CHAPTER ONE

INTRODUCTION

1.1 This Study

A little over 200 years ago the only human land-uses that the Australian continent supported were those of the Aboriginal hunter/gatherer tribes, while today Australian agriculture provides food and fibre to support a nation of approximately 20 million people, as well as to export. To enable the present-day crop and livestock production to occur, extensive land modifications, and consequently considerable environmental change, has taken place since European settlement. In response to the changes that have occurred to the environment, many of the 55-plus macropod species (kangaroos, wallabies, tree-kangaroos, hare-wallabies, rock-wallabies, nailtail wallabies and rat-kangaroos) that were or are known to exist in Australia (Strahan 1995) have undergone significant changes in population density, structure and/or distribution (Calaby 1971).

The Black-striped Wallaby (*Macropus dorsalis*) is one species that has undergone large changes in density and distribution. It is probable that before agricultural development the Black-striped Wallaby was widespread throughout its range. However, there is now concern that the overall distribution of the species has declined in recent years (G. Lundie-Jenkins pers. comm.), as large areas of habitat suitable for use by the wallaby for sheltering, resting and feeding, have been extensively modified (Cogger *et al.* 2003), forcing the species to retreat into smaller, more densely populated areas of habitat.

Prior to this habitat change, Black-striped Wallabies would have spent the day resting or sheltering under vegetation, emerging into natural clearings at dusk to feed on native grasses and browse species. The widespread, yet limited, amount of feed available within those clearings, and predation by native predators such as dingoes and eagles, as well as hunting by Aborigines would have kept local populations of the wallaby in check. However, loss of shelter and feeding habitat means insufficient natural clearings are available for feeding, forcing the species to change its feeding behaviour to survive. Black-striped Wallabies are now commonly seen emerging from their shelter habitat at dusk to feed on adjacent pastures and crops (Kirkpatrick 1995). Although decline in the species' distribution has occurred, unlimited easy access to abundant nutritious pastures has allowed Black-striped Wallaby populations to survive in remaining areas of suitable shelter habitat. Some populations have even grown into higher than normal densities for the size or area of shelter habitat (Baxter 1995).

This study arose out of the perceived problem that the densities of Black-striped Wallabies in fragmented patches of Brigalow (*Acacia harpophylla*) vegetation were too high, causing detrimental impacts to their shelter habitat and competing with adjacent surrounding agricultural enterprises.

The specific aims of the study are given in detail in Section 1.5; however in summary, the study attempted to establish how Black-striped Wallabies were utilising, and impacting upon, the shelter habitat and adjacent agricultural land at the chosen Study Site. Preferences for shelter habitat and feed, and levels of impact were investigated, with the development of management strategies in mind.

The project also attempted to evaluate the density and distribution of the species at the chosen Study Site and current influences on population structure (e.g. predation levels).

The different components of the project are presented in separate Chapters and Sections. This first chapter explains the current status of the Black-striped Wallaby.

1.2 Land Use Change in the Brigalow Belt Biogeographic Region

The Brigalow Belt Biogeographic Region (BBR), extends from Townsville in Queensland to northern New South Wales and covers an area approximating 36 million hectares (Bailey 1984). The region is typically characterized by the Brigalow tree (*Acacia harpophylla*), which has a number of variant growth forms: virgin, whipstick and sucker. Each of these variants grows in vegetation associations with a wide variety of other trees, shrubs and ground covers (Johnson 1964). In Australian ecological literature the term 'scrub' is used to describe dense communities of bushes, shrubs and trees (Carpenter 1956 cited in Johnson 1964). Hence, the characteristic communities formed by Brigalow associations are often referred to as Brigalow 'scrub'.

Brigalow soils are reasonably fertile but it is common for them to have high salt content at relatively shallow depths (Isbell 1962). Soil types within the bioregion vary, but can be grouped by into five main categories: deep gilgai clay soils, sedentary clay soils, alluvial clay soils, miscellaneous deep clay soils and light textured red soils (Isbell 1962). These groupings are very broad and there are further variations within the groupings due to geographic locations.

The bioregion stretches over a number of climate zones but it is generally accepted that the BBR has a winter rainfall zone in the south and a summer rainfall zone in the north. Areas in between can be any one of a range of sub-climates depending upon when the majority of the 600 to 700mm average rainfall occurs (Lloyd 1984b). Nevertheless the area as a whole is generally referred to as having a sub-tropical climate.

The large expanses of land with fertile soils and reasonably good climate meant the region was recognised as having good potential for crop and livestock production (Donohue 1984) and development of the region was seen to be economically viable once roads and mechanical aids became available (Bureau of Agricultural Economics 1963). Land modification, such as clearing of trees and shrubs and manipulation of watercourses, has since become a large part of the BBR's agricultural history with large areas of land cleared to make way for cropping and introduced pasture grasses.

The history of the BBR's development has been documented by many authors (Land Administration Commission 1968, Donohue 1984, Lloyd 1984a, Partridge *et al.* 1994).

Original settlement of the BBR was mostly in areas of open old-growth Brigalow forests where cattle grazing could be undertaken without extensive modification of the landscape. However, once those areas were utilised settlers turned to areas covered with more dense Brigalow communities. Such dense Brigalow vegetation communities required clearing, as they could not support cattle grazing or cropping in their natural state. Difficult to clear by axe though, development of these BBR vegetation communities was slow. Until the mid 1960's large areas the BBR still remained largely undeveloped, with only a few small areas cleared by ringbarking with axes (Donohue 1984).

The first major turning point in the agricultural development of the BBR was the spread of the Prickly Pear or Cactus (*Opuntia stricta*) from homestead gardens at the turn of the 20th century. The Cactus quickly became prevalent across the landscape and by 1900 an estimated 4 million hectares were overrun. By 1920 that area had increased to 24 million hectares with the Cactus invading undeveloped Brigalow country, as well as land that had already been partially cleared for agriculture. The Cactus was finally brought under control in the mid 1920's when the Cactoblastis moth (*Cactoblastis cactorum*) and cochineal insect (*Dactylopius opuntiae*) were introduced as biological control agents (McFadyen 1982). During the following summers large fires swept through the BBR, fuelled by the mass of fibrous material left by the dead Cactus. As *Acacia harpophylla* is a fire-sensitive species large areas of vegetation were severely affected by the fires, effectively 'opening up' 8 million hectares of Brigalow country.

The Great Depression of the 1930's began shortly after and in an attempt to alleviate the urban unemployment problem the government encouraged people to relocate to the country and work on properties helping to clear the land. Many of those who relocated stayed to take up their own blocks after the Great Depression had finished.

The next significant step in the development of the BBR came about in the late 1930's with the advent of World War 2 and the associated development of large machinery. After the war, small tractors, gun carriers, tanks and bulldozers became accessible and provided settlers with machinery to push and clear the Brigalow vegetation more quickly and efficiently. One particularly effective method involved two bulldozers dragging between them a large chain with a heavy demolition ball in the middle.

By the late 1950's/early 1960's the agricultural and economic potential of the BBR was evident with large areas of the southern BBR cleared and under agricultural production. However, only a relatively small amount of the central Queensland BBR had been cleared. To encourage settlers to move into the area and develop it agriculturally, the then State Government established the coordinated incentive Brigalow Development Scheme. The scheme undertook the 'reclaiming' of 4.5 million hectares of land and its re-division into blocks averaging 4,000ha in size. The sub-divided blocks, along with the availability of loaned finance for clearing and grassing of land, provision of water facilities, boundary and internal fencing and cattle yards, were then allocated to interested settlers by ballot. The scheme was progressive for its day and, combined with the more efficient clearing techniques meant a large area of land was cleared in a short time.

Once cleared the land was sown with introduced pasture grasses or crops. Paddocks were fenced for sheep and cattle, and dingoes were baited, shot or trapped to curb predation of livestock. Water storage facilities such as dams, weirs, bores, tanks and troughs were put in place to provide water for humans, livestock and crop irrigation.

The outcome of agricultural development of the BBR has contributed significantly to Queensland's cropping, beef and sheep production and brought millions of dollars to the state (Office of Economics and Statistical Research 2002).

Unfortunately, the BBR's development has also had adverse effects. Little thought was given to selective clearing of the landscape to ensure that Brigalow ecosystems, and the faunal species within them, were not severely affected or completely destroyed. Before and during the height of the Brigalow Development Scheme little was known of the ecosystems within the BBR or to what extent the ecosystems could be cleared without becoming fragile or lost completely. It is reported by Smyth (1997) that all vegetation associations in the BBR have evidence of degradation to some extent; and in the semi-arid BBR region alone, it is estimated that 95% of an original 6 million hectares have been cleared, thinned or degraded (Catterall *et al.* 1997).

Certain ecosystems have been affected more than others. Of the 163 regional ecosystems within the BBR, 43 are now classified as 'of concern' and another 27 are 'endangered' (Sattler and Williams 1999). Without guidance, settlers cleared first those ecosystems lying on more fertile loamy soils e.g. semi evergreen vine thicket (Softwood Scrub). Once the more fertile accessible land had been cleared and was being utilised to full capacity, areas with less productive soils were cleared, even if unlikely to ever be highly productive.

Along with the changes to the vegetation associations, changes in the density and distribution of many fauna species within BBR ecosystems have also occurred. Of the fauna species found within the BBR, 51%, 18%, 34% and 4% of the bird, mammal, reptile and amphibians species respectively are currently considered rare and threatened (Environmental Protection Agency 1999). The combination of predation from introduced carnivores (Dickman 1996, Burbidge and Manly 2002), altered fire regimes (Wilson 1994), climate change, competition with livestock grazing, shooting, trapping and over-harvesting,, and loss of habitat through urbanisation (Environmental Protection Agency 1999) is likely to have influenced fauna species survival (Johnson *et al.* 1989). However, agricultural development (primarily vegetation clearing) is considered to be the major factor affecting species, density and distribution (Glanznig 1995 cited in Smyth 1997).

Complete loss of some fauna species has occurred with at least 5 mammal, 2 bird and 1 reptile species are now considered extinct (Smyth 1997); however, other threatened species have managed to survive in small pockets or patches of remnant or regrowth vegetation, commonly referred to as fragments.

1.3 Fragments in an Agricultural Landscape

Fragments are isolated patches of remnant (untouched or partially disturbed) and regrowth vegetation. Areas of vegetation have been left uncleared due to time and financial constraints, inappropriate topography or the presence of waterways, and to prevent salinity, provide windbreaks or for aesthetic reasons. Fragments are also created when clearing is undertaken through forests for roadways or power easements. Regrowth fragments are formed for indefinite periods of time if re-clearing (chemical application, burning or re-pushing) is not carried out and a proportion of the original plant species are able to re-establish from root-stock or the soil seed-bank. National Parks and Reserves, which cover less than 5% of the BBR (Thackway and Cresswell 1995) often become fragments when the surrounding land is left for agricultural production or urban development.

Research on fragments has increased over recent years as we have come to realise how vital they are for the ongoing survival of the species and ecosystems. However, fragments create problems for agriculturalists, supposedly providing a place for stock to hide and weeds to grow (Hobbs and Atkins 1988, Abensperg-Traun *et al.* 1998).

Fragment isolation also means populations of faunal species become trapped within them unable to translocate to other areas (Kimber *et al.* 1999). This has the potential to heighten over-use of the available resources within and surrounding the fragment, increase the risk and effect of disease outbreaks and fire, and reduce fauna species' genetic pool. The size and effective isolation of the fragment will determine the degree to which these problems arise, with smaller fragments more likely to be impacted upon by stock and weeds, and less likely to provide enough appropriate habitat for fauna diversity (Kimber *et al.* 1999). Smaller fragments can also be completely subjected to 'edge effect'. 'Edge effect' refers to penetration of the edges of the fragment of effects and biota from the surrounding matrix habitat, and may lead to the occurrence of higher predation, invasion by weeds and increased use by fauna travelling to and from the surrounding pasture for feed. Larger, wider fragments have smaller proportions of their area subjected to 'edge effect' and in some cases function similarly to originally forested landscapes (Fahrig 2003).

In the past problem fragments were often cleared as they were seen to be occupying land that could otherwise be used more productively. However, some fragments could not be cleared and growing pressure for agriculturists to become more environmentally aware has meant clearing is no longer an acceptable 'quick fix' solution either. Fencing has become the alternative for stock and native fauna control. However, fencing is not always appropriate due to topography, and requires money and labour for construction and maintenance (Lundie-Jenkins 1999). This does not always fix problems such as over-grazing by macropods, as it is likely the macropods will simply moved onto another area such as neighbouring landholders. In addition, fencing fragments can create problems for non-target species by further minimising the ability of animals to disperse to others areas. Animals can become physically caught up against and in fences, thereby increasing the risk of predation. Variations of fence design may help fauna species to disperse and different styles of fencing, each with varying cost and degree of success and/or impact, have been trialed by researchers and agriculturalists (Statham 1994, Lundie-Jenkins 1999).

The best solution to the problems of fragments, and created by fragments (without removing them) is to minimise their isolation (Bennett *et al.* 2000). A number of government incentives (e.g. Land for Wildlife, Nature Refuges) have been developed in recent years to encourage property owners to retain and maintain suitably sized areas of forested habitat. Future local and regional property planning, and revegetation of areas between existing fragments, to ensure connectivity of uncleared forested habitats has also become a priority for many regions.

1.4 Macropod Response to Land Use Change in the Brigalow Belt Biogeographic Region

The response of macropod species to the changes that have occurred to the landscape since European settlement has depended upon the extent of change and the species' ability to adapt (Calaby 1971, Burbidge 1977, Johnson *et al.* 1989, Dickman 1994).

A number of macropod species, particularly those within the critical weight range (CWR, non-flying mammals with a mean adult body weight between 35 and 5500g, (Burbidge and McKenzie 1989)) seem to have been most at risk of decline (Johnson *et al.* 1989) and have suffered severe reductions in density, distribution or both. In Queensland alone, one macropod species is considered extinct (Desert Rat-kangaroo, *Caloprymnus campestris*), 3 are considered endangered (Bridled Nailtail Wallaby, *Onychogalea fraenata*; Proserpine Rock-wallaby, *Petrogale persephone*; Northern Bettong, *Bettongia tropica*) and 2 are considered vulnerable (Brush-tailed Rock-wallaby, *Petrogale penicillata*; Long-nosed Potoroo, *Potorous tridactylus*).

In comparison, many larger macropods have dealt with the changes very well and generally continue to exist in wide distribution and/or high density. Conditions present in the developed rangelands for example, seem to favour larger grazing macropods and major eruptions in populations of those species are now common, some to such an extent that they are considered pests, e.g. Eastern Grey Kangaroo, *Macropus giganteus*; Red Kangaroo, *M. rufus* (Olsen 1998). Other medium-sized macropods, while reduced in distribution, have adapted to the changes brought about by agricultural development and manage to survive in areas where suitable habitat and food resources are available.

The development of grazing land has meant large areas of vegetation have been cleared to enable cropping and pasture grazing. This has drastically changed the habitat available to macropods for sheltering and feeding. Smaller macropod species have not responded well to the changes as they generally require these specific forested habitats for food and shelter. Larger macropod species, which inhabit open grazing land (Caughley 1964), are not as dependent on trees and shrubs for shelter, and thus have not been impacted upon to such a degree. However, some medium-sized species prefer dense vegetation for protection. These species have shown a mixed response to the landscape changes, as reduced preferred habitat for shelter is now available. These species are surviving however, where suitable habitat remains (Calaby 1971).

Once lands were cleared, they were sown with both native and introduced tropical pasture species such as Buffel grass (*Cenchrus ciliaris*), Rhodes grass (*Chloris gayana*) and native species including Green panic (*Panicum maximum*), Queensland Bluegrass (*Dichanthium sericeum*) and Black Speargrass (*Heteropogon contortus*) as these were considered to have more nutritional value, greater productive value and be faster growing than (other) native pasture species. Some of the introduced pasture species have done so well they are now dominant in areas where they were sown, are spreading to areas where they were not sown (e.g. Buffel grass) and do not allow growth of native grass and forb species (McDonald and Jones 2002). The clearing of scrub may encourage more growth of native species, but if a reduction in plant species diversity occurs, the availability of year round forage may be reduced by the interrupted seasonal succession of production by a diversity of species.

A reduction in native grasses, forbs and browse plant species due to over-dominating introduced pastures has meant a decline in food supply for the generally smaller browsing macropods e.g. Bridled Nailtail Wallaby (*Onychogalea fraenata*) (Dawson *et al.* 1992). However, kangaroos such as the Eastern Grey (*M. giganteus*) which has a 99% grass diet (Jarman and Phillips 1989), are more likely to have benefited from the provision of high-quality pasture, although many introduced grass species go through perennial cycles, affecting the nutritional value to macropods at various times of the year. The diet of many medium-sized wallabies (e.g. Black-striped Wallabies, *M. dorsalis*; Red-necked Wallabies, *M. rufogriseus*) contains not only a large percentage of grass species but a percentage of browse species also (Jarman and Phillips 1989). These macropods may be able to adapt their diet in response to a change in available plant species more readily than the Bridled Nailtail Wallaby, for example, but only as long as the introduced pasture species fulfil nutritional requirements all year round.

Livestock require drinking water and many crops need irrigation. Agricultural development meant rivers and creeks were dammed and artificial watering points (dams, troughs and bores) were established. Permanent water is reported to be available at less than 10km distances apart throughout Australia's arid and semi-arid rangelands (Landsberg *et al.* 1997). Watering points usually become focal points for livestock and macropods, thereby increasing grazing and trampling of vegetation in those areas. Impacts such as these affect the smaller sized macropods who utilise those environments (refer Landsberg *et al.* 1997). Australia now has more feed with accessible water all year round (except in times of severe drought). Previous to agricultural development, such abundance of feed in close proximity to water would have been available only throughout good wet seasons, functioning as a natural regulator of macropod abundance.

Once pasture and water were established livestock animals were introduced. In most areas of the BBR cattle were more appropriate than sheep due to climatic conditions, the presence of dingoes and dense scrub, and problems with grass seed (e.g. Black Speargrass) becoming embedded in the sheep's fleece. Cattle trampling undergrowth and feeding upon herbaceous forbs are most likely to have affected smaller macropods by destroying the microhabitats used for shelter and competing with macropods for food (Dawson *et al.* 1992, Ellis *et al.* 1992, Tiver and Andrew 1997).

Control of dingoes by baiting, trapping and shooting was regularly undertaken to prevent injury to adult stock and calf and lamb losses. Dingoes are known to prey upon macropods (Corbett 1995) and increases in densities of certain species of macropod may be attributed to the extensive control of dingoes (Shephard 1981, Pople *et al.* 2000). The removal of dingoes though is thought to have allowed the European Red Fox and Feral Cat spread or reach higher densities (Saunders *et al.* 199, Corbett 1995, Burbidge and Manly 2002) and, while not likely to prey upon larger macropods the foxes and cats would prey upon adults and young of smaller critical-weight-range macropods and juveniles of medium-sized macropods.

Therefore the variations in macropod species response to landscape change throughout the BBR are probably due to specific habitat preferences, feeding behaviours and the species' ability to avoid predation and adapt to change. For example, the Whiptail Wallaby (*M. parryi*) and Red-necked Wallaby (*M. rufogriseus*) are similar to kangaroos. They select more grass species than browse species, shelter in relatively more open habitat and are not so dependent upon 'scrub'-like vegetation, and their larger-than-CWR size affords them some protection from predation. Therefore, they have exhibited little change in density/distribution (ANPWS 1988). Similarly, the Black-striped Wallaby (*M. dorsalis*) is primarily a grazing species with some ability to adapt its diet to include introduced pasture species and avoid predation from foxes and cats; therefore densities of the species maybe considered quite secure where suitable habitat exists. However, being a 'scrub'-dwelling species they have declined in distribution, as there is less suitable shelter habitat available to them.

1.4.1 The Black-striped Wallaby

The overall distribution of Black-striped Wallabies throughout the BBR is thought to have been adversely affected by agricultural development, although in some areas the species has benefited from the region's development and its local density has increased to the extent that it is considered a pest (Calaby 1971).

Populations of the species are usually reported as occurring in high densities (Gould 1973, Evans 1992, Kirkpatrick 1995; and anecdotal), however, being a social species, Black-striped Wallabies form groups, possibly giving a false impression of over abundance.

Habitat modification of large areas of Brigalow 'scrub' has meant large losses of suitable shelter habitat for Black-striped Wallabies, bringing about a reduction in the distribution of the species. The Black-striped Wallaby is a fringe dweller, sheltering in scrub edges during day but coming out into open spaces at night to feed. Historically, the species would have spent daylight hours resting amongst thick shelter vegetation, emerging into small clearings at dusk to feed through the night (Kirkpatrick 1995). The amount of edible grass or preferred plant species would have been limited in such shelter vegetation, keeping populations at low levels. Being primarily a grazer, the wallaby has taken advantage of the increased feed that became available when land was cleared and introduced pasture grasses and crops were sown. A change in feeding behaviour, a constant source of feed and a reduction in predators (dingoes, eagles and humans) means the species can increase in density, where suitable shelter habitat remains.

Populations of Black-striped Wallabies can even exceed normal population levels and become over-abundant in localised areas. The high densities of Black-striped Wallabies in fragments and the associated perceived impacts to adjacent agricultural land creates anger and frustration in agriculturalists. In such pest situations the species is considered far from threatened by many property managers. However, while fragments have allowed the species to survive so far, isolated populations are at higher risk to the effects of disease, fire and a reduced genetic diversity.

Threats of further range reduction through habitat loss due to further land clearing, and concerns raised by agriculturalists who feel the species is severely impacting upon their livelihood, have brought about the formation of a Queensland Environmental Protection Agency coordinated Black-striped Wallaby Discussion Group, which recognises the species requires management from both agricultural and conservation perspectives.

The need for knowledge regarding the ecology and behaviour of Black-striped Wallabies is essential for their management, either as an endangered or pest species. A sizeable population of Black-striped Wallabies exists in a remnant fragment on Brigalow Research Station, near Theodore, Central Queensland. Approximately 500ha in size, the remnant consists of a number of Brigalow scrub associations and is considered to be of high conservation and research value, because of its size and the length of time it has been monitored.

1.5 Aims of This Study

The primary aim of this project was to determine what level of impact the Black-striped Wallaby (*M. dorsalis*) population was presenting at Brigalow Research Station.

Information gained from the project would aid development of management strategies for the species.

The effect the species was having on the agricultural enterprise and the retained remnant scrub were studied with equal emphasis. A number of Sampling Areas were focussed upon to gain better overall understanding of the population's density, the use of the different vegetation habitats by the wallaby and the impacts of dingo predation.

The specific objectives of the project were:

a) to determine the level of impact Black-striped Wallaby grazing was having on the remnant scrub habitat and adjacent pastures on Brigalow Research Station,

b) to determine the wallabies' interaction with, and degree of impact on, the various remnant vegetation types used for sheltering,

c) to establish if the population was functioning similarly to lower-density Black-striped Wallaby populations, specifically in feeding and sheltering preferences, and

d) to discuss the findings of the project in terms of their implications for management of the species.

CHAPTER TWO

THE STUDY SPECIES, THE STUDY SITE AND GENERAL RESEARCH METHODS

2.1 Introduction

Black-striped Wallabies have been recorded inhabiting areas of the Brigalow Belt Bioregion for many years (Gould 1863, Calaby 1971, Troughton 1973). It is likely that the species has been present on Brigalow Research Station for a long period of time. However, anecdotal evidence suggests that over the last decade the density of the Black-striped Wallaby population on the Research Station has increased and the species is now considered a pest by the land managers (M. Jeffery pers. comm.). Similar reports of large-sized populations of wallabies have been noted in other areas of the Brigalow bioregion (Lundie-Jenkins 1999, Mathieson and Smith 2003), particularly where there are patches of remnant or regrowth Brigalow (*Acacia harpophylla*) adjacent to improved pastures or crops (Jarman *et al.* 1991). The current study was designed to evaluate existing Black-striped wallaby densities on the Research Station and the resources they obtain from agricultural and natural ecosystems. This chapter describes the study species, its habitat and behaviour, the study site and outlines the research methods used.

Brigalow Research Station was chosen as the study site because the property was already used for research, and therefore had appropriate facilities in place, and because the site was known to have a high density Black-striped wallaby population, which the land managers wished to manage in an ecologically and agriculturally sustainable manner.

2.2 The Species

2.2.1 Description

The Black-striped Wallaby (*Macropus dorsalis*) was first described by Gray in 1837, although at that time the species was scientifically named *Halmaturus dorsalis* (Gould 1973). The species belongs to the Order Diprotodonta possessing syndactyl toes and basic herbivorous dentition, including one pair of strongly developed incisors on the lower jaw (Strahan 1995). The Macropodoidea superfamily is the largest within the Diprotodonta order, and contains two Families. The larger Macropodidae family contains 41 kangaroos, wallabies, hare-wallabies and pademelons of which thirteen species, including the Black-striped Wallaby, are contained within the Macropus genus (Strahan 1995). Kangaroos and wallabies differ in size, social nature, habitat preference, dietary requirements and feeding behaviour and consequently have varying ability to cope with the effects of human intrusion.

Initial descriptions of the Black-striped Wallaby (Figure 2.1) noted that although males weighed more than females (in excess of twenty to twenty-five pounds) both sexes were generally brown, with rusty-red colouring on the shoulders and a black stripe running down the centre of the back starting from the occiput (Gould 1863).

More recent descriptions of the species support Gould's initial comments. Troughton (1973) and Kirkpatrick (1995) described the wallaby as predominantly brown-grey with rufous colouring across the shoulders, a white stripe along the hips and a black dorsal stripe running from between the ears to the base of the tail. Known as a medium sized wallaby species, measuring 1.2-1.5m from nose to the end of the tail, Kirkpatrick (1995) and Johnson and Delean (2002) report adult males average 16-20kg and adult females average 6.5kg in live weight. Finlayson (1931) also noted that the species has one of the longest macropod tails, with the ratio of head and body length to tail length exceeded by only three other wallabies in Queensland (*M. irma*, *M. parryi* and *M. rufogriseus*).

Figure 2.1 A large male Black-striped Wallaby feeding in an improved pasture paddock.

2.2.2 Distribution and Status

Largely known as a scrub-dwelling species of the central Queensland Brigalow Belt bioregion, the species' current distribution (Figure 2.2) extends from Chillagoe, northwest of Townsville, down the eastern edge of Queensland, to northern New South

Wales, and westwards out to the Blackall region (Jarman *et al.* 1991, Kirkpatrick 1995, Johnson 2003, Mathieson and Smith 2003).

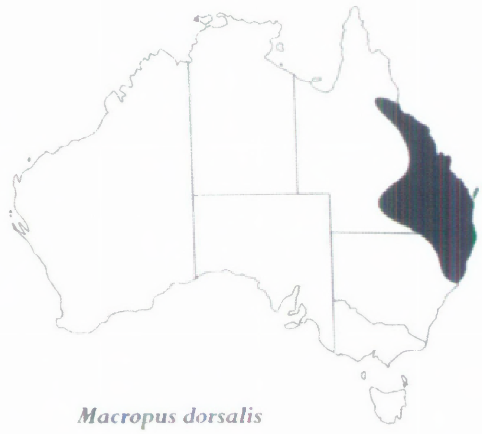

Figure 2.2 Current distribution of the Black-striped Wallaby (Macropus dorsalis) (Strahan 1995).

Gould (1863) described the species as "*abundant in all the scrubs clothing the sides of the hills that run parallel to the rivers Mokai and Namoi ... It is especially abundant at Brezi ... extremely numerous in the Brigaloe brush on the lower Namoi"*. Troughton (1973) recorded the species as most abundant in the dense undergrowth on the north coast of New South Wales and very abundant in dense Brigalow forests and lantana patches on the south coast of Queensland.

Black-striped Wallabies have not been recorded again in the areas between the Mokoi and Namoi rivers as documented by Gould (1973). Kirkpatrick (1995) suggests that removal and modification of large areas of Black-striped Wallaby's preferred shelter habitats for agricultural purposes has influenced the species' density and distribution. Cogger *et al.* (2003) supports this theory stating that originally 247,600km^2 of Queensland would have been suitable habitat for Black-striped Wallabies, but in 1999 only 84,154km^2 (34%) remained, due to agricultural modification. Shooting and snaring by land holders, predation by foxes and cats, grazing by stock in refuge areas and inappropriate fire regimes which affect habitat composition by removing dense understorey layers for shelter are also thought to have influenced the species current distribution and status (Cogger *et al.* 2003, Mathieson and Smith 2003). All these impacts are thought to have influenced Black-striped Wallaby populations in some way or another throughout its whole former range but especially in New South Wales. Even over the last few decades, numbers of Black-striped Wallabies have declined in many areas of New South Wales and the species is now sighted only rarely and in small remnant populations (Smith and Smith 1991, NSW NPWS 1999). The species is now classified as 'Endangered' in that state (NSW Government 1995, NSW NPWS 1999). This may well explain the anomalies in reported distributions, particularly the absence of Black-striped Wallabies from areas once noted by Gould (1863) as containing an abundance of the species.

In Queensland, although their distribution is patchy and the species has disappeared from some areas, Black-striped Wallabies seem to be surviving well in areas where suitable shelter habitat remains. So much so, that the species is considered a pest in many areas and is therefore classified as 'common with management concern' (State of QLD 1994, Kirkpatrick 1995, Olsen 1998, Lundie-Jenkins 1999, Mathieson and Smith 2003).

2.2.3 Sheltering Habitat

Black-striped Wallabies are commonly found in thick vegetation (forest or scrub) with dense shrubby understorey, for example regrowth Brigalow (*A. harpophylla*), softwood vine scrubs and Lantana (*Lantana camara*) thickets (Kirkpatrick 1995). The species is reported to also be found in remnant or older Brigalow forest with a closed canopy but with good visibility from ground level to about 1m high (Evans 1996). Similarly, in New South Wales, the species inhabits dense and wooded areas, such as Brigalow, rainforests or dense wet sclerophyll forest with vines, creepers and dense understorey with adjacent pastures, such as Buffel grass (*Cenchrus ciliaris*) (Rabbidge 1987, Jarman *et al.* 1991).

2.2.4 Feeding and Diet

Black-striped Wallabies emerge from their diurnal or day-time shelter location at dusk and move onto nearby open grassed areas, improved pastures and crops to feed. Individuals remain within close proximity of each other and do not venture out from shelter more than a few hundred metres (Kirkpatrick 1995, Evans 1996).

Black-striped Wallabies are primarily grazers but have a varied diet containing at least seventy-five plant species (Ellis *et al.* 1992, Evans and Jarman 1999). According to previous studies undertaken in Central Queensland by Dawson *et al.* (1992), Ellis *et al.* (1992) and Evans and Jarman (1999), monocotyledons form the greatest part (approximately 84%) of the Black-striped Wallaby's diet with the rest consisting of dicotyledons (mainly forbs 12%) and some browse species (4%).

2.2.5 Home Ranges

Male and female Black-striped Wallabies have relatively small home-ranges all year round. Home-ranges are roughly oval in shape averaging 91±11ha. Central areas of 13±2ha are situated at the ecotones or boundaries between the species' shelter habitat and adjacent open grassy paddocks (Evans 1996, Evans and Jarman 1999). An individual's home-range is not defended, and can overlap with those of many other individuals.

2.2.6 Behaviour

In behaviour this species acts very similarly to most other Macropod species (Heathcote 1989). The species is gregarious and forms groups consisting of up to twenty or so members, although solitary individuals, particularly older adult males, are often seen (Kirkpatrick 1995, Evans 1996, Hoolihan and Goldizen 1998). Groups often consist of varying numbers of different-aged males and females, suggesting an 'open-membership' situation (Hoolihan and Goldizen 1998). Heathcote (1989) suggests the presence of an age-related dominance hierarchy among females.

The species is shy and secretive (Troughton 1973) and spends diurnal hours resting in more or less permanent camps, under vegetative shelter, or sunbaking in small clearings within the shelter scrub. Individuals move onto grassed areas amongst shelter scrub and adjacent open grassed paddocks at dusk to feed, returning to the shelter scrub around dawn (Kirkpatrick 1995, Evans 1996). Generally, Black-striped Wallabies move along established routes forming well-worn pads. Kirkpatrick (1995) observed that when alarmed, the group will move off in the same direction, quickly forming a single file along the pad, and it requires continued disturbance to divide or scatter the group. However, in some cases, when disturbed, individuals of the group will move off in the same general direction, away from the danger, but not necessarily forming one single file (personal observation).

2.2.7 Reproduction and Longevity

Kirkpatrick (1995) and Johnson and Delean (2002) reported that sexual maturity was reached by females at an average of 11.3 months and by males at 15.7 months. Gestation periods were approximately 33-36 days, pouch lives extended from 192 to 225 days and weaning occurred 81-159 days after pouch emergence. Subsequent births occurred 29-30 days after the previous young left the pouch. In captivity Black-striped Wallabies have an expected life span of 10 to 15 years (Kirkpatrick 1995), but little is known of individual life expectancy in the wild.

2.2.8 General Management

Black-striped Wallabies have been indirectly 'managed' for many years.

> *"I found no difficulty in procuring as many specimens as I pleased; it was however, more often shot as an article of food than for any other purpose. Its flesh is excellent, and when the vast continent of Australia becomes more thickly inhabited, it will doubtless be justly esteemed. The natives often resort to the haunts of this species ... both for the sake of their flesh as food and for their skins as articles of clothing ... various modes of capturing them, sometimes making use of large nets ... driven by dogs ... spearing or killing them with the waddy as they pass the open spots"* (Gould 1863)

Aborigines were easily able to hunt and catch the species, using their flesh for food and their hide for clothing. Such use of the Black-striped Wallaby, while indirectly controlling numbers, is unlikely to have greatly affected the species' overall population density.

However, European settlement brought about changes to the Black-striped Wallaby's shelter habitat, which has had a greater effect on the species (Cogger *et al.* 2003). In New South Wales the species has not coped well with the loss of shelter habitat and population numbers have diminished. In other areas the species has responded to the habitat changes by becoming heavily concentrated in small areas where patches of suitable shelter habitat remain, particularly if there are improved pastures or crops to feed upon nearby.

The reduction in numbers throughout New South Wales, but apparent explosion in population densities in areas of Queensland where patches of suitable shelter habitat remain, therefore requires a two-pronged management approach to ensure the Black-striped Wallaby's long-term survival overall but at reasonably sustainable population densities.

Management at present is undertaken on a case-by-case basis. In general, official Black-striped Wallaby management for over-population falls into a small number of categories; do nothing, undertake regulated shooting under Queensland Environmental Protection Agency permit, clear the patches of vegetation used by the wallaby for refuge (Baxter 1995), or fence the area of habitation. Management for survival protection, which has largely only been recognised as a priority in New South Wales, includes such techniques as maintaining known/potential habitat, introducing predator control programs, and introducing grazing regimes that reduce or increase the amount of refuge available to the wallaby, depending upon whether densities are too high or low (Environmental Protection Agency 1999). Implementation of an overall strategy that is effective, cost-efficient and agriculturally and environmentally sustainable is yet to be achieved.

2.3 The Study Site – Brigalow Research Station

2.3.1 Purpose and General Description

The Study Site, Brigalow Research Station was founded in 1963 at the beginning of the Brigalow Development Scheme. Currently owned and managed by the Department of Primary Industries, as a 'Reserve for Experimental Purposes', the Research Station was set up to establish guidelines for stable, productive land-use for settlers (Loxton 2002). The 3,595ha property was selected because it contained a cross section of the soil types and vegetation associations representative of the Brigalow Belt bioregion. Activities on the Research Station focus on many aspects of beef cattle production and resource management.

2.3.2 Location

Brigalow Research Station is located within the Fitzroy-Dawson Catchment, approximately 225kms south-west of Rockhampton, latitude 24°50' S, longitude 149°47' E at an altitude of 151m above sea level (Figure 2.3).

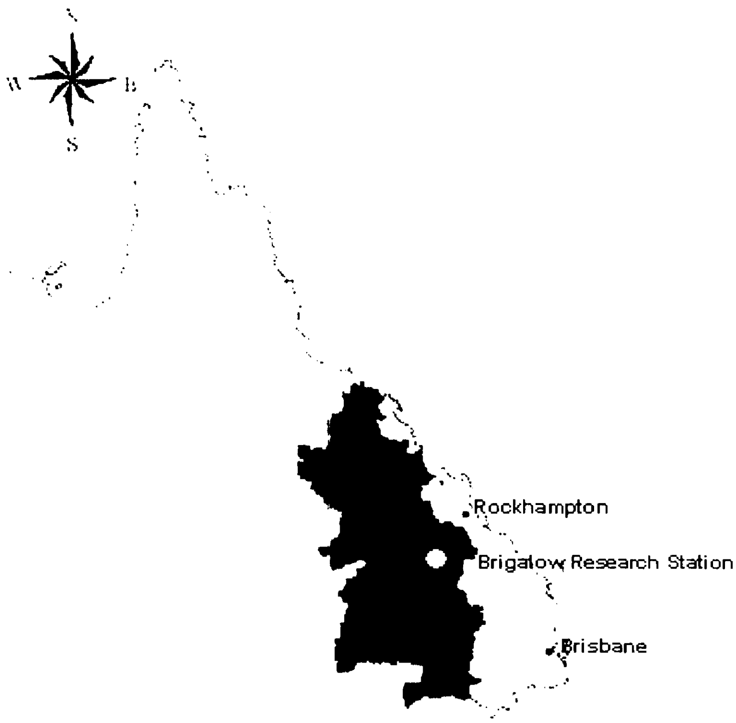

Figure 2.3 Location of the Study Site, Brigalow Research Station. The Queensland Brigalow Belt is shown as the area in black.

2.3.3 Topography and Soils

The land is generally flat with the occasional watercourse gully. Soil types found on the property can be grouped into 5 broad categories; sedentary clays, dark cracking gilgai clays, texture-contrast or duplex soils, red and brown loams, and sands (Webb 1971, 1972). The highly fertile dark cracking clays are dominant on the eastern half of the property, whereas the less fertile duplex clays are found mainly on the western half of the property. The red and brown loams are contained in an area running down the eastern edge of Roundstone Creek (Figure 2.4).

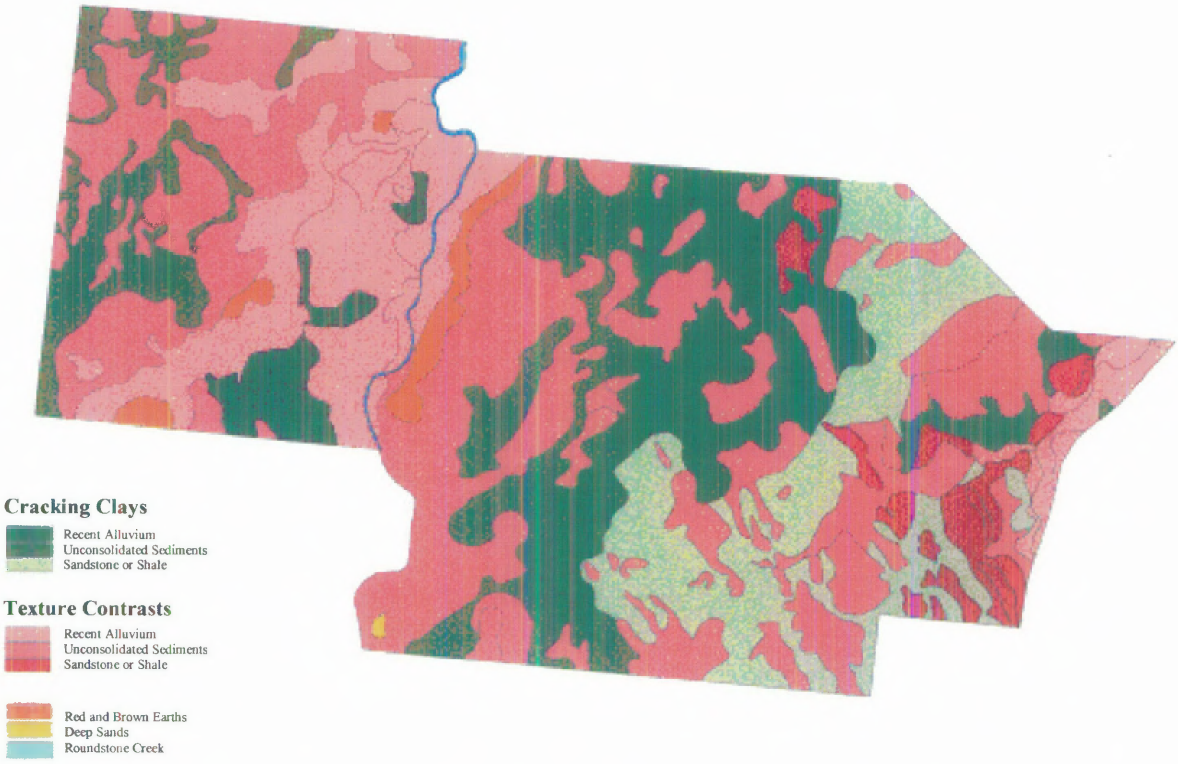

Figure 2.4 Soil map for Brigalow Research Station. The most dominant soils, the cracking clays and the texture contrast or duplex soils, are shown respectively in various shades of green and in pink. Modified from Webb (1971).

2.3.4 Native Vegetation

Johnson (1971) reported that twenty-six Brigalow vegetation associations were represented on Brigalow Research Station in 1963. For easier mapping display these twenty-six communities have been grouped into the following six major vegetation communities: Brigalow (*A. harpophylla*); Brigalow-Belah (*A. harpophylla-Casuarina cristata*); Brigalow-Dawson Gum (*A. harpophylla-Eucalyptus cambageana*), Belah (*Casuarina cristata*), open forest and semi-evergreen vine thicket, of which there is approximately 40ha and is hereafter termed softwood scrub (Figure 2.5).

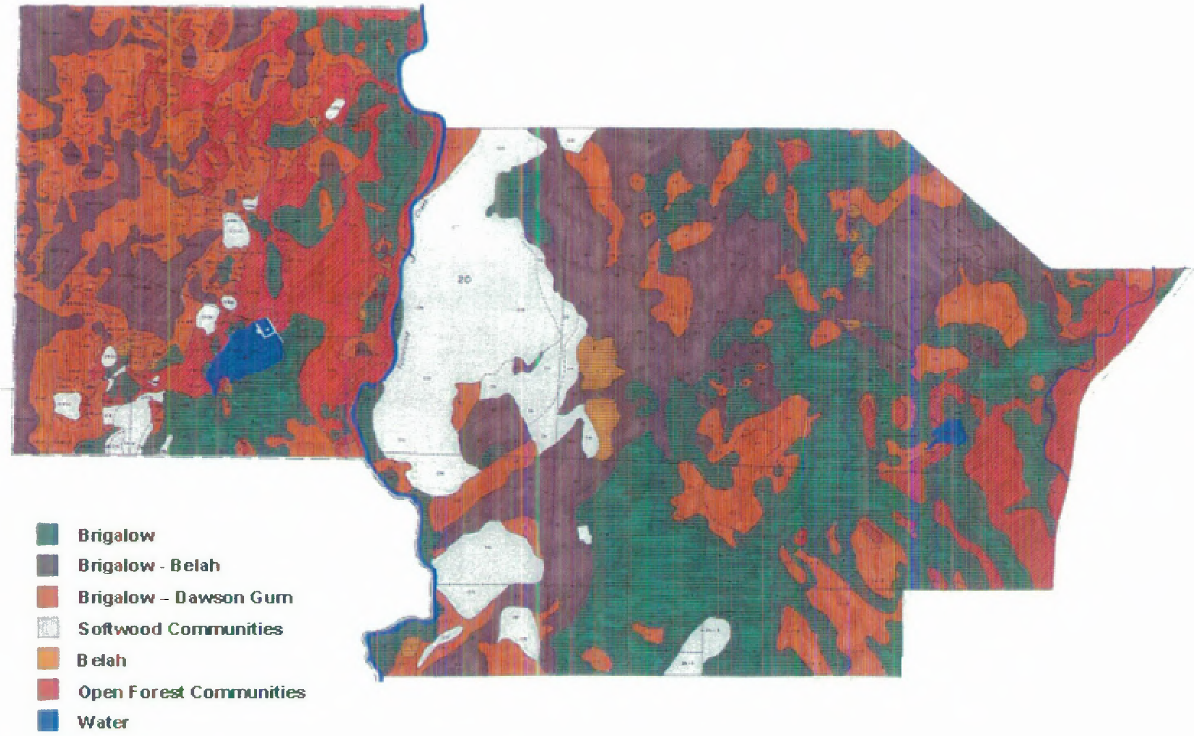

Figure 2.5 Major vegetation associations/communities recorded on Brigalow Research Station prior to clearing in 1970. Modified from Johnson (1971).

Most of the twenty-six associations are still represented within a 500ha stand of remnant vegetation left uncleared for reference research purposes (Johnson 1971, Johnson and Anderson 1999). The stand of remnant vegetation, often referred to as the 'Reference Site', is situated along the northern boundary of the property and covers an area approximately three kilometres long and 400m wide (Figure 2.6). The remnant Reference Site is not actively managed for weeds or pests but has been fenced off from cattle since the property was established. This study focused on the remnant Reference Area as it formed the primary shelter habitat utilised by Black-striped Wallabies at the Study Site.

Figure 2.6 Aerial photo of the Study Site, Brigalow Research Station, with the property boundary outlined in red and the remnant vegetation area (Reference Site) outlined in yellow.

2.3.5 Fauna

Systematic fauna surveys and opportunistic observations undertaken since 1999 have detected 47 reptile, 15 amphibian and 28 mammal species on the Research Station (see Appendix A). This list includes 11 introduced (feral and domestic) species, 2 vulnerable reptile species; the Brigalow Scaly-foot (*Paradelma orientalis*) and the Ornamental Snake (*Denisonia maculata*), and 1 rare reptile species, the Golden-tailed Gecko (*Strophurus taenicauda*) (White *et al.* 2002). A total of 210 bird species have also been recorded on the property including 1 vulnerable species, the Squatter Pigeon (*Petrophassa scripta*), and 5 rare species: the Black-necked Stork (*Ephippiorhynchus* *asiaticus*); the Cotton Pygmy-goose (*Nettapus coromandelianus*); the Freckled Duck (*Stictonetta naevosa*); the Grey Falcon (*Falco hypoleucos*); and the Grey Goshawk (*Accipiter novaehollandiae*) (Jeffery and Whitby 2000).

Of the 18 native mammal species recorded, 3 other species of Macropod exist in addition to the Black-striped Wallaby. The most common macropod on the Research Station, Black-striped Wallabies dominate the remnant area (see Section 3.3.1 for species densities). The species is also found in the more densely wooded areas along Roundstone Creek and amongst a patch of 60-year-old regrowth Brigalow located at the western end of the Research Station. Total number estimates for the other macropod species are not available, although a number of small groups of Eastern Grey Kangaroos (*M. giganteus*) are seen daily grazing in the open pastures and resting under shade trees during the day, solitary Swamp Wallabies (*Wallabia bicolor*) are often seen in the early morning around the dam and riparian areas at the eastern end of the property and occasionally along Roundstone Creek, and two Whiptail or Pretty Face Wallabies (*M. parryi*) have been sighted more than once in a gully covered by Brigalow-Dawson Gum forest, on the western side of Roundstone Creek (pers. obs.).

While spotlighting, feral cats are commonly sighted along the edge of the remnant scrub, out in the open pasture, and around the machinery sheds. Foxes are not common, only occasionally detected on the western side of Roundstone Creek. On the other hand, dingoes are common and although exact numbers are uncertain it has been estimated that there would be at least a dozen adults, if not more, at the Study Site at any one time (B. Ward pers. comm.).

2.3.6 Water

The Research Station has numerous watering points for stock with each paddock containing at least one trough. Troughs are supplied by three large man-made dams and two smaller ones, which are also accessible for drinking by both stock and native animals. Accessible water is also available at a man-made dam situated approximately 300m north of the boundary at the eastern end of the Reference Site, on neighbouring 'Highworth' (see Figure 2.10). Natural water is also usually available from the semi-permanent, sandy-bottomed, spring-fed Roundstone Creek, which runs north through the property, and during the wetter summer months in many of the larger gilgais or melonholes which are saucer-like depressions that form natural reservoirs for rain-water in dark cracking clay areas.

2.3.7 Activities within Developed Areas

Agricultural activities on Brigalow Research Station focus on beef production. These include a 300-head-capacity feedlot, accompanying feed preparation and machinery sheds, various supplementary cropping activities and pasture-grown beef production. Eighty-five percent of the 3,595ha property was cleared in the 1960's and has since been planted with pasture grasses including introduced Buffel grass (*Cenchrus ciliaris*), and Rhodes grass (*Chloris gayana*) and native species, Green Panic (*Panicum maximum*) and Queensland Bluegrass (*Dichanthium sericeum*). Approximately 524ha of the Research Station is still under native pasture, 34ha has been planted with *Leucaena leucocephala*, and 325ha is used for cultivation. Sorghum and wheat cropping is undertaken as a method of controlling woody weed regrowth and to provide the beef cattle feedlot with grain. It is common practice to blade-plough paddocks when regrowth has become prevalent or if the pasture requires rejuvenation. Used for agricultural research activities, the 2,088ha of permanent 'improved' pastures are divided into approximately eighty paddocks, the largest being 197ha. The Research Station has a sustainable carrying capacity of 1,200 adult cattle equivalents, stocked at one adult beast to two and a half hectares; however, the number of head run on the property varies depending upon the research projects being undertaken and seasonal conditions (A. Barnes pers. comm.).

Other activities on the Research Station focus upon long-term monitoring of the effects of agricultural activities on soil erosion, soil water, soil fertility, soil salinity and groundwater and productive capacity within Brigalow Belt environments (Cowie *et al.* 2002). This research, coordinated by the Department of Natural Resources, is carried out at the eastern end of the remnant vegetation stand in an area referred to as the Brigalow Catchment Study Site (see Figure 2.10).

2.3.8 Current Wallaby Management

A strategic wallaby management plan has never been formulated for the Research Station, although perfunctory measures have been undertaken in specific areas. Shooting was undertaken from time to time in an attempt to lessen the number of wallabies grazing on the improved pastures and crops. No wallaby shooting was undertaken in the one and a half years leading up to, or during, the study.

To prevent extensive over-grazing and disturbance by macropods in the Brigalow Catchment Study Site, areas within and around this section of the remnant were fenced off to exclude macropods in the early 1980's. The fence was constructed of 10cm square net fencing from ground level to 2m high and 65mm mesh net fencing from ground level to 900mm high. The 900mm high mesh net fencing and a barbed wire strand at 1200mm from the ground, was extended 3kms around the south eastern edge of the Reference Site in February 1999 (see Figure 2.10), to prevent large numbers of Black-striped Wallabies moving onto adjacent Buffel Grass (*Cenchrus ciliaris*) paddocks and a newly-established crop of *Leucaena leucocephala* (A. Barnes, pers. comm.).

It has been suggested that dingoes may provide suitable controls on Black-striped Wallaby densities by predation (Evans 1992). This management strategy does pose a threat of injury or death of cattle through predation and so dingoes are regularly shot and trapped on neighbouring properties. Dingoes were under only minimal control on the Research Station, with less than half a dozen or so shot each year (B. Ward pers. comm.). It is therefore presumed that the large stable population of dingoes at the Study Site was controlling wallaby numbers to some degree. In June 2002, towards the end of this study, baiting with sodium fluoroacetate (1080®) was undertaken to control an increase in feral pig numbers, and is thought to have consequently reduced dingo numbers on the Research Station by at least half (B. Ward pers. comm.).

2.4 Weather Conditions, Sampling Areas and General Methods

2.4.1 Climate and Weather Conditions during this Study

The property has a sub-tropical climate with typical summer wet season storms and maximum temperatures regularly in the high thirties to low forties centigrade. Winters are usually dry, and although short and mild in general, can be harsh with occasional frosts. Based on nearly 30 years of meteorological data, the average annual rainfall for the Research Station approximates 713mm (Loxton 2002) with two-thirds of this rain falling in spring and summer (Figure 2.7).

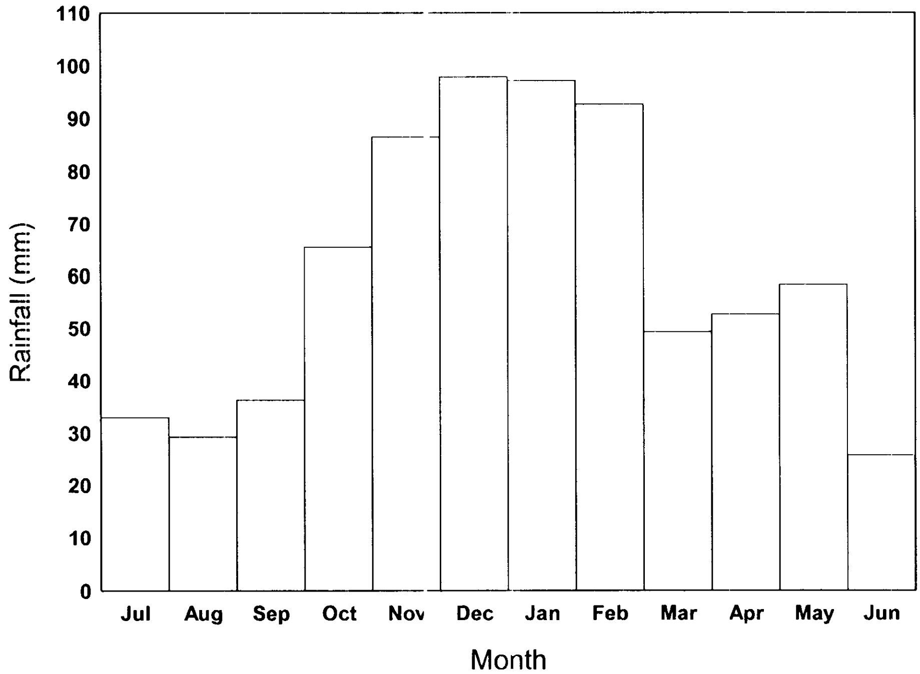

Figure 2.7 Average monthly rainfall for Brigalow Research Station (based on data collected from 1974 to 2002).

Overall weather conditions during this study were typical. Most rain fell during the summer months, although there were only 170 rain days during the 1096 days of the study period (June 2000 to July 2003) giving a total rainfall of 1,764 mm. Dividing this total over the 3 years of fieldwork gives a slightly-below-average annual rainfall of 588mm (Figure 2.8).

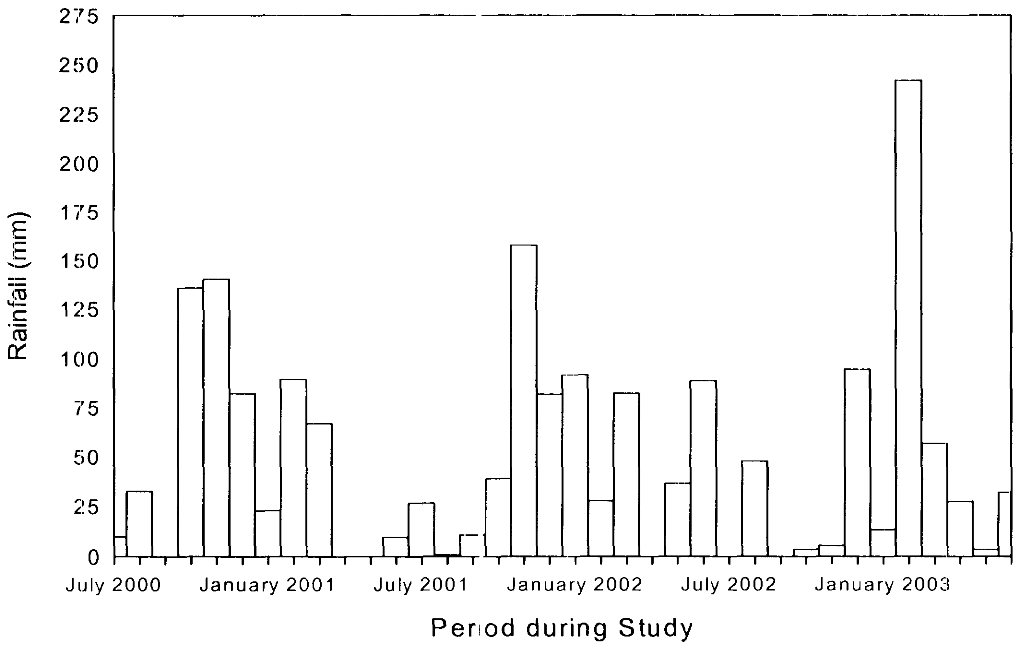

Figure 2.8 Monthly rainfall for Brigalow Research Station during the period of the study.

Reference to yearly rainfall totals over the past thirty years suggests that occasional drops in annual rainfall over periods of 2 or more years are normal (Figure 2.9). Therefore, in terms of both total annual rainfall and pattern of rainfall, the study period could be regarded as typical.

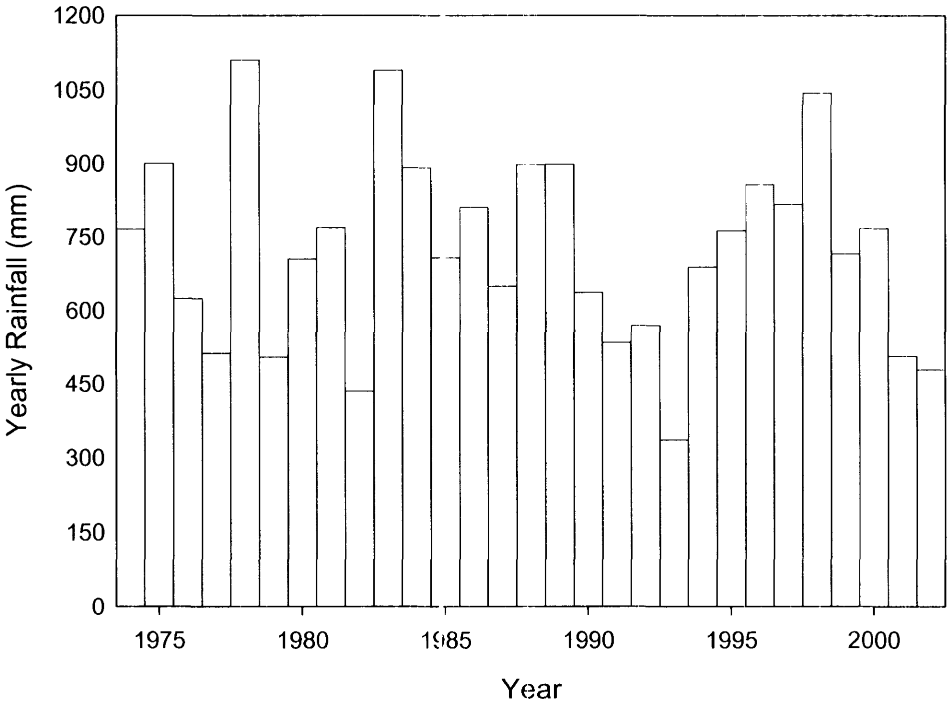

Figure 2.9 Annual rainfall for Brigalow Research Station, 1974 to 2002.

2.4.2 Sampling Areas

The research was undertaken in four main Sampling Areas (Figure 2.10), chosen based on anecdotal information and preliminary observations because they differed in aspects of vegetation type, availability of pasture and water, and most importantly, Black-striped Wallaby density.

The majority of research techniques were undertaken within Sampling Areas 1, 2 and 4 These Sampling Areas consisted of, and centred around, three parallel transects of the same length, spaced 50m apart.

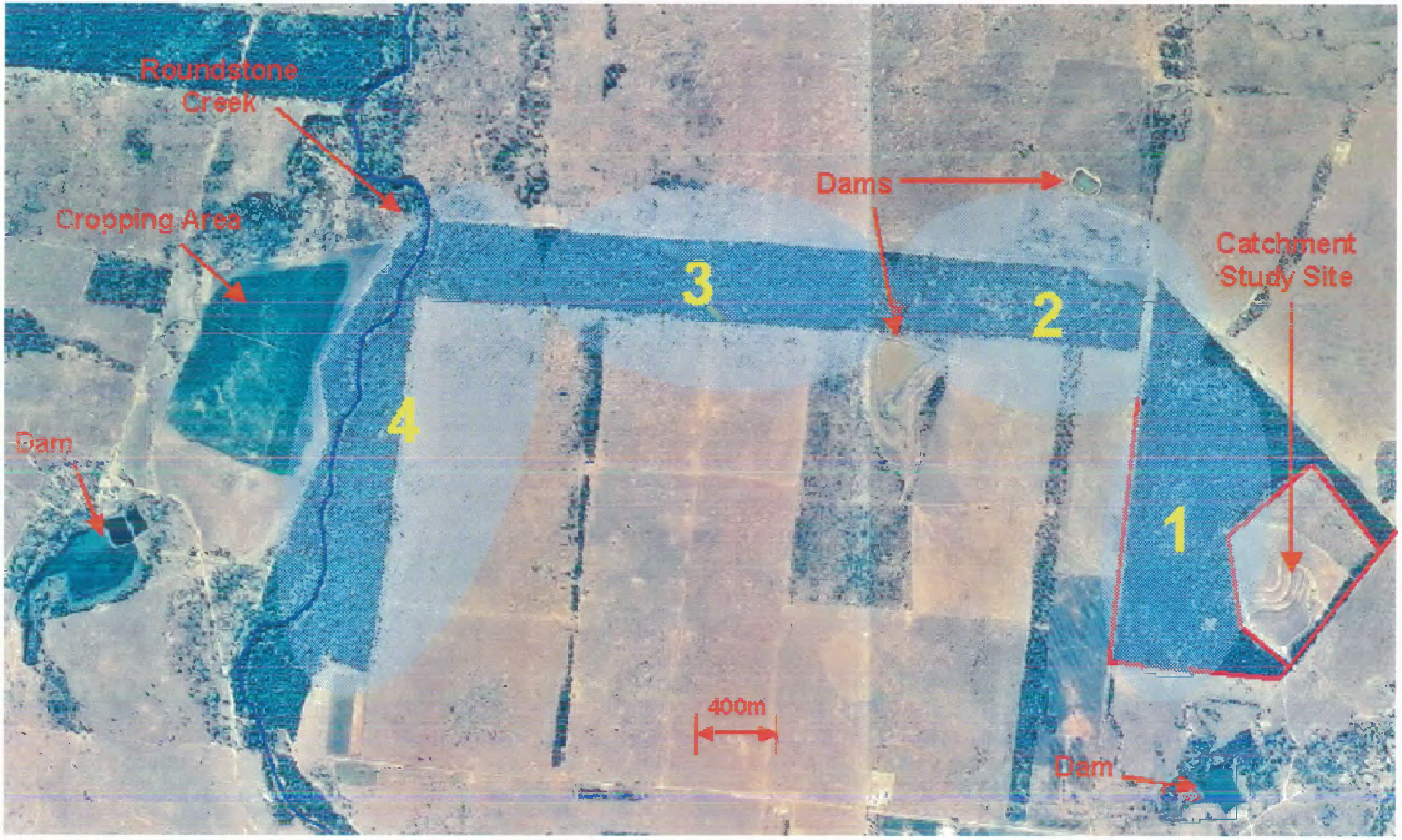

Figure 2.10 Aerial photo of Brigalow Research Station showing the four main Sampling Areas of the study (shaded grey), the wallaby fence (in red) and dams. Sampling Site 5, a minor Sampling Site located on the western side of Roundstone Creek (in blue), is not shown.

Sampling Area 1 was an area of low wallaby density, located at the eastern end of the remnant scrub (refer Figure 2.10). Gilgais featured often on the dark cracking and duplex clays in this sampling area and the habitat was primarily Brigalow (*A. harpophylla*) forest with an understorey of *Carissa ovata*, *Eremophila mitchelli*, *Geijera parviflora*, *Alectryon diversifolius*, *Eremophila deserti* and *Santalum lanceolatum* at varying densities (Figure 2.11a). A 900mm-high mesh fence was erected around this end of the remnant in February 1999, to exclude wallabies. Prior to this fence being built, numbers of Black-striped Wallabies were high in this area (A. Barnes, B. Ward, pers. comm.). Exclosure monitoring, radio-tracking and pad coverage were undertaken within this Sampling Area. Faecal pellet counts and habitat studies were also undertaken along 550m-long transects, running in an east-west direction through the centre of the Sampling Area.

Sampling Area 2 was an area of medium wallaby density situated at the eastern end of remnant scrub patch. Mature Brigalow (*A. harpophylla*) forest also predominated in this Sampling Area, but in the form of younger 'Whipstick' Brigalow. Generally this Sampling Area, on dark cracking and duplex clays, was more open than Sampling Area 1 although similar understorey species were present (*Carissa ovata*, *Eremophila mitchelli*, *Geijera parviflora*, *Alectryon diversifolius*, *Eremophila deserti* and *Santalum lanceolatum*) (Figure 2.11b). This Sampling Area had two other vegetation components within it, which contrasted significantly to the remnant shelter vegetation. The southern section (Figure 2.11c) was a completely cleared paddock sown with Buffel Grass (*Cenchrus ciliaris*). The paddock was rarely grazed prior to, or during the period of this study, and the Buffel grass was up to 50cm high across most of the paddock throughout the entire study. The vegetation to the north of the remnant lay within neighbouring

'Highworth'. Although the neighbouring property was agriculturally modified at some point and continually grazed by cattle, 2-3m-tall Brigalow regrowth had become predominant for approximately 150m from the remnant vegetation (Figure 2.11d). Grass cover was reduced between the regrowth trees and consisted primarily of native species *Aristida* sp., *Thellungia* sp., *Enneapogon* sp., and *Chloris* sp. During wetter months *Parthenium hysterophorus* infestation was a problem and became more intensified each year. Transects for faecal pellet counts and habitat studies within this Sampling Area were 800m long, running in a north-south direction. Of the transects' total length, 200m was within the southern *Cenchrus ciliaris* paddock and 200m within the regrowth paddock to the north. Exclosure monitoring, radio-tracking and pad coverage were undertaken within the remnant vegetation section of this Sampling Area.

Sampling Area 3 (Figure 2.11e) was primarily used for spotlighting, observation counts, faecal pellet counts and radio-tracking. The area comprised of a number of differing soil types ranging from loams, to cracking clays with gilgais. Correspondingly, the vegetation of the area was a mixture of open Brigalow with *Eremophila* sp. understorey, sections dominated by Belah (*Casuarina cristata*), and Softwood Scrub (described below). Vegetation to the north of this section of the remnant did not contain regrowth as Sampling Area 2 did but had a thicker ground cover of native grass species. Some sections however were very heavily infested with *Parthenium hysterophorus*. The vegetation to the south of Sampling Area 3 was similar to the pasture component described in Sampling Area 4 (below). The density of Black-striped wallabies in Sampling Area 3 was thought to be somewhere in between those of Sampling Areas 2 and 4.

Sampling Area 4 was considered to have the highest wallaby density. The area, approximately 500m wide in the middle, ran along the eastern side of Roundstone Creek on red and brown loamy soil and was dominated by a *Macropteranthes leichardtii* semi-evergreen vine thicket (Softwood Scrub). Although thick and not readily accessible it is typical of the vegetation type to have very little understorey (Figure 2.11f). In addition in some parts of the area, particularly where Black-striped Wallaby groups were 'camping', there was very little leaf litter. The Sampling Area also encompassed 200m of pasture (*Cenchrus ciliaris*, *Chloris gayana*, *Dichanthium sericeum*) to the east, which was periodically grazed by cattle (Figure 2.11g). Faecal pellet counts and habitat studies were undertaken on approximately 550m-long transects, running east to west through to centre of the Sampling Area. Exclosure monitoring, radio-tracking and pad coverage were undertaken within the remnant Softwood Scrub section of this Sampling Area.

Sampling Area 5 was an additional minor Sampling Area used only for observation counts and spotlighting studies. This Sampling Area was a cropping area (sorghum or wheat) that ran along the western edge of Roundstone Creek.

Black-striped Wallaby carcasses and skulls were recorded, and/or collected, from all five Sampling Areas and from locations outside those specific Sampling Areas.

a) Sampling Area 1. Brigalow (A. harpophylla) forest with varying density of shrubby understorey.

b) Sampling Area 2. Whipstick Brigalow with Eremophila sp. understorey.

c) Sampling Area 2. Buffel grass (Cenchrus ciliaris) paddock.

d) Sampling Area 2. Regrowth Brigalow (A. harpophylla) with patchy native grass cover.

Figure 2.11a-d. Vegetation associations of each Sampling Area.

e) Sampling Area 3. Mixed remnant vegetation Brigalow with Eremophila sp. understorey, Belah and Softwood Scrub.

f) Sampling Area 4. Softwood Scrub vegetation.

g) Sampling Area 4. Paddock of Buffel grass (Cenchrus ciliaris), Rhodes grass (Chloris gayana) and Queensland Blue grass (Dichanthium sericeum).

Figure 2.11e-g. Vegetation associations of each Sampling Area.

2.4.3 General Research Techniques

Research methods were chosen to fulfil the major aims of the study, namely: to measure the Black-striped Wallabies' level of impact on the pasture and remnant vegetation; to determine the species' interaction with, or use of, the various scrub types; and to devise possible management strategies for the species.

A pilot study was undertaken in September 2000 to trial different research methods, giving consideration to time and financial constraints. Field trips, usually of five to ten days' duration, were then undertaken seasonally from January 2001 to May 2003 to carry out the various data-gathering methods chosen. Day trips were also undertaken to radio-track wallabies and a total of 143 days were spent in the field (30 in summer, 32 in autumn, 32 in winter and 49 in spring).

A summary of each of the methodologies used is given in Table 2.1. Detailed explanations can be found in the following chapters.

Vehicular drive counts and stationary observation counts were undertaken to obtain an estimate of the density of Black-striped Wallabies in various areas on the Research Station. Counts were made every season to determine whether densities changed with season. A small number of wallabies were radio-tracked to help determine how extensively the remnant vegetation was used by individuals and to investigate whether individuals were sedentary or mobile. Habitat preferences and sheltering requirements were investigated by monitoring faecal pellet counts and relating them to measured habitat variables along transects within three of the sampling areas, using standard statistical procedures.

Exclosures were erected, in three Sampling Areas and in one improved-pasture paddock under high wallaby grazing, to monitor the seasonal grazing behaviour of the wallaby population. The extent of wallaby impact due to general disturbance was established by determining the proportion of ground area covered by wallaby pads. Grazing habits of the wallabies were also studied by identifying plant species eaten at the study site by microscopic analysis of faecal pellets.

To gain information about the population dynamics, Black-striped Wallaby skulls were collected, cleaned and aged where possible. Finally, causes of mortality were investigated by recording details such as the size, sex, location and probable cause of death of any wallaby carcasses found.

The statistical procedures, analysis of variance (ANOVA) and residual maximum likelihood method (REML) were undertaken using Genstat 6th Edition (Genstat 2002). Data analysed by REML is shown as means and mean standard errors of means (mean SEM) as given by the analysis output.

Table 2.1 Summary of research methods used and the localities where each was undertaken.

Research Technique	Locality Where Undertaken	Survey Period
1. Vehicular Spotlight Counts	Along one survey route around the perimeter of remnant vegetation.	Spring 2002, Summer 2003
2. Observations Counts	At a number of locations monitored repeatedly each fieldtrip. Focussing on Sampling Areas 1, 2/3 & 4.	All field trips
3. Radio-tracking	11 wallabies trapped from a number of locations around the remnant vegetation.	All field trips
4. Utilisation of Remnant Vegetation (faecal pellet counts)	Along evenly spaced transects crossing the remnant vegetation from east to west in Sampling Areas 1 & 4, and from north to south in Sampling Areas 2 and 3.	Spring 2000 - 2002, Autumn 2002
5. Shelter Preferences (faecal pellet counts & vegetation monitoring)	Along three transects evenly spaced 50m apart in Sampling Areas 1, 2 & 4.	Summer, Autumn, Winter, Spring 2001
6. Paddock Utilisation (faecal pellet counts)	Along a number of randomly located transects within the pasture areas of Sampling Areas 2, 3 & 4.	Most field trips Autumn 2001 – Summer 2002
7. Scrub Exclosures	Two replicated open and closed exclosures within the remnant vegetation areas of Sampling Areas 1, 2 & 4.	Spring 2001 & 2002, Autumn 2001-2003
8. Pasture Exclosures	Six exclosures (two open, two half open and two closed) at the northern end of the paddock within Sampling Area 4.	Autumn & Spring 2001-2002
9. Pad Coverage	40 sites randomly scattered throughout the remnant vegetation and surrounding pasture paddocks.	Summer & Winter 2002
10. Dietary Analysis	Faecal pellets collected from evenly spaced locations along the three transects within Sampling Areas 1, 2 & 4.	Summer, Autumn, Winter, Spring 2001
11. Water Usage	Monitoring of gilgais and dams within the remnant vegetation and surrounding paddocks.	Field trips 2002
12. Skulls & Carcasses	Collection and recording of skulls and carcasses found over the entire Research Station	All field trips