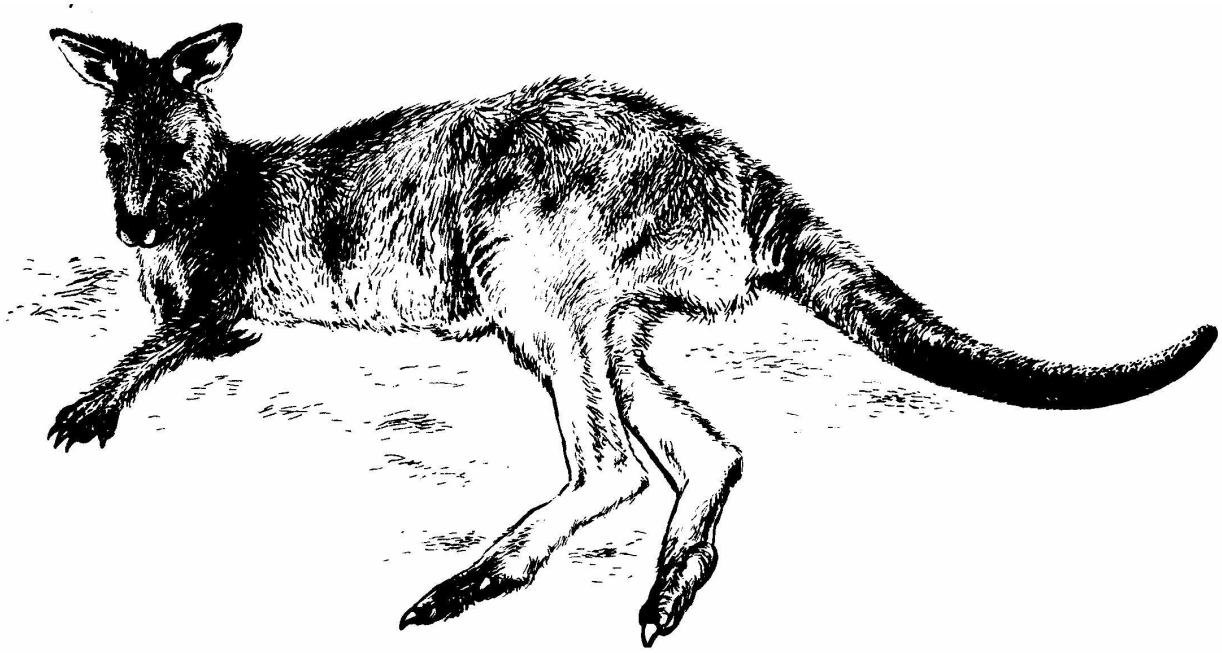
Status and Management of the Forester Kangaroo in Tasmania

2000



Zoë Tanner and Greg Hocking

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CONTENTS

1 INTRODUCTION

The forester kangaroo, *Macropus giganteus tasmaniensis* (Le Souef 1923), is generally recognised as the Tasmanian subspecies of the eastern grey kangaroo, *Macropus giganteus giganteus* (Shaw 1790), which is widespread throughout eastern Australia. On the Australian mainland, the eastern grey kangaroo inhabits heathland, shrubland, woodland and open forest of the coast, mountains, slopes and plains. Less than 1% of the species' current total range occurs in Tasmania (Pearse and Wapstra 1988), where forester kangaroos are restricted to the flatter and drier areas in the eastern half of the state, below 1000 metres. The forester kangaroo is Tasmania's largest marsupial, and only species of kangaroo, but its status is currently insecure due to a number of factors.

The forester kangaroo suffered a massive decline in numbers between the early 1800s and the 1950s (Pearse and Wapstra 1988), and now inhabits only 10% of its pre-European range (Hocking & Driessen 1996) (Fig. 1). The original decrease in range was due to the shooting of forester kangaroos for human consumption and dog meat, which began with the arrival of white settlers in Tasmania in the early 1800s. This was exacerbated by the loss and fragmentation of habitat, due to clearing of land for agriculture. This practice has resulted in the isolation and reduction of populations, and is an ongoing process. Although the species' status has improved since its lowest point in the 1950s, activities such as land clearance and poaching continue to threaten the viability of the forester kangaroo in Tasmania.

This study aimed to determine the current status of the forester kangaroo in Tasmania by:

1. Obtaining information from landowners regarding the range of forester kangaroos and trends in local populations.

2. Investigating the trends of the last twenty years, during which time this agency has been monitoring numbers. This part of the study involved on-ground surveys of forester kangaroo numbers.

2 HISTORY

2.1 Distribution and habitat prior to European settlement

The former range of forester kangaroos has been reconstructed by Wapstra (1976) and Barker and Caughley (1990) using two sources:

1. The diaries of George Augustus Robinson (edited by Plomley 1966), who travelled the state on foot between 1827 and 1834, making extensive observations on Tasmania's wildlife.
2. Vegetation maps, which allow an estimate of the distribution of dry sclerophyll forest and heathland, habitats suitable for the forester kangaroo (Jackson, 1965).

From Robinson's diaries, it is clear that forester kangaroos were abundant in the Northeast, the Midlands, and the eastern part of the Central Plateau, but absent from the western part of the state. Where forester kangaroos were abundant along the coast, they were observed on heath or grassy plains, whilst inland, they were abundant on marshes. The forester kangaroo reached its highest densities in the coastal areas of the Northeast, and in some of the eastern river valleys, notably those of the Macquarie and South Esk (Barker and Caughley 1990).

Suitable areas, where forester kangaroos could have occurred in the past, included the Midlands, the upper Derwent Valley, parts of the Central Plateau, the East Coast, and the Northeast (Barker and Caughley 1990). Excluding areas of wet sclerophyll forest and rainforest, this area is comprised of about 2.6 million hectares. Much of this habitat is of a very low carrying capacity for forester kangaroos (Wapstra 1976).

Fire has been important in maintaining forester kangaroo habitat because it promotes growth of those plants eaten by kangaroos, and if used regularly, prevents dense regrowth of scrub and heathland, which hinders movement of kangaroos (Pearse and Wapstra 1988). Prior to, and during European settlement, the Aborigines burnt the countryside regularly (Plomley 1966). This practice was continued by European graziers to provide feed for their sheep and cattle and is still used on bush runs.

2.2 Impact of European settlement

The first confirmed sighting of forester kangaroos in Tasmania was recorded in 1798 by Flinders at Green Island in Port Dalrymple in the Tamar Valley (Flinders 1814, cited in Barker & Caughley 1990). Soon after the arrival of Europeans in Tasmania in 1803, the range of forester kangaroos began to decrease. By the end of 1808, overhunting had made it difficult to find forester kangaroos close to the settlements of Hobart and Port Dalrymple (Barker and Caughley 1990).

Settlement was limited to the lower Derwent and Tamar Valleys until the early 1820s, when the pastoral industry expanded, and the lowland woodlands and forests in the eastern half of the state were settled for grazing. Land grants were made along the banks of the main rivers, which had been burnt by Aborigines to encourage grasslands (Barker and Caughley 1990). The grasslands enhanced the forester kangaroo's habitat, but also made these places ideal for grazing sheep, resulting in the settlers killing forester kangaroos to prevent competition. By 1844, the Derwent Valley, Midlands and much of the East Coast had been settled. Later, extensive areas

ground during the winter months (Barker and Caughley 1990). The grazing of sheep in forester kangaroo habitat increased, and forested refuge areas were removed to promote grasses, breaking up a continuous distribution of habitat.

By 1850, the forester kangaroo had declined to the extent that comments were made on its scarcity (Barker and Caughley 1990). In 1852, Louisa Anne Meredith noted that "[the forester] kangaroo has become in all inhabited districts an extinct animal... So many idle vagabonds have been in the constant habit of roaming about with packs of twenty or thirty huge dogs each, to procure kangaroo skins for sale, that the forest species is now rarely seen" (Ellis 1979).

Forester kangaroos were hunted for sport and to provide meat. Dogs were necessary for hunting in early years, as the colony was initially undersupplied and dependent on ammunition being imported from overseas. They became a problem, becoming feral and attacking both wildlife and the settlers' stock (Barker & Caughley 1990).

From the 1870s, forester kangaroos were also affected by rabbit control. Trails of poisoned baits containing strychnine or phosphorus were laid, and packs of dogs were taken on to the paddocks and runs and allowed to hunt (Pearse and Wapstra 1988). Populations of forester kangaroos and other native herbivores declined. Previous removal of refuge areas had broken the populations up into small groups, and hunting, poison, and dogs wiped out many of these.

Thus, by the early 1900s, as a result of hunting and to a lesser extent land clearance, the species was in serious decline (Wapstra 1976). By 1950, forester kangaroos were to be found in only two areas: the Midlands and the Northeast of Tasmania (Pearse and Wapstra 1988). Little is known about the rate of decline. Wapstra (1976) assumes it to be a gradual process keeping pace with land alienation, and estimated the range of the forester, at the time, to be about 140-000 hectares, or 5.4% of its range at the time of European settlement.

3 HISTORY OF MANAGEMENT

3.1 Legal protection

Forester kangaroos received partial protection under the *Game Protection Act* 1879, which made it an offence to hunt them between 1 August and 30 January of the following year. Later, under the *Game Protection Act 1898*, forester kangaroos were listed as fully protected (Pearse and Wapstra 1988). Forester kangaroos have remained fully protected since that time, and are now protected under the *National Parks and Wildlife Act* 1970, and can only be culled legally under a crop protection permit issued by the Director of the Parks and Wildlife Service.

In 1970, a House of Representatives Select Committee on Wildlife Conservation was set up to look at wildlife conservation in Australia (Anon. 1972). Kangaroos were of immediate concern, and an interim report was produced on this subject (Anon. 1971). This report concluded that of the large kangaroos, only the Tasmanian forester kangaroo was under threat. This threat arose from habitat destruction.

In 1974, a report prepared by State and Commonwealth wildlife authorities listed the forester kangaroo as second priority in a list of 13 species of macropods urgently in need of having an area of their habitat reserved (Burbidge 1977).

3.2 Control of poisons

The killing of kangaroos as a side-effect of rabbit eradication subsided after 1952, when the control over the use of poisons became the responsibility of the Department of Agriculture, which introduced compound 1080 to replace other poisons. Although 1080 poison is capable of killing forester kangaroos (McIlroy 1982), field observations have indicated that the strength of the poison in baits used to poison rabbits is not usually sufficient to kill foresters (Pearse and Wapstra 1988). The use of 1080 declined after 1956 when the myxomatosis virus was introduced to the state. Today, 1080 is still used to control browsing rabbits, wallabies and possums on crops and forest plantations. Recently, reports have been received of 1080 killing forester kangaroos in the Northeast.

3.3 Enforcement activities

Illegal shooting of foresters is thought to be a contributing factor to the species' decline in Tasmania. In the late 1960s, a concerted policing effort was carried out, and between 1967 and 1969, 32 people were convicted of a total of 60 charges concerning the illegal culling of forester kangaroos (Pearse and Wapstra 1988). This had a positive effect, with a decrease in the number of offenders detected. Forester kangaroo protection remains a high priority of enforcement activities.

3.4 Establishment of Mt William National Park

Because of its remoteness and relatively poor soils, the Northeastern part of the state did not undergo pastoral development until the early 1970s. Prior to 1970, forester kangaroos were

generally low. In the early 1970s, a large pastoral company acquired 50 000 ha of land, and began developing improved pasture to run sheep and cattle. Development created a mosaic of bush and pasture, and generally improved the carrying capacity of the land for forester kangaroos.

The Parks and Wildlife Service succeeded in setting aside a reserve in 1973, now known as Mt William National Park. The park reserved a representative sample of the range of natural communities in the Northeast of the state, but its carrying capacity for forester kangaroos was low. Further additions to the Park, which increased its area to 10 595 ha, did little to improve the situation.

Because the pastoral company's land holdings were large, the manager was reasonably tolerant of the increase in the number of forester kangaroos, and the future of the population seemed assured. However, in 1977, the company put up for sale about half of its holdings, which included all of the forester kangaroo habitat with a high carrying capacity. It was predicted that the new landowners would undertake extensive clearing, which would destroy forester kangaroo refuge areas. Thus, a further 3 217 ha of land adjacent to Mt William National Park was purchased, increasing the size of the park to 13 812 ha. The new area included 1 000 ha of improved pasture, which was maintained with superphosphate until the late 1980s, when lack of funds led to the discontinuation of this practice.

Many landowners in the Northeast district reported in 1976 that a decline of forester numbers had occurred in that area in the previous 10-20 years, which was likely to be a result of large scale land clearing during that time, resulting in fragmentation of habitat (Wapstra, 1976). There has recently been further anecdotal evidence of the population's decline in the Northeast region (Cronin 1998), which was disputed by other sources which claim that forester kangaroos are increasing in the region. It is likely that forester kangaroos are being increasingly attracted to areas of developed pasture and crops where they are more easily seen, and therefore appear more common. However, habitat is declining due to little regeneration within the National Park and clearing of forest on private land, leading to a drop in numbers. Thus, the Mt William National Park and general Northeast region provided one of the focal points for the current study.

3.5 Management of population increase

By 1970, the remnant populations in the Midlands had increased in both size and range (Pearse and Wapstra 1988), and were damaging fences and feeding on crops and improved pastures in competition with domestic stock. Landowners requested that the number of forester kangaroos be reduced.

Rather than cull the forester kangaroos, the PWS decided to attempt to increase the range of the species by live-trapping problem animals and releasing them in suitable habitat no longer occupied by forester kangaroos.

Trap and release program

Landowners with suitable release sites were contacted by the PWS, and permission obtained to release forester kangaroos on their properties. Not all landowners approached agreed to take forester kangaroos, because some regarded them as a potential pest (Pearse and Wapstra 1988). Cage traps were used to trap the animals where they had forced holes through netting fences on well-established runs. Once trapped, animals were tagged and transported in trailers to the release sites. Between 1971 and 1978, 2038 forester kangaroos were trapped. Over 1900 forester kangaroos were released, with mortality of trapped animals being low. For example, in 1977 and 1978, 94% of trapped animals were released, healthy, into the wild (Pearse and Wapstra 1988).

Releases were made at 18 locations (Fig. 2), and surveys were carried out at most sites to determine success of the operation. Freycinet National Park failed as a release site, probably because the area of suitable habitat was too small to support a viable population. On the Central Plateau, the forester kangaroos encountered heavy snowfalls shortly after their release in early winter, and the animals did not survive (Pearse and Wapstra 1988). At all but these two sites (Freycinet and the Central Plateau), the release was successful, and resident breeding populations were established (Pearse and Wapstra 1988), but populations do not necessarily remain to this day.

At Kempton, the population increased to such a density that permits were issued to two landowners to shoot 75 animals in 1978 and 1979. However, at present, the Kempton population appears to be declining (see Section 5). Another successful release site was Asbestos Range National Park (Now Narawntapu National Park), where the population had increased to about 200 by 1987, but has now decreased to as few as fifty animals.

On Maria Island, 45 animals were released during 1969 and 1970 on an area of pasture and grassland cleared and developed by former settlers. This population had increased to about 2000 by 1985, and began to have a serious impact on the native vegetation. The population continues to increase, and is managed by a long-term culling regime.

The release program caused some concern among landowners, as when released, some animals moved to adjacent properties where owners objected to their presence. It remains an issue between landowners and the agency today, as several landowners believe that forester kangaroos were released onto their property without their permission, or even knowledge. However, this can be explained by the fact that foresters have been known to move up to 10km in search of better habitat (Pearse and Wapstra, 1988), and thus have moved onto neighbouring properties from legitimate release sites.

Opposition reached a peak in 1975 when a number of landowners in the Western Tiers area, where three adjacent properties had agreed to the release of forester kangaroos, requested that the program cease. This request was supported by two rural municipal councils. Following a series of meetings, it was agreed that if there was a possibility that forester kangaroos might move from the release site to a neighbouring property, the neighbours' approval would first have to be gained. This made it difficult to find appropriate sites, and no more animals were trapped after 1978.

Overall, the release program was successful in increasing the forester's range, thus giving it greater security (Pearse and Wapstra 1988).

Introduction of a culling program

In the late 1970s, farmers in areas where forester kangaroos were causing damage began to criticise management provisions, particularly the refusal of the PWS to undertake quick and effective control by shooting. This criticism raised the concern that the relationship between the PWS and landowners was poor, and that confrontation might result. This relationship remains an issue, and will be discussed in later sections of this report.

As a result of a meeting between the PWS and landowners, it was decided that shooting should be introduced as a control measure. Publicity over this decision was well received, and attracted no adverse comment (Pearse and Wapstra, 1988). In the first year, 1976, Wildlife Rangers undertook all the shooting, but in 1977, a system was introduced where landowners and their agents could shoot forester kangaroos under permit. This latter system is still in place today. In response to an application, a DPIWE wildlife officer assesses the property, and recommends how many animals can be shot under permit. The permit specifies the number of forester kangaroos to be shot, and the landowner is issued with a plastic self-locking tag to be placed on the carcass of each forester kangaroo shot. The tag, which must remain with the skin, acts as a deterrent to illegal shooters, and aids in their detection. An annual quota is set for each district, and permits issued in accordance with the quota.

Some landowners are not content with the current crop protection system (see Section 5), and there are reports of landowners culling animals without permits if the permits are too difficult to obtain.

Monitoring

Since 1980, forester kangaroo population trends in the Midlands of Tasmania have been regularly monitored using a system of line transect surveys. Since 1983, this has also occurred in the Northeast of Tasmania. The results of these surveys have been used each year in determining the number of forester kangaroos to be culled under crop protection permits in each area.

In conjunction with the 1999 field survey, a questionnaire was sent out to landowners. The results of the questionnaire were used to choose areas to establish additional transects, and to formulate management prescriptions for the forester kangaroo. The results also extended knowledge of the forester kangaroo's range, and the conflict issues between landowners and forester kangaroos. The field surveys and questionnaire survey will be further detailed in Sections 5 and 6 respectively.

4 THE CURRENT PROBLEM

The relationship between forester kangaroos and agriculture is the most important issue pertaining to the survival of forester kangaroos, as most of the current range is on private land.

4.1 Impact of forester kangaroos on agriculture

Conflict between the forester kangaroo and landowners arises because foresters graze on crops and improved pasture and damage fences. Quantitative data on damage caused to pastures and crops in local situations is not available. However, mobs of forester kangaroos feeding in open paddocks can be more obvious than wallabies and deer, making it appear as if foresters cause more damage than other grazing animals.

Damage to fences allows stock to stray within and between properties, wallabies and rabbits to enter crops and pasture, and requires labour and materials to effect repairs.

4.2 Impact of agriculture on forester kangaroos

Threats to the survival of the forester kangaroo posed by agriculture include:

1. *Land clearing and pasture improvement*.

Land clearing and pasture improvement can result in fragmentation of populations, reducing total numbers and increasing vulnerability of sub-populations.

Improvement of land through topdressing of existing pastures, establishment of pastures, or planting crops is a significant investment, so landowners may become less tolerant of forester kangaroos. This is likely to more than offset the advantage to the forester kangaroos of the provision of a superior food source.

2. Fragmentation of ownership.

Many of the larger properties in Northeast Tasmania have been subdivided into smaller holdings. Land development is often an economic necessity for smaller holdings, and the density of foresters tolerated on larger holdings may not be acceptable on smaller holdings for financial reasons. Also, additional fencing between holdings may be a hazard for forester kangaroos, as they can get caught in fencing wire.

3. *Unsustainable culling*

Unsustainable culling of populations of forester kangaroos as competitors for crops and pastures places pressure on those populations.

However, it is important to recognise that the survival of the forester in its remaining range is in part due to the goodwill and efforts of individual landowners.

5 LANDOWNER INFORMATION AND OPINIONS

5.1 Introduction

In 1999, a questionnaire (Appendix 1) was sent out to landowners and managers (from here on, the term "landowners" is used) in order to:

1. Determine more accurately the range of the forester kangaroo.
2. Ascertain landowner perceptions of population trends.
3. Establish what impact the foresters are having on properties within their range.
4. Gather ideas on how the forester kangaroo could be better managed and conserved in the future.

5.2 Methods

Landowners within the range of the forester kangaroo were identified using the Department of Primary Industries, Water and Environment (DPIWE) Land Information Services database. Many properties had multiple titles, resulting in multiple questionnaires being sent to some landowners. Thus, it was difficult to ascertain how many individual landowners received questionnaires, but this is estimated to be about 280. Respondents were given the option to remain anonymous, but only 3% chose to do so, with a further 2% withholding their name but giving the property name. There were no reminder notices sent out, but a follow-up letter was sent to twenty of the 158 respondents to ask for further comments on the crop protection permit system.

5.3 Results and Discussion

Of the 280 questionnaires sent out, 158 were returned (56%), covering properties with a total area of over 311 000 hectares. The response of landowners was very positive, with only 14% of those respondents with forester kangaroos on their land reacting negatively to the species. Fifty percent of respondents with forester kangaroos on their property liked them as long as they are kept at an acceptable level, and 36% of respondents with forester kangaroos were positive towards them without conditions.

Estimating the forester kangaroo range

Of the respondents, 36% had never had foresters on their property; 11% had foresters in the past; and 53% currently have forester kangaroos on their property (this 53% covers 85% of respondents' land). It was found that the range was larger than expected, indicating that the extent of properties surveyed by questionnaire was not large enough to encompass all of the land on the borders of the forester kangaroo range. The distribution of forester kangaroos revealed by this survey is mapped in Appendix 2. It proved impractical to gather information from each respondent about exact localities of kangaroos within their properties, so information has been generalised to cover the entire property, rather than just those parts where kangaroos actually occur.

Perceptions of population trends

Landowners with forester kangaroos on their properties (53% of respondents) were asked how the numbers had changed in the last five years. Fifty five percent of respondents in the Nile region said that numbers had increased, 23% said numbers had remained constant, 18% thought numbers had decreased, and the remainder were unsure (Graph 1). In the Ross area, 29% of respondents stated that foresters have increased, 36% said numbers had remained stable, 17% said that numbers had decreased, and the remainder were unsure (Graph 2). In the Northeast, only 20% (i.e. 3 respondents) suggested there had been an increase in this period. Sixty percent said that numbers had stayed the same, and 20% were unsure. None felt that there had been a decrease (Graph 3).

In the Kempton area, where forester kangaroos were released in the 1970s, all respondents felt that numbers had decreased. Sixteen percent of Kempton respondents (4 individuals) currently have forester kangaroos on their properties, though the numbers are declining, and a further 20% (5 individuals) have had them in the past, but not any longer.

Impact of forester kangaroos on farms within their range

The 53% of respondents who had forester kangaroos on their property were asked what damage, if any, these animals cause. Many respondents recorded two or three types of damage, but over 20% said that there was no noticeable damage. The types of damage listed by landowners, and the numbers of landowners who listed them (only those landowners with kangaroos on their properties) are as follows:

- damage fences, usually by breaking or stretching the wire (70%)
- eat improved pasture (55%)
- damage/eat crops (29%)
- damage establishing trees (1%)
- drink stock water (1%)
- disturb stock when feeding (1%)
- disturb lambing sheep (1%)
- transfer weed seed and disease between properties (1%)
- cause damage to cars on the road (1%)

Landowner comments on management and conservation of forester kangaroos in the future

Landowners' suggestions for the future management and conservation of the forester kangaroo have been summarised into 38 general statements, which are listed in Appendix 3. The more common suggestions are listed below.

1. Twenty four percent suggested something similar to the current management system, in which the forester kangaroo is protected, but culling is allowed, in order to achieve acceptable numbers.

2. Fourteen percent suggested that forester kangaroos should be protected on, or restricted to, Crown Land or National Parks, while 8% thought that forester kangaroos should be protected on, or restricted to, unimproved grazing land or bush.
   - There are considerable difficulties associated with restricting kangaroos to any area, even if the philosophy was acceptable to other landowners, the DPIWE and the community.

3. Ten percent said that they would like to see a sustainable number of kangaroos protected.
   - This is consistent with the aims of this agency.

4. Five percent would like to see the populations supplemented, or have animals introduced to other parts of the State, while 6% would like to have the forester kangaroo range restricted to its present boundaries.
   - The DPIWE does not intend to relocate forester kangaroos.

5. Five percent suggested that landowners should be financially compensated for having forester kangaroos on their properties.
   - See paragraph on the Wildlife Credits Fund Project Proposal in section on Management.

6. Five percent would like to see forester kangaroos managed by way of a Property Based Game Management Plan with the DPIWE.
   - See Management section, which proposes revisions to crop protection permits for culling kangaroos.

In addition, several landowners have suggested that the current culling system does not meet their needs, and some landowners have pointed out that management of the forester kangaroo needs to be workable for landowners so that people are not tempted to do the wrong thing. Landowners said that permits are not issued fast enough, or for a long enough period to deal with the problem at hand, and there is too much administration involved in acquiring permits and distributing them to shooters.

Several landowners would like to be able to manage their own forester kangaroo populations without involvement from the DPIWE. However, as forester kangaroos are wholly protected, the agency is responsible for enforcing the legislation, and therefore permits are required. The proposed changes to the permit system should satisfy the needs of most landowners, without compromising the responsibilities of the DPIWE or the conservation of the forester kangaroo.

5.4 Relationship between landowners and the DPIWE

The landowners' positive response to the questionnaire shows an interest in the issue of forester kangaroo management and a willingness to co-operate with the agency. It is significant that 30% of respondents (covering 56% of respondents' land) have Property Based Game Management Plans with the DPIWE.

The agency is fortunate that such a large proportion of people involved has shown interest and co-operation, and is taking advantage of this by making an increased effort to co-operate with landowners. Over the last few years, public consultation has become a crucial management tool for dealing with environmental and social issues, and it is no longer appropriate for decisions to be made without consultation with the people who will be affected. The initial contact via the questionnaire has the potential to form the beginnings of a strong relationship between some of

the landowners/managers and the agency. For example, some of the respondents, who showed a particular interest in the management of the forester kangaroo, were asked to supply further suggestions for revisions to the Crop Protection Permit policies.

The relationship between landowners and the DPIWE remains one of the most pertinent issues to successful conservation and management of the forester kangaroo in Tasmania.

6 THE FIELD SURVEY

6.1 Introduction

Assessing trends in the population and culling levels are important elements of managing a population that is regularly culled (Southwell *et al*. 1995), such as the forester kangaroo. Southwell (1989) recommends that the line transect count method, with observers walking along randomly or independently located transects, is potentially the most accurate transecting method for estimating macropod population density.

Line transect counts of macropod populations are best suited to sparsely or moderately wooded country, as dense shrubby vegetation hinders inconspicuous movement by the observer, potentially forewarning the kangaroos of his or her approach and allowing kangaroos to move away unseen and unheard. Line transects are also best suited to populations of low to moderate density, because with dense populations, animals fleeing from the observer may cause others further along the line to flee unseen (chain flushings) or these animals may be confused with uncounted animals (Southwell 1989). For both these reasons, the Tasmanian population of forester kangaroos is an ideal subject for the line transect method: they occur in moderately wooded country, and occur at a moderate density. It is not possible to undertake aerial surveys in Tasmania, because much of the forester kangaroo habitat is at least lightly wooded, so animals are not visible from the air.

In assessing the conservation requirements of the forester kangaroo, population size *per se* is of less significance than trends in population size and range (Wapstra 1976). The key to successful management of the population is to find a balance between damage mitigation culling and conservation of forester kangaroos. Exact numbers need not be known to establish such a balance. In fact, exact numbers would prove somewhat meaningless, except to use in comparisons with populations on the mainland of Australia. The method used here is inappropriate for determining an actual density of forester kangaroos, but gives a reliable *index* of trends in the population. However, total numbers are of interest to many farmers whose land supports populations of forester kangaroo. To find a reasonable estimate of density, it would be necessary to design a survey specifically for this purpose. The benefits of this activity are unlikely to outweigh the costs (see Appendix 4), especially since the accuracy of density estimations is often questioned (McNamara 1986).

6.2 Methods

Three core regions where forester kangaroo populations occur were identified in the late 1970s, and the long-term study areas used for the transects were established within these areas (Fig. 3):

- Nile region (established in 1980)
- Ross region (1980)
- Northeast region (Mt William National Park and surrounding private) (1983)

In 1999, three additional areas were surveyed to provide baseline data and allow comparison with the long-term areas (Fig. 3):

- West of Campbell Town
- South of Avoca
- North of Gladstone

Forester kangaroos are grazing animals that prefer grassland, woodland and open forest. They sometimes move into cleared country to feed, but generally remain within 500 metres of forest edges. Areas with substantial tree or shrub cover are avoided. Suitable habitat can thus be broadly described by a combination of topographic and vegetation criteria.

The Tasmap 1:100 000 map series was used to position the transects for the long-term study areas. Information from the questionnaires helped to decide where to establish the additional study areas in 1999, which were based on the Tasmap 1:25 000 map series.

Six to eight transects between 5 and 12 km in length were established at each study area, designed to traverse the core forester kangaroo range within each population. The transects ran on either west-east gridlines (Ross and Campbell Town); north-south gridlines (Avoca and Gladstone); or on a south-west to north-east orientation (Nile and Northeast). Surveys were repeated on 2 to 3 successive days. During each survey, all transects were surveyed on foot each day. Each observer, unaccompanied, surveyed two transects per day. The transects were walked at an average speed of 3-4 km/hr, commencing at around 9 am and being completed by 4 pm. The Tasmap 1:25 000 series maps, and compasses, were used for navigation.

All native and feral mammal species seen were noted together with the following information:

- Number of individuals.
- Sex of each animal.
- Whether individual was juvenile or adult, determined by size.
- Distance from the observer to the animals as measured by range-finders ("Ranging-1200" paralax rangefinder up to 1999; and two Bushnell Compact 600 laser rangefinders in 1999).
- Angle between the line of the transect and the sighting.
- Vegetation in which the sighting occurred.
- Activity of the animal when sighted.

Ross and Nile transects were carried out yearly between 1980 and 1986; biennially between 1986 and 1994, and were not repeated again until 1999. Transects in the Northeast were carried out annually between 1983 and 1986, and repeated in 1993, 1999 and 2000. Surveys took place between July and September.

6.3 Transect locations

The locations of transects are shown in Fig. 3. The Midlands region (encompassing the Ross and Campbell Town study areas in the south, and the Nile and Avoca study areas in the north) is all under private ownership and used for grazing sheep and cattle. The grazing properties in the Midlands are generally large by Tasmanian standards (2 000 - 10 000 hectares). They consist of cleared paddocks of improved pasture and bush runs with extensive areas of open forest. The Northeast region (encompassing the Northeast study area and the Gladstone study area) is mostly under private ownership, though the Mt William National Park comprises about 14 000 ha. The balance of the Northeast population is covered by two large properties, making up 30-000 ha. The areas of forest in the Northeast are less extensive than those of the Midlands, and many of those that are present have a dense understorey of heathy shrub species.

Nile
The Nile Plateau forms the northern core range for forester kangaroos in the Midlands, and is an area of approximately 105km^2 of woodland and open forest with a grassy understorey, surrounded by improved pasture. Eight transects were surveyed three times by four people over three consecutive days (Appendix 5, Map1).

Ross
The Ross area forms the southern core range for forester kangaroos in the Midlands. The area covers 216km^2, and is composed of woodland and open forest with a grassy understorey, interspersed with patches of improved pasture. It is bounded to the west by cleared pasture land, and to the east by denser forest unsuitable for forester kangaroos. Eight transects were surveyed by four people three times over three consecutive days (Appendix 5, Map 2).

Northeast
The long-term study area in the Northeast covers 80km^2, and comprises the northern section of Mt William National Park, and the private property surrounding it to the north and west. It consists of woodland, open forest, heathland and scrub, with some areas of improved pasture. Eight transects were surveyed three times by four people over three consecutive days except in 1999, when six transects were surveyed twice by three people over 2 consecutive days (Appendix 5, Map 3).

Campbell Town
Six transects of 7-8 km each were placed along east-west gridlines, running west from Ashby Road (Appendix 5, Map 4). The transects, covering 96 km^2 of open forest and woodland with a grassy understorey, crossed several properties and were surveyed by three people on two consecutive days in July 1999.

Avoca
Four transects of 6-7 km each were placed on north-south gridlines, running south of Esk Main Road (Appendix 5, Map 5). The transects were surveyed in July 1999 (by two groups of two people) only once, as no forester kangaroos were sighted. Four more transects were proposed for the second day (see map), but were not undertaken due to bad weather.

Gladstone
This area is mostly covered by improved pasture, crops and heathland, but there are also sections of scrub and open forest present, more fragmented than those in the Midlands. In July 1999, two transects of 10 km each were undertaken in the Aberfoyle Hills area (Appendix 5, Map 6) by two groups of two people. The transects were designed so as to utilise only half a day, so that transport time from Hobart could be included in a two-day trip. Also, there appeared only to be few, if any, stretches of wooded habitat large enough to undertake long transects, like those in the Midlands. The Gladstone transects were undertaken only once, as the second day was utilised to undertake a reconnoiter on a neighbouring property, where not enough suitable habitat was found for daytime line transect surveys. However, both of these areas could potentially be surveyed by standardized spotlight surveys to gain an index of abundance. This option was examined by accompanying local shooters who pointed out where forester kangaroos are most abundant in the evenings (Appendix 5, Map 7).

6.4 Analysis

Estimates of kangaroo density may be obtained from a line transect count by modelling the decrease in frequency of sightings away from the transect line or observer using an appropriate line transect model. The Gates (1969) density function model (Fig. 4) was used to transform the forester kangaroo sightings into an estimate of population size within the core range. This model uses the average distance over which animals are seen during a survey to determine the width of the strip effectively surveyed along each transect. For example, in dense bush, animals are seen at closer distances on average, hence the effective transect width is narrower than in more open country.

$$N = \frac{A.m\ (2n-1)}{2LR}$$

N = number of forester kangaroos in area surveyed
A = area surveyed
m = mean mob size
n = number of mobs sighted
L = length of transects walked
R = mean radial sighting distance (km)

Figure 4 - Density function model used for analysis (Gates 1969).

Each year, an estimate of density was obtained, using the Gates (1969) model, for each of the daily counts done in a particular area. The mean of these daily estimates was used to estimate the size of each population, with standard error, for each year the surveys were undertaken. This estimate of population size was divided by the area surveyed to obtain an estimate of the number of kangaroos per square kilometre.

The percentage of yearlings in each population was also determined each year from the survey results.

The number of tags issued (representing forester kangaroos permitted to be culled) under Crop Protection Permits was determined for each core population each year. These are given as number culled per 100 square km.

Annual rainfall statistics for the period 1980-1999 were obtained for the Ross and Nile areas, and the period 1983-2000 for the Northeast study area. These statistics were obtained from Mount Morriston, Launceston Airport, and Swan Island Lighthouse weather stations, respectively.

Figures for population growth were determined by expressing estimates of population size logarithmically. The difference in successive log values represented the rate of growth of the population for that period.

For the Nile and Ross populations, relationships between the three variables (population growth, rainfall and culling levels) were examined using regression and correlation analyses. Insufficient data were available for the Northeast population for these analyses.

Regression analysis was used to examine the relationships between rainfall and numbers culled and rainfall and population growth (SAS Institute Inc. 1989). Time lags between occurrence and effect were examined by performing several different analyses using different time scales. Only the period 1980-1986 could be analysed in this way, as it was the only period in which information on population growth was available in consecutive years. The results for these analyses are presented in the form of the coefficient of determination, r^2. This is a measure of the proportion of the total variation in the dependent variable explicable by its linear relationship with the independent variable.

Correlation analysis was used to examine the relationships between numbers culled and population growth. This was undertaken in Microsoft Excel (Microsoft Corporation 1997). The results of these analyses are presented in the form of the Pearson correlation co-efficient (r).

6.5 Results

Estimates of population size, percentage of yearlings in the population, and numbers culled in the Nile and Ross forester kangaroo populations between 1980 and 1999 are given in Tables 1 and 2. Table 3 gives the same information for the Northeast between 1983 and 1999. Trends in population size (expressed as the number of animals per km^2), numbers culled per km^2 and rainfall are given in the accompanying graphs (Graphs 4-6). A comparison of the relative density of kangaroos in each population is given in Graph 7.

During 1999, most of the transects were sampled on three consecutive days, and the precision of population estimates obtained was high, with a coefficient of variation equal to approximately 7% at Nile and 8% at Ross indicating that population fluctuations of as little as 30% should be detectable (Caughley 1979). However, the coefficient of variation for the Northeast was much higher, at 18%. Southwell (1989) found that low density populations require more effort in sampling than high density populations, which may be the reason for the low precision for this area.

Table 1 - Estimates of population size, percentage of yearlings, and numbers culled in the Nile core area. "nd" indicates that no data is available.

Year	Population estimate	Standard error	Percentage yearlings	Number culled
1980	3161	141	32.9	525
1981	2694	342	29	280
1982	2177	179	34.3	355
1983	2205	99	35	325
1984	2272	339	30.4	305
1985	2310	62	34.9	245
1986	2686	125	26.6	252
1987	-	-	-	470
1988	3057	202	29	260
1989	-	-	-	305
1990	3121	174	31.1	310
1991	-	-	-	173
1992	2169	235	30.2	130
1993	-	-	-	130
1994	2733	211	31.5	nd
1995	-	-	-	nd
1996	-	-	-	nd
1997	-	-	-	109
1998	-	-	-	55
1999	4131	219	32.1	87

Table 2 - Estimates of population size, percentage of yearlings, and numbers culled in the Ross core area. "nd" indicates that no data is available

Year	Population estimate	Standard error	Percentage yearlings	Number culled
1980	6674	105	37	980
1981	6671	513	29.8	325
1982	6103	798	32.8	585
1983	3850	254	35.1	525
1984	4101	238	32.6	440
1985	4611	724	37.1	325
1986	4123	27	33	365
1987	-	-	-	415
1988	5464	450	33.6	305
1989	-	-	-	370
1990	4571	808	33.7	310
1991	-	-	-	145
1992	4712	739	31.6	30
1993	-	-	-	72
1994	4465	650	38.4	nd
1995	-	-	-	nd
1996	-	-	-	nd
1997	-	-	-	143
1998	-	-	-	125
1999	6785	285	33.6	84

Table 3 - Estimates of population size, percentage of yearlings, and numbers culled in the Northeast core area. "nd" indicates that no data is available.

Year	Population estimate	Standard error	Percentage yearlings	Number culled
1983	968	295.7	31.3	30
1984	1299	310.9	33.5	25
1985	1109	104	28	40
1986	1552	241.1	31	26
1987	-	-	-	117
1988	-	-	-	95
1989	-	-	-	95
1990	-	-	-	85
1991	-	-	-	50
1992	-	-	-	74
1993	1180	232.2	25.3	59
1994	-	-	-	nd
1995	-	-	-	nd
1996	-	-	-	nd
1997	-	-	-	60
1998	-	-	-	87
1999	351	42.2	28.8	70
2000	1153	139	36.3	61

Population Trends

Trends in population size are expressed as an index of relative abundance, rather than absolute abundance. This allows comparison between population numbers and trends within this study, but does not give actual numbers of kangaroos. Any changes in population size of more than 30% should be detectable due to the generally high precision of population estimates (Caughley 1979).

In broad terms, forester kangaroo populations in the Midlands areas of Nile and Ross show similar trends. In both populations there was a decline in numbers of around 40% between 1980 and 1983. Between 1983 and 1988, there was a steady increase in the Midlands populations, followed by a decrease of around 30% at Nile and 15% at Ross between 1988 and 1992. Between 1992 and 1999, forester numbers increased sharply in the Midlands area, with numbers restored to the level of 1980 in the Ross population, and exceeding those of 1980 (35% higher) in the Nile population.

In the Northeast, the population increased by 35% between 1983 (first year surveyed) and 1986. Since then, the population seems to have been relatively stable, except in 1999, when it appeared to be at 35% of the 1983 population. This is equivalent to about 4 foresters per km^2, compared with 32 at Ross and 39 at Nile. However, in 2000, the population was estimated at 14 foresters per km^2, which is comparable to the population numbers from the Northeast between 1983 and 1993. During this period, there has been a decline in the number of kangaroos observed outside of the National Park. In 2000, only three forester kangaroos were seen on private land compared with 196 in the National Park.

In 1999, two of the three additional areas surveyed (Campbell Town and Gladstone) had population densities estimated as approximately 16-19 forester kangaroos per $km^{2,}$ about half that of Nile (Graph 7). No animals were detected at Avoca where over the 30 km of transect was surveyed, suggesting that the population in this area is very sparse. However, forester kangaroos are known to occur in the area.

Culling levels

The number of kangaroos culled in the Nile and Ross areas each year showed very similar trends (r=0.9, $p<0.001$).

The number of tags given out under the crop protection permits issued in both Nile and Ross areas has declined dramatically since 1980. Over 500 tags were issued in 1980 for the Nile core area, whereas under 100 were issued in 1999, a reduction of 80%. Figures are similar for the Ross core area, where 980 tags were issued in 1980, compared with 84 in 1999, a reduction of 90%. Numbers of tags issued in the Northeast has remained relatively stable.

Population Trends versus Culling Levels and Rainfall

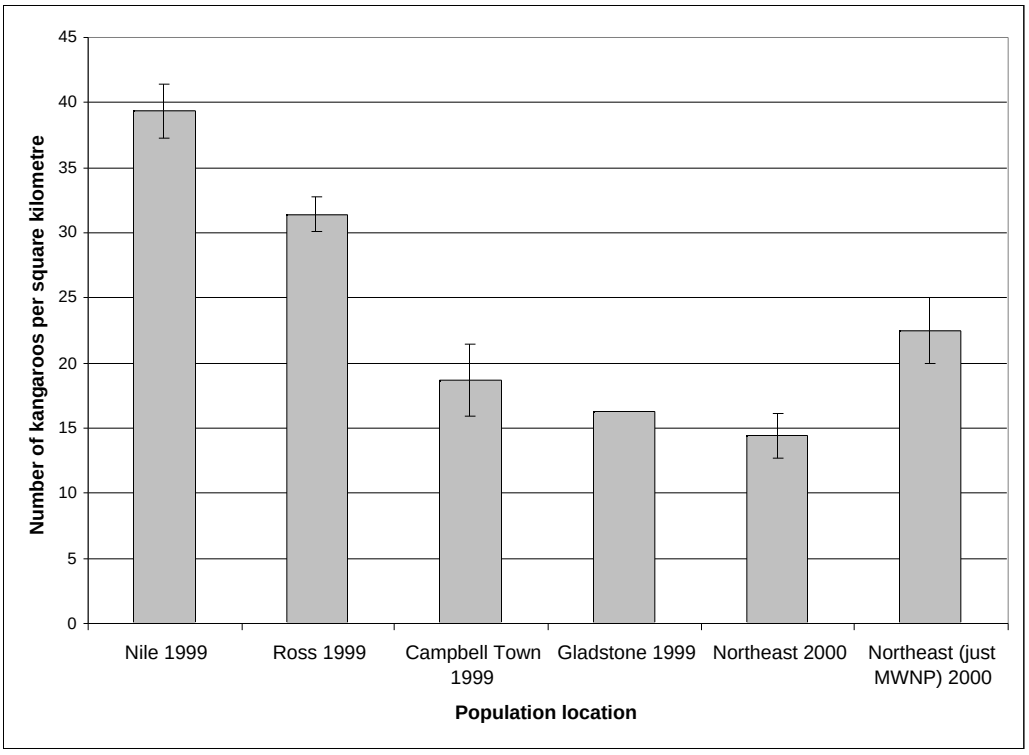
Between 1981 and 1986, population growth in the Nile and Ross populations was found to be associated with both culling levels and annual rainfall.

- As expected, population growth was negatively correlated with the number culled in the preceding year. For example, high culling levels in 1980 resulted in population decreases at Ross and Nile between 1981 and 1982. At Nile, this relationship was highly significant (r=0.88).

- Population growth was positively correlated with culling levels during the following years. This was particularly so at Nile, where an increase in culling followed both one year after an increase in population (r=0.81), and two years after (r=0.92).

- Culling levels were higher during years of low rainfall. Of particular note are the peaks in culling levels associated with the droughts of 1982/83 and 1987 (see Graphs 4 and 5).

- Rainfall was positively correlated with population growth in the following year. For example, a high rainfall in 1983 resulted in a population increase between 1984 and 1985. This trend was particularly strong at Ross (r^2=0.7, p<0.05).



Graph 7 - Kangaroos per square kilometre, 1999 - 2000. MWNP = Mt William National Park.

6.6 Discussion

Population Densities

Marked differences were observed in the relative density of forester kangaroo populations in different areas. The highest densities of 30-40 kangaroos per km^2 were observed in the core Midlands populations at Ross and Nile where densities were up to twice those in the Northeast and Gladstone study areas and higher than found in Mt William National Park (15-20 per km^2). This difference is attributed to the better grazing conditions available in the grassy forests and woodlands of the Midlands compared with the heathy forests and heathlands of northeastern Tasmania.

By comparison, Southwell et al. (1997) estimated the density of eastern grey kangaroos in the eastern highlands of northern New South Wales and Queensland to be approximately 5 per km^2. However, within this extensive area ground surveys of the type undertaken in Tasmania have revealed populations of eastern grey kangaroos with densities comparable to those found in Tasmania.

Population Trends

The survey results provide evidence of a recovery in forester kangaroo numbers in the Ross and Nile areas since 1992. This was associated with the policy of restricting culling levels, which applied from 1991 onwards. At Nile, this trend was likely to have been reinforced by the apprehension in 1994 of several poachers involved in the illegal taking of forester kangaroos.

In contrast, kangaroo numbers in the Northeast study area have remained fairly stable at approximately 14 foresters per km^2 between the early 1980s and 2000. The low estimate obtained during the 1999 survey of 4 foresters per km^2 is considered questionable and attributable to inexperienced observers rather than reduced kangaroo numbers.

The proportion of yearlings in the three core areas has remained remarkably constant, at around 30%, over the survey period. This contrasts markedly with the situation elsewhere in Australia where droughts have resulted in massive mortality among yearlings. For this reason, the Tasmanian forester kangaroo population does not undergo the large fluctuations in numbers which characterise kangaroo populations in drier parts of Australia (Hocking 1991). Most importantly, this lack of variation in the proportion of yearlings in the population suggests that breeding and survival of young are not significantly affected by rainfall.

Influences on Population Trends

Culling levels, have been identified as the major factor impacting on forester kangaroo population trends.

As expected, population growth was negatively correlated with the number of kangaroos culled in the preceding year. The population decline observed in the Midlands during the 1980s is attributed to high culling levels.

Culling levels, as measured by the number of tags distributed, in the Nile core area between 1980 and 1990 accounted for 12% of the estimated population during that period, whereas between 1990 and 1999, culling accounted for only about 3% of the estimated population. Between 1980 and 1990, culling levels for the Ross population accounted for about 7% of the estimated population, and between 1990 and 1999, culling accounted for only 2% of the

population. Research undertaken elsewhere in Australia indicates that culling levels of up to 20% are sustainable in grey kangaroo populations.

Culling levels were positively correlated with the level of population growth during the preceding year. Thus, landowners react to high levels of kangaroos by requesting more culling tags.

The level of culling was also influenced by rainfall. Although this relationship is not statistically significant, high numbers of permits were requested in years of below average rainfall. Low rainfall impacts on kangaroo populations in two ways, both of which increase the demand by farmers for culling:

1. Less native food is available, so that animals move from bush areas on to pasture in search of food.
2. Food available to stock is reduced, thereby increasing competition with kangaroos.

Changing land-use may mean that conflict with forester kangaroos may change. With the decline of the wool market, an intensification of farming in Tasmania can be expected. Increased use of land for cropping is likely to result in forester kangaroos being attracted to the high-value crops to feed, leading to more pressure to cull.

The level of poaching, although unknown, has been of concern for a number of years. The results of this study indicate that the amount of poaching is not currently so great as to produce a declining population. It appears that poaching may have a significant effect on population growth, however, as the population at Nile seems to have grown rapidly at some stage between the 1994 and 1999 surveys, coinciding with the apprehension of two poachers in 1997.

6.7 Summary

Forester kangaroo populations at Ross and Nile suffered a decrease during the 1980s and early 1990s, due to the high levels of culling which occurred in that period. These two populations have now recovered from the decline in numbers. The Northeast population has remained relatively stable over the survey period (1983-2000), excluding the survey results from 1999, which appear to be an anomaly. Numbers of kangaroos on private land in the Northeast study site, however, appear to be declining.

Forester kangaroo population growth has been determined by culling levels. Demand from farmers for culling is higher when kangaroo numbers are higher and during periods of low rainfall when competition with stock for feed is greater.

Although there was a significant relationship between rainfall and population growth, it appears that forester kangaroos in Tasmania are not especially susceptible to drought, as the number of yearlings has remained stable over the study period.

7 THREE HUMMOCK ISLAND AND RELATED ISSUES

7.1 Background

Forester kangaroos on Three Hummock Island

Approximately twelve forester kangaroos were introduced to Three Hummock Island, on the northwest coast of Tasmania, in 1975. The island is approximately 80 square km, and it is estimated that there are now 400-600 foresters on the island (R. Alliston, pers. comm. and S. Cronin, pers. comm.). Three Hummock Island has been a nature reserve since 1977, and is currently the focus for a modest ecotourism business "Three Hummock Island Escape", which brought 114 people to the island in 1999 and 123 in 2000.

A draft management plan for Three Hummock Island (Wilmott 1999) proposes that forester kangaroos be "removed" from the Island, in order to allow a more natural ecosystem to re-establish. The management plan does not detail the method for removal, but given that the cost of translocating these animals would be enormous, and translocation sites limited, it can be assumed that the proposal is to cull the animals.

Other than philosophical reasons, the main argument for removing forester kangaroos from Three Hummock Island is a concern that a similar situation may arise to that at Maria Island, as discussed below.

The situation at Maria Island

Between 1969 and 1971, 45 forester kangaroos were introduced to Maria Island. By 1985, the forester kangaroo population was estimated at 2000 animals. This corresponds to a rate of increase of 27% per annum, which is similar to the Maximum Rate of Increase calculated for the western grey kangaroo in Kinchega National Park (Bayliss 1985).

The population crashed during the autumn/winter of 1987, and there was a major public outcry over what was widely seen as negligence on the part of the PWS in allowing this situation to develop. Selective culling of sick and distressed animals was carried out in 1987, minimising both suffering to the affected animals, and concern to the public visiting the island, while allowing natural processes to operate on the population, as far as possible.

However, by 1991, numbers had built back up to 1987 levels. In 1993, a vegetation survey was undertaken, which found that browsing and grazing by macropods was having an unacceptable impact on vegetation, causing regeneration failure of many trees, shrubs and herbs in grassy forest and heathland communities, and erosion problems along the foreshore and watercourses (Hocking 1998). A long-term and sustained culling program was introduced in 1994, which aimed to reduce macropods to levels that did not cause significant damage to the vegetation of the Island. In the winter of 1994, 724 forester kangaroos were shot; less than 50% of the population. Since then, numbers shot have been much lower (338 in 1995; 37 in 1997; 267 in 1998; 25 in 1999 and 5 in 2000), but culling will need to be maintained so as to control damage by macropods.

7.2 Methods

A survey of the forester kangaroo population on Three Hummock Island was undertaken in October 1999. It proved impractical to obtain a population estimate, as much of the island is covered in dense scrub. The only easily traversable parts of the island are those with improved pasture or dune grasses and their associated communities. Two transect surveys were established through this habitat in order to obtain an index of density.

Transect 1 originated at the homestead, and followed a bearing of 15 degrees magnetic north to the secondary sand dune at the southwest end of West Telegraph Beach, where it changed direction, and ran parallel to the coast, ending at the beach (Map 7, Appendix 5). This transect was approximately 1.5 km in length. Transect 2 ran through a region known as Arizona Run, following the road, as marked on Map 7 (Appendix 5).

Another density index was taken by counting the forester kangaroos in the paddock between the two houses (marked on Map 7, Appendix 5) at dusk. This was done by standing in the middle of the paddock, just as it was almost too dark to see (7:30 pm in mid-October), and counting all kangaroos.

7.3 Results

On transect 1, 58 forester kangaroos were counted on day one, and 55 on day two. On transect 2, 21 forester kangaroos were counted on day one, and 20 on day two. The highest number recorded in the paddock, over five evenings of observation, was 93. Table 4 shows number of kangaroos counted in the paddock, and weather conditions during the counts. Any trends in numbers on the transects, and numbers counted in the paddock, in future years should reflect similar trends in the whole population, although this does depend on the attractiveness of the pasture compared with the bush.

Table 4 – Number of kangaroos recorded in the paddock at Three Hummock Island, and weather conditions during the counts.

Number of kangaroos	Weather conditions
84	Fine
69	Fine
30	Windy and wet
39	Windy and wet
93	Foggy

Anecdotal evidence suggests numbers are increasing, but any damage the forester kangaroos have caused to the vegetation is as yet undetectable, apart from some tracks up the stabilised secondary dunes, which are vegetated by marram grass. The methods used to gain an abundance index are simple and quick, and could be adopted by the residents on the island to undertake regular monitoring of numbers.

7.4 Discussion

A number of reasons have been put forward for eradicating the forester kangaroo population on Three Hummock Island. These include:

1. The introduction of forester kangaroos to the Three Hummock Island Nature Reserve was an unsound management decision at the time, and would certainly not be acceptable today, when nature reserves are viewed as natural environments with minimal human interference.

2. A situation similar to that at Maria Island may arise. That is, native vegetation could be damaged by pressure from large numbers of macropods, thereby threatening conservation values of the island. Furthermore, the sight of large numbers of dead and starving animals as a result of a boom-and-bust cycle may distress visitors to the island.

3. The forester kangaroo may provide competition for the Tasmanian pademelon, *Thylogale billardierii*, the only other macropod on the island. The pademelon is thought to have been re-introduced to the island in 1900 (Hope 1973), but this may have been a supplement to an elusive population that had not become extinct. Although it may not be the original population, the species is probably native to the island (Hope 1973). However, it is doubtful that the pademelon population is threatened by forester kangaroos, as pademelons have out-competed forester kangaroos at other sites where they occur together.

There are several arguments against eradication of the kangaroo population:

1. Although introduction of forester kangaroos to the island is now considered an unsound management decision, the population continues to serve its original purposes as a reserve population to be drawn upon if the Tasmanian populations were to decline, and to provide genetic diversity.

2. A situation comparable to that at Maria Island is unlikely to occur, because the vegetation utilised by foresters on Three Hummock Island is largely introduced pasture and marram grass, so that any damage to vegetation is unlikely to have a significant effect on the conservation values of the island. As yet, there is little sign of any damage to the vegetation, except on the stabilised secondary dunes where there are tracks through the marram grass, about 500 mm wide. There is no sign of any further erosion, such as dune blowouts, resulting from the tracks. The forester kangaroos appear to be in good health, and the improved pasture on the island is thriving, although it was seen at its best (in mid-spring).

3. There are few other places in Tasmania where forester kangaroos can be observed at such close quarters in the wild. It is a good opportunity for visitors to Tasmania, and even holidaying Tasmanians, to get a closer look at this Australian icon. Education of this sort is likely to lead to a better awareness and interest of conservation issues in general.

4. Most of the island is very densely vegetated, making eradication very difficult, time consuming and costly, particularly in terms of person-time. It must be considered that there may be higher priorities for utilising the time of those DPIWE staff capable of shooting foresters, such as removing feral cats, goats, pigs and rabbits from other areas in Tasmania.

5. Since sheep were removed from the island in 1998, forester kangaroos have played an essential role in keeping the improved pasture under control, which dramatically reduces the risk of wildfire. Wildfire is a major issue for both the heritage values of the area, and the environmental values.

6. The proposal to eradicate forester kangaroos from Three Hummock Island is likely to be met with opposition from conservation groups and individuals, and may also be viewed unfavourably by the general public. Unless there is proof that there are adverse effects on the conservation values of the island, it is unlikely that these concerns will be allayed.

8 RECOMMENDATIONS FOR MANAGEMENT OF FORESTER KANGAROOS IN TASMANIA

8.1 Monitoring program

Monitoring population trends in the three core populations is vital to help the DPIWE to decide upon appropriate management regimes for the forester kangaroo. At present, in years when the long-term surveys are run, at least 27 person-days are spent undertaking field work (3 people spending 3 days in each of 3 regions), and at least 6 person-days are spent preparing for the field trips and analysing the data. This is a significant outlay of time, and it can be difficult to find people to participate in surveys. These large demands on resources have resulted in a five-year gap between the last surveys and those undertaken in 1999. It is therefore recommended that only one of the three areas is monitored each year, rotating areas so that each one is monitored every three years.

In addition to the Campbell Town area, two more areas could be established and monitored regularly to form a more comprehensive coverage of the forester kangaroo range. This would mean that instead of using single spotlight counts to decide how many permits to provide (which tends to be unreliable), the DPIWE would have a better idea of trends and status of populations in each area, on which a more well-founded decision could be based. However, areas that are unsuitable for transects, such as some properties in the Gladstone area, could possibly be monitored for trends in forester population using more intensive standardised spotlight counts.

To improve repeatability of the surveys in future years, starting times and directions travelled should be more standardised than they are at present, so that time of day has a smaller effect on counts. Beginning in 1999, accurate bearings are now recorded so that in the future, a perpendicular model can be used to gain less biased estimates. The data will also continue be analysed with a radial model to compare pre-1999 trends with post-1999 trends.

8.2 Culling program

It is recommended that an annual quota of tags be supplied to each landowner who requests a permit. Landowners will have 6 months to use tags. The number of tags distributed will be based on the number allocated to that property in recent years, adjusted for any trends shown by the field surveys. The total number of tags for a region will not exceed 10% of the population estimated for that region. This will result in faster issuing of permits to landowners, although number of tags distributed will not necessarily increase. If additional tags are required throughout the year, they may be applied for, and provided on the basis of a property inspection including a spotlight survey, as currently occurs.

Landowners with Property Based Game Management Plans will have tags issued for a 12 month period, to fit in with their permits for culling other animals such as deer and wallaby. This may encourage landowners to develop Property Based Game Management Plans with the DPIWE, which will allow more support and advice to reach these landowners, providing more opportunity for education on avoiding problems with forester kangaroos.

These three changes (making the process faster, co-ordinating forester kangaroo permits with other permits, and allowing more time for tags to be utilised) should satisfy the needs of most

landowners who responded to the questionnaire without compromising the responsibility of the agency to protect the species.

8.3 Management in the Midlands

All forester kangaroos in this region occur on privately owned land. To conserve the population, a balance must be maintained between the conservation requirements of the population, and reducing the problems that the forester kangaroos cause on private property. To be successful with this, it is crucial for the DPIWE, to form and maintain co-operative relationships with those landowners with forester kangaroos on their properties. Most landowners appear to be interested in the welfare of this species, and it is of utmost importance that landowners are encouraged and provided with advice and support regarding alternative ways to deal with forester problems. One way to do this is to continue to develop Property Based Game Management Plans for properties in this region.

8.4 Management in the Northeast

The long-term survival of the forester kangaroo in the Northeast outside the Mount William National Park was predicted by Wapstra (1976) to be doubtful, due to the expected continuation of land clearing. Wapstra (1976) asserted that this was likely to result in further fragmentation of populations, possibly resulting in non-viable population levels. Unfortunately, this prediction appears to have become reality at least for the private land surveyed during this project. During two days of surveying the area in 1999, no forester kangaroos were seen on the private properties adjacent to the park, which form a substantial part of the transects. Only 3 foresters were seen in this area in 2000. This may partly be due to the fragmentation of one of these properties, resulting in further clearing of refuges in the area.

Overall, however, numbers within the area surveyed have remained relatively stable in the last 18 years, although there appeared to be a serious decrease in 1999, followed by a return to normal levels in 2000. The density of kangaroos in the Northeast is considerably lower than in the Midlands populations, and by no means could the Northeast population be said to be thriving. This could be partly due to the decline of the improved pasture in the national park, which has not been fertilized since the late 1980s.

The national park has significant value in that it provides long term security of habitat, though its significance in terms of numbers carried is at present limited. It is not appropriate for the pasture improvement program to be reinstated, as this would not be in accordance with the agency's policy of discouraging exotic species in National Parks. Thus, fire management remains an important aspect of management of the national park, as fire encourages regeneration of grasses, which provide food for forester kangaroos. An area of 4 600 ha was burnt patchily in 1996 and 1997. The northern end of the national park is one of the next areas to be burnt, which should be beneficial to the kangaroos, as they inhabit this area in preference to the rest of the park.

8.5 Three Hummock Island

In order to decide whether or not forester kangaroos should be removed from the island, further research needs to be undertaken. The vegetation on the island should be regularly monitored to enable adverse changes to be detected before any damage becomes irreversible, and the forester kangaroo population should be monitored for health and trends in numbers. If substantial adverse effects are caused by an excess of forester kangaroos, it may be appropriate to eradicate the species from Three Hummock Island, or initiate a long-term culling program similar to that at Maria Island. Adverse effects may include damage to native flora; erosion of dunes/soils; threatening the Tasmanian pademelon population; and creating a boom-and-bust cycle, resulting occasionally in large numbers of dead forester kangaroos, which may distress visitors to the island.

8.6 Looking to the future

Recently, the DPIWE and the Midlands Bushweb Project have proposed the introduction of a "Wildlife Credits Fund Project". This project would be an incentive scheme for private land managers for the conservation of native wildlife. The scheme would work by allowing the ecosystem services that wildlife provides to be given an economic value, which would raise the status of wildlife from an economic threat to an economic benefit. Essentially, landowners would be financially supported in managing their land for the conservation of wildlife. This financial support could come from: higher premiums for fauna-friendly products; wildlife credits (similar to carbon credits); sponsorship; and/or eco-tourism. The proposal is currently under consideration for funding, and a prospectus is being developed. This project could possibly have major implications for the conservation of forester kangaroos in the future.

9 RECOMMENDATIONS IN SUMMARY

9.1 Monitoring

1. Monitoring of the core populations in the Ross, Nile and Northeast regions using transect surveys should continue, with at least one core region monitored per year.

2. In addition to the Campbell Town transects, two further study areas should be established, in order to get a better idea of trends in a broader area. One of these additional study areas should be in the Northeast, where spotlighting could be substituted for transect surveys. One non-core region should be surveyed each year, beginning with the Northeast in the year 2000.

3. The current field survey methods should be maintained in order to obtain population trends, rather than altering the method in order to get more accurate numbers. However, bearings (between the transect and the kangaroo) should be recorded accurately so that a perpendicular model can be used to estimate trends in the future.

4. Start times and points should be standardised to minimise the effects of time of day on numbers of foresters counted.

5. Standardised spotlight counts of forester kangaroos should be investigated at "Cape Portland" and "Rushy Lagoon", and undertaken annually until trends become evident.

9.2 Culling program

6. An annual quota of tags will be distributed to those landowners who apply for permits. The number of tags will be based on numbers given in previous years, and will depend on trends as understood from transect surveys. Total number of tags distributed in each region will not exceed 10% of the estimated total population in that region. Those landowners with a Property Based Game Management Plan will be given permits valid for twelve months in conjunction with other permits.

7. Additional tags beyond quota can be applied for, and will be considered. The decision will be based on spotlight surveys of the property conducted on application for additional tags.

8. Education and support should be offered to landowners with regard to preventing conflict with forester kangaroos, especially those landowners who plan to convert more pasture to crops.

9.3 Mt William National Park and Northeast

9. The northern section of Mt William National Park should be subjected to a regeneration burn.

10. Enforcement activities aimed at minimising illegal taking of forester kangaroos should be increased in the Northeast.

9.4 Three Hummock Island

11. Vegetation monitoring should be undertaken on Three Hummock Island in order to ascertain what the forester kangaroo impacts are.

12. An annual forester count could be undertaken by the lessees on Three Hummock Island, with their agreement. This count would be undertaken in the paddock, as described in the methods section, taking the maximum number over five or more evenings.

13. If impacts of forester kangaroos on Three Hummock Island are found to threaten conservation values of the island, culling or eradication should be considered.

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Appendix 1 - QUESTIONNAIRE

Your Details (This section is optional. Confidentiality is assured)

1. Name:.....

2. If you are interested in being further involved, please provide your phone number:..... ☐ I would be happy to be contacted by the Project Officer
   ☐ Please send me results of the questionnaire

3. Employment category (please tick all applicable boxes for this question)

☐ Owner ☐ Farm Manager ☐ Other.....

4. Do you live on the property?

☐ Yes ☐ No ☐ Other.....

Property Details

(When showing areas, please show whether **hectares** or **acres** are used.)

5. Property name (optional):.....

6. Nearest Town:.....

7. Total size of the property:.....

8. What do you farm?.....

9. How much of your holding is either permanent pasture or cropping land?.....

10. How much of your holding is either run country or unimproved pasture?.....

11. How much of your holding is normally in crop?.....

12. Is your property covered by a Property-based Game Management Plan?

☐ Yes ☐ No

Forester kangaroos on this property

13. How many years have you been at this property?

☐ less than 2 yrs ☐ 2-5 yrs ☐ 6-10 yrs ☐ 11-20 yrs ☐ over 20 yrs

14. Since you have been at this property, have Foresters been present at any time?

☐ Yes ☐ No (If "No", please go to question **28** [last question])

15. Since you have been at this property have numbers of Forester kangaroos:

☐ Stayed the same ☐ Decreased ☐ Increased ☐ I don't know

16. How many Forester kangaroos do you estimate are **now** on this property?

☐ None ☐ Less than 20 ☐ 20-100 ☐ 100-200 ☐ 200-500 ☐ 500-1000 ☐ over 1000

If you can, please provide a more accurate figure.....

Recent Changes

17. In the **last 5 years**, has the number of Forester kangaroos on this property:

☐ Decreased (go to **18**) ☐ Increased (go to **19**) ☐ Stayed the same (go to **20**)
☐ I don't know (go to **20**) ☐ No Foresters (go to **28**)

18. If the number has **decreased**, how much of the population present 5 years ago **still remains**?

☐ Under 50% ☐ over 50% Go to question **20**

19. If the number has **increased**, how much has it increased by?

☐ Under 50% ☐ 50 - 100% ☐ Over 100%

Your views on Forester kangaroos

20. How do you feel about having Forester Kangaroos on this property
.....

21. If Forester kangaroos cause damage, what do they do?
.....

22. If **any wildlife** causes damage on your property (or would cause damage if not managed), what do you think this would cost each year?

☐ Less than $100 ☐ $100-500 ☐ $500-1000 ☐ over $1000 ☐ Other.....

23. What percentage of this do you think is caused by Forester kangaroos?
☐ 100% ☐ 80% ☐ 60%☐ 40%☐ 20%☐ 0 - 20% ☐ 0%

24. Is damage caused by Foresters a significant property management issue for you?
☐ Yes ☐ No (go to **27**)

25. What are you currently doing to manage Forester kangaroos?
.....
.....

26. Is this effective?

☐ Yes ☐ No ☐ Other.....
Comments.....

27. Of the Foresters on your property, what percentage would be acceptable?

☐ 100% ☐ 80% ☐ 60% ☐ 40% ☐ 20% ☐ less than 20%

28. In what ways would you like to see Forester kangaroos managed and conserved in the future?

Your time and comments are gratefully appreciated. If you would like to make any comments about the questionnaire, Forester kangaroos or wildlife in general, please attach them to the questionnaire.

Appendix 3 – LANDOWNERS' COMMENTS FOR MANAGEMENT AND CONSERVATION OF FORESTER KANGAROOS IN THE FUTURE

There were 92 comments in total, which have been summarised into 38 categories. The number of comments within each category is noted.

- Similar protection as presently occurs, with selected culling when forester kangaroos are causing unacceptable levels of damage. 22.
- Controlled/protected on Crown Land / National Parks. 13.
- Have a sustainable number of forester kangaroos. 9.
- Controlled/protected on unimproved grazing land/bush. 7.
- Prevent numbers/range from increasing. 6.
- Use Property Based Game Management Plans to manage forester kangaroos. 5.
- Supplement populations. 5.
- Landowners should be compensated for the expense. 5.
- Meat and hides processed. 4.
- Neighbours should keep forester kangaroos at acceptable numbers. 3.
- Landowners should decide when to cull. 3.
- Cull forester kangaroos at Mt William National Park. 3.
- Bennetts wallabies, Tasmanian pademelons (rufous wallabies) and possums should be culled to allow more feed to be eaten by forester kangaroos. 2.
- More controls to stop poaching. 2.
- Set up a state reserve / game park to protect them. 2.
- Develop the pasture at Mt William National Park. 2.
- Burn Mt William National Park / other areas to promote new growth. 2.
- Reduce other pests on private land / national parks so that there is less total impact. 2.
- Regular (annual/biennial) culling. 2.
- Reduce Numbers. 2.
- 100% protection. 2.

- Advice from DPIWE. 2.
- Leave them as they are. 1.
- Licensed farming. 1.
- Improve fencing to keep them out of pasture. 1.
- Prevent forester kangaroos from being subjected to mass culling. 1.
- Retain more native grassland. 1.
- DPIWE assist in control of numbers. 1.
- Discussion with DPIWE on one-to-one basis or in small groups. 1.
- Sponsor pride in landowners who have forester kangaroos. 1.
- Make more landowners aware of Land For Wildlife. 1.
- Culled by Field and Game shooters. 1.
- Breeding program. 1.
- Tighter control over shooting. 1.
- Crop protection permits needs to be workable/easy to obtain so people are not forced to do the wrong thing. 1.
- Educate public to take an interest in conservation. 1.
- Use DPIWE money for disease control of livestock. 1.
- Should be confined to areas that have traditionally been their habitat. 1.

Appendix 4 - EVALUATION OF METHODS USED IN FIELD SURVEY

Appropriate Measure of Abundance

There are three ways in which abundance can be measured (Southwell 1989):

1. As population size. This measure has a biological meaning only when the population has a distinct boundary.
2. As absolute density (the number of animals per unit area).
3. As a density index. i.e., some measurable correlate of absolute density.

The accuracy of the surveys in this study, in estimating an absolute density, is open to question. Differential visibility (eg depending on mob size) as well as other potential biases mean that estimates of absolute density should be used with caution. Other studies using this method of survey suggest that an accuracy of around 30% can be expected (Southwell 1989).

Provided an appropriate index is used, relative indices of densities can be just as effective as measurements of absolute density in monitoring abundance (Southwell 1989). A density index is appropriate for this study, as population trends are just as useful as absolute densities for making sound management decisions. Since relative indices are far cheaper and easier to obtain (Southwell 1989), use of absolute estimates for monitoring would be wasteful of time and resources. Even though measurement of absolute density may be desirable (e.g. for comparing densities to populations on the mainland of Australia), it is not beneficial enough to justify the cost.

The data from this study could not be used to obtain absolute densities, because the method used does not meet the assumptions of line transect surveys closely enough. However, failing these assumptions does not invalidate estimation of a density *index*. As long as the method remains constant between surveys, the counts will still provide a valid density index for population monitoring (Southwell 1989).

Line Transect Assumptions

The three main assumptions for line transects are as follows:

1. Animals on the line must never be missed (it is not of concern if all animals are not seen, as long as those directly on the line are seen).
2. Animals must not move large distances away from or toward the transect line before being sighted, and animals must not be counted twice.
3. Distances and angles must be measured accurately.

Kangaroos are not likely to move far before being seen if within the observer's visual field. However, they are highly mobile and tend to avoid approaching humans, so that there is a high possibility of undetected movement beyond the observer's visual field, consequently resulting in the violation of the first two assumptions. The failure of these two assumptions is exaggerated by the method used in this study, because rather than walking 1 km per hour as has been suggested (Southwell et al. 1997), we walked at the faster speed of 3-4 km per hour, which means that it is likely that more noise is made, flushing the animals before they are seen, and less animals are likely to be seen, as more effort is required to navigate obstacles. The distances walked in our survey were also a possible cause for failure of all assumptions, due to tiredness (differential between observers) towards the end of the transect, making observations less likely and measurements less accurate. Through a pilot study, Southwell et al. (1995) found that a

maximum of 10 km of transect could be walked consistently in a day, considering day length, ease of walking, time getting to and from a base to transects, speaking to landholders, and the cumulative fatigue of walking transects over several consecutive days. However, the route could be up to 5 km from vehicular access, meaning an extra 10 km would be walked.

As densities of kangaroos increase beyond 30 kangaroos per km^2, a density dependent negative bias is increasingly evident as the result of movement by animals in response to surveyors (Southwell et al. 1995). The relatively low density of forester kangaroos in most areas in Tasmania means that the flushing of one animal/cluster is unlikely to cause flushing of others (chain flushing). Also, macropods tend to move away from the transect line at obtuse rather than acute angles, thus reducing duplicate sightings (Southwell 1994). However, in the core region at Nile, animals could be as abundant as 39 kangaroos per km^2, which implies that there could be a density dependent negative bias due to chain flushing. However, numbers may not be this large, as the model used (Gates 1969) model is positively biased by about 30% (C. Southwell, pers. comm.).

Reactive movement can also lead to violation of the assumption relating to accuracy of distances and angles. However, this is not such a problem in the areas studied here, as there are many landmarks so that if an animal is flushed, distances and angles can be taken from a stationary object nearby the original position, such as a tree.

Repeatability and Precision

Accuracy is not an essential quality of an abundance index, but repeatability and precision are more important (Southwell 1989). Repeatability depends on the variations in the conditions of counting, and precision is related to random errors associated with sampling. If the sampling effort is inadequate, then abundance estimates will be imprecise and inferences about the population can not be made with confidence (Southwell 1989).

Many factors are known to affect counts of macropods, including time of day, temperature, cloud cover and vegetation density. Because so many factors affect countability, it is difficult to determine how repeatable counts of macropods are. Sightability is most affected by time of day, and possibly weather, through feeding and resting activities and related habitat use (Southwell et al. 1995). During the middle of the day, macropods generally rest, whereas in wet weather, macropods extend their feeding activity through the midday period (Southwell et al. 1995). The effects of many factors of countability can be negated by strict standardization of counting procedures, but some factors are beyond control. Lighting and weather conditions can change within days and between days, and the ability to standardize for such variables is limited, especially in climates like Tasmania's. It is sensible to standardize within limits and then ignore variation beyond these limits. In future years, starting times and directions travelled should be more standardised than they are at present, so that time of day has a smaller effect on counts. Unfortunately, there is no practical solution to standardising weather conditions.

Ideally, one attempts to obtain a very precise estimate of abundance (very low coefficient of variation) so that real trends are not masked by large sampling errors. However, this usually requires a very large effort in counting, and a reasonable compromise between precision and effort must be met. The effort required to obtain an estimate of specified precision is the sampling intensity. During this study, the transects were usually repeated three times, and the precision of population estimates obtained was high, with a coefficient of variation equal to

approximately 7% at Nile and 8% at Ross indicating that population fluctuations of as little as 30% should be detectable. However, the coefficient of variation for the Northeast is much higher, at 18%. Southwell (1989) found that low density populations require more effort in sampling than high density populations, which may be the reason for the low precision for this region.

Placement of Transects and Stratification

One of the most important aspects in the design of a transect survey is the placement of transects within the survey area. Strict random placement is ideal theoretically, but impractical logistically. The overriding practical principle for unbiased sampling is that the distribution of transects is independent of the distribution of animals being surveyed. The transects for this study were placed systematically. Because they are parallel and equally spaced, the design is unbiased (Southwell 1989).

Another important part of survey design is stratification. If the distribution of animals in a survey area is clumped, the most precise estimate of density is obtained by dividing the area into strata within which distribution is homogeneous and combining densities measured separately in each strata (Southwell 1989). However, this is not as important for a density index, as long as the strata remain constant. It does become a problem in determining a density index if the strata are altered from one year to the next, preventing repeatability. For example, if a large area of woodland is cleared, or some forest is burnt, visibility will be altered, and a greater proportion of the population will be sighted.

Estimators

To obtain an estimate of density from the data provided by the survey, one must have a model or estimator relating the data to true density. There are two types of estimators: radial and perpendicular. Radial models merely require the shortest distance between the animal and observer, whereas for perpendicular models, bearings and radial distances are used to obtain perpendicular distances. During this study, until 1999, bearings were grouped into three levels, rather than being recorded accurately (ungrouped). Thus, it is not possible to transform the radial distances into perpendicular distances, so a radial model must be used. The Gates (1969) model has been used to obtain estimates of density for this study. Southwell (1994) found this model to be the most biased (positively) of all models, radial and perpendicular. Thus, population estimates in this study are likely to be overestimated, unless a negative bias has outweighed the positive bias. Beginning in 1999, accurate bearings are now recorded so that in the future, a perpendicular model can be used to gain less biased estimates. The data will also continue be analysed with a radial model to compare pre-1999 trends with post-1999 trends.

Analytical Unit

Because forester kangaroos aggregate into mobs, to ensure correct estimation of variance, the cluster should theoretically be the unit of measurement and analysis (Southwell and Weaver 1993). Density is then calculated as the product of cluster density and mean cluster size. A disadvantage of using clusters as the analytical unit is that the number of clusters detected will

estimation of density. Thus Southwell and Weaver (1993) prefer to use individuals as the basis of analysis, despite their aggregating into clusters, and risk unreliable estimation of variance.

Because this model assumes a non-clumped distribution of animals and forester kangaroos are clumped into mobs, calculations have been based on mobs, rather than individuals. Southwell and Weaver (1993) point out that it is difficult to obtain perpendicular distances for individual animals within a cluster (i.e. mob) in the wild, as animals tend to flush when sighted.