

*Wacol government precinct kangaroo
management strategy*
Background Document



DRAFT

Wacol Government Precinct kangaroo management strategy
Background Document

This document presents background information compiled by the QPWS to support the development of strategies for managing kangaroos in the Wacol Government Precinct. It is based primarily on research conducted by the Queensland Parks and Wildlife Service (QPWS) and information derived from files and reports, earlier reports by consultant Neil Finch of the University of Queensland and information from discussions with community stakeholders.

Citation:

Environmental Protection Agency (2007) *Wacol Government Precinct kangaroo management strategy: Background Document*. Environmental Protection Agency, Brisbane.

DRAFT

Contents

1 Introduction

1.1 The Wacol Government Precinct

1.2 History of human and kangaroo populations at Wacol

1.3 Case studies in management of overabundant eastern grey kangaroo populations

2 Current status of kangaroo population

2.1 Abundance and distribution

2.2 Population changes and dynamics

2.3 Animal health and body condition

3 Bibliography

DRAFT

1 Introduction

1.1 The Wacol Government Precinct

For the purposes of this draft management strategy, the Wacol Government Precinct is considered to encompass both the state government and adjacent lands, including land administered by Brisbane City Council and a small number of freehold residential and industrial properties. The Precinct has an area 1230ha, dominated by state government (790ha); Brisbane City Council (260ha); golf courses (~75ha); and some residential and industrial properties (~105ha).

The state government interests incorporate several institutions and facilities including a number of correctional facilities (such as the Sir David Longland Correction Centre); the Mental Health Centre (The Park); the Wacol Waste Water Treatment Facility; and the Department of Primary Industries and Fisheries (DPI&F) Tick Fever Research Station. Brisbane City Council owns and manages a significant bushland reserve to the east of the Precinct, colloquially known as "Pooh Corner". Two golf courses (Wolston Park and Gales); and approximately 250 residential and industrial properties are also encompassed within the Precinct for management purposes.

The Precinct is located 16km from Brisbane CBD, between Wacol and Gales in Brisbane's south-west (Figure 1). The Precinct is bounded to the south by Woogaroo Creek; to the east by Ipswich Motorway and the Ipswich to Brisbane railway line; to the north by easements for electricity transmission lines and the housing estates of Riverhills and Sumner; and to the west by the Brisbane River. These barriers have effectively isolated the resident kangaroo population as a geographically independent group, and necessitates their administration as a single management unit as described by Moritz (1994).

Vegetation and site assessment

The majority of the vegetation on the Wacol Government Precinct has been cleared for cattle grazing, facilities, golf courses and urban development. The EPA's biodiversity planning assessment process (BPA) has indicated that the remaining remnant vegetation includes areas of state, regional and local significance. On the 790ha state government lands, 57ha of remnant vegetation and 202ha of non-remnant vegetation remains, providing kangaroos with 310ha of open grazing. Within the fenced area of the DPI&F Tick Research Station, there is an additional 130ha, however, a 1.8m chain wire fence has excluded the majority of kangaroos from this areas since its completion in June 2005. The state lands include 32ha of endangered and 4ha of 'of concern' regional ecosystems [Endangered 12.5.3 *Eucalyptus tindaliae* and/or *E. racemosa* open forest on remnant Tertiary surfaces; Of concern 12.3.11 *Eucalyptus siderophloia*, *E. tereticornis*, *Corymbia intermedia* open forest on alluvial plains].

The BCC lands are represented almost equally by Pooh Corner (137ha) and the parklands along Wolston Creek (123ha). Pooh Corner is fully forested, with the majority consisting of remnant vegetation (116ha), comprising two endangered regional ecosystems [Endangered 12.3.3 - *Eucalyptus tereticornis* woodland to open forest on alluvial plains (89ha); and Endangered 12.5.2 - *Eucalyptus tereticornis*, *Corymbia intermedia* on remnant Tertiary surfaces (9ha)]; and 21ha of non-remnant vegetation. The Wolston Creek parklands are predominately cleared and consist of native grasses and 45ha of non-remnant vegetation. The parklands to the north of Wolston Creek appear to be less utilised by kangaroos than the adjacent state government lands. Access by kangaroos to the north side of the Creek is hindered by the (currently) brackish water and muddy edges of Wolston Creek. A small land-bridge, partially barricaded by barbed wire, allows some animals to cross Wolston Creek directly from the state government lands. The difficulty negotiating this crossing, the apparent absence of any water points on the north side of the Creek and the relative unpalatability of the tall, coarse native grasses, may be factors contributing to the relatively low numbers of kangaroos observed in the northern parklands. In contrast, the large amount of kangaroo dung observed in the Centenary Memorial Gardens (on the south side of Wolston Creek), indicates that kangaroos heavily graze the irrigated lawns surrounding the

cemetery. This availability of 'green pick' on the east side of Wacol Station Road, may be a factor contributing to the frequency of kangaroo-vehicle accidents near the Memorial Gardens.



Figure 1 Location and plan map of Wacol Government Precinct.

At the southern end of the Precinct, the two golf courses also present high quality grazing opportunities for kangaroos, through the provision of irrigated, improved grasses and access to water. However, the golf courses appear to be less heavily utilised by kangaroos than the state government lands. While there appears to be no direct barrier separating the kangaroo populations, the relatively sedentary nature of eastern grey kangaroos and the partial barriers formed by urban/facilities development and the forested hills may reduce the interchange of animals from the open paddocks to the north.

1.2 History of human and kangaroo populations at Wacol

Information on the history of human land use and kangaroo populations at the Wacol site was obtained from historical records and short interviews with people with knowledge of the history of the area in question.

Land Use History

The area in question has been used for a variety of purposes, including mental and rehabilitation institutions, correctional facilities, primary industries research facilities and, in the past, for farming. Farming has been carried out since the 1850s and has included horse breeding and mixed farming with crops, animal fodder, pigs, dairy and beef cattle. Present land use is a mix of residential and institutional buildings, remnant bushland, pasture and golf courses. Most of the facilities are currently closed, and there are plans for major redevelopment of most of the area through the Westgate development scheme. With the Westgate Development Proposal for "public access open space", DPI&F will remove the breeder herd from the Tick Fever Research Facility before August 2009.

Apart from the timbered ridges in central and north eastern portions of the site, all the remaining area has been planted to improved pastures. Some areas were regularly cultivated and planted to Lucerne, corn, as well as various forage crops.

Fencing of the DPI&F managed portion of the site occurred in two phases during 2004 - 2005. The security gate was the last link to be closed and was commissioned in June 2005. Fencing was done for a number of reasons:

1. The primary reason for erecting the fence was to upgrade the security around the DPI&F site following a post-September 11 risk assessment of the Department's Biosecurity operations.
2. Secondly, because of the need to quarantine animals. The tick fever vaccine is produced from the blood of specially bred calves that have to be free of contaminating infections. Exposure to ticks carried by kangaroos poses an unacceptable risk to the vaccine.
3. Thirdly, because of the increase in kangaroo numbers, DPI&F could no longer grow a winter cereal forage crop increasing the cost of their operations significantly.

Records of Grey Kangaroos in the Wacol Area

No written mention of eastern grey kangaroos were found in the early historical records (pre-1940) of Wolston House and farm, although there is mention of dingos, wedge-tailed eagles and foxes preying on livestock and poultry (Story, 1998; National Trust, 2007). Information for the period post-1940 was gathered through brief phone interviews. Long-term residents in Wacol area and staff at the DPI&F research facility, Corrective Services and Queensland Health were interviewed.

Through the Richlands and Inala History Group, long-time residents in their 70s or 80s were interviewed. They all remember there being grey kangaroos present in the district from their childhood. However, it is possible that there may be confusion over the species present. The following are quotes from some of those that were interviewed:

- "I always remember there being grey kangaroos around Wolston House and on the prison farm. The prison farm and mental/rehabilitation institutions used to be fenced off so kangaroos did not get on the road and get run over. It was only in the last five years that I have seen eastern grey kangaroos near the house".
- "I remember going walking in the bush with my father near the alcohol rehabilitation centre, and seeing wallabies and kangaroos. I do not recall any problems with kangaroo numbers until the last few years, when numbers exploded".
- "I worked at the repatriation hospital after the war, and then at Wolston Park Hospital. I have memories of grey kangaroos around when I was young. They were often shot by local men, either for dog food or sport".

Logan Steele of Queensland Health, said that one of their chefs had a grandfather who used to go shooting kangaroos out west, with friends. They brought back joeys in the 1950s and released them in the Alcohol Rehabilitation Centre at Wacol. A group of about 6-9 kangaroos hung around and were like pets. These were released in the late 1970s. Steele says that he remembers no natural population of greys around before that.

Shane Hopgood at Corrective Services was interviewed and this led to John Phillips, a former employee of QBuild at the Wacol site. Mr Phillips worked at Wacol for about 15 years, from 1980. He said that around Wolston Park Hospital there were a number of grey kangaroos. They lived for much of the time in the rubbish dump, but came up to be fed at the hospital. He also mentioned that when the John Oxley Youth Detention Centre was built, many kangaroos were disturbed from the bushland and the number of road kills increased.

Bert de Vos of the DPI&F Tick Fever Research Station, has worked at Wacol since 1982. He was told some of the history prior to this by a former farmhand, who has subsequently died. DPI&F brought the old dairy farm from Wolston House in 1960. The farmhand grew up at Wolston Park Hospital in the 1950s and mentioned both grey kangaroos and emus, brought back as juveniles and released at the hospital. Bert arrived in 1982, and says that he didn't see a kangaroo until a year or two after he arrived, and that in the early-mid 1980s they were so unusual that people would stop to watch them. Kangaroos became much more obvious in the late 1980s and by the early 1990s populations were growing rapidly and it was recognised that there might be a potential problem. DPI&F first approached EPA regarding the population in the late 1990s. Red-necked wallabies and swamp wallabies have always been present, although they are not commonly seen out on the pasture. Paul Kukulies of DPI&F, who used to work with Corrective Services, was interviewed. He said that he came to work for Corrective Services in 1988. At that time there were large vegetable gardens near where Wolston Creek crosses Wacol Station Road, while the north side of Grindle Road was used for beef cattle. There had also been a dairy farm in the pasture north-west of Moreton Correctional Facility, running about 400 cows on irrigated pastures. He remembers there being a small population of kangaroos on the grass to the east of Moreton and on the hill around the Training Centre, but they did not come into the vegetable gardens. He also confirmed that the DPI&F fenced their area off partly because the grazing pressure was so great from the kangaroos and partly because of potential interference with tick research programs. TFC staff members are more familiar with Lot 494 than the others. The resident TFC veterinarian recalls that he saw kangaroos on this property for the first time around 1988 or 1989. Before that, there were only the odd red-necked wallaby and swamp wallaby on the river bank.

Overall these preliminary investigations indicate that there appear to be few definitive records of whether eastern grey kangaroos were present at Wacol prior to the introduction of the orphaned population. The long-term residents all stated that there were grey kangaroos in the past, but there may be doubt about some of their identifications of the different species in Wacol. Others, such as Logan Steele (Queensland Health) and Paul Kukulies (formerly Corrective Services, now DPI&F) do not think there was a grey kangaroo population prior to their introduction in the 1950s. Brad Wilson, at Brisbane City Council, was spoken to regarding the locations of the nearest populations of eastern grey kangaroos. He said that he had checked records of sightings over the past five years, and there was a scattering throughout the area, mainly in the Greenbank and Karawatha green corridor, but also across the river in Moggill and Bellbowrie.

1.3 Case studies in management of over-abundant eastern grey kangaroo populations

The eastern grey kangaroo readily adapts to altered landscapes that still provide food, water and shelter. The eastern grey kangaroo is susceptible to rapid increases in population size due to the species' capacity to respond to temporary or long term increases in the availability of food and water. Changes to landscape such as vegetation clearing for pasture, especially when irrigated, or urban development with expanses of lawn will benefit eastern grey kangaroos. These

landscape alterations can have two main effects on eastern grey kangaroo populations. Firstly, positive changes to resource availability will result in high reproductive rates and an increase in the population. Golf courses, irrigated sports fields and suburban parks and farmland with artificial water sources for stock can provide favourable habitat for eastern grey kangaroos. As these populations of kangaroos are landlocked by development, freeways or fencing they can become a management issue.

The novelty of mobs of eastern grey kangaroos in urbanised areas is often negated when there is kangaroo and human conflict. Conflict can result from:

- Injury to persons from dominant, aggressive animals or animals that have been habituated to people through feeding harassing members of the public;
- Damage to property such as vehicles during road strikes or gardens through overbrowsing; and
- Impacts on commercial interests, such as competing for resources with live stock and quarantine issues.

Management may also be required in response to animal welfare concerns where an overabundant population may have limited available food resources due to overbrowsing and/or drought, are effectively confined in a particular area and unable seek alternative browse.

The overabundant eastern grey kangaroo population at Wacol Government Precinct is not an isolated case but is typical of many situations occurring on the east coast of Australia where kangaroo populations have become overabundant and are in conflict with landowners or the community. The following case studies of management of overabundant eastern grey kangaroo populations are provided for comparison to the Wacol Government Precinct kangaroo population and associated management issues.

Case Study 1: Puckapunyal Military Area

The Puckapunyal Military Area is an approximately 44 000 ha fenced site owned by the Commonwealth and managed by the Department of Defence (DoD). It is located in central Victoria and is one of the most heavily used Army training areas in the Australia. Sheep grazing was a historical feature of the site until their removal in 1993 (Anderson *et al.*, 2007). Cattle were introduced under a strictly controlled regime so that pasture growth could be regulated to cushion the impacts of armoured vehicles (A Anderson *et al.*, 2007). During the 1980's and 1990's a major issue emerged for the DoD in the form of an increasing population of eastern grey kangaroos. During drought conditions in 2002-2003, grazing by kangaroos and cattle had exceeded the food resource and lead to much media interest about the mismanagement of a starving 80 000 strong kangaroo population.

A kangaroo management plan was developed utilising information derived from annual population censuses conducted since 1983 and a number of kangaroo condition investigations conducted in the 1990's. Contractors for the DoD culled nearly 30 000 kangaroos after recommendations from a consultant that the site could sustainably support 45 000 to 50 000 kangaroos.

Case Study 2: Yarralumla

Government House, Yarralumla is the official residence of Australia's Governor General. The property has expansive gardens with irrigated lawns and a lake. The population of eastern grey kangaroos unintentionally became a captive one when they were confined as a result of the grounds being fenced for security reasons. By the early 1990's this enclosed population of approximately 160 kangaroos were reported to be damaging vegetation and soiling the lawns of Yarralumla.

A management program was developed to achieve both reduction in the population and a limiting of population growth. As part of this program two thirds of the kangaroos, many of them females and young, were removed from the site. The males in the remaining population were vasectomised effectively resulting in a non breeding, stable population.

Case Study 3: The Pines Golf Course, Sanctuary Cove Resort

Sanctuary Cove Resort is at Hope Island on Queensland's Gold Coast. In the past, eastern grey kangaroos were widely dispersed through Hope Island and surrounding areas. In the last 10 years this area has seen a boom in development, particularly marina developments connecting to the Coomera River. Only small, fragmented areas of native habitat remain and the eastern grey kangaroo population has been greatly reduced and isolated due to urban development and associated threats such as vehicle strikes. A resident population has persisted at The Pines Golf Course and contribute to the amenity of the area. Sanctuary Cove management are committed to the retention and management of the animals at a sustainable level.

Due to the small closed nature of the Sanctuary Cove kangaroo population growth has been limited through reproductive control measures such as sterilisation and hormone implants. The population is being monitored by an annual survey to assess the success of the treatments.

2 Current status of kangaroo population

2.1 Abundance and distribution

Aerial Survey

Aerial surveys of the eastern grey kangaroo population were conducted over the Wacol Government Precinct during April 2007. A total of 6 east-west transects, between 6 and 0.6 km long and spaced 0.75 km apart were established (see Figure 2). Placement of the survey lines was based on a stratification of the area on the basis of dominant vegetation and existing landuse. This was undertaken to ensure sampling effort was distributed proportionally to density on the basis of pre-survey recognisance that indicated that high densities were associated with open pasture areas. The stratification also enabled accurate estimates of kangaroo density and population to be calculated for different land types and jurisdictions. A total of 5 strata were defined across the site including Open Pastures, Wooded, Fenced Pastures, Golf Courses and Complexes.

A Robinson R44 helicopter was used for all surveys and was flown at 61 m (200 ft) above ground and at 93 km h⁻¹ (50 kn) with the rear doors removed. Two rear-seat observers counted out either side of the helicopter, each surveying one half of a transect line. Sightings of all large non-domestic animals were recorded in distance classes up to 150 m perpendicular to the transect line that are delineated with tape on an aluminium boom that is placed underneath the observers and that extends out from the helicopter. All data was recorded into a digital data recorder. The start, finish positions and flight directions for all transects were determined during surveys from GPS operated by the pilot. Height above the ground was checked regularly using a laser range finder. Transects were flown between 7:30am and 9:00am on Friday 27th April 2007.

Line transect analysis

Initially, histograms of the data were examined for evidence of heaping (i.e. clumping of data at particular distances), evasive movement prior to detection. Counts were analysed by the computer program DISTANCE (Buckland *et al.* 1993). To assist interpretation of the survey data separate densities were calculated for each of the vegetation/land use strata traversed by the aerial surveys and these were used to derive both overall population estimates and estimates for different management areas in the site.

Results

The estimated densities and populations for eastern grey kangaroos determined for each of the sampling strata within the area covered by the aerial survey are indicated in Table 1. Densities varied from 0.32 kangaroos/ ha in the Golf Courses to 1.88 kangaroos/ ha in the open pastures. The estimated total population of kangaroos within the survey area of 1,352 represents an average density of 1.10 kangaroos/ ha over the 1,231 ha² area covered by the aerial survey.

Strata Description	Density Estimate (kangaroo/ ha)	Strata Area (ha)	Population Estimate
Open Pastures	1.88	381	716
Wooded	1.14	415	473
Fenced Pastures	0.97	128	124
Golf Courses	0.32	124	40
Complexes (Excluded)	0	183	0
TOTAL	1.10	1231	1353

Table 1. Density and population estimates for eastern grey kangaroos in different strata within the area covered by aerial surveys.

During the initial meetings of the working group the survey area was also divided into a number of Critical Assessment Areas. The distribution and extent of these different Critical Assessment Areas is indicated in Figure 2. The estimated densities and populations for kangaroos determined for each of the Critical Assessment Areas are indicated in Table 2.

Critical Assessment Area	Density Estimate (kangaroo/ ha)	Strata Area (ha)	Population Estimate
CAA1	1.39	519	722
CAA2	1.16	305	355
CAA3	1.20	94	112
CAA4	0.95	105	100
CAA5	0.30	208	63
TOTAL	1.10	1231	1352

Table 2. Density and population estimates for eastern grey kangaroos in each of the Critical Assessment Areas defined by the working group as determined by aerial surveys.

The densities of eastern grey kangaroo estimated for the Wacol Government Precinct during the current aerial surveys are extremely high when compared with densities recorded for free living “wild” kangaroos from other rural regions of Queensland. Broad scale aerial surveys across Queensland record maximum regional densities for eastern grey kangaroos in the range 0.2-0.5 per ha. The average kangaroo density of 1.10 animals/ ha over the area covered by the Wacol surveys is equivalent to the density recorded for the Puckapunyal population in Victoria.

2.2 Population changes and dynamics

Aerial surveys of the eastern grey kangaroo population in Wacol have previously been completed in 2000 and 2003 by the University of Queensland (Finch 2000, Finch 2003). Whilst these surveys adopted a novel methodology, and hence can't be directly compared with the current surveys, they do at least provide an indication of the kangaroo population at Wacol for those periods. The comparative results from these previous aerial surveys and the current survey are summarised in Table 3. The estimated population of 1352 determined from the current surveys would appear to be a decline from the population recorded by Finch (2003) in 2003. Whilst the differences in the survey methodologies don't allow for a robust statistical comparison the fact that Finch (2003) counted at least 1800 separate animals during his second day of surveys suggests a minor decline in the population since 2003. A preliminary analysis of the trends in

pasture condition was completed in order to examine this suggested decline and to examine the dynamics of the Wacol kangaroo population.

Table 3. Results of aerial surveys of eastern grey kangaroo population at Wacol Government Precinct between 2000 and 2007

Date	Estimated Popln	Source
Nov 2000	1000+	Finch (2000)
May 2003	850-1800	Finch (2003)
April 2007	1352	QPWS (2007)

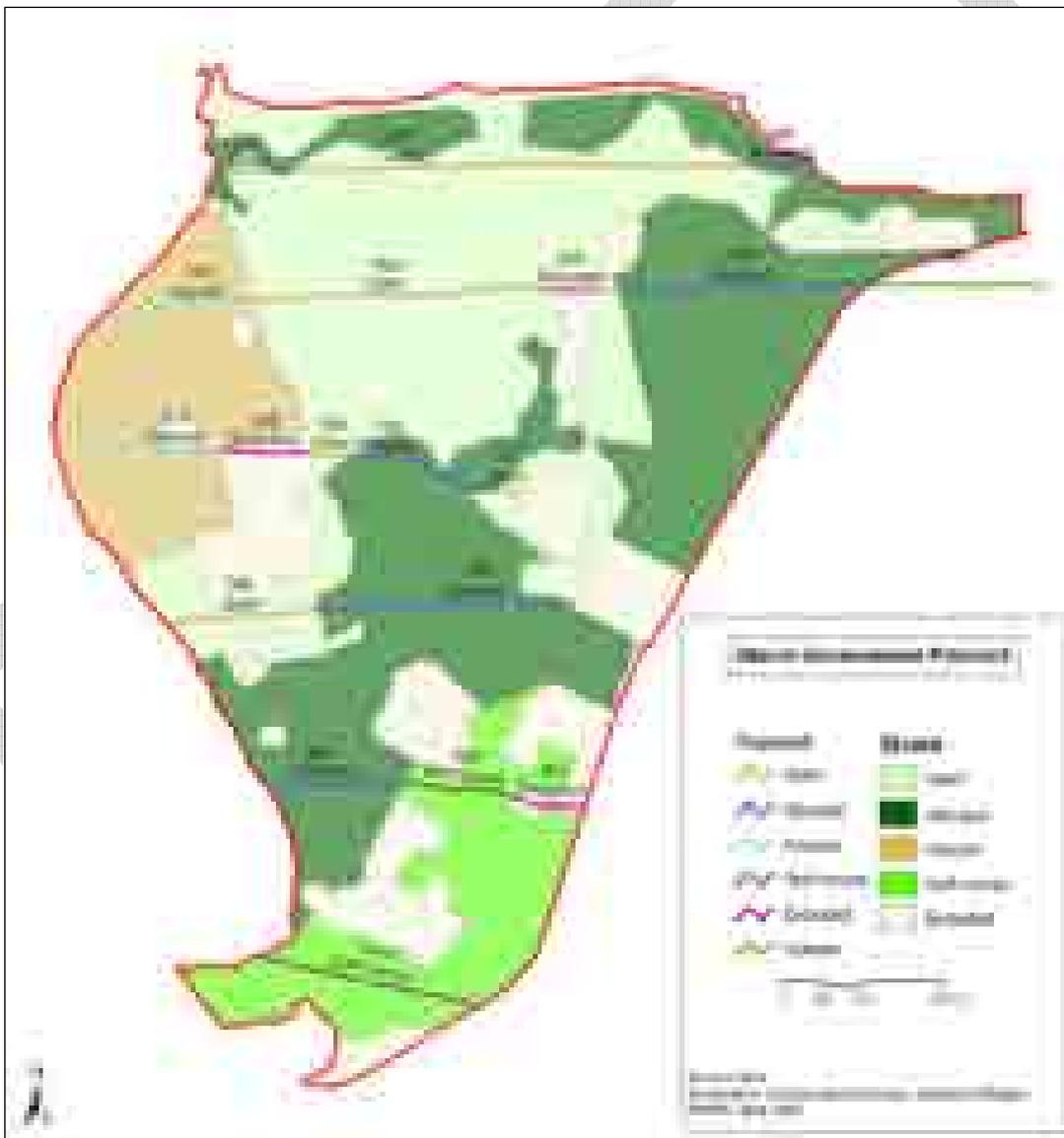


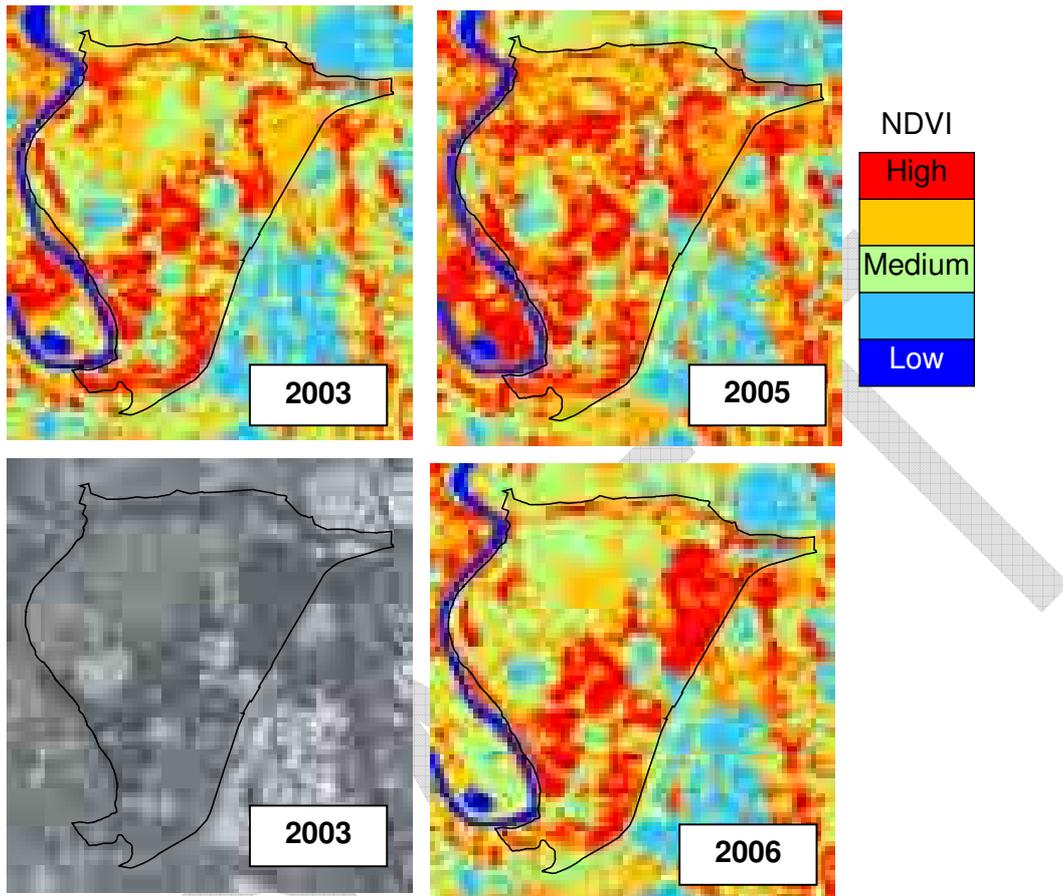
Figure 2. Location of transect lines and stratification used for aerial surveys of eastern grey kangaroo population in Wacol Government Precinct.

Following years of research relating to the commercial harvesting of kangaroos the dynamics of kangaroo populations are reasonably well understood, with changes in population growth rates being most strongly influenced by rainfall-driven food supply (Caughley and Sinclair 1994; Bayliss and Choquenot 2002; Sibly and Hone 2002; Sinclair and Krebs 2002). In the case of a grass eating herbivore like the eastern grey kangaroo population models have largely been based directly on food supply such as pasture biomass (Bayliss 1987). In situations where food supply has not been directly measured rainfall has been used as a surrogate. Another potential alternative is to use satellite imagery which has the advantage of being directly related to the pasture response (Hobbs 1995) and being recorded throughout remote, arid areas where rainfall recording stations are sparsely located and rainfall can be patchy.

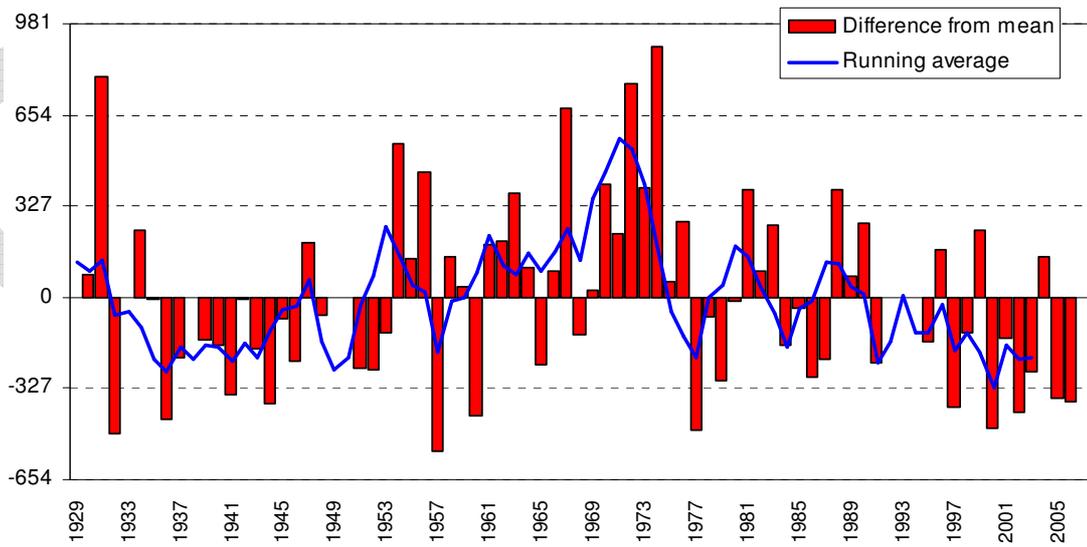
In order to gain an understanding of the potential dynamics of the eastern grey kangaroo population available satellite imagery for the Wacol area, obtained from the State Land and Tree Study (SLATS) program, were analysed for the Normalised Difference Vegetation Index (NDVI). This index is a measure of green vegetation derived from satellite multispectral image data (Tucker et al. 1985; Lillesand et al. 2004) using an advanced very high-resolution radiometer. The NDVI is calculated as the difference in the near infrared (channel 2) and visible red (channel 1) parts of the electromagnetic spectrum. Green vegetation strongly reflects near-infrared radiation but absorbs visible red light, thereby responding to changes in herbage biomass and quality (i.e. greenness). A number of studies have found a strong relationship between plant production and NDVI (e.g. Paruelo et al. 1997) including in the Australian rangelands (Hobbs 1995).

The results of the analysis of NDVI for vegetation cover across the Wacol Precinct show a strong and continuing decrease in the greenness of the open pasture areas on the site from 2003 through to 2006. Figure 3 below shows the patterns derived from the preliminary analysis of NDVI greenness for the Wacol area. The reduction in the areas of red in the open pasture areas of the study site for the NDVI image between the 2005 and 2006 images indicates a substantial downward change in the condition of the pasture for that period. The rainfall records for the Archerfield area also reflect ongoing drought conditions in the area that have prevailed in South-east Queensland over that period (see Figure 4). They provide further evidence to support the conclusion that pasture availability and quality has declined over the area. Whilst these analyses have not yet been ground truthed they clearly infer a steady and ongoing decline in the availability of green feed within the pastures at Wacol that is coincident with the decline in the kangaroo population suggested from the aerial survey data.

Whilst the kangaroo population would appear to have declined in response to the ongoing drought conditions and their effect on pasture the densities of kangaroos at the Wacol site are still extraordinarily high given the conditions. The presence of some watered areas within the Wacol precinct including the Lawn Cemetery, golf courses and the Water Treatment Plant overflow has probably buffered the population from the full effects. The provision of artificial water sources and some supplementary feeding of domestic stock are also likely to have affected the rate of decline of the kangaroo population. The provision of artificial water sources may enable the kangaroos to maintain body condition and reproduction on poorer quality food than they might otherwise do in the absence of such water points. Control and/or elimination of these non-natural food and water sources should therefore be a key focus in management to bring the resident population to a more normal balance with available natural food and water.



**Rainfall Annual Difference From Mean
Archerfield (mean = 1062mm s.d. = 327mm)**



2.3 Animal health and body condition

At the present time no comprehensive assessments have been conducted to evaluate the health and body condition of individual animals within the kangaroo population at Wacol. A limited number of autopsies and health assessments have been completed by a veterinarian on road killed animals obtained from the RSPCA. The sample of animals examined to date in this way were all considered to be in good condition, free of diseases and had full stomachs. Additional animals will be examined on an opportunistic basis. Visual assessments of the animals encountered during the aerial surveys, by QPWS with experience in kangaroo populations, support the veterinary assessments that kangaroos within the Wacol population are in good health and body condition.

3 Bibliography

- Anderson, B., Bryce, M., Theobald, J., Oakley, J., Wilkes, T. and Harte, C. 2007. Habitat management for tanks and Tuans: Evolving approaches at Puckapunyal Military Area. *Ecological Management & Restoration* 8: 11-25.
- Bayliss, P. 1987. Kangaroo dynamics. In *Kangaroos: their Ecology and Management in the Sheep Rangelands of Australia*. Eds G. Caughley, N. Shepherd, and J. Short, pp. 119-134. Cambridge University Press, Cambridge.
- Bayliss, P. and Choquenot, D. 2002. The numerical response: rate of increase and food limitation in herbivores and predators. *Philosophical Transactions of the Royal Society of London B Biological Sciences* 357: 1233-1248.
- Buckland, S.T., Anderson, D.R., Burnham, K.P. and Laake, J.L. 1993. *Distance Sampling: Estimating Abundance of Biological Populations*. Chapman and Hall, London, reprinted 1999 by RUWPA, University of St. Andrews, Scotland.
- Caughley, G. and Sinclair, A.R.E. 1994. *Wildlife Ecology and Management*. Blackwell Scientific Publications: London.
- Finch, N. 2000. *Survey of a population of the Eastern Grey Kangaroo at the Tick Fever Research Centre, and a proposed management plan for the population*. University of Queensland, School of Animal Studies, Gatton.
- Finch, N. 2003. *Survey of a population of Eastern Grey Kangaroos at the Wacol Government Precinct*. University of Queensland, School of Animal Studies, Gatton.
- Hobbs, T.J. 1995. The use of NOAA-AVHRR NDVI data to assess herbage production in the arid rangelands of central Australia. *International Journal of Remote Sensing* 16: 1289-1302.
- Lillesand, T.M., Kiefer, R.W. and Chipman, J.W. 2004. *Remote Sensing and Image Interpretation*. Wiley, New York.
- Moritz, C. 1994. Defining 'Evolutionary Significant Units' for Conservation. *Trends in Ecology & Evolution* 9: 373-375.
- National Trust Queensland. 2007. Files relating to Wolston House and Ian Sharp's notes for *The Wolston Story*.
- Paruelo, J.M., Epstein, H.E., Lauenroth, W.K. and Burke, I.C. 1997. ANPP estimates from NDVI for the Central Grassland Region of the United States. *Ecology* 78: 953-958.
- Sharp, I. 1998. *The Wolston Story*. National Trust Queensland (Brisbane West Branch), Brisbane.
- Sibly, R.M. and Hone, J. 2002. Population growth rate and its determinants: an overview. *Philosophical Transactions of the Royal Society of London Series B-Biological Sciences* 357: 1153-1170.
- Sinclair, A.R.E. and Krebs, C.J. 2002. Complex numerical responses to top-down and bottom-up processes in vertebrate populations. *Philosophical Transactions of the Royal Society of London Series B-Biological Sciences* 357: 1221-1231.
- Tucker, C.J., Vanpraet, C.L., Sharman, J. and Van Ittersum, G. 1985. Satellite remote sensing of total herbaceous biomass production in the Senegalese Sahel: 1980-1984. *Remote Sensing of Environment* 17: 233-249.