inform management programs (see Chapter 4). The focus of this research was on assessing the impact of feral pigs rather than on estimation of their population density. The level of survey effort needed to attain a density estimate was not practical given the physical and cultural environment and the time available.

Feral pigs, especially when widely dispersed, are (a) difficult to observe in dense vegetation, (b) are wary of people and (c) are only active at night and in the very early daylight hours and around dusk (Auld and Tisdell 1986, Caley 1997). Like many other vertebrate pest species, their presence is often only surmised from the damage that they cause (Auld and Tisdell 1986). Indicators or signs of pig presence have been widely used in the study of feral pigs (Alexiou 1983, Hone 1988b, Bowman and Panton 1991, Pavlov et al. 1992, Mitchell and Mayer 1997), although it is unclear if animal sign is actually correlated with population density (Hone 1988a) or animal activity (Taylor and Friend 1984). Pig digging has been found to be a reliable indicator of past pig presence and has been widely used as a way of broadly quantifying the damage that pigs cause (Bratton 1975, Hone 1988a, 1988b, Bowman and McDonough 1991, Bowman and Panton 1991, Laurance and Harrington 1997, Mitchell and Mayer 1997).

Feral pigs use different vegetation types for different activities; thus, a broad range of signs that encompass all aspects of behavior could act as indicators of pig presence and activity. Dung pellets have been used as a sign of pig presence (Hone 1988b, Hone and Stone 1989, Bowman and Panton 1991, Hone 1995). As fresh dung implies very recent presence of pigs in the area, the presence of fresh dung may be an accurate indicator of the extent of seasonal presence of pigs. Other indicators of feral pig presence and activity are resting places or wallows (Pavlov et al. 1992), presence of tracks (Pavlov et al. 1992), the area of ground surface trampled (Bowman and Panton 1991), rubbing and tusk marks on trees (Bowman and Panton 1991), sightings (Pavlov et al. 1992) and dead pigs or carcass remains (Cooray and Mueller-Dombois 1981).

Previous studies have attempted to correlate pig activity with environmental variables. The amount of pig damage (as indexed by digging) has also been found to vary significantly with vegetation type in far north Queensland (Mitchell and Mayer 1997). Relationships between other environmental variables and pig activity have been explored including the presence of roads or vehicle tracks (Mitchell and Mayer 1997), slope position (Laurance and Harrington 1997, Mitchell and Mayer 1997), presence of rocks (Hone 1988b, Laurance and Harrington 1997, Mitchell and Mayer 1997), distance to water, groundcover and canopy cover (Laurance and Harrington 1997). Food availability and the phenology of fruiting plants are also important determinants of habitat use by feral pigs (Dardaillon 1987). In the Top End, seasonal flooding is known to affect habitat use by pigs (Ridpath 1985, Hone 1990a). The type of vegetation has been found to strongly influence the density of pig populations (Caley 1993) and the extent of pig digging (Bowman and McDonough 1991). The amount of groundcover has also been found to be weakly but positively associated with diggings (Bowman and McDonough 1991).

Signs have also been used to determine habitat use by feral buffalo. Dung pats were used as an index of buffalo use in monsoon forest habitat in Kakadu National Park (Braithwaite et al. 1984). Swim channels and wallows have also been used as indicators of buffalo activity (Taylor and Friend 1984).

As all survey work was undertaken on Aboriginal land it was important that local Aboriginal people consented to and valued the field study component of the project. The local *Wanga Djakamirr* rangers played an integral part assisting in survey tasks including the determination of site locations. Their identification of signs of pigs and contribution to the understanding of pig habitat use was extremely valuable (Plates 7 and 8). This participation enabled a two-way transfer of knowledge and skills between myself as the researcher and Aboriginal collaborators, which is an essential aspect of any work undertaken with indigenous people.

An exploratory summary of the data collected is provided in the following section.

Plate 7: Rangers identifying pig sign in a rainforest near Gatji.

Plate 8: Ranger identifying buffalo wallows at Djanyirrbirri.

3.2 Methods

3.2.1 The study design

The area of the Arafura Swamp and catchment is more than 10,365 km^2 (Brennan et al. 2003) and is described in Chapter 2. This size and the poor access of much of the area meant that it was not possible to survey all areas where pig infestations were reported to occur. This study area was approximately 600 km^2, centred around Ramingining community on the western edge of the Arafura swamp (Figure 3.1). This area was chosen because I had previously worked in this community and possessed some familiarity with the local area and its people. Most of the landowners for the study area resided in or near Ramingining, enabling regular contact. Surveys were restricted to the western side of the Glyde River for practical reasons of logistics and access.

In order to assess the seasonal occurrence of pigs in different vegetation types a systematic survey method that recorded pig presence and activity in each of the sampled vegetation types was required. It was not possible to monitor the habitat use of individuals directly; thus, a range of pig signs were used to identify areas in which pigs had previously been present. Signs of the presence and activity of buffalo were recorded simultaneously. A repeated measure design was used, with surveys undertaken in four consecutive seasons to determine the effect of seasonal variation on feral pig activity. The survey design was nested with three levels (decreasing in size) comprising sites, plots and quadrats.

Nine sites were chosen in different geographic areas across the overall study area (Figure 3.1). As the survey work was done in collaboration with local landowners, sites were selected that I was familiar with (i.e. had been to previously with custodians) and that I was given permission to work on (see also Section 3.2.2.1). It is probable that my collaborators suggested sites based on a prior knowledge of pig activity in the area as upon exploration all sites contained some evidence of pig activity. Sites encompassed a range of vegetation types, landform types and features and were varying distances from the coast and outstations as described in Table 3.1. Site selection was determined with the aim of providing independence, i.e. to minimise the probability at any given sampling time that pigs from one site would also be using the other sites. This had to be within the limits of logistical constraints. Previous research indicated that mean aggregate home ranges of feral pigs in a tropical woodland environment (tracked over a period of 12 months) was 33.5 km^2 for boars and 24.1 km^2 for sows, with seasonal movements being between a half to a fifth of this area (Caley 1997). The home ranges of feral pigs were found to vary inversely with resource abundance and density (Singer et al. 1981); hence, in the resource rich Arafura Wetlands the home ranges of feral pigs could be expected to be smaller. However, true independence of sites may have only been achieved at the more remote sites - Gatji, Crossing and Garanydjirr.

Within each site, two scales of assessment were used. These were broad sampling units (plots) located in different vegetation classes within each site which were the core unit of assessment of pig activity and environmental factors, and finer-scale elements within the plots (quadrats) in which some more detailed measurements were recorded.

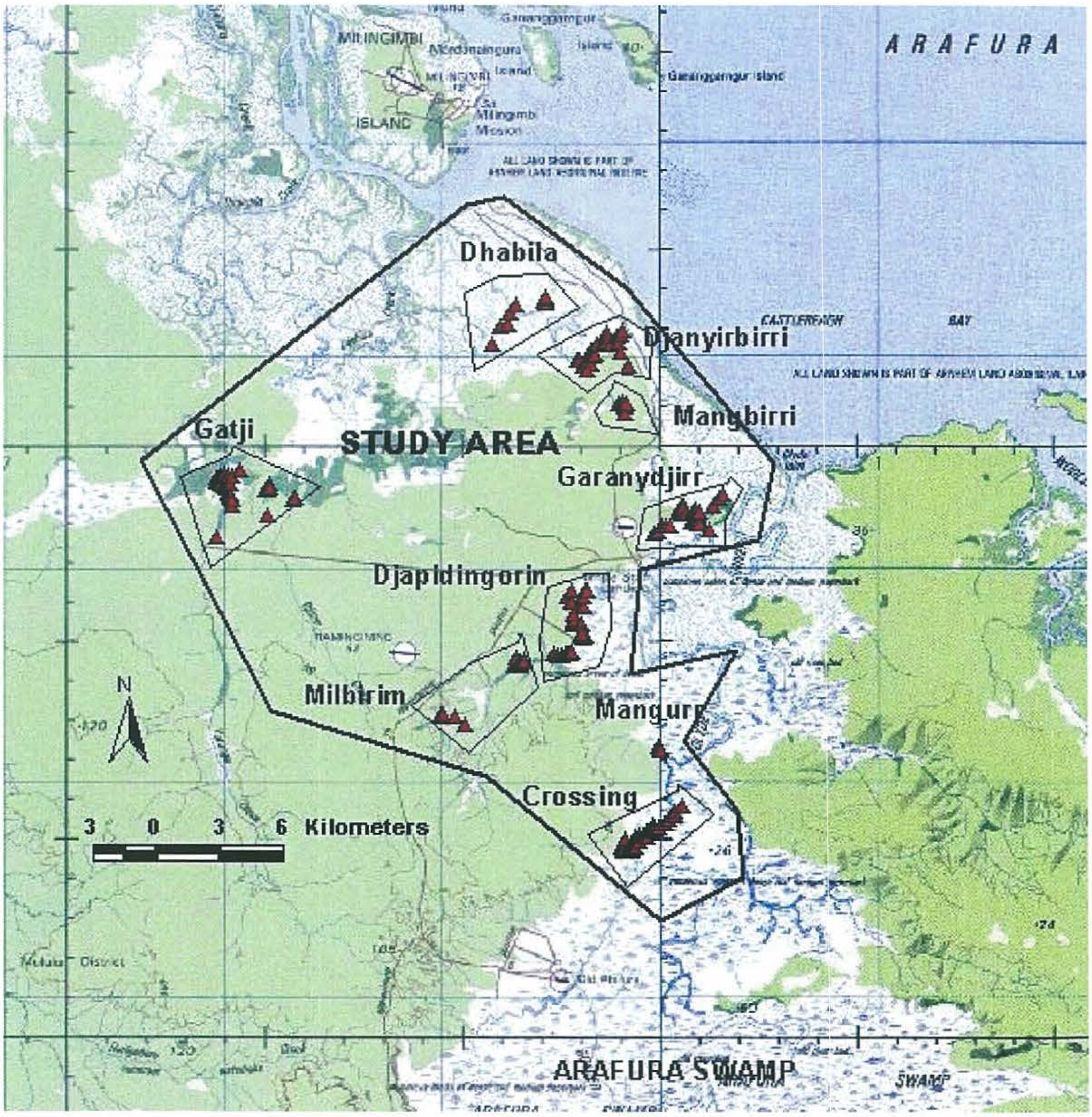


Figure 3.1: Study area showing nine sites and plot locations (shown as triangles) within each site area.

NB: The position of the roads on the topographic base map is approximate; as such plot locations on the map do not always match the descriptions given in the text.

Table 3.1: Descriptions of the location and important features of each site.

Sites	Site description
Crossing	West side of the Glyde River floodplain just downstream of maximum tidal influence. Northern bottleneck of the main Arafura Swamp. Site encompasses footslope and escarpment area above the floodplain. Low areas inundated throughout the wet season. Area extensively used for grazing cattle throughout the dry season.
Dhabila	Chenier ridge and surrounding coastal floodplain west of the main road approximately 5 km south of the barge landing at Dhabila. Area encompasses seasonal creeks that drain floodwaters after the wet season and that can also inundate areas during 'king tides' in the dry season.
Djanyirrbirri	Area approximately 2 km from the coast where the floodplain meets eucalypt woodland, paperbark forests and monsoon forests on higher ground. A swampy channel runs through the site, which remains moist in sections well into the dry season.
Djapidingorin	Along the western edge of the Glyde River floodplain, approximately 3.5 km northeast of Ramingining where it meets paperbark forest and rises into eucalypt woodland. The area also encompasses sections alongside Ramingining Creek.
Garanydjirr	'Island' (elevated area that is not inundated by floodwaters during the wet season) on the western Glyde River floodplain 5 km from the river mouth. Also a semi-permanent outstation. Site includes the island, floodplain surrounding the island and parts of the nearby 'mainland' which joins the island via a causeway. Cattle are occasionally grazed on this part of the floodplain.
Gatji	Area approximately 13km west of Ramingining. Yarunga Creek forms a large billabong just north of Gatji outstation. The billabong drains into extensive paperbark forests.
Mangbirri	A paperbark swamp some 11km south of the barge landing at Dhabila. The site encompasses areas on both sides the barge landing road.
Mangurr	Area north of the bottleneck of the Arafura Swamp (and north of the site, Crossing). Encompasses the Glyde River floodplain and footslope pandanus vegetation.
Milbirim	Area 2 km east of Ramingining, which is part of the Ramingining Creek system. This site also includes upstream sections of the creek system located 4.5 km south of Ramingining near the airstrip.

3.2.2 Plot selection

A total of 192 plots (each 50 x 50m) was located across the 9 site areas. The vegetation classes surveyed are described in Table 3.2. The number of plots established was not equal for all environments nor was it in proportion to the size of each vegetation class, but rather was related to an a priori assessment of habitat use by pigs. At another site incorporating an environmental mosaic from wetlands to upland eucalypt forest in the Top End, Bowman and Panton (1991) found that pig digging was concentrated in wetland communities, with very little evidence of use within the widespread eucalypt communities. Elsewhere in the Top End, Hone (1990a) also reported that pigs were absent from eucalypt communities in the dry season and were only present there in small numbers in the wet season. Based on this information and on information from Aboriginal assistants, the number of plots established was higher than their relative extent in wetlands (mainly sedgelands and paperbark swamps) and lower in eucalypt woodland. This approach was adopted to maximise returns from sampling effort, a pragmatic choice reflecting the reality of major constraints on fieldwork effort in this remote region. Table 3.3 shows the number of plots located in each vegetation class within each site.

Table 3.2: Vegetation classes surveyed and associated environmental variables.

Vegetation class	Description	Summary of environmental variables	Estimated percentage of vegetation class in study area**
SED* Sedge	Various sedge associations occur in the area; species include *Eleocharis spp., Pseudorhaphis spinescens, Nymphaea spp., Ipomoea aquatica, Hymenachne acutigluma, Leersia hexandra, Cyperus spp., Hanguana malayana.*	Usually inundated for several months of the dry season, soft soils usually wet silt/clay; canopy cover can vary dpending on whether sedge is the ground cover beneath PBK or ground cover in open areas.	See monocot as % of sedge varied with season
GRA* Grassland	Mixed annual and perennial grasses including *Oryza rufipogon, Imperata cylindrica, Panicum decompositum, Heteropogon triticeus, Paspalum spp., Phragmites vallatoria.*	Usually only inundated for a short time in the dry season and becoming very dry on hard cracking clay soil as the season progresses.	See monocot as % of grassland varied with season
MONOCOT	The vegetation classes sedge and grassland were combined when data was analysed across seasons.		40%
PBK Paperbark	Mixed paperbark forests (mostly *Melaleuca viridiflora* and *M. Cajaputi*, some *M. leucadendra*).	Occur on the fringes of floodplains in some areas but can also form extensive forests. They are inundated for variable time periods into the dry season and generally occur on moist sandy loam or clay soils.	20%
PBKW Paperbark woodland	Mixed woodland community, containing *Corymbia spp., Lophostemon spp., Banksia spp, Erythrophleum chlorostachys, Pandanus spiralis, Grevillea pteridifolia* and *Melaleuca spp* (>20%).	Generally occur on sandy loam soils, in close proximity to permanent water sources such as billabongs and freshwater creek systems. Inundation not extending long into the dry season.	<5%
MVF Monsoon forest	Broad range of canopy species including *Litsea glutinosa, Drypetes deplanchei, Buchanania arborescens, Polyalthia australis, Cupaniopsis anacardioides, Canarium australianum , Carallia brachiata, Sterculia quadrifida, Pouteria sericea.*	Both wet and dry monsoon forests occur in the study area. Mainly occur on sandy soils, although they can also be found on deep clay loam soils.	<5%
PAN Pandanus	Open woodland or grasslands with *Pandanus spiralis* (>20%).	Occurs on a range of soils and is often situated near water sources such as billabongs and streams. Often is found in the area between floodplains and forests.	<5%
WDL Woodland	*Eucalyptus miniata* and *Eucalyptus tetrodonta* open forest, often with *Cycas arnhemica* and *Livistona humilis* palms.	Widespread vegetation community, generally in sandstone and lowland country on well-drained soils including rocky areas.	30%

*NB: Grassland and sedge communities are often found together with dominant species being dependent on depth and duration of inundation in these classes. ** Percentages of vegetation classes were estimated from data collected by Parks and Wildlife Commission, Northern Territory as presented in Brennan et al. (2003).

Plots were located as randomly as possible given a range of constraints as described in section 3.2.2.1 and as such the distance between plots was variable. Plots were marked with metal fence droppers placed at each corner and each plot was numbered and had its geographic location recorded by Geographic Positioning System (GPS). All plots were surveyed once in each season except when access was not possible. Each plot contained four 5 x 5 m quadrats, one randomly placed in each quarter of the plot; these were not re-surveyed, such that a new set of quadrats was chosen randomly each season. Randomisation of quadrats was acheived by dividing a plot into a grid of 25 numbered squares (each $5m^2$) and selecting a numbered square from a bag containing a full set of squares. No record was kept of the seasonal within plot locations of these quadrats.

Table 3.3: Number of plots of each vegetation class within each site.

	Vegetation classes						
Site	**Sedge-Grassland* (monocot)**	**Monsoon Forest**	**Woodland**	**Pandanus**	**Paperbark**	**Paperbark woodland**	**Total**
	SED-GRA	MVF	WDL	PAN	PBK	PBKW	
Garanydjirr - GAR	22	5	2	4	0	0	33
Djanyirrbirri - DJA	12	4	2	0	3	1	22
Milbirim - MIL	0	5	4	0	2	8	19
Gatji - GAT	11	6	2	4	10	0	33
Djapidingorin - DJN	10	6	2	6	4	3	31
Crossing - CRO	20	0	2	0	10	0	32
Mangurr - MGR	2	0	0	3	0	0	5
Mangbirri - MAN	0	1	0	0	6	0	7
Dhabila Rd - DHA	10	0	0	0	0	0	10
All Sites	87	27	14	17	29	18	192

* many plots in this vegetation class are defined as *sedge* in the wet season and *grassland* in the dry season and as *monocot* when data are analysed across all seasons

3.2.2.1 Constraints to site and plot selection

Site areas were chosen after considerable consultation with local Aboriginal people who could speak for the country and give advice on suitable places to survey as well as obtaining permission from appropriate landowners. Site choices were constrained by distance from Ramingining. Survey sites involved day trips only as Yolngu assistants wished to return to their families each evening.

Some sites could only be partially utilized for cultural reasons, which prevented true randomisation of plots within sites. For example, at one site it was necessary to keep away from a certain area that was sacred; at another site Yolngu informants requested that no survey work be undertaken in a specific area that was considered to be a place of great danger.

3.2.3 Seasonal timing of surveys

Plots were surveyed in each of four main seasons: the late dry (October/November 1999), wet (March 2000), early dry (June 2000) and mid dry (August/September 2000) in an attempt to correspond to the major environmental seasonal distinctions. Accessibility to some plots varied throughout the year because of wet season inundation (only 40% of plots could be surveyed in the wet season). Aside from difficulty of access, plots that were inundated (≥10cm water depth) were not surveyed because signs of pigs were not visible in such conditions. The survey recorded when a plot was inundated with floodwater and when plots were inaccessible (usually due to inundation on route to the plot) this was also noted.

The temperatures recorded during each of the seasonal surveys were average as shown in Table 3.4. Although rainfall occurred later than normal (as indicated by lower than average October rainfall and higher than average November rainfall) during the survey, the overall rainfall pattern at this time of year was close to average (Table 3.4) and is unlikely to have had any significant impact on the results.

Table 3.4: Climate data during the period of each seasonal survey showing date of survey and relative seasonal conditions*.

Survey date	Average maximum temp °C	Survey maximum temp °C	Average rainfall (mm)	Survey rainfall (mm)
Late dry season Oct/Nov 1999				
Oct 1999	32.7	32.3	26.5	13.5
Nov 1999	33.6	33.9	92.9	141
Wet season March 2000	31.4	30.5	291.4	306.3
Early dry season June 2000	29.3	27.9	6.3	3
Mid dry season Aug/Sept 2000				
Aug 2000	29.8	28.1	0.6	0
Sept 2000	31.3	n/a	0.8	0

*NB. Rainfall data have only been collected for the last 5 years from Ramingining. Temperature data are from Millingimbi. The means of the last 5 years have been shown to match the rainfall record (Bureau of Meteorology).

3.2.4 Sampling times

Surveys were undertaken at any time of day except during the late dry season when they were carried out either early in the morning (6-10 am) or late in the afternoon (4-6 pm) due to high temperatures and humidity. This could potentially have affected sightings of animals, but as there were very few sightings during any of the survey times I suggest that any such bias was of little consequence.

Sampling each plot took between 15 and 40 minutes depending on conditions and vegetation type. Monsoon forests usually took the longest amount of time due to thick vegetation making both movement and survey tasks very slow. Plots in more open vegetation types such as grassland (when grass height was low) and coastal floodplains were much quicker to survey. Plots with no damage were also quicker to survey than plots with digging or trampling present as less estimation and calculation work was required.

The next section details the specific variables measured in each survey.

3.3 Survey content

The pig activity variables and environmental variables that were measured each survey are described below. Table 3.5 shows the structural level(s) surveyed and the scale of measurement for each variable.

3.3.1 Pig activity variables

Each variable is described below with definitions of categories within each variable also described where necessary.

Pig digging was recorded if there were obvious signs of ground disturbance including any pronounced scarification or visible signs of soil turnover by pigs. Diggings were identified as originating from pigs rather than other animals primarily by depth and/or the presence of other signs of pigs nearby. The total area dug was estimated as a percentage of the area of the $50m^2$ plot as well as a percentage of the area of each of the four $5m^2$ quadrats nested within each plot. When estimating area dug and area trampled, constant (mental) calibration of damaged area was achieved by regularly referring to a grid diagram of different sized shaded areas (see Figure 3.2). This ensured consistency of estimations across time and vegetation classes.

Estimates of the age of diggings were made so that recent or fresh activity could be distinguished from older activity, to enable the differentiation of current and cumulative damage. Digging was recorded as being **fresh** (moist soil turned over by pigs, no leaves or vegetation in base of diggings), **medium** (weathered soil and some leaf litter in diggings) or **old** (diggings covered by leaf litter, plants germinating in diggings, weathered soil) after Mitchell and Mayer (1997). It is estimated that fresh diggings would be no more than one week old, medium diggings could be up to 3 months old, and old diggings are likely to be more than 3 months old.

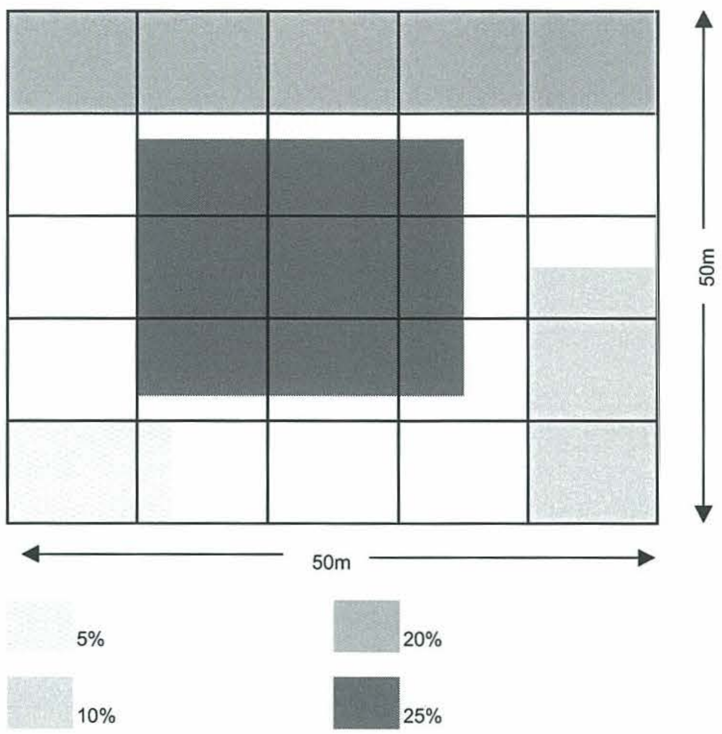


Figure 3.2: Example calibration grid with different sized shaded areas - plot area divided into 10x10m (4%) squares.

Trampling was recorded when a, b or c (see below) occurred in conjunction with the presence of either pig or buffalo foot prints. (a= vegetative ground cover was non existent in an area surrounded by cover; b= vegetative ground cover was significantly less than that of surrounding areas; c= vegetative ground cover was flattened). This variable was confounded by the simultaneous presence of pigs, buffalo and in some areas, cattle. As it was not possible to determine which animal(s) had caused the trampling in most instances this variable is recorded as a sign for both pig and buffalo. The total area trampled was estimated (again using the calibration grid described above) as a percentage of the area of a $50m^2$ plot as well as a percentage of the area of each of the four $5m^2$ quadrats, i.e. trampling was recorded in each plot and quadrat.

Live pigs and carcasses were recorded as the number of live pigs sighted within 100m of the plot during each of the surveys. Dead pigs or carcass remains including the presence of bones, skin and other remains were recorded within the plot. The variables

live pigs and **carcasses** were amalgamated for the purpose of data analysis as sightings of either live pigs or carcasses were too rare to be statistically useful.

Resting places were recorded as **wet** or **dry**. Wet rests occurred in open area on the edges of swamps, and dry rests occurred in shady places under trees or amongst grasses (personal observation). These were recorded at the plot and quadrat level. Wet pig rests were differentiated from buffalo wallows on the basis of size.

Trunk scarification was recorded when there were rubbing markings on tree trunks, tusk marked trees were included. This variable was estimated as the percentage of trees with scarification at both plot and quadrat level. Scarification may have been from buffalo or pigs and was distinguished as such primarily by the height of the markings.

The **number of trails** present was recorded in each plot and quadrat. In the majority of cases trails had been made or used by a combination of pigs, buffalo, cattle and sometimes people. It was not possible to differentiate usage unless clear footprints were present, even then the possibility of use by other animals could not be excluded.

Dung pellets of feral pigs were counted within each plot and each quadrat. Dung pellets were only counted if intact, i.e. they could be picked up without disintegrating (after Hone and Stone 1989). The numbers of dung pellets were recorded in 2 categories. **Fresh dung** was moist and fetid and **old dung** had a dry, hard surface. After counting, pellets were removed from the plots to prevent recounting in the next survey as it is possible for dung to persist for up to 16 months in some situations (Hone and Martin 1998).

3.3.2 Environmental variables

A range of environmental variables was recorded from each plot.

The **season** during which sampling was undertaken was recorded as described in section 3.2.3. The **vegetation class** each plot was located in was recorded and these are described in Table 3.2

% vegetation cover was estimated visually as a percentage of the ground surface of a $50m^2$ plot covered by vegetation of any type i.e. a ground level vegetation profile. Trees, shrubs and herbaceous ground cover were all considered vegetation cover for this measure and were not segregated. % vegetation cover was also estimated as a percentage of the area of each of the four $5m^2$ quadrats. This variable was measured to determine whether the activity of pigs was dependent on amount of vegetation around them.

Distance to water was defined as the estimated distance in metres from the middle of the plot to the nearest waterbody. In the late dry season when water was scarce, the nearest waterbody to the plot was often a permanent creek or billabong located some distance away. If I was unsure of where the nearest waterbody was located, I sought this information from locals and visited the waterbody to determine the distance from the plot. For statistical analyses, distances were assigned ordinal values as follows:

0. Plot wholly or partially inundated
1. 1 - 49m
2. 50 – 99m
3. 100 – 499m
4. 500 – 999m
5. 1000m or more

Distance to shelter was defined as the estimated distance in metres from the middle of the plot to the nearest place of shelter. An area was only considered to be shelter if vegetation was dense enough to provide good shade cover. This meant that most shelters were monsoon vine forests or paperbark forests and some were eucalypt woodland and pandanus stands. For statistical analyses, distances were assigned ordinal values as follows:

0. Plot in shelter
1. 1 - 49m
2. 50 – 99m
3. 100 – 499m
4. 500 – 999m
5. 1000m or more

Slope position was recorded as the topographic position of the plot within the landscape. The categories of slope position were floodplain, footslope, upslope and drainage floor as indicated in Figure 3.3.

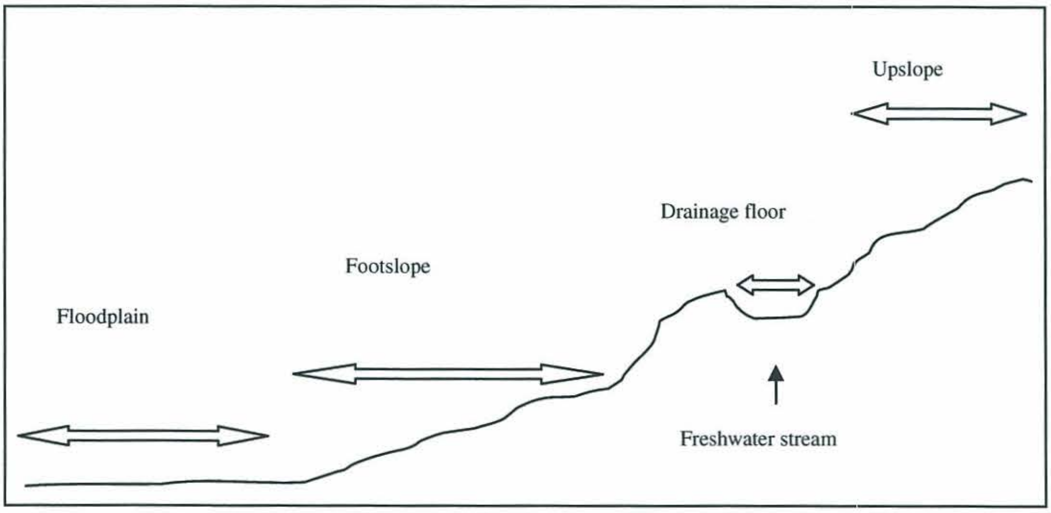


Figure 3.3: Sketch representation of topographic slope positions within the landscape.

Soil type was recorded for each plot as one of the following broad texture classes (McDonald et al 1984):
Silt (either Silty loam or Silty clay loam), Clay, Clay loam, Loam, Sandy loam and Sand.

Amount of fallen fruit: the total amount of fruits collected on the ground of each quadrat was weighed using a spring balance and recorded in the following categories

1. = 0g
2. = 1-250g
3. = 251-500g
4. = 501-750g
5. = >750g

Table 3.5 shows the level, scale and minimum and maximum values of each variable recorded.

Table 3.5: Survey structure and scale of recorded variables including the minimum and maximum values recorded in a plot.

	Plot	Quadrat	Scale	Min/Max value
% area with fresh diggings	✓	✓	continuous	0-100%
% area with medium diggings	✓	✓	continuous	0-85%
% area with old diggings	✓	✓	continuous	0-100%
% area trampled	✓	✓	continuous	0-100%
% area with vegetation cover	✓	✓	continuous	5-100%
Live pigs/carcasses within 100m of plot periphery	✓	-	continuous	0-15
Resting places – wet	✓	✓	continuous	0-16
Resting places – dry	✓	✓	continuous	0-17
% trees with trunk scarification by pigs	✓	✓	continuous	0-80%
Pig/buffalo tracks	✓	✓	continuous	0-30
Fresh dung pellets	✓	✓	continuous	0-32
Old dung pellets	✓	✓	continuous	0-23
Buffalo swim channels	✓	✓	continuous	0-7
Buffalo dung pats	✓	✓	continuous	0-32
Buffalo wallows	✓	✓	continuous	0-12
Buffalo within 100m of plot perimeter	✓	-	continuous	0-12
% trees with scarification by buffalo	✓	✓	continuous	0-80%
Distance to water	✓	-	interval	0-5
Distance to shelter	✓	-	interval	0-5
Soil type	✓	-	categorical	
Amount of fallen fruit	-	✓	interval	0-3

3.4 Exploratory data summaries

The results presented in this chapter are largely descriptive and pre-analytical and are intended to provide an overview of the data. They describe sample sizes, the range of values attained by the various pig and buffalo signs measured and some simple summaries of data distributions.

Due to seasonal inundation by floodwaters, the number of plots that were accessible for each seasonal survey varied. The total number of plots (n=192) was surveyed in the late dry season; only 76 could be surveyed in the wet season, 160 in the early dry season and 190 in the mid dry season. Note that no plots within the site Mangurr were surveyed in the wet or early dry seasons due to the entire area being inaccessible. All results represent only those plots that were surveyed in a season. All signs of old pig and buffalo activity in the late dry season were cumulative, having been made at some stage since the last wet season. It is unlikely that any signs made earlier would persist after wet season rains although it is possible that some protected areas may show signs of longer-term disturbance.

3.4.1 Signs of pig activity

Digging, dung and restplaces are three key signs of pig activity. The percentage of plots in which these signs were recorded is shown for each season in Figure 3.4.

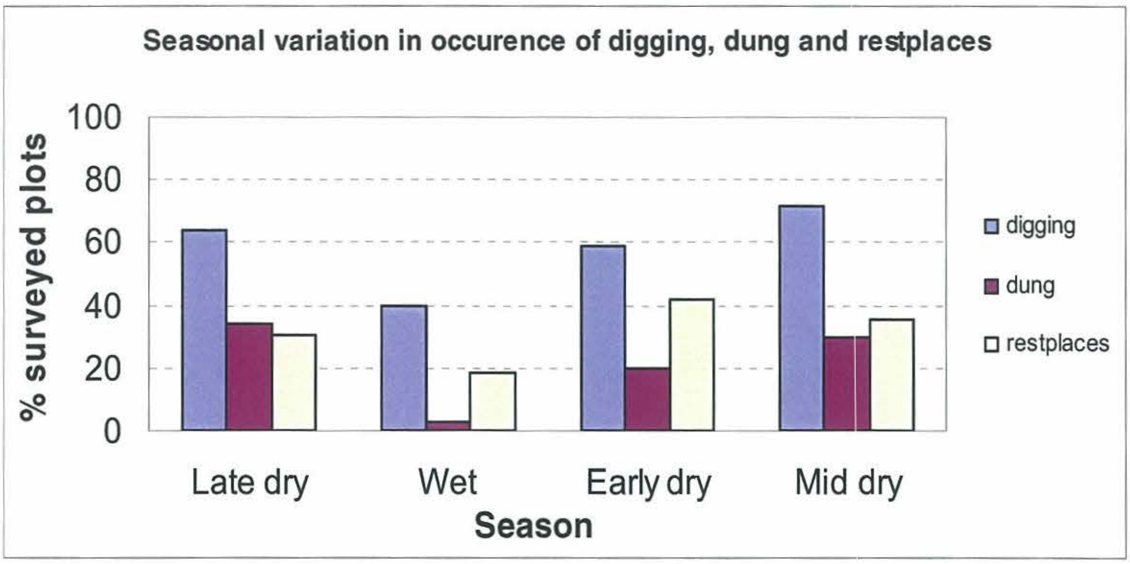


Figure 3.4: Percentage of surveyed plots with digging, dung and restplaces each season.

3.4.1.1 Seasonal occurrence of pig digging

Across all seasons, feral pig diggings were recorded in 61.8% of surveyed plots and 12.7% of the total area surveyed (averaged across seasons) had been dug by pigs. The number of plots with extensive pig digging was low as shown in Figure 3.5.

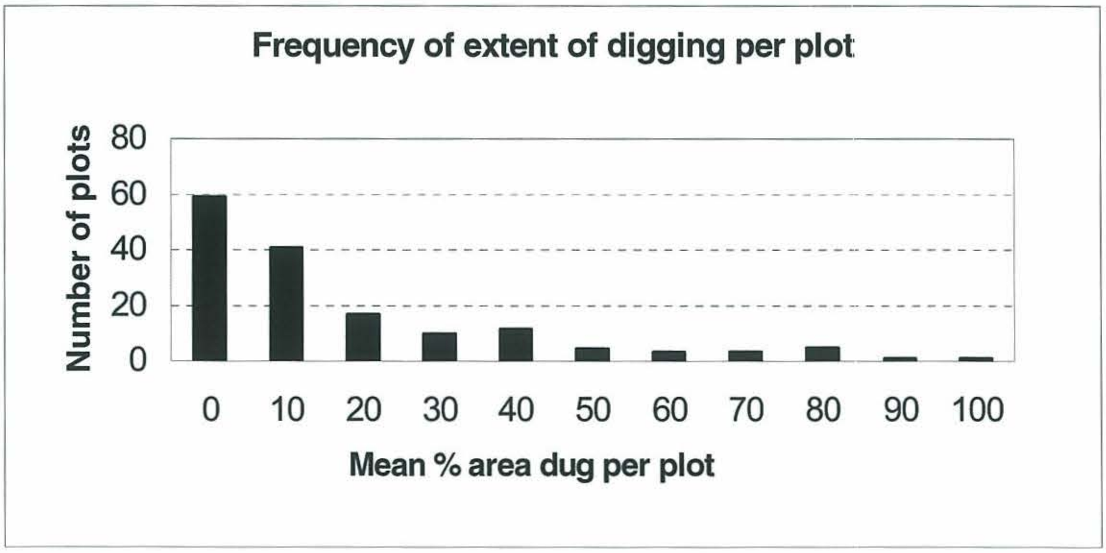


Figure 3.5: The frequency distribution of the % area of diggings per plot averaged across seasons.

The mean percentage of surveyed plots containing digging of any category each season was 63.6 % in the late dry, 39.5 % in the wet, 58.8 % in the early dry and 71.6 % in the mid dry season (Figure 3.4). The percentage of surveyed plots containing diggings of each age category is shown for each season in Figure 3.6. Medium aged diggings were not found in the wet season.

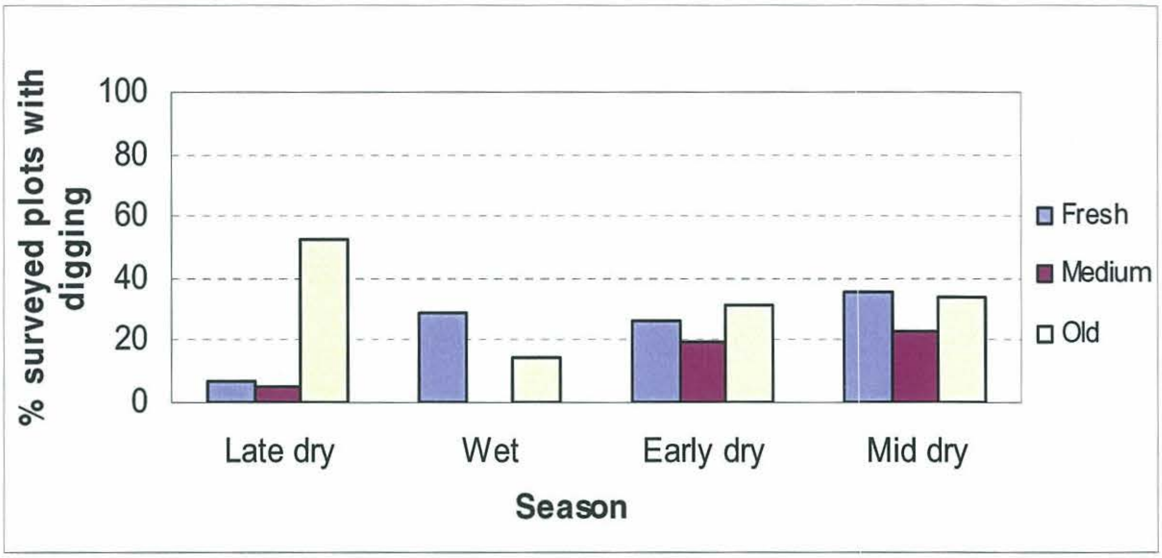


Figure 3.6: Percentage of surveyed plots with diggings of each age category.

Diggings were found in all seasons at five of the nine sites (Figure 3.7). Plates 9, 10 and 11 show pig digging in different vegetation classes and different seasons. As previously noted, no surveys were undertaken at Mangurr in the wet or early dry seasons. In the wet season very few plots could be surveyed at Crossing, Dhabila and Mangbirri due to inundation and those plots that were surveyed did not contain pig digging. Diggings were recorded in each vegetation class in all seasons except in paperbark vegetation in the wet season, when all paperbark plots were inaccessible (Figure 3.8).

Plate 9: Pig digging in paperbark vegetation at Djanyirrbirri in the late dry season.

Plate 10: Pig digging in monocot vegetation at Djanyirrbirri in the early dry season.

Plate 11: Pig digging in monocot vegetation at Djanyirrbirri in the late dry season.

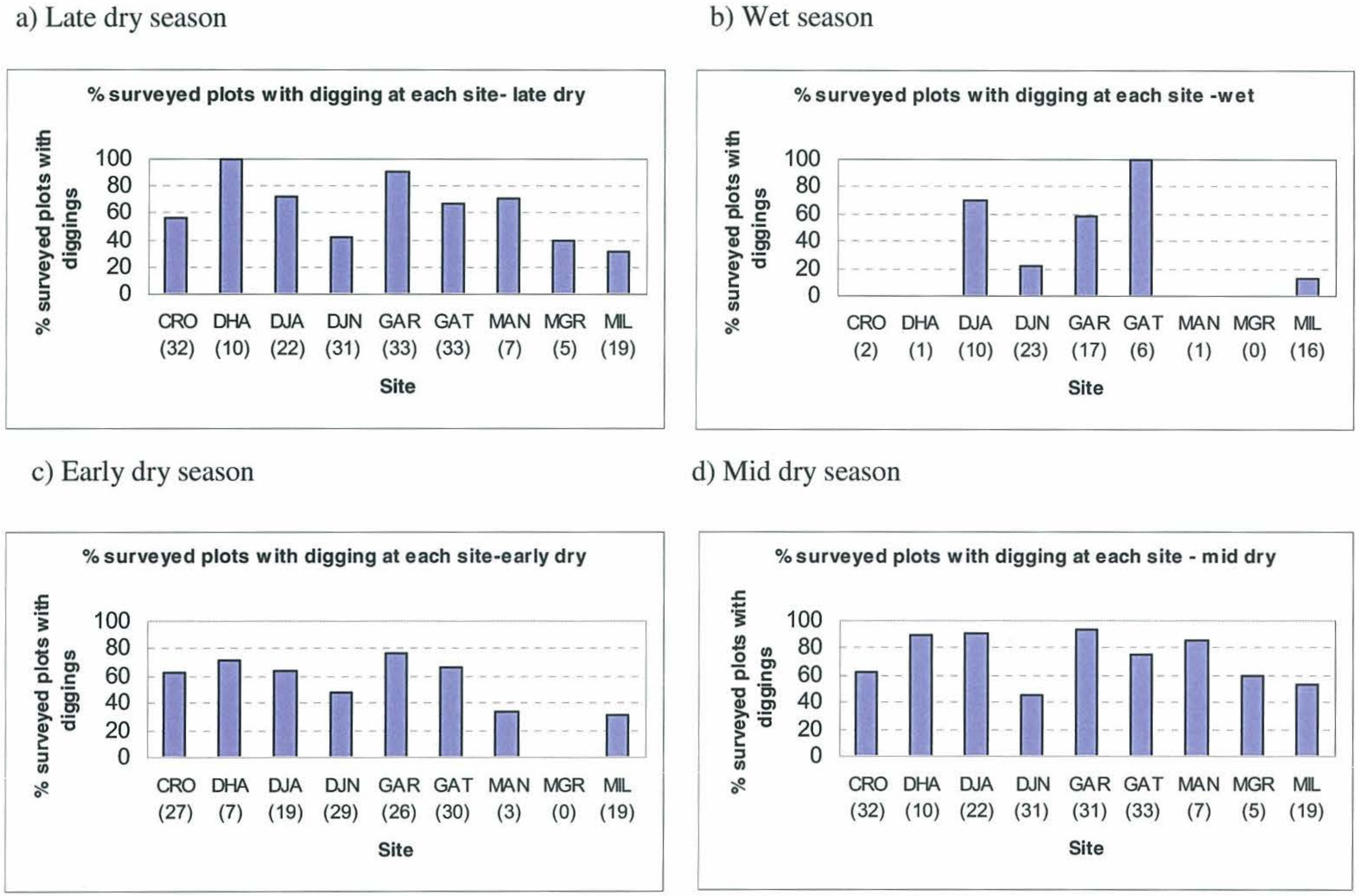
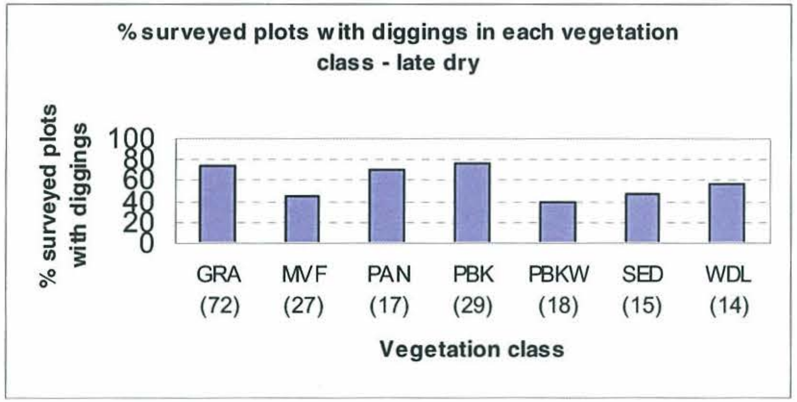
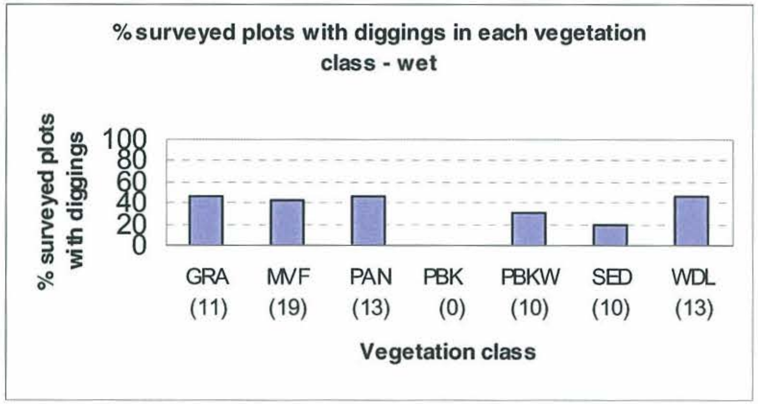


Figure 3.7: Percentage of surveyed plots with diggings of any age at each site each season. The number of surveyed plots at each site each season is shown in brackets.

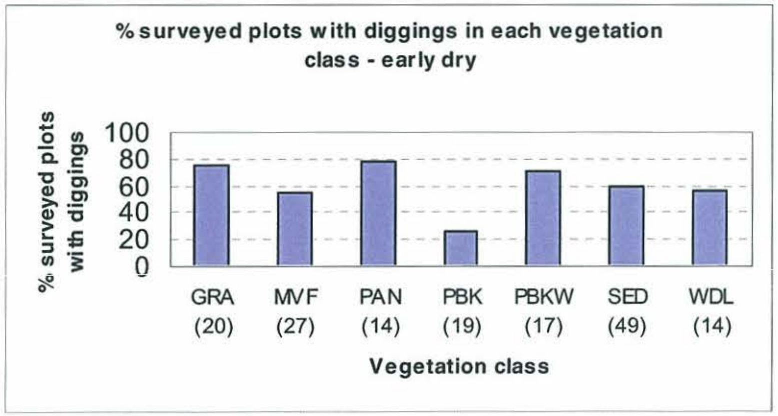
a) Late dry season



b) Wet season



c) Early dry season



d) Mid dry season

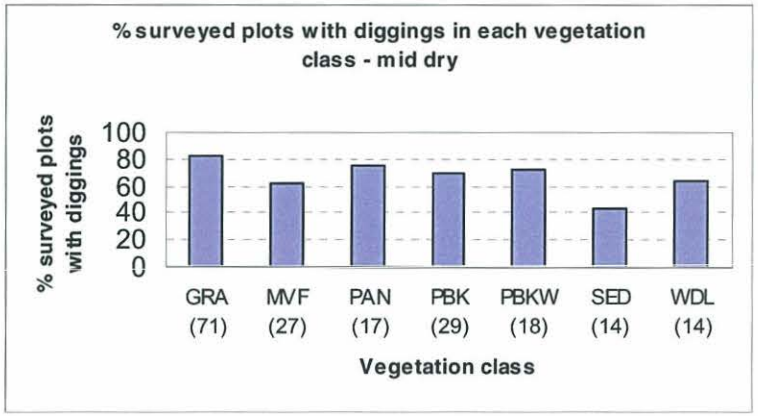


Figure 3.8: Percentage of surveyed plots with diggings of any age in each vegetation class in each season. The number of surveyed plots in each vegetation class each season is shown in brackets.

The mean percentage area of fresh, medium and old diggings recorded in each plot varied each season as shown in Figure 3.9. There was also variation in the mean % area dug (total) per plot within and between sites each season (Figure 3.10) and within and between vegetation classes each season (Figure 3.11). In all seasons, the percentage of plots containing fresh digging was greatest within 500m of water (category 3) as shown in Figure 3.12.

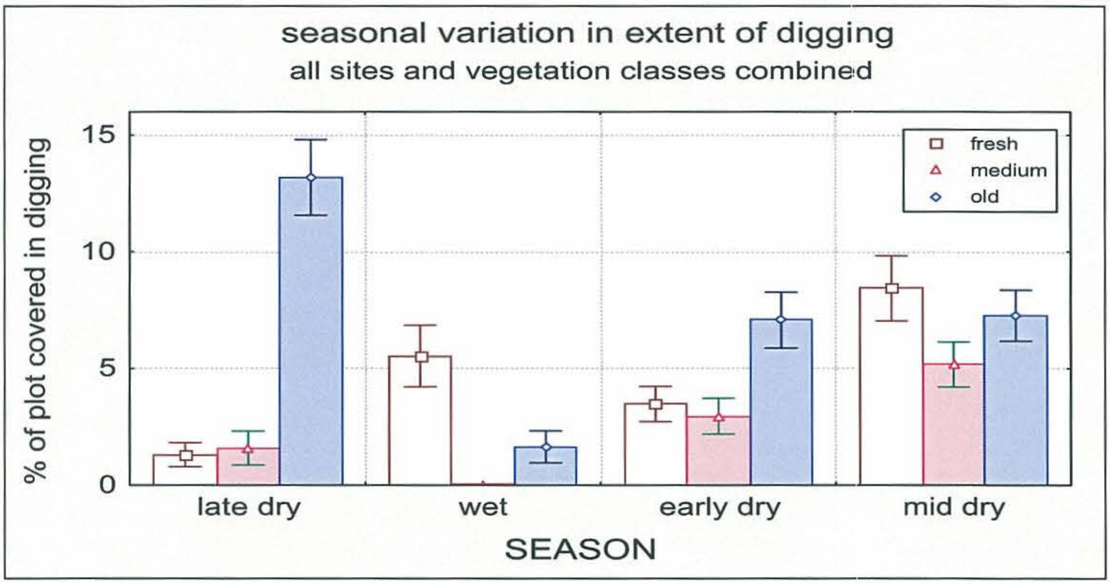


Figure 3.9: Percentage area of plot with diggings of each age category each season.

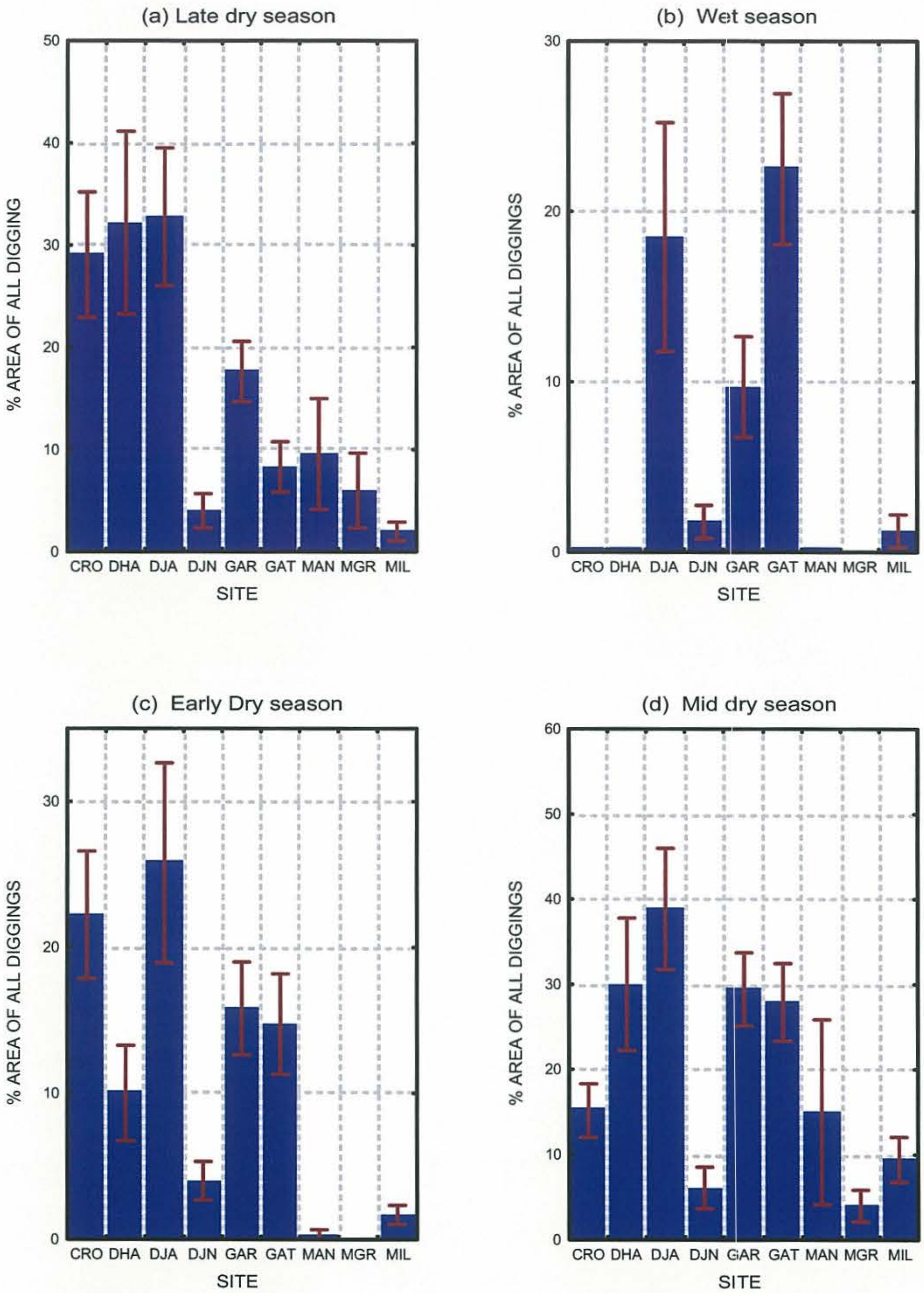


Figure 3.10: Mean % area of diggings (total) per plot at each site in each season. The number of plots surveyed at each site each season is shown in Figure 3.7.

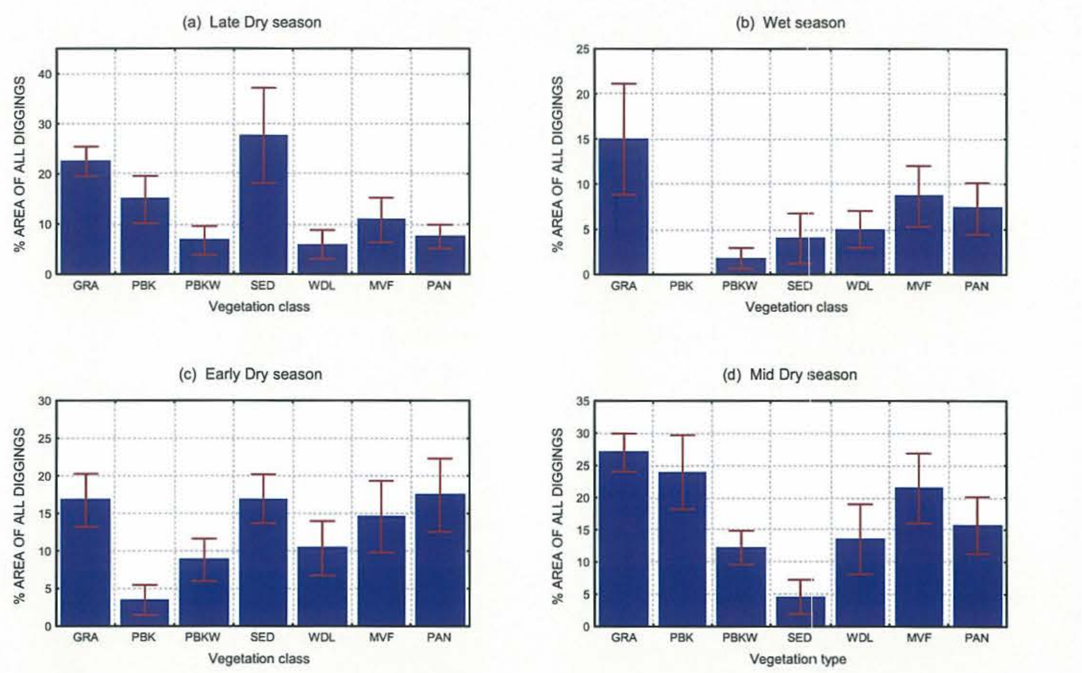


Figure 3.11: Mean % area of diggings per plot at each vegetation class in each season. The number of plots surveyed in each vegetation class each season is shown in Figure 3.8.

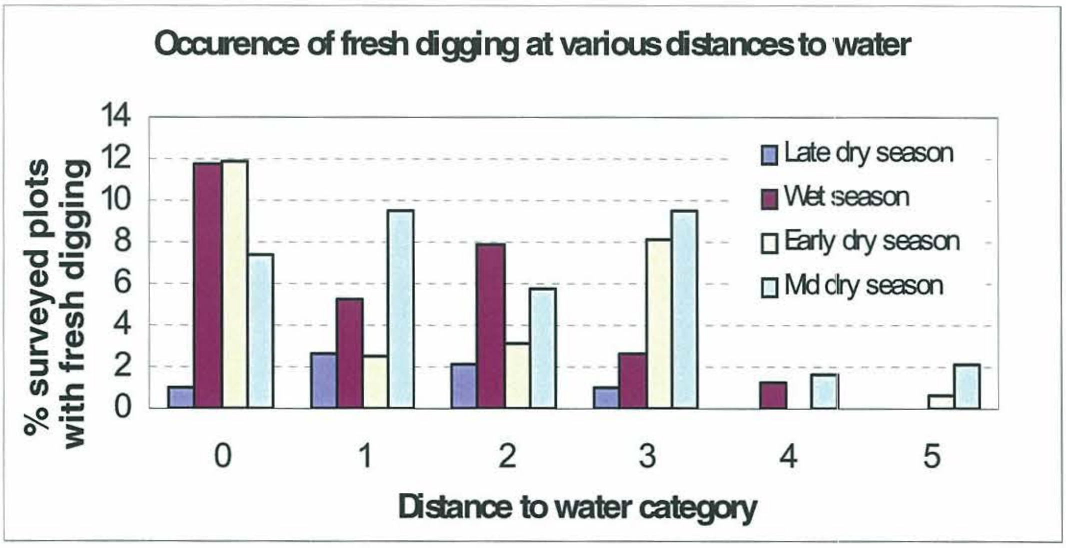


Figure 3.12: Percentage of surveyed plots with fresh diggings at varying distances to water each season.

3.4.1.2 Late dry season digging

Diggings were found in all site areas in the late dry season but not all age categories of digging were recorded at each site (Figure 3.13). There were no fresh diggings at Djanyirrbirri, Gatji or Mangurr this season and there were no medium aged diggings at Dhabila, Garanydjirr, Mangurr or Milbirim. Diggings were recorded in all vegetation classes in the late dry season (Figure 3.14), although no medium age diggings occurred in monsoon forests, pandanus, sedge or woodland and no fresh diggings were recorded in paperbark woodlands or woodlands. All fresh diggings recorded this season occurred within 500m of water, 50% of these are within 50m of water (Figure 3.12). The mean % area of fresh, medium and old diggings per plot varied with site and also with vegetation class in the late dry season (Figure 3.15 and Figure 3.16 respectively).

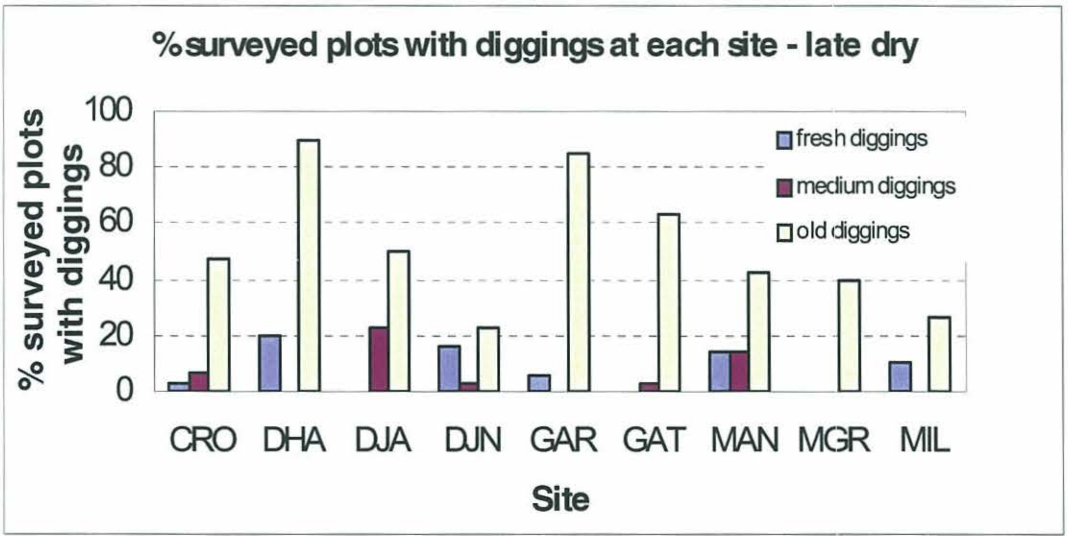


Figure 3.13: Percentage of surveyed plots with fresh, medium and old diggings at each site in the late dry season.

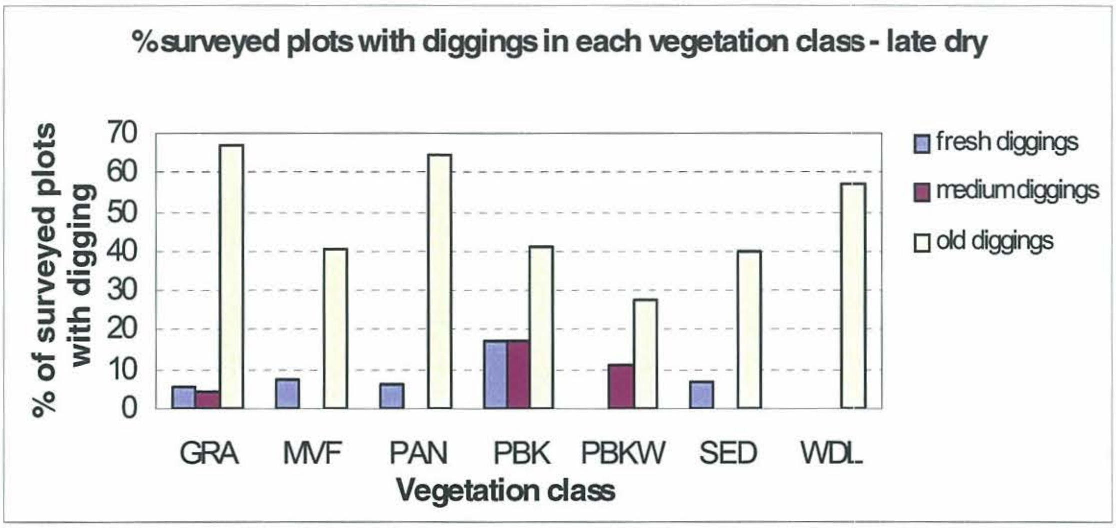


Figure 3.14: Percentage of surveyed plots with fresh, medium and old diggings in each vegetation class in the late dry season.

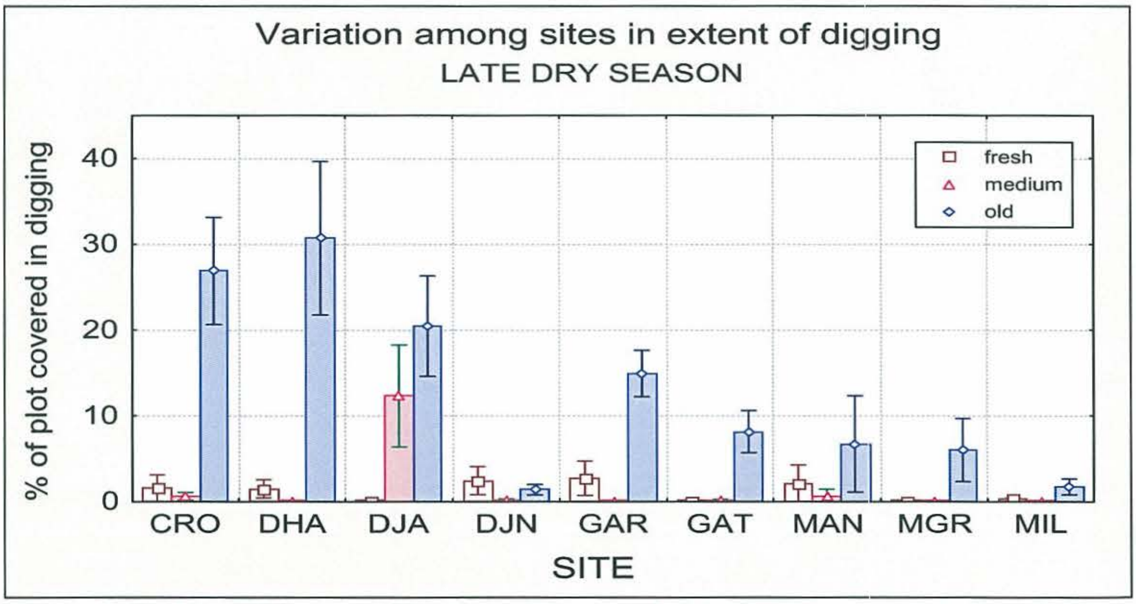


Figure 3.15: Mean % area of fresh, medium and old diggings per plot at each site in the late dry season.

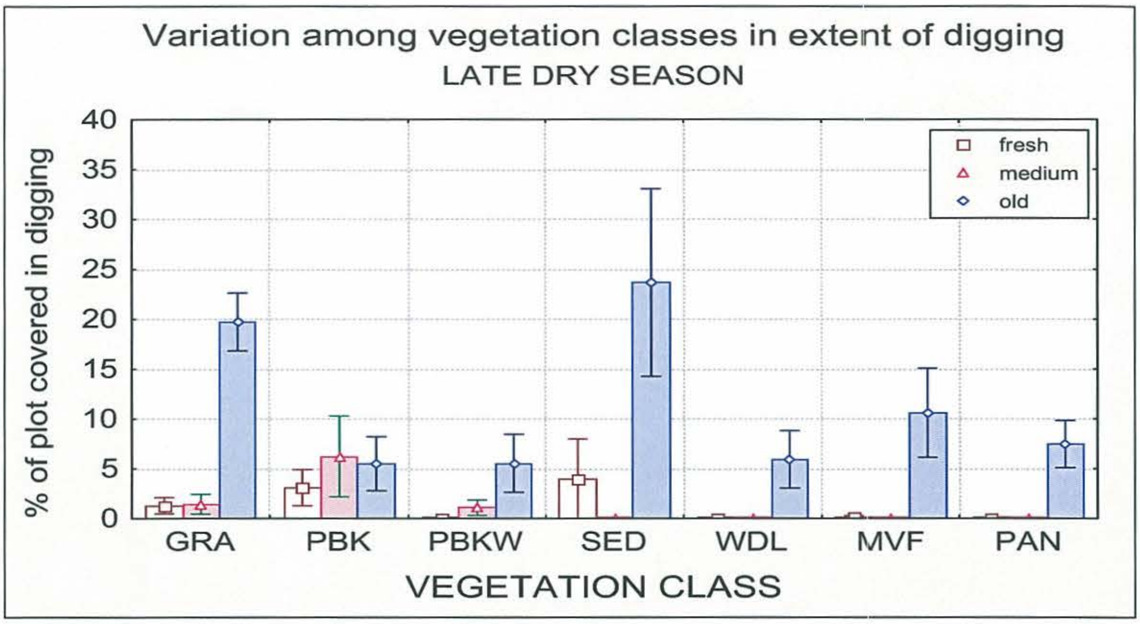


Figure 3.16: Mean % area of fresh, medium, old and all diggings per plot in each vegetation class in the late dry season.

3.4.1.3 Wet season digging

During the wet season only a limited number of plots could be surveyed as previously noted. Diggings were recorded in 39.5% of surveyed plots. Fresh diggings occurred in 28.9% of surveyed plots (Figure 3.6), most (86.5%) of which occurred within 100m of water (Figure 3.12). There were no medium diggings recorded in the wet season at all and 14.5% of surveyed plots contained old diggings, as shown in Figure 3.6.

There were no diggings of any category recorded at the sites Crossing, Dhabila and Mangbirri (Mangurr was not accessible) as shown in Figure 3.17. Only fresh diggings were recorded at Djanyirrbirri. There were no diggings of any category recorded in paperbark vegetation (Figure 3.18) as all of these plots were underwater or inaccessible and could not be surveyed. In sedge vegetation, no old diggings were found in any of the surveyed plots.

The mean percentage area dug per plot was less than 20%. The mean percentage area of diggings was low in most sites (Figure 3.19) and in all vegetation classes in the wet season (Figure 3.20).

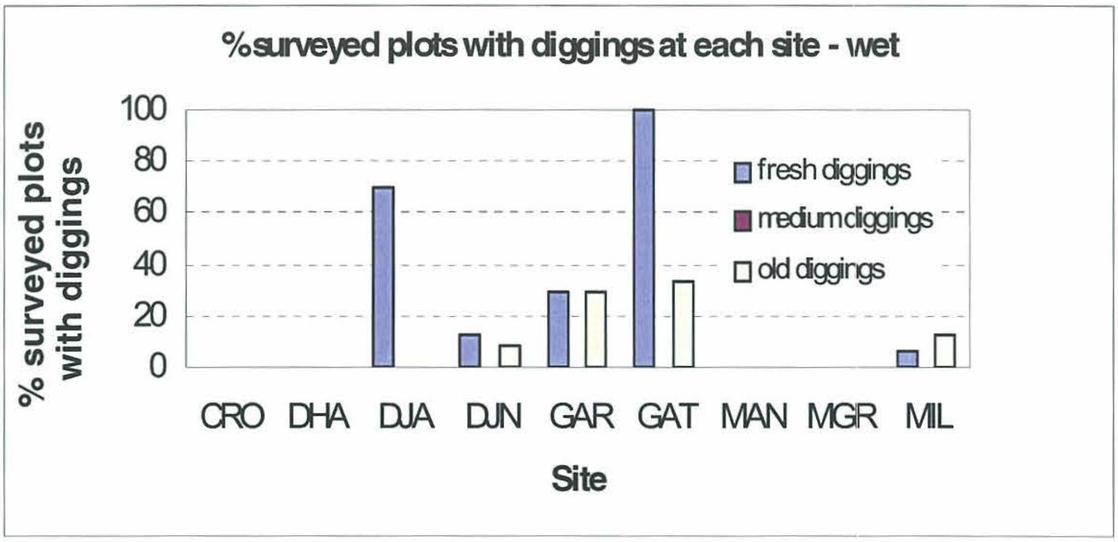


Figure 3.17: Percentage of surveyed plots with diggings at each site in the wet season.

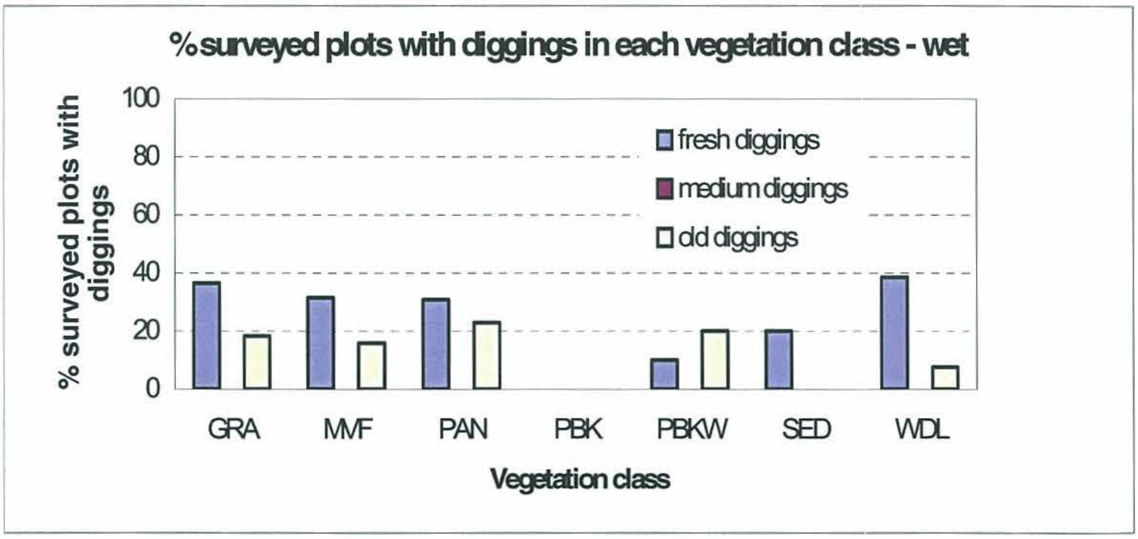


Figure 3.18: Percentage of surveyed plots with diggings in each vegetation class in the wet season.

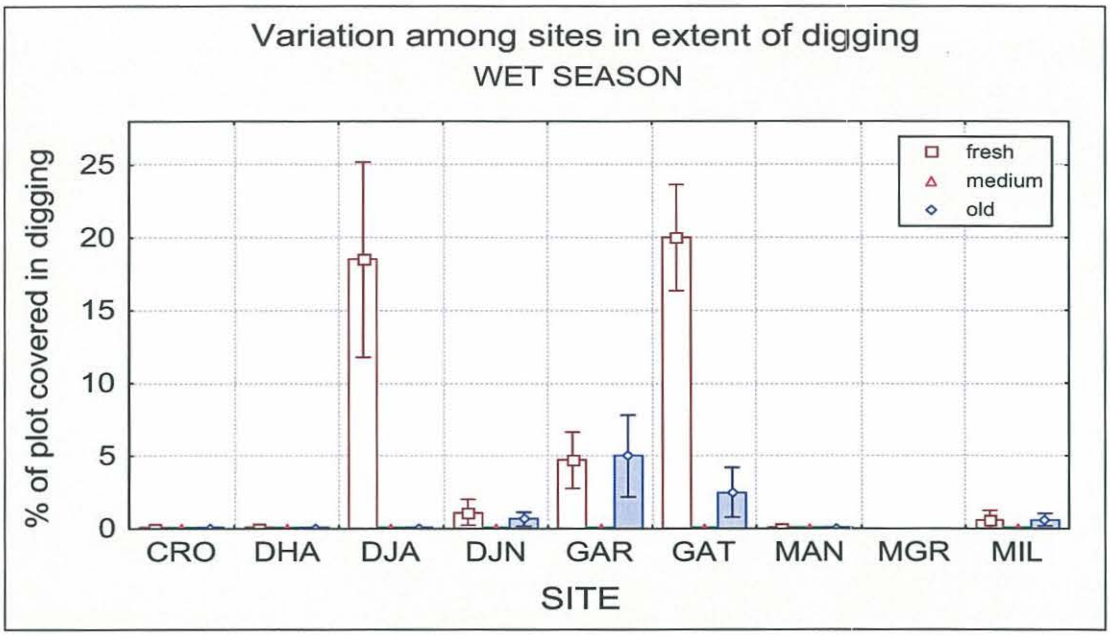


Figure 3.19: Mean % area of diggings per plot at each site in the wet season.

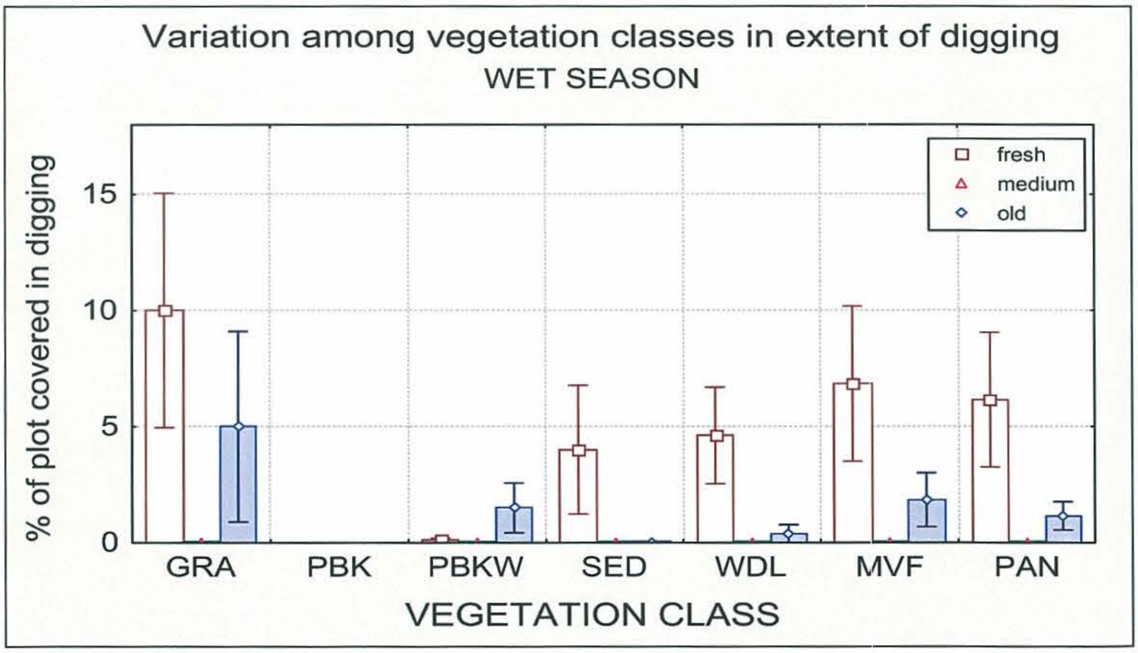


Figure 3.20: Mean % area of diggings per plot in each vegetation class in the wet season.

3.4.1.4 Early dry season digging

In the early dry season 58.8% of surveyed plots contained diggings of any category. Fresh diggings occurred in 26.3% of surveyed plots, 19.4% contained medium diggings and 31.3% of surveyed plots contained old diggings as shown in Figure 3.6. Fresh and old digging was recorded at all sites except Mangbirri (and Mangurr as it was still inaccessible) this season (Figure 3.21). Medium aged diggings were recorded at Mangbirri and all other sites except Dhabila. All vegetation classes contained diggings of each age category except sedge, in which no medium diggings were present (Figure 3.22).

Most plots with fresh diggings (98%) occurred within 500m of water this season (Figure 3.12). The mean percentage area of diggings per plot was less than 20% in all plots at all sites this season with all fresh and medium diggings covering less than 10% of each plot at all sites (Figure 3.23). The mean % area dug per plot in each vegetation class was also low as shown in Figure 3.24.

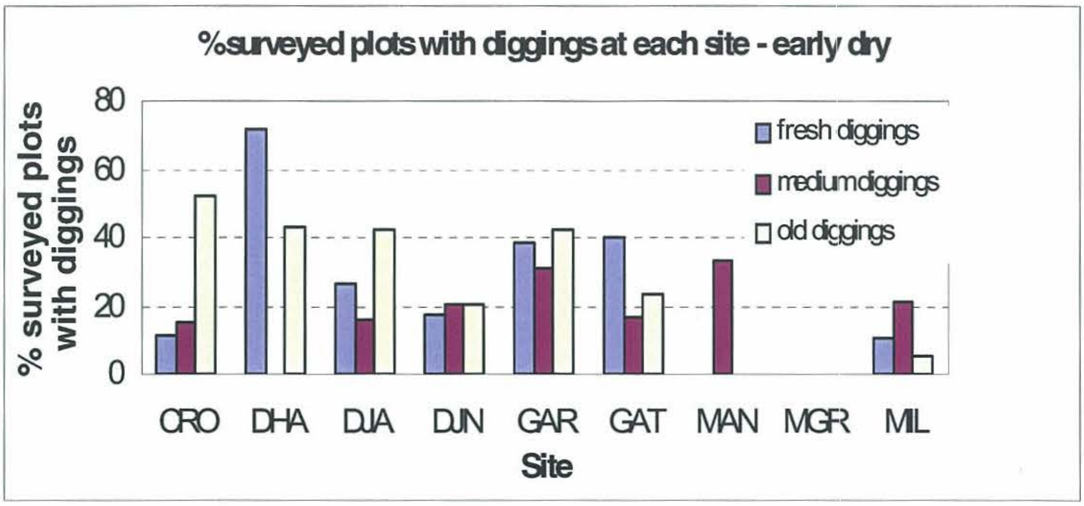


Figure 3.21: Percentage of surveyed plots with diggings at each site in the early dry season.

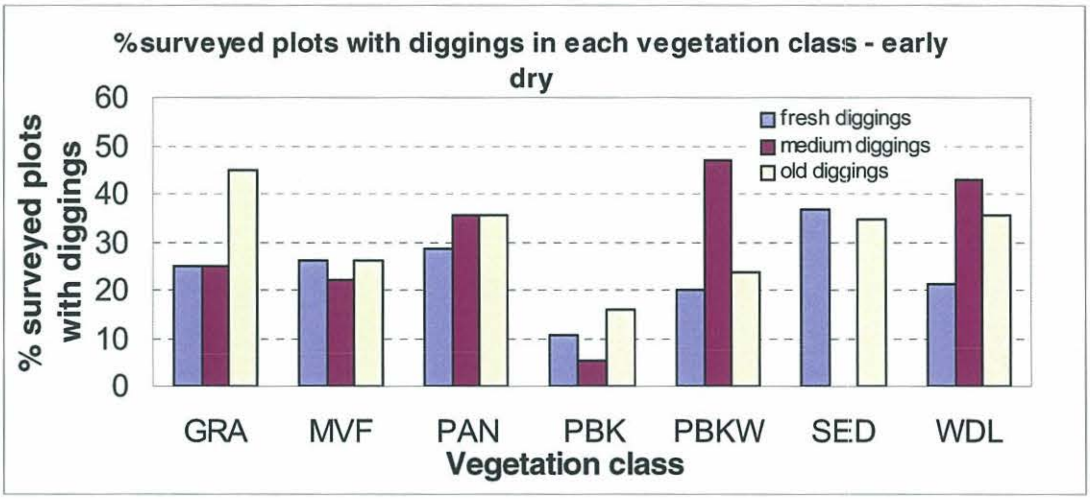


Figure 3.22: Percentage of surveyed plots with diggings in each vegetation class in the early dry season.

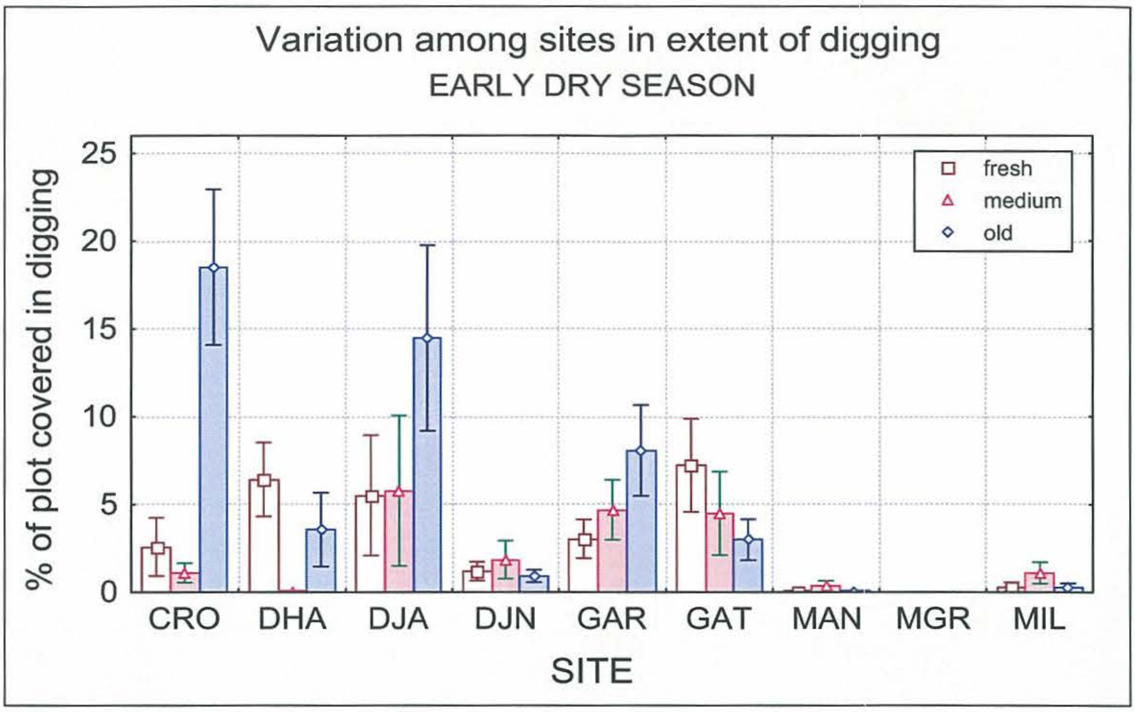


Figure 3.23: Mean % area of diggings per plot at each site in the early dry season.

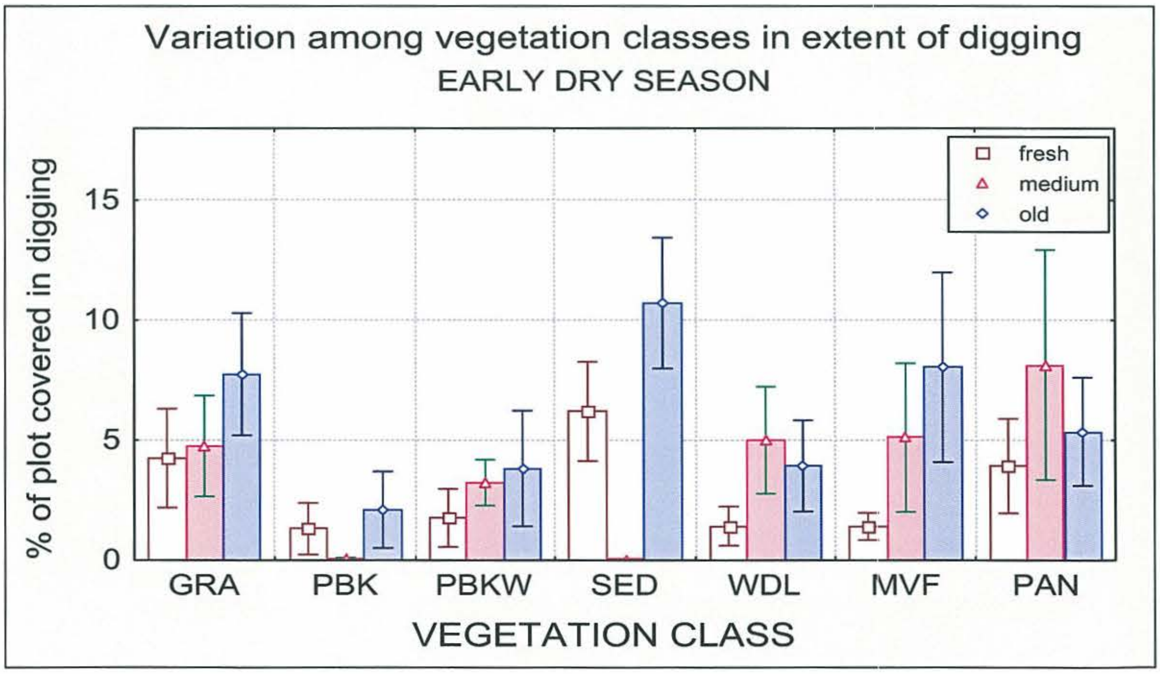


Figure 3.24: Mean % area of diggings per plot in each vegetation class in the early dry season.

3.4.1.5 Mid dry season digging

In the mid dry season 71.6% of surveyed plots contained diggings of any category. Fresh diggings occurred in 35.8% of surveyed plots, medium diggings occurred in 23.2% of surveyed plots and old diggings in 34.2% of surveyed plots (see Figure 3.6). Diggings of all categories were recorded at all sites except Mangurr and Mangbirri where only fresh diggings were found (Figure 3.25).

Only one plot in each of grassland and sedge vegetation classes was unable to be surveyed this season due to inundation. All ages of digging were recorded in each vegetation class except sedge where fresh diggings were the only age category recorded (Figure 3.26). Most plots with fresh diggings occurred within 500m of water (89.6%) as shown in Figure 3.12. The mean % area dug per plot in each age category varied between sites (Figure 3.27.) and between vegetation classes this season (Figure 3.28).

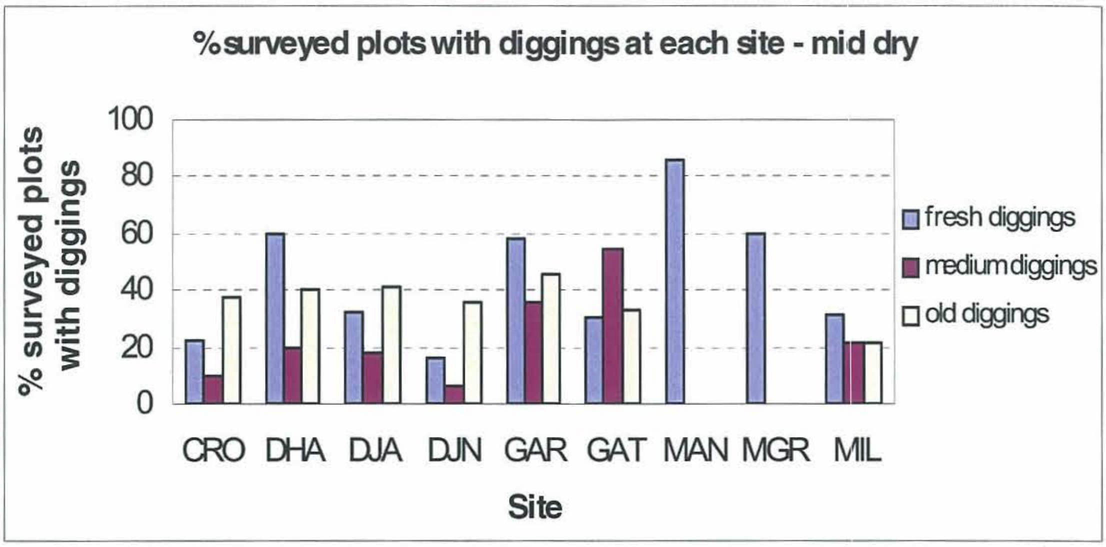


Figure 3.25: Percentage of surveyed plots with diggings at each site in the mid dry season.

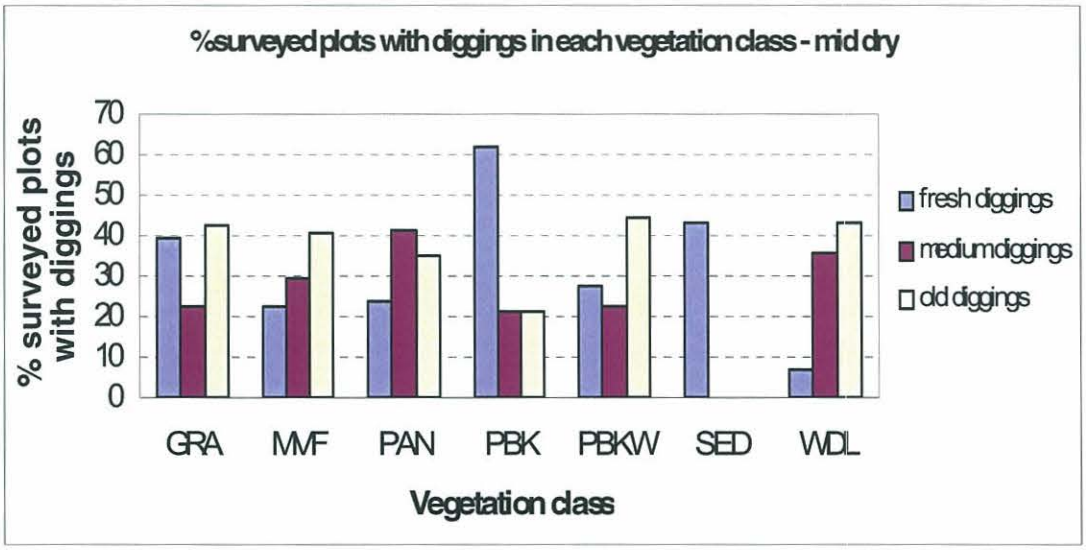


Figure 3.26: Percentage of surveyed plots with diggings in each vegetation class in the mid dry season.

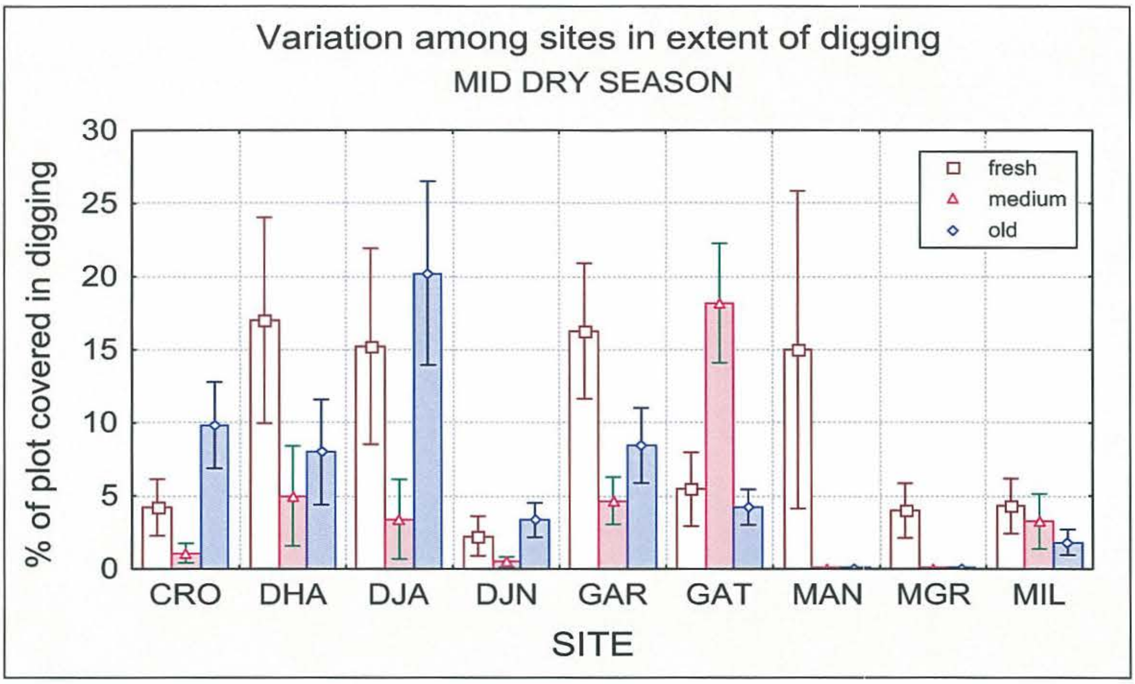


Figure 3.27: Mean % area of diggings per plot at each site in the mid dry season.

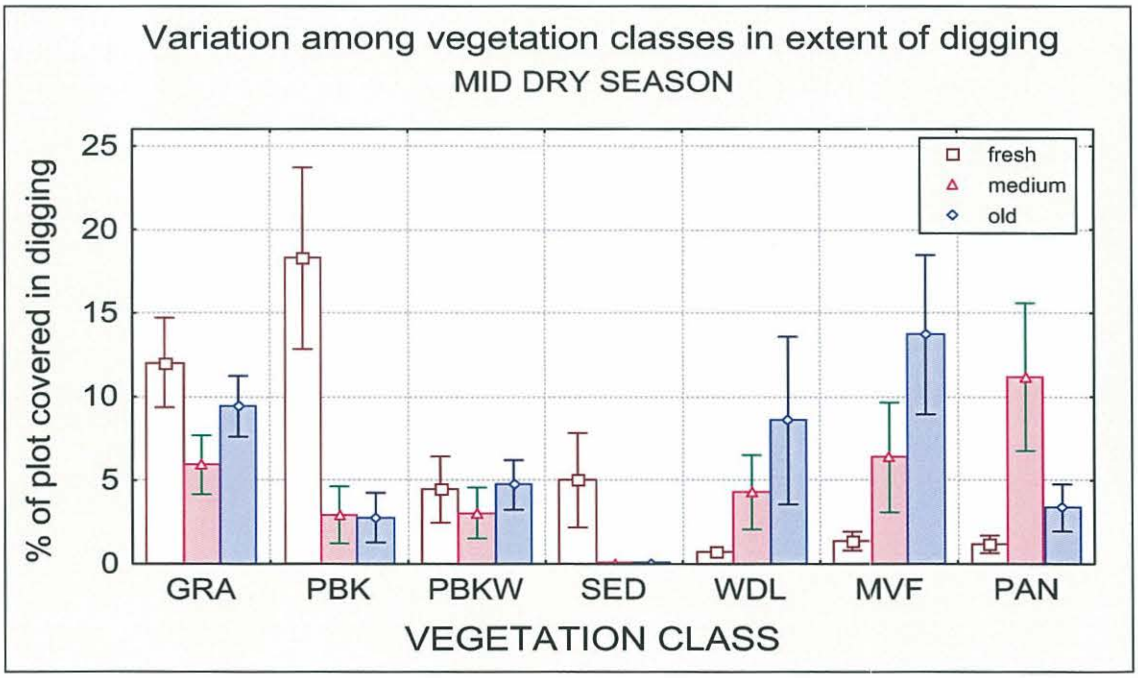


Figure 3.28: Mean % area of diggings per plot in each vegetation class in the mid dry season.

3.4.1.6 Seasonal occurrence of pig restplaces

All restplaces recorded were new in that they had not been recorded in previous seasons. Restplaces were recorded as being wet or dry. These categories were combined for analyses because the number of wet restplaces recorded was very low. Plate 12 shows a dry resting place near Mangbirri. The mean % of surveyed plots containing restplaces across all seasons was 27%.

Plate 12: Dry resting place used by pigs near Mangbirri.

3.4.1.7 Late dry season restplaces

In the late dry season, 30.7% of all plots contained restplaces (Figure 3.4). The overall mean number of restplaces recorded in the late dry season was 1.15 per plot as shown in Figure 3.29. Restplaces were recorded in all sites (Figure 3.30a) and the mean number of restplaces per plot at each site is shown in Figure 3.32a. Restplaces were also recorded in all vegetation classes in the late dry season (Figure 3.31a) and the mean number of restplaces per plot in each vegetation class is shown in Figure 3.33a.

3.4.1.8 Wet season restplaces

Only 18.4% of surveyed plots contained restplaces in the wet season (Figure 3.4). The total number of restplaces recorded in the wet season was very low (n=34) with the average number of restplaces per plot being 0.45 (Figure 3.29). No restplaces were recorded at Dhabila, Gatji or Milbirim and Mangurr (inaccessible) as shown in Figure 3.30b. The mean number of restplaces per plot at each site in the wet season is shown in Figure 3.32b. Restplaces were not found in any sedge plots or paperbark woodland plots this season and all paperbark plots were inaccessible (Figure 3.31b). The mean number of restplaces was 1.0 per plot in monsoon forests and 0.6 in pandanus plots (Figure 3.33b).

3.4.1.9 Early dry season restplaces

In the early dry season, 41.9% of surveyed plots contained restplaces (Figure 3.4). In the early dry season the average number of restplaces was 1.3 per plot as shown in Figure

3.29. Restplaces were recorded in all sites except Mangurr, which was inaccessible, as shown in Figure 3.30c. The mean number of restplaces per plot in each site is also shown (Figure 3.32c). Restplaces were recorded in all vegetation classes in the early dry season (Figure 3.31c) and the mean number of restplaces per plot in each vegetation class is shown in Figure 3.33c.

3.4.1.10 Mid dry season restplaces

Restplaces were recorded in 35.3% of surveyed plots in the mid dry season (Figure 3.4). The overall mean number of restplaces per plot in the mid dry season was 1.18 (Figure 3.29). All sites except Dhabila contained restplaces this season (Figure 3.30d) and the mean number of restplaces per plot at each site is shown in Figure 3.32d. Restplaces were recorded in all vegetation classes (Figure 3.31d) and the mean number of restplaces per plot in each vegetation class is also shown (Figure 3.33d).

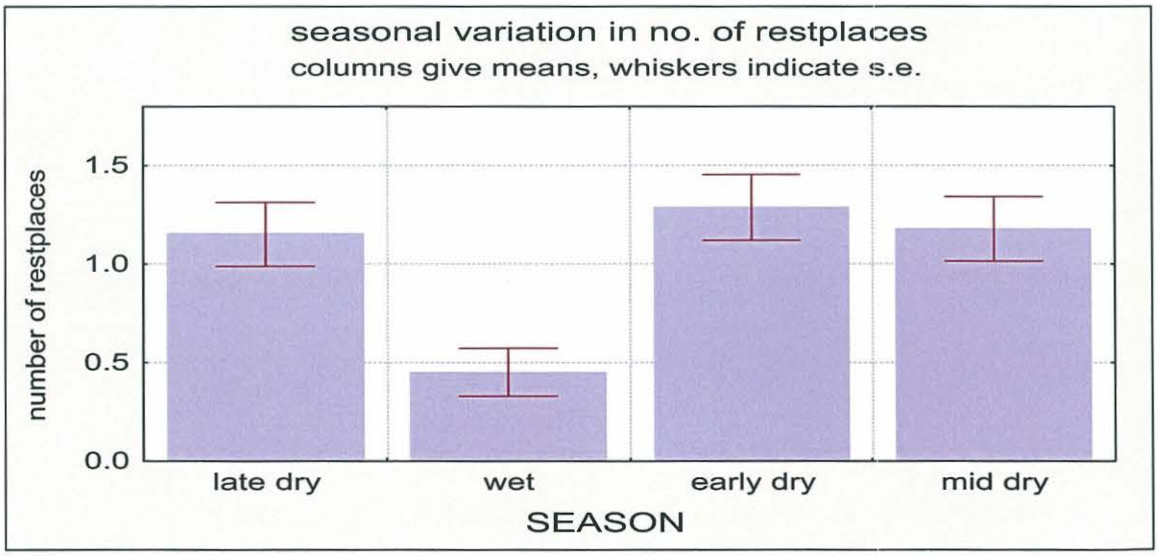
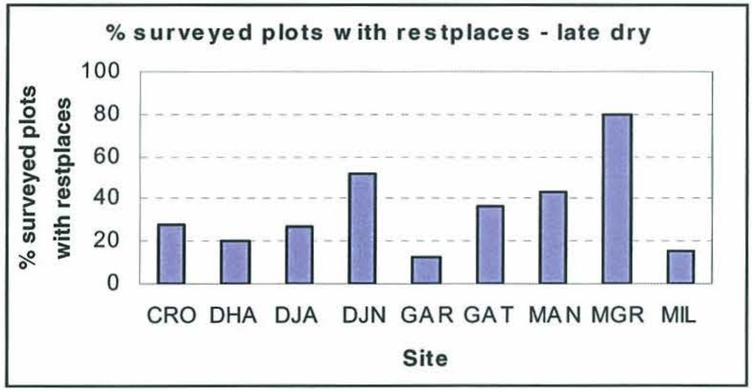
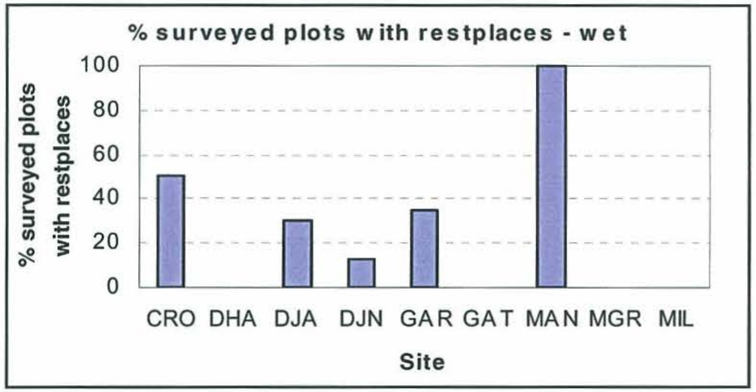


Figure 3.29: Mean number of restplaces per plot each season.

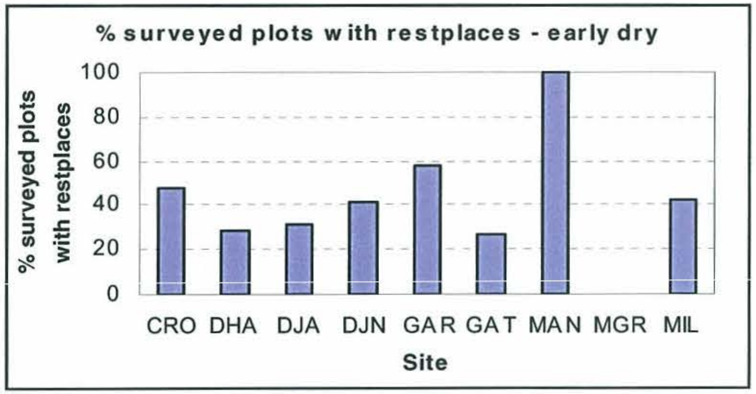
a) Late dry season



b) Wet season



c) Early dry season



d) Mid dry season

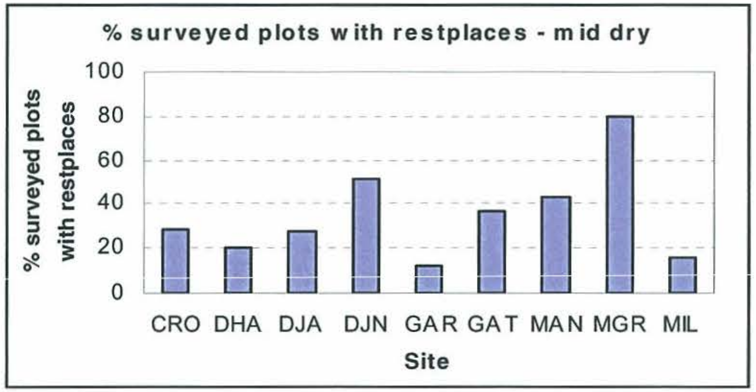


Figure 3.30: Percentage of surveyed plots with restplaces at each site each season.

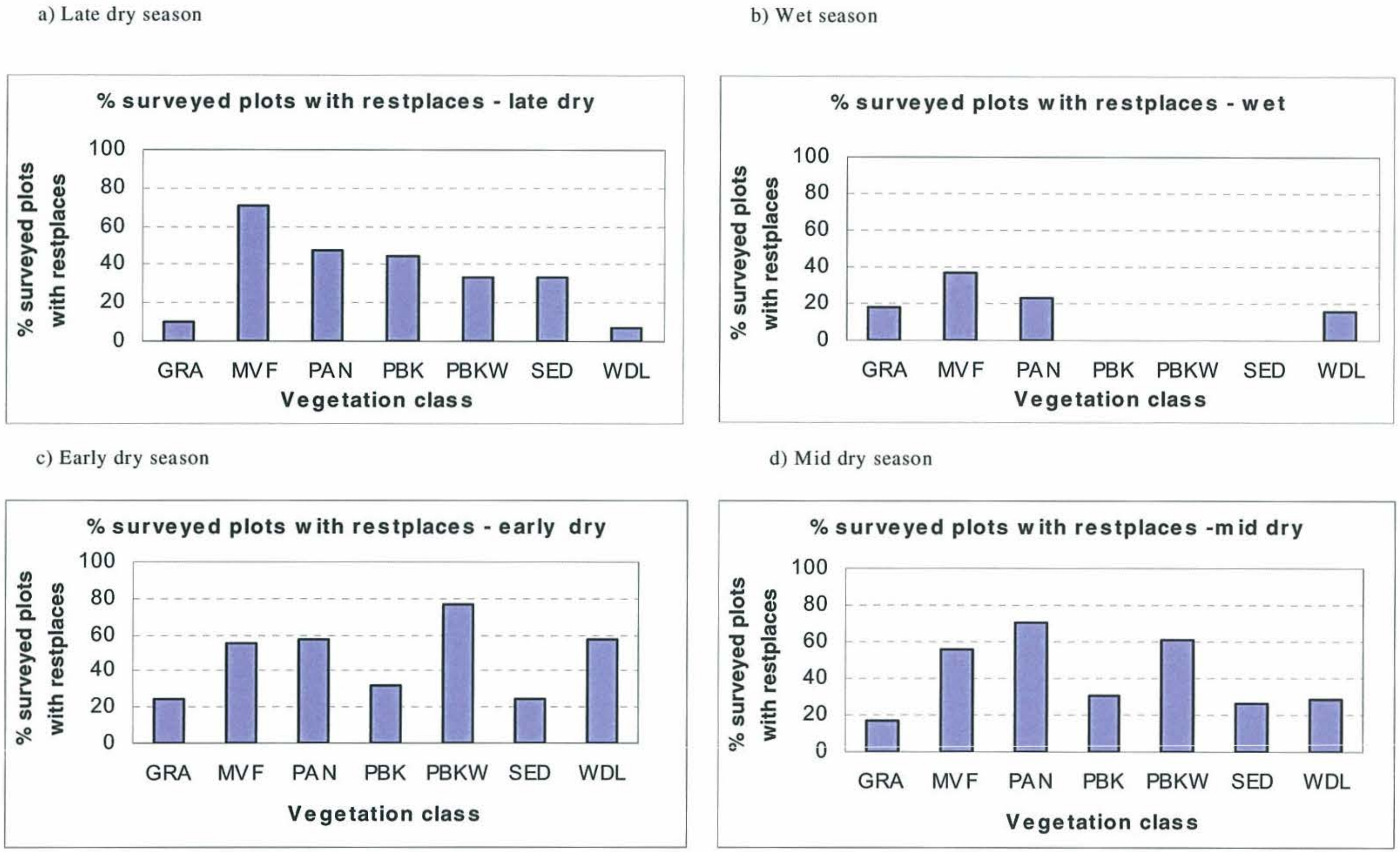


Figure 3.31: Percentage of surveyed plots with restplaces in each vegetation class each season.

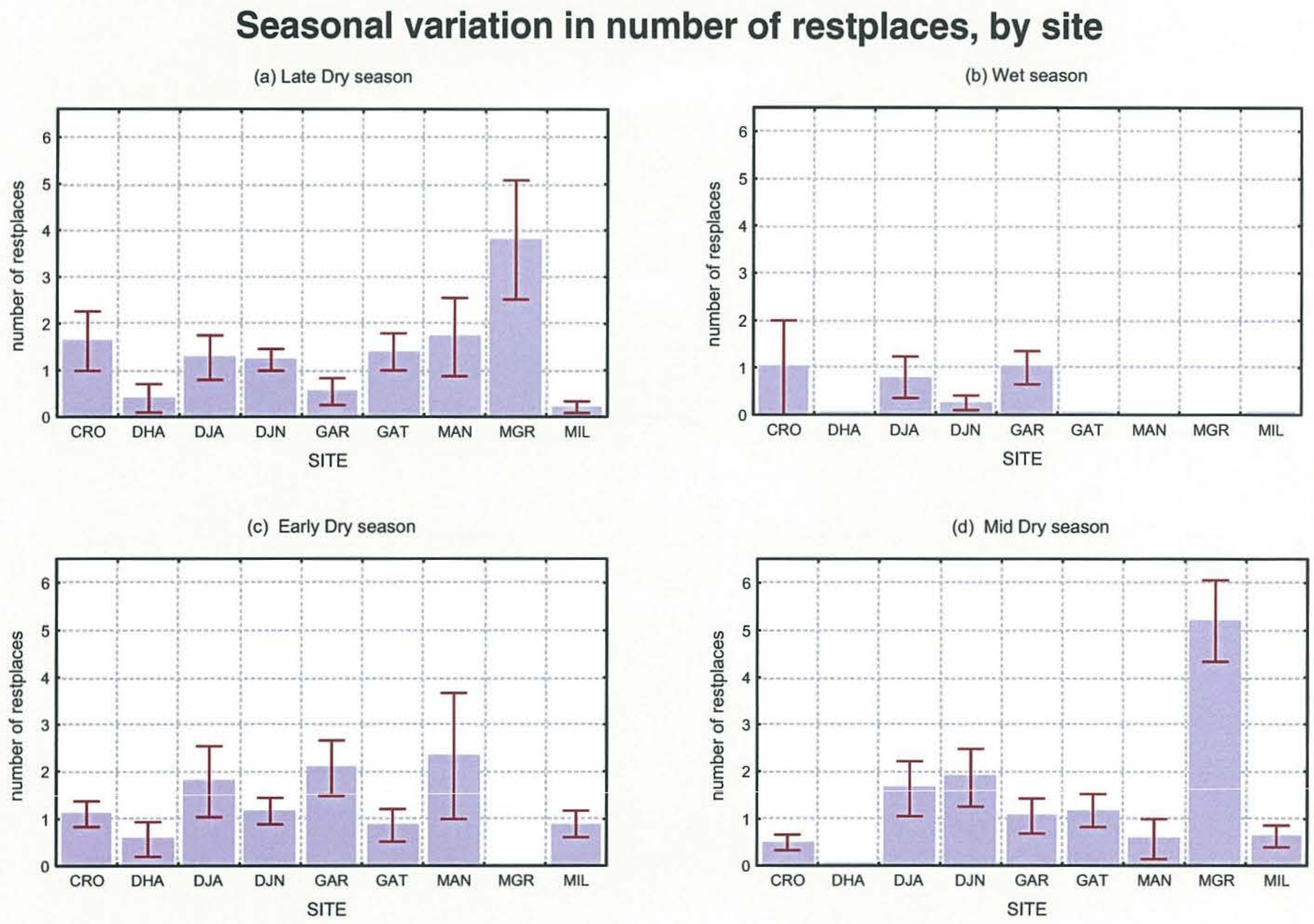


Figure 3.32: Mean number of restplaces per plot at each site in each season.

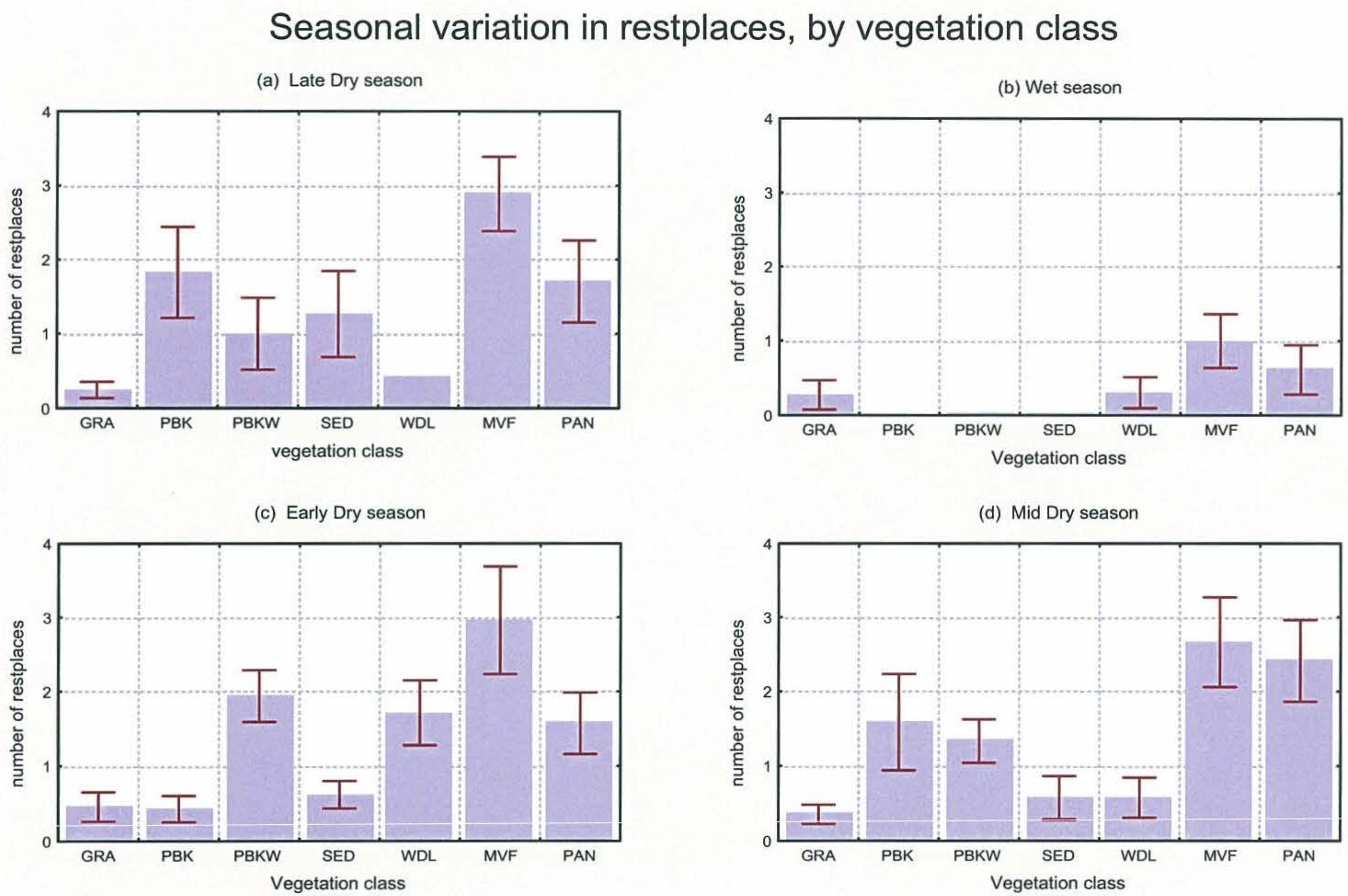


Figure 3.33: Mean number of restplaces per plot in each vegetation class in each season.

3.4.1.11 Seasonal occurrence of pig dung

The mean percentage of surveyed plots containing dung of any category, across all seasons, was 21.6%. Fresh dung was recorded in 8.4 % of plots and old dung was recorded in 18.3% of plots.

3.4.1.12 Late dry season pig dung

In the late dry season 34.4% of plots contained dung (Figure 3.4). The mean number of dung pellets (fresh and old) this season was 2.3 (Figure 3.38). There was no fresh dung recorded at the sites Dhabila, Mangbirri, Mangurr or Milbirim in the late dry season (Figure 3.34a). Old dung occurred at all sites (Figure 3.35a). The mean number of fresh and old dung pellets per plot at each site is shown in Figure 3.39a and Figure 3.40a respectively. Fresh dung was recorded in all vegetation classes except pandanus and woodland (Figure 3.36a) and old dung was found in all vegetation classes (Figure 3.37a). The mean number of dung pellets per plot in each vegetation class in the late dry season is shown in Figure 3.41a (fresh dung) and Figure 3.42a (old dung).

3.4.1.13 Wet season pig dung

Very few surveyed plots contained any dung in the wet season. Old dung was not recorded in any plots this season. The only sites where fresh dung was recorded were Djanyirrbirri and Djapidingorin (Figure 3.34b). Fresh dung pellets were only recorded in sedge and monsoon forest vegetation (Figure 3.36b). As the total number of dung pellets recorded in the wet season was 3.0 it was not possible to reliably interpret this sign in the wet season.

3.4.1.14 Early dry season pig dung

In the early dry season 20% of surveyed plots contained dung pellets (Figure 3.4). The mean number of dung pellets per plot this season was 1.1 pellets (Figure 3.38). Fresh dung was found in all sites except Mangurr and Milbirim (Figure 3.34c). Old dung was only found in four sites; Djanyirrbirri, Djapidingorin, Garanydjirr and Gatji (Figure 3.35c). The mean number of fresh and old dung pellets per plot found at each site are shown in Figure 3.39c and Figure 3.40c. Fresh dung pellets were recorded in all vegetation classes (Figure 3.36c) and old dung pellets were recorded in all vegetation classes except paperbark woodland (Figure 3.37c). The mean number of fresh and old dung pellets per plot recorded in each vegetation class is shown in Figure 3.41c and Figure 3.42c.

3.4.1.15 Mid dry season pig dung

There was 29.5% of surveyed plots that contained dung of any category in the mid dry season (Figure 3.4). The mean number of all dung pellets per plot was 1.5 (Figure 3.38). Fresh dung was found in all sites except Djanyirrbirri, Mangbirri and Mangurr in the mid dry season (Figure 3.34d). Old dung was found in all sites except Crossing (Figure 3.35d). The mean number of fresh and old dung pellets recorded per plot in each site is shown in Figure 3.39d and Figure 3.40d. All vegetation classes contained fresh dung in the mid dry season (Figure 3.36d). Old dung was found in all vegetation classes except sedge (Figure 3.37d). The mean number of fresh and old dung pellets recorded per plot in each vegetation class is shown in Figure 3.41d and Figure 3.42d.

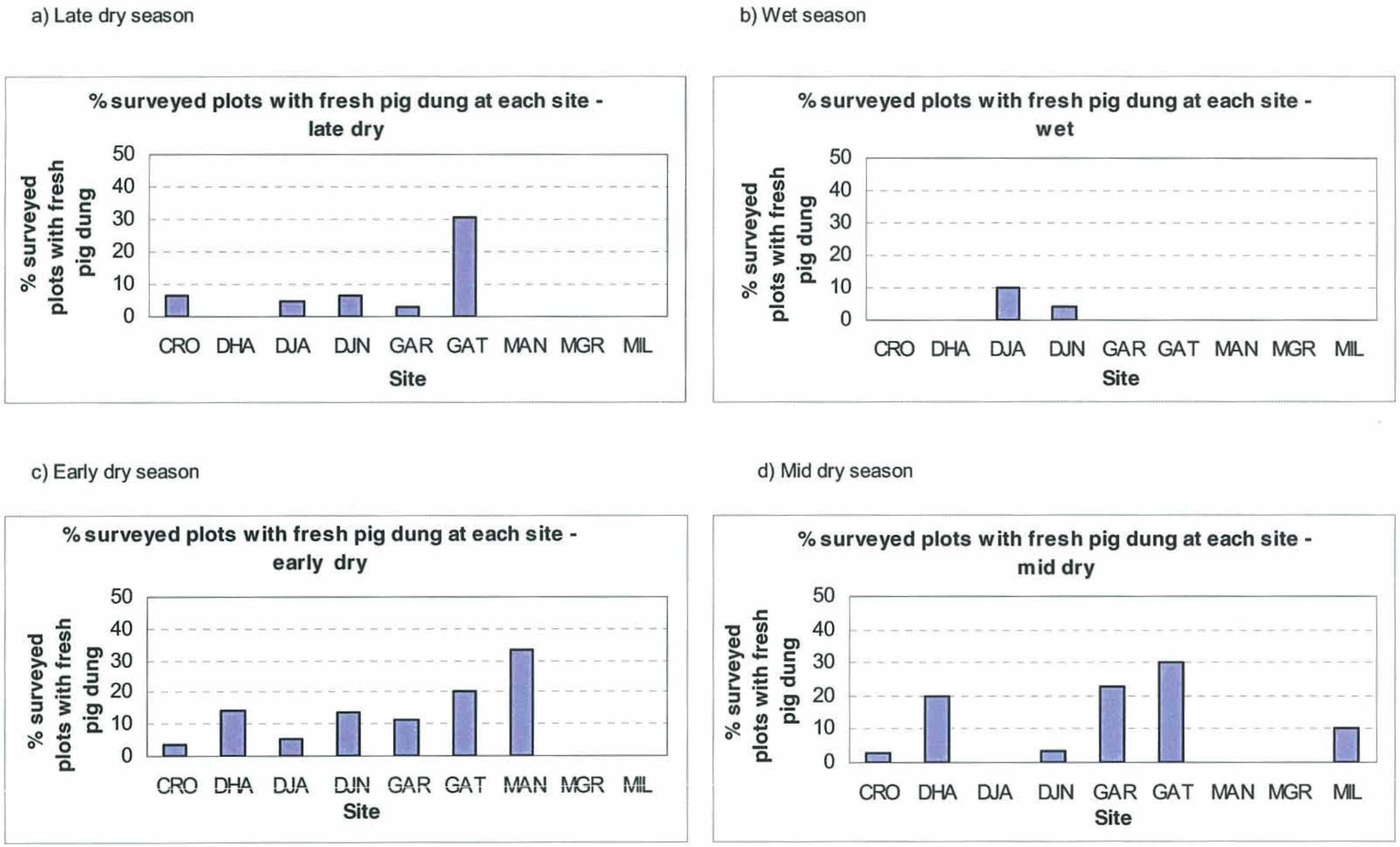


Figure 3.34: Percentage of surveyed plots with fresh pig dung at each site each season.

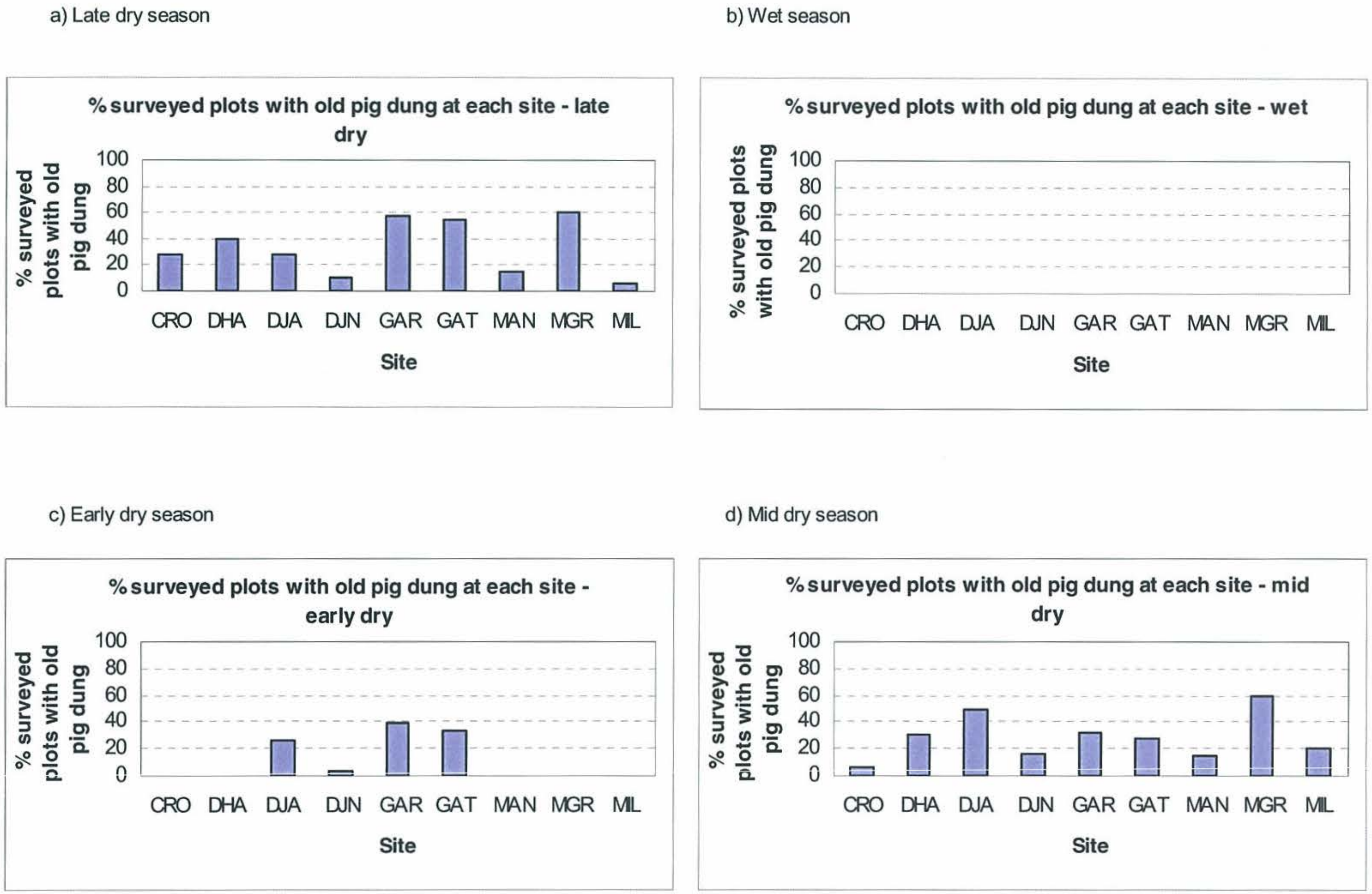


Figure 3.35: Percentage of surveyed plots with old pig dung at each site each season.

a) Late dry season

b) Wet season

c) Early dry season

d) Mid dry season

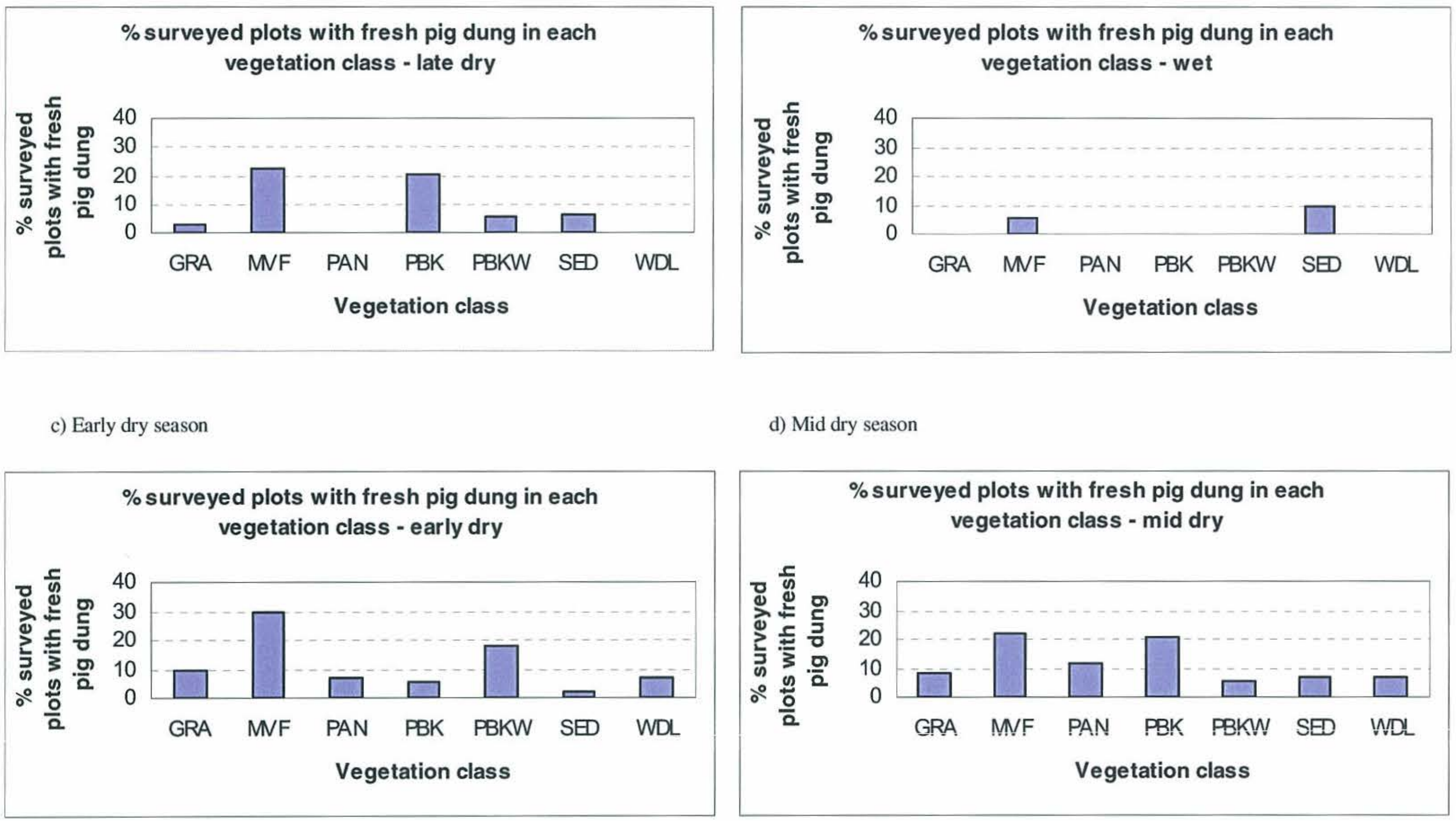
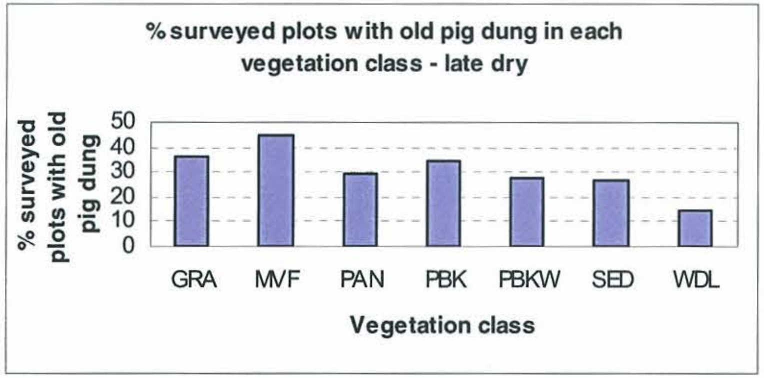
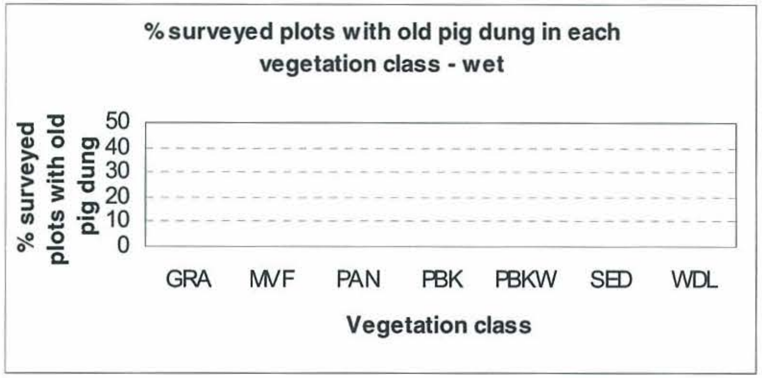


Figure 3.36: Percentage of surveyed plots with fresh pig dung in each vegetation class each season.

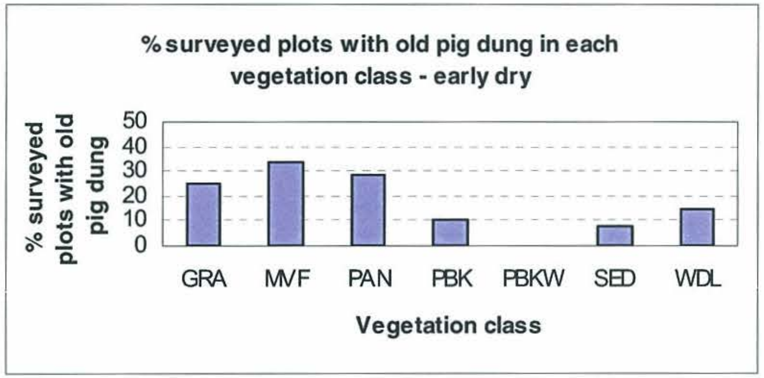
a) Late dry season



b) Wet season



c) Early dry season



d) Mid dry season

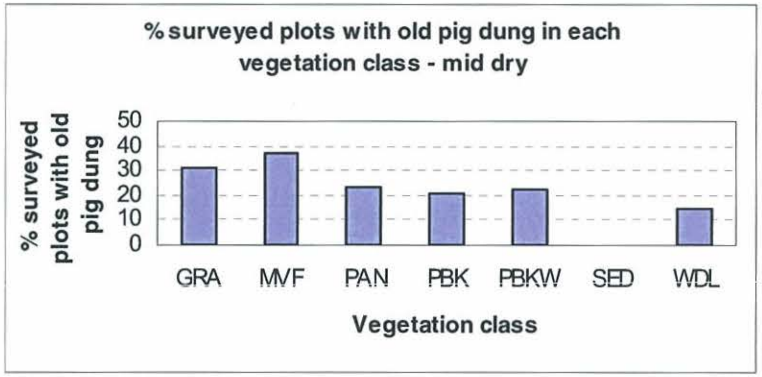


Figure 3.37: Percentage of surveyed plots with old pig dung in each vegetation class each season.

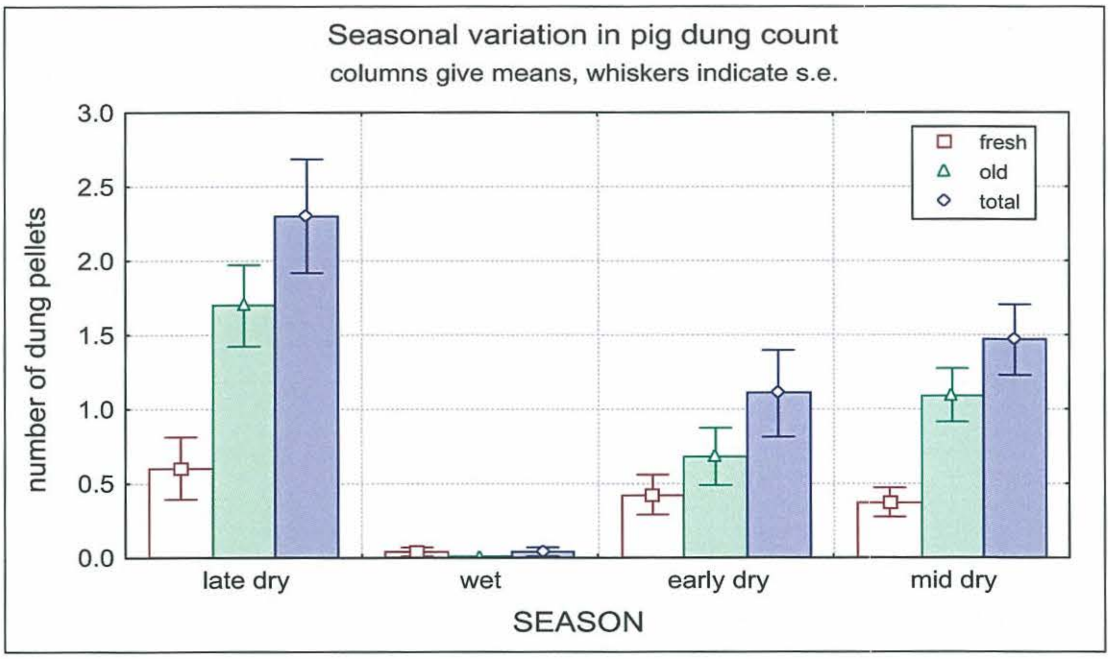


Figure 3.38: Mean number of pig dung pellets per plot each season.

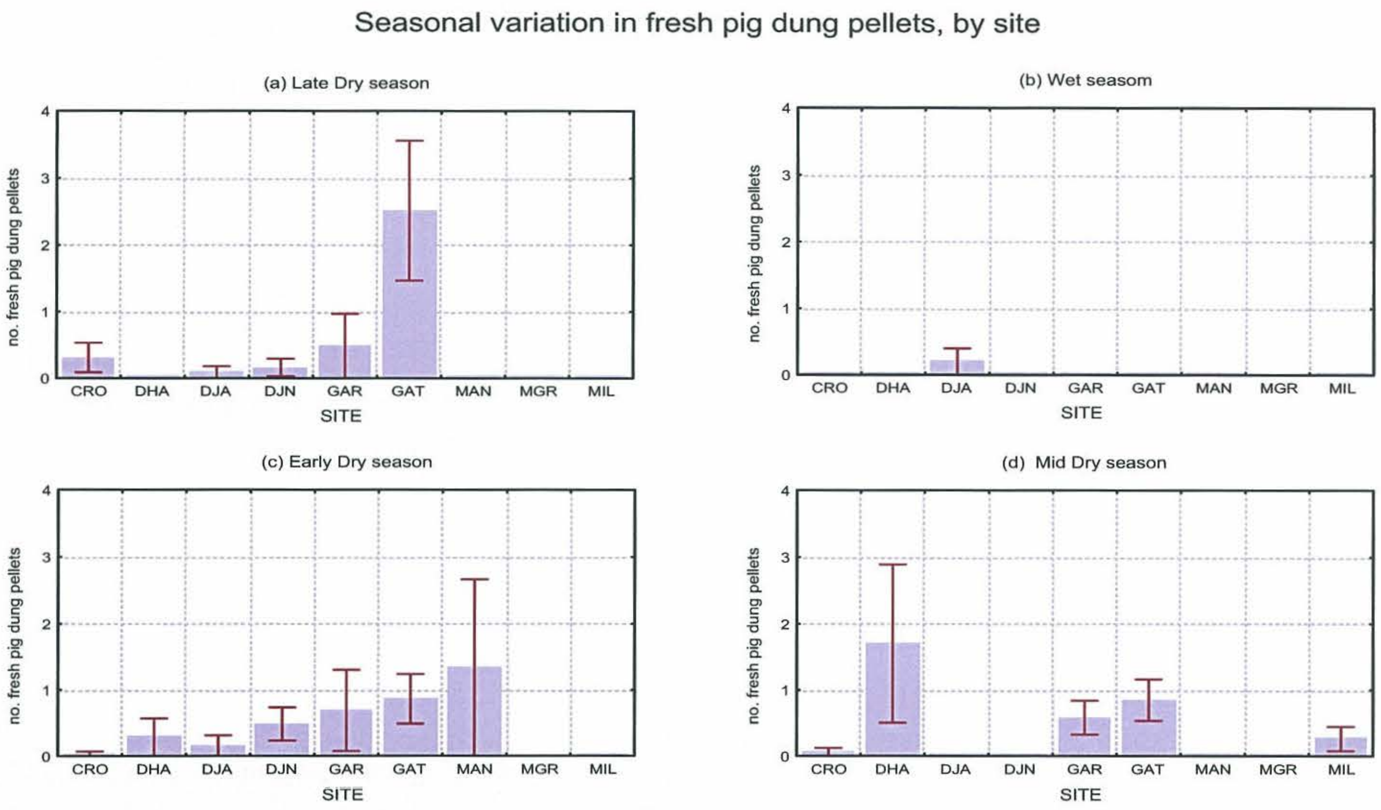


Figure 3.39: Mean number of fresh pig dung pellets per plot at each site each season.

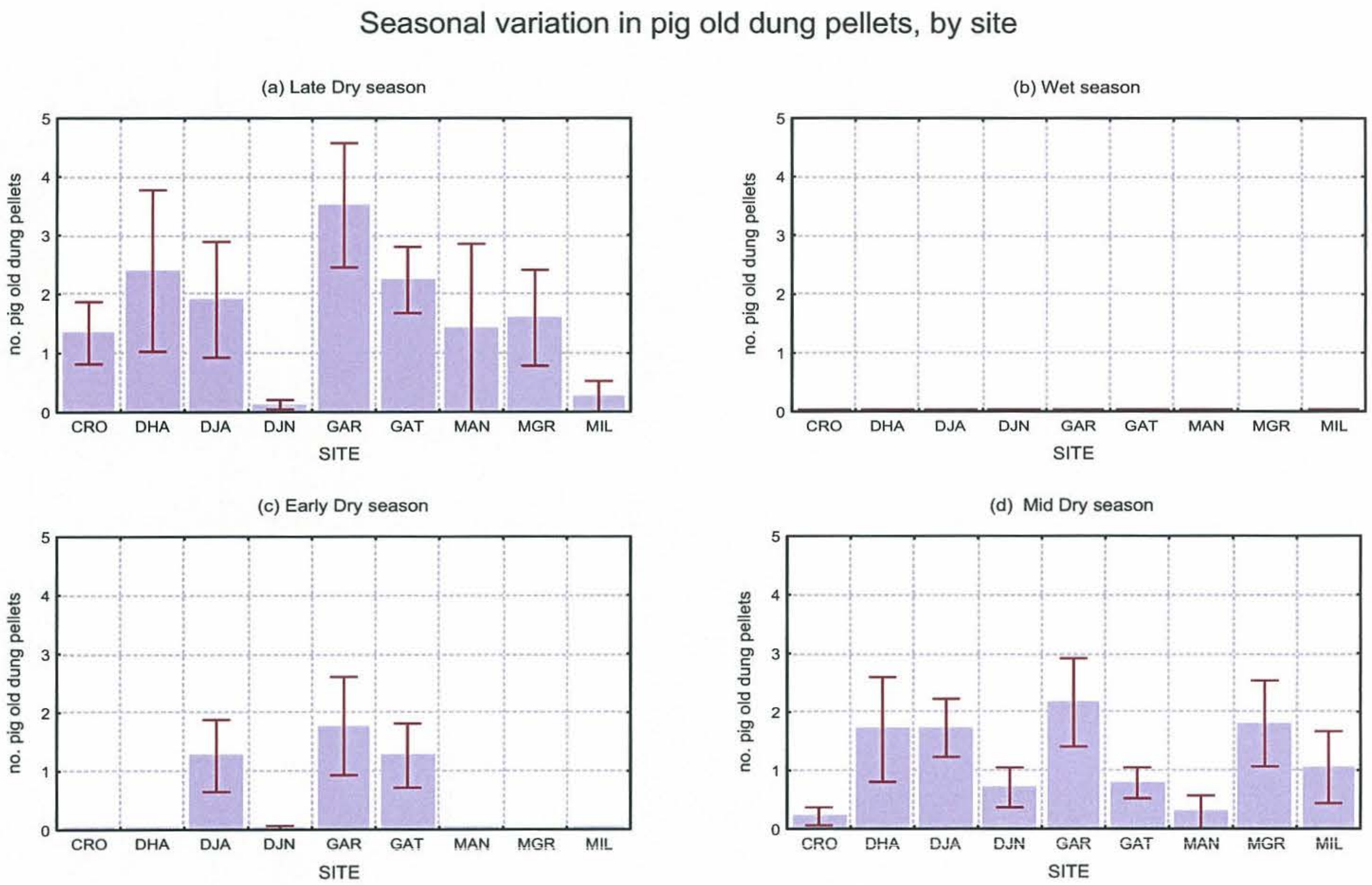


Figure 3.40: Mean number of old pig dung pellets per plot at each site each season.

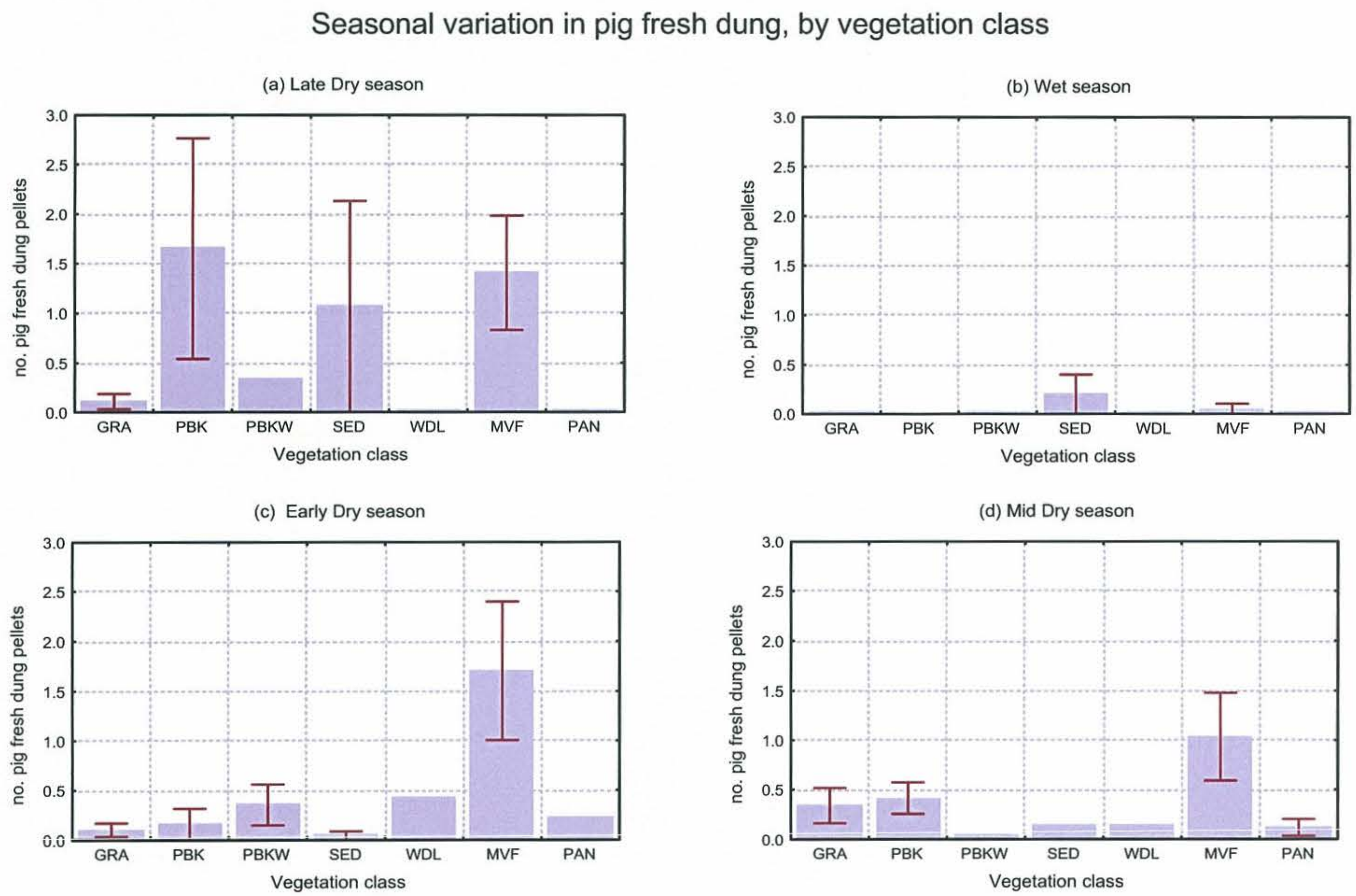


Figure 3.41: Mean number of fresh pig dung pellets per plot in each vegetation class each season.

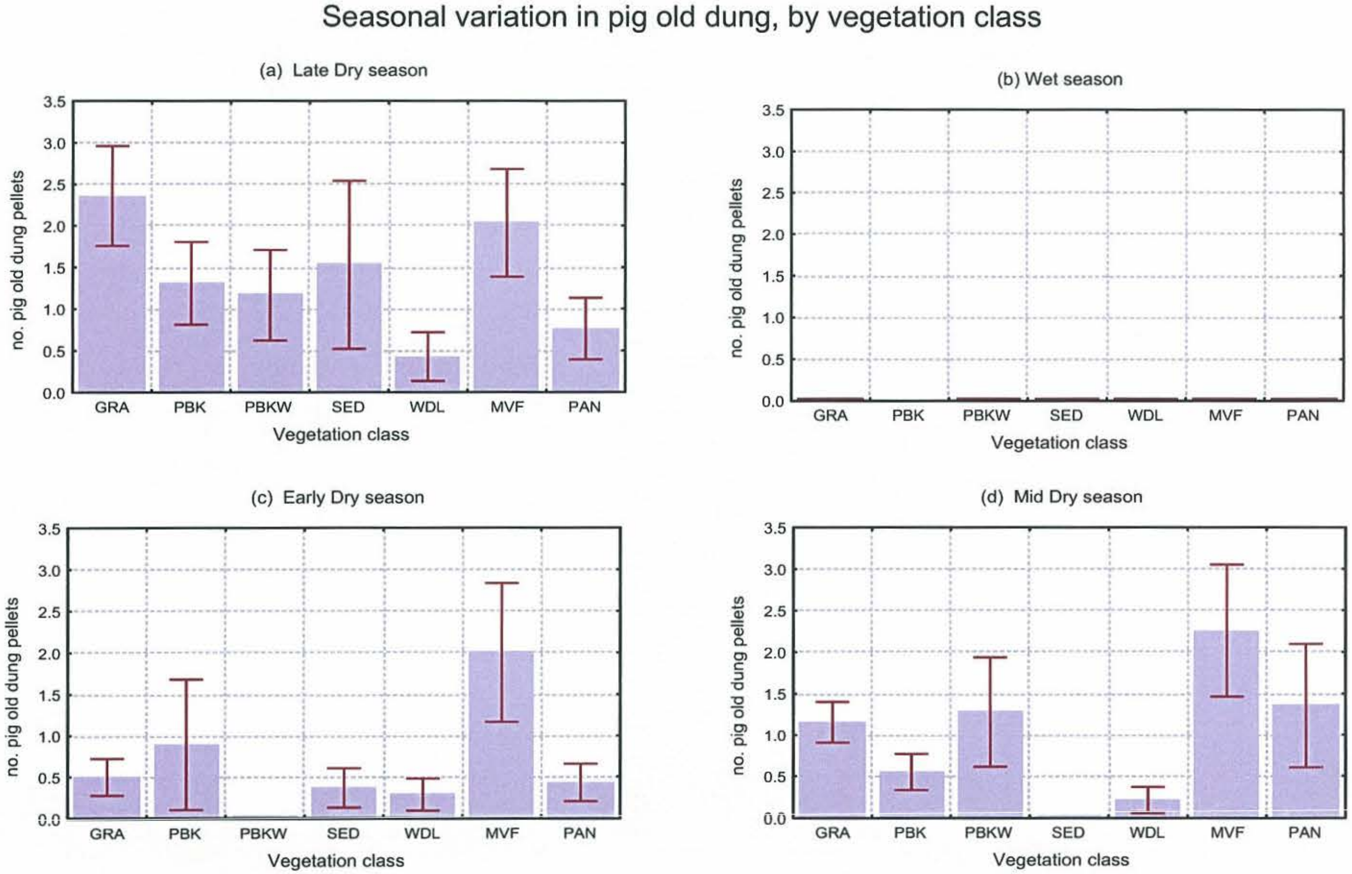


Figure 3.42: Mean number of old pig dung pellets per plot in each vegetation class each season.

3.4.1.16 Other signs of feral pigs

Data were also collected on other signs of feral pigs: *% area trampled per plot*; *number of trails*; *scarification* and the number of *live pigs and carcasses* per plot. Very few live pigs or carcasses were recorded throughout the survey and thus this sign has not been considered any further. For the remaining signs it was not possible to clearly distinguish whether pigs or buffalo made the sign. This ambiguity was less for the sign *scarification* but larger pigs and smaller buffalo may mark similar areas on a tree. Thus, given the quality and clarity of the data for pig diggings, restplaces and dung, data for these other signs have not been explored further here.

3.4.2 Signs of feral water buffalo

Signs recorded to indicate the presence and activity of feral water buffalo were: *% area trampled per plot*; *number of trails*; *scarification; dung pats; wallows; swim channels* and *sightings*. Of these signs, the first three are in common with pigs and due to possible ambiguity have not been considered further as discussed above. Water buffalo dung pats are clearly distinguishable from pig dung and as such their occurrence has been explored in the following section. The data obtained for *wallows*, *swim channels* and *sightings* were insufficient to analyse.

3.4.2.1 Water buffalo dung pats

Water buffalo dung pats were recorded each season. The data need to be considered with caution at some sites such as Crossing, where herds of cattle are commonly found, as cattle pats and buffalo pats can be indistinguishable (Triggs 1996). Buffalo dung pats were found at all sites in the late and mid dry seasons but were only found at Crossing, Djapidingorin and Gatji in the wet season (Figure 3.43). The mean number of buffalo dung pats per plot at each site in each season is shown in Figure 3.45. Buffalo dung pats were recorded in all vegetation classes in the late, early and mid dry seasons but were only found in grassland, pandanus, sedge and woodland habitats in the wet season (Figure 3.44). The mean number of buffalo dung pats per plot in each vegetation class is shown in Figure 3.46.

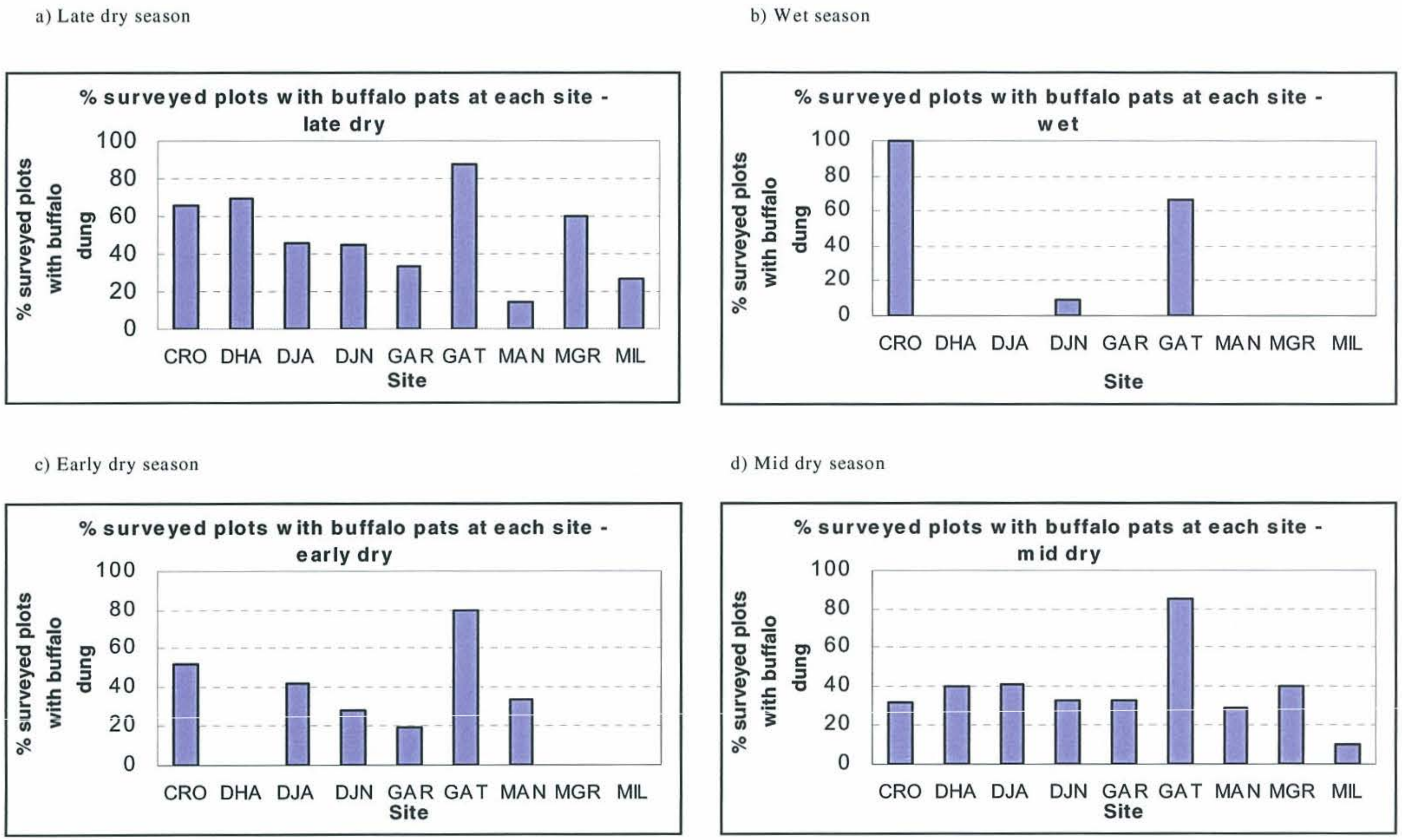


Figure 3.43: Percentage of surveyed plots with buffalo dung at each site in each season.

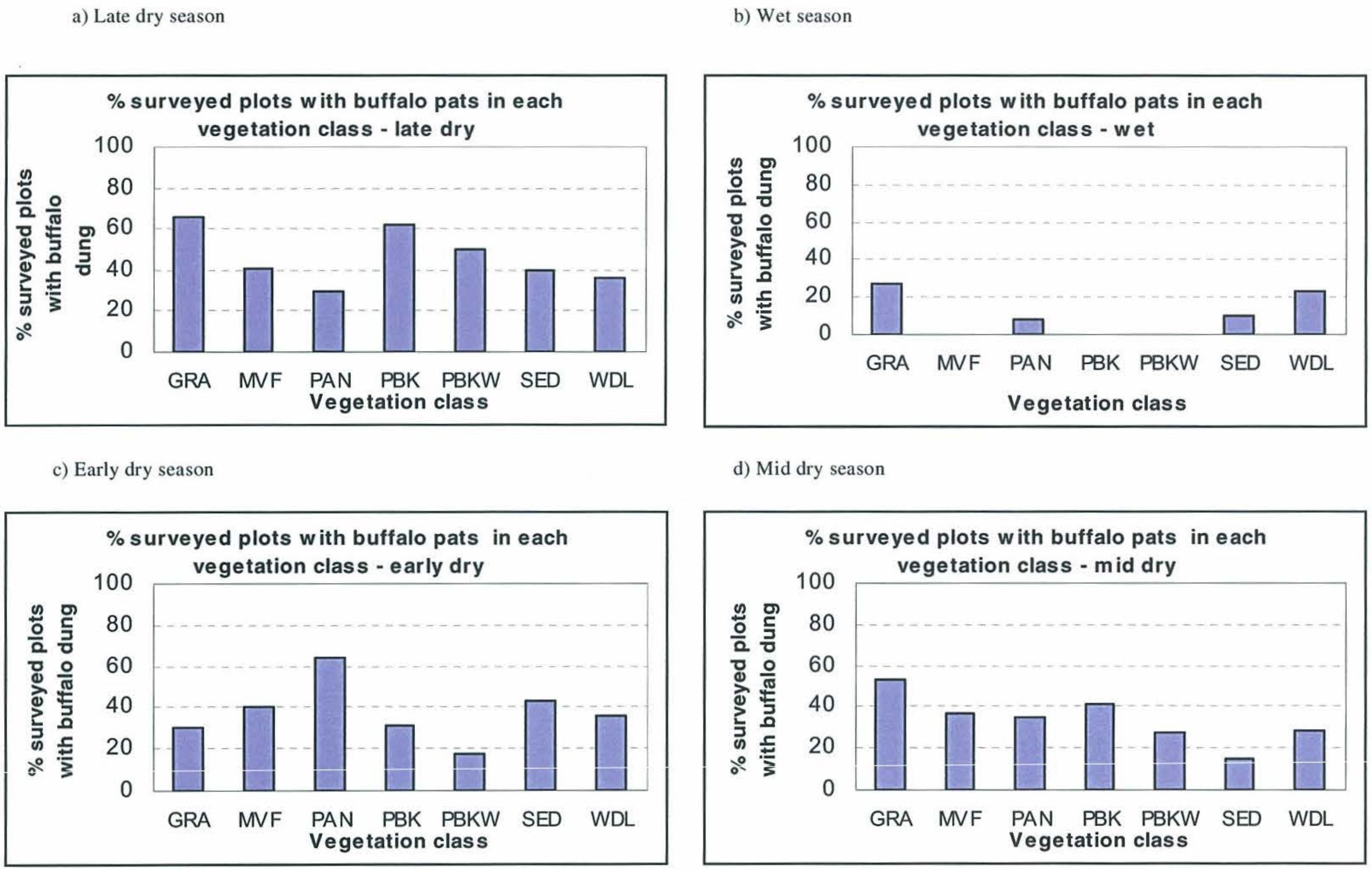


Figure 3.44: Percentage of surveyed plots with buffalo dung in each vegetation class in each season.

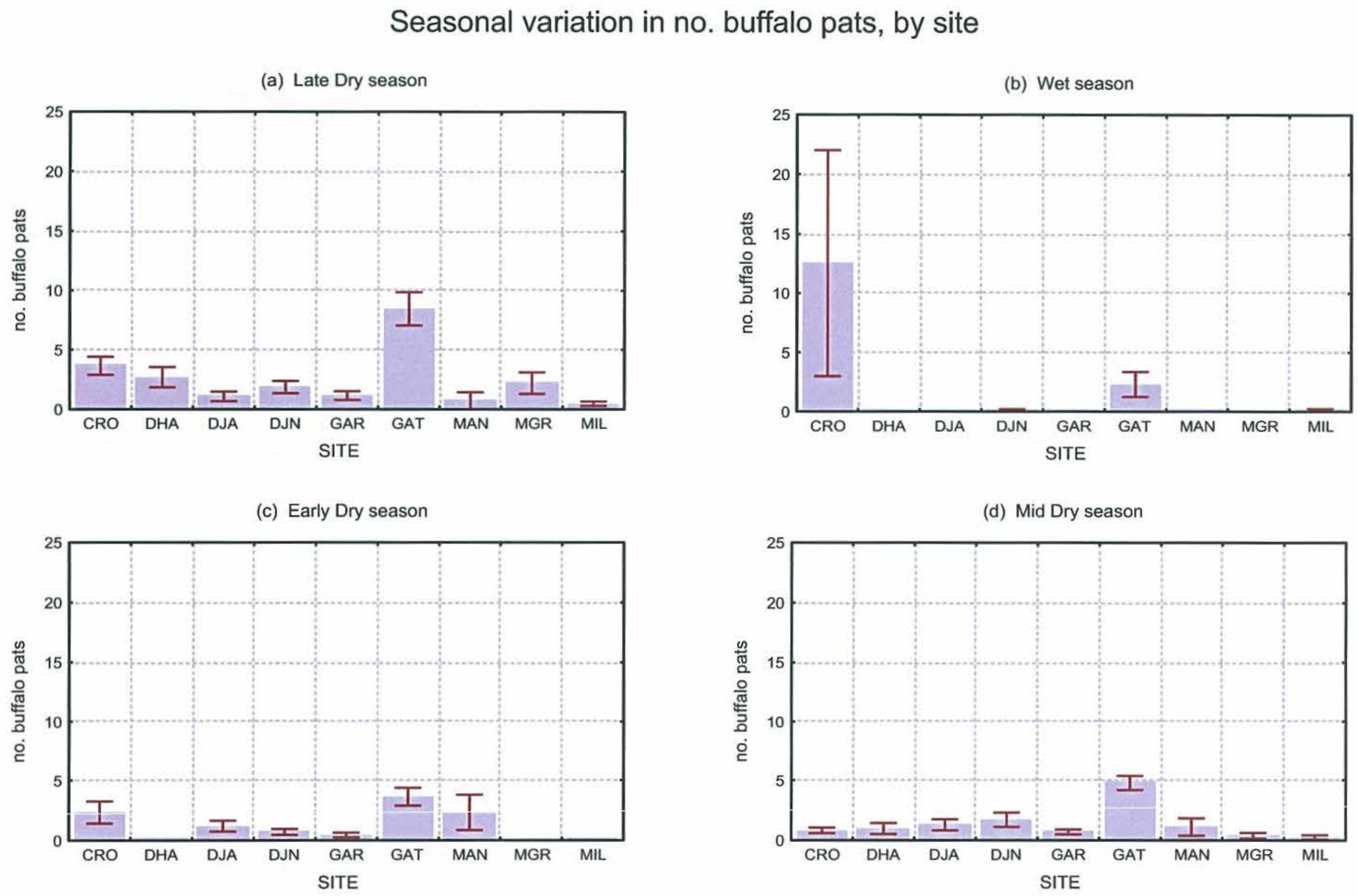


Figure 3.45: The mean number of buffalo dung pats per plot at each site in each season.

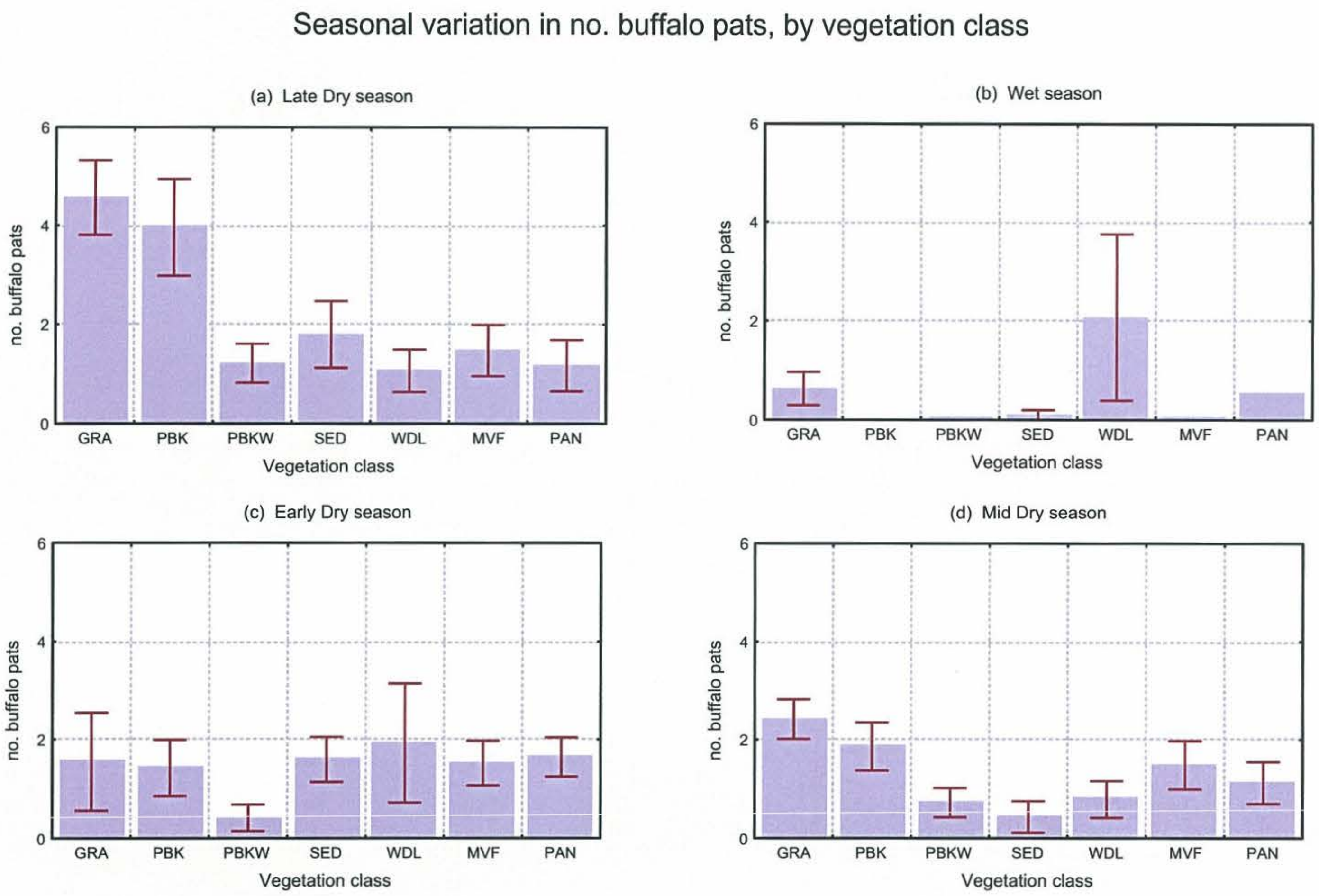


Figure 3.46: The mean number of buffalo dung pats per plot in each vegetation class in each season.

3.4.3 Relationships between the various measures of pig and water buffalo impacts

Spearman rank correlation coefficients were used to examine the interrelationships between the various indices of pig and buffalo use in each season. As this examination was intended to be exploratory, any inferences made should be treated with caution. The results suggest considerable seasonal variation in the network of correlations. In the late dry season (Table 3.6a), pronounced temporal changes in activity patterns were evident with significant negative correlations between the number of fresh diggings and the number of both medium and old diggings - although, somewhat inconsistently, this pattern was not evident for fresh and old dung counts. The number of resting places per plot was positively associated with the count of fresh dung (suggesting that both indices are measures of recent activity), but negatively associated with the number of old diggings and the total number of diggings. The measure of buffalo activity was positively associated with counts of all ages of pig dung, but was negatively related to the amount of recent pig digging. This may be because in the late dry season, soils in many habitats have become almost impenetrable and pigs may be digging in places not commonly used by buffalo.

In the wet season (Table 3.6b), there were few significant correlations between measures, with the only (three) significant correlations being between subset and composite variables (e.g. the number of fresh diggings and the total number of diggings). This suggests that at this season, pigs use different habitats for different purposes.

The number of significant intercorrelations had increased in the early dry season (Table 3.6c), although there were no significant correlations between digging parameters and counts of dung. Nonetheless, the number of resting places per plot was significantly related to all dung count variables and also to the total number of diggings and the number of medium-aged diggings. There were no significant correlations between the different-aged digging counts, although counts of the number of fresh and old dung per plot were highly correlated. In this season, counts of buffalo and pig dung were significantly positively correlated which suggests that they use the same areas for at least some activities.

In the mid-dry season (Table 3.6d), there was far more association between the digging and the dung variables, indicating relative consistency in type of use by pigs. However, there were no significant positive correlations among the differently-aged scores for digging (and indeed a significant negative correlation between fresh and medium-aged diggings), indicating a temporal change in use of plots in the period up to the mid-dry season. Again, there was a positive association between counts of buffalo activity and of pig dung, with medium-aged pig diggings also positively associated with number of buffalo dung.

The relatively low correlations between different variables suggest that the indices are measuring different parameters of use and thus corroborate the need for assessing different measures of pig and buffalo activity, as was done in this study. Fresh digging and restplaces are not correlated in any season, which clearly demonstrates that pigs use different habitats for different activities as suggested by Bowman and McDonough (1991). This differential habitat use is further discussed in Chapter 4. The data also show that there is a pronounced seasonal shift in use of habitat, which is probably correlated with seasonal variation in resource availability as discussed in Chapter 6. In addition, there is a reasonably high overlap between occurrence of buffalo and of pigs which is consistent with their similar habitat requirements for shelter during the heat of the day.

Table 3.6: Spearman rank correlation coefficients (across plots) for pig and buffalo variables.

a) Late dry – any value ≥ .16 is evidence of an association between these variables this season (based on p<0.05)

	Medium digging	Old digging	Total digging	Restplaces	Fresh dung	Old dung	Total dung	Buffalo dung
Fresh digging	-.06	**-.19**	**.16**	.10	.07	-.03	-.01	**-.17**
Medium digging		**-.23**	**.16**	.04	.02	**.17**	**.16**	.04
Old digging			**.82**	**-.30**	**-.17**	.02	-.02	.01
Total digging				**-.28**	-.13	.14	.09	-.03
Restplaces					**.25**	.09	.10	.04
Fresh dung						**.30**	**.49**	**.24**
Old dung							**.96**	**.28**
Total dung								**.33**

b) Wet– any value ≥ .44 is evidence of an association between these variables this season (based on p<0.05)

	Medium digging	Old digging	Total digging	Restplaces	Fresh dung	Old dung	Total dung	Buffalo dung
Fresh digging	na	-.03	**.84**	.19	.11	na	.11	.18
Medium digging		na	na	na	na	na	na	na
Old digging			**.44**	.01	-.07	na	-.07	-.01
Total digging				.21	.08	na	.08	.11
Restplaces					-.08	na	-.08	-.06
Fresh dung						na	na	na
Old dung							**1.0**	-.06
Total dung								-.06

c) Early dry– any value ≥ .19 is evidence of an association between these variables this season (based on $p<0.05$)

	Medium digging	Old digging	Total digging	Restplaces	Fresh dung	Old dung	Total dung	Buffalo dung
Fresh digging	-.11	.07	**.43**	.07	.01	.16	.14	.05
Medium digging		-.05	**.34**	**.30**	-.06	-.12	-.08	-.08
Old digging			**.71**	.04	.07	.13	.13	.06
Total digging				**.21**	.01	.10	.09	.11
Restplaces					**.27**	**.19**	**.25**	.05
Fresh dung						**.41**	**.71**	**.20**
Old dung							**.87**	**.30**
Total dung								**.29**

d) Mid dry– any value ≥ .14 is evidence of an association between these variables this season (based on $p<0.05$)

	Medium digging	Old digging	Total digging	Restplaces	Fresh dung	Old dung	Total dung	Buffalo dung
Fresh digging	-.04	**-.14**	**.47**	-.06	**.20**	**.25**	**.27**	.09
Medium digging		.12	**.41**	.08	**.20**	**.23**	**.22**	**.20**
Old digging			**.49**	.12	.13	.11	.11	.07
Total digging				.01	.12	**.26**	**.25**	.12
Restplaces					.12	**.27**	**.26**	0
Fresh dung						**.40**	**.61**	**.18**
Old dung							**.94**	**.29**
Total dung								**.29**

3.4.4 Environmental variables

3.4.4.1 Variables chosen for statistical modelling

Six environmental variables were chosen for statistical modelling of pig activity: *vegetation class, slope position, % vegetation cover, soil type, distance to water* and *distance to shelter*. The relationships between pig activity and these variables are discussed in Chapter 4.

3.4.4.2 Other environmental variables

Fallen Fruit

Fallen fruits were not commonly recorded during the study. This may be because of rapid disintegration or consumption after falling to the ground. Further, as the wet season survey was conducted late during the season for practical reasons, wet monsoon forests which fruit mainly in the wet season (Bach 2002) may have completed fruiting and any fallen fruit may already have disintegrated or been consumed before the time of the survey. The greatest mean abundance of fallen fruit in a plot was recorded during the late dry season (Figure 3.47). Most of the fruit recorded in this season was from the screwpalm, *Pandanus spiralis.* The greatest mean abundance of fallen fruit recorded across all seasons occurred in monsoon forests (Figure 3.48). Much of the recorded fruit in monsoon forests was also from the screwpalm, *Pandanus spiralis*. Although not a monsoon forest species, screwpalms often occur along the margins of monsoon forests and these ecotone areas were included in the boundaries of many plots.

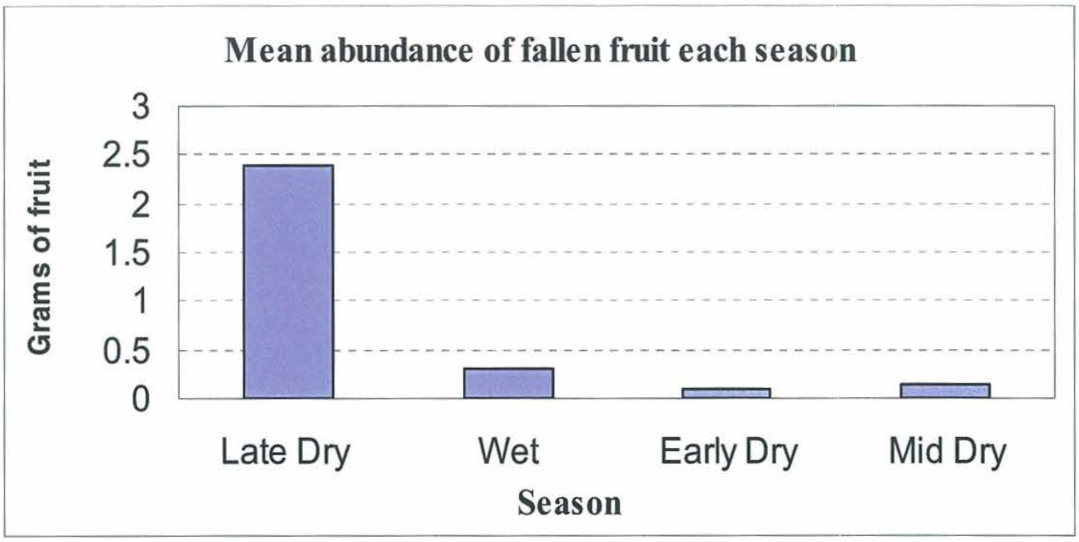


Figure 3.47: Mean abundance of fallen fruit per plot each season.

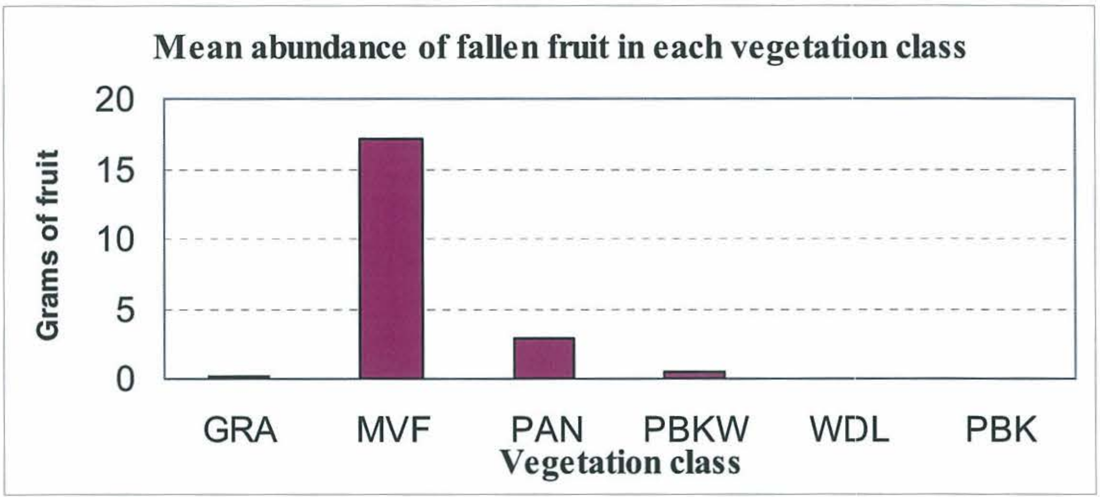


Figure 3.48: Mean abundance of fallen fruit per plot in each vegetation class.

3.5 Discussion

Following is a very brief discussion of the key findings from exploration of the data. A more in depth discussion of feral pig diggings, restplaces and dung can be found in Chapter 4, where pig activity has been modelled.

3.5.1 Pig diggings

Feral pig diggings in the study area were recorded in 61.8 % of surveyed plots and 12.7% of the total area surveyed (averaged across seasons) was dug by pigs. These results are slightly lower in frequency of occurrence than those of Mitchell and Mayer (1997), who found that 67% of all transects surveyed in the wet tropics World Heritage Area region of north Queensland contained pig diggings but higher than the average 4% of the surface area disturbed by feral pigs that they recorded. The occurence of pig digging recorded in this study was greater than that found in another part of the Queensland wet tropics region where diggings were detected in 47.4% of plots (Laurance and Harrington 1997). It was also greater than that recorded in Namadgi National Park (ACT) where pig diggings occurred in between 18.1% and 26.6% of plots, depending on season (Hone 1988a). The extent of digging in Namadgi National Park was also lower than in the Arafura area with on average 2.7% of the ground dug by pigs during a 12 month study (Hone 1988a). Table 3.7 compares the various results discussed above.

Table 3.7: Comparison of frequency and area of pig digging from this and other studies around Australia.

STUDY AREA	FREQUENCY OF OCCURENCE OF DIGGING	AREA OF DIGGING
Arafura wetlands and surrounds (this study)	61.8%	12.7%
Wet Tropics World Heritage Area, North Queensland (Mitchell and Mayer 1997)	67%	4%
Wet Tropics, Queensland (Laurance and Harrington 1997)	47.4%	N/A
Namadgi National Park, ACT (Hone 1988a)	18.1-26.6% (seasonal variation)	2.7%

Many of the surveyed sites in this study showed little or no pig digging and only a few sites had high digging activity (Figure 3.5), which is consistent with the findings of Hone (1988a) and Mitchell and Mayer (1997). The mean % area of fresh pig diggings recorded during the dry season (late, early and mid dry) was high in paperbark plots. Similarly, Mitchell and Mayer (1997) recorded more diggings in coastal habitats, which included paperbark swamps. Also consistent with these findings were estimates of feral pig population density showing greater numbers of pigs in paperbark swamps in the dry season (Hone 1990a).

3.5.2 Restplaces

In this study the mean number of restplaces per plot varied between 0.45 in the wet season and 1.3 in the early dry season, which is lower than the 1.6 -5.0 restplaces per hectare recorded in an Hawaiian rainforest (Cooray and Mueller-Dombois 1981).

3.5.3 Dung pellets

The number of surveyed plots containing dung pellets varied between 2.6% in the wet season and 34.7% in the late dry season. The mean number of dung pellets per plot varied from between 0.04 in the wet season to 2.3 in the late dry season. Estimates in mountain forest and woodland vegetation in Namadgi National Park were lower, with pig dung occurring in only 1.09% of plots (Hone 1988b). This difference is expected given that the population density of pigs has been found to be higher in Top End wetlands than in colder areas of south-eastern Australia (see Hone 1990b, Choquenot et al. 1996).

The highest mean numbers of dung pellets were found in grassland, monsoon forest, sedge and paperbark vegetation in the late dry season. This is partly consistent with the findings of Bowman and Panton (1991) who recorded high numbers of dung pellets in coastal plains (similar to the grassland category in this study) and sedgelands at the same time of year; however, these authors recorded few dung pellets in monsoon forests.

Very few dung pellets were recorded in the wet season. As the survey for the wet season was undertaken late in that season for practical reasons, dung pellets may have disintegrated with the large amount of regular rainfall. It is also possible that pigs were using various locations as refuges from floodwaters that were not part of the area surveyed in this study. These areas may have included woodland vegetation on high ground, which were little surveyed as part of this study. Also, as many plots could not be surveyed due to inaccessibility in the wet season, the dung counts in the early dry season may be representing both wet and early dry season activity and thus be artificially high. The very low numbers of dung pellets that occurred in woodland habitats was either because seasonal burning had destroyed any evidence of pellets or because burnt areas were unattractive to pigs, possibly due to reduced availability of food and low shelter.

3.5.4 Buffalo

High numbers of buffalo dung pats were recorded in all seasons at Gatji. Buffalo were commonly observed at this site and a number of wallows was also recorded here. The site has an ideal habitat mosaic for buffalo, consisting of vast floodplain areas and extensive paperbark forests with a plentiful permanent water supply. Buffalo activity (as reflected by dung) was generally low at Milbirim in all seasons. This may be because this site is frequently visited by people.

In the late dry season, a high mean number of buffalo dung pats occurred in grassland and paperbark plots. Buffalo need to spend the hot, daylight hours of the late dry season in cool places or in wallows (Ridpath 1991). Paperbark forests, where both shade and water persisted until late in the dry season, accommodated these requirements. Buffaloes are also attracted by an abundance of preferred foods such as sedges and other aquatic plants, which often remain in isolated swamps on the coastal floodplains (Ridpath 1991) where grassland is the dominant vegetation. Buffaloes generally access these swamps when temperatures are cooler, such as during the night or very early in the morning, during the late dry season (personal observation).

The number of dung pats was very high at Crossing in the wet season. Only two plots that were located on high ground could be surveyed at this site in the wet season. Cattle and buffalo use these areas in the wet season as a refuge from floodwaters, and as the numbers of cattle were generally high in this area (personal observation) the majority of the dung pats probably originated from the cattle. Plots in woodland vegetation also had a high number of dung pats in the wet season reflecting their use at this time of year as a dry refuge from the flooding. Buffalo also use monsoon forests as daytime resting areas or camps throughout the year (personal observation); however, no dung was recorded in monsoon forests in the wet season. This may be because buffalo preferred woodlands at this time of year or because they were using monsoon forest areas that were not surveyed.

A high percentage of surveyed pandanus plots contained buffalo dung pats in the early dry season, which is probably due to buffalo passing through this habitat when moving from monsoon forests where they rest, to floodplains where they graze. The activity in this type of vegetation may also be because buffalo like to feed on the leaves of the palm *Pandanus spiralis* (Tulloch 1974, Ruskin 1981), which is found in this habitat. In the mid dry season, buffalo dung pats were recorded at all sites and in all vegetation classes reflecting the unrestricted movement this season. A high mean number of buffalo dung pats occurred in both grassland and paperbark plots. Food and water were generally plentiful in both of these vegetation classes.

3.5.5 Concluding remarks

The exploratory data summaries show that feral pig and buffalo activity was widespread across the study area during the time of the survey. Analysis of the relationships between the key variables found few correlations, supporting the need to measure a range of different indices of animal sign as was done in this study. The next chapter examines the relationships between the seasonal presence and activity of pigs and specific environmental variables at each site using statistical modelling techniques.

CHAPTER 4: Seasonal habitat use by feral pigs in the northern Arafura Wetlands and surrounds

4.1 Introduction

Statistical modelling is used here to assist with understanding seasonal variation in habitat use by feral pigs, specifically to identify important variables that explain habitat use and that may be used to obtain predictions about species occurrence in unsampled areas of a similar landscape. Statistical modelling aims to derive a mathematical representation of the relationship between an observed response variable and a number of explanatory variables and obtain a suitable frequency distribution for random variation (Collett 1991). Hypothesis testing is implicit in this modelling process. The explanatory variables are usually chosen based on the current understanding of the biology of the species to be modelled (Nicholls 1991).

This chapter examines the relationships between feral pig presence and activity (based on signs) and a range of environmental attributes over four main seasonal periods. The methods of data collection were explained in the previous chapter and some preliminary exploration of the data was undertaken.

The principal questions addressed here are:

Do feral pigs favour particular habitats and does this pattern vary with season?

What environmental attributes influence this pattern of habitat use by feral pigs?

Using statistical modelling techniques, the variables that best explained spatial and temporal variation in the occurrence and abundance of feral pig sign were identified. Key factors that underlie feral pig distribution within the study areas are discussed.

4.2 Methods

Three response variables were used in the analyses: pig *digging*, pig *dung* and pig *restplaces*. These variables are defined briefly below and more detailed definitions can be found in Chapter 3, section 3.3.1.

Pig *digging* was recorded if there were obvious signs of ground disturbance including any pronounced scarification or visible signs of soil turnover by pigs. The total area dug was estimated as a percentage of the area of each $50m^2$ plot as well as a percentage of the area of each of the four $5m^2$ quadrats nested within each plot. *Digging* was recorded as being fresh (moist soil turned over by pigs, no leaves or vegetation in base of diggings), medium (weathered soil and some leaf litter in diggings) or old (diggings covered by leaf litter, plants germinating in diggings, weathered soil), after Mitchell and Mayer (1997). *Restplaces* were recorded as wet or dry but were amalgamated for these analyses. Wet rests occurred in open area on the edges of swamps, and dry rests in shady places under trees or amongst grasses (personal observation). *Dung* pellets of feral pigs were recorded in 2 categories: fresh dung was moist and fetid and old dung had a dry, hard surface. *Dung* pellets were removed from the plots after each count to prevent them being recounted in the next survey (after Hone 1988a, Hone and Stone 1989, Hone and Martin 1998). Each of these three variables was recorded at both plot and quadrat levels.

The data have a multi-level spatial structure with fixed sites (n=9), random plots within sites (n=10-30), random quadrats within each plot (n=4) and a single level temporal structure which is season (4 time periods). These factors are the design variables and are both fixed and random. The six explanatory variables selected for consideration in the analyses were: *vegetation class; % vegetation cover; slope position; distance to water; distance to shelter* and *soil type*. These variables are described in section 3.3.1 and Table 3.5 in Chapter 3. They include a mixture of continuous, categorical and ordinal variables and fixed and random effects. It was not possible to include all variables that were measured in the field in the statistical analyses. Variables for analysis were selected on the basis of statistical properties, colinearity among variables, biological significance and field knowledge.

The correlation structure among explanatory variables was initially explored using principal component analysis. This was to determine whether there were any latent variables that could be extracted from the set of explanatory variables. The evidence was that there was none. Each variable tells something a little different.

4.2.1 Derivation of response variable *Presence of pigs*

The distribution properties of the response variables (*diggings, dung* and *restplaces*) at both the plot level and the quadrat level were investigated using frequency histograms (Appendix 1). It was obvious that there were many zero values in the response variables; therefore, it was necessary to derive an aggregate measure by creating a new discrete binary variable called *Presence of pigs*. The variables that were used to create *Presence of pigs* were *diggings* (of any age category), *dung* (fresh or old) and *restplaces* (wet or dry) which were physically attributable to pigs. If there was a non-zero value for any of those variables in the plot or quadrat then pigs were classed as present in that plot or quadrat; if the values in both the plot and quadrat were zero then there was no evidence of pigs.

4.2.2 Derivation of response indices *Pig activity [1]* and *[2]*

A principal component analysis (PCA) was undertaken on data combined for all seasons using the complete data set (including zeros) of the variables *diggings*, *restplaces* and *dung* in order to determine if variation in pig activity could be accounted for with fewer dimensions. The PCA showed that more than 70% of variation is explained by two scores (*Pig activity index [1]* and *Pig activity index [2]*) as shown in Table 4.1. Both of these indices are centered at zero (i.e. the mean of the indices is zero) so that negative numbers are interpreted as lower levels of activity (or none) and positive numbers correspond to higher levels of activity. The distributional properties of the data were not ideal, especially for the wet season data and for the early dry season data, due to many plots with no activity (Appendix 2); hence, caution should be exercised in the interpretation of these results.

Restplaces and *dung* are given the most weight in *Pig activity index [1]* (*PAI1*), approximately twice the weight of *digging* (see Table 4.1). *Pig activity index [2](PAI2)* represents a contrast between *diggings* and *restplaces*. *Digging* is given the most weight in, and is negatively associated with, this index. *Dung* counts make almost no contribution to this *PAI1*.

Table 4.1: PCA weightings for *PAI1* and *PAI2*.

PCA WEIGHTINGS	*Digging*	*Restplaces*	*Dung*	Variation explained by each score
Pig activity index 1	0.247	0.452	0.487	40.97%
Pig activity index 2	-0.643	0.265	0.079	31.46%

4.2.3 Derivation of response variable *Fresh diggings*

Analysis of *fresh diggings* was undertaken in two stages: the first models the presence of *fresh diggings* (i.e. age of diggings = *fresh*) in plots and the second analyses the *conditional abundance* of *fresh diggings*. In the first stage, *fresh diggings* is a binary response variable, which is simply the presence or absence of *fresh diggings* in a plot across all seasons. For the analysis of conditional abundance, only plots where *fresh diggings* were present in a season were included. The log(abundance) has been analysed where abundance is measured as the average of the average % area from quadrats and the % area from plots.

4.2.4 Modelling

In developing the models the aim was to find the best set of explanatory variables that significantly accounted for variation in the presence/absence and abundance of pig sign. In this case the potential explanatory variables were the measured environmental variables (*vegetation class, % vegetation cover, slope position, distance to water, distance to shelter and soil type*), and the response variables were the signs of pigs in each of three forms

- *Presence of pigs* (binary),
- *Pig activity indices [1]* and *[2]*, and
- the abundance of *fresh diggings* (treated in two analyses: presence/absence and abundance given presence).

I was assisted in deriving these models and the resulting inference by Mr. R.B Cunningham and Ms C. Donnelly (Statistical Consulting Unit, The Australian National University). General principles applied in this modelling are outlined in Chapter 8 of Weisberg (1985) and for details of modelling binary data see Collett (1991). In this study, values of $p<0.001$ were considered very significant, $p<0.05$ were significant, and $0.10>p>0.05$ were weakly significant. Refer to Collett (1991) for explanation of how p-values are determined. As well as statistical significance, rules such as parsimony (the model should include as few terms as possible) and biological significance were used in applying and interpreting the models.

4.2.5 Modelling response variable *Presence of pigs* using Logistic Regression and Generalised Linear Mixed Modelling

The probability of occurrence of pig sign or *Presence of pigs* was modelled using logistic regression and Generalised Linear Mixed Modelling (GLMM). Logistic regression (a form of Generalised Linear Modelling) is used when the response variable is binary, i.e. takes the form of presence/absence data (McCullagh and Nelder 1989, Collett 1991). It works with log(odds) and takes the form:

Logit (p) = log(p/1-p) = Constant + effect of each environmental variable

+ effect due to each of the other variables

+ possible interactions between variables

where p is the expected probability of occurrence.

The probability of *Presence of pigs* must exist within the range zero to one, and as such the model uses the logit link. As fitted values are antilogits, the transformation to logits ensures that these values can never be less than zero or greater than one. As observed or predicted probabilities approach zero or one, the corresponding logit transformation approaches large negative or positive values respectively (Nicholls and Cunningham 1995).

The variance function is assumed to be defined by Binomial distribution. Estimation is by iterative reweighted least squares. Binomial distribution generally provides a good approximation to the distribution of binary data. As such, an estimate of the scale parameter is not needed; it can be set to one because the variance depends only on p (R.B. Cunningham pers. comm.2002).

When random effects are included, Generalised Linear Mixed Modelling (GLMM) is required. GLMM uses a mixture of iterative reweighted least squares and Restricted Maximum Likelihood (REML) for estimation. Iterative reweighted least squares estimates the effects (fixed) of explanatory variables and REML estimates the random effects and components of variance in a mixed model. While simple r^2 statistics are not applicable to these models, the slope of the line and the spread of the data and p-value all provide information on the goodness of fit for these models.

Initially, *site* was included as an explanatory variable in the model *Presence of pigs*. This was a *site* specific analysis with *site* as a fixed effect to account for the spatial distribution of the pigs. Each of the six explanatory variables was also modelled without the effect of *site* using logistic regression to determine which affected the response variable *Presence of pigs*. The patterns of response were then confirmed with the inclusion of *site* using GLMM to account for the dependence of the data. This involved repeating the six models where *site* was included as a random effect and each of the covariates as fixed effects. Unless stated in the results, the same inferences were found in the GLMM. The 'best model' was then obtained by fitting all of the covariates (excluding *site*) in a logistic model. Terms were excluded from the model in turn until all remaining terms were statistically significant (usually p=0.05). This model was then refitted to include *site* as the random effect using GLMM to ensure that the model was still valid when the effect of *site* was accounted for.

4.2.6 Modelling response variables *Pig activity indices [1]* and *[2]* using a Generalised Linear Mixed Model approach

A mixed model approach was used to further examine which explanatory variables may affect the occurrence of pig signs as represented by *Pig activity indices [1]* and *[2]*. The pig activity indices were each used as response variables in these models and variations between *site* and between *plot ID within site* became the random effect and each of the explanatory variables in turn became the fixed effect. Estimation is by iterative reweighted least squares and REML.

Mixed model structure

Response variable = Constant + Fixed effects (explanatory variables)

+ Random *site* effect

+ Random plot (within *site*) effect

Then all significant variables were combined in a single 'best fit' model to determine which were most significant in explaining variation in the response variables.

4.2.7 Modelling response variable *Fresh digging* combining data across all seasons.

The modelling of *fresh diggings* was a two-stage analysis. The first stage modelled the presence of *fresh diggings* in a plot across all seasons. Because this analysis was done combining all data, the covariate-season interaction (i.e. whether the effect of the explanatory variables on the probability of *fresh diggings* varies with season) may be important. This was examined for significance using logistic regression with the site-season interaction as fixed effects. If there was no interaction with season, the effect on the presence of *fresh diggings* was the same across seasons. Those covariates with a significant effect on the probability of *fresh diggings* were then analysed using GLMM to confirm that the effect was still significant when the structure of the data was accounted for (*plot* was a random term to account for the 'repeated measures' nature of the data and the covariate or covariate-season interactions were the fixed term in the model).

The second stage modelled the *abundance of fresh diggings* by analysing the log(abundance) of *fresh diggings*. The *abundance of fresh diggings* is defined as the % area of fresh diggings, hereafter referred to as abundance. This analysis used REML as the method for estimating covariate effect on the *abundance of fresh diggings*. This analysis was conditional on the presence of *fresh diggings* and so the effects of covariates must be considered concurrently with the Stage 1 analysis. As for Stage 1, if there was no covariate.season interaction, the effect on the log(abundance) of *diggings* was the same across seasons, given *fresh diggings* were present.

4.3 Results

4.3.1 Response variable *Presence of pigs*- late dry season

Three of the nine sites were excluded from this analysis: Dhabila and Mangurr, because pigs were present in all plots within these sites, and Mangbirri because after removal of one of the plots from this site that had undue influence on the regression model, pigs were then present in all plots in this site. There was a significant difference in the probability of *Presence of pigs*, which can be explained by the *site* variable ($p<0.001$) as shown in Figure 4.1. The probability of occurrence of pigs was over 77% in all sites except Milbirim (probability = 47.37%).

Evidence showed that pigs were found more often on footslopes and floodplains than on the drainage floor or upslope positions (Figure 4.2). This pattern of *Presence of pigs* on the various *slope positions* remained the same when *site* was included in the model as a random effect.

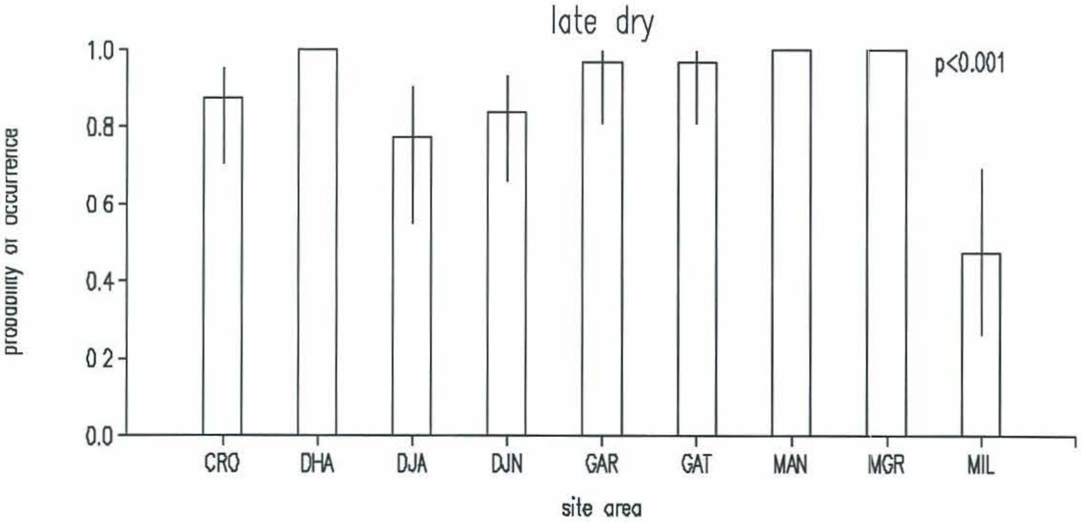


Figure 4.1: Probability of *Presence of pigs* at each site in the late dry season showing p-value and 95% confidence intervals.

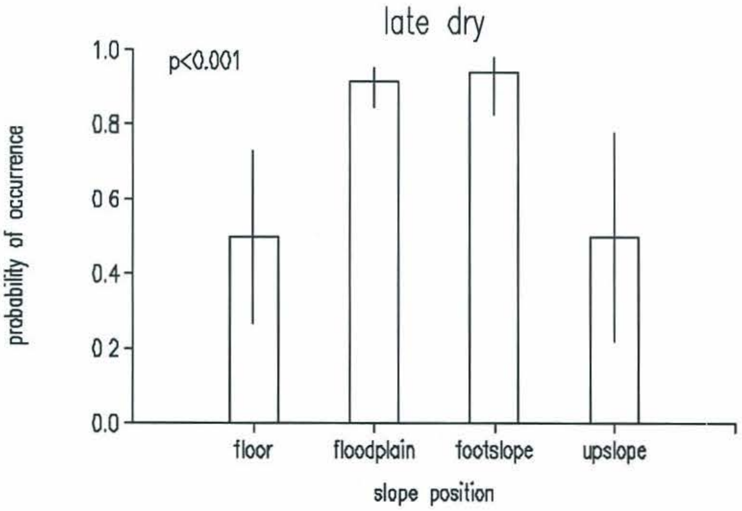


Figure 4.2: Probability of *Presence of pigs* at each slope position in the late dry season showing p-value and 95% confidence intervals.

4.3.2 Response variable *Presence of pigs* - wet season

Five sites were excluded from this analysis: Gatji and Mangbirri because pigs were always present; and Crossing, Dhabila and Mangurr because pigs were not found there at all during the wet season (because large areas of these sites were underwater and/or inaccessible during the wet season and hence could not be surveyed). In the remaining four sites the probability of occurrence of pig sign was greatest at Djanyirrbirri and Garanydjirr (Figure 4.3). No differences were found in the probability of *Presence of pigs* between the different vegetation classes. Pigs were more likely to be found on footslope positions in the wet season and to a lesser extent on floodplains (Figure 4.4). They were also most likely to occur on sandy soils and least likely to be found on clay loam soils (Figure 4.5). This pattern of use changed slightly when *site* was included as a random effect rather than a fixed effect in the model (the GLMM analysis – details not presented here) such that pigs were least likely to occur on silt soils. *Presence of pigs* decreased as *% vegetation cover* increased (detail is not shown in graphical form for this variable). The probability of *Presence of pigs* also increased with increasing *distance to water* (detail is not shown in graphical form for this variable). When all variables were combined in a 'best fit' model, *slope position, soil type and % vegetation cover* were retained as significant terms

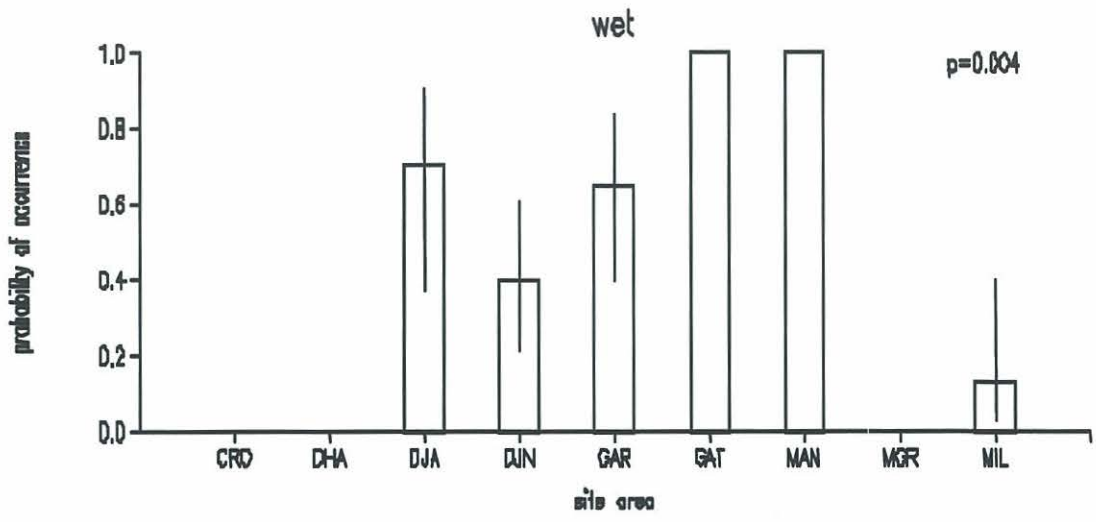


Figure 4.3: Probability of *Presence of pigs* at each site in the wet season showing p-value and 95% confidence intervals.

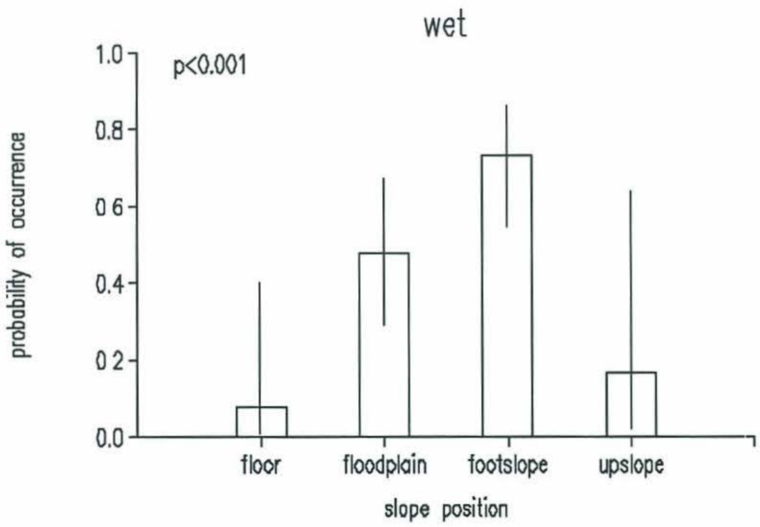


Figure 4.4: Probability of *Presence of pigs* at each slope position in the wet season showing p-value and 95% confidence intervals.

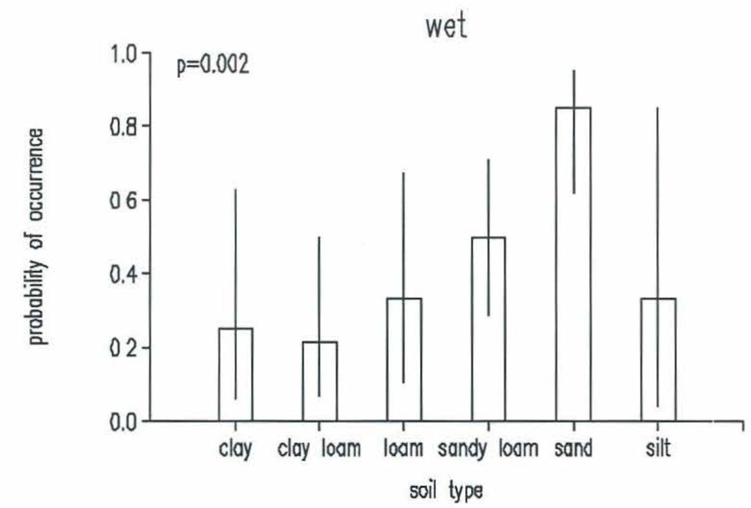


Figure 4.5: Probability of *Presence of pigs* at each soil type in the wet season showing p-value and 95% confidence intervals.

4.3.3 Response variable *Presence of pigs* - early dry season

Six sites were included in this analysis. Dhabila and Mangbirri were excluded, as pigs were always present in these sites in the early dry season. Mangurr was also excluded, as it was inaccessible due to floodwaters. Figure 4.6 shows that pigs were most likely to occur at Gatji, Garanydjirr and Crossing than at other sites. Pigs also preferred footslope and floodplain *slope positions* in the early dry season (Figure 4.7). Pigs were more likely to occur on sand than other *soil types* and least likely to occur on loam soils (Figure 4.8). When the effect of *site* was included in the model as a random effect, the lowest probability of *Presence of pigs* occurred on clay soils (detail is not shown in graphical form for this variable). The probability of occurrence of pig sign decreased as *% vegetation cover* increased (detail is not shown in graphical form for this variable). When the covariates were all included in a 'best fit' model *slope position, soil type* and *% vegetation cover* were significant in explaining variation in *Presence of pigs.*

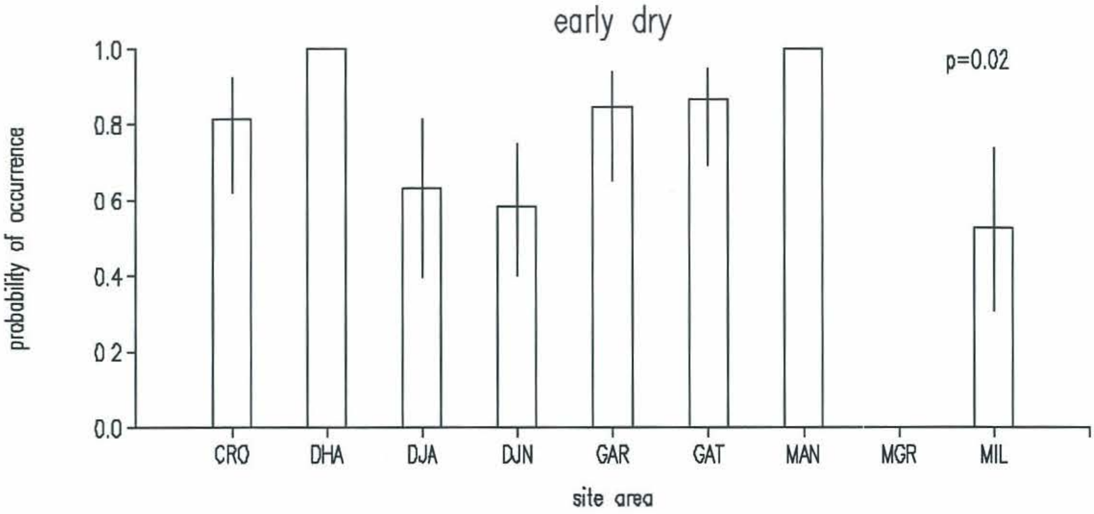


Figure 4.6: Probability of *Presence of pigs* at each site in the early dry season showing p-value and 95% confidence intervals.

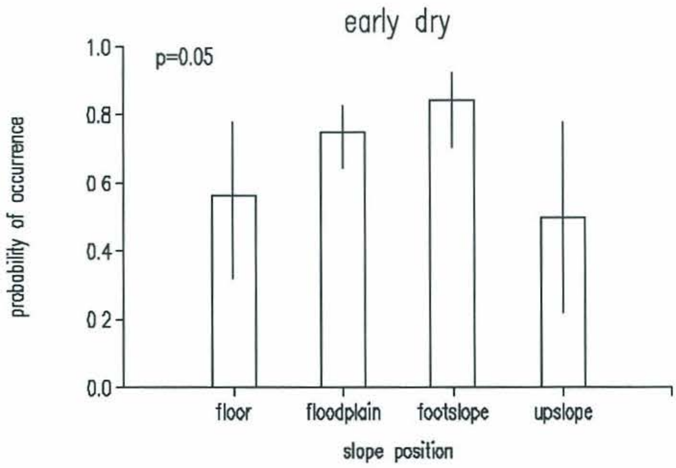


Figure 4.7: Probability of *Presence of pigs* at each slope position in the early dry season showing p-value and 95% confidence intervals.

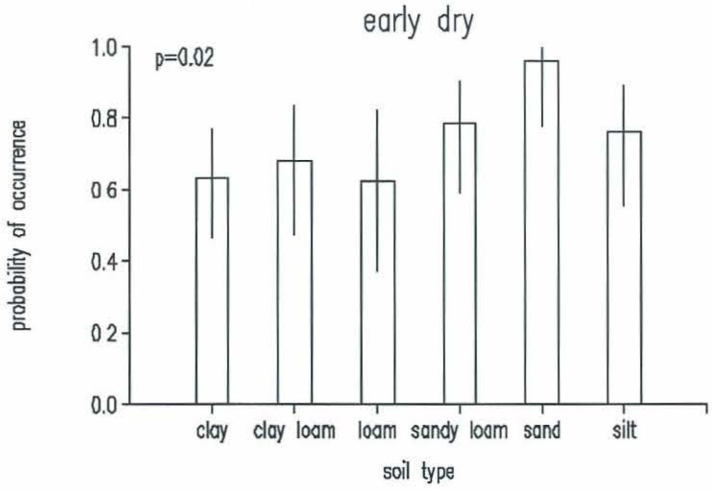


Figure 4.8: Probability of *Presence of pigs* at each soil type in the early dry season showing p-value and 95% confidence intervals.

4.3.4 Response variable *Presence of pigs* - mid dry season

The sites Dhabila, Mangbirri and Mangurr were excluded from the mid dry season analysis because pigs were always present. Evidence showed that of the six sites included in the model, pigs were most likely to occur at Garanydjirr and least likely to occur at Milbirim (Figure 4.9). Pigs also showed preference for certain *vegetation classes*, with the highest probability of occurrence being in pandanus and the least being in sedge (Figure 4.10). Figure 4.11 shows that footslopes and floodplains were the *slope positions* on which probability of occurrence of pigs was greatest. *Slope position* was the only significant explanatory variable retained in the 'best fit' model.

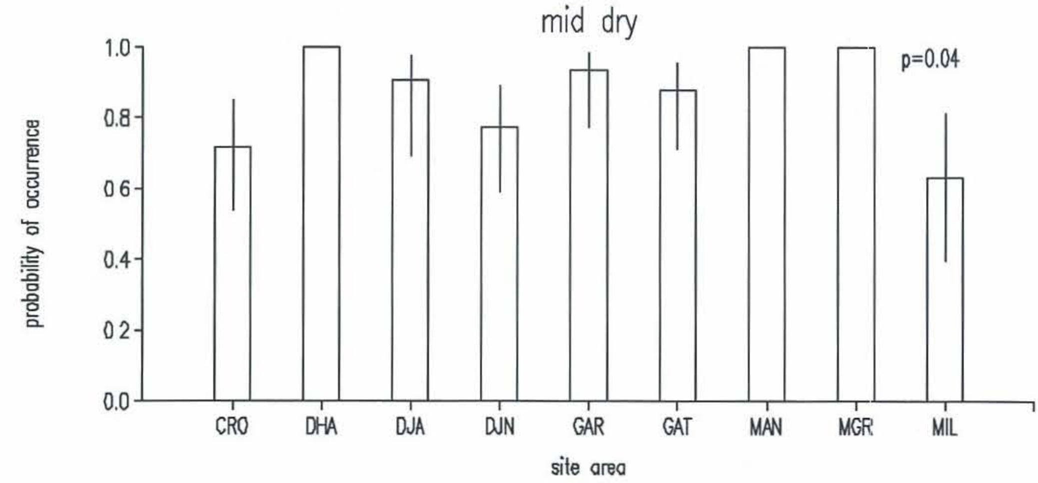


Figure 4.9: Probability of *Presence of pigs* at each site in the mid dry season showing p-value and 95% confidence intervals.

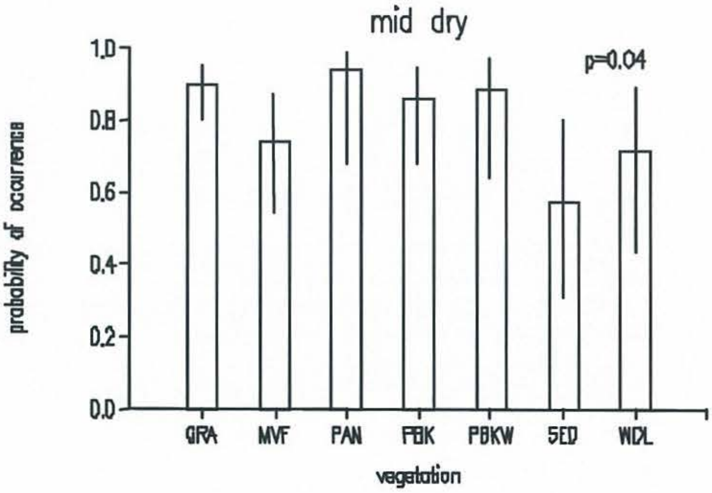


Figure 4.10: Probability of *Presence of pigs* at each vegetation class in the mid dry season showing p-value and 95% confidence intervals.

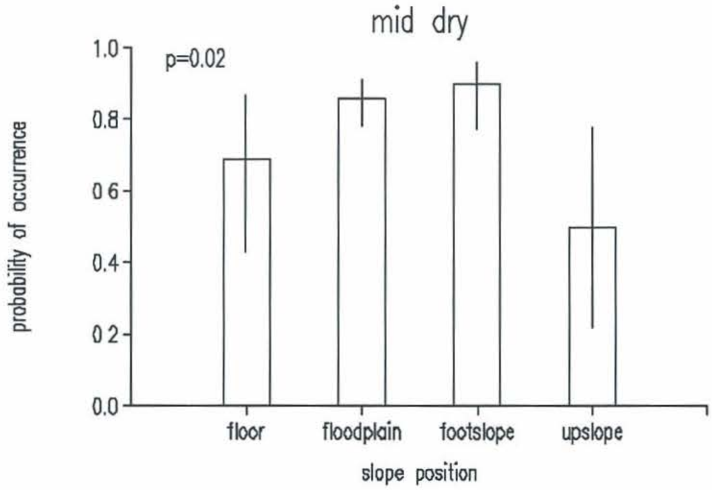


Figure 4.11: Probability of *Presence of pigs* at each slope position in the mid dry season showing p-value and 95% confidence intervals.

4.3.5 Summary of results for response variable *Presence of pigs*

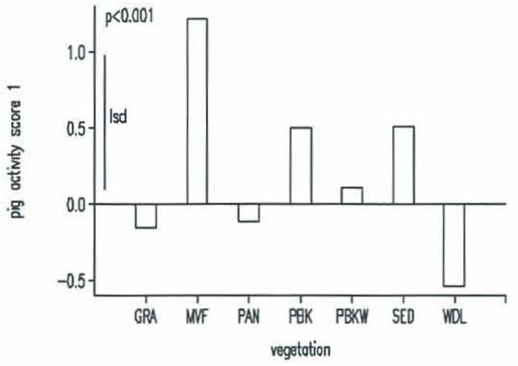
The models for each season are collated and summarised in Table 4.2 (p.183). In all seasons, the probability of *Presence of pigs* was higher on footslopes and floodplains. In the drier seasons (late dry and mid dry), *slope position* was the only significant explanatory variable. In the wetter seasons (wet and early dry), *soil type* and *% vegetation cover* also helped to explain variation in the probability of *Presence of pigs.* Pigs were more likely to be found on sandy soils and least likely to occur on clays and silts. Pigs were also more likely to be found in areas of lower *% vegetation cover* in the wetter seasons.

4.3.6 Response variable *Pig activity index [1]* –late dry season

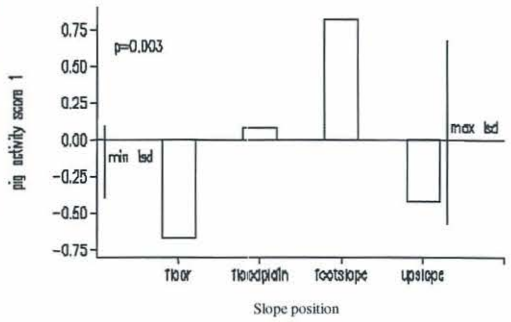
The variables that were statistically significant in explaining variation in the response variable *Pig activity index [1]* (*PAI1*) for the late dry season were *vegetation class*, *slope position*, *vegetation cover* and *distance to shelter* as shown in Figure 4.12. A very high level of activity (as represented by *PAI1*) occurred in monsoon forest plots. Paperbark and sedge plots also showed a high level of activity. Little or no activity occurred in woodland plots. *PAI1* was greatest on footslope positions and was very low on drainage floor positions. Activity was also higher in plots with very low *% vegetation cover* and decreased as *% vegetation cover* increased. There was a non-linear relationship between *PAI1* and '*distance to shelter*' with activity decreasing from Category 0 (0m) – Category 3 (100-500m) and then increasing again as *distance to shelter* became greater. The line through the *distance to shelter* graphs does not imply that the trend is linear over increasing logarithmic distance classes but simply makes trends easier to visualise with the line present. There was no evidence of a significant difference in activity in different *soil types* or at different *distance to water* categories.

The 'best fit' model showed that variation in *Pig activity index [1]* is explained by three variables, *vegetation class*, *slope position* and *% vegetation cover*.

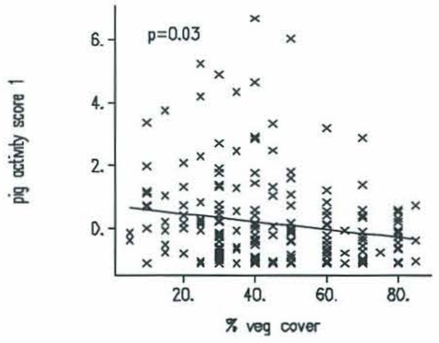
Vegetation class (showing lsd =2x average s.e.d).



Slope position (showing min and max lsd = 2x average s.e.d).



% vegetation cover



Distance to shelter

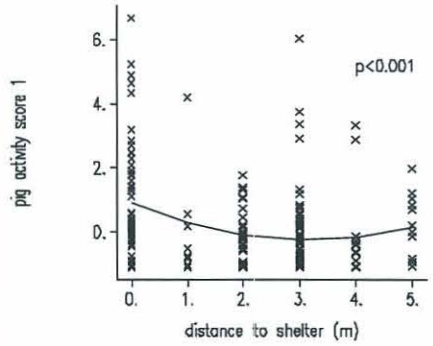


Figure 4.12: Covariates that were significant in explaining variation in *Pig activity index [1]* in the late dry season.

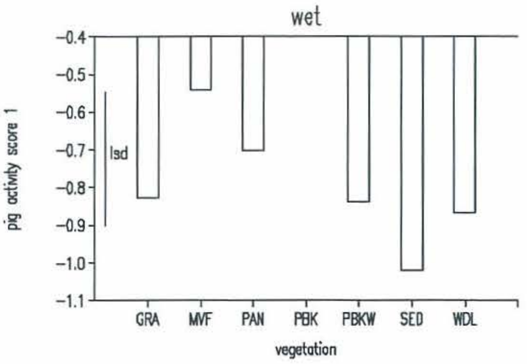
4.3.7 Response variable *Pig activity index [1]* – wet season

In the wet season all six variables were significant (although some only weakly so) in explaining variation in *pig activity index [1]* as shown in Figure 4.13. As many plots were not surveyed in the wet season the distributional properties of the data are not ideal, and these results should be interpreted with caution.

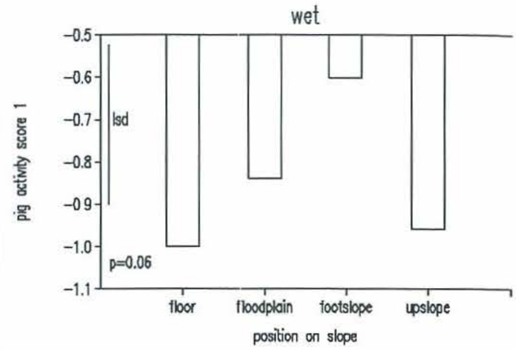
There was strong evidence of a decrease in *PAI1* as *% vegetation cover* increased. Significant variation in activity levels occurred in different *soil type*s was recorded with the highest levels of activity occurring in sand soils and little or no activity occurring in clay loam, loam and sandy loam soils. *PAI1* increased linearly as *distance to water* increased (detail is not shown in graphical form for this variable). There was weak evidence of a negative linear relationship between *distance to shelter* and activity (detail is not shown in graphical form for this variable), i.e. more pig activity was recorded closer to shelter. Evidence for variation in *PAI1* across *slope position* was also weak but showed that most activity was on the footslope and floodplain positions, and little or no activity occurred on the upslope or drainage floor positions. *PAI1* showed weakly significant variation among *vegetation classes*. Most pig activity occurred in monsoon forest plots and least activity occurred in sedge plots.

The combined model reduces to *% vegetation cover* as the 'best' explanatory variable for *Pig activity index [1]* in the wet season.

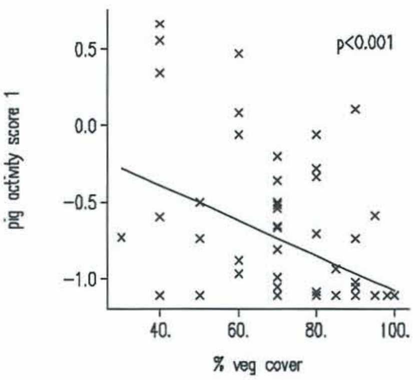
Vegetation class (showing lsd = 2x average s.e.d).



Slope position (showing lsd = 2x average s.e.d).



% vegetation cover



Soil type (showing lsd = 2x average s.e.d).

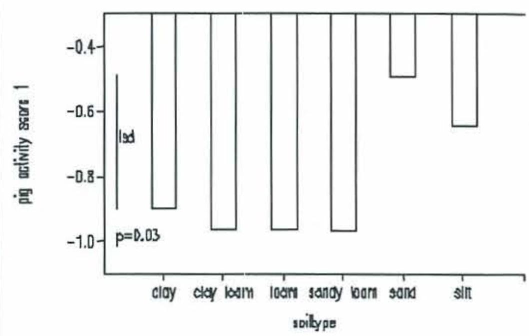


Figure 4.13: Covariates that were significant in explaining variation in *Pig activity index [1]* in the wet season.

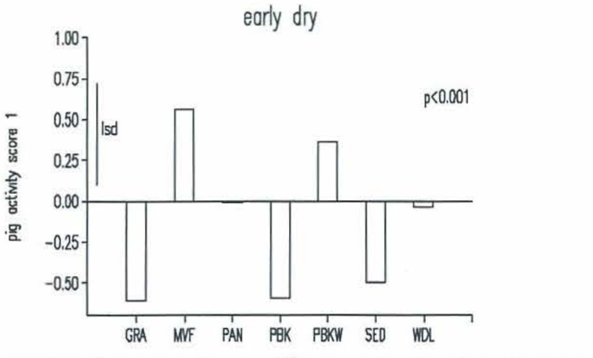
4.3.8 Response variable *Pig activity index [1]*– early dry season

In the early dry season all six variables were significant in explaining variation in *Pig activity index [1]* as shown in Figure 4.14. Again, in this season, there were many plots with no pig activity, and as such the distributional properties of the data are not ideal and the results must be interpreted with caution.

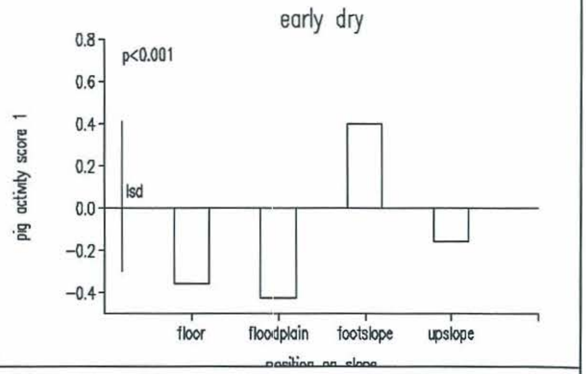
Pig activity index [1] decreased strongly and significantly with increasing *% vegetation cover* and *distance to shelter*. There was also strong evidence of a non-linear relationship between *distance to water* and *PAI1*. *Pig activity index [1]* increased as *distance to water* increased to category 2 (1-49 m). At distances to water greater than 100m (categories 3-5), *Pig activity index [1]* decreased and was at its lowest when furthest from water. Pig activity was highest on footslope positions and lowest on drainage floor and floodplain positions. Sandy loam soil had the most pig activity and clay soils had the least. *PAI1* was greatest in monsoon forest and paperbark woodland plots at this time of year. The plots with the least amount of activity were in the *vegetation classes* sedge, paperbark and grassland.

When all variables were combined in the 'best fit ' model the variables responsible for variation in *PAI1* in the early dry season were *soil type*, *distance to water* and *% vegetation cover*.

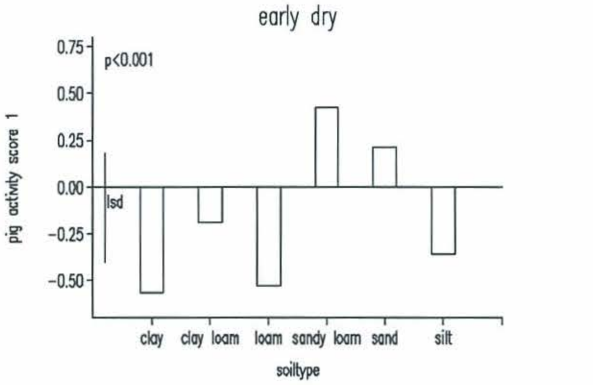
Vegetation class (showing lsd = 2x average s.e.d).



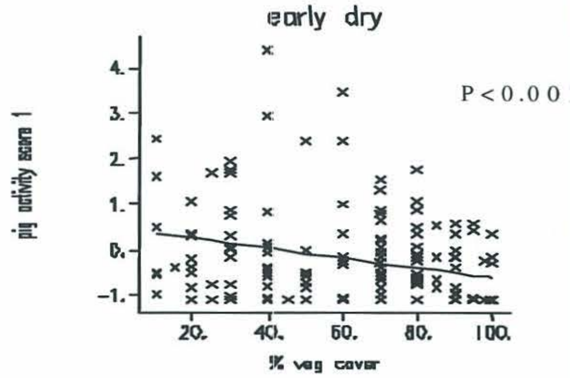
Slope position (showing lsd = 2x average s.e.d).



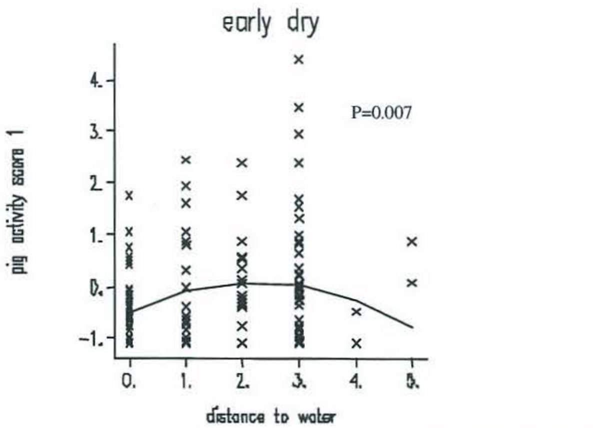
Soil type (showing lsd = 2x average s.e.d).



% vegetation cover



Distance to water



Distance to shelter

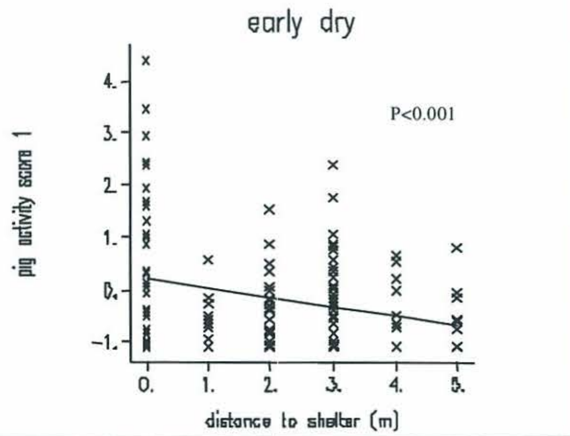


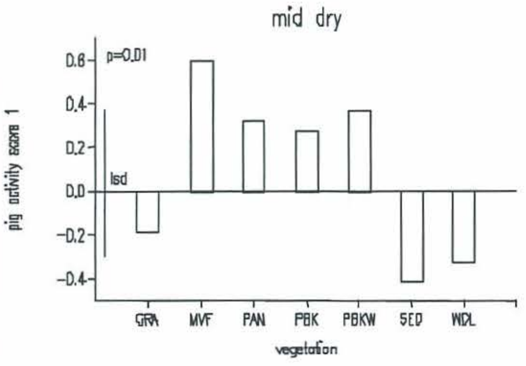
Figure 4.14: Covariates that were significant in explaining variation in *Pig activity index [1]* in the early dry season.

4.3.9 Response variable *Pig activity index [1]* – mid dry season

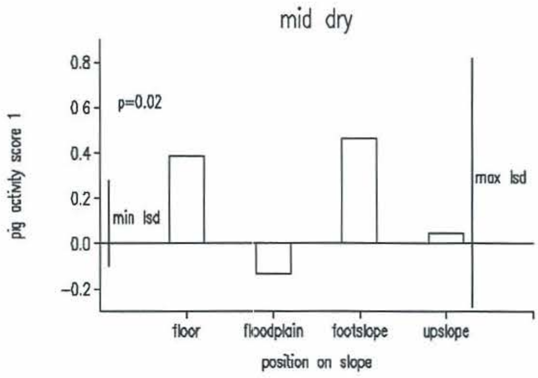
In mid dry season, *Pig activity index [1]* showed significant relationships with all explanatory variables except *% vegetation cover* (Figure 4.15). The strongest relationship was with *distance to shelter* with PAI1 being greatest closest to shelter. Similarly, PAI1 was greatest closest to water. Plots in monsoon forests had the most pig activity followed by plots in paperbark woodland, pandanus and paperbark, which had more pig activity than was found in the remaining vegetation classes. Plots positioned on footslopes had the highest activity and those on drainage floors showed a little less activity. *Pig activity index [1]* was lowest on floodplain positions. *Soil type* was weakly significant in explaining variation in *PAI1* with sand and loam soils having the highest pig activity and silt having the lowest pig activity.

The 'best fit' model included *distance to water* and *distance to shelter.*

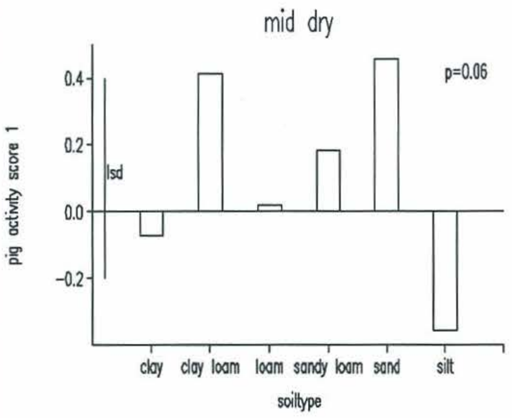
Vegetation class (showing lsd = 2x average s.e.d).



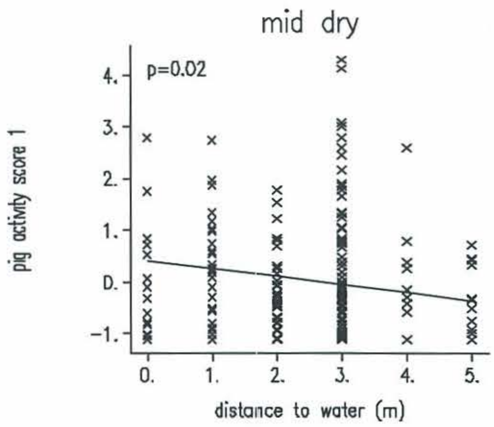
Slope position (showing min and max lsd = 2x average s.e.d).



Soil type



Distance to water



Distance to shelter

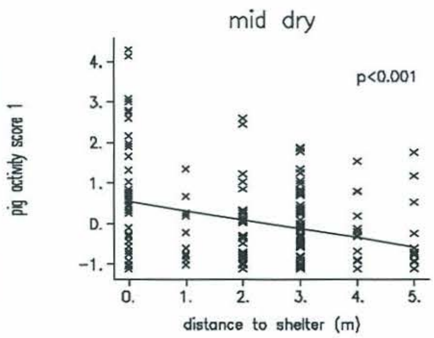


Figure 4.15: Covariates that were significant in explaining variation in *Pig activity index [1]* in the mid dry season.

4.3.10 Summary of results for *Pig activity index [1]*

The seasonal models are collated and summarised in Table 4.2 (p.183). In the late dry, wet and early dry seasons, pig activity (as represented by *PAI1*) was highest where *% vegetation cover* was low and decreased as *% vegetation cover* increased. *% vegetation cover* was not of any significance in the mid dry season. Pig activity was greatest on footslope positions and in monsoon forest vegetation in all seasons. In the late dry season, *PAI1* was greatest both very close to and very far from shelter. In all other seasons, pig activity was highest when close to shelter. There was seasonal variation in the response of *PAI1* to various d*istances to water*. In the wet season, activity (*PAI1*) is greatest furthest from water, while in the mid dry season activity is greatest close to water.

4.3.11 Response variable *Pig activity index [2]* – late dry season

All explanatory variables were significant in explaining variation in *Pig activity index [2]* in the late dry season (Figure 4.16). *Diggings* were significantly more prevalent in grassland and sedge plots and there were more *restplaces* in monsoon forest, paperbark woodland and woodland plots. More *diggings* occurred on floodplains and more *restplaces* on the drainage floor, footslope and upslope positions. As *distance to water* increased, more *restplaces* and fewer *diggings* occurred. The number of *restplaces* decreased as *distance to shelter* increased. Silt and clay soils contained more *diggings* than other *soil type*s and sand and loam based soils contained more *restplaces*. The response to *% vegetation cover* was non-linear and showed an increase in *PAI2* (i.e. an increase in *restplaces*) as *% vegetation cover* increased to around 50%. Above this, more equal amounts of *digging* and *restplaces* occurred.

The 'best fit' model for *PAI2* included two variables, *% vegetation cover* and *distance to shelter*.

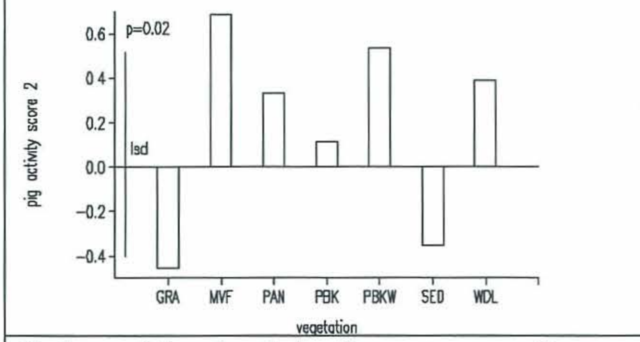
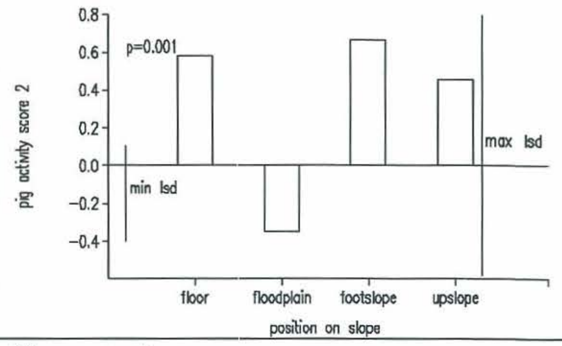
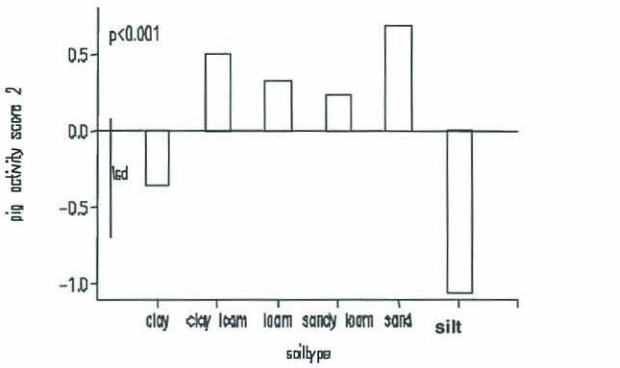
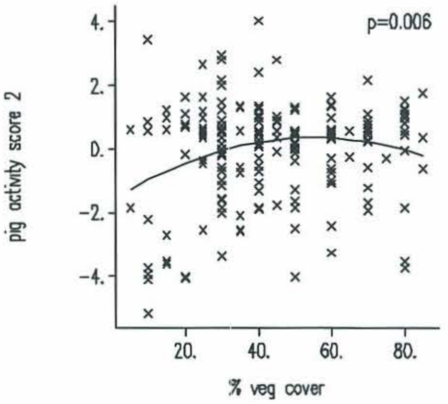
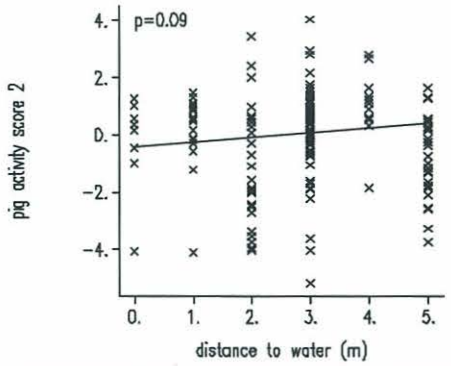
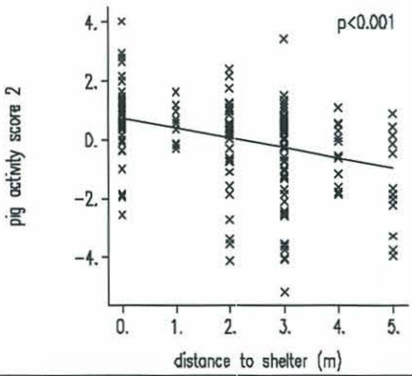
Vegetation class (showing lsd = 2x average s.e.d). 	*Slope position* (showing min and max lsd = 2x average s.e.d). 
Soil type (showing lsd = 2x average s.e.d). 	*% vegetation cover* 
Distance to water 	*Distance to shelter* 

Figure 4.16: Covariates that were significant in explaining variation in *Pig activity index [2]* in the late dry season.

4.3.12 Response variable *Pig activity index [2]* – wet season

This index was weakly associated with *% vegetation cover* in the wet season. Figure 4.17 shows a linear increase in *Pig activity index [2]* as *% vegetation cover* increased i.e. there were more *restplaces* and less *diggings* as *% vegetation cover* increased.

% vegetation cover was the only term included in the best fit model for *PAI2* in the wet season.

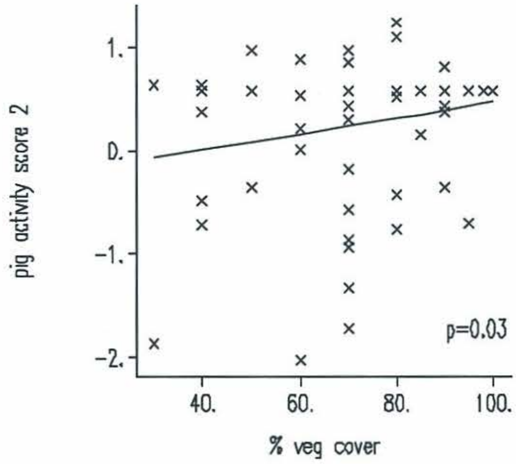


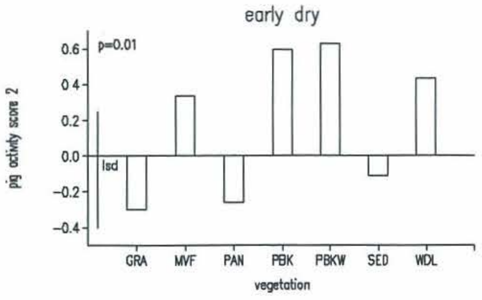
Figure 4.17: ***Pig activity index [2]*** **at each** ***% vegetation cover*** **class in the wet season showing p-value.**

4.3.13 Response variable *Pig activity index [2]* – early dry season

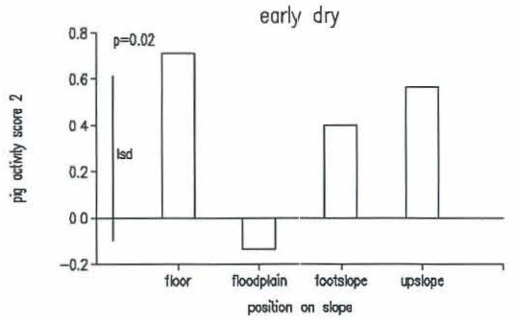
All variables except *distance to water* were significant in explaining variation in *Pig activity index [2]* in the early dry season as shown in Figure 4.18. More *diggings* were found in grassland and pandanus plots and more *restplaces* occurred in paperbark and paperbark woodland plots. *Digging* was the main type of activity in plots located on floodplains and more *restplaces* occurred in the other *slope positions*. There was evidence of a non-linear response to *distance to shelter* which showed more *restplaces* close to and far from shelter but less in the mid range distances. There was also weak evidence for a non-linear response to *% vegetation cover,* but this relationship is not informative and will not be discussed further. Weak evidence suggested that more *diggings* occurred in 'silt' than in other *soil type*s.

The 'best fit' model showed that variation in *Pig activity index [2]* could be explained by two variables, *% vegetation cover* and *vegetation class.* While *% vegetation cover* shows a curvilinear response that is statistically significant, the relationship does not have a great deal of predictive power in a practical sense as prediction inference is more difficult than explanation. Relationships need to be very strong with high precision for accurate predictions.

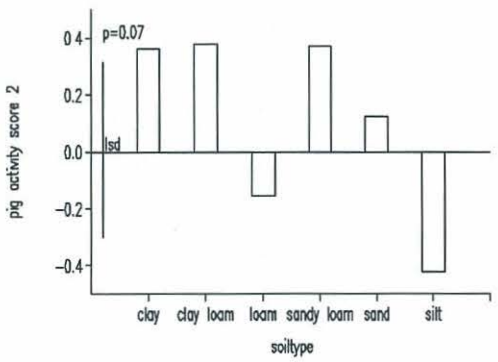
Vegetation class (showing lsd = 2x average s.e.d).



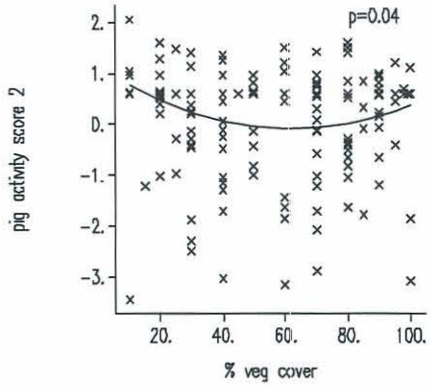
Slope position (showing lsd = 2x average s.e.d).



Soil type (showing lsd = 2x average s.e.d).



% vegetation cover



Distance to shelter

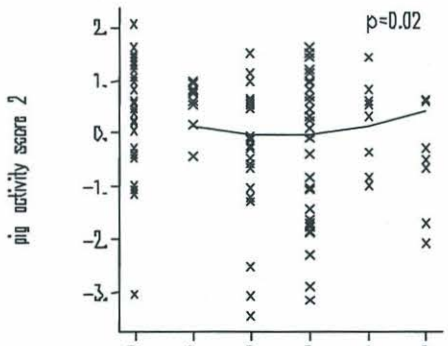


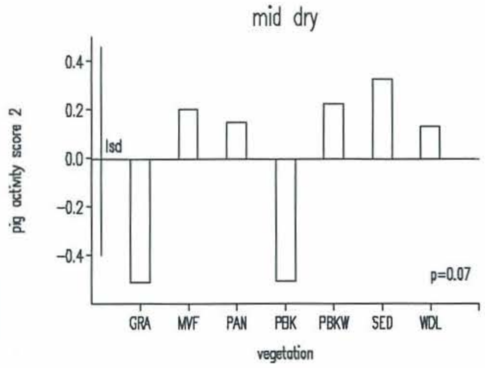
Figure 4.18: Covariates that were significant in explaining variation in *Pig activity index [2]* in the early dry season.

4.3.14 Response variable *Pig activity index [2]* – mid dry season

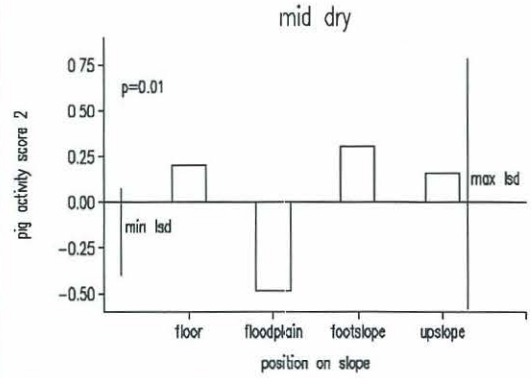
All explanatory variables were significant in explaining variation in *Pig activity index [2]* in the mid dry season as shown in Figure 4.19. More *diggings* occurred on floodplains and in clay soils. There were more *restplaces* recorded as *distance to water* increased. At distances below 100m (category 2) there were more *diggings*, at distances between 100-500m there were more equal amounts of *digging* and *restplaces* and above 500m *restplaces* were marginally more common. The *distance to shelter* variable also showed a significant negative relationship to *PAI2* with more *diggings* occurring as *distance to shelter* increased and more *restplaces* as *distance to shelter* decreased. *Vegetation class* and *% vegetation cover* both showed a weak relationship to *PAI2*. Grassland and paperbark plots contained more *diggings* than the other *vegetation classes* and *restplaces* were found to increase as *% vegetation cover* increased.

The variables that were significant in explaining variation in *Pig activity index [2]* in the 'best fit' model were *distance to water*, *distance to shelter* and *% vegetation cover*.

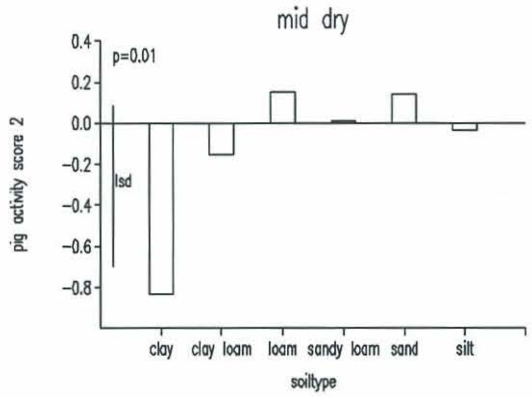
Vegetation class (showing lsd = 2x average s.e.d).



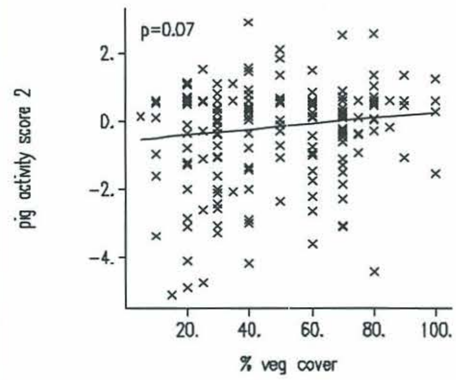
Slope position (showing min and max lsd = 2x average s.e.d).



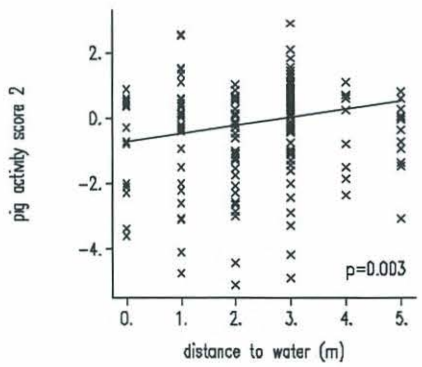
Soil type (showing lsd = 2x average s.e.d).



% vegetation cover



Distance to water



Distance to shelter

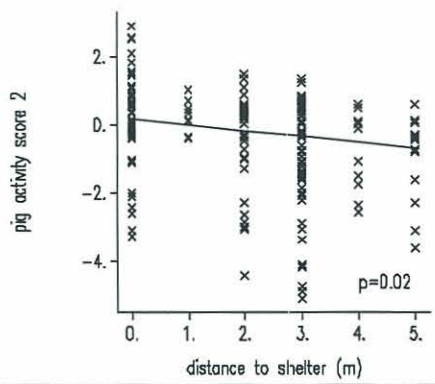


Figure 4.19: Covariates that were significant in explaining variation in *Pig activity index [2]* in the mid dry season.

4.3.15 Summary of results for *Pig activity index [2]*

The seasonal models for *PAI2* are summarised in Table 4.2. The response of *pig activity index [2]* to different *% vegetation cover* varied each season. Diggings were more common in grassland vegetation and on floodplains in all seasons except the wet season. Restplaces were found on footslopes in the drier seasons (late and mid dry) and on drainage floors in the early dry season. Diggings were recorded in both clay and silt soils, and restplaces in sand or loam based soils in all seasons except the wet season. In the drier seasons, more diggings were recorded close to water and more restplaces were recorded close to shelter.

4.3.16 Results for response variable '*Fresh diggings – presence and conditional abundance*'

4.3.16.1 Stage 1 – Modelling the presence of *fresh diggings* across all seasons

All covariates except *soil type* were significant in explaining variation in the probability of '*fresh diggings*' across seasons. The probability of presence of *fresh diggings* was lowest in the late dry season and highest in the mid dry season (Figure 4.20). There were significant differences between the probability of *fresh diggings* between seasons and sites. At most sites the probability of *fresh diggings* was greatest in the mid dry season, but at Dhabila and Djapidingorin *fresh diggings* were most likely to be found in the early dry season and at Gatji and Djanyirrbirri in the wet season (Figure 4.21).

The effect of *vegetation class* on the probability of '*fresh diggings*' varied among seasons (Figure 4.22). There was no occurrence of *fresh diggings* in the late dry season in woodlands or paperbark woodlands, nor in the wet season in paperbark, hence these were excluded from this model. In the late dry season, the highest probability of *fresh diggings* occurred in paperbark. Woodland and monsoon forest vegetation had the highest probability of presence of *fresh diggings* in the wet season. In the early dry season, paperbark woodland, monocot, monsoon forest and pandanus vegetation had the highest probabilities of *fresh diggings*. Paperbark and monocot vegetation had the highest probabilities of presence of *fresh diggings* in the mid dry season.

Slope position had a significant effect on the probability of *fresh diggings*, which also varied with season as shown in Figure 4.23. No *fresh diggings* were recorded in the upslope category in the late dry season so this was excluded from the analysis. In all other seasons the probability of *fresh diggings* occurring on an upslope position was low. The probability of *fresh diggings* in the late dry season was also low in all other *slope positions*. In the wet season, the probability of *fresh diggings* was more than twice as high on footslopes than in any other *slope position*. In the early dry season the probability of *fresh digging* was highest both on footslopes and floodplains. Floodplains and drainage floors had the highest probability of *fresh diggings* in the mid dry season.

The effect of *% vegetation cover* on *fresh diggings* was consistent across seasons and as such season and *% vegetation cover* were fitted as additive fixed terms to the model. *% vegetation cover* had a significant effect on the probability of *fresh diggings* as shown in Figure 4.24. The highest probability of *fresh diggings* occurred in the 20-30% *vegetation cover* category and the lowest occurred where vegetation cover was greater than 90%.

The interaction between season and *distance to water* was also significant in explaining variation in the probability of occurrence of *fresh diggings*. The probability of *fresh diggings* decreased as *distance to water* increased in all seasons except the wet season. In the wet season the probability of *fresh diggings* increased with increasing *distance to water* (detail is not shown in graphical form for this variable).

The effect of *distance to shelter* on the probability of *fresh diggings* varied each season (Figure 4.25). The relationship between the probability of *fresh diggings* and *distance to shelter* each season was non-linear. There was no occurrence of *fresh diggings* in the late dry season in *distance to shelter* classes 1 and 4, or in the wet season in class 5 so these were excluded from the model. In the late dry, early dry and mid dry seasons the probability of *fresh diggings* was highest in category 5 (furthest distance from shelter – more than 1000 m). The probability of *fresh digging* was greatest in categories 2 (distance 1-49 m) and 0 (i.e. under shelter) in the wet season. In the mid dry season the probability of presence of *fresh diggings* was fairly even in each distance category except in category 5 where the probability was higher.

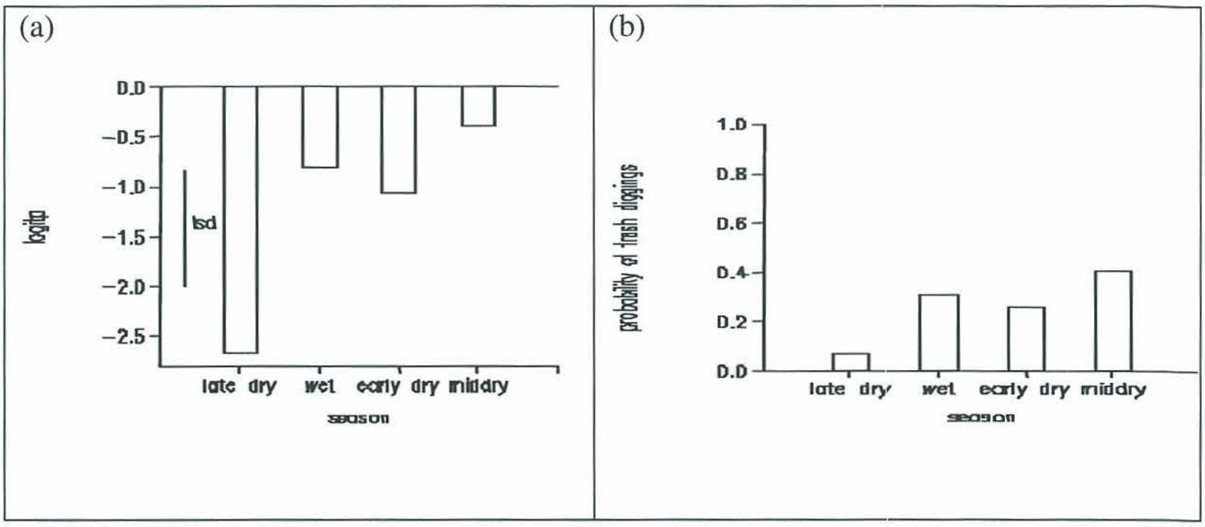


Figure 4.20: ***Fresh diggings*** **in each season showing (a) logit scale with lsd and (b) estimated probability.**

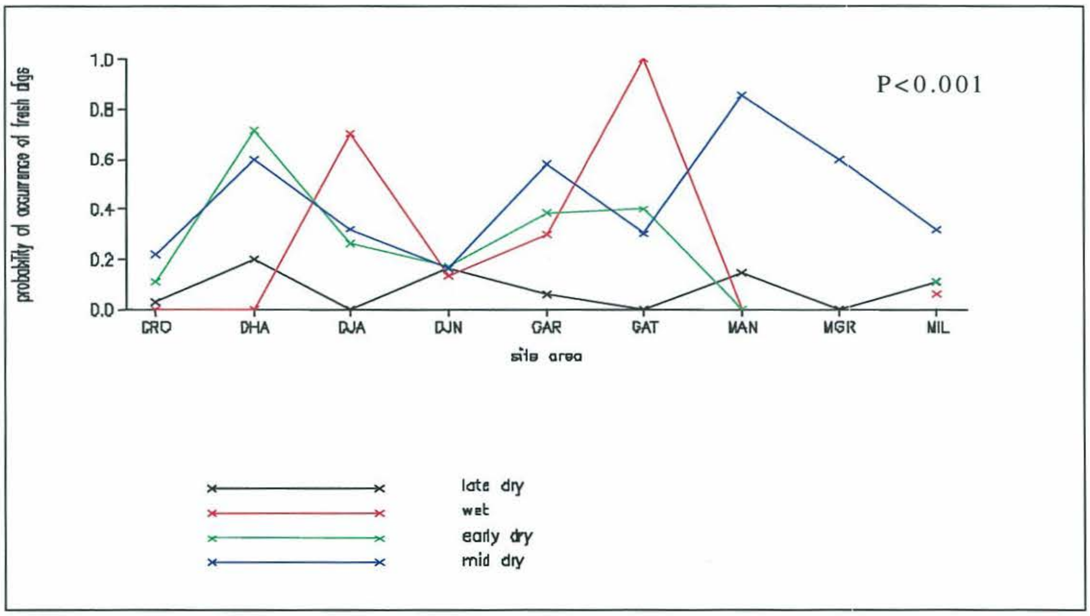


Figure 4.21: Estimated probability of ***fresh diggings*** **at each site.**

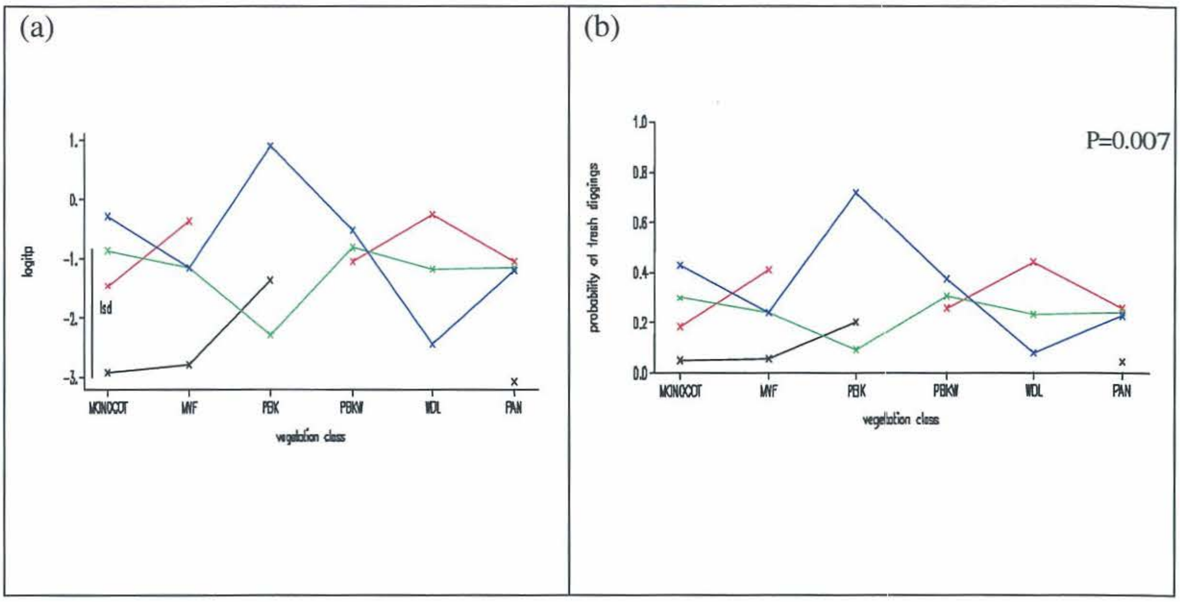


Figure 4.22: ***Fresh diggings*** **in each** ***vegetation class*** **showing (a) logit scale with lsd and (b) estimated probability.**
See Figure 4.21 for season legend.

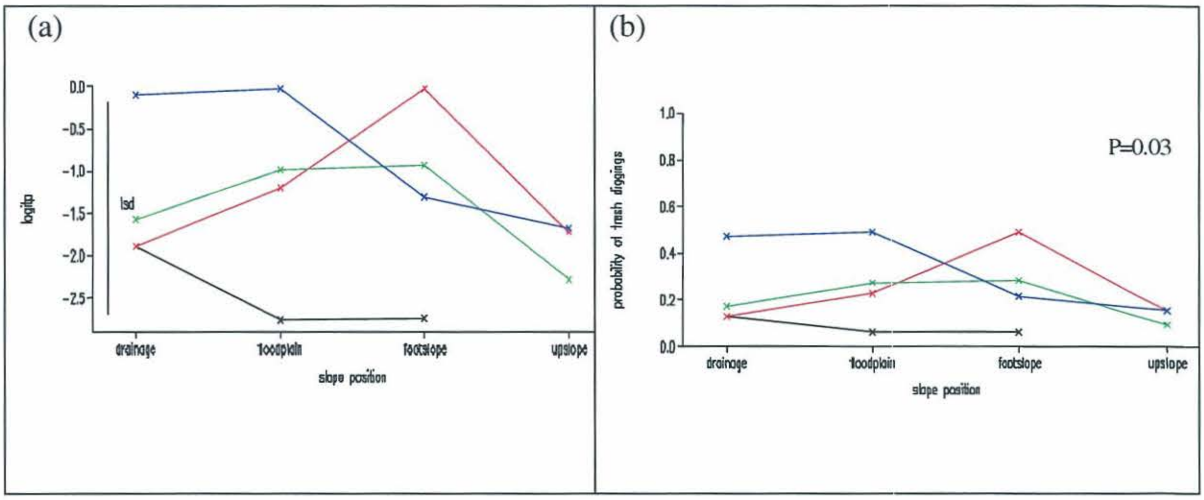


Figure 4.23: ***Fresh diggings*** **in each** ***slope position*** **showing (a) logit scale with lsd and (b) estimated probability.**
See Figure 4.21 for season legend.

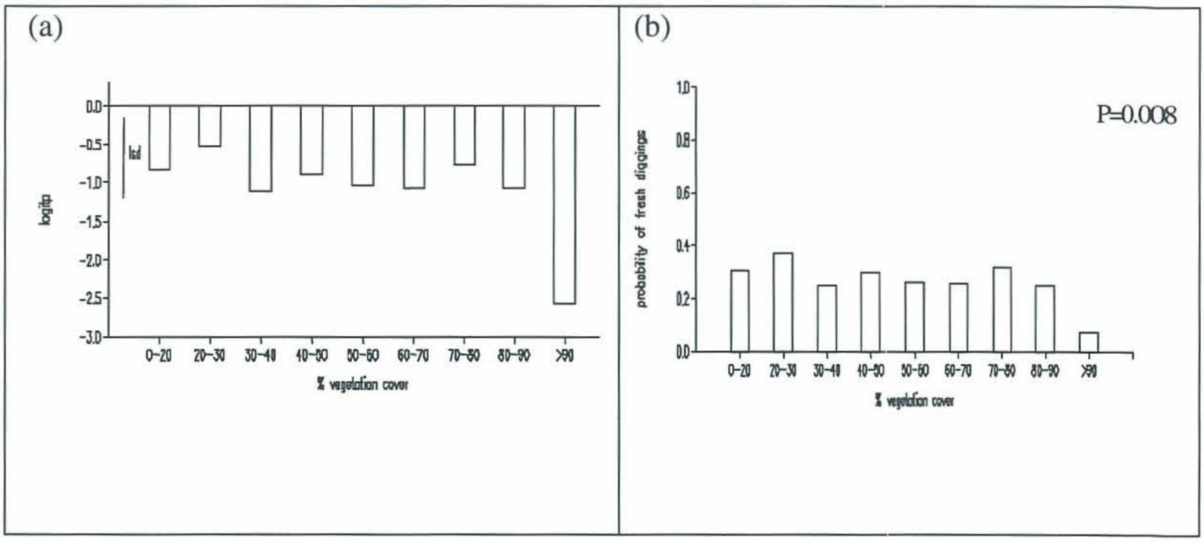


Figure 4.24: ***Fresh diggings*** **in each** ***% vegetation cover*** **class showing (a) logit scale with lsd and (b) estimated probability.**

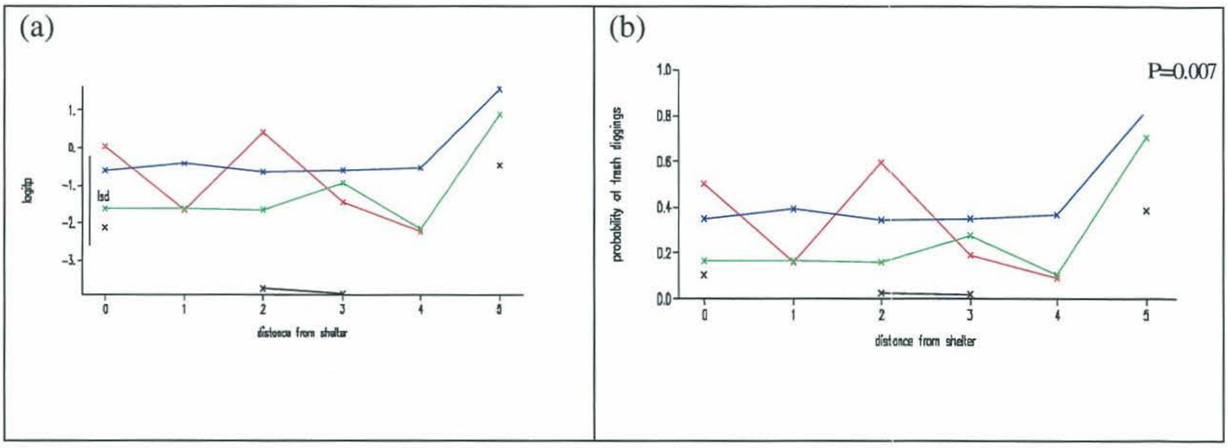


Figure 4.25: ***Fresh diggings*** **in each** ***distance to shelter*** **class showing (a) logit scale with lsd and (b) estimated probability.**
See Figure 4.21 for season legend.

4.3.16.2 Stage 2 – Modelling the conditional *abundance of fresh diggings*

All results obtained from modelling the *abundance of fresh diggings,* given evidence of the presence of fresh diggings, should be interpreted with caution due to imbalance in the number of observations included in each model. There was weak evidence of a seasonal effect on the *abundance of fresh diggings*. Figure 4.26 shows that the highest *abundance of fresh diggings* occurred in the mid dry season and the lowest occurred in the early dry season.

Vegetation class also had a weak effect on *abundance of fresh diggings* that varied each season (Figure 4.27). In the late dry season the highest *abundance of fresh diggings* was found in monocot and paperbark vegetation. Monsoon forest, pandanus and monocot vegetation had the highest *abundance of fresh diggings* in the wet season. In the early dry season, pandanus and monocot vegetation had the highest *abundance of fresh diggings* and in the mid dry season, monocot and paperbark vegetation had the highest *abundance of fresh diggings.*

Whilst *soil type* had no effect on the probability of occurrence of *fresh diggings*, it did affect conditional abundance (i.e. whilst occurrence of *fresh diggings* was based on other factors, once pigs were present they were preferentially *digging* in a particular *soil type*). This effect varied according to season as shown in Figure 4.28. In the late dry season, silt, clay loam and clay had the highest *abundance of fresh diggings.* The highest *abundance of fresh diggings* was found in the *soil types* silt and clay in the wet season, and clay loam, loam and silt in the early dry season. In the mid dry season the highest *abundance of fresh diggings* was found in clay soils.

The effect of *slope position* on *abundance of fresh diggings* was the same each season. The effect of season (adjusted for *slope position*) on the *abundance of fresh diggings* was weak but the effect of *slope position* (adjusted for season) on the *abundance of fresh diggings* was significant. If the seasonal effect was removed from the model, the effect of *slope position* was still significant and the results from this model are shown in Figure 4.29. The highest *abundance of fresh diggings* occurred in floodplain plots and the lowest in drainage floor plots. The data used in this analysis are unbalanced, with very uneven numbers of observations in each season and in each *slope position* category. The large error reflects the unbalanced nature of the data and this model should be interpreted with caution.

The effect of *distance to water* and *distance to shelter* on *abundance of fresh diggings* was also consistent across seasons. The effect of *distance to water* adjusted for season was weak and the effect of season adjusted for *distance to water* was also weak. The *abundance of fresh diggings* decreased as *distance to water* increased (detail is not shown in graphical form for this variable). *Distance to shelter,* adjusted for season, had a significant effect on *abundance of fresh diggings* and season adjusted for *distance to water* also had an effect, although weak. The relationship between abundance and *distance to shelter* was positive and linear, i.e. abundance increased as *distance to shelter* increased. The wet season had the highest *abundance of fresh diggings* and the early dry season had the lowest (detail is not shown in graphical form for this variable).

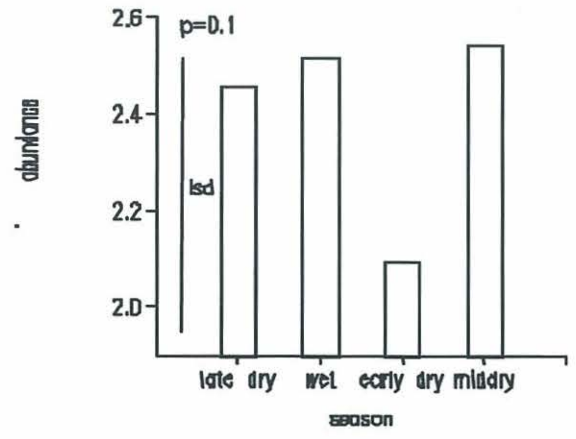


Figure 4.26: Estimated *abundance of fresh diggings* given the presence of diggings for each season.

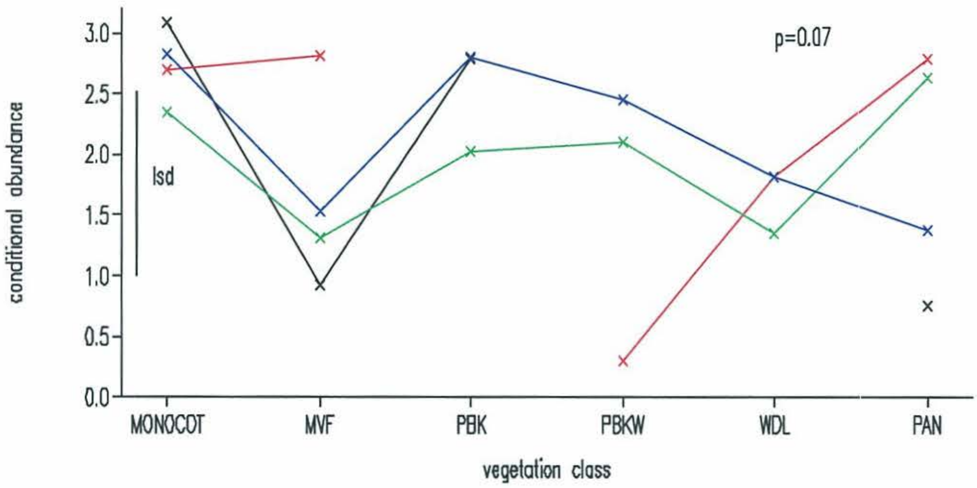


Figure 4.27: Estimated *abundance of fresh diggings* at each *vegetation class* each season.

See Figure 4.21 for season legend.

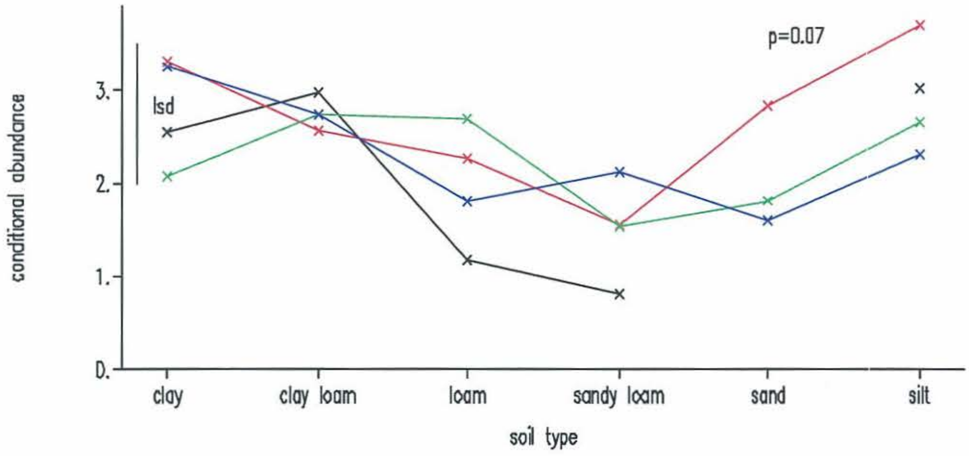


Figure 4.28: Estimated *abundance of fresh diggings* at each *soil type* each season. See Figure 4.21 for season legend.

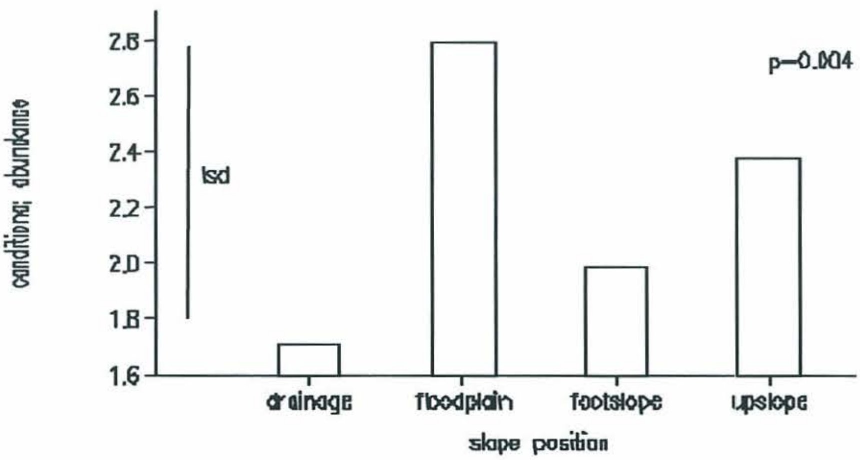


Figure 4.29: Estimated *abundance of fresh diggings* at each *slope position*.

4.3.16.3 Summary of results for *fresh diggings* and conditional *abundance of fresh diggings*

The significant variables from the modelling of *fresh diggings* and *abundance of fresh diggings* are summarised in Table 4.2. The probability of *fresh diggings* and *abundance of fresh diggings* were highest in the mid dry season. The effect of *site, vegetation class, slope position, distance to water* and *distance to shelter* on the probability of *fresh diggings* varied seasonally. The highest probability of *fresh diggings* occurred at the 20-30% *vegetation cover* category. In all seasons, *abundance of fresh diggings* was highest on floodplains and lowest in drainage floor positions. Abundance also increased as *distance to water* increased in all seasons. Similarly, in each season, the *abundance of fresh diggings* increased as *distance to shelter* increased. The effect of *vegetation class* and *soil type* on the *abundance of fresh diggings* varied seasonally.

4.3.17 Drivers of feral pig activity

The variables that are significant in explaining variation in each response variable are summarised in Table 4.2. There are a number of strong consistencies in the data. The following discussion considers the relationship between these drivers, in conjunction with knowledge and observations from fieldwork, to develop a coherent picture of seasonal feral pig activity in the northern Arafura Swamp region.

Table 4.2: Seasonal summary of significant explanatory variables for each response variable.

	Late Dry	**Wet**	**Early Dry**	**Mid Dry**	**All year**
Presence of pigs	Site ***Slope position***	Site ***Slope position*** ***Soil type*** ***% vegetation cover* (-ve)** *Distance to water*	*Site* ***Slope position*** ***Soil type*** ***% vegetation cover* (-ve)**	*Site* ***Slope position*** Vegetation class	Site Slope position
Pig Activity Index 1	***Slope position*** **Vegetation class** ***% vegetation cover* (-ve)** *Distance to shelter*	*Slope position* (w) Vegetation class (w) *Soil type* ***% vegetation cover* (-ve)** *Distance to water* *Distance to shelter* (w) (-ve)	*Slope position* Vegetation class ***Soil type*** ***% vegetation cover* (-ve)** ***Distance to water*** *Distance to shelter*(-ve)	*Slope position* Vegetation class *Soil type* (w) ***Distance to water* (-ve)** ***Distance to shelter* (-ve)**	Slope position Vegetation class Distance to shelter
Pig Activity Index 2	*Slope position* Vegetation class *Soil type* ***% vegetation cover*** *Distance to water* (w) ***Distance to shelter* (-ve)**	***% vegetation cover***	*Slope position* **Vegetation class** *Soil type* (w) ***% vegetation cover*** *Distance to shelter*	*Slope position* Vegetation class (w) *Soil type* ***% vegetation cover* (best fit only)** ***Distance to water*** ***Distance to shelter* (-ve)**	% vegetation cover
Fresh Diggings					*Slope position* *Vegetation class* *% vegetation cover* *Distance to water* (-ve except wet season) *Distance to shelter*
Abundance of fresh diggings					*Slope position* *Vegetation class* (w) *Soil type* (w) *Distance to water* (w) (-ve) *Distance to shelter* (w)

NB: Variables in **bold** are also significant in the 'best fit' models; those with the symbol (w) are only weakly significant i.e. p=0.1>0.05; (-ve) indicates that linear relationships are inverse.

Feral pig activity was widespread throughout the study area, with a minimum of 48.7% (wet season) and a maximum of 85.9% (late dry season) of surveyed plots containing pig sign (either digging, restplaces or dung) as shown in Figure 3.4 (Chapter 3). Habitat use by feral pigs in the northern Arafura Swamp region appears to be driven largely by season and then by a series of environmental variables. This seasonal response to habitat use has been commonly observed in many tropical animals (Redhead 1979, Crawley 1983, Karr and Freemark 1983, Friend et al. 1988, Ridpath 1991, Madsen and Shine 1999). It has also been seen to occur specifically with foraging and microhabitat selection by feral pigs (McIlroy 1993, Mitchell 1993).

Various studies have put forth a variety of reasons for the seasonal distribution of feral pigs, including rainfall and temperature patterns in Malaysia (Diong 1973), food availability in USA (Kurz and Marchinton 1972, Brisbin et al. 1977, Graves and Graves 1977, Singer et al. 1981) and density of vegetation cover in the USA (Barrett 1978). The results from this study suggest that seasonal variation in habitat use by pigs in the northern Arafura Swamp region was largely in response to seasonal flooding and drying, which itself has a significant influence on resource distribution and abundance. Hone (1990a) compared seasonal densities of feral pigs (obtained by aerial survey) in the Top End of the Northern Territory and also concluded that seasonal flooding was the main cause of seasonal patterns of feral pig distribution.

The broad pattern of habitat use by feral pigs recorded in this study was as follows. Throughout the late dry season, pigs congregated near any remaining water sources (drying swamps, permanent billabongs, creeks and rivers). As the wet season progressed, pigs were gradually driven to areas of higher ground as floodwaters began to cover many areas. In the early dry season, pigs followed receding floodwaters and began to access some areas on low ground. This pattern continued into the mid dry season when movement of pigs was potentially unlimited until water became scarce and was once again the lure to an area in the late dry season. The consistent record of pig activity on floodplain and footslope positions is a strong reflection of this movement pattern. The occurrence of low levels of fresh activity in the late dry season and high levels in the mid dry season also reflects this movement pattern.

Within the bounds of dry, accessible land, the data suggest a logical pattern of habitat use based on the availability of food, water and shelter. This is reflected in the seasonal variation of significant environmental variables that explain the distribution of signs of feral pigs in the study area (see Table 4.2).

Food availability and dry-season induced food shortage has been observed to affect population density and dynamics of the feral water buffalo (Freeland and Boulton 1990, Ridpath 1991) and the feral pig (Caley 1993) in Top End savanna habitats. Caley (1993) observed that feral pig density in a Top End savanna woodland habitat was lowest in the late dry season and highest in the mid dry season and that antecedent rainfall (as an indicator of food availability) had a large impact on the observed fluctuations in population density despite pigs breeding all year round. It is possible that factors other than food availability may have some impact on the observed seasonal variation in activity of feral pigs in this region. Corbett (1995) suggested that interference competition by feral buffalo could limit pig populations in tropical floodplain environments in the late dry season by compacting soils, thereby reducing access by pigs to important underground foods. Corbett (1995) also suggested that dingo (*Canis familiaris dingo*) predation may limit pig populations. Dingo predation on feral pigs is greatest in the wet season when their preferred prey species, dusky rats (*Rattus colletti*) and magpie geese (*Anseranas semipalmata*), are less accessible (Corbett 1995). While dingoes are present in the Arafura Swamp region, it was not within the scope of this study to determine whether dingo predation may have had an impact on the observed seasonal activity of feral pigs.

The results of the statistical analyses are discussed for each season below.

4.3.18 Late dry season drivers of feral pig activity

The probability of *Presence of pigs* was high (more than 77%) for most sites in the late dry season. As the late dry season was the first survey, the data reflect cumulative usage throughout the entire season or longer and as such may be biased. Thus, caution must be exercised when interpreting this information. There was a lower probability of occurrence of pigs at Milbirim (47%) possibly due to the regular presence of people nearby, deterring pigs from this area. This *site* is very close to town (Figure 3.1) and the local dry tip, as well as Ramingining Creek, which runs through this *site* and is used for swimming and fishing by many locals.

Recent pig activity was best represented by the probability of *fresh diggings*. The probability of *fresh diggings* was lowest in the late dry season, reflecting both that the availability of food and surface water was very limited and the ground was hard (for *digging*) in many places at this time of year. Food resources were restricted to above ground items in areas where *digging* was not possible. These constraints would have encouraged pigs to move to areas where food and water were readily available, which is reflected in the data. *Fresh diggings* were more likely to be found closer to water this season, confirming the importance of surface water to pigs at this dry time of year.

The estimated probability and *abundance of fresh diggings* was high in paperbark forests. These areas remain wet until very late in the dry season, perhaps due to their high canopy cover, and are preferred for foraging at this time of year because of the food and water they provide and because of the cool, shaded protection they offer to pigs. Hone (1990) also found that pig densities were high in paperbark swamps in the late dry season. The *sites* Dhabila, Djapidingorin and Mangbirri had the highest probabilities of *fresh diggings* this season. In all of these *sites* there were plots located along the edges of drying swamps, which were suitable foraging grounds for pigs.

The highest probability of *fresh diggings* was on drainage floor *slope positions* although this probability was still very low. All plots in drainage floor positions were located at Milbirim, where a permanent creek system and extensive monsoon forest provided extensive cover in sandy soils where *digging* was easy. Although the probability of *Presence of pigs* is lowest at Milbirim, this response variable considers pig sign of any age. *Fresh diggings* are higher here in the late dry season when water and shade are so important.

Floodplains showed high levels of *digging* activity in the late dry season (*PAI2*-more *diggings* on grassland and sedge vegetation types). Some of this activity may have occurred in the earlier parts of the dry season when water was still available. Current activity was also high in monocot vegetation (high *abundance of fresh diggings*), which mainly occurs on open floodplains. At this time of year monocot vegetation suitable for *digging* would occur in areas where surface water persisted late into the dry season such as slow drying swamps, springs, permanent billabongs, creeks or rivers. These places were commonly some distance away from shelter in the middle of the floodplain (personal observation), which is reflected by the higher occurrence of *diggings* (including *fresh diggings*) as *distance to shelter* increases.

The intense heat and humidity during the late dry season encouraged pigs to rest during daylight hours, in dry, cool places such as monsoon forests, paperbark woodlands and woodlands. The majority of *restplaces* (*PAI2*) were recorded in these *vegetation classes*. Bowman and McDonough (1991) found that *digging* was rare in monsoon forests as pigs predominantly used these forests as resting areas.

Monsoon forests, paperbark and sedge had the most pig activity (*PAI1*) in the late dry season. This index, being composed mainly of *restplaces* and *dung,* represents resting areas (e.g. monsoon forests where I observed both *restplaces* and *dung* to occur) and foraging areas (e.g. paperbark forests and sedge vegetation where I observed both *digging* and *dung* to occur). High activity levels on footslopes, and to a lesser extent on floodplains could be correlated with activity in these *vegetation classes* (the confounding effects of some variables is discussed later).

Very low levels of activity (*PAI1*) occurred in woodlands, which may be explained by the extent of burning throughout the drier months leaving the woodland areas less sheltered for pigs. Further, woodlands tend not to contain abundant food resources at this time of year (personal observation). Hone (1990a) also found that pigs avoided woodland areas in the dry season.

Pig activity (*PAI1*) decreased as *% vegetation cover* increased. There are several coexisting reasons for this finding. Firstly, low activity in areas where *% vegetation cover* is high may be reflecting those plots in paperbark swamps that are still inundated.

The drier edges of the forests may have been extensively dug over, leaving little vegetation (and possibly obscuring any signs of *dung*), and the wetter parts may be supporting aquatic plants. It is possible that pig *digging* is actually affecting the explanatory variable *(% vegetation cover)* in this situation. In these areas pigs would be most likely to be digging for worms, snails and other animals (including long-necked turtles) in the wet mud. Secondly, an abundance of dung was found along tracks in grassland areas with *% vegetation cover* between approximately 10-50%. Pigs use these tracks through the grassland to move between their daytime resting places in the monsoon forests and their nocturnal feeding grounds on the floodplains. Thirdly, the highest numbers of restplaces and dung pellets occurred in monsoon forests with a lower *% vegetation cover*. This may be because these forests are not as thick and impenetrable at ground level as those with a higher *% vegetation cover,* making access for pigs easier.

4.3.19 Wet season drivers of feral pig activity

In the wet season, pig activity (as represented by *Presence of pigs*, *PAI1* and *fresh diggings*) was highest on footslopes. Pigs used these areas heavily at this time of year, in response to the fact that most topographically lower areas were flooded and hence unavailable. While the probability of *fresh digging* increased as *distance to water* increased, most *fresh diggings* (86% of plots with *fresh diggings*) occurred in plots less than 100m from water. This result reflects that pigs needed to be close to water for drinking and for food resources, both of which could be found on the footslopes at the edges of floodwaters. Variation in the probability of *fresh diggings* also occurred between *sites*, which may have been influenced by the low numbers of plots able to be surveyed due to flooding.

The probability of *fresh diggings* was highest closer to shelter and in woodland and monsoon forest plots. Many of the plots in these vegetation classes occurred on sandy soils, which are usually dry in the wet season and are easy to dig. Pigs may have used woodland areas for resting during the day and some foraging of fruits, earthworms and tubers at this time of year, but these were probably not key resource areas. The use of woodland habitats was mainly confined to footslopes, i.e. close to the edges of their preferred foraging habitats and to water. Hone (1990a) found that pigs only used woodland when other preferred areas were flooded in the wet season.

Some monsoon forests were dry throughout the wet season and were extensively used for resting and as key foraging places (high *abundance of fresh diggings*). Although pigs do not forage very much in monsoon forests throughout the year, this changes in the wet season when Orange-footed Scrubfowl eggs (*Megapodius reinwardt*) are present, underground tubers are developing and fallen fruits become plentiful. Wet monsoon forests have their peak fruiting period during the wet season and dry monsoon forests have their peak fruiting period during the wet and early dry seasons (Bach 2002). *Abundance of fresh diggings* was also high in pandanus plots, which were also a key area for resting. The location of many areas of pandanus vegetation along the margins between monsoon forests and floodplains means that pigs are regularly moving through these areas, foraging along the edges of the adjacent floodwaters.

The *abundance of fresh diggings* was highest on floodplains, suggesting that in areas where floodplain access was possible these were the favoured places for *digging*. Much of the vegetation on these floodplain areas was monocot (also showed high abundance of *fresh diggings*) which in the wet season would consist mainly of sedges (*Eleocharis* spp.) that are a favourite food source of pigs. Mitchell and Mayer (1997) suggested that soft soils, bulb-producing plants, availability of soil moisture and high soil-invertebrate populations (especially earthworms) in lowland swamp areas would encourage digging by feral pigs. Intense digging activity in wet areas was also recorded by Bratton et al. (1982), while Kotanen (1994) found that pig diggings were associated with damp ground or seeping water.

Hone (1990a) found large numbers of pigs isolated on small islands on open floodplains in the wet season. In this study, pigs were observed throughout the year at Garanydjirr (a topographically raised area or 'island' surrounded by floodplain -- see Figure 3.1).

Although *PAI1* was greatest in monsoon forests, the overall activity level recorded was low. As the wet season survey was undertaken late in the season for practical reasons of access, many *dung* pellets may have disintegrated with the large amount of rainfall and evidence of *restplaces* may have been more difficult to detect. *Diggings* may also have disappeared more rapidly during the wet season leaving fewer old and medium *diggings* to be recorded. It is also likely that pigs were using several monsoon forest plots that were inaccessible to me during the wet season.

The probability of *Presence of pigs* and pig activity (*PAI1*) decreased as *% vegetation cover* increased in the wet season. Pig digging may again have interfered with *% vegetation cover* here, as low *% vegetation cover* where pig presence and activity was high may be due to pigs removing some of the vegetation cover while foraging. Also, many plots (78%) with high vegetation cover (>80%) were in or directly alongside water, which may have been too wet for pigs at that time as 87% of the plots that were inundated (or 0m from water) did not contain any fresh diggings.

4.3.20 Early dry season drivers of feral pig activity

In the early dry season there was still a considerable amount of surface water present after wet season flooding. This was reflected in the data, with the probability of *presence of pigs* and activity (*PAI1*) being greater on footslopes. The probability of *fresh diggings* was also highest on footslopes and floodplains suggesting that current seasonal *digging* by pigs was occurring in both of these *slope positions*.

The probability of *fresh diggings* was similar in most vegetation classes, showing that pigs used a diverse range of habitats as floodwaters continued to recede and new areas became available. The conditional *abundance of fresh diggings* was high in monocot plots, which would have been favored by pigs as they started to dry (this is also reflected by the high *abundance of fresh diggings* in silt and clay soils which are the main soils on which monocot vegetation occurs). The lowest probability of *fresh diggings* occurred in paperbark forests, which may have been a result of dense canopy cover causing floodwaters to dry more slowly (68% of all surveyed paperbark forest plots in this season were wholly or partially inundated) and thus preventing pigs accessing areas other than the edges.

More *digging* activity (*PAI2*) occurred on floodplains (*PAI2* was also high in the grassland vegetation class), as many of these areas were still moist and easy to dig. In addition, sedge corms and other food resources were relatively high in abundance on floodplains. More activity (*restplaces* and *dung - PAI1*) occurred in monsoon forest and paperbark woodland plots, which provided adequate shelter at this time of year. Pigs may also have been attracted to dry monsoon forests as the fruiting period of many trees in this habitat continues into the early dry season (Bach 2002). The high amount of activity in monsoon forest plots may also be representative of wet season activity in areas that were not surveyed at that time.

More *diggings* (*PAI2*) and the highest *abundance of fresh diggings* occurred in pandanus plots. Pandanus vegetation occurs mainly on sandy soils, which pigs find easy to dig (82% of PAN plots with any *digging* occurred in sand or sandy loam). In addition, the position of many pandanus plots on the margins between monsoon forests and floodplains makes them an important transitional area for pigs to forage during the early dry season. Yams commonly occur in these pandanus-monsoon forest margins.

The probability of *fresh diggings* was greatest furthest from shelter (distance category 5- more than 1000 m from shelter) but also showed a peak at distance category 3 (between 100-499 m from shelter). The variation in the probability of *fresh diggings* at these *distance to shelter* categories may be reflecting differences in the patterns of receding floodwaters between sites. At Dhabila (Figure 3.1), where the probability of *fresh diggings* is highest this season, floodwaters probably would have receded quite early; this area is quite close to the coast and is sparsely vegetated, allowing maximum evaporation. Dhabila is situated in the middle of a vast floodplain and pigs would have travelled far from sheltered areas to reach foraging grounds, such as late drying swamps, located within this site.

The probability of *fresh diggings* decreased as *distance to water* increased, as pigs forage for important foods including worms and *Eleocharis* spp. at the edge of the drying floodwaters. The probability of *fresh digging* was highest both on footslopes and floodplains. This further demonstrates that pigs dig for food along the edges of floodwaters, i.e. on footslopes in areas that retain water longer and on floodplains where the waters recede earlier.

The variation in activity (*PAI1*) at different *distance to water* categories may be a reflection of the type of index. *Pig activity index 1* is mostly influenced by *restplaces* and *dung* and less influenced by *diggings*. Higher levels of activity occurred at the medium distances to water which could be interpreted as *dung* deposited whilst travelling between shelter and water, or *restplaces* in monsoon forests or pandanus vegetation, which occurred at varying distances to water.

Overall, the *abundance of fresh diggings* is lowest in this season, probably because in areas where there is an abundance of foods, pigs were restricted to digging along the edges of receding floodwaters.

4.3.21 Mid dry season drivers of feral pig activity

The probability of *fresh diggings* and the abundance of *fresh diggings* in sampled areas were highest during this season, reflecting the more widespread use of the study area by pigs. Food was plentiful and movement was largely unrestricted this season, with pigs using new areas as they became accessible after floodwaters receded further.

More *diggings* including *fresh diggings* were recorded closer to water where food is abundant and soils are softer for *digging*. The probability of *fresh diggings* was highest both on floodplains and drainage floors, the lowest topographic positions where surface water may have still remained or only recently dried out and soils were likely to be softer and easier to dig. The highest probabilities of *fresh diggings* occurred at the sites Mangbirri, Dhabila and Garanydjirr where surface water remained until late in the dry season in many plots, supplying pigs with drinking water and a soft *digging* environment. These remaining waterpoints also attracted long-necked turtles, which aestivate in the soft mud until flooding occurs again. Pigs are known to dig up these animals for food (Choquenot et al. 1996) and were observed doing so during this study.

The probability of *fresh diggings* was highest in paperbark forests. These areas were slowest to dry out, probably due to high % canopy cover (72% of paperbark plots had a tall canopy cover of greater than or equal to 40%) and thus provided foraging opportunities later in the season than other areas. The paperbark forests may also have been favoured at this time of year for the shade they provided to foraging pigs with some evidence that they were used for resting/shelter (high activity - *PAI1*). *Abundance of fresh diggings* was also highest in paperbark forests, because these areas had begun to dry and to become accessible to pigs for foraging. It was also high in monocot vegetation, suggesting that where monocot vegetation was still moist, it was an important foraging area for pigs.

The lowest probability of *fresh diggings* occurred in woodland. Although high usage of woodland areas was not common in the mid dry season, burning regimes may have further decreased the attractiveness of woodland areas to pigs seeking food and or shelter at this time. Caley (1997) suggested that pigs might avoid woodland habitats because of a lack of security or food or both.

The probability of *fresh diggings* is highest furthest from shelter suggesting that much of the available food and water is located far from dense shelter, probably in permanent or late drying swamps and other waterbodies. Pigs follow tracks from their daytime resting places in monsoon forests to feeding grounds on floodplain areas at night (personal observation). More activity and *restplaces* (*PAI1* and *PAI2*) occurred closer to shelter and in the shady monsoon forest plots, reflecting this daytime resting behavior by feral pigs.

In the mid dry season, more *diggings* were recorded where *% vegetation cover* was low and more even numbers of *restplaces* and *diggings* were recorded where *% vegetation cover* was high. A possible explanation is that in areas where vegetation cover was lower, such as in paperbark forests and grassland, there was considerable *digging* as pigs took advantage of plentiful food supplies as flooded areas dried out. However, some grassland and paperbark plots had very high *% vegetation cover*. In these plots *digging* may have been restricted by inundation (at least 7% of plots were wholly or partially still inundated during this season).

The use of sedge plots by pigs was inconsistent this season. Some sedge plots were still inundated during this survey and had not been dug over by pigs. However, two-thirds of sedge plots surveyed in the mid dry season were found on the river floodplain at the Crossing site, an area that was commonly used by pigs and was also heavily grazed by cattle. As the sedge vegetation is widespread in this area, cattle and pigs probably move through the area quite quickly, constantly seeking better patches of sedge to feed on. When each section being grazed degrades to below a certain level, the animals move on. This movement probably occurs in conjunction with drying patterns, which may be accentuated by digging and grazing. At this site, this pattern of movement explains why some sedge plots are not dug over at all (i.e. either still inundated or completely missed by pigs) and others are only partially dug.

4.3.22 General Considerations

In this study, many explanatory variables showed consistency across seasons. This could be a result of two things: that the sampling measured the same signs each season or that the same explanatory variables do explain variation in the response variables each season. The survey design protocols specified that signs recorded must be *fresh* or recorded as *old* (e.g. as in category '*old diggings*') and as such different signs were recorded each season. The response variables *Presence of pigs*, and *Pig activity index [2]* did amalgamate all *digging* categories (diggings made very little contribution to *Pig activity index [1]). Restplaces* were only recorded if fresh and, although dung was recorded as fresh or old, pellets were removed from plots after each survey to ensure that these were not recounted in the following survey. Even if the inclusion of all *digging* categories had some effect on the results, it would be limited to the early and mid dry seasons as many signs are washed away in the wet season.

The correlation structure among explanatory variables was tested for using principle component analysis (see section 4.2). This suggested there was no correlation. However, while each variable does explain something different about the data, there is an ecological relationship between *vegetation class*, *soil type* and *slope position*. *Vegetation classes* usually occur on specific *soil type*s. Dry monsoon forests usually occur on sandy loam and sand soils (Russell-Smith 1991) and wet monsoon forests are found on organic clay loams (Russell-Smith 1993). In this study, woodland plots were mainly on sand loam and sand soils; grassland and sedge plots were mainly on clay and silt soils; pandanus plots occurred mainly on sand and paperbark plots were mainly on clay and loam soils. In most models where soil type is significant, pigs are probably responding to the *vegetation class* rather than *soil type* although in some instances pigs may be seeking particular invertebrate food sources that occur in certain soils.

Slope position is also connected closely to some vegetation types but not exclusively so. While there is confounding between *vegetation class* and *slope position*, the overriding pattern of pig activity in response to inundation is clearly demonstrated by *slope position* as signs of pigs occurred in multiple *vegetation classes* on the same topographic position.

Pig diggings may also have had a confounding effect on *% vegetation cover*, which may be reduced by pig activity in an area. This has been noted for the two models where the results may have been affected.

Digging was less common on upslope positions each season, which is consistent with the findings of Hone (1995) and Mitchell and Mayer (1997). Nevertheless, it is important to note that there may have been some bias in recording of sign as *digging* would have been more easily observed and more persistent in the softer soils that commonly occur in the lower slope positions. Many of the upslope positions had hard and very rocky soils, which may have obscured signs of pig activity.

4.3.22.1 Data exclusions

In the modelling of *Presence of pigs,* various *sites* were excluded from each seasonal model because there was no variation (either because pigs occurred in all or none of the plots in that *site*). The exclusion of these *sites* does not result in the loss of any of the variable classes in any season. Three *sites* (Dhabila, Mangurr and Mangbirri) were excluded in all seasons. In the late dry season, these three *sites* were excluded due to pigs being present in all plots. Within the area encompassed by each of these *sites* there are late drying swamps that are key areas for pig foraging in the late dry season. Mangurr was an excluded *site* where, in the wet season, *presence of pigs* would have probably been very high along an area of raised ground with pandanus vegetation on the floodplain margins. When this area was finally accessible and surveyed in the mid dry season, each plot had been trampled across 80-100% of its area.

In the early and mid dry seasons, Dhabila, Mangbirri and Mangurr were excluded. Dhabila and Mangbirri were excluded because pigs were present in all plots in both seasons. Mangurr was excluded in the early dry because it was inaccessible, and in the mid dry because pigs were present in all plots. Many of the areas within these sites are early to dry out after wet season flooding, and hence were areas where there may have been a high probability and abundance of *fresh diggings* and other signs.

In modelling the probability of *fresh diggings* across seasons some variable classes were excluded from the model because *fresh diggings* were not present. In the late dry season, there was no occurrence of *fresh diggings* in woodland or paperbark woodland *vegetation classes*, upslope positions, nor in *distance to shelter* categories 1 and 4. In the wet season, there was no occurrence of *fresh diggings* in paperbark vegetation or in *distance to shelter* category 5, and these were also excluded from the model.

4.4 Concluding remarks and recommendations

This chapter demonstrates that feral pigs use a range of habitats throughout the year, which often vary with season. Some habitats such as monsoon forests are used all year round but serve different functions in the wet and dry seasons. Tropical swamp habitats are known to be 3-5 times more productive than tropical savanna or deciduous forest habitats (Golley and Misra 1972). As this study area is focused on the Arafura wetland environment, patterns of use by species may be more accentuated here than in other areas. Intense productivity and the distribution patterns of permanent water throughout the area may explain the preference pigs show for wetland habitats throughout much of the year. Refuge from flooding along with the presence of abundant fruit and other foods may influence habitat use by feral pigs in the wet season.

This research has established a set of environmental criteria that showed clear seasonal associations with pig activity in the northern Arafura Swamp region. Thus, based on this set of criteria, pig control can be directed at particular locations each season with the aim of improving the effectiveness and efficiency of control. The criteria for predicting the locations of pig foraging and resting activity each season are outlined in Table 4.3 and have already been discussed. All criteria are important and are listed from broadest to narrowest in a landscape sense. The set of criteria that should be used depends on the type of control method to be employed. The criteria for predicting pig foraging activity will be most appropriate for most control methods (trapping, baiting and aerial shooting), but the criteria for pig resting will be informative for hunting pigs on foot during the daytime.

Based on these models and observations, the most effective time to target feral pigs for control is in the late dry season when pigs are concentrated around remaining watering and foraging locations (e.g. permanent or late-drying swamps), such as those at the sites Djapidingorin, Mangbirri and Dhabila. Feral pigs are often in poor physical condition by this time of year due to the shortage of high quality food and, for adult sows, the nutritional demands of previous pregnancies and lactation (Caley 1993). Thus, the mortality of feral pigs is highest in the late dry season (Caley 1993) and control efforts in conjunction with this mortality will have the greatest impact on pig populations. A number of control methods could be used in the late dry season. Trapping (using bait) could be undertaken in either paperbark or monocot vegetation and, at this time of year, the appeal of bait is high as food is scarce. Poisoned bait is an efficient method for a quick reduction in numbers of feral pigs, but it can affect non-target species (Choquenot et al. 1996) and may not be appropriate in the Arafura Swamp area. Aerial shooting, which requires clear vision of the animals, could be undertaken on open floodplains.

Generally poor access to many areas due to floodwaters and pigs preference for foraging close to shelter in the wet season means that extensive, costly control action at this time of year is not recommended. Local opportunistic control (such as community-based hunting on foot, possibly in conjunction with some trapping) in accessible areas such as the footslope ecotone areas between monsoon forests or woodland vegetation and floodplains at Djanyirrbirri, Gatji and Garanydjirr would be appropriate and valuable at this time of year (see Chapter 7 for further discussion of management recommendations).

In the early dry season, aerial shooting of pigs on areas of non-inundated floodplain could be undertaken in areas where pig density was known to be high, such as Dhabila, Gatji, Djanyirrbirri and Garanydjirr. Local opportunistic control at this time of year should also be continued to assist in maintaining reduced numbers of pigs throughout their peak feeding and breeding time.

In the mid dry season, pigs are widespread due to maximum access to habitats and a high abundance of food. This increases the difficulty of control and reduces its effectiveness. Nevertheless, some local opportunistic control effort should be maintained in monocot and paperbark vegetation at key locations such as Dhabila, Djanyirrbirri, Mangbirri, Garanydjirr and Mangurr.

Table 4.3: Key environmental criteria for predicting pig foraging and resting activity each season.

Late dry season – foraging	**Late dry season – resting**
low topographic position (drainage floor or floodplain)	all slope positions except floodplain
close to water	close to shelter
paperbark forest or monocot vegetation	monsoon forest and paperbark woodland vegetation
Wet season – foraging	**Wet season - resting**
footslope or non-inundated floodplain	high % vegetation cover
close to water	
close to shelter	
pandanus vegetation	
Early dry season – foraging	**Early dry season - resting**
footslope or non-inundated floodplain	all slope positions except floodplain
close to water	close to or far from shelter
far from shelter	paperbark and paperbark woodland vegetation
monocot and pandanus vegetation	
Mid dry season – foraging	**Mid dry season - resting**
low topographic position (drainage floor or floodplain)	all slope positions except floodplain
close to water	high % vegetation cover
far from shelter	sedge, paperbark woodland and monsoon forest vegetation
paperbark and monocot vegetation	

Control of feral pigs in the Arafura wetlands is necessary for conservation of the natural and cultural environment. Feral pigs are impacting on local Aboriginal food resources and aspects of culture (Chapters 5 and 6). Further, coastal Arnhem Land is a high-risk area for the introduction of exotic diseases, many of which are carried and transmitted by feral pigs. Swift and effective control of feral pigs will be necessary in the event of an exotic disease outbreak.

By predicting specific areas to be targeted for pig control, these models provide a substantial guide for improving the management of feral pigs in this part of the Northern Territory. The models may also be extrapolated to ecologically similar areas. Understanding the seasonality of pig activity across different habitats and association with environmental characteristics will enable the optimisation of control measures by knowing which locations to target at particular times in the seasonal cycle. This may increase the effectiveness of the control as well as minimise the costs.

The cultural environment of the Arafura Wetlands and surrounds also plays an enormous role in determining appropriate management strategies for this area. The next chapter considers Yolngu perceptions of feral animals on their land and whether these animals may be affecting country. Yolngu ideas about control of feral animals and whether there is any potential to earn income from these animals are also discussed.

CHAPTER 5: Yolngu perceptions of feral pigs and buffalo

5.1 Introduction

The presence of feral animals, the damage they cause and their control is of concern to many landowners across Australia. On Aboriginal land these issues are made more complex by the dominant culture being Aboriginal, which is different to elsewhere in Australia. This has the potential to lead to differences in perceptions and aspirations with regard to feral animal management between Aboriginal landowners and European dominated government conservation agencies.

Feral animals are generally perceived by land management and conservation agencies as an environmental threat which must be controlled and where possible eradicated. In many cases, there is little or no acknowledgement of indigenous concerns that such animals may have cultural significance or be important as food or material resources (Rose 1995). Similarly, ideological disparity exists where threatened native species such as sea turtles and dugongs that are high on conservationist agendas also have high social and spiritual value to indigenous people as a consumptive resource (Kwan et al. 2001). Where there is awareness of indigenous perspectives, European environmental managers often find it difficult to understand and accommodate them. This means that communities are rarely given the opportunity to act upon their own values, and have their aspirations and priorities recognised and respected (Suchet 2001).

Human perceptions of animals are a topic of immense importance to wildlife management and one that has been little researched. Managing humans is as relevant to managing wildlife as is managing specific species and their habitats (Leopold in Kellert

1983). Understanding human attitude can 'provide environmental managers with information about public support and beliefs, information about goals necessary to set standards and information about the current and future behavior of relevant parties' (Heberlein 1989: p37).

Attitudes are formed directly through experience and observation and indirectly through external influences and they are inextricably linked to other attitudes and social context (Benzaken 1992). Where wildlife is concerned, there are economic, psychological/social and ecological values to be considered (Shaw and Zube 1980). Different attitudes amongst different stakeholders can mean that these values can be prioritised very differently and that different behavioral outcomes ensue.

Strang (1997) explains that culture, which involves ideas, beliefs and values provides the context for human environmental interactions. Aboriginal worldview and culture strongly influence the way feral animals are perceived and also very strongly influence people's aspirations concerning the potential control or non-control of these animals. Yolngu culture is intricately tied to the land, and Yolgnu people have a strong holistic relationship with the land. There is no separation between people and the environment in traditional Aboriginal ideology (Rose 1992, Bradley 2001), as Lim (1997:6) explains with particular reference to Yolngu from the northern Arafura wetlands:

> ... to talk of culture as an entity separate from nature is to miss the point. There does not appear to be such a dichotomy in Yolngu ideology, as the realms of the cultural, natural and supernatural intertwine seamlessly. So, it must be realised early in any management strategy that to ignore one domain would be lead to irrecoverable losses in the other.

As part of a sustaining holistic system Yolngu have personal responsibility for ensuring that country is cared for. Broadly speaking, 'healthy country' is country where the well being of all species (human and non-human) and sacred places associated with the area is maintained. Accordingly, when country is not healthy it is a given that its inhabitants will not be healthy either (Rose 1996, Baker 1999). This idea is amplified when sacred sites are involved. Yolngu have described severe personal sickness in response to country or sites to which they are spiritually linked being mismanaged, damaged, or disturbed (Neate 1993).

Before feral animal management can be considered on Aboriginal land it is essential that there is an understanding of people's perceptions of these animals and the effects that they have on country. Understanding the aspirations of all stakeholders is also essential when discussing land management initiatives (Suchet 2001). The potential disparity of stakeholder views regarding feral animals can pose particular challenges to decision-makers in this field. However, anthropologists have recognised that the consideration of different stakeholder views within western society can be very difficult and that these difficulties are further increased in a cross-cultural context (Trigger 2002).

This chapter addresses the need to develop an understanding of Yolngu perceptions of feral pigs and buffalo, including their cultural significance, and also brings to light Yolngu people's aspirations regarding management of these animals, both of which must be appropriately considered when planning for management. The predictive models of seasonal pig activity and recommended effective control strategies developed in Chapter 4 can only be implemented with an awareness of these perceptions and aspirations. Without this part of the story, discussions and decision-making processes towards a management strategy that is consistent with the social, political and cultural domains of Yolngu way of life will be unworkable.

5.2 Methods

Posters informing people about this study were placed around Ramingining community. Although not all people could read, the posters were written in *Gupapuyngu* (the main Yolngu *lingua franca*) to maximise the numbers of readers and included photographs of myself and aspects of the work being done.

Qualitative methods were primarily used in this part of the research. A combination of participant observation and semi-structured interviews (Appendix 3) was used to collect information about individual and community perceptions of feral pigs and buffalo. Overall, three separate sets of questions were addressed. Each set was structured along themes that were conceptually sequential. Most interviews were conducted opportunistically over several sessions during the dry season 2000.

The first interview established the level of awareness of feral animals including how they fitted into culture. It also determined initial overall perceptions of feral animals including whether attempts should be made to eradicate them. The behavior of pigs and buffalo and the effect of these animals on local Aboriginal resources was investigated in the second interview. The final interview focussed on the control of feral animals in this area, including potential business enterprises that could make use of these animals.

Due to my limited language skills, it was necessary to be assisted by a local Yolngu (*Ganalbingu* speaking) woman who introduced me to people and acted as an interpreter (where needed) during many of the interviews. While I asked her to act only as an interpreter and not to answer questions or prompt people during the interviews, I cannot guarantee that her views or interpretations did not influence the answers of the respondents. I conducted nearly all interviews in English, with only occasional dialogue (usually in *Gupapuyngu* language unless talking to a *Ganalbingu* speaker) added by my assistant for clarification.

Interviews were usually conducted in a relaxed situation and mainly in places where people felt comfortable such as around the campfire at their homes, or whilst sitting in a day or 'dinnertime' camp (see Meehan 1988) while out hunting. In many cases, people would consult those around them regarding their answers to various questions as knowledge about country and experiences can vary between people.

The people interviewed were Yolngu men and women of different ages as shown in Table 5.1. Some lived permanently in Ramingining community and some spent various amounts of time at outstations on their traditional lands. People interviewed came from a variety of eduactional and occupational backgrounds. 19 people were interviewed initially (Interview 1), 12 women and 7 men as shown in Table 5.1. Four people became unavailable for the following two interviews reducing the number of people involved in these interviews to 15. These people included two rangers (male) who left the community to live elsewhere and two women who were too busy to continue their participation. In some interviews, it was possible to pose all of the questions and in others, the respondents preferred to discuss issues in a less structured manner. As such, the number of respondents for each question may vary. The names of all respondents have been changed for privacy reasons.

Table 5.1: Details of respondents involved in this study.

Name	Age	Gender	Clan group	Language	Country(s)	Mothers Country(s)	Occupation	Potential influences
Mick	30-50	Male	Gakamangu	Gupapuyngu	Ramingining	Bundatharri, Dhabila, Dhamala, Manyallalak	Ranger	Significant exposure to western views and practices in land management
Jessica	Under 30	Female	Ganalbingu	Ganalbingu	Ngalindi	Wulkabimirri	Shop assistant & student	Good education level
Julie	Over 50	Female	Wulaki	Djinang	Gatji	Djimardi	None	Sons are rangers
Annie	Over 50	Female	Ganalbingu	Ganalbingu	Ngalindi, Gadiwinga	Wulkabimirri	Artist (weaver)	Well traveled throughout Australia, although little English spoken
Molly	30-50	Female	Ganalbingu	Ganalbingu	unknown	Mulgurum	Health worker	Well educated
Margaret	Under 30	Female	unknown	unknown	Galiwinku	Nangalala	None	Exposed to western views through living in Darwin for significant periods
Andrew	30-50	Male	Wanybarrngga	Djambarrpuyngu	Madharrakma (Galiwinku outstation)	Djiliwirri (Galiwinku outstation)	Ranger	Significant exposure to western views and practices in land management
Jack	Under 30	Male	unknown	unknown	unknown	unknown	Ranger	Significant exposure to western views and practices in land management
Gary	30-50	Male	unknown	Djambarrpuyngu	unknown	Sandy Point (& all Mildjingi country)	Ranger	Significant exposure to western views and practices in land management
Caroline	30-50	Female	Gakamangu	Djambarrpuyngu	Djiliwirri (Galiwinku outstation)	Mapurru	Teacher	Well educated and traveled

Name	Age	Gender	Clan group	Language	Country(s)	Mothers Country(s)	Occupation	Potential influences
Joanne	Under 30	Female	Marrangu	Djinang	Dhamala	Yathalamarra	Art centre assisstant	Good education; exposed to western views through living in a large city for significant periods
David	30-50	Male	Marrangu	Djinang	Dhamala	Yathalamarra	Airline agent	Well educated and traveled
Robert	30-50	Male	Gakamangu	Gupapuyngu	unknown	unknown	None	A close family member is a ranger, thus exposure to western views and practices in land management
Jane	Under 30	Female	Gurralpa	Djinang	Nangalala	Ramingining	Shop assistant and teachers aid (previous)	A close family member is a ranger, thus exposure to western views and practices in land management
Lily	30-50	Female	Murrungun	Djinang	Nangalala	Gumbaranga (other side of Murwangi)	Teachers aid (previous)	A close family member is a ranger, thus exposure to western views and practices in land management
Ella	Over 50	Female	Gakamangu	Gupapuyngu	unknown	Woolen River	Health worker	Good education level
Mary	30-50	Female	Marrangu	Djinang	Dhamala	Yathalamarra	Health worker	Good education level
Ruby	30-50	Female	Murrungun	Djinang	Nangalala	Ramingining	Teachers aid	Good education level
Billy	Over 50	Male	unknown	Djambarpuyngu	unknown	unknown	Artist/ gardener	Good education level; traveled and has close relationships with many Balanda

I initiated the majority of the interviews by approaching people and asking to talk with them about feral animals. Respondents were chosen based on availability and willingness to be interviewed. Two people (Ella and Caroline) requested that I come and talk to them about feral animals, pigs in particular. The level of concern and anger they felt about the pig problem probably prompted this action. Overall, the respondents who were most willing to provide information were women (of any age). It was more difficult to engage men in interviews and those men that were involved were rangers who I knew well and community members who I had developed relationships with. It is likely that my gender and associations with particular community members was a factor in self-selection of the respondents. In principle, most people were prepared to engage in discussion providing they were not busy. The reality was that people were often busy (and often had other issues to deal with that they considered a higher priority) and interviews were postponed many times (and sometimes completely) because of this.

Fieldwork with Yolngu was never as simple as going to collect data or talk about bush foods in a certain place. It invariably included a significant proportion of time devoted to hunting and gathering activities. If these activities required additional time, Yolngu prioritised this. On many occasions, the intended ethnographical work was not accomplished on that day.

5.2.1 Limitations

The information presented in this chapter is highly contextual, requiring close knowledge of local anthropology and ethnography as well as language, and should not be used as a substitute for consultation regarding future proposals or actions. Whilst members of several clan groups were invariably represented in the interviews, these people do not necessarily speak for the entire clan just as the views given by Yolngu in this thesis are not necessarily representative of all Yolngu or other Aboriginal groups. Indigenous people tend to speak only where they have a right to speak and where they have some knowledge and while this study scoped a range of views held by people, it must be understood that people have varying affiliations to different areas, which will have influenced these views.

This study provides preliminary insight into Aboriginal perceptions of feral animal issues and the diversity of understanding and opinion that occurs amongst Yolngu living in this area. It must be understood that whilst most discussions and answers given by respondents were unambiguous, I will have imposed some level of interpretation on responses which may be influenced by my non-Aboriginal background. Personal background, as other researchers have found, can unavoidably influence data collection (Rose 1995, Suchet 2001). Throughout the study, I endeavored to remain neutral and open to all points of view on the matter of feral animals. Nevertheless, my background as an ecologist and the type of research being undertaken brings to these observations and discussions a particular view of feral animal management issues that may have influenced the information collected. Further, the community possessed an unavoidable prior knowledge of the research, which in some cases may have influenced people's responses to questions. Aboriginal people often do not want to offend or disappoint researchers and will often construct discussions around what the researcher is hoping to hear (Johannes and Lewis 1993, Bulmer and Healey 1993).

The work was limited significantly by my language skills and cultural knowledge. Whilst an interpreter was used when communication difficulties were evident, there were still boundaries to comprehension that were not possible to overcome in the circumstances. Some responses to questions were omitted from this discussion due to poor communication or understanding of the question or its objective. Work of this kind would be greatly enhanced by strong language skills and increased familiarity with the local people and their social politics.

5.3 Results

Overall, Ramingining community members involved in this study are active hunters and gatherers whose knowledge of their country is strong. They value their traditional food supplies and their responsibilities for looking after their land. Most people interviewed went hunting for a variety of food resources at least every weekend. Hunting trips were usually day trips to nearby seasonally resource rich areas but could be longer when time and other resources permitted.

5.3.1 Awareness of feral animals

Not all respondents understood the meaning of the term 'feral', many people seemed to associate 'feral' with being wild, or at least labeled the animals we were discussing as 'wild ones'. As such, some people also named several native animals as being feral. When asked what feral animals she was aware of, Jessica explained that 'goose, turtle, file snake and buffalo – they belong; and pig it doesn't belong'. Despite this lack of clarity all respondents thought that pigs were feral animals and most named buffalo as a feral animal. Only four respondents included cattle as feral animals.

People observed various numbers of pigs in different social groupings. Mick said that he has seen 'sometimes one, sometimes a family' of pigs and Annie described with dismay that she has seen '*dharrwa*' (many) pigs when out hunting. Joanne explained that recently she saw 'a big mother one and too many little ones' whereas David said that he had seen 'just a few'. All respondents suggested that the numbers of pigs were the same or more than last year and all said that this was the most pigs there had ever been in the area. Mick was angry about the number of pigs saying 'Pigs are breeding more now, they damage the land, they've got no name those animals, no culture they are rubbish animals.' Robert agreed that the number of pigs had increased and explained that 'there are more (pigs) this year, they are everywhere now including the other side of the swamp.' Joanne summed up the situation very clearly from a resource perspective when she said 'Maybe next year will be too many (pigs) and later more still, then there will be no more goose and we will have to start eating pig.'

People were also asked if they had seen more pig digging this year than last year. Most respondents said that the amount of digging had increased, and one respondent stated that it was the same as last year. When talking about pig digging at his outstation, Bundatharri (see Figure 2.1), Mick explained that 'yes, (digging) is spreading from Gatji to Bundatharri, maybe this year there will be more damage.' David also described how increased digging by pigs had affected country saying '(there is) more (digging) – places that were completely smooth 20 years ago are all bumpy and dug over.'

Most of the answers about how many buffalo people saw at each encounter were the same as for pigs with '*dharrwa*' (many) being the most common response. In addition, David explained that 'in the afternoons you see big mobs of buffalo coming out of the bushes onto the floodplain at dusk.' The numbers of buffalo were also thought to be either the same or more than last year with current numbers of buffalo being the most that people recall ever seeing.

5.3.2 Feral animals as a food resource

Most people stated that pigs were eaten. This answer did not necessarily imply that the respondent ate pig (although some said that they did) but that they knew of other Yolngu who ate pig. Not everybody in the community eats pig meat and people's reasons vary for eating it or not. Andrew said that 'only some people eat pigs, others don't like the taste'. Mary clarified her viewpoint regarding eating pig meat saying that 'it tastes *maynymak* (good) but I only eat it if there is no other *warakun* (meat) available.' Ella said 'I eat pig because wild meat is good to eat, buffalo too'. Robert expressed the need to be careful when eating pigs; 'I eat pig, it is sweet, I only eat the meat not the stomach or anything and I don't eat it if it (the animal) looks sick.' Billy explained his reasons for not eating pig; 'I don't eat pigs, not wild ones because I was told that they were dirty, I do eat pork from the shop though'. All respondents said that everybody ate buffalo meat in the community.

5.3.3 Are feral animals a part of Yolngu cosmology?

All respondents clearly agreed that pigs do not have any 'dreaming' and as such no moiety (patrilineal division encompassing land, plant and animal species) or place within Yolngu ideology. While perhaps not every native animal fits into Yolngu cosmology, those that are prominent as a resource (such as kangaroo) generally do belong. Most people explained that there was no 'ownership' or affiliation with pigs (despite their potential value as a food resource), although three respondents suggested that pigs were owned by Yolngu landowners. Different interpretations of this question affected the results. Some people interpreted this question to mean religious or totemic 'ownership' of these animals while others interpreted 'ownership' as a personal or community possession.

The discussions about buffalo were less conclusive. Several people acknowledged that buffalo had been in the area a long time. More than half of the respondents thought that buffalo had a dreaming and belonged to the *Yirritja* moiety and as such buffalo were owned by some Yolngu. David explained that 'some people at a Maningrida outstation claim that buffalo is their dreaming'. Jane also made this suggestion independently. Annie further specified that 'buffalo is dreaming for Gupapuyngu people'. Ruby said 'buffalo is *Yirritja* and some people at Millingimbi sing and dance buffalo'. Some respondents named other community members for whom buffalo was a dreaming animal. Jessica suggested that 'buffalo was from Galiwinku, Lake Evalla and Yirrkala - they have a buffalo *bungul* (ceremony)'. It was also suggested by Molly that 'Tiwi Islanders dance buffalo but no one from here has buffalo dreaming'.

Five respondents claimed that buffalo has no dreaming association at all. Mick stated vehemently that 'buffalo has no dreaming, no culture' and that 'it doesn't belong to the land'. Mostly these people stated that buffalo were not owned by anyone although Andrew stated that buffalo were owned by 'overseas mob'. Billy said that he 'was not sure if buffalo had a dreaming'.

5.3.4 Origins of feral animals

Some Yolngu people said that they did not know where feral pigs came from, whilst others had various beliefs regarding their origin and the time when pigs were first seen in the Arafura area. Some people were aware that feral pigs had originated overseas.

Molly suggested that 'pigs came from New Guinea or maybe Africa', while Andrew thought that 'pigs maybe came from Asia'. Ella said that 'pigs came from Oenpelli or Darwin, spread from there; they came from somewhere else before Oenpelli. Maybe pigs came with islander people maybe from Papua New Guinea. Because missionaries were from Fiji, they might have brought pigs'. She also explained that 'at Nangalala when there were stock cows, they brought the pigs then with missions in the 1960's. The pigs at Millingimbi came with the missionaries who then brought them here.' David explained that 'pigs came from Asia, before there was no pigs only one at Djimarda (a Maningrida outstation) as a pet then it bred up and came here, lots of them.'

People explained that pigs were established in other parts of the Northern Territory (such as Maningrida, Oenpelli, Darwin, Bulman and Roper River) before they arrived in the Arafura area. Jane said 'don't know, pigs maybe came from Bulman'. Robert wasn't certain about the origins of pigs either but thought that pigs may have spread from Oenpelli. Billy explained that 'pigs came a few years ago to Ramingining through Gunbalanya (Oenpelli) or a few piglets came here and people kept them and fed them, then they ran away and bred more and more every year. Before that in 1950's I saw pigs near Mary River, they came from that way. Also in the 1970's people brought back pig from Jim Jim way (part of Kakadu National Park) and looked after it at Mulgurrum (an outstation near Crossing).' Molly had also seen pigs in other places saying 'I've seen lots of pig at Oenpelli and down to Pine Creek and Jim Jim.' Billy and Molly both recall that pigs were first seen in the area in the 1970's.

Several people remember that piglets had come from various places as pets and people fed them and looked after them. There were only a few pigs at this time but later they ran away into the bush and bred. Annie said that 'pig first came as a pet from Bulman or

Roper and had babies then they ran away; then the same thing happened at Yathalamarra and Nangalala.' Annie first recalls seeing pigs in the area around 1975. Joanne also said that 'pigs first came with Yolngu as a pet at Nangalala, and then they bred up.' She thinks that pigs were first at Nangalala in 1975-77, which concurs with the timing Billy suggested.

When questioned about whether pigs arrived before or after white man, most people said that pigs arrived in the area either at the same time as Balanda or after Balanda. Margaret explained that 'pigs were not here before Balanda, there were none when the mission was first established at Nangalala.' However, Caroline suggested that 'Balanda brought pigs here with the mission stations' which could imply that they brought them sometime after they first established.

Some people did not know what pigs were or what they looked like before they arrived in the area, others said that they had seen pigs in books or seen pigs that the missionaries kept at Millingimbi. When asked where pigs were first seen in the local area, people named homeland centers (outstations) including Nangalala, Yathalamarra, Gatji and Bundatharri as well as a hunting place called Djapidingorin (Figure 2.1). When specifically asked whether pigs occurred at Maningrida (to the west of Ramingining, see Figure 1.2) or Mirrngadja (in the south east corner of the Arafura Swamp, see Figure 2.1) before Ramingining, many people thought that there were pigs at Maningrida but that they were not at Mirrngadja.

Most people had some ideas about where buffalo might have come from. It was believed by many people that they had come from overseas (Asia, India, Timor and China were suggested) although some people suggested that it was a local animal.

Robert said 'it (buffalo) comes from India'. Julie said that 'buffalo are from Timor, belongs there, not here.' She also said that 'buffalo have been here for a long time since my great great grandfather's time.' Ruby explained that 'buffalo have always been here'.

Some people thought that buffalo had come to the area with the Macassans from Sulawesi on one of their many seasonal journeys to the area. Others thought they came with pastoralists who ran the cattle station in the 1930's or 40's. David said 'buffalo were here (before Balanda), they came with the Macassans who tried to grow rice in paddocks, it got washed away in the wet and buffalo ended up running away.' Molly explained that 'buffalo came from India, they came from overseas, Macassan people and stockmen from Murwangi who brought the first cattle, maybe they brought the buffalo. My father told me that buffalo came with Macassans from Indonesia and Captain Cook.' Annie explained that 'buffalo and cattle came in the 1930's or 40's when they started the (cattle) station, long time ago.' Origins in other parts of the Northern Territory including the buffalo station at Mary River were also suggested. Billy said that 'buffalo came from buffalo station at Mary River - Jim Blyth and others, they had heaps of pigs and buffalo there.'

Buffalo were first seen near homeland centers including Nangalala, Yathalamarra, Gatji and Bundatharri. It was thought that there were only a few buffalo originally but that they had 'bred up' since then. Billy recalled 'in the 1940's I had heard about buffalo and seen tracks but I hadn't seen the animal yet, in 1960's there were not so many buffalo but since then they have bred a lot, in the 1980's there were not so many buffalo but then the numbers increased a lot after that.' The lower numbers of buffalo in the 1980's may be related to the Brucellosis and Tuberculosis Eradication Campaign (BTEC) that was operating at this time.

5.3.5 Perceptions of feral animal impact on country

The majority of people believed that pigs were bad for country and did not belong here. Nobody could name any good things that pigs did but there were a variety of negative effects on country, which pigs were held responsible for. These included digging, eating bush foods, fouling waterholes, damaging sacred places, eating other animals and causing sickness. Billy said 'they are not Yolngu animals'. He also explained 'country was beautiful before pigs, medicine was on trees, the animals came. Can't chase wallabies anymore because of the holes. Before there was no digging, only light from wallabies not heavy animals. Pigs are killing our food, killing everything that moves and grows on the land. In a few years if pigs grow more and more we won't find anymore roots in the swamp.' Ruby explained that 'pigs are not good, they make worse the swamp for long-necked turtle, goanna, file snake and python, they make swamp muddy for those animals and they eat those animals too'. Annie stated that 'pigs swim in small creeks and eat fish, file snake and turtle, they are damaging the land, there is less bush food now and they leave sickness when they drink from waterholes.' According to Caroline, 'pigs damage country, they dig all around, can't find roots, string, yam or long-necked turtle anymore, they are messing up swamps and waterholes, dreaming places and places people rely on for drinking water. The animals are urinating in the swamp. They make too many holes that make it hard for hunting. I'm worried about people's health'. A similar view was expressed by Ella who explained that 'they (pigs) dig long-necked turtle and eat all our bush tucker, pigs bring sickness, people used to get water from swamps and springs but pig mess up too much now, pigs are weeing in swamps which is bad- we are worried about sickness, there are no foods left so we need to eat pigs now, dog dreaming waterhole is bad now - all messed up from pigs.'

Most people thought that there should be no pigs or fewer pigs, only one woman suggested that there should be more pigs because they are good. Feral pigs were seen by most people as not fitting in with other animals and even harming other dreaming animals. Mick explained that 'pigs tackle and chase other animals, pigs have strong teeth'. Jack added '(pigs) spoil (things), fight together, eat file snakes, other snakes including king brown, *nyiknyik* (small rodents), worms; snake and pig fights and pig wins'. Mary said 'they cause problems for *djanda* (goanna) and turtle, we didn't get many goanna this year or last year because pigs ate them, same for turtle'. There was also concern about pigs at outstations. One outstation group complained about the pigs that were pets at a neighboring outstation and thought they should be killed. The outstation group who kept the pigs didn't see them as a problem as they were pets despite the fact that they acknowledged the extensive damage caused by the 'wild' pigs less than 50 metres from their homes.

Interestingly, little concern was expressed over the damage pigs might do to gardens that people have planted. One respondent had an extensive garden in the main community that was well fenced and as such is not likely to have had trouble with pigs. Other gardens existed and were being developed at various outstations. Concern about pigs messing up these gardens had been mentioned but only occasionally to explain to the resource center that they needed fencing materials for these outstations.

Approximately two-thirds of respondents believed that buffalo were damaging to country, the remainder believed that they did not harm country at all. Eight respondents stated that buffalo do not belong in this place while seven others stated that they did belong. Nevertheless, a majority of people (81%) thought that fewer or no buffalo would be preferable and only two respondents thought that more buffalo would be acceptable. People expressed various concerns about the effects of buffalo including reduced hunting capacity in the area and habitat destruction. Robert stated that 'buffalo is sometimes OK and sometimes makes holes.' Jane said 'buffalo break trees and chase people', while Mick explained that 'they (buffalo) bring weeds on their feet.' Andrew stated that 'buffalo walk through the swamp and make too much mud when goose hunting'. Billy explained 'buffalo are very heavy animals, they knock down trees, dreaming trees and places, destroy goose nests. These animals make so many tracks that *djanda* (goanna) can't dig for holes in the hard ground and not enough grass grows for burning. Women can't see *djanda* or turtle tracks anymore'.

Five respondents thought that there were some good things about buffalo. David said that 'buffalo were generally alone'. Lily said 'there are no bad things about buffalo, they just walk around.' Ella explained that 'buffalo is fine, he moves around, doesn't live in the same place, sometimes they go other places in dry season – maybe where there is good water to drink' Ruby said 'buffalo do nothing good but they always live in the bush, not too close to camp which is good'. Margaret thought that the only good thing about buffalo was its meat.

There were mixed responses as to whether buffalo fit in with or cause any harm to native animals. Some people had definite beliefs that buffalo were a problem for other animals. Joanne said that 'buffalo feet damage turtle place' and Billy said 'buffalo knock down goose nests'. Many respondents did not think that buffalo were harmful to country as David explained 'they keep to themselves, sometimes hang with the bullicky (cattle)'. Lily thought that buffalo were not a problem saying 'they don't harm other animals, buffalo eats grass like pigs. Pigs eat worms and digs with nose, they live in the same country as each other'.

There were several sacred sites that people specifically mentioned being concerned about. One of these was a waterhole and people were very keen to fence the area to protect it. Much of the current concern about pigs and buffalo is amplified by the damage they are causing to sacred site areas as mentioned by several respondents. Mick explained that these animals are often seen as having 'no respect' and 'no culture' and Billy said that they are thought to be responsible for damage to sacred places. The protection of sacred sites from damage caused by pigs and buffalo is extremely important to Yolngu. They believe that if these sacred sites are not protected from damage, then country is not being properly cared for and people may become sick as a result.

5.3.6 Fear of feral pigs and buffalo

Several people had stories to tell about being chased by pigs and/or buffalo. David said 'I was chased by a pet pig but not hurt, I've also been chased by buffalo but not been hurt. A long time ago a man was nearly killed by a buffalo but that was before I was born.' However, most people said that these animals did not frighten them, although a few people mentioned being frightened if they came across pigs or buffalo in jungles. Julie said that if this happened, people would climb trees for safety. People generally make a lot of noise in these areas hoping that pigs and buffalo will run away from them. Ruby and several other women explained that 'buffalo only get angry and chase people when they are being shot at.'

5.3.7 Control of feral animals

Overall, when asked whether pigs and buffalo should be controlled people expressed support for the idea. Many people do not like them and suggestions by Yolngu to 'get rid of them all' or 'keep numbers low' were common. Nearly all respondents thought that reducing the numbers of pigs and buffalo was a good idea and the main sentiment was that if these animals went away, the land would be better. Mick said 'land and vegetation and animals would go back to normal' and Julie said 'country good, water full and clean, trees grow up good, swamps clean.' Joanne explained 'good country, Yolngu would be happy, better roads, less trouble with vehicles, less hurting of people who fall into holes and hurt ankle, knee and back.' David said 'everything would be smooth; if we shoot them all (pigs and buffalo), landscape would go back to normal.' Ella said 'country would come back good again, clean swamp, clean water, clean dreaming places, now we have to boil the water to drink it.' One positive perception Yolngu held about pigs and buffalo was their value as a source of meat. Some concerns were expressed about a reduction in the availability of meat if pigs and buffalo were removed from the land although this was mainly with respect to buffalo as many people do not value pig meat very highly.

All respondents believed that some form of feral pig control was necessary and many thought that complete eradication was preferable to help protect spiritual places as well as food resources. Nearly all people thought that buffalo should also be controlled but it was obvious that they were not considered to be as much of a problem as pigs. When asked whether they would prefer to have pigs and buffalo taken away or have them stay, most respondents thought that the pigs should be taken away from this country and many suggested that both pigs and buffalo be removed. Julie thought that some should remain to ensure that royalty payment from safari hunting operations at Murwangi cattle station continued.

Three respondents thought that all the pigs should be taken away but that some of the buffalo should remain. Robert explained 'leave some, getting rid of pig is OK but leave some buffalo for meat. It is also good to leave buffalo for trophy horns for tourists so landowners can get money and good jobs for Yolngu.' Lily thought they should all stay whilst Jane said that most should go but some of each should remain.

The only form of control of pigs and buffalo to date has been opportunistic shooting by Yolngu for meat and a very small number of safari hunters seeking boar tusks and large buffalo horns. Most thought that control was the responsibility of both Yolngu and Balanda. In terms of Yolngu, killing pigs was seen to be a good job for the rangers and anyone else who had a gun that could help them. Some people thought that Balanda should teach Yolngu how to do this work. Mick stressed that Yolngu must be involved saying 'everyone together but they (Balanda) have to listen to Yolngu and have to have Yolngu present.' Billy stated that control should be undertaken by the army saying 'I think it should be used as army training with a helicopter, kill them all, bring some meat to Yolngu, get rid of them; I expect government people or government funding to help get rid of pigs.'

Many people commented that pigs that are shot should be brought back to Yolngu as food rather than the meat be wasted. Ella said 'shoot pigs and give meat to outstations.' Caroline said 'pig meat is OK for dogs, better to use them to make healthy dogs rather than just leave the animal.' She also asked 'can the skin be used for anything?'

Some people were aware of several control methods but shooting was the most commonly suggested. Trapping was also thought to be a good form of control with one woman suggesting that it would be better than shooting because pigs often get away after being shot. Other people didn't care how it was done as long as the pigs were gone. When asked what Yolngu could do to help try to get rid of the pigs, many people suggested asking the rangers for help as well as shooting and eating the pigs. Ella suggested 'get rangers to talk to people and tell them how to look after their homelands by shooting pigs.' Annie said 'we could take pigs to Murwangi (cattle station) they can send them to Darwin and give money to landowners. If they don't, I will tell the rangers to kill all the pigs.' Jessica explained 'we need to get people to help rangers, more Yolngu to help, ask Balanda for money so more Yolngu can work with you to help kill pigs, 30 or 40 Yolngu so they can spread out, 5 or 6 to each of Bundatharri, Gatji, Gulpulil, Garanydjirr; these are the main places, that way pig can be gotten rid of.' Many people also thought that more guns and trucks were needed in order to control the pigs.

Billy expressed concern that many of the younger people in the community had no desire to look after country or any perceptions of the problems that feral animals were causing. He also suggested that many young people do not remember the land before these feral animals arrived and thus have no comparison to its current state – 'Young people who were born after country had already changed won't always know to get rid of these animals'.

People's views about whether permission from landowners was needed to shoot pigs varied. Some thought that you only needed permission to shoot other Yolngu animals, not pigs and buffalo; others thought that if you were a Balanda person, you needed permission, but if you were Yolngu you didn't; some thought you didn't need permission at all.

5.3.8 Earning an income from feral animals

Most people thought it was possible to earn money from pigs and many suggestions were put forth as to how this could be done. Jessica said 'instead of killing the pig, get live ones to sell to other places so landowner can earn money.' Annie said 'Yolngu should have a pig farm, round them up, keep them, then send piglets to Darwin.' Andrew said 'if they want to, I don't know how, maybe a market around the community, sell the meat to the community.' Margaret suggested 'have a business selling meat for pets.' Mick suggested 'tourists paying landowners and rangers for shooting.' A few people thought that the most important thing was that the pigs were controlled and as such, income from these animals should not be expected. Alternatively, it was suggested that any money earned from pig control should be put back into the ranger unit as Mick explained 'to improve wages and equipment, bullets and rifles, get the right bullets for pigs and buffalo.'

Overall there seemed to be acceptance about the idea of tourism in the area with a few Yolngu groups considering the potential of setting up camps at outstations as bases for safari hunters and other tourists. These outstation camps would be set up and run for tourists and would cease to function as outstations for Yolngu during the tourist season. The majority of respondents thought that safari hunting was a good idea and a good way to help the rangers control feral pigs. There were a number of conditions that some people placed on this activity including that the landowners should received money from this tourism. Billy said 'safari is OK as long as all Yolngu clans work with the safari.' Andrew though that there was no need for people to pay saying 'its OK to shoot them and not give landowner money as long as they are not selling the meat, because the damage is bad.' Half of the respondents thought that Yolngu should run the safari operation themselves and the others thought that it would be good for Yolngu and Balanda to do it together.

All respondents thought that a pet meat industry was a good idea and most suggested that both Yolngu and Balanda should run such an industry. Jessica suggested 'best way is to teach Yolngu how to do it.' Margaret agreed saying 'both, Balanda teach Yolngu, then Yolngu take over.'

5.4 Discussion

5.4.1 What does feral mean?

The Oxford Dictionary defines the term 'feral' as meaning wild or untamed (Sykes 1976). It is also commonly used to refer to species that are exotic (i.e. originating from another country) which have successfully bred outside of captivity. Some Yolngu, like many non-indigenous people, did not fully understand the meaning of 'feral' as being of exotic origins. It may have been interpreted in some cases purely as 'wild and untamed' as when Yolngu named a variety of native species as feral alongside pigs and buffalo. Similar responses were recorded amongst Yolngu living at Donydji, a community south east of the Arafura Swamp (N. White pers. comm.2002).

Europeans categorise animals into domestic or tame, and wild or feral (Suchet 2001). Usher (1995) suggested that wildlife is '...not an objective description but a cultural statement of the relationship of people and animals (and habitat) in an agricultural, settler heritage. It appears to have no direct equivalent in Aboriginal languages.' Nevertheless, Yolngu make a clear distinction between domestic animals (pets) which are called *gurrutumirr* and wild animals called *wa:rrang* (often called 'wild ones' when English is spoken) even when they are the same species. *Wa:rrang*, which translates as wild (and is the word for dingo), is used in opposition to *gurrutumirr*, which translates as having a place within the family or within the 'close' construction of relations. Both *gurrutumirr* and *wa:rrang* could be either native or introduced animals. Various animals were kept as pets in the community including dogs, cats, pigs, young wallabies, whistling kites, pythons and immature long-necked turtles.

Similarly, Hamilton (1972) found that the Yankunytjatjara of the Everard Ranges made a distinction between domestic dogs and cats, and wild ones. It was not uncommon for wild animals with domestic equivalents to be killed but if a domestic animal was injured or killed, even by accident, this action was strongly condemned (Hamilton 1972). This attitude also prevailed in Ramingining where I observed serious consequences following the killing of a pet pig. Domestic animals were not usually eaten even when wild animals of the same species were (see also Hamilton 1972). This was equally apparent where pigs were concerned in Ramingining.

5.4.2 Awareness of the issues

People's history and experiences are contextual and formative of their current attitudes towards, and interactions with, the land (Strang 1997). However, attitudes and aspirations are not static; they are in a continual state of development and change as a result of new circumstance or influence. Baker (1999) for example, notes that Yanyuwa environmental knowledge is continually evolving, as people have been open and retentive towards new information and experiences in this matter. Attitudes to new or unfamiliar issues are more susceptible to change than those towards familiar issues (Pearce and Moscardo 1988). As Nugent (1988:2) explains with respect to changes caused by feral animals in Central Australia:

> ....the degree to which Aboriginal people have been exposed to Western attitudes and influenced by them needs to be considered. In these circumstances it can be difficult to resolve what is a 'traditional' objective opinion on these changes to their country and what is a synthesis of views.

Feral animals and weeds have recently become hot topics discussed widely amongst indigenous communities in the area, especially those where land management activities have recently broadened. The discovery of small outbreaks of the aggressive weed *Mimosa pigra* on custodial estates belonging to people living at Ramingining and Maningrida was the main incentive for these northern communities to formalise and develop local land management initiatives, including the community ranger program (Smith 2001).

The development of perceptions and aspirations regarding feral animals amongst Arnhem Land Aboriginal people has been influenced by many external factors including the views of European land managers, scientists, representatives from various government agencies and tour operators. This is especially true about perceptions of feral pigs as a relatively recent arrival in the Arafura area. For example, Murwangi cattle station, which has an entirely Yolngu management board, was involved in pig control in conjunction with government agencies. It was also operating a safari hunting tourism business shooting pigs and buffalo, a venture that paid royalties to some landowners living at Ramingining. Although this business and other ranger activities only directly involved a few Yolngu, much consultation and discussion would have followed with others resulting in increased community awareness of land management issues. My arrival and research intentions may also have aroused people's interest and led to increased discussion about wild pigs around the community. It is impossible to determine the full extent that these various external influences have affected Yolngu awareness and perceptions.

5.4.3 'Belonging' of feral animals

Yolngu involved in this study were clear about feral pigs not belonging to their culture in any way with most respondents stating that pig has no dreaming and does not belong to this land. People's recollection of the arrival of feral pigs within their lifetime will have influenced the belief that these animals do not belong to, or originate from, this area. Bradley (2001) in discussing Yanyuwa people's views regarding the introduced cane toad (*Bufo marinus*) explains that when things have no connection or relationship to anything, they are often considered 'utterly meaningless'. This same sentiment is felt by Yolngu about feral pigs and is especially obvious in Mick's statement 'they (pigs) are rubbish animals' (see Interview 2 question 3).

Conversely, there were a range of views, some contradictory, that were held about buffalo. Buffalo is firmly entrenched in the Yolngu subsistence economy being an important food source and as Altman (1982b) notes for the eastern Gunwinggu people, buffalo hunting is important in this region. Yolngu respondents in this study expressed different thoughts about whether buffalo belonged to Yolngu mythology. Mick (a ranger who belongs to a Gupapuyngu speaking clan) explained that buffalo had no dreaming and that it did not belong to anyone. However, Jane told me specifically to ask Mick about buffalo dreaming as it was his 'grandmother'. Annie also explained that buffalo was dreaming for Gupapuyngu speaking people. Eight respondents (only one of these was male) said that buffalo belonged to the *Yirritja* moiety and most women I spoke to mentioned either people or local clan groups that had spiritual associations with buffalo. Interestingly, some women who stated that buffalo did have spiritual connections with local clans did not necessarily believe that these animals belonged in the area. It may be possible that Mick was not willing to discuss with me any views other than the one he presented. All other male respondents either stated that buffalo had no dreaming or expressed uncertainty about the dreaming status of buffalo, which may also have been indirectly asserting an unwillingness to discuss the matter.

These apparent contradictions about buffalo may have developed over the long time period buffalo have been present in the Top End and are not exclusive to the people at Ramingining. Altman (1982b) explains that buffalo has to some extent been integrated into eastern Gunwinggu mythology and art despite the fact that there is no ceremony in which buffalo features as a totem nor are there any consumption or production taboo's associated with buffalo, which are normally associated with totemic animals. This partial integration seems to have lead to some confusion with younger people unsure about the status of buffalo often saying that it has no 'skin name' (social category/subsection) as it is a Balanda animal, whereas older people demonstrated detailed mythological knowledge about buffalo (Altman 1982b). Altman (1982b) suggested that integration of buffalo into mythology may have been more complete in the past but has been undermined by European notions of buffalo being an introduced animal.

5.4.4 General perceptions of pigs and buffalo

Feral pigs are a relatively new arrival to the Arafura Swamp area and they have no place in the spiritual realm that Yolngu and 'dreaming animals' exist within. Billy clearly stated that "they (pigs) are not Yolngu animals". Due to their holistic view of the land and species as parts of a balanced system, reliable food productivity (with seasonal variation) is an indicator of the health of country to many Aboriginal groups (Rose 1992, Bradley 2001). Divergences from this balance, such as unusually low supplies of particular foods, can be seen as reflections of a disturbed spiritual world, which people feel responsible for.

Most Yolngu involved in this study strongly dislike the presence of feral pigs on their land. The main concern that people expressed about feral pigs was that they were eating many important Yolngu foods. It is not that Yolngu were not concerned about other impacts on the land but rather that resources provided a meaningful gauge. The signs of pig activity in many places are also very obvious and severe and most people have a clear conception of the physical changes that these animals have affected on country since their arrival. In addition, pigs can be dangerous when encountered, especially to women and children, which may have increased people's dislike for them.

Not all Aboriginal communities share this disdain of feral pigs, in fact many Cape York communities consider pigs to be an important food source (Wilson et al. 1992b). Feral animals have been present in Central Australia over generations of Aboriginal people. Through this long association, the animals are seen to have the right to live on country and whilst some changes to the land are acknowledged, they are mainly seen as natural (Rose 1995).

Most Yolngu believe that feral pigs don't fit in with other animals. This perception is likely to be derived from observing the impacts on food animals and their habitats especially in resource rich locations (e.g. the impact on swamps as key long-necked turtle habitats). Not all exotic species are thought of as not fitting in. Some weed species, which are relatively new introductions, are not considered to be harmful to Yolngu land, they are eaten by some animals and thus have been accepted as part of the landscape (Smith 2001).

Whilst there was recognition amongst Yolngu that buffalo cause some problems to the land (e.g. making wallows and compacting the ground in long-necked turtle habitats), they have been in this area for a long time and some respondents thought of them as fitting in and belonging to the country. Other people clearly did not think that buffalo belonged and others took the perspective that buffalo were not a major concern to country stating that buffalo 'just walk around' (Lily). Buffalo do not directly consume any of the same foods as Yolngu. They do eat spike rush (*Eleocharis* spp.) but Yolngu in this area no longer regularly consume the corm of this plant. Some of the damage made by buffalo is subtler than that made by pigs, which may partially account for some people's perceptions of these animals. Further, as buffalo have been in the area for a long time any changes to the land are likely to be more familiar than the recent and obvious changes caused by pigs and may even be considered normal by some members of the younger generations.

In central Australia, Rose (1995) found that notions of land degradation as western land managers describe is not common among Aboriginal people, who although acutely aware of changes to the land, see it as a 'natural' result of land use, i.e. if cattle are using the land it is expected that some changes will take place. Yolngu have a long

Buffalo and pigs are free from consumption restrictions associated with taboos allowing access to this food source by all community members, which may contribute to their popularity as a source of meat (Altman 1982b).

6.4.2 Effects of pigs on Yolngu hunting patterns

There is definite spatial overlap in the places from which people and pigs obtain many of their seasonal food resources and consequently there is increased pressure on resources in these areas. Yolngu assistants told me that it generally takes more time to find certain bush foods than it used to. Increased pressure from feral pigs may be the reason Yolngu need to spend longer procuring bush foods, especially those that have probably been reduced in supply, such as long-necked turtle and yams. Increased hunting time aside, feral pigs have had a limited effect on peoples hunting patterns to date. Yolngu assistants told me that fear of feral pigs had prevented a few women hunting in monsoon forests but that most people were not frightened. Degradation of hunting places, including decreased abundance of resources, is of greater concern. Although I was only told about one place where hunting for long-necked turtle had been abandoned due to pig and buffalo damage, this could extend to other places if these feral populations continue to grow.

It is important to be aware that the availability of resources is not the only reason that people choose to collect food at particular locations. Social, cultural, economic and logistical factors also influence people's behavior including sentimental attachment to place, religious activities, employment demands on time and the availability of vehicles and water (Povinelli 1993). I observed many of these factors affecting people at Ramingining. Hunting trips were most common on weekends due to the fact that many history of involvement with pastoralism in the Arafura area (Chapter 2) that may have also influenced their perceptions of buffalo. The effects of buffalo on the land are similar to cattle and perhaps buffalo are actually thought of like cattle. It is unclear whether Yolngu perceive lesser damage as natural and greater damage as a problem or whether it is increasing awareness of land degradation in general that is driving perceptions. Understanding this issue is further complicated by the fact that income earned from pastoralism (and safari tourism) may have affected peoples perceptions about any damage cattle and buffalo might be causing.

In the early 1970's, Meehan (1988) noted that Anbarra people were wary of buffalo and altered their foraging patterns if buffalo were observed grazing nearby. Anbarra women and children at that time were sure that buffaloes would attack them (Meehan 1988). This fear probably also existed amongst Yolngu women at this time. While fear of buffalo remains today amongst some Yolngu women, those I spoke to have become familiar with the presence of buffalo and generally expect to come across them in the bush. Women are alert and wary of buffalo when hunting but most are no longer frightened.

Threats to sacred places commonly elicited greater interest and concern than non-sacred areas. Several Yolngu involved in this study expressed considerable anxiety about the effect pigs and buffalo were having on sacred sites and waterholes. Similar concerns have been recorded amongst the Yanyuwa who acknowledge that cattle have been responsible for damaging a mythological site and also for the premature drying out of lagoons (Baker 1999). Some Aboriginal people in Central Australia also expressed concerns about sacred site and waterhole damage but generally they accepted the presence of feral animals with some people believing they had little effect on country or native animal species (Nugent 1988, Rose 1995). The main feral animals discussed in the Central Australian study were horses, donkeys and camels that do not share the same food resources as Aboriginal people, which may have counter-balanced people's perceptions about the impacts of these animals.

The need to protect sacred sites has been recognised by European law under sacred sites and heritage protection legislation (Rose 1995). However, the importance of protecting country as a holistic entity has not been recognised in this way. The pragmatic side of protecting sacred sites from feral animals involves physical protection of these sites (e.g. surrounding them with heavy wire mesh fencing). Yolngu are aware that this kind of protection is necessary and are seeking assistance to undertake this task.

Some Yolngu may have been reluctant to suggest buffalo were bad for country or should be removed because of the possibility of cultural significance to some groups. Spiritual beliefs (or lack of awareness?) may also explain the unwillingness to include cats in discussions about feral animals. Only one person mentioned the domestic cat as being a feral animal, but they stressed that this was a different animal to the native cat (Northern Quoll *Dasyurus hallucatus*), which is spiritually very significant to these people. No Yolngu respondents mentioned that large numbers of feral cats roam the floodplains at night (as I observed), nor was it suggested that cats might be responsible for the rarity of a number of small mammals including the False Water-rat (*Xeromys myoides*) and Golden Bandicoot (*Isoodon auratus).*

5.4.5 Management of land and animals

People conceptualise things differently depending on their background and experience. It is important to understand how Yolngu conceptualise feral animals and land management. Do the concepts and actions behind these terms mean the same thing to Yolngu as they do to other land managers? Yolngu relate to the land and animals as kin and care for or 'manage' the land in accordance with their own systems of belief and knowledge. For example, killing animals for food is a part of Aboriginal people's interaction with the natural world and is not wasteful. This interaction has rules and is premised on respect for all parts of nature, which have equal rights as equivalents in the natural system (Smyth 1994, Suchet 2001). This perspective makes it very difficult for many Aboriginal people to accord validity to the western interventionist style of land management. Thus, controlling animals (often by killing them) for the benefit of conservation or economics does not fit into the Aboriginal worldview (Rose 1995).

Over the last decade, Aboriginal people have had increasing contact with western land managers and a multitude of new land management challenges and consequent technologies on offer. Ecological changes such as the introduction of feral animals and weeds may require new and different approaches to management than those used previously (Rose 1995).

Full involvement in all land and animal management activities is a common desire for many Aboriginal groups with most feeling that it is their land and their job to look after it. They know the 'Law' and are responsible for carrying it out properly (Nugent 1988, Rose 1995, Bradley 2001, Robinson and Munungguritj 2001). Local people's involvement ensures some control over actions and decisions made about managing their land. It also functions to protect people (both local and outsiders) and places by guiding the activities of outsiders (i.e. preventing them doing the wrong thing or going to the wrong places which could lead to harm for them and/or Yolngu). Local rangers, who are generally well supported by the community, provide some of this community involvement. Many Yolngu involved in this study commented that control of feral animals and weeds is good work for the rangers. It was suggested that they are the right people to do ranger work having both traditional knowledge of the physical and spiritual nature of the land as well as the resources and new information provided through ranger training.

The inception of rangers and the desire for further training and resources demonstrates a degree of acceptance by Yolngu of the need for the inclusion of western land management concepts to adequately care for custodial lands under new circumstances. Nevertheless, within the community traditional and western management roles remain fairly distinct. Whilst at work, community rangers primarily engage in 'western management' issues (such as weeds and feral animals, restoration arising from infrastructure developments, collaboration with government agencies, the development of businesses based harvest of traditional products). Traditional management issues such as burning are still very much in the domain of the traditional owners. Burning as a land management tool has only become a task for local rangers or western land managers in areas where traditional owners no longer have access to country.

While the role or action of the ranger is based on western land management ideas, by the nature of the work, rangers have the opportunity to be on and observe country which is as an integral part of traditional land management (Povinelli 1992). Negotiation of traditional community political structures is also inherent in ranger work. Although this study has not attempted to delve into the political world of the Yolgnu, there must be acknowledgment and awareness that internal political processes will be at play when decision making regarding land management and more specifically feral animals is being negotiated.

5.4.6 Attitudes towards control

The attitude amongst some Aboriginal people in Central Australia was that feral animals were not really causing harm to country and consequently people couldn't understand the point of control programs for feral animals (Rose 1995). Conversely, many Yolngu believed that feral animals were having a detrimental effect on country and most people interviewed clearly thought that removing or reducing the numbers of these animals would improve the health of country. Thus, perceptions of the effect of feral animals on country have influenced people's ideas about management and control.

Whilst there was a strong desire to control feral pigs and buffalo amongst Yolngu involved in this study, this desire did not exclude the possibility of earning an income from these animals (e.g. via the sale of meat or safari hunting tourism) or maintaining small numbers of animals for subsistence. Smith (2001) found that Aboriginal people in the Top End expressed little or no desire to remove or control weeds species that they considered highly useful. Similarly, the value of buffalo meat to Yolngu will influence management of this species. This was clearly pointed to by several Yolngu who suggested leaving some buffalo for meat or for safari tourism. Given that feral animal management strategies may be influenced by the economic or subsistence value of these animals, finding a balance between management for control and maintaining the value of these species may be the most appropriate and beneficial approach.

Yolngu were not opposed to any control methods that were discussed, including shooting, in fact many suggested that shooting was a good way to control pigs and buffalo. This view was in contrast to that of many people in Central Australian communities who preferred control methods that did not harm the animals and suggested that shooting was wasteful or cruel and that leaving carcasses could bring disease and flies to the area (Nugent 1988). Several Yolngu people also thought that leaving carcasses was wasteful and suggested that the meat could be used as food.

Whilst many animals are important food sources to Aboriginal people, many are also important to people spiritually through personal and tribal connections. These animals were once human and are important links to the spiritual world and any 'unnatural' killing of tribal animals is thought to bring sickness to people (Suchet 1996, 2001). Community members who consider buffalo to be spiritually important might want these animals to be controlled in a culturally appropriate manner (perhaps mustered and sent elsewhere). This issue needs further discussion within the community.

5.4.7 Earning an income from feral animals

Many Aboriginal communities are becoming interested in the potential of tourism and the commercial use of wildlife (both native and feral animals) as sources of income (Wilson et al. 1992a, Rose 1995, Bomford and Caughley 1996b, Davies et al. 1999). Despite the fact that most Yolngu thought it was possible to earn money from feral animals, there was little consideration or enthusiasm for the logistics or effort involved in such operations. Similarly, Rose (1995) found that many people in Central Australia did not fully perceive the amount of work involved in running tourism ventures or did not have the skills or desire to do so. Many Yolngu were very aware of the concept of safari hunting tourism as it was being undertaken on a very small scale at Murwangi cattle station. Some profits from this operation were passed on to some landowners making people very aware of the potentially lucrative nature of this type of venture. To overcome lack of experience in this kind of work whilst still accessing some of the financial benefits, some Yolngu thought that working in partnership with Balanda was a good solution.

5.4.8 Interpretation and influence

People have different relationships to their land, such as primary owner or manager/caretaker (Williams 1986, Keen 1994), and these relationships have associated responsibilities which influence both the areas people are willing to comment on and also the perspectives they present regarding 'management' of a place. Yolngu have connections to more than one place but their discussions were generally focussed on country that they were very familiar with and were able to speak for (usually their traditional lands if these were nearby and visited often). Although the questions posed about feral animals were not specific to any one location, the variable impacts of feral animals on different locations may account for some of the variability in the results.

Gender also influenced responses about the effects of feral animals. The results reflect that foods commonly collected by women are more likely to be affected by feral animals than those obtained by men (Chapter 6). Males made more general comments about the effects of feral animals whereas women generally made very specific comments about the effects on particular food resources (see Appendix 3).

Variation in responses regarding the origins of feral pigs may reflect personal experience. In some cases people had seen pigs in other places, or heard about them being in other places, before they were seen locally and concluded that they came from this place. Stories told by Balanda or other Yolngu might also have influenced people's beliefs. Family histories may have influenced beliefs about the origin of buffalo. People whose families were involved in pastoralism may believe buffalo were brought to the area with the cattle, whereas others may recall stories of the Macassan visitors and believe that they brought buffalo to their land.

Interpretation can also affect people's responses to questions. Variation in the responses to where buffalo came from may be attributed in part to differences in the way the question was interpreted. Some people seem to have interpreted the question to mean where did the animal originate i.e. which country; others to mean 'where was it before coming to the Arafura Swamp'.

The phrasing of questions can also greatly affect the response given by people. Nugent (1988) found that more general questions such as asking whether an animal harms the country would elicit a negative response, but more specific queries, such as whether the animal makes the ground bumpy or muddies waterbodies would usually elicit a positive response. He noted that this was more often the case when people were unconcerned about the issue of feral animals. The more general open-ended questions that were asked in this study elicited a variety of responses, which included both the negative and positive views of feral animals. In this study, those people with a strong negative view of feral animals would provide an immediate and positive response to the general question type. Nugent (1988) also noted this type of response in this situation. Specific queries were not asked in response to obtaining a positive view of these animals.

Perhaps the individual responses reflected a perspective with a different emphasis (weighting of the balance of perspective) depending on context or other factors that may not be immediately apparent to westerners.

External information can have great influence on some people's beliefs and ideas. Two respondents had very different views about eating pig meat that were probably derived from external information. Ella said that she eats pig because it is wild meat and that is good for you. As a health worker she is likely to have been exposed to campaigns advocating wild meat as being lean and healthy. Conversely, Billy said that he only eats pig if it is bought from the shop as he has been told that wild pig meat is dirty. This type of information may have originated from the Australian Quarantine Inspection Service (AQIS) who monitor the area for diseases in pigs.

5.5 Concluding comments

This work demonstrates that there is a diversity of opinion about feral animals (pigs and buffalo), influenced by people's current situation and background (their country, their community position and relationships with others and external influences). Diversity in opinion and views is a normal occurrence that would be expected to be found in any society as Smyth (1994:5) notes:

> Aboriginal and Torres Strait Islander peoples belong to diverse, *contemporary* communities, each containing individuals with different perspectives, life experiences and aspirations. While there are many shared interests based on their status as indigenous Australians, it should be expected that there is a diversity of opinion within communities about all issues, including the significance of land and sea.

Understanding Yolngu perceptions and aspirations concerning feral animals and gaining insight into the factors that have influenced these is essential for the development of successful management programs in the Arafura wetlands. With this awareness, western land managers can work with Yolngu to make management more appropriate to the local situation. Recognising the diversity of people's perceptions and goals is also paramount. This diversity demonstrates a need for further exchange of ideas within the community on the issue of feral animals and has implications for the levels of consultation that must be undertaken about all land management issues. Where disparity occurs between the goals of indigenous people and those of western land managers, mutual understanding can make negotiation more meaningful. Whist this discussion has emphasised the need for western land managers to understand the indigenous perspective, it is also essential that Yolngu understand the western science paradigm. Negotiating with government and non-indigenous people has become a necessary aspect of looking after country for Aboriginal people (Baker et al. 2001a). By making this process more approachable and relevant, indigenous capacity to negotiate and participate on equal terms will improve.

The following chapter considers how the seasonal use of habitat and resources by feral pigs affects resources and food items that are important to Yolngu people living in the Arafura Swamp area.

CHAPTER 6: Ecosystem and resource use by feral pigs – how does this affect Yolngu?

6.1 Introduction

There are an enormous variety of resources found in the natural environments of the Arafura Wetlands and surrounds in Arnhem Land. The regular climatic cycles that dominate the area dictate an equally regular resource cycle making the timing and locality of available resources, particularly staple vegetable resources, highly reliable (Thomson 1949, Rudder 1978/79, Altman 1984, Russell-Smith et al. 1997, White 2001b). Resource availability is especially stable in coastal environments because of greater habitat diversity in these areas (White 1978) and high primary productivity due to reliable water and nutrient availability. Yolngu have an incredible depth of understanding of their local resources, where and when they are found, their duration of availability, how to use and prepare the resources and their significance to other animals.

Whilst the resources used today in the Arafura wetlands are very similar to those recorded by Thomson in the 1930's (Thomson 1949), the contemporary diversity and intensity of resource use has decreased since that time. Some resources that were previously important are either rarely used or not used at all today; however, details of the habitat(s) in which they occur and seasonal availability are still remembered by many of the older Yolngu people.

Despite the contemporary changes that have occurred to Aboriginal diet and lifestyle, bush foods and subsistence activities are still very important to Yolngu both for obtaining food items and for maintaining culture. Regularly visiting country and being aware of its current state or changes that are occurring within it are essential to Yolngu culture and people's identity or relationship with the land. The importance of people's continuing presence in country and interaction with country has also been noted for other Aboriginal groups (see Rose 1992, Povinelli 1993, Suchet 1996, Bradley 2001). Hunting and gathering excursions also provide excellent opportunities for teaching children about land, resources and procurement techniques. In addition, some degree of status amongst male community members is achieved through hunting, with prestige given to a successful hunter (White 1985, Altman 1987, White 2001b).

I observed that many Yolngu families living in Ramingining went hunting (including fishing and gathering vegetable foods) each weekend in the dry season. Whilst store bought food was readily available, people preferred to collect bush equivalents to market goods, especially meat products, whenever it was possible to obtain them. Several people who I interviewed were also aware of the health benefits of eating wild animals. Native animals have higher proportions of polyunsaturated fatty acids than introduced animals and non-domesticated introduced animals have less saturated fat than their domesticated counterparts (White 2001). While frozen meat (usually beef and chicken) was available from the store, it was expensive and not commonly purchased (personal observation).

No estimates were made of the relative contribution of bush foods and market foods to the diets of Yolngu living at Ramingining or surrounding outstations. However, it is important to be aware that these people had regular access to market goods, which was constrained only by the amount of money available to purchase these goods and, for people living at outstations, the availability of a vehicle to transport these goods (White 2001).

People living at outstations tended to rely on their traditional knowledge and skills to collect bush foods and supplemented these with market goods such as flour, sugar, tea, milk and tobacco obtained during trips to town. The majority of people who live at outstations around Ramingining only do so during the dry seasons, preferring to come to town where market goods are readily available during the wet season. In the wet season, the contribution of bush foods to Yolngu diet declined as the hunting range was greatly restricted due to extensive flooding.

The introduction of store bought carbohydrates, which are inexpensive and readily available, has enabled a reduction in the use of bush carbohydrates such as cycad nuts (*warraga*), yams (*baltji, djitama*) and spike rush corms (*raki*), some of which require extensive preparation prior to consumption. Altman (1984) found that this shift to store bought carbohydrates resulted in a reduction in the overall contribution made by Gunwinggu women to the subsistence economy. This decline in carbohydrate production has also occurred at Ramingining (personal observation) and Donydji (White 1985) and has resulted in Yolngu women changing their subsistence target strategy to focus on small game (eg. long-necked turtle, goanna) and fish (including shellfish) rather than plant food. As such, they still contribute significantly to contemporary Yolngu diet (White 1985, 2001b).

Another change to traditional lifestyle that has occurred was higher local population densities in association with the establishment of Ramingining town. This has resulted in increased exploitation of the environment surrounding the town, dramatically reducing local productivity (see also White and Meehan 1993). In addition, Yolngu ability to procure many bush food resources has become more efficient with the introduction of technology such as vehicles, firearms and other equipment (White and

Meehan 1993). Vehicles have enabled increased distances to be traveled on hunting trips allowing larger quantities of foods to be brought back to camp for distribution. While this provides dietary benefits to the community and relieves some of the pressure on resources near town, it is at a greater cost to the environment overall (White and Meehan 1993).

Today, Yolngu diet includes feral buffalo and cattle and some people also eat feral pig. Pigs are estimated to have arrived in the Arafura region between the mid 1970's (see Chapter 5, section 5.3.4) and mid 1980's (Caley 1993) and so are relatively new additions to the subsistence economy. Buffalo and cattle have been in the area much longer. Cattle were originally introduced to the Arafura Wetlands in the late 1800's when Florida station (now Murwangi) was established. Buffalo are thought to have become feral in northern Australia in the late 1820's (Letts 1962), but according to Yolngu interviewed during this study, they were not seen in the Arafura area until the 1940's (see Chapter 5, section 5.3.4).

The inclusion of feral animals to varying extents in the diets of many Aboriginal groups throughout Australia is quite common today. In Central Australia feral cats and rabbits are eaten and have to a large extent replaced the now rare small native mammal fauna that was once part of people's diet (Rose 1995). Altman (1984) found that feral animals were included in people's diet at Momega outstation in central Arnhem Land where they could account for as much as 20% of bush food consumption during some months. Feral animals are also an important food source for Aboriginal people in Kakadu National Park where traditional owners have requested that small herds of feral buffalo be allowed to remain for community use (Kakadu Board of Management and Parks Australia 1999). Feral pigs are seasonally hunted by Belyuen Aboriginal people on the

Cox Peninsula (Povinelli 1983) and no doubt are hunted by indigenous people in other parts of the Top End. Pigs are also intensively harvested around Cape York where they are a highly valued protein source, especially during the dry season when these animals are particularly fat (Roberts et al. 1996).

Hunting activities have changed to some degree with the introduction of feral pigs and buffalo into the diet of Arnhem Land Aboriginal people. Buffalo and pigs are more dangerous and harder to kill with their thick skin than most native animals, and consequently changes to hunting technology (the use of firearms) and techniques (the need to retreat after firing and the constant need to be cautious) have taken place (Altman 1982b). Nevertheless, Aboriginal men enjoy buffalo hunting, and as buffalo is considered the hardest animal to kill, considerable prestige is bestowed on a successful buffalo hunter (Altman 1982b, White 2001b). As Altman (1982b) noted with regard to the Gunwinggu, hunting introduced animals appears to have been incorporated into Yolgnu economic life without changes in the social organisation of production, i.e. composition of hunting parties and appropriate distribution of meat.

Bush food resources and the integrity of the landscape and people's interactions with it are fundamental parts of contemporary Yolngu existence (Rose 1992, Lim 1997, Bradley 2001). The introduction and success of feral animals has altered the landscape and the availability of many native species, which may be having a significant effect on Yolngu culture and life. Knowing where and when animals are found and their behaviours has always been an essential facet of Aboriginal traditional knowledge. It is an inherent part of the way people think about and observe their natural environment. Consequently, Yolngu have a good understanding of pig and buffalo behaviour and habitat use and they are also acutely aware of changes that occur to their custodial lands.

Their knowledge of an area has usually been obtained from years of observation embedded with stories or oral histories that are passed down through generations. This time frame, preserved in Yolngu knowledge, gives a level of understanding and a depth of perception to our understanding of the effects feral pigs may be having on the environment and Yolngu food resources, making Yolngu contribution to management decisions extremely valuable.

Yolngu perceptions of feral animals and the impacts on their land were discussed in Chapter 5. This chapter compares the resources and environments used by Yolngu and by feral pigs (and to a lesser extent, buffalo) and then poses the question: if there is overlap, how may this affect Yolngu? The impact on Yolngu may be due to (i) resource depletion through direct consumption by feral pigs; (ii) resource depletion through interference by feral pigs in the environment (e.g. consumption by pigs of the prey of the resource considered); (iii) reduction in Yolngu hunting efficiency (e.g. where pigs break up the soil surface or buffalo trample and so obscure signs and tracks); (iv) pollution by feral pigs; and/or (v) reduced hunting access through intimidation.

This assessment of feral animal impact upon resources and lifestyle is complicated by a range of other factors affecting traditional resource use such as the establishment of the township and associated consequences and the availability of technology as discussed earlier. These complications make it difficult to disentangle the impacts of feral animals from other factors operating concurrently. This is discussed where relevant.

6.2 Methods

There is little information available on the impacts of pigs in this area and their effects on Yolngu resource use. Pigs were rarely seen during this study due to their largely nocturnal habits. When they were seen it was usually from a distance and it was not always possible to directly observe what they were eating. As such, this analysis relies on direct reporting by Yolngu. Consequent constraints in the analysis of this information are discussed in section 5.4. Information about the seasonal use of habitats and food resources by people, feral pigs and buffalo was obtained through participant observation and semi-structured interviews with Yolngu. The relative importance of these foods in contemporary Yolngu diet was also estimated. Ethno-ecological information was recorded in collaboration with a number of Yolngu over the duration of the study period. Interviews were mainly conducted in English and the methods used and people interviewed have been described in section 5.2 and Table 5.1 (Chapter 5).

In addition to those people formally interviewed, much information was gathered from people (mainly women) who were present on hunting trips. This information is also presented in the results. These included older women with excellent knowledge about resources, including those which are no longer commonly used. Hunting trips were an excellent forum for talking to people and gathering knowledge and much information was given openly by Yolngu whilst on these outings.

The resources discussed in this study are those that I observed to be in regular use throughout the duration of the study, unless otherwise noted. It has also been noted if a particular resource is considered a 'staple' food item in contemporary Yolngu diet. 'Staple' has been defined here as an item that 'over at least some extended period of the annual cycle probably provides a major carbohydrate, fat or protein source' (after Russell-Smith et al. 1997). As in Russell-Smith et al. (1997), my classification of food items as 'staple' has been done conservatively, with only well documented items included. Nevertheless, some individuals in the community may have limited access to bush foods for a variety of reasons and thus 'staple' food items may not be as important for these people.

Three staple food items were chosen for more detailed discussion with respondents – yams (*Dioscorea* sp.), long-necked turtle (*Chelodina rugosa*) and magpie goose (*Anseranas semipalmata*). Plate 13 shows a group of people hunting for long-necked turtle at Garanydjirr. Plate 14 shows Yolngu women with a long-necked turtle collected from Mangbirri. Plate 15 shows a Yolngu family with several geese after an afternoon hunting.

Plate 13: Family hunting for long-necked turtle with fellow researcher Guan Lim near Garanydjirr

Plate 14: Yolngu women exhausted but happy after a successful long-necked turtle hunt.

Plate 15: Yolngu family with magpie geese hunted at Mangbirri.

Yams were chosen as they develop in an underground habitat, and are readily accessible to pigs as a food source. Feral pigs favour these vegetable foods and often dig them up before they are fully mature. Long-necked turtle was chosen because of the aestivation time spent underground and the fact that both people and pigs hunt long-necked turtles during this aestivation period. Magpie geese were chosen because their feeding and breeding success depends on healthy swamp habitats where appropriate nesting material and food (*Eleocharis dulcis* and *Oryza rufipogon*) can be found. Feral pigs and buffalo use these swamps extensively as a source of food and water.

Hunting trips provided the opportunity to observe what resources were being targeted in different locations and to enquire about what other resources (not currently being targeted) were found at this place. All of the sites that were used to record pig impacts during this study were also used by Yolngu for hunting (including fishing and gathering) at various times of the year. With the exception of Dhabila and some sections of Djapidingorin, all sites were located close to permanent freshwater (Figure 3.1). The Dhabila sites and some of the Djapidingorin sites were in the middle of the floodplains and whilst there was water in the area for much of the year it did not usually persist throughout the entire dry season.

For ease of discussion, I have based the information about resource collection around the vegetation classes used in the pig survey (as described in Chapter 3, Table 3.2) although these do not always concur with Yolngu habitat classifications. The vegetation classes and their corresponding Yolngu classifications, where they exist, are listed in Table 6.1.

Table 6.1: Descriptions of vegetation classes and corresponding Yolngu classifications (Gupapuyngu language).

Vegetation classes	**Yolngu** classifications
Sedge (SED)/Grassland (GRA)	These vegetation classes occurred on floodplain areas, called *gurrpulu.* Grasses and sedges are generically called *mulmu.*
Monsoon forest (MVF)	*retja*
Pandanus woodland (PAN)	*gungamirringur*
Paperbark forest (PBK)	*gulungulun*
Paperbark woodland (PBKW)	n/a
Woodland (WDL)	*diltji*

While coastal dunes, beaches and mangrove ecosystems were not studied directly in this project, these ecosystems are important to Yolngu for a variety of resources including mud crabs, shellfish, mangrove worms and sea turtle eggs. Pigs also use beach and dune ecosystems to some degree, digging up marine turtle nests when in season (Choquenot et al. 1996) and feeding on crabs, fish and clams washed up onto the shore (Pullar 1950). Yolngu have reported that pigs also use mangrove ecosystems where they feed on mangrove worms (*Terodo* spp.), land snails (*Xanthomelon pachystylum.*), mangrove snails or long bums (*Telescopium telescopium*) and possibly mud crabs (*Scylla serrata*).

Fish were not usually included in the discussions with Yolngu although other water dwelling animals such as the Arafura file snake (*Acrochordus arafurae*) were mentioned. Hence, the majority of the data on freshwater fish as a food resource has been sourced from a previous study in the same area (Dee 1995). Small fish were usually used as bait rather than eaten. Only those fish that were commonly caught and eaten have been included here as staples.

Yolngu explained the season and duration of availability of each resource as well as whether they thought the resource was used by feral pigs. The information about the foods that pigs might eat has been gleaned from Yolngu knowledge, personal observation and literature. Yolngu assisted in the identification of any unfamiliar fruits or plants by providing the Yolngu name for the plant (Plate 16) and looking in botanical guides for pictures of the plant. As pictures are not an accurate way of identifying plants, if there was any doubt, the information was cross-checked with botanists from the Darwin herbarium.

Plate 16: Ranger sharing his knowledge about the fruit of *mulunu* or cluster fig (*Ficus racemosa*).

As explained in Chapter 3, the seasons considered in this study are the late dry season (surveyed in October/November 1999) which encompasses the Yolngu seasons *Rarranhdharr* and *Dhuludur*, the wet season (surveyed in March 2000) or *Barra'mirri* and *Mayaltha*, the early dry season (surveyed in June 2000) called *Midawarr* and the mid dry season (surveyed in August/September 2000) called *Dharratharramirri*.

The following results are structured broadly according to subject matter.

6.3 Results

6.3.1 Seasonal availability and location of Yolngu (food) resources

Dependence on bush foods varies throughout the study area. Nancy, an older Ganalbingu woman who is an ardent hunter living in Ramingining town, explained that 'most people from outstations get bush foods but less people from town get them'. Bush foods are less essential for people living in town where shop food is readily available. Nevertheless, many people living in town relish bush foods including meat, fish, fruits and vegetable foods and go in search of them most weekends in the dry season and other times where possible. Nancy clarified, 'people don't hunt much in the wet season because it's too wet, not much bush food, people eat mostly shop food'.

Before the availability of market goods, very little vegetable food was available during the wet season and hunting for game was the mainstay of people's subsistence (White 1985, 2001b). In the early dry season, resources including vegetable foods and freshwater fish become plentiful. By the middle of the dry season, vegetable items are more abundant and varied; mudcrabs are plentiful, as are freshwater fish and waterbirds.

During this 'cold' period, the burning of grass begins and concurrently people hunt for various terrestrial animals such as goanna and wallaby. As the dry progresses, long-necked turtles have buried themselves in the mud and can be collected. File snakes and other water snakes are also easier to locate, as they become far more concentrated as waterbodies contract.

The seasonal availability and vegetation class where many Yolngu food resources can be located is shown in Table 6.2. This is a conservative list of resources that excludes some wet season items and less frequently used species. Although Yolngu use a great variety of species, many of them (especially fruits) are only available for very short periods of time. Fruiting peaks in the late dry/early wet season in open forests (White 1978, 1985) and mostly throughout the wet season and into the early dry season in monsoon forests (Bach 2002).

Table 6.2: The seasonal availability and habitat of common Yolngu food resources (as informed by Yolngu), including whether the resource is also eaten by feral pigs.

Food or Resource Type	Yolngu name in local dialect	Eaten by people (personal observation)	Eaten by pigs (personal and/or Yolngu observation)	Location (vegetation class)	Yolngu season it is available to eat
VEGETABLE					
Water lily root (*Nymphaea violacea*)	*d̲hirrpu/djirrdjarra*		yes	MONO, PBK	*Mayaltha, Midawarr, Dharratharramirri*
Water lily stem/flower (*Nymphaea violacea*)	*dhulumburrk*	yes	yes	MONO, PBK	*Midawarr*
Water lily seeds-inside of root (*Nymphaea violacea*)	*dhatum*		yes	MONO, PBK	*Mayaltha, Midawarr, Dharratharramirri*
Lotus lily (*Nelumbo nucifera*)	*bamanyagani*		yes	MONO, PBK	*Mayaltha, Midawarr, Dharratharramirri*
Sedge corm (*Eleocharis dulcis*)	*ragi/rakay*		yes	MONO, PBK	*Midawarr-Rharrandharr*
Cheeky yam (*Dioscorea bulbifera)*	*djit̲ama*		yes	MVF	*Midawarr* (end)-*Dharratharramirri*
Round yam	*baltji*	yes	yes	MVF	*Midawarr* (end)-*Dharratharramirri*
Long yam (*Dioscorea transversa*)	*ganguri*	yes	yes	MVF, WDL	*Midawarr* (end)-*Dharratharramirri*
Bush potato *(Ipomoea abrupta)*	*bawang*	yes	yes	MVF, WDL	*Midawarr* (end)-*Dharratharramirri*
Bush carrot *(Ipomoea graminea)*	*d̲uynga/gan̲ay'*		yes	WDL	*Midawarr* (end)-*Dharratharramirri*
Bush potato (*Amorphophallus galbra*)	*l̲uwiya*		yes	MVF	*Barramirri-Midawarr*
Taro (*Colocasia esculenta*)	*djamandarra*		yes	MVF, WDL	*Rarrandharr-Dhuludur*

Food or Resource Type	Yolngu name in local dialect	Eaten by people (personal observation)	Eaten by pigs (personal and/or Yolngu observation)	Location (vegetation class)	Yolngu season it is available to eat
Cycad nut (*Cycas arnhemicus)*	*warraga*	yes	Not the nut, but the inside of the trunk of the plant is eaten	WDL, PAN	*Barramirri-Rharrandharr*
Bush peanut (*Sterculia quadrifida)*	*baḻkpaḻk*		unsure	MVF, WDL	*Dhuludur*
Pandanus nut (*Pandanus spiralis*)	*gunga ngatha/ḻ"aḻuk*		yes	PAN, WDL	*Midawarr* (nut)
Palm cabbage (*Hydriastele wendlandiana*)	*darra/wuldjarra/birdbird*	yes	yes	MVF	*Barramirri-Midawarr*
Palm cabbage (*Livistona humilis)*	*Dhalpi*		yes	WDL, PAN	*Barramirri-Midawarr*
Bush sugarcane	*darrtjal*	yes	yes	PAN, WDL	*Barramirri-Midawarr*
MEAT					
Magpie goose (*Anseranas semipalmata*)	*gurrumatji/gurrumba*	yes	Immature birds only	MONO	*Dharratharramirri-Rharrandharr*
Long-necked turtle (*Chelodina rugosa*)	*nyungura/banda*	yes	yes	MONO, PBK	*Dharratharramirri-Rharrandharr & Dhuludur*
Buffalo (*Bubalus bubalis*)	*daytung/nganaparra*	yes	Only as carrion	MONO, PBK, WDL, MVF, PAN	all year
Goanna (*Varanus* spp.)	*djanda*	yes	yes	MONO, MVF, WDL, PBK, PAN	all year
Pig (*Sus scrofa*)	*pigipigi*	yes	Only as carrion	MONO, PBK, WDL, MVF, PAN	all year

Food or Resource Type	Yolngu name in local dialect	Eaten by people (personal observation)	Eaten by pigs (personal and/or Yolngu observation)	Location (vegetation class)	Yolngu season it is available to eat
Water python (*Liasis fuscus*)	*mundukul*	yes	yes	MONO, PBK, WDL	*Dharratharramirri-Rharrandharr*
Fish in mud	*gangurrk*		yes	MONO	*Midawarr*
Cow (*Bos taurus*)	*bullicky*	yes	Only as carrion	MONO, PAN, PBK, WDL, MVF	all year
Ibis (*Threskiornithidae* sp.)	*garrala*	yes	Immature birds only	MONO	*Dharratharramirri-Rharrandharr* (not staple)
Agile wallaby (*Macropus agilis*)	*weti*	yes	Only as carrion	MONO, PAN, WDL, MVF, PBK	all year
Euro (*Macropus robustus*)	*gartjambal*		Only as carrion	MONO, PAN, WDL, MVF, PBK	all year
Arafura file snake (*Acrochordus arafurae*)	*djaykurr*	yes	yes	MONO, WDL	*Dharratharramirri-Rharrandharr & Dhuludur*
Whistling duck (*Dendrocygna* sp.)	*gudirrdirr*		Immature birds only	MONO	*Dharratharramirri-Rharrandharr*
Blue tongue lizard (*Tiliqua scincoides intermedia*)	*durburthumun*	yes	yes	MONO, WDL	all year
Saltwater crocodile (*Crocodylus porosus*)	*baru*	yes	Only as carrion	MONO	all year
Freshwater mussels (*Velesunio angasi*)	*djarrdi<u>t</u>*	yes	yes	MONO	*Dharratharramirri-Rharrandharr & Dhuludur*
Freshwater prawns (*Macrobrachium rosenbergii*)	*<u>d</u>akawa*		yes	MONO	*Dharratharramirri-Rharrandharr & Dhuludur*
Land snails (*Xanthomelon pachystylumi*)	*me<u>nd</u>un*	yes	yes	MVF	*Rharrandharr*

Food or Resource Type	Yolngu name in local dialect	Eaten by people (personal observation)	Eaten by pigs (personal and/or Yolngu observation)	Location (vegetation class)	Yolngu season it is available to eat
Mangrove snails (*Telescopium telescopium*)	*nonda*	yes	yes	MONO	*Barramirri Mayaltha*
Orange-footed scrubfowl (*Megapodius reinwardt*)	*gulawurr*		Immature birds only	MVF	all year
Red flying fox (*Pteropus scapulatus)*	*warrnyu*		no	MVF	*Dharratharramirri-Rharrandharr & Dhuludur*
Black flying fox (*Pteropus alecto*)	*warrnyu*		no	MVF	*Dharratharramirri-Rharrandharr & Dhuludur*
Barramundi (*Lates calcarifer*)	*raytj'djuk*	yes	yes (if trapped in drying billabong/creek)	MONO	*Midawarr-Dharratharramirri*
Salmon catfish (*Arius leptaspis*)	*garlki, buliya*	yes	yes (if trapped in drying billabong/creek)	MONO	*Midawarr-Dharratharramirri*
Ox-eye herring (*Megalops cyprinoides*)	*birkarr, bidilmi*	yes	yes (if trapped in drying billabong/creek)	MONO, WDL, PBK/W	*Midawarr-Dharratharramirri-Rarrandharr*
Spangled perch (*Leiopotherapon unicolor*)	*wudubal, ri:mu*	yes	yes	MONO, WDL, PBK/W	*Midawarr-Dharratharramirri-Rarrandharr*
Hyrtl's catfish (*Neosiluris hyrtlii*)	*gali, naytjirrik,*	yes	yes	MONO, WDL, PBK/W	*Midawarr-Dharratharramirri-Rarrandharr*
Saratoga (*Scleropages jardinii*)	*baypingga*	yes	yes (if trapped in drying billabong/creek)	MONO, WDL, PBK/W	*Midawarr-Dharratharramirri-Rarrandharr*
EGGS					
Magpie goose eggs	*mapu/yorti*		yes	MONO	*Mayaltha-Midawarr*

Food or Resource Type	Yolngu name in local dialect	Eaten by people (personal observation)	Eaten by pigs (personal and/or Yolngu observation)	Location (vegetation class)	Yolngu season it is available to eat
Long-necked turtle eggs	*mapu/yorti*		yes	MONO, PBK	*Mayaltha-Midawarr*
Saltwater crocodile eggs	*mapu/yorti*		yes	MONO	*Dhuludur*
Orange-footed scrubfowl eggs	*mapu/yorti*		yes	MVF	*Mayaltha*
FRUITS					
Emu berry *(Grewia rutusifolia)*	*muritjumun/ mutamuta*	yes	yes	PAN, WDL	*Midawarr-Dharratharramirri-Rharrandharr*
Bush banana (*Leichardtia australis*)	*yamany/yawuny*		yes	MVF	*Midawarr-Dharratharramirri*
Fruit (*Mimusops elengi*)	*wawurru*		yes	MVF	*Dharratharramirri*
Tamarind (*Tamarindus indica*)	*djumbung*	yes	yes	MVF	*Dharratharramirri-Rharrandharr*
Fig (*Ficus opposita*)	*muthir'*	yes	yes	WDL, PAN	*Dhuludur-Barramirri*
Fruit (*Ganophyllum falcatum*)	*dilminyin*		yes	MVF	*Barramirri Mayaltha*
Fruit (*Carallia brachiata*)	*djapa*		yes	MVF	*Dhuludur*
Fruit (*Smilax australis*)	*dapu*		yes	MVF, WDL	*Dharratharramirri*
Wild grape (*Ampelocissus acetosa*)	*wuluymung'*		yes	MVF, WDL	*Midawarr-Dharratharramirri*
Cluster fig (*Ficus racemosa*)	*mulunu/djanpa*		yes	MVF	*Dharratharramirri-Rharrandharr-Dhuludur*
Cheesefruit (*Morinda citrifolia*)	*guninyi*	yes	yes	MVF	*Rharrandharr-Dhuludur*
Seed (*Canarium australianum*)	*deti*		unsure	MVF, WDL	*Rharrandharr*
Fruit (*Drypetes lasiogyna*)	*gawatjark*		yes	MVF	*Midawarr*

Food or Resource Type	**Yolngu name in local dialect**	**Eaten by people (personal observation)**	**Eaten by pigs (personal and/or Yolngu observation)**	**Location (vegetation class)**	**Yolngu season it is available to eat**
Banyan - fruit and string (*Ficus virens*)	*genydja/dawu*		yes (fruit)	MVF	*Dharratharramirri- Rharrandharr*
Fruit (*Tacca leontopetaloides)*	*nguthumu*		yes	MVF, WDL	*Midawarr*
Fruit (*Lea rubra)*	*wurrmburrku*		yes	MVF	*Dharratharramirri*
Fruit (*Vitex glabrata*)	*wundan*		yes	MVF, WDL	*Dhuludur-Barramirri*
Fruit (*Pouteria sericea*)	*wungapu*		yes	MVF, WDL	*Midawarr-Dharratharramirri*
Devils twine/Dodder laurel Fruit (*Cassytha filiformis)*	*yarrngiyarrng/burrun burrun*		Yes, fruit only	MVF, WDL	*Rarrandharr*
Billy goat plum (*Terminalia carpentariae)*	*mapudumun*	yes	yes	PAN, WDL	*Dhuludur*
Milky plum (*Persoonia falcata*)	*dangapa*	yes	yes	PAN, WDL	*Dhuludur-Barramirri*
Red bush apple (*Syzygium suborbiculare*)	*ngarrani*	yes	yes	PAN, WDL	*Dhuludur-Barramirri*
Wild passionfruit (*Passiflora foedita)*	*burtang/g"anga*	yes	yes	PAN, WDL	*Barra'mirri-Midawarr-Dharratharramirri*
Cocky apple (*Planchonia careya*)	*dhanggi*		yes	WDL, PAN	*Dhuludur-Barramirri*
Fruit (*Flueggea virosa)*	*raga*		yes	MVF, WDL	*Midawarr*
Green plum (*Buchanania obovata*)	*munydjutj*	yes	yes	WDL	*Dhuludur*
Native grape (*Cayratia trifolia*)	*galun*		yes	WDL	*Midawarr-Dharratharramirri-Rharrandharr*

Food or Resource Type	Yolngu name in local dialect	Eaten by people (personal observation)	Eaten by pigs (personal and/or Yolngu observation)	Location (vegetation class)	Yolngu season it is available to eat
Fruit *(Terminalia ferdinandiana)*	*nga<u>n</u>'kabakarra*		yes	WDL	*Midawarr-Dharratharramirri*
Fruit & vines for armbands (*Flagellaria indica*)	*guwatjura*			MVF	*Dhuludur-Barramirri*
HONEY					
Sugarbag (collected from *Eucalyptus tetrodonta*)	*djarrawarre/guku*	yes		WDL	*Rharrandharr*

Thomson (1949) recorded that fruits available in the wet season (e.g. *ngarrani* red bush apple – *Syzygium suborbiculare; dangapa* Milky plum – *Persoonia falcata; dhanggi* Cocky apple – *Planchonia careya; munydutj* Green plum - *Buchanania obovata*) were often eaten in large quantities as they were the only vegetable food available at the time. Other bush fruits were traditionally 'snack' items, opportunistically harvested when ripe whilst people were moving through country (Thomson 1949). This has remained largely unchanged with many fruits still gathered and consumed as 'snacks' in this way. Bush fruits are highly sought after by children who are generally aware of the locations of fruit bearing trees along well used hunting tracks.

Seasonal variation in the number and type of food resources used by Yolngu within each vegetation type is summarised in Figure 6.1. Fauna dominates resource diversity within floodplain areas and to a lesser extent in paperbark forest and paperbark woodland vegetation types. Many plant foods are also found in floodplain (including wetlands) habitats which are described as 'rich in food plants' (White 1985) although the majority of these are no longer commonly used by Yolngu in the Ramingining area today. Monsoon forests and woodlands contain a range of fauna, fruit and vegetable foods in all seasons which, coupled with the fact that many patches of these vegetation types are accessible throughout the year, makes them reliable places in which to find food even in leaner seasons. White (1985) also noted that woodland habitats harbour a range of root foods as well as animal species that are important food sources for Yolngu. Pandanus dominated ecosystems are transitional habitats that commonly lie between the floodplains and the monsoon forests. People and animals exploit these habitats when other key areas are flooded and as they move between nearby key resource grounds – the floodplains and the monsoon forests. The early dry season (*Midawarr*) is the time of year when many animals have good levels of fat, a feature sought after by people as a rich source of energy. It is also the time when the floodplains begin to be accessible for hunting once again, which is why Yolngu sometimes refer to *Midawarr* as the good hunting season or harvest time (White 1985). Throughout the drier parts of the year, permanent waterbodies such as larger and spring fed creeks and billabongs are an important focus for people's hunting efforts. Many of these billabongs exist within woodlands and partly explain the faunal diversity that occurs there in the mid-late dry season (Figure 6.1). Some sites with permanent water are also found on floodplains and in paperbark forests, which also have a diverse faunal assemblage in the mid-late dry season.

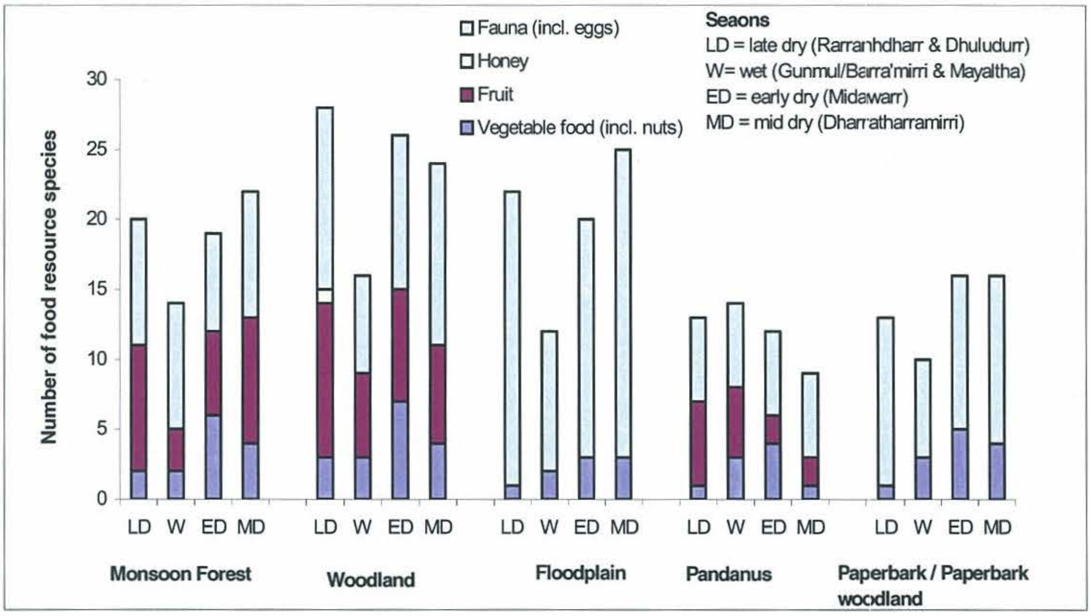


Figure 6.1: Number of species consumed by Yolngu in each habitat.

6.3.2 Effects of feral pigs and buffalo on bushfoods and other resources

One of the most common statements made by people about the diet of feral pigs was that 'pigs eat everything'. They find foods in wet and dry soils according to Mick, one of the rangers interviewed. People also mentioned specific items eaten by pigs. Annie said that pigs swim in creeks to eat fish, filesnakes and turtle. She also said 'pigs eat goanna, goose and eggs, waterlilies, *djitama* (yam), *raki* (*Eleocharis* sp.), fruits from small trees and the ground; they eat a big mussel called *ragultha* at *Bundatharri* area'. I also observed pigs eating the spike-rush (*Eleocharis* sp.). Mary stated that pigs at Dhabila (on the coast) ate crabs, long-bums, snails and mangrove worms. She said 'I have seen an open mangrove worm tree where pigs had been'. Interestingly, Ruby said that pigs eat 'turtles, file snakes, mussels, python and goanna, they don't eat yams'. When asked where pigs find these foods, people generally said swamps, jungles or everywhere; Joanne explained 'pigs follow their noses and go there and dig holes'. While it was difficult to observe what foods pigs were eating, the information offered by Yolngu concurs with evidence provided by observation and stomach contents analysis from pigs in northern Queensland (Pavlov and Graham 1985) and other studies (Pullar 1950; Giles 1980; Ridpath 1991; Mitchell 1993).

Pigs appear to consume many resources that are important foods for Yolngu (Table 6.2). Mick explained 'pigs eat everything that Yolngu eat....pigs are the main animal that can damage a lot of our foods and destroy the land, big animals, they can eat a lot, the most'. In discussion about the diet of feral pigs, Yolngu were mainly concerned with food items that were important to people but were nevertheless very aware of many other foods eaten by pigs.

Annie said that now there are less bushfoods especially goanna, turtle and *baltji* (yam). Ella said 'there are no foods left, we need to eat pigs, all bush tucker is gone, plants and grasses are not growing, mud everywhere'. I also observed large areas of floodplain that was muddied and devoid of groundcover (Plate 17). Joanne explained that 'pigs eat everything people eat including stuff around camps like bananas, mango, billy cans (contents)' and on one occasion I observed this occurring (Plate 18). Sally reported that 'those pigs are *yakurr* (bad), we have been in the mangroves and seen where pigs have been. They've got really hard noses, they get those *ragultha* (mussels) and smash their shells to get them out then eat them'.

Billy said 'Yolngu food is original food from here, pig and buffalo, it is not their food. Food is getting short now for a long time since buffalo came. We used to eat *raki* (*Eleocharis dulcis* corm) but now we have to buy peanuts from the shop. Waterlilies are all gone. We can't eat them because the pigs and buffalo get to them first. Country was beautiful before pigs, medicine was on trees, the animals came. We can't chase wallabies anymore because of the holes. Before there was no digging, only light (digging) from wallabies, not heavy animals. Pigs are killing our food, killing everything that moves and grows on the land. Some important trees get knocked down by animals'. Only two people said that pigs did not eat the same foods as Yolngu; Robert clarified this saying that pigs did eat Balanda food, rubbish, lettuce and cabbage but not Yolngu foods.

Some of the male respondents did not wish to discuss turtle and yams and suggested that I talk to the women about these foods. Most people stated that goose hunting occurs in the same locations as always and that geese can still be found at these usual places which was consistent with my observations (although these were over a short time period). Jessica said that Yolngu change where they hunt geese sometimes to give some places a rest. Mick explained that 'goose places are still good but that when it starts to dry up (the swamps), pigs go along edges and eat anything from animals to weeds'. He was concerned about the effects this might have on the geese.

There was a mixed response about whether the number of geese or goose eggs had changed or stayed the same. Some people stated that the numbers of geese and eggs were the same. Jessica said that there were fewer geese this year because Yolngu had been taking too many eggs the year before instead of leaving them in the nest. Annie independently made the same statement. Joanne explained that 'the numbers of geese were the same but goose hunting was getting harder because of pigs and buffalo. Caroline independently stated that hunting was more difficult and people were getting hurt from the holes in the ground made by pigs. I observed that floodplain environments were dotted with holes and pugging (Plate 19). Some holes (wallows) that were made by buffalo were very wide and deep (approximately 2 metres wide by 60+ cm deep) as shown in Plate 20. Those made by pigs were generally smaller and shallower (usually >1m wide and >40cm deep) but still made driving and walking very difficult (Plate 21). Billy also said that 'goose nests have been knocked down by pigs and buffalo'. In response to queries about whether pigs eat goose eggs or not, some people confidently stated that pigs did eat goose eggs whilst others said that they were not sure or had never seen pigs eating these eggs.

Plate 17: Extensive damage from pigs and buffalo near Gatji.

Plate 18: Pig at Gatji feeding on leftovers from a billy can.

Plate 19: Aerial view of Crossing floodplain showing damage from pigs, buffalo and cattle in the early dry season.

Plate 20: Buffalo wallows near Gatji in the late dry season.

Plate 21: Smaller wallow probably made by pigs.

People were also asked whether long-necked turtle hunting places were the same as they had always been. It was explained to me that these animals were still found in the same places but there were less of them and they were harder to find. Jessica said that if turtles could not be found in a particular place then the hunting party would move and try another swamp. Lily and Ruby thought that the number of long-necked turtles available had not changed, however the majority (70%) of respondents thought that there were fewer turtle now. Most people attributed this decline to pigs but some thought that Yolngu had been taking too many turtle to eat themselves. Whilst hunting for turtle at Djanyirrbirri, Helen told this story: 'before when I was a young girl we used to come here from Millingimbi for turtle hunt. There were tracks everywhere from turtle, we could follow them and we would find the turtle all of the time. Now it's too hard. The tracks can't be seen because of pig mess and buffalo mess'.

Julie independently explained that women could no longer see the breathing holes of the turtles in the mud because of the very deep pig digging. Annie told me that 'it started to get hard to get turtle in 1975-76, now we find some turtles that are OK, others have been already broken by pigs and buffalo'. I observed damaged long-necked turtles on several occasions. Mary said that turtle eggs were also hard to find because pigs were eating them. She also explained that there were some places where pigs have dug so extensively that people no longer look there for turtle because none were found there anymore. Andrew and Mick, who are rangers, mentioned specific places where turtles are rare or no longer found such as Gatji Creek and Mangbirri. Andrew explained that Mangbirri swamp along the roadside was good for turtle once, but 'people don't use as much any more, no good hunting because of pig'.

Responses about the locations and availability of yams (*Dioscorea* sp.) varied. Some women were adamant that yams were very hard to find now and when they could be found there were not many of them. Joanne said 'pigs dig everywhere for yams, they get all yams before people get to them, in both sandy country and *retja* (jungle)'. Commenting about a recent hunting trip to Gulpulul, an outstation on the east side of the Glyde River, Annie said, 'we were looking for yam last time and couldn't find any, there used to be a lot of yams, everything has been eaten by pigs'. She also said that it had been difficult to find yams for 10 or 20 years now. Joanne suggested that the size of yams has decreased because of damage caused to them by pigs 'there are less yams, used to get big yams at *bumbudjari* (a jungle near Gatji) now only get little yams, pigs damage them so much that they only grow small. Pigs dig yams before people get to them because they get to them in the wet when the grass is still long before people can get there. Pigs have been digging yams since they had families, a long time. They have been getting worse each year'. Jessica attributed the decline in yam numbers to Yolngu taking too many as well as pigs eating them. Lily, Mary and Ruby believed that the number of yams was the same as always and that yams could still be found in all of the usual places. Possible reasons for the differences in people's observations are discussed in section 6.4.3.

Some people said that all hunting places were still used and that 'everywhere was still OK for food', others said there was less food available at most places. Garanydjirr jungle was named as being particularly damaged from pigs.

6.3.3 Habitat use by feral pigs and buffalo and seasonal overlap with Yolngu hunting grounds

Most ground dwelling fauna are affected by seasonal flooding. During the wet season, feral pigs and buffalo move inland or anywhere on higher country to escape the floodwaters. Another key seasonal driver of habitat use for feral pigs, buffalo and many other fauna species is the persistence of water late into the dry season (as shown for feral pigs in Chapter 4). I observed pigs foraging in remaining patches of wet swamp in the middle of the open floodplain late in the dry season. These areas of wet swamp were the only sources of fresh water for several kilometers. During the drier parts of the year buffalo live in places near water where there is adequate vegetation cover as protection from the heat. Ridpath (1991) recorded that these animals preferred swampy and forested margins of sedgelands, creeks, rivers and waterholes as well as monsoon forests. These seasonal factors are fundamental to resource availability and thus, logically, they also influence Yolngu hunting patterns throughout much of the seasonal cycle.

The main vegetation classes used for seasonal food collection by Yolngu and key foods in each class as identified by Yolngu are shown in Table 6.3. There is spatial overlap in the places where people and pigs obtain many of their seasonal food resources i.e. hunting areas used by people are often favoured by pigs as feeding grounds. Fresh pig activity (shown here as the probability of occurrence of fresh diggings as determined in Chapter 4, section 4.3.16) is high in many of the vegetation classes and hunting areas (sites) where people collect seasonal resources (Table 6.3). This overlap is greatest in the wet, early and mid dry seasons. Broad-scale seasonal impact of feral pigs is similar to that recorded by Caley (1993) with population densities of feral pigs being higher in floodplain and wetland habitats than in woodland and forest habitats throughout the drier parts of the year (see also Hone 1990a).

Table 6.3: Overlap of vegetation classes and sites used by Yolngu and feral pigs each season.

Season	**Resources of high subsistence value to Yolngu (determined by observation and information provided by Yolngu)**	**Vegetation class where resource occurs and probability of occurrence of fresh pig diggings (as determined in Chapter 4)**	**Sites where I observed people procuring the resource in that season and probability of occurrence of fresh pig digging (as determined in Chapter 4)**
Late dry	*magpie goose*	monocot (p= 0.05)	MAN (p=0.14)
	long-necked turtle	monocot (p= 0.05), paperbark forests (p=0.2)	MAN (p=0.14), GAR (p=0.06), DJA (p=0)
	*file snake**	monocot (p= 0.05), woodland (p= 0), paperbark forests (p=0.2)	GAT (p=0)
	wallaby	woodland (p= 0)	Not observed
	goanna	woodland (p= 0), paperbark forests (p=0.2)	DJN (p=0.16), DJA (p=0), MAN (p= 0.14)
	fruit eg. milky plum,green plum, wild peach	woodland (p= 0), monsoon forests (p=0.06)	MIL (p=0.11), MAN (p= 0.14)
Wet	*fruit eg. milky plum, wild passionfruit, fig, red bush apple*	woodland (p= 0.44), monsoon forests (p= 0.41)	DJA (p=0.70), GAR (p=0.29), GAT (p=0.99)
	palm cabbage	woodland (p= 0.44), monsoon forests (p= 0.41)	MIL (0.06)

Season	Resources of high subsistence value to Yolngu (determined by observation and information provided by Yolngu)	Vegetation class where resource occurs and probability of occurrence of fresh pig diggings (as determined in Chapter 4)	Sites where I observed people procuring the resource in that season and probability of occurrence of fresh pig digging (as determined in Chapter 4)
Early dry	*freshwater fish**	monocot (p=0.29), woodland (p=0.24)	GAT (p=0.40), MIL (0.11), CRO (p=0.11)
	goanna	monocot (p=0.29), woodland (p=0.24)	GAT (p=0.40), DJN (p=0.17)
	wallaby	monocot (p=0.29), woodland (p=0.24)	Not observed
	underground tubers	woodland (p=0.24), monsoon forests (p= 0.24)	GAR (p=0.38), GAT (p=0.40),
Mid dry	*magpie goose*	monocot (p=0.43)	MAN (p=0.86), GAR (p=0.58), DJA (p=0.32), GAT (p=0.30), DJN (p=0.16), DHA (p= 0.60)
	long-necked turtle	monocot (p=0.43), paperbark forests (p=0.71)	MAN (p=0.86), GAR (p=0.58), DJA (p=0.32), GAT (p=0.30), DHA (p= 0.60), MGR (p=0.6)
	*file snake**	monocot (p=0.43), woodland (p=0.08), paperbark forests (p=0.71)	GAT (p= 0.30)
	*freshwater fish**	monocot (p=0.43), woodland (p=0.08)	GAT (p=0.30), MIL (0.32), CRO (p=0.22)
	goanna	woodland (p=0.08), paperbark forests (p=0.71)	MIL (p=0.32), GAT (p=0.30)

* these aquatic species occur in creeks, rivers or swamps that are located in the specific vegetation class

Whilst knowledge of seasonal habitats used by feral pigs and buffalo is vital to management, understanding daily habitat use by feral pigs and buffalo is essential to complete the picture. While Margaret suggested that they were found 'everywhere', most people said that pigs were found in swamps and jungles during the daytime, wherever there was shade and it was cool. Other locations mentioned included in paperbark forests, near rivers, in grass, in escarpment country under ledges and in creeks. Mick explained that pigs like to be in 'cool places such as rainforests or bush where there is cool green grass for sleeping; quiet place where no-one will sneak up, hide themselves, daytime is sleeping time'. These responses are consistent with my observations. On several occasions I disturbed pigs sleeping under shrubs in monsoon forests or under pandanus or cycad palms during the daytime while conducting surveys (Plate 22).

Plate 22: Pigs disturbed from daytime rest in pandanus woodland vegetation near Garanydjirr.

At dusk pigs come out of shelter to hunt and feed through the night, as Julie explained 'they walk around (and) look for food at night'. Some people suggested that they come out to the floodplains, swamps and riverbanks as Annie described 'they go out in the plains, clear places'. I observed pigs foraging in swamps at night and also saw pigs returning to shelter (forested areas) along the edges of the floodplain early in the morning after feeding far out on the sedge covered floodplains throughout the night. Several younger women thought that pigs were in the jungles during the night or that they slept in the scrub.

Robert suggested that pigs go to certain places 'looking for shade and food' and Ella independently made the same statement. Mick explained that pigs go to places 'where it is green and shady, looking for food and water and looking for soft ground for digging and trees for rubbing'. They go to swamps 'for a cooler place for daytime and for digging and eating long-necked turtle' according to Jessica. David said 'they go to swamps because they are cooler and closer to water'.

While some Yolngu were concerned about the effects of buffalo they did not consider them to be as destructive as pigs. All respondents said that buffalo only eat grass and some people suggested that they eat weeds from the swamps. Mary thought that they might also eat trees and leaves. People suggested that buffalo used various habitats for the same reasons as pigs. In addition, Mick suggested that buffalo were also looking for good places to make wallows. Many respondents thought that buffalo lived in the jungles and swamps during the daytime. Others said that buffalo live anywhere and just walk around. Buffalo are also thought to feed at night out on the open floodplain areas. However, Mary and Joanne said that buffalo often stay around camps at night.

6.4 Discussion

There are a number of constraints to this analysis of the effects of feral animals on Yolngu resources and hunting. There is very little quantitative information available on Yolngu resource use and it was not practical to conduct experiments to determine this information within such a large community during this study. Coincident social factors including changed population density and technology may also be affecting resources and hunting. In addition, fluctuations in resources occur from year to year can make it difficult to detect unnatural variation (i.e. variation caused by feral animals or people).

Recognising that these limitations were unavoidable in this study, this analysis relies largely on direct reporting by Yolngu. This is sometimes self-contradictory at least partly due to differences among individuals in experience. While these differences could be expected in any society, they must be considered in conjunction with the information presented.

Notwithstanding, the picture is reasonably clear. Feral animals, particularly pigs, overlap in resource use with Yolngu. Further, many Yolngu believe that the presence of feral animals, particularly pigs, has led to decreased availability of traditional bush foods. My observations suggest that people are justifiably concerned about the effects of feral pigs and buffalo on their land and resources.

6.4.1 Effects of pigs on Yolngu resources

Despite changes to country and resources since the introduction of feral animals to the area, people still view the area as being rich in food resources as a whole - 'plenty of bush tucker around here' (Helen). Yet when talking about certain individual food items in some areas, Yolngu acknowledge that supplies may not be as plentiful or easy to obtain as they once were. Yolngu involved in this study believe that many food resources are being affected by feral pigs but those most commonly cited were long-necked turtle and yams. It is not clear whether these were mentioned so frequently because they are favoured Yolngu food items or because they are thought to be most severely affected by pigs.

Yams are an important vegetable food source for Yolngu and are still harvested by many women. Traditionally, yams and other tubers were seasonal staples and were 'managed' by Yolngu to ensure ongoing supply. Some Yolngu women still retain this knowledge of how to manage these resources. Many Aboriginal groups manage resources, including Yanyuwa women, who also manage yams to ensure ongoing supply (Baker 1999). Several Yolngu women involved in this study suggested that yams have been getting more difficult to find over the last 10-20 years. This time frame is consistent with the time that feral pigs are thought to have been present in the area. Pigs consuming yams is a plausible explanation for the decrease in availability of yams. This argument is supported by the fact that Yolngu have noticed yam vines growing in certain places but these have been dug up, presumably by pigs, before they matured.

The time period of the last 10-20 years also coincides with the establishment of Ramingining township and the concentration of many people's hunting efforts in nearby areas. This may also have contributed to the reduced availability of yams. However, some women suggested that the number and location of yams had not changed. This variation in responses may be reflecting that people from different clan groups hunt and gather in different locations and these locations may be differentially affected by pigs.

The reduced abundance and consequent difficulty Yolngu have had finding long-necked turtle may also be attributed to either pigs or the concentration of Yolngu hunting efforts in the area or a combination of both. Certainly pigs eat turtles as Yolngu have found, and I also observed damaged, partially eaten turtles. Another possible explanation for these observations is predation by dingoes (*Canis familiaris dingo*). Yolngu have explained that the trampling and digging of the ground caused by buffalo and pigs affects both the integrity of the turtle habitat and Yolngu ability to find the turtles by observing tracks and breathing holes. Yanyuwa women living at Borroloola have also found that they cannot find freshwater turtles and they attribute this to the effect of cattle trampling the ground (Baker 1999).

Magpie geese are a major food resource for Yolngu and feral pigs could potentially affect the population density of these birds. Pigs consume native rice (*Oryza rufipogon)* and spike rush corm (*Eleocharis* sp.) and also damage the habitat these aquatic species grow in through their digging activity. Magpie geese use these plants for food as well as nesting and declines in their abundance may have an effect on goose populations. To date, Yolngu have not needed to alter the locations where they hunt geese. This may be because the pattern of water distribution on the floodplain has remained largely unaltered and the availability of food for the geese is still adequate. It is possible that a decline in water quality or dry season quantity (via alteration in drying patterns as a result of digging) and reduction in food abundance or distribution may occur as a result of pig activity. This may lead to a reduction in the numbers of Magpie geese the area can support or force Magpie goose populations to move to more suitable habitats.

The densities of Magpie goose populations, even in the absence of feral animals, are known to vary substantially between years and between locations, largely depending upon the amount and location of rains in the wet season. This natural oscillation has made it hard to detect any underlying changes due to feral animals and the environmental modification they cause (Whitehead et al. 1992). However, there has been a suggestion (although the data are inconclusive) of a gradual decline across the Top End (Bayliss 1989, Bayliss and Yeomans 1990). If Magpie goose populations are consistently low over a number of years, Yolngu may need to consider managing the goose population by reducing their current harvest intensity. Management may be necessary whether the decline is due to feral animals or other factors.

Current harvest levels of long-necked turtle, yams and geese by Yolngu may be unsustainable with the added pressure pigs are having on these animals. Yolngu may need to reduce their own harvest to compensate for the losses caused by feral pigs in order to manage local resources. Annie suggested that some Yolngu were taking too much of various resources. Jessica independently made the same suggestion. It is not clear whether they believed that everybody should be taking less or that some people were just taking too much. Is the effect pigs are having on resources changing the way people use resources or view over-use of resources? While this is not easily tested, it may provide a possible reason for different behaviors or thoughts regarding resource use within the community.

It is difficult to know whether some Yolngu dietary changes, such as ceasing to eat Spike-rush corm (*Eleocharis* sp.) have occurred as a result of the degradation of habitat by pigs and buffalo or as a result of the availability of store foods or perhaps a combination of both. As the numbers of pigs and buffalo have increased, the effect on wetland habitats via consumption and compaction may have been great enough to reduce the availability of the Spike-rush corm (*Eleocharis* sp.) and other aquatic species such as waterlilies (*Nymphaea violacea*) and lotus lilies (*Nelumbo nucifera*). It is also probable that trampling and digging activity by pigs and buffalo alters the drying patterns of floodwaters by increasing the exposed surface area of the ground thus speeding up drying, which may further affect wetland vegetation. Similar effects were noticed by Yanyuwa people who reported that cattle were damaging country and eating waterlilies and causing the early drying of lagoons in the Borroloola area (Baker 1999).

Meehan (1988), working in Central Arnhem Land between the Blyth and Liverpool Rivers, noted that sources of freshwater, such as wells and swamps, dry up earlier or are polluted because of buffalo use. The fouling of many waterbodies by feral animals has led some Yolngu to suggest that these animals may be the cause of sickness. Yolngu no longer drink water from many of these places and are unsure about consuming foods (especially raw vegetable matter such as lily stems and flowers) that come from these fouled waterbodies.

Feral pigs may also affect the much favoured but short-lived seasonal supply of edible fruits. Pigs are known to consume any edible fruits that drop on the ground (Pavlov and Graham 1985), which may preclude Yolngu from collecting the fruit. Although Yolngu do not collect all of the fruit that they consume from the ground, I observed many occasions when people, especially children, collected fruit, including green plums

(*Buchanania obovata*) and milky plums (*Persoonia falcata*), from the ground. The time and duration of fruiting as well as the time of fruit fall are important to consider. Fruits may be knocked to the ground by birds or bats feeding in the canopy at anytime during fruiting, thus creating a supply for ground dwelling species. The time of fruit fall may be equally important providing ground dwelling animals such as feral pigs with an abundance of fruit. In the long-term, pigs may affect seedling recruitment in rainforest species (Bach 2002) which may ultimately affect frugivorous species, such as flying foxes, that are important food resources to Yolngu. Feral pigs may act as dispersers of some fruiting species that have small, hard seeds but larger softer seeds that characterise the families *Myrtaceae* and *Lauraceae* are probably destroyed by chewing (Pavlov et al. 1992). Observations of feral pig dung in this study revealed the presence of *Pouteria sericea* seeds but their viability is unknown.

The magnitude of impact of feral animals is highly variable depending upon their population density. Overlap in resource use may be trivial if there are low numbers of feral animals but profound if their abundance is high. Currently there is very little control of feral animal numbers and this adverse situation is likely to be maintained unless the extent of the problem is recognised and substantial resources are directed at more systematic and effective control mechanisms. While many Yolngu are aware of the problem, securing funding and logistical support to manage feral pigs will be a challenging and lengthy process.

It is possible that some of the damage caused by feral pigs and buffalo may be offset to some degree by their value as food resources. Due to their high abundance it is possible that feral pigs could become more important calorifically than traditional animals of a similar size, like wallaby, if the presence of native species becomes increasingly rare.

people had work commitments during the week. I also observed that people would act on opportunity to get to various places, for example accompanying me to my study locations on some occasions in order to hunt and gather. Thus, even when the impact of feral pigs on resources is severe, this may not lead to the abandonment of hunting practices in that area.

I observed groups of Yolngu hunting for magpie goose and long-necked turtle on floodplains that were damaged to various degrees (dug and trampled) from feral pigs and buffalo. Guan Lim (pers. comm. 2001), a fellow researcher in the area suggested that in his experience, Yolngu did not use to any great extent areas that were badly damaged because there were few, if any, resources to be exploited in those areas. Further, travel through those areas either by foot or vehicle was difficult because of the damaged, uneven ground. However, in the late dry season I observed Yolngu hunting in extensively damaged areas, targeting late drying waterbodies that pigs had ploughed earlier in the season (personal observation). In many cases, some resources still existed in these places.

6.4.3 People's knowledge and understanding of the issues

Variation in people's awareness of which animals and plants are affected by pigs relates to the overall knowledge base held by the individual. For example, 'saltwater people' (as explained in Chapter 2) generally would not have the detailed knowledge of inland environments that people belonging to freshwater clans would have and vice versa. Similarly, people are more familiar with their own clan estate or country for which they bear responsibilities and as such may not comment about other areas.

The frequency and duration of time people spend engaged in hunting activities is likely to affect their knowledge of country and, more specifically, of feral animals issues. Davies et al. (1999) suggested that people who hunt frequently in a particular area have an increased awareness (based on extensive experience and observation) of the need to conserve locally rare species than those who hunt only occasionally. This concept is well illustrated by Annie, an older *Ganalbingu* woman who is a keen and regular hunter, commenting about other Yolngu taking too many goose eggs in the previous season and thus affecting the current harvest of adult geese.

Men and women hold different degrees of specialisation with regard to secular knowledge (Rudder 1978/79). Men are more familiar with hunting larger game animals whilst women and children concentrate on smaller animals, vegetables and fruits and hence are more knowledgeable about these resources. In some cases this led to a deferral of certain questions to the opposite gender and in other cases may have affected people's responses to some questions.

Whilst age is not a basis for rights over secular knowledge, learning and experience certainly increase with age. Most children are now in school until the age of 15 or 16, reducing the time available to them to gain full understanding of the natural world (Rudder 1978/79). Some of the younger men and women (5 respondents were under 30 years of age) may have a more limited knowledge and experience base compared to the older people (4 respondents were over 50 years old), which may explain some of the differences in opinion about the impacts of feral animals. Further, young people would not know the country as it was before the arrival of feral animals, especially buffalo and cattle, which have been in the area for many years. This was recognised by one of the older men, who stated that younger people would not remember what country looked like before these animals came and so could not understand the seriousness of the changes to the land. To young people, pig diggings and associated effects on country may be perceived as normal. People who have spent considerable time away from the community (e.g. in Darwin) may also have limited knowledge about their country and thus have reduced awareness of issues such as feral animals.

6.5 Concluding remarks

Yolngu people and various fauna species living in and around the Arafura wetlands rely on the regular seasonal availability of various resources in specific locations. Whilst these resource cycles still continue, feral pigs and buffalo have disrupted some of the certainty about bush food availability that Yolngu have depended on over their many years of occupation of the area. Povinelli (1993:239) describes how traditionally based subsistence activities are integral to life for Belyuen people:

> Hunting and gathering provides Belyuen men and women with the intricate knowledge of the physical and mythical landscape that imbues mythic metaphor with meaning as it provides the group with foods (Povinelli 1992); moreover, their food collection practices produce cultural and social identity as they produce their economic and political well-being.

Similarly, Yolngu life and subsistence behaviors are entwined with the spiritual world. Improved nutrition from harvesting and consumption of wildlife products compared to store bought foods (Naughton et al. 1986, O'Dea et al. 1988, White and Meehan 1993, White 2001a) along with increased fitness from subsistence activities are indirect social and economic benefits of subsistence harvest (Davies et al. 1999). These benefits may be reduced if habitat degradation and competition from feral animals persists.

It would appear that feral pigs may fundamentally alter people's relationships with the land; most outwardly by affecting the subsistence economy but also by affecting other relationships to the land, including comprehension of the physical landscape and responsibility for maintaining healthy country. Broader ramifications on the metaphysical relationships to land may also result. The concerns that some Yolngu are taking too much of various resources may also indicate that changes occurring on the land may also be affecting changes in some people's moral choices. While it is only supposition that over use of resources is evidence of a change in attitude to land and resources by some Yolngu, it is nevertheless a feasible consequence of an uncontrolled feral animal population and younger generations that may not fully understand how this will impact on the land.

Without strong levels of control, feral pigs are likely to continue to thrive in the Arafura Wetlands area and, together with buffalo, cause further changes to the country that is so important to Yolngu people.

CHAPTER 7: Final discussion and recommendations for management of feral pigs in the northern Arafura Swamp

7.1 Introduction

Land degradation, feral animals and weeds and declining biodiversity are among the greatest threats facing the environmental and economic integrity of this country, but addressing these issues can be both complex and expensive. In this study, I have examined some of these issues in a specific region, the Arafura Swamp and surrounds. It is characterised by relatively intact environments where, so far, only a minimal amount of environmental modification (in the form of ecological burning and small-scale cattle grazing) has occurred. The human population in this region is overwhelmingly Aboriginal and these people maintain strong traditional links with the land and its biota. This is a land where it should be possible to maintain environmental integrity, and where this outcome is especially important for the area's landholders.

Many studies have shown that feral pigs can seriously threaten the environment and biodiversity. This study demonstrates that pigs are widely distributed in the Arafura Wetlands and immediate surrounds, use a wide range of wetland and adjacent habitats, and potentially threaten natural and cultural values. This research contributes to our understanding of a range of aspects regarding feral pigs and their management in the northern Arafura Swamp. The 'pest status' (Olsen 1998) of the feral pig to those Yolngu involved in this study has also been demonstrated. The results suggest, and Yolngu custodians involved in this research agree, that pigs are having a significant affect on this landscape and its people. This warrants the implementation of strong and effective control measures.

The results presented here are primarily directed at western land managers who are involved in facilitating feral pig management in this or comparable areas. The research also provides documentation of the current state of pig damage in the northern Arafura Wetlands and surrounds for future reference. In this chapter, a feral pig management strategy for the northern Arafura Swamp is described that is based on key findings from this study.

This research indicates (a) that traditional bush foods continue to be a part of the Yolngu subsistence economy and (b) that Yolngu believe that pigs are threatening the abundance and continued availability of many of these resources (Chapter 6). The effects feral pigs have on some resources in the study area are direct, for example, the consumption of food sources such as yams and long-necked turtle. Threats from feral pigs in this area can also be indirect via habitat degradation (such as disturbance to soil and vegetation) caused by feral pigs, and the ecological changes (such as long term changes to patterns of drying of floodplain as a result of a changed ground surface topography i.e. holes, wallows, swim channels) that occur as a result of introducing a foreign predator into a natural system, albeit an extremely dynamic system. Such changes to the ecosystem or food chain, will most likely affect the resources Yolngu rely on. Pigs do provide an additional food source for some Yolngu, and this may be economically significant. Although the consumption of pigs could potentially reduce hunting pressure on native animals (Roberts et al. 1996), pig meat is not well liked by most Yolngu. Thus, the detrimental impact that pigs are having in this wetland environment is likely to be more significant than any benefits they provide.

Asian water buffalo have impacted on Yolngu subsistence production by disrupting hunting practices due to the uneven ground surface these animals create. While in other parts of the Top End, their local effect on vegetation and fauna species has been shown to be mostly reversible (Braithwaite and Werner 1987), ongoing research by colleagues as part of the broader Arafura study (described in Chapter 1) has suggested that this may not be the case in the Arafura area. Their work indicates that buffalo have a more complex and wide-ranging effect on biodiversity and productivity, including long-necked turtle populations (N.White pers.comm. 2002). More specifically, buffalo are having a significant effect on soil structure, particularly on coastal wetlands (N.White pers.comm. 2002). These findings concur with those of Letts et al. (1979) and Whitehead et al. (1990), who suggest that buffalo can have landscape-wide impacts that overall are probably far more substantial than that of pigs.

Indigenous Australians have adapted to many changes over the last two hundred years, including significant changes to their land and resources. Adaptations such as the use of firearms and 4WD vehicles have made bush food more accessible to many of the people at Ramingining. People are able to visit their custodial lands frequently from the town base, where schools and other infrastructure are available. Subsistence behavior has also changed with targeted selection of species now common. These changes and adaptations notwithstanding, many aspects of Yolngu life, including their social and spiritual structures, have remained strong. Similarly, in natural resource management, Yolngu have adopted various western methods and management practices, where necessary, to manage a changed and dynamic landscape.

As is occurring in many places in Australia (Davies et al. 1999, Kakadu Board of Management and Parks Australia 1999, Dorrington 2001, Kwan et al. 2001, Baker et al. 2001b), indigenous and non-indigenous peoples are collaborating in the Arafura Swamp area to facilitate successful land management strategies. While incorporating western management techniques requires a strong interface with local Aboriginal culture, the level of understanding required to do this remains problematic in the northern Arafura Swamp. Yolngu management of land (as is the case for other indigenous Australians) is governed by a structure that stems from people's social and cultural relationships to each other and spiritual connections to their country. Robinson and Munungguritj (2001) pointed to the need 'to ensure that Yolngu input and knowledge is appropriate for the context, place or purpose' when undertaking a collaborative approach to management. In applying this sentiment, appropriate Yolngu representatives need to play a key role in development of management strategies in the northern Arafura Swamp to ensure that outcomes are consistent with the social, political and cultural aims of the community. Without this ownership (by which I mean local input and decision making about the development of a process), management may not be implemented or will fail in its aims as has been suggested elsewhere (Wilson et al. 1992a, Dale 1996, Gambold 2001).

Developing a management framework that is consistent with traditional domains of Yolngu life presents a significant challenge for mainstream natural and cultural resource management agencies and the individuals involved as White (2001a) has explained. Understanding the full extent and implications of feral animal issues on Yolngu land requires both Yolngu and western knowledge systems. Managing the problem requires all involved to be able to work between and within these systems in a landscape that has been shaped by both Yolngu custodians and more recently by the influence and actions of outsiders on their land.

During the course of this study the complexity of the Yolngu social and political world became apparent. A preliminary insight into Yolngu perceptions and aspirations regarding the management of feral pigs is reported here. It provides an important base for discussing community-based management as an approach to controlling feral pigs in this region while providing tangible benefits to the community. Management strategies that minimise the impact of feral pigs on this environment and on local indigenous food resources can be expensive and difficult to implement, especially in an environment where season strongly affects the availability of resources and accessibility to various locations. Consequently, an understanding of the effects of season on the behaviour of pigs in terms of their use of habitat is essential when developing management plans.

Before considering management options I revisit some of my key findings in the form of a series of questions and answers about the ecological and social impacts of feral pigs in the northern Arafura Swamp area. I then make some recommendations for management of feral pigs that complement the aspirations that the Yolngu involved in this study had for their land. While these management recommendations are for feral pigs, they may also have some applications for buffalo. It must be remembered that the views expressed by those involved in this study were diverse and that these views do not necessarily represent those of the entire Ramingining community. This highlights the fact that management plans will not be appropriate to the needs and aspirations of all community members and as such, further research should be undertaken before any management strategies are implemented.

7.2 What are the key features of seasonal pig habitat use in the northern Arafura Swamp?

Pigs were widespread throughout the study area. Signs of pig activity were found in more than 85% of surveyed plots each season. The results presented in Chapter 4 showed that seasonal variation in habitat use by pigs was largely in response to the annual flooding and drying cycle and the consequent influence of this on resource distribution and abundance. The distribution patterns of permanent water throughout the area and the intense productivity of wetlands may explain the preference feral pigs showed for these habitats as foraging grounds throughout much of the year. Some habitats such as monsoon forests were used all year round but served different functions according to season.

Key features of seasonal pig habitat use are:

Late dry Season: Access to the limited surface water at this time of year is of high importance to pigs. Pigs favoured places where water or moisture persisted, such as along the edges of drying swamps (e.g. at Dhabila, Djapidingorin and Mangbirri) and in paperbark forests for foraging. Woodlands (including paperbark woodlands) and monsoon forests were generally cooler than open floodplains and were used as daytime resting places providing relief from the intense heat and humidity of the late dry season.

Wet season: Pig distribution was firstly in response to extensive flooding and then, on dry land, was in response to resource distribution. Food resources occurred mainly at the edges of floodwaters and these areas were used extensively by pigs. Pigs also favoured woodland areas and monsoon forests in the wet season. While woodlands are not resource rich habitats, those areas used by pigs were mainly close to water and other preferred habitats. Monsoon forests were key foraging places for pigs at least partially because these forests have their peak fruiting period during this time (Bach 2002) and it is also when underground tubers are developing.

Early dry season: Pig foraging activity was concentrated along the moist edges of floodwaters i.e. on footslopes in areas that retained water longer and on floodplains where the waters receded earlier. While, a diverse range of habitats were used for foraging by pigs as floodwaters continued to recede and new areas became available, pandanus vegetation was favoured as sandy soils enable easy digging. Monsoon forest and paperbark woodland plots continued to provide good shelter this season.

Mid dry season: Abundant food and unrestricted movement during this season suggests that pigs were dispersed to their maximum ranges. However, foraging was most prevalent at sites where areas of surface water remained until late in the dry season (such as Mangbirri, Dhabila and Garanydjirr in paperbark forests and monocot vegetation) suggesting these areas contained an abundance of food. Woodland vegetation was little used at this time of year.

7.3 What are Yolngu views on how feral pigs and buffalo affect their way of life?

Yolngu way of life is being affected by a number of feral animals. The research reported here relates mainly to feral pigs, but Yolngu perceptions of buffalo were also discussed as part of this study. The damage these animals do to land can affect custodial responsibilities such as looking after sacred sites. While examining field sites as part of this research, Yolngu assistants expressed considerable anxiety about sacred areas that have been damaged by pigs and buffalo. Further, the digging and wallowing actions of these animals make the ground hazardously uneven for walking and driving on. This can affect people trying to get around on their land to undertake day to day activities such as hunting or attending ceremonies.

This research showed that feral pigs have a significant effect on food resources used by Yolngu. The levels of impact that feral animals have on these resources depend on their population density. Low numbers may impinge very little on bush foods but at high densities the impact may be severe. The effects of pigs on resources used by Yolngu have been shown to be both direct (consumption) and indirect (competition, habitat destruction). Yams and other underground tubers as well as long-necked turtles were most commonly cited by Yolngu assistants as being affected by pigs, but equally common was the statement that 'pigs eat everything'. This indicates that pigs are affecting many foods that Yolngu value. Two older Yolngu women involved in this study specified that yams and long-necked turtles have been gradually becoming more difficult to find over the last 10-20 years. This coincides with the time period that pigs have been present in the area (see Chapter 1, section 1.2.3 and Chapter 5, section 5.3.4). It is also consistent with the findings from this study in that pig diggings were extensive in the habitats where long-necked turtle are found (monocot and paperbark forests) and also in monsoon forests and woodland habitat in the wet season when yams and other root vegetables are almost ready for harvest. Findings from this study concur with research in other parts of Australia (Choquenot et al. 1996) which suggest that pigs also affect a range of bird species including magpie geese, goannas, other medium sized reptiles including snakes, fruits and aquatic species such as spike-rush corm (*Eleocharis sp.*), waterlilies (*Nymphaea violacea*) and lotus lilies (*Nelumbo nucifera*).

Yolngu believe that increased competition for these food resources has led to a reduction in their availability. This reduction has contributed to modifications to Yolngu diet and to a disruption of contemporary hunting practices. While some of the disadvantages to the subsistence economy caused by feral pigs and buffalo can be offset to some extent by their value as food resources, there is no compensation for loss to biodiversity or the cultural values associated with the land, flora and fauna affected by pigs and buffalo.

The value of bush foods to many Yolngu is both cultural and economic as well as having clear health benefits. The families and individuals I worked with in Ramingining were partly dependent on bush foods for subsistence. While the cost of the impact of pigs in dollar terms is not straightforward to estimate, a significant reduction in the availability of bush foods is likely to dramatically increase the amount of income (often sourced from welfare) that people are forced to spend on market foods.

The ecological effects of subsistence wildlife use in Australia are largely undocumented (Altman 1982a, Altman and Allen 1992, Altman et al. 1996, Bomford and Caughley 1996b, Davies et al. 1999). This makes it impossible to distinguish the impact of indigenous harvest (of long-necked turtles, for example) from other factors, such as feral pigs, that are also little understood in terms of ecological effects. Most likely, both are contributing to the reported effects of reduced harvest, but further research is required to confirm this. Further, baseline data on native animal populations in the area is limited and as such the best source of information about changes to these populations may be Yolngu.

7.4 Do Yolngu recognise a problem and want to do something about it?

The different roles and experiences of men and women of various ages led to varying perspectives about feral pigs and their impacts. Lifestyle, for example, was a key factor affecting people's perceptions. Yolngu that spent a significant amount of time out hunting, and thus relied more heavily on traditional foods, were much more likely to have a detailed understanding of the effects of feral pigs on land and resources. Conversely, Yolngu who rarely went to the bush to collect food were not likely to be acutely aware of the effects that pigs have on these resources. Other factors that affected people's perceptions were external influences such as the level of western education and the extent of interaction with Balanda.

Aboriginal people can have different views on pests depending both on the location and the animal in question. For example, pigs are generally disliked in Arnhem Land, but are valued as a resource by many Aboriginal communities on Cape York Peninsula where they have been plentiful since at least the 1920's (Thomson 1935). As different people in the Arafura Swamp area have custodial responsibilities for different areas of land, aspirations regarding feral animal control in this area can vary. While there were different views about the degree of impact feral pigs have on land and resources amongst those Yolngu involved in this study, most (95%) expressed some concern about the effect pigs were having on land (including sacred sites and waterholes) and food resources. All were keen to implement some degree of control and most (89%) expressed a desire for complete eradication of feral pigs. Yolngu involved in this study were much less concerned about the effects of buffalo. While many people (63%) were aware of and described some of the impacts of buffalo, only 32% of people wanted buffalo to be completely eradicated, preferring to maintain a small number of these animals for food. Those landowners who receive royalty payments from safari hunting tourism also saw the value of keeping small herds of buffalo to maintain this income. Not surprisingly, people who relied more heavily on bush resources or were employed as rangers were most aware of the impact pigs and buffalo had on land and resources.

The diversity of views supports the need to have a detailed understanding of the local historical, political and social contexts that exist when undertaking land management initiatives in the area. In addition, the involvement of men and women of all ages is important in land management decisions and activities with indigenous people (Davies et al. 1999), as the custodial roles associated with the land can be different for men and women of various ages. These different and often dynamic perspectives are essential to consider when planning for feral pig management.

7.5 How does the local political and social context affect management of feral animals?

Devolution of responsibility to local communities and the resulting empowerment of these communities is an approach that has been adopted for wildlife management programs overseas (Wilson et al 1992). In Zimbabwe, for example, the CAMPFIRE program began with the aim of using the economic benefits of wildlife management to change people's attitudes and encourage the value of conservation. It has since developed to encompass the goals of political empowerment and community development (Murphree 1997 in Suchet 2001). Local strategies are also appropriate for feral animal management in Aboriginal communities, where clan groups existing in close proximity to one another, may not share common goals. Knowledge and aspirations are local and not bound by overarching legislation or political framework that does not allow for individual group control and each community's needs are accommodated because they determine actions themselves (Walsh and Mitchell 2002).

Ideally, all landowning groups in the Arafura Swamp area and in neighboring areas should be involved in defining the extent of the feral animal problem and in developing a coordinated approach to decision making and management planning for feral animal control in their region. While a regional approach to land management issues that themselves are of regional or broader concern in the Arafura area would be best, this approach will be fragmented by responsibilities geographically defined by clan boundaries. The social and political alliances and barriers that exist amongst the relevant groups of Yolngu custodians need to be considered. As such, feral animal management strategies must have a local context and ownership (i.e. local indigenous directive, planning and action). This will be very difficult to achieve for feral pig management in this area and it will be necessary to promote an enhanced understanding amongst traditional custodians of the long-term effects of feral pigs on their land.

Where Yolngu custodians continue to desire different outcomes, as may be the case in the Arafura area, coordinated management planning, as Olsen (1998) suggests, can aim to achieve each group's goals. However, I concur with the comment by Olsen (1998) that common goals will be easier to achieve, will provide a forum for sharing ideas and strategies and may also be more likely to secure funding. The coordinated management planning process could be facilitated by local rangers and where relationships between groups are not amicable (such as between Yolgnu groups in the northern and southern Arafura Swamp), or where there are negotiation breakdowns between groups, a facilitator such as a land management coordinator needs to assist so that common regional goals can still be achieved.

Strong indigenous ownership of the management process affects the role of land management coordinators and other collaborators in that they need to be aware of the local social and political context and of their level of understanding of this. Through literature and my earlier research experience in the Ramingining area (see Dee 1995), I was aware of the complexity of Yolngu society and the effects of this on land management (and other) decision making processes in the area. During this study, the extent of the political complexity of the region also became obvious. This significantly impacts on land management in the Arafura area and even with the level of experience I had gained from working with these people, I felt that I needed to tread cautiously with regard to many issues. I felt that my understanding of the local politics was extremely deficient. Thus, without in-depth knowledge of the social and political complexity of the community, it is important that the land management coordinator acts as a facilitator only, rather than imposing inappropriate models and expectations on the community. As a facilitator, they should provide information in a form and at a level that is relevant to the awareness, perceptions and aspirations of the local community (Rose 1995).

7.6 Are there practical mechanisms/management strategies to control feral pigs?

Based on the findings from this study, a combination of 'sustained management' and 'targeted management' (Olsen 1998) may be the most appropriate strategy to reduce the damage to habitat and traditional Aboriginal food resources by feral pigs in the Arafura Swamp area. Olsen (1998) describes sustained management as 'when pest animal density is reduced and then maintained at, or near, a threshold density at which there is no increase in benefit (damage reduction) from additional control'; and a variation of targeted management 'is to conduct control only at critical times'. As Olsen (1998) explains, it is rare that the threshold density can be determined because the relationship between pest animal density and the level of damage is rarely known; consequently, an arbitrary level of pest density, or amount of damage, that is found to be acceptable by the land manager may be used. The chosen level of damage will depend on the reasons for control and desired outcomes. Areas of digging and/or other signs of pigs may be used as 'indicators' to monitor whether control is reducing damage. Monitoring the availability of Yolngu resources that are affected by pigs, such as long-necked turtles and yams, may also be suitable. However, both of these indicators would be influenced by other factors such as whether pigs re-use areas each year, the amount and location of resources and the water levels in swamps, which is dependent on annual rainfall. While acknowledging these limitations, these indicators, especially if combined with direct assessment of pig numbers at regular intervals, will provide the best gauge of the success of the project overall.

Sustained management usually involves two steps: 'an initial knockdown aimed at removing a high proportion of the population; followed by periodic maintenance control to slow or prevent recovery' (Olsen 1998). The initial knockdown will be most effective if it targets the time of year that pigs are most stressed due to environmental conditions. This type of control strategy may only be effective when communities are supportive of broad scale culling of the animals in question, as this initial intensive control is integral to the overall success of the strategy. As Yolngu do not generally agree with killing animals without making use of the resource, it is likely that they would expect some use to be made of the animals such as collecting the carcasses to process them locally for pet meat.

The initial knockdown should involve a combination of aerial shooting and trapping of feral pigs when they are at their most vulnerable i.e. at the end of the dry season (especially in years when the wet is predicted to be late in arriving). Maintaining control throughout the annual seasonal cycle should occur to prevent the population from increasing significantly. This maintenance should be undertaken by local people (rangers and community members) using a combination of on-ground methods (trapping, opportunistic shooting by local hunters) in those habitats and locations where pigs have been predicted to be most likely to occur each season (as outlined for each season below and described in detail in Chapter 4).

Existing Aboriginal hunting practices have a minimal effect on pig populations, as hunting is opportunistic and undertaken by the few people with access to firearms. However, if intensive hunting could occur in key areas at specific times, this may reduce pig numbers if undertaken as part of a broader long-term control program.
Based on the results from this study, a recommended management strategy would control pigs using a range of methods that vary according to season.

The late dry season is the most effective time to control feral pigs as they are concentrated around the relatively few remaining watering and foraging locations (e.g. permanent or late-drying swamps). Control efforts in conjunction with high pig mortality at this time of year will have the greatest impact on pig populations. A number of control methods could be used in the late dry season. Trapping (using bait) could be undertaken in either paperbark or monocot vegetation and, at this time of year, the appeal of bait is high as food is scarce. Aerial shooting could be undertaken on open floodplains providing adequate funding is available. See Choquenot (1996) for discussion on the effectiveness of various control methods.

Generally poor access to many areas due to floodwaters, and the preference pigs have for foraging close to shelter in the wet season means that extensive, costly control action (such as aerial shooting) at this time of year is not recommended. Local opportunistic control (such as hunting on foot, possibly in conjunction with some trapping in known high use areas) can be undertaken in accessible areas such as the footslope ecotone areas between monsoon forests or woodland vegetation and floodplains at Djanyirrbirri, Gatji and Garanydjirr. Local opportunistic control measures such as community-based hunting and trapping efforts would be invaluable in this environment. However, in many areas this control would cease in the wet season (and in some areas into the early dry season), as many outstation groups move to town at this time, enabling pigs to feed and breed without disturbance.

Control measures in the early dry season could include aerial shooting of pigs in areas of dry floodplain or along floodplain margins where pig density was known to be high (such as Dhabila, Gatji, Djanyirrbirri and Garanydjirr). Trapping in these areas may also be successful. Local opportunistic control would further assist in maintaining reduced numbers of pigs throughout this peak breeding time.

In the mid dry season pigs were dispersed to their maximum ranges, increasing the difficulty and effectiveness of control. Some local opportunistic control effort could be maintained in key vegetation types that pigs use for foraging, especially at key sites such as Dhabila, Djanyirrbirri, Mangbirri, Garanydjirr and Mangurr where pig activity was high.

Achievable management goals that address issues that are a priority to the community (such as sacred site protection) are essential so that Yolngu can see the benefits of their actions and maintain interest in the process. Overlays on maps can be used to show where damage is most intense each season and to target those areas where intense damage overlaps with areas of high conservation or cultural value. Management of a pest species is not static and it will be necessary to adapt the management strategy to best integrate the environmental, social and economic aspects of pest control as needed (Olsen 1998). 'Learning by doing' or adaptive experimental management, such as feedback about the effectiveness of control based on the models, can be used to continually improve management and monitoring practices (Olsen 1998).

7.7 Why use a community-based management strategy?

The social and political merits of community-based management were discussed in Chapter 1. In addition to these merits, in the context of feral pig management, community-based management (i.e. landowners and family networks, and rangers) in collaboration with external 'specialists' where necessary, is the most economically viable form of feral pig control. Aboriginal people account for the majority of Arnhem Land's population. They travel widely within and between their traditional lands and hunting and collecting food and other resources is an important part of actively managing their land. Thus, they are acutely aware of what resources are available at different places and will immediately see changes that take place in the landscape and in patterns of resources availability. This awareness of their local environment and their availability, *in situ*, to contribute to the development and implementation of management strategies makes them a valuable asset in any attempt to control feral pigs in this remote area.

The value of locally aware indigenous custodians has also been recognised by AQIS, who have developed education programs about how to recognise disease symptoms and parasites in feral pigs and buffalo. These programs also aimed to increase awareness amongst indigenous landowners of the potential threat that exotic disease poses to Australia. Some community members across coastal Arnhem Land have participated in these programs, and have been encouraged to contribute to an effective reporting system to ensure early detection of disease presence across the northern coastal area of Australia.

Collaboration with external 'specialists' when appropriate, can foster the development of mutual trust between indigenous people and external collaborators such as conservation agencies by each party developing an understanding of the others needs and priorities in a management sense. In working with rangers and families from Ramingining, there was a two-way knowledge exchange that fostered respect between us. I agree with Davies et al. (1999) that this type of management, which demonstrates the value of indigenous knowledge and perspective by incorporating it into management decisions, is an important way of reaffirming the wisdom and authority of indigenous elders and community rangers. It generates the interest and pride of both older and younger generations of indigenous people. It can also encourage strong community leadership, which is an important factor in the success of land management initiatives and dispute resolution. Community-based management should ideally offer tangible returns for Aboriginal people, such as economic benefits, which also provide the community with added incentive to support the project.

7.8 Can the community derive any economic benefits from controlling feral pigs?

Opportunities for employment and economic development are few in the Arafura area (as on many Aboriginal lands) due to remoteness and inadequate infrastructure. Commercial use of wild animals can provide opportunities for developing economic activities that are in harmony with Yolngu way of life and custodial responsibilities. Harvest and marketing of wild species by Aboriginal people has had mixed success as there are many barriers to indigenous wild harvest including legislation and policy, marketing, location and infrastructure which are discussed in Whitehead (2003). Buffalo harvest and domestication supplemented by safari tourism has been successful in the Eva Valley area of the Top End, but for some other Aboriginal groups their inability to secure adequate funding, amongst other problems, has seen these projects fail (Wilson et al. 1992a). In central Arnhem Land, successful projects include the ranching of saltwater crocodiles and freshwater turtles to commercially relevant size (Bawinanga Aboriginal Corporation 2002). In the Arafura area, there has been a successful saltwater crocodile egg harvest and safari hunting tourism operation run alongside the Murwangi cattle business.

Feral pig meat has been harvested in Australia since 1980 for export mainly to countries in the European Union where it is marketed as 'Wild Boar'. Although the market tends to be volatile with prices fluctuating from year to year, the annual value of feral pig exports has been between ten and twenty million Australian dollars (Ramsay 1994). There is considerable consumer interest in wild food products because of their perceived 'green and natural' credentials. Such food can be marketed at premium prices. Marketing feral pig meat as harvest by Aboriginal people of a wild clean animal could return higher prices for the meat internationally. This 'Indigenous origin' marketing approach may be essential to compete in high volume markets where remoteness is a disadvantage, although whether the premium associated with this marketing is adequate to offset the locational disadvantage, now and in the future, is unclear (Whitehead 2003).

Other options for commercial use of feral pigs include the supply of meat to the domestic market and for pet food. While serious logistical constraints to such an operation exist in many remote areas, these could be minimised in the Arafura Swamp area by using a portable chiller to take pig carcasses to the already existing meat processing facility at the nearby Murwangi cattle station. Processing feral pigs in this way could offset some of the costs of controlling their numbers as well as providing additional employment opportunities within the community.

Safari hunting tourism, although having little impact on the feral pig population, could also be used to earn money to support land management projects, including feral pig control. A similar process operates in Kowanyama, where camping fees levied on recreational fishers are used to fund land management activities (Davies et al. 1999). Safari hunting tourism has provided a source of income, in the form of royalty payments, for some traditional landowners in the Arafura area. While safari tourism has been successful on some Aboriginal lands, there are very different points of view about safari hunting in the Arafura area and complex political issues have arisen between different Yolngu clan groups as a result of this activity. Some of the concerns include the possible effects on sacred sites, disturbance to local communities, and what happens to the animals after they are killed - is it in accordance with Yolngu beliefs (i.e. is the meat being used)? The diversity of opinion in this situation further emphasies the fact that issues can be very difficult to manage in the Arafura area because of the complexity of the local social and political arena.

Most Yolngu involved in this research expressed interest in deriving some economic benefit from controlling pigs, either in the form of short-term employment, subsistence harvesting (obtaining meat for people and dogs) or as a commercial enterprise. However, further research is needed to determine the full range of views held by the traditional custodians. In addition, the economic viability of the commercial use of feral pigs in this area still must be determined. While this diversification into game meats could reduce reliance on income from cattle and relieve some of the pressure cattle place on this sensitive wetland environment, this research suggests that there are political sensitivities regarding this in the Arafura Swamp area.

It is essential that indigenous people's objectives regarding the wild harvest of feral animals are clear. Although most Yolngu involved in this study wanted to control pigs to reduce damage to their land and resources, some people considered pigs to be highly valuable as a resource. As such, there may need to be a negotiated balance between economic and conservation objectives. When managing feral species to minimise ecological impacts, they must be controlled as a pest rather than managed as a resource for harvest. Managing feral pigs as a pest does not preclude commercial gain as pigs can still have commercial potential after intensive control programs have significantly reduced their numbers. However, if commercial harvest is to be considered as a part of a feral animal control program then there must be integration between the two objectives so that the ecological impacts caused by that species are not perpetuated (Ramsay 1994).

7.9 Conclusion

This research provides a baseline for understanding the problem of feral pigs and to a lesser extent, buffalo in the northern Arafura Swamp area. Prior to this research there was no documented understanding of the distribution and movement of feral pigs in this very large, seasonally variable, tropical wetland. The results indicate that a series of environmental features drive feral pig distribution and activity patterns in this area. While, for practical reasons, the focus of this study was on the more accessible northern part of the landscape (an area approximately 10% of the total wetlands complex), the physical observations and conclusions should be relevant to the broader wetlands complex and also to comparable environments elsewhere in northern Australia.

Many people, indigenous and non-indigenous, are aware of the damage done by feral pigs, however, before this research there were no quantitative data on the impacts or costs of feral pigs in this environment. This is the first study to rigorously quantify observable physical disturbances by feral pigs in the Arafura Swamp and its surrounds. Baseline data presented here can be used to monitor changes to feral pig disturbance patterns in the future. However, exactly how physical disturbance translates into damage (by which I mean some kind change that is irreversible or difficult to reverse) to an ecosystem is extremely difficult to determine. Exclosures that monitor changes to vegetation over long periods of time (more than 10 years to account for natural climatic variation) would be necessary and could be staffed by the local indigenous rangers. Long term studies of how populations of native animals respond to changes in pig population density in this dynamic ecosystem are required. The need for further research to focus on key environmental issues such as saltwater intrusion and altered seedling recruitment that are likely to be affected by pigs was identified.

Until this research was undertaken, there was no documented understanding of whether the costs of feral animal damage were appreciated by Yolngu in the northern part of the Arafura Swamp, where a Yolngu land management program was being developed. This work clearly shows that most Yolngu involved in this study perceive feral pigs to be impacting on their traditional resource base and other aspects of their lifestyle. These people were very aware of the effects of feral pigs and expressed concern about the impact of these animals on their land and resources. This awareness and concern was demonstrated by a great deal of discussion about pigs and how to 'get rid of them' with scientists from the Parks and Wildlife Commission, Northern Territory and myself. Some Yolngu were also shooting pigs whenever the opportunity arose.

In the course of the broader Arafura Wetlands and Surrounds Research Program (described in Chapter 1), it was found that there was a range of views held by Yolgnu about the effects of feral pigs on the landscape and resources in the southern part of the swamp (N.White pers. comm. 2001). The views of these people have been influenced by workshops and conversations with researchers and other outsiders (N.White pers. comm.2001). Similarly, the perceptions held by Yolngu in the northern part of the swamp have been influenced by a range of social (by way of relationships) and external factors as discussed in Chapter 5.

The costs of the impacts of feral pigs on the community as well as the extent of the damage recorded justify the investigation of control options. While the basic options for feral pig control are the same (e.g. shooting, trapping, poisoning etc.), the way these are applied and in what combination, and the timing of implementation will vary in different places. These different strategies depend on the outcomes that are desired from the control as well as the local environment, including location and availability of the animal's key requirements such as water, food and shelter. Thus control strategies applied in other parts of Australia would not be effective here. The results from this study favour a particular control strategy, which is based on the specific nature of the physical and cultural environment in the northern Arafura Swamp area. In recognising that best practice approach to pest management emphasises control of the damage that pests cause rather than simple reduction in pest numbers (Olsen 1998), the results from this study can be used to concentrate control effort in the most vulnerable and affected habitats.

Feral animals are but one of the land management issues facing indigenous land managers today. The findings from this study are important for the Yolngu people and their local environment but also provide a benchmark for other areas and other problems by showing the value of collaborative engagement. The results obtained from the rigorously conducted ecological component of this research concur with views presented by Yolngu, further demonstrating the value of collaborative research. The research reported here provides an example of the benefits of working closely with Aboriginal people to determine management strategies that are appropriate to the local context. Working closely with Aboriginal people also highlighted the need for understanding the complexity of the situation and diversity of opinion, which requires an in-depth understanding of the local social and political arena.

While awareness and recognition of the value of traditional Aboriginal ecological knowledge have led to increased involvement of Aboriginal people in land use planning, this has rarely translated to indigenous self-determination in land management. Most Aboriginal communities simply do not have the resources nor the systems in place to manage emerging natural resource issues. My research has shown that feral pigs are a serious problem, both for the environment and for the contemporary lifestyle of Yolngu people. This knowledge should galvanise people into action. In the Ramingining community, the process of developing a community-based management system has begun with the establishment of a ranger program and the employment of local rangers. However, commitment to this process is varied and it is unclear how people's views translate into management actions now and in the future. These challenges, along with the complex local political and social agenda, make it difficult to achieve clear decisions and action regarding land management initiatives in this area. An increased focus on community participation and benefit should be developed in line with community aspirations to stimulate people's commitment. While suggestions have been made here about appropriate actions based on information about feral pig ecology and the aspirations of at least some Yolngu custodians, the final test will be to trial the management strategy and actually find out what will and will not work. Evaluation of these trials can then inform the refinement of the management strategies. Both ecological and social systems in this region are extremely dynamic and the results from this study are only a snapshot of the effects of feral pigs on land and local people. Future observations and changing perspectives should continue to inform management strategies.

My experience suggests that sufficient time (often much longer than expected) must be devoted to finding the required level of community involvement and that involvement is very dependent on community motivation. Successful management of feral pigs depends on people working together with adequate support (both resources and information) from government agencies. There is still much to learn about working with indigenous people on land management issues and about the best ways to provide resources and support to ensure that successful land management is within reach of all Australians.

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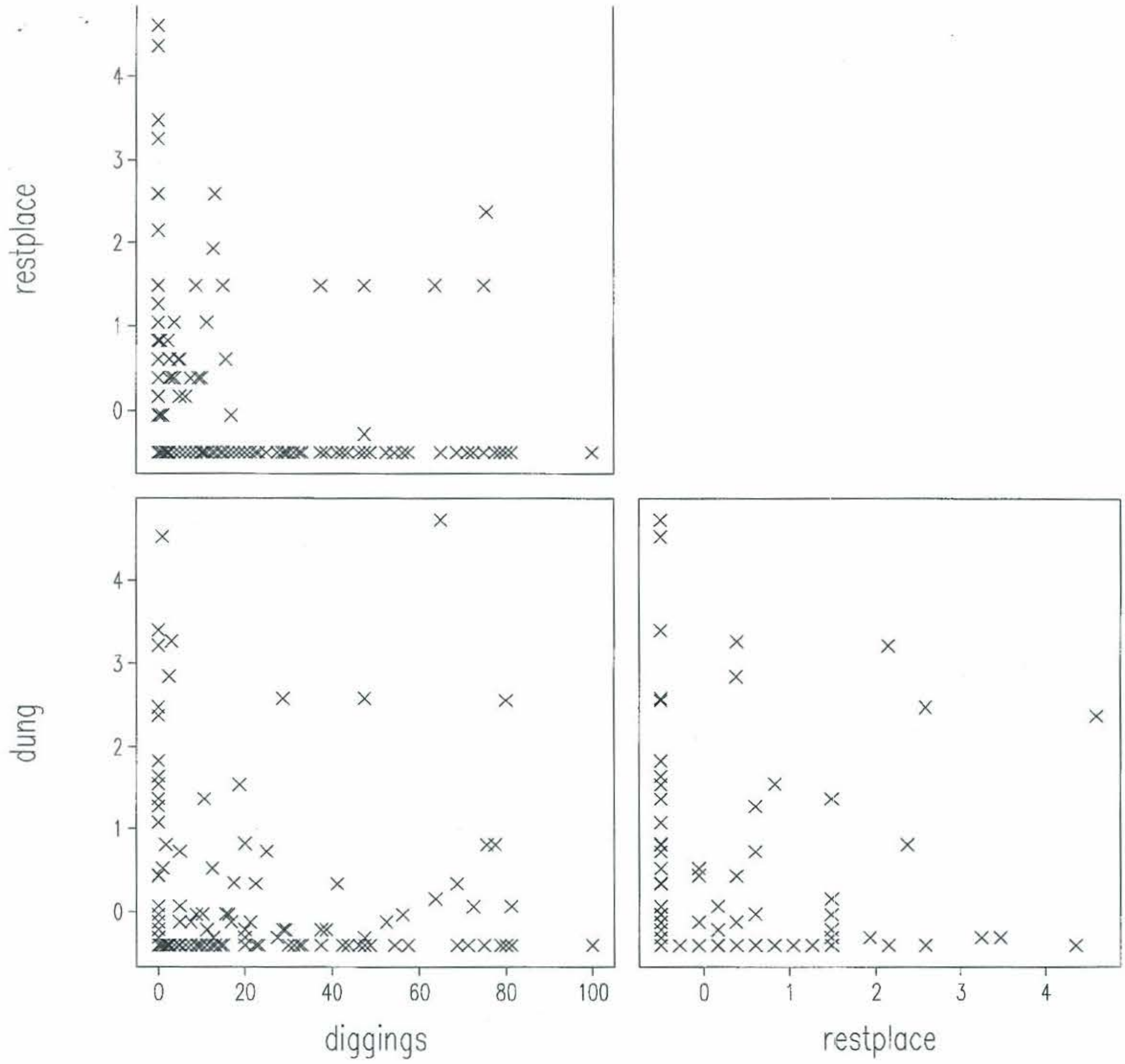
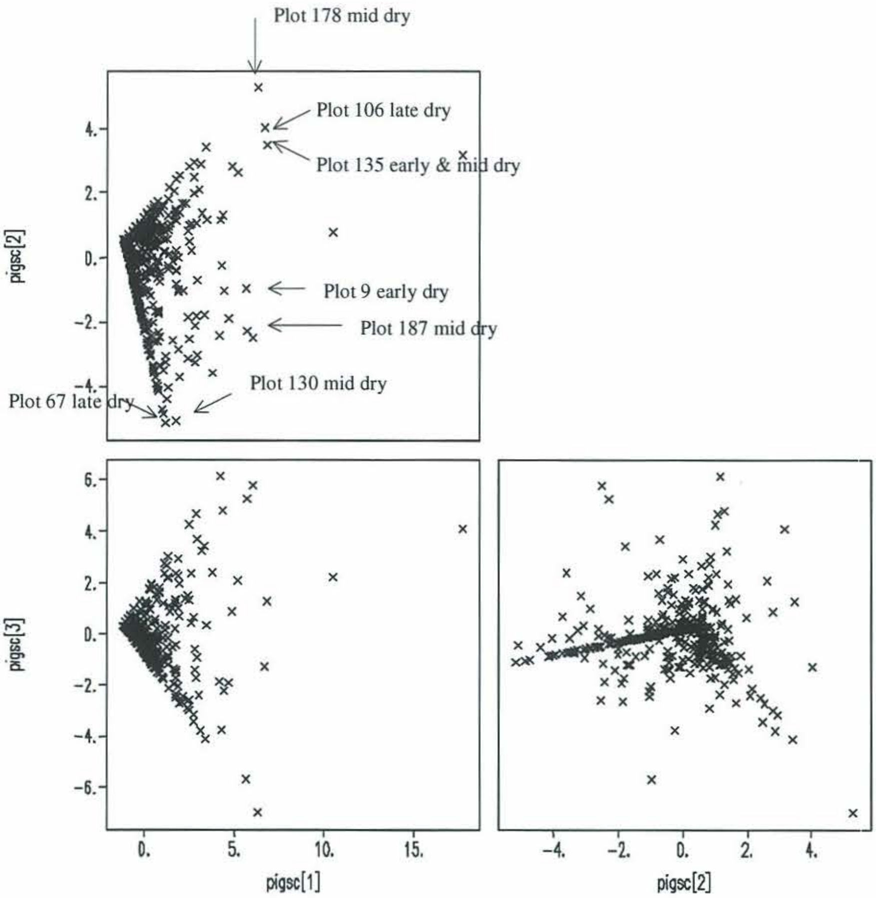
Appendices

Appendix 1: Distribution properties of the response variables diggings, restplaces and dung shown as plotted histograms.



Appendix 2: Scatterplot matrix of pcp scores.



Scatterplot matrix showing the 3 pcp scores (pigsc [1-3]). As pig score [1] and pig score [2] were used as response variables in this study (Pig activity index [1] and [2] respectively), only the top graph is of interest.

Appendix 3 Interview questions and responses.

Interview One

1. How often do you go out hunting?

Mick: every weekend mostly

Jessica: every weekend

Julie: most days

Annie: every weekend

Molly: no response

Margaret: every weekend

Andrew: all weekend

Jack: on weekends

Gary: on weekends

Caroline: not often

Joanne: everyday

David: every weekend

Robert: on weekends

Jane: one day each weekend

Lily: usually once or twice a week

Ella: every weekend

Mary: on weekends

Ruby: sometimes on weekends

Billy: no response

2. What feral animals are you aware of?

Mick: pig, buffalo, bullicky, cane toad, banteng

Jessica: goose, turtle, file snake, buffalo - they belong; and pig - doesn't belong

Julie: pig, buffalo and also upset because there is too much crocodile in *Gatji* billabong/creek now

Annie: pigs, buffalo, bullicky

Molly: pigs and buffalo

Margaret: pigs

Andrew: pigs and buffalo

Jack: pigs & buffalo

Gary: pigs & buffalo, donkeys near Bulman, there was horses but they were collected by *Murwangi* by Malcolm Armstrong

Caroline: pigs, buffalo, and upset that *Murwangi's* cattle goes everywhere, it should be fenced

Joanne: pigs

David: buffalo, pig, cat, dingo

Robert: pigs and buffalo

Jane: pigs and buffalo

Lily: buffalo, *gumbarla* (emu), pig, wallaby, goose

Ella: pigs

Mary: pig, cow, buffalo

Ruby: pig, it doesn't really belong

Billy: no response

3. Does anyone own these animals?

Mick: no, doesn't belong to the land

Jessica: pigs - no; buffalo - they been here a long time

Julie: no, no one owns either animal

Annie: no response

Molly: no

Margaret: no, pigs are wild ones so are buffalo

Andrew: nobody owns pigs but buffalo are owned by overseas mob

Jack: landowner

Gary: landowners own them and if others shoot them they need permission from the landowner

Caroline: pigs are not owned, buffalo are *Yirritja*

Joanne: nobody

David: buffalo: some people at Maningrida outstation claim buffalo is their dreaming; Pig: no owners; Cat: native cat is dreaming for me, but not feral cat (clouds in Milky way - *Mardudu* are fire being lit by cat); Dingo: has dreaming, dog dreaming, owned by *Burinyala*

Robert: not owned by anyone

Jane: buffalo belongs to some people, no-one owns pigs

Lily: Yolngu people

Ella: no response

Mary: pigs - no; buffalo - Maningrida area

Ruby: pig is not owned, I don't know about buffalo

Billy: no response

4. Are any of these animals used for food?

Mick: yes, both

Jessica: yes both

Julie: yes, both, I eat pig sometimes

Annie: yes, both

Molly: yes, both

Margaret: yes

Andrew: yes both

Jack: some people eat pigs

Gary: buffalo, pigs

Caroline: pigs - I don't eat it and neither does anybody else; Buffalo is good meat

Joanne: pigs and buffalo are eaten

David: buffalo and pig- yes, both. I eat pig, it is sweet, only eat the meat not the stomach or anything and I don't eat it if it looks sick. Buffalo, I eat only fat ones

Jane: yes, both

Lily: yes, both

Ella: I eat pig because wild meat is good to eat, buffalo too

Mary: yes, both

Ruby: yes, I eat pig and buffalo

Billy: Yes both. I don't eat pigs, not wild ones because I was told they were dirty, I do eat pork from the shop though

5. Does everybody in the community like to eat them?

Mick: yes, both

Jessica: no, I don't like pig, some people do especially people who drink kava. Everyone eats buffalo

Julie: no

Annie: no, some people eat pig; everyone eats buffalo

Molly: everyone eats buffalo, good meat; most people eat pig, May's family and Tank people, its not too good, sharp teeth

Margaret: no, only some like pig but all like buffalo

Andrew: no, only some people eat pigs others don't like the taste; everybody eats buffalo

Jack: some people eat pigs

Gary: buffalo - all eat; pigs - some eat and some don't

Caroline: everyone eats buffalo

Joanne: no only some people like pigs but everyone eats buffalo

David: everyone eats buffalo; some people eat pig

Robert: no response

Jane: yes

Lily: everyone eats buffalo, some people eat pig

Ella: no response

Mary: pig - some people, it tastes *manymak* (good) but I only eat it if there is no other *warakun* (meat) available. Buffalo - everybody eats it

Ruby: some people eat pig but not all

Billy: Some people eat pig, everyone eats buffalo

6. Do any of these animals have a dreaming?

Mick: pig and buffalo has no dreaming, no culture

Jessica: pig has no dreaming; buffalo is from *Miwatj* (from Galiwinku, Yirrkala, Lake Evalla) they have buffalo *bungul* (ceremony)

Julie: no response

Annie: buffalo is dreaming for *Gupapuyngu* people

Molly: no dreaming for pig; Tiwi people dance buffalo and pig but no one from here has buffalo dreaming

Margaret: no, they are wild ones

Andrew: no neither of them

Jack: no dreaming for pig

Gary: buffalo dreaming, don't know about pigs, probably not, some stories about pigs and dreamtime

Caroline: pigs - no; buffalo is *Yirritja*

Joanne: pig has no dreaming, buffalo has dreaming

David: buffalo: some people at Maningrida outstation claim buffalo is their dreaming; Pig: no Dreaming

Robert: no

Jane: pigs - no I don't think so; buffalo - some people from Maningrida, see **Mick** it is his Grandmother

Lily: buffalo is dreaming for *Gakamangu* people; pig – nothing

Ella: no dreaming for pig, buffalo is dreaming from Maningrida people

Mary: pigs - don't know; buffalo- dreaming for Hazel

Ruby: pig has no dreaming; buffalo is *Yirritja* and some people at Millingimbi sing and dance Buffalo

Billy: there is no dreaming for pig, I'm not sure about buffalo

7. Where did these animals come from?

Mick: don't know where either came from

Jessica: pigs: don't know; buffalo: seen them around but don't know where they came from they have been here for many years.

Julie: pigs are from somewhere else; buffalo are from Timor, belongs there not here

Annie: pig first came as a pet from Bulman or Roper and had babies then they ran away; then the same thing happened at *Yathalamarra* and *Nangalala*; buffalo and cattle came in the 1930's or 40's when they started the station, long time ago

Molly: pig: came from New Guinea or maybe Africa; buffalo: came from India. They came from overseas, Macassan people and stockmen from *Murwangi* (brought first cattle) maybe they brought the buffalo; My father told me that buffalo came with Macassans from Indonesia and Captain Cook. Pigs they came from Oenpelli, I've seen lots of pig at Oenpelli and down to Pine Creek and Jim Jim

Margaret: pigs - don't know they are not from here; buffalo are from here, there used to be no pigs only buffalo

Andrew: pigs maybe came from Asia; buffalo, maybe they came from Timor or China as they are used for rice growing

Jack: pigs came from *Gunbalanya* (Oenpelli) way, kangaroos also from there. More recently they came from *Yathalamara* and *Matjaljari* (rainforest?)

Gary: long time ago balanda people brought in buffalo from Asia and pigs too. Pigs came across from Oenpelli, they don't belong here

Caroline: balanda brought pigs here with the mission stations

Joanne: pigs first came with Yolngu as a pet at *Nangalala* then they bred up. Buffalo came with the Macassans a long time ago. It has been here for a long time. It came from Maningrida outstation called Buluadro? which is the first turn off on Darwin rd after the Maningrida turn off. This place is Bunungur country, their great great great grandfather saw buffalo first.

David: buffalo and pig both come from Asia; before there was no pigs, only one at Djibama outstation (Maningrida outstation) as a pet, then it bred up and came here, lots of them

Robert: pigs - not sure, I think it spread from Oenpelli way; buffalo - came from India

Jane: don't know, pigs maybe came from Bulman

Lily: buffalo and pig came from the bush

Ella: pigs came from Oenpelli or Darwin, spread from there, they came from somewhere else before Oenpelli. Maybe pigs came with islander people maybe from PNG. Because missionaries were from Fiji, they might have brought pigs

Mary: pigs - don't know; buffalo - some from Asia, some from here

Ruby: pigs - don't know; buffalo - they have always been here

Billy: pigs came a few years ago to Ramingining through Gunbalanya or a few piglets came here and people kept them and fed them, then they ran away and bred more and more every year. Before that in 1950's I saw pigs near Mary River, they came from that way. Also in the 1970's people brought back pig from Jim Jim way and looked after it at Mulgurrum. Buffalo came from buffalo station at Mary River (Jim Blyth and others). They had heaps of pigs and buffalo there.

8. Do these animals belong here?

Mick: no they don't belong

Jessica: pigs: no; buffalo: yes

Julie: no, buffalo belongs in Timor

Annie: no

Molly: they don't belong

Margaret: pig doesn't belong; buffalo is OK, it does belong

Andrew: neither belong

Jack: pigs don't belong in the area

Gary: they don't belong here

Caroline: pigs don't belong

Joanne: pigs sort of belong and buffalo do belong

David: no

Robert: no

Jane: pigs don't belong here; buffalo do belong here

Lily: buffalo and pig belong here

Ella: no response

Mary: pigs - no; buffalo - yes

Ruby: all animals belong, but pig doesn't really belong, sometimes they have diseases and can make people sick

Billy: no, these are not Yolngu animals

9. Were they here before balanda came?

Mick: Pigs: yes, not sure; buff: yes, not sure

Jessica: pigs: no; buffalo: yes

Julie: pigs came after balanda; buffalo came before balanda, they were here before the Macassans

Annie: no, both came at the same time as balanda

Molly: pig not here before balanda, Buffalo were, they came with the Macassans

Margaret: pigs were not here before balanda, there were none when the mission was first established at Nangalala only buffalo that people used to hunt with spears. Buffalo were here before balanda

Andrew: pigs - yes, pink and black and white, when I was in Millingimbi they were in a farm, now thats all gone. Buffalo - only one or two

Jack: no pigs before balanda

Gary: no response

Caroline: no, balanda came first then pigs then buffalo

Joanne: pigs came after balanda in 1975-77, buff came with the Macassans

David: buffalo were here, they came with the Macassans who tried to grow rice in paddocks, got washed away in the wet and buffalo ended up running away; pigs probably were not here before balanda, cat has been here a long time, dingo was here before balanda

Robert: pigs were not here before balanda came; buffalo were here before balanda they came with the Macassans

Jane: pigs, no; buffalo, yes

Lily: yes, both

Ella: pigs came with balanda; buffalo came from Indonesia before balanda or maybe with first stockmen, cows came with stockmen during mission time

Mary: pigs - no; buffalo - a few were here

Ruby: pigs came after balanda, buffalo came before balanda, they have always been here

Billy: no response

10. Do you think these animals are good/O.K for country?

Mick: both are bad for country

Jessica: pigs: bad; buffalo: bad

Julie: no response

Annie: pigs: bad; buffalo: bad

Molly: pigs: bad , ruining nature and food; buffalo and cattle are the same, they damage all turtle, buffalo, pigs and cattle should be in a farm, fenced

Margaret: pigs are damaging paddocks - no good. Buffalo are OK because they are always in waterholes

Andrew: pigs are bad and buffalo too

Jack: they spoil everything, pigs are bad

Gary: pigs are bad for country they make a mess, they are also bad as pets, smell bad
Caroline: pigs and buffalo are damaging all of our food and country
Joanne: pigs are bad; buffalo are bad, they are damaging the plains
David: Pigs and Buffalo are bad for country; Cats and Dingos are OK for country
Robert: buffalo is sometimes OK, sometimes makes holes
Jane: both are not good for country
Lily: yes, both are good
Ella: pigs are bad for country, buffalo are fine
Mary: pigs - bad; buffalo - bad
Ruby: pigs are not good, they make worse the swamp for long neck turtle, goanna, file snake and python, they make swamp muddy for those animals and they eat those animals too.Buffalo are OK but when they are shot at they can get wild and angry but they don't do any damage to country.
Billy: no, they are bad

11. Would it be better if there were more or less of these animals?

Mick: just none of the pigs or buffalo
Jessica: less
Julie: no response
Annie: get rid of pigs and all wild buffalo
Molly: better with no pigs, buffalo or cattle
Margaret: less pigs and less buffalo
Andrew: less of both
Jack: less
Gary: get rid of pigs; before pigs and buffalo swamp was alright, now in dry floodplains are bumpy, people are ready to shoot them, some people want to keep pigs for meat and hunt specifically for pigs
Caroline: pigs - kill them all, I don't like buffalo either
Joanne: better if there were no pigs but should leave some buffalo
David: Pigs and Buffalo should be less; Cat, doesn't matter, either way; Dingo, don't know, less maybe, they are OK not as bad as the ones in Central Australia
Robert:
Jane: better if no pigs and just a few buffalo
Lily: more of both because they are good food
Ella: no response
Mary: less of both
Ruby: less pigs, more buffalo is OK
Billy: less

12. Do these animals harm the other dreaming animals or do they fit in OK?

Mick: pigs tackle and chase other animals, pigs have got strong teeth
Jessica: no response

Julie: no response

Annie: no response

Molly: don't fit in

Margaret: no response

Andrew: no response

Jack: spoil, fight together, eat file snakes, other snakes including king brown, nyiknyik, worms. Snake and pigs fight and pig wins

Gary: . pigs eat turtles, snakes, dig holes for worms, small mice -nyiknyik - easy for pigs to dig out, live in wet habitat like pigs. Pigs don't get bandicoot because they live in the bush

Caroline: no response

Joanne: yes, we don't get turtle properly now, just get pig foot, pigs eat turtle and we often find turtle with no legs or arms. They also cause bad roads. Need to fence whole place to stop buff and cows and pigs. Put fence around all area from Murwangi to the north. Buffalo feet damaghe turtle place and make roads rough.

David: Buffalo: don't know they keep to themselves, sometimes hang with the bullicky; Pigs: they are bad, they eat lots of turtles, they eat whatever they come across, dig their big noses into swamps and eat them so when women go there they don't see any bcause pig ate them; Cats and Dingos are OK

Robert: no response

Jane: fit in with other animals

Lily: no they don't harm other animals; buffalo eats grass, like pigs. Pigs eat worms and digs with nose. They live in the same country as each other.

Ella: no response

Mary1. Do these animals harm the other dreaming animals or do they fit in OK ...

Ruby: no response

Billy: no response

13. What would happen if these animals went away?

Mick: pigs and buffalo: good, land and vegetation and animals would go back to normal, they bring weeds on their feet

Jessica: get rid of them all to make land back to normal where it used to be

Julie: country good, water full and clean, trees grow up good, swamps clean

Annie: land and food would go back to how it was before

Molly: if all gone, nature would grow up again, grass, trees, turtles and fishes will live again

Margaret: it would be good if pigs went away, country would go back to normal. it would also be better if buffalo went away because old ladies hunting get scared of being chased by buffalo

Andrew: pigs - be normal country no damage, more yams - long and round yams; buffalo - normal country.

Jack: digging fix up, things better, pig very dangerous one - watch out, we shoot them

Gary: if pigs and buffalo went away the floodplain bumps would improve, go away

Caroline: country would go back to normal as before

Joanne: pigs - good country, Yolngu would be happy, better roads, less trouble with vehicles, less hurting of people who fall into holes and hurt ankle, knee, back. Buffalo - land would be good

David: Buffalo: everything would be smooth; if we shoot them all pigs and buffalo, landscape would go back to normal

Robert: less meat, only cows from Murwangi then; country would get better

Jane: it would be better on the land

Lily: it would be bad if they were gone

Ella: country would come back good again, clean swamp, clean water, clean dreaming places, now we have to boil the water to drink it

Mary: country would look meinmuk (good) like before, less bumpy

Ruby: it would be good for country, for both of them to go away, it would make people happy because they damage country

Billy: the country was beautiful with medicines on the trees and the animals came, that was before pigs were here, land would be smooth and clean, more food would be available for Yolngu people

14. Would you like to see them taken away or have them stay?

Mick: yes, when I see them I shoot them but instead of wasting I eat them

Jessica: away

Julie: want to leave a few buffalo and pigs too for royalty money

Annie: taken away

Molly: taken away

Margaret: taken away

Andrew: go

Jack: taken away

Gary: . taken away - shoot them

Caroline: taken away

Joanne: Take away all the pigs but leave some buffalo

David: get rid of them all

Robert: leave some, getting rid of pig is OK but leave some buffalo for meat. It is also good to leave buffalo for trophy horns for tourists so landowners can get money and good jobs for Yolngu.

Jane: get rid of most but leave some

Lily: stay

Ella: leave buffalo just shoot the pigs

Mary: taken away

Ruby: go

Billy: get rid of all pigs and buffalo

15. Can you think of any good/bad things these animals do?

Mick: no good things for either; pigs (bad) eat long necked turtle, lily roots. Pigs and buffalo have no respect, help themselves to food, now not so much small animals

Jessica: pig-good: nothing; pig-bad: digging, eating fresh turtle; buffalo - nothing good

Julie: nothing good for either animal

Annie: pigs- bad: swim in small creeks and eat fish, file snake and turtle; damaging land, less bush food now; leave sickness when they drink from waterholes;

Molly: no good things; (bad) damaging country, digging, trampling, all plants get stamped on

Margaret: good pigs - nothing; good buffalo - only meat

Andrew: pig - good: nothing; bad: digging, damaging hunting area, eating turtle. Buffalo - good: nothing; bad: walk through swamp, too much mud when goose hunting

Jack: spoil things

Gary: .bumpy country, eat other animals

Caroline: pigs damage country, they dig all around, can't find roots, string, yams or long neck turtle anymore. They are messing up swamps and waterholes, dreaming places and places people rely on for drinking water. The animals are urinating in the swamp. They make too many holes that make it hard for hunting. I'm worried about people's health.

Joanne: pigs and buffalo don't do anything good for country. Bad things include eating turtles, making roads bad.

David: Buffalo: nothing good except being alone, bad in that they are wrecking the land; Pigs: nothing good, bad - digging, stealing Yolngu food

Robert: pigs - bad: they are humbug for roads, especially for outstation mob, they make a mess if you keep them as a pet. Buffalo - they just make mess

Jane: good things: none; bad things: pigs dig holes, buffalo break trees and chase people

Lily: buffalo - just walking around, no bad things. Same for pigs.

Ella: pigs do only bad things, they dig long neck turtle and eat all our bush tucker, pigs bring sickness, people used to get water from swamps and springs but pig mess up too much now, pigs are weeing in swamps which is bad- we are worried about sickness, there are no foods left so we need to eat pigs now, dog dreaming waterhole is bad now - all messed up from pigs. Buffalo is fine, he moves around, doesn't live in the same place, sometimes they go other places in dry season - maybe where there is good water to drink

Mary: pigs and buffalo do nothing good

Ruby: pigs do nothing good, I'm not happy with baby pigs being made pets, it makes the town dirty. Buffalo do nothing good but they always live in the bush, not close to camp which is good

Billy: pigs are killing our food, killing everything that moves and grows on the land, some important trees get knocked down by these animals, make holes in the land so its hard to drive and hard to chase wallabies, destroy goose nests. Buffalo are very heavy animals, they knock down trees, dreaming trees and places, destroy goose nests. These animals make so many tracks that djanda (goanna) can't dig for holes in the hard ground and not enough grass grows for burning. Women can't see djanda or turtle tracks anymore.

16. When did people first see these animals in the area?

Mick: don't know

Jessica: don't know

Julie: saw pigs first time after Ad Borsboom was here; buffalo have been here for a long time since my g.g.grandfathers time

Annie: pigs came about 1975

Molly: pigs first seen in 1974 when the cyclone came, pigs at Ramingining came as a pet from Oenpelli; buffalo came with the Macassans in 20's, 30's 40's maybe, in my great, great grandfathers time

Margaret: don't know, I was in Darwin

Andrew: pigs - don't know; buffalo - barge landing when I was 14 y.o

Jack: no response

Gary: no response

Caroline: in 1972 there were no pigs in Ramingining, they came in 1985-8 when Ramingining was becoming a town

Joanne: 1975-77 at Nangalala

David: Buffalo - don't know; Pig - saw when young in Millingimbi in a garden, then across here and heard stories of pigs running around Djapidingorin - said it was big and had a baby, this was when I was 18 yrs old (now 41)

Robert: no response

Jane: there were no pigs in the 80's, they came after that; buffalo were here when I was young

Lily: long time ago

Ella: at Nangalala when there wwas stock-cows, they brought the pigs then with missions in the 190's. The pigs at Millingimbi came with the missionaries who then brought them here.

Mary: pigs - 1981-83 when my father saw tracks from hunting, he had heard they were coming from Maningrida area, someone there had a pet pig and it got angry and loose and came this way. Buffalo - long time before I was born, since Millingimbi mission

Ruby: pigs, about 1981-82. I saw them at Nangalala before this as others had pigs here in the early 80's. Buffalo were here before balanda

Billy: pigs: 1970's; buffalo: In the 1940's I had heard about buffalo and seen tracks but I hadn't seen the animal yet, in 190's there were not so many buffalo but since then they have bred a lot, in the 1980's there were not so many buffalo but then the numbers increased a lot after that

17. How many were there?

Mick: no response

Jessica: don't know

Julie: pigs - there was 1, 2 or 3

Annie: just a couple as pets

Molly: pigs: only a few then had lots and lots of babies; Buffalo:just a few, but since then they have bred up

Margaret: no response

Andrew: no response

Jack: no response

Gary: no response

Caroline: no response

Joanne: just one or two as pets

David: pig: big one and a baby; Buffalo: rice workers

Robert: no response

Jane: lots of pigs, few buff, mostly cows and horses at Murwangi

Lily: don't know

Ella: 2 pigs

Mary: 4-8 pigs were here

Ruby: pigs, 2 pets at Nangalala a male and female that made babies

Billy: no response

18. Where were they?

Mick: no response

Jessica: don't know

Julie: pigs were around Gatji

Annie: Yathalamarra, Nangalala

Molly: pigs were first in town (not bush), then when they had babies they went bush and made big families in the bush

Margaret: no response

Andrew: buffalo - barge landing

Jack: no response

Gary: no response

Caroline: no response

Joanne: Nangalala

David: Pigs: Djapidingorin

Robert: no response

Jane: Pigs were around town, Yathalamara, swamps, Bundatharri; Buffalo were Gatji, Bundatharri and Galadjapan

Lily: don't know

Ella: Nangalala, then they got scared and ran away and spread from there

Mary: wulungir

Ruby: Nangalala

Billy: no response

19. Were there pigs at Maningrida before they were at Ramingining?

Mick: no, don't know how they got here, came from no-where datung (buffalo), means 'nothing' not connected to the land or animals

Jessica: don't know

Julie: pigs were at Maningrida first, came from there all the way or came from Oenpelli

Annie: yes, at Maningrida first

Molly: there were pigs at Maningrida in yards but none at Mirrnadja

Margaret: no response

Andrew: yes, at Maningrida first but not Mirrngadja.

Jack: no response

Gary: no response

Caroline: no response

Joanne: saw some on the road to Darwin near Oenpelli, ran over it and said 'whats that - that is something strange'. They were at Maningrida and Oenpell before Ramingining.

David: pigs were breeding at Maningrida before they came here

Robert: pigs were at Maningrida first

Jane: Don't know

Lily: don't know

Ella: they were at Maningrida first

Mary: yes at Maningrida, don't know about Mirrngadja

Ruby: don't know

Billy: there were pigs at Maningrida before here, some young ones were there

20. Had you been told about/heard of pigs before you actually saw them?

Mick: no

Jessica: no

Julie: no, I didn't know about them

Annie: seen them in pictures

Molly: no

Margaret: no response

Andrew: no

Jack: no response

Gary: no response

Caroline: no response

Joanne: seen it in books first - 3 little pigs

David: only heard of the garden pig at Millingimbi

Robert: yes, had pets in town then someone started shooting them and they ran off and thats how it spread

Jane: no

Lily: no

Ella: heard stories about pigs before I saw them, stories from when travelling to Darwin

Mary: in books

Ruby: I was scared, I knew it was a pig as kids were saying it was a pig

Billy: I knew what they looked like because missionaries at Millingimbi had a few pigs

21. Are pigs or buffalo Yirritja or Dua or neither?

Mick: neither, no culture

Jessica: pigs are nothing; buffalo I don't know

Julie: neither

Annie: pigs: nothing; buffalo: Yirritja for Gupapuyngu people from here

Molly: no response

Margaret: pigs are nothing; buffalo are Yirritja

Andrew: both are neither

Jack: no response

Gary: no response

Caroline: pigs - nothing; buffalo - yirritja

Joanne: pigs are nothing, buffalo are Yirritja

David: buffalo is yirritja, pig is nothing, native cat is dua, dingo is yirritja

Robert: no, they have no dreaming

Jane: pigs: no dreaming; Buffalo: yirritja

Lily: both are neither

Ella: pigs are nothing

Mary: pigs - nothing; buffalo - yirritja

Ruby: pigs are nothing; buffalo is Yirritja

Billy: no response

Interview 2

1. Why do pigs/buffalo go where they go?

Mick: pigs: swamp area, soft ground areas where they can dig; floodplain for cool time, and jungles where its green and shady buffalo: same places as pig, floodplain and normal bush, comes out every morning and walks around, looks for cool place in the afternoon, night time is in plains and rivers Pigs and buffalo go looking for food and water, and looking for soft ground for digging and trees for rubbing, buffalo want to make wallows

Jessica: see pigs in swamps, bush, jungle; buffalo are everywhere. Pigs go there for digging or eating long-necked turtle; buffalo go to make holes for his pond, in swamp. Both go to the jungle for a cooler place for daytime then go to plains and swamp at night

Julie: no response

Annie: no response

Margaret: pigs go to swamp country; buffalo go to swamp, paperbarks and jungle

Andrew: pigs and buffalo are everywhere in the bush, swamp, forest, plains country

Caroline: no response

Joanne: they go everywhere, pigs smell food, they hide under trees and tall grass and pandanus. buffalo just walk

David: pigs: go to swamps because they are cooler and closer to water; buffalo: to paperbark swamps because they are cooler and closer to water

Robert: looking for shade and food

Lily: pigs and buffalo are at Bundatharri, Murwangi, Nungulmar (near Nangalala), Mangurr. They are in swamp country, floodplains and jungles. They go walking, digging, hunting, looking for food.

Ella: to dig for food, they dig everywhere, bush, swamp, jungle

Mary: pigs go to hunting area, *Dhabila*, *Badarr* and swamp areas around *Mangbirri* and *Yathalamarra*; buffalo go everywhere, they walk around, make holes and eat grass, trees and leaves

Ruby: pigs: go for food and cool places, shade; paperbark swamps where they eat turtle, jungles in cool places; buffalo: go for food and shade

Billy: no response

2. How many pigs/buffalo do you usually see each time?

Mick: pigs, sometimes one, sometimes a family; buffalo, sometimes one, sometimes a family

Jessica: 20-25 pigs each time in the jungle; buffalo are the same 20-25

Julie: no response

Annie: dharrwa (many) pigs and buffalo

Margaret: pigs, one with tusks; buffalo dharrwa (many)

Andrew: no response

Caroline: no response

Joanne: pigs, I see a big mother one and too many little ones; buffalo, I see dharrwa (many), 50 or 60 little ones and big ones

David: just a few, but in the afternoons you see big mobs of buffalo coming out from the bushes to the floodplain at dusk

Robert: no response

Lily: different numbers of pigs and buffalo

Ella: no response

Mary: pigs: *dharrwa*, 20 young and old; buffalo: *dharrwa*

Ruby: no response

Billy: no response

3. Are there more this year than last year or previous years ?

Mick: pigs and buffalo: more, breeding more now, they damage the land, they've got no name, rubbish animals, got no culture

Jessica: same numbers of pigs and buffalo

Julie: yes, more

Annie: no response

Margaret: no response

Andrew: there are more this year of both pigs and buffalo

Caroline: no response

Joanne: pig: same number, maybe next year will be too many and later more still, then there will be no more goose we will have to start eating pig; buffalo: yes, more

David: yes, more of pigs and buffalo

Robert: more this year, they are everywhere including the other side of the swamp

Lily: same numbers of pigs and buffalo

Ella: more

Mary: pigs: more, each year more. In 1981 there was only a little bit, today getting more and more. Buffalo: more

Ruby: less before, now more, more each year

Billy: no response

4. Has there ever been this many before in your memory ?

Mick: the most now

Jessica: no, this is the most

Julie: no, this is the most

Annie: no response

Margaret: no response

Andrew: no, this is the most

Caroline: no response

Joanne: both are most ever, getting worse and worse every year

David: no, this is the most

Robert: this is the most

Lily: this is the most

Ella: no, this is the most ever

Mary: most of both now

Ruby: most now

Billy: no response

5. Where do pigs/buffalo live during the day ?

Mick: both live in cool place like rainforest or bush with cool green grass for sleeping, quiet place where no-one will sneak up, hide themselves, daytime is sleeping time

Jessica: pigs: jungle; buffalo: jungle

Julie: pigs and buff: swamps, jungles, cool places

Annie: pigs and buffalo: bush where there is shade and cool, especially the paperbarks and jungles near rivers and swamps

Margaret: pigs: jungle, grass, everywhere; buffalo: everywhere

Andrew: pigs: jungle; buffalo: swamp in water

Caroline: pigs and buffalo: bushes and swamp

Joanne: both live where they (people) hunt for goose in swamp area, sleep in the mud where it is cooler; buffalo rest in swamp and plains near cool water; when people go hunting for goose they often scare pigs that are sleeping in grass, the pigs run into the swamp and frighten all of the geese that then fly away

David: both live in swamps, cool places

Robert: pigs and buffalo: swamp and jungle and bush; during the wet they go inland, anywhere on higher country

Lily: pigs: jungles, sleeping in wet ground on edges of swamp; buffalo: sleeping

Ella: pigs: jungle and wherever there is good shade

Mary: pigs: swamp where it is cooler, in jungles eating yams; buffalo: swamp, jungle, walk around

Ruby: pigs: paperbark swamps, jungles; buffalo: live anywhere, jungles

Billy: pigs: in escarpment under ledges in paperbark country, swamps, little creeks, jungles

6. Where do pigs/buffalo live during the night ?

Mick: they live in rivers, floodplain and bushes, night time is food time

Jessica: pigs: swamps; buffalo: swamps

Julie: pigs and buff: walk around, look for food at night

Annie: pigs and buffalo: out in the plains, clear places

Margaret: pigs: jungle, grass, everywhere; buffalo: everywhere

Andrew: pigs: out of the jungles in the floodplain; buffalo: walk around

Caroline: pigs and buffalo: resting on roads

Joanne: buffalo stay around camps, they walk around Yathalamarra all night; pigs sleep in scrub

David: both come out onto the floodplains

Robert: pigs and buffalo: swamp and jungle and bush

Lily: pigs: back to the jungles; buffalo: walk around

Ella: pigs: come out for food

Mary: pig: in jungles; buffalo: swamps, jungles, camps and walks around

Ruby: pigs: some same and some different places

Billy: pigs: hunts and feeds, comes out to the plains, same for buffalo

7. What foods do pigs/buffalo eat ?

Mick: pigs eat anything, find foods in wet and dry soils; buffalo eat grass and weeds from swamps, good tasting grass

Jessica: pigs: long necked turtle, mud, maybe looking for other things in the mud, snails maybe, they eat yams; buffalo: grass only

Julie: pigs: yabbies, everything, goose, freshwater turtle and eggs, saltwater turtle eggs, crocodile eggs, little birds eggs (djundjunukl = pardalote).

Annie: pigs swim in small creeks to eat fish, file snakes and turtle, now there are less bush foods especially goanna, turtle and baltji. Pigs eat turtle, goanna, file snake, goose and eggs, yams, waterlilies, djitama (cheeky yam?), raki (eleocharis sp), fruits from small trees and the ground; they eat big mussel called *ragultha* at *Bundatharri* area

Margaret: pigs: long neck turtle, pandanus, yams - round and long, bush potato, grass, worms; buffalo: only grass

Andrew: pigs: long necked turtle, long and round yams, ragi (eleocharis sp), worms - these are the only things I've seen pigs eat, I don't know what else they eat; buffalo: grass. They both eat swampy weeds and then they spread them.

Caroline: pigs: eats worms, dig the ground, long necked turtle, yams, insects and beetles, raki (*Eleocharis* sp.)

Joanne: pigs eat crab sometimes, I've seen their tracks. Pigs eat Mandapirri (oyster/barnacle?), weti (wallabies) also eat this. I don't think thay eat ragudha (sp. large cockle), they eat plants, yams, cheeky yams, lillies, sweet potato-walangarri (in dry country), murlna (round sweet potato, biscuit size), retjarngu (?), ganay (?), raki (eleocharis sp.), turtle, amll freshwater fish, worms, dakawa (prawns), nyiknyik (rats and mice), guthin' (rat), bapi (snakes)-all kinds, pigs eat all eggs from all animals; buffalo eat only grass

David: pigs eat turtle, lily, worms, anything that comes close to them; buffalo just eats grass

Robert: pigs: worms, lily nuts, water chestnuts (*Eleocharis* sp.)

Lily: pigs only eat worms; buffalo eat grass

Ella: pigs: long necked turtle, lily, *raki* (*Eleocharis* sp.), *galun*, *djitama*, *muliangar*, *baltji*, snails, *rungi*

Mary: pigs at *Dhabila* they eat crab, long-bums, snails, mangrove worms. I have seen an open mangrove worm tree where pigs had been. At *Badarra* they eat turtles and worms. At *Mangbirri* they eat worms and turtle. They also eat *galun*, *warrama* , palm cabbage, roots inside of the cycad as well as the nut; Buffalo eat grass, trees and leaves.

Ruby: turtle, goanna, file snake, python, mussels (*ragultha*), they don't eat yams

Billy: pigs: turtles, pigs upturn them wrong way and eats them or leaves them to die; pigs eat turtle eggs, *djaykurr* (file snake), freshwater fish, king/queen fish called (*nyungala*), *gangurk* (destroys the holes of this fish), yams, *djitama* (cheeky yam), *raki* (*Eleocharis* sp.), waterlilies.

8. Where do they find these foods ?

Mick: no response

Jessica: no response

Julie: no response

Annie: no response

Margaret: some places

Andrew: no response

Caroline: no response

Joanne: swamps, everywhere, pigs follow their noses and go there and dig holes

David: no response

Robert: no response

Lily: worms are found on the edges of swamps

Ella: no response

Mary: *Dhabila, Badarra, Mangbirri*, swamps, jungles

Ruby: no response

Billy: no response

9. Do they eat some of the same foods as other animals? Which foods?

Mick: no response

Jessica: no response

Julie: no response

Annie: no response

Margaret: no response

Andrew: no response

Caroline: no response

Joanne: no response

David: no response

Robert: no response

Lily: no same foods

Ella: no response

Mary: no response

Ruby: no response

Billy: no response

10. Do they eat some of the same foods as Yolngu people? Which foods?

Mick: pigs eat everything that Yolngu eat, bush fruits, rotten animals, yams, not crab, doesn't eat salt water foods only foods from freshwater, sweet foods, eats turtles, pig nose can smell animals for food, snakes, cats, any small animals. Pigs are the main animal that can damage a lot of our foods and destroy the land, big animals-they can eat a lot - the most

Jessica: yes, turtles and yams

Julie: no response

Annie: no response

Margaret: no response

Andrew: no response

Caroline: no response

Joanne: they eat everything people eat including stuff around camps like bananas, mango, billy cans, they eat turtle and yams

David: pigs: turtle, lily, bread, chips, bullicky

Robert: no same traditional foods but they will eat balanda (European) foods, rubbish, lettuce, cabbage

Lily: no same foods

Ella: there is too much bush tucker that pigs are eating, there is no more *djitama* and *baltji* at *Garanydjirr*, no more lilies and turtles, whole swamp is dry. There are no foods left, we need to eat pigs. All bush tucker is gone, plants and grass is not growing, mud everywhere.

Mary: crab, long-bums, mngrove worms, turtle, *galun* (?), *warrama* (?), palm cabbage, cycad nut

Ruby: yes, turtle, goanna, file snake, python, mussels (*ragultha*)

Billy: yes, Yolngu foods is original foods from here, pig and buffalo it is not their food. Food is getting short now for a long time since buffalo came. We used to eat raki but now we have to buy peanuts from the shop. Waterlilies are all gone. We can't eat them because the pigs and buffalo get to them first.

11. Have there been changes in places where people go to hunt goose?

Mick: same places, goose places still good. when it starts to dry up pigs go along edges and eats anything from animals to weeds

Jessica: yes, we change places to give rest to other places

Julie: no response

Annie: no response

Margaret: no

Andrew: no, same places

Caroline: no response

Joanne: no, same places

David: no, I move around with the geese for hunting

Robert: no, same

Lily: no, goose still the same

Ella: no response

Mary: no

Ruby: no, same spots

Billy: no response

12. Have the numbers of geese or goose eggs changed at all ?

Mick: pigs eat goose eggs

Jessica: not much goose this year because people got lots of eggs last year instead of leaving some in the nest

Julie: no response

Annie: there are less geese this year because Yolngu take too many eggs

Margaret: no

Andrew: pigs eat crocodile eggs but I don't know about goose eggs

Caroline: goose hunting getting harder for people because of holes from pigs, people hurt themselves; there are not many goose eggs

Joanne: same numbers but harder to catch from pigs and buffalo; mapu (eggs) are the same, when its goose egg time pigs go out looking for and eating goose eggs

David: no, still the same numbers of geese, I don't know about eggs

Robert: I don't collect them any more because I have no transport, no boat

Lily: still the same, the eggs come in wet season time

Ella: no response

Mary: goose is the same, lots of geese. I've never seen pigs eating goose eggs

Ruby: no, 10, 20 or more, plenty of geese

Billy: goose nests have been knocked down by pigs and buffalo

13. Are there places where geese used to be but are now not there any more? When did these changes happen? Have they been getting worse each year?

Mick: no
Jessica: no response
Julie: no response
Annie: no response
Margaret: no
Andrew: less geese now in some places (but here he is referring to the context of seasonal movement) eg. the geese that were at Garanydjirr have now gone to different places because these areas were drying up, next year there will be lots again
Caroline: no response
Joanne: no
David: no response
Robert: no response
Lily: no
Ella: no response
Mary: no response
Ruby: no
Billy: no response

14. Have there been changes in places where people go to hunt turtle?

Mick: yes
Jessica: they are in the same places but if there are none they (people) try another swamp
Julie: no response
Annie: no response
Margaret: no response
Andrew: yes
Caroline: no response
Joanne: same places but much less turtle and harder to find, can't see turtles noses any more because of pig digging. A long time ago it was very beautiful country and land.
David: this is womens job
Robert: no response
Lily: no
Ella: no response
Mary: yes
Ruby: no
Billy: no response

15. Have the numbers of turtle or turtle eggs changed at all?

Mick: pigs eat turtle eggs, not saltwater turtle but they can eat their eggs in the sand

Jessica: less turtle now, less in the swamps because people are taking too many

Julie: yes, we can't find turtle, pigs digging very deep. Used to see tracks and holes from turtles, now its really hard to find

Annie: it started to get hard to get turtle in 1975-76, now we find some turtles that are OK, others have been already broken by pigs and buffalo

Margaret: there are less long necked turtle

Andrew: less in some places

Caroline: you used to be able to see tracks for long necked turtle

Joanne: no response

David: no response

Robert: no response

Lily: same numbers of turtle and eggs

Ella: no response

Mary: there are less turtle now, we don't find turtle *mapu* (eggs) because pigs are eating them

Ruby: no, lots of turtle around

Billy: no response

16. Are there places where turtle used to be but are now not there any more? When did these changes happen? Have they been getting worse each year?

Mick: some places have no turtle e.g. Gatji creek had a lot of taro and turtle and file snake, pig and buffalo came along and now there are less

Jessica: no response

Julie: no response

Annie: no response

Margaret: no response

Andrew: near Mangbirri (on the edge of the road, for turtle, now nothing), people don't use as much any more, no good hunting because of pig

Caroline: no response

Joanne: no response

David: no response

Robert: no response

Lily: no

Ella: no response

Mary: there are some places we don't go to any more where pigs have dug, because there are no turtle

Ruby: no response

Billy: no response

17. Are there any other places you used to go hunting that you don't go to any more? Why?

Mick: no response

Jessica: no response

Julie: no response

Annie: no, most hunting places you get a little but still less

Margaret: there used to be lots of waterlilies, turtles and yams

Andrew: no response

Caroline: I want to be able to get fresh meat from the land, make camp, but now too scared of pigs and buffalo

Joanne: no response

David: no response

Robert: no same, everywhere is still OK for food

Lily: all the same hunting spots

Ella: *Garanydjirr* jungle is very bad from pigs

Mary: no response

Ruby: no

Billy: no response

18. Is it because you are scared of pigs or because they have eaten food from these places (only ask this question if previous answer is pigs)?

Mick: no response

Jessica: no response

Julie: no response

Annie: no response

Margaret: no response

Andrew: no response

Caroline: no response

Joanne: no response

David: no response

Robert: no response

Lily: no response

Ella: no response

Mary: no response

Ruby: no response

Billy: no response

19. Has anyone ever been chased by a pig/buffalo? Hurt? Where?

Mick: yes, I was chased by a pig, I got a stick and hit the pig on the nose; there are lots of buffalo around Bundatharri, sometimes people get hurt there and get chased when they go hunting, buffalo are clever, you need to be smarter than him to get him

Jessica: my sister was chased by a pig but not hurt, people are not frightened about jungles, people make lots of noise to scare the pigs away; buffalo don't chase you except when they get angry when you try to shoot them

Julie: chased in jungles by pigs and buffalo, people climb up trees for safety

Annie: I was chased by a buffalo, some are getting angry because people are shooting them. When they (people) try to go hunting in jungles and other places for food if they see pigs they often run away because they are too frightened of pigs and buffalo

Margaret: yes, people have been chased. People are too scared of pigs in jungles and they don't find many stems of the yam vines any more

Andrew: no

Caroline: no

Joanne: yes, around Yathalamarra, buffalo get really close to the house

David: I was chased by a pet pig but not hurt, I've also been chased by buffalo but not been hurt. A long time ago a man was nearly killed by a buffalo but that was before I was born

Robert: no-one has been chased by pigs, buffalo have chased people but no-one has been hurt

Lily: yes, me and my husband were chased but the pig ran away

Ella: no, pigs run away from people, they are smart and people are not scared

Mary: never been chased by pigs, but people have been chased by buffalo, but not hurt

Ruby: pig: no; buffalo chase people but no-one hurt

Billy: no response

20. Are there any places people used to get yams that they can't find yams any more?

Mick: you would need to talk to Julie about that

Jessica: when there are less or no yams people try different places

Julie: no response

Annie: on the other side of the swamp at Gulpulil, we were looking for yam last time and couldn't find any, there used to be a lot of yams, everything has been eaten by pigs.

Margaret: no response

Andrew: no response

Caroline: pigs dig all around, digging for yams you can't find them

Joanne: pigs dig everywhere for yams, they get all yams before people get to them, in both sandy country and *retja (*monsoon forest)

David: no response

Robert: no response

Lily: no

Ella: yes, there are no yams left in the jungles

Mary: no, still the same places and the same number of yams

Ruby: no

Billy: no response

21. Has the amount of yams changed? When did these changes happen? Have they been getting worse each year?

Mick: no response

Jessica: there are less because people are taking too many and because pigs are eating them, this started happening about 3 years ago

Julie: yes, its been hard to find yams for 10-20 years now

Annie: less yams, it started to get hard to get yams in 1975-76

Margaret: less yams now because of pigs

Andrew: there are less yams

Caroline: no response

Joanne: there are less yams, used to get big yams at bumbudjari (jungle place near Gatji) now only get little yams, pigs damage them so much that they only grew small. Pigs dig yams before people get to them because they get to them in the wet when the grass is still long before people can get there. Pigs have been digging yams since they had families, a long time. They have been getting worse each year.

David: no response

Robert: no response

Lily: still lots of yams, still easy to find them

Ella: it has been hard to get yams for a long time now, many years

Mary: no

Ruby: no, plenty of yams

Billy: no response

22. Have you seen more digging from pigs this year than last year?

Mick: yes, spreading from Gatji to Bundatharri, maybe this year there will be more damage

Jessica: yes, more digging

Julie: no response

Annie: more digging, pigs are everywhere

Margaret: same as last year

Andrew: there is more digging, digging all through the year

Caroline: no response

Joanne: yes

David: more, places that were completely smooth 20 years ago are all bumpy and dug over

Robert: more digging

Lily: see new ones and old ones -more

Ella: no response

Mary: more digging

Ruby: more this year

Billy: no response

Interview 3

1. Do you think pigs and buffalo should be controlled (i.e. keep numbers low)?

Mick: yes

Jessica: get rid of them

Julie: yes, get rid of all pigs, leave a few buffalo for food, because they are running the place, digging lots of ground

Annie: yes

Margaret: keep numbers low

Andrew: yes

Caroline: yes, get rid of them all

Joanne: yes

David: yes

Robert: keep less

Lily: yes, shoot so there are less

Ella: pigs should be gotten rid of, buffalo are OK

Mary: shoot some, I think next year and later this place will be worse, no grass

Ruby: good to keep both low

Billy: yes

2. Who should do this - Yolngu, rangers, balanda?

Mick: everyone together but they have to listen to Yolngu and have to have Yolngu present

Jessica: get outsiders to help rangers get rid of pigs and keep buffalo numbers low

Julie: balanda train Yolngu to do the jobs of getting rid of pigs

Annie: balanda should kill the pigs, Yolngu could go with balanda to show them how to get the pigs so when balanda leaves, Yolngu will know how to do it

Margaret: rangers

Andrew: both balanda (Parks and Wildlife and DPIF) and Yolngu

Caroline: best job for rangers and whoever has a gun to help ranger

Joanne: job for everybody

David: rangers

Robert: rangers job or anyone with a gun

Lily: Yolngu, balanda or rangers

Ella: rangers, council and others

Mary: rangers

Ruby: ranger

Billy: army, I think it should be used as army training with a helicopter, kill them all, bring some meat to Yolngu, get rid of them; I expect government people or government funding to help get rid of pigs

3. How should this be done ?

Mick: shooting, bait, trapping, fresh bait and trap

Jessica: no response

Julie: no response

Annie: best way is to make a trap because when they shoot them, they run away, so instead dig a hole or make different kinds of traps to get those pigs

Margaret: shoot all the pigs, shooting is the best way

Andrew: any way, just get rid of them

Caroline: kill them and butcher them, some people can cook them

Joanne: shoot them every year because both are too many

David: shooting

Robert: run them over

Lily: shoot them

Ella: shoot pigs and give meat to outstations

Mary: shooting

Ruby: shoot them

Billy: air safari, helicopter, trapping young pigs and sending them to starving people - slowest way, quickest way is army, trap them inside jungles, put a fence around jungle

4. What can Yolngu people do to stop pigs damaging the country?

Mick: if balanda can train Yolngu to do it (stop pigs)

Jessica: need to get people to help rangers, more Yolngu to help, ask balanda for money so more Yolngu can work with you to help kill pigs, 30 or 40 Yolngu so they can spread out, 5 or 6 to each of *bundatharri, gatji, gulpulil, garanydjirr* these are the main places, that way pig can be gotten rid of

Julie: no response

Annie: we could take pigs to Cattle station manager he can send them to Darwin and give money to landowners, if he doesn't I will tell all the rangers to kill the pigs

Margaret: don't know

Andrew: shoot and eat them

Caroline: no response

Joanne: no response

David: just ask rangers (to help stop the pigs)

Robert: no response

Lily: don't know

Ella: get rangers to talk to people and tell them how to look after their homelands by shooting pigs, otherwise sickness

Mary: nothing

Ruby: no response

Billy: no response

5. Is there anything stopping people from getting rid of pigs/buffalo? Guns? yindi djama?

Mick: need more guns, do both ways, shoot and traps; camp out especially the rangers

Jessica: need more guns and trucks

Julie: no response

Annie: no response

Margaret: not enough guns

Andrew: is there enough guns?

Caroline: no response

Joanne: some, but Yolngu got no rifle, only have single shot gun, waste too many shells

David: no response

Robert: no response

Lily: pigs, buffalo, digging is humbug, it makes people tired

Ella: no response

Mary: nothing, lots of people have guns

Ruby: no response

Billy: Yolngu are lazy with drugs which makes it hard to look after the land

6. Do you think it is possible for landowners to earn money from pigs? How?

Mick: yes, tourists paying landowners and rangers for shooting, to improve to up wages and equipment, bullets and rifles, get the right bullets for pigs and buffalo

Jessica: yes, instead of killing the pig, get live ones to sell to other places so landowner can earn money

Julie: no response

Annie: should have a pig farm, round them up, keep them then send piglets to Darwin; run by Yolngu

Margaret: business selling meat for pets

Andrew: if they want to, I don't know how, maybe a market arouns the community, sell the meat to the community

Caroline: no response

Joanne: some would want to shoot for money, others would want to just shoot; I don't think people would pay money for pig meat, there are enough (pigs) they would get their own. Shouldn't expect money for shooting because they destroy; payment is just by shooting to help us, you make help fix up country.

David: no response

Robert: selling meat, buffalo horns

Lily: no response

Ella: no response

Mary: no

Ruby: no response

Billy: no response

7. If people are shooting pigs on someone else's country do they need landowner permission?

Mick: balanda need permission, Yolngu don't need permission

Jessica: no response

Julie: no response

Annie: no response

Margaret: no, because its just a pig

Andrew: no response

Caroline: no response

Joanne: In Yathalamarra area if you shoot you don't have to pay

David: no need for Yolngu people to ask but balanda (european) people need to ask

Robert: no response

Lily: sometimes

Ella: no response

Mary: no permission needed for pigs or buffalo but you need permission to shoot other Yolngu animals

Ruby: no response

Billy: no response

8. What do you think of safari hunting tourism for people to come and pay money to shoot pigs and buffalo?

Mick: royalties are not paid well to landowners, Cattle station manager kept money in his pockets, needed to see landowners more

Jessica: safaris are OK

Julie: safari at *Gatji* run by Yolngu would be good because Cattle Station Manager is not giving landowners the right money

Annie: no response

Margaret: good idea as long as landowners get money

Andrew: its OK to shoot them and not give landowner money as long as they are not selling the meat, because the damage is bad

Caroline: good idea because it is helping rangers, people could be paid by the horns and teeth or the money from safari could be used to help the rangers

Joanne: good idea

David: no, but it would be OK if they got meat for people and payed landowner

Robert: good to have buffalo for trophy horns for tourism, landowners get money

Lily: OK

Ella: good if it helps get rid of pigs

Mary: OK

Ruby: good to get rid of pigs this way

Billy: safari is OK as long as Yolngu all clans work with the safari

9. Who should look after the tourist operation, Yolngu or balanda?

Mick: if Yolngu were trained by Balanda they could do it

Jessica: better by Yolngu with help from balanda

Julie: no response

Annie: no response

Margaret: Yolngu

Andrew: both, for training

Caroline: no response

Joanne: Yolngu

David: Yolngu

Robert: good job for Yolngu

Lily: look after by both

Ella: no response

Mary: no response

Ruby: both together

Billy: Yolngu and balanda, because balanda have guns and things

10. What do you think of a small pet meat industry using pigs for pet meat, people shooting them, then getting the carcass ready for pet meat?

Mick: good idea for pig and buffalo

Jessica: pet meat is OK

Julie: no response

Annie: no response

Margaret: OK

Andrew: no response

Caroline: pig meat is OK for dogs, better to use them to make healthy dogs rather than just leave the animal. Can the skin be used for anything?

Joanne: Good idea, people would like to do this *djama* (work)

David: good idea

Robert: good idea, we should build a big abbatoir and sell meat to Darwin or anywhere

Lily: *meinmuk* (good)

Ella: good idea for pets and also sell meat to people

Mary: pet meat is a good idea, the Arts Adviser was shooting pigs and bringing meat for dogs

Ruby: good business

Billy: pet meat is OK but good to keep pigs in pen and sell to Darwin and overseas

11. Would it be better for this business to be run by Yolngu or balanda?

Mick: first get balanda doing job, then give it to Yolngu for job

Jessica: best way is to teach Yolngu how to do it

Julie: no response

Annie: no response

Margaret: both, balanda teach Yolngu, then Yolngu take over

Andrew: no response

Caroline: Yolngu

Joanne: Better for balanda to do *djama* and pay Yolngu

David: both should share, balanda teach Yolngu

Robert: Yolngu should run it

Lily: both Yolngu or balanda

Ella: no response

Mary: balanda and Yolngu together

Ruby: both

Billy: both, jobs for Yolngu and balanda