The Distribution and Abundance of Fallow Deer in the Central Plateau Conservation Area and Adjacent Areas in Tasmania

A Baseline Monitoring Program

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Nature Conservation Report 07/02

Department of
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Executive Summary

Fallow deer (*Dama dama*) occur in the central highlands of Tasmania including areas that are adjacent to the World Heritage listed Central Plateau Conservation Area (hereafter CPCA). Reports of fallow deer sightings made by recreational users of the reserve as well as observations made by Parks and Wildlife Service staff, Inland Fisheries Service staff and land managers suggest that fallow deer in these areas have increased in abundance and that they have expanded their range to include parts of the CPCA.

The primary aim of the project was to establish baseline information regarding the distribution and abundance of fallow deer in the CPCA and adjacent areas. The baseline survey used reported sightings of fallow deer and ground searches for fallow deer sign to determine fallow deer distribution. Spotlight counts, an aerial count and pellet group standing crop density indices were used to measure fallow deer relative abundance at selected sites within and adjacent to the CPCA

Established fallow deer populations exist in several areas adjacent to the CPCA, particularly around Liawenee and north-west of Bronte Park. Fallow deer also occur within the CPCA at least on a seasonal basis in the area known as the Nineteen Lagoons and along the Pine River and Nive River valleys. Management options were investigated and evaluated in the light of the results of the baseline surveys. Recommendations include:

1. A report register for fallow deer sightings be established and maintained by by the Parks and Wildlife Service;
2. Surveys to be repeated in 3-5 years to measure any changes in distribution or abundance over time.

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1. Introduction

1.1. Fallow Deer

1.1.1. Evolution and classification

Members of the order Artiodactyla (even-toed ungulates) represent one of the most successful groups of large mammals. Along with other families of this order, the Cervidae (deer, elk, moose, and caribou) evolved during the Miocene (Harrington 1985). Fallow deer (*Dama dama*) are believed to have evolved in the Mediterranean region of Europe, the Middle East and Asia Minor. The species *Dama dama* consists of two sub-species; European fallow deer (*Dama dama dama*) and Persian fallow deer (*Dama dama mesopotamica*). The Persian fallow deer is 35-40% heavier than the European form and its antlers have palms near the base as opposed to palms at the distal end like those that occur in the European fallow deer (Chapman and Chapman 1997). Fossil evidence suggests that the two sub-species evolved from the same stock and that they once occupied overlapping ranges in the Middle East (Chapman and Chapman 1980). Recently, some taxonomists (e.g. Myers *et al.* 2005) have regarded the two sub-species as separate species (*Dama dama* and *Dama mesopotamica).* However the International Union for the Conservation of Nature and Natural Resources (IUCN) currently recognises the two forms as sub-species.

1.1.2. Ecology

<u>Habitat Selection</u>

Fallow deer occur in a wide variety of habitats throughout their distribution around the world including temperate forest, tropical seasonal forest, grassland, woodland and savannah (Chapman and Chapman 1980). In New Zealand fallow deer predominantly inhabit valley sides and river flats but commonly move to higher elevations above the tree line in spring, (D.M. Forsyth, Arthur Rylah Institute for Environmental Research, Victoria, pers. comm. 2005; Wodzicki 1950). When describing habitat use by fallow deer in Britain, Thirgood (1995) reports that fallow deer populations will substitute a habitat in one area for a different habitat in another area provided it offers the same effective resources.

<u>Diet</u>

Fallow deer are ruminants, which means they have a four-chambered stomach for bacterial fermentation of food. Being predominantly grazing animals, fallow deer prefer a mosaic pattern of open areas for feeding interspersed with scrub, forest or woodland for cover (Chapman and Chapman 1997). They prefer sweet, soft grasses, coarser species such as rushes and sedges being mostly avoided (Wodzicki 1950). Although most of the diet of the fallow deer is obtained through grazing, they may include browsed material such as new shoots, soft bark, seed heads, flowers and leaves. The proportion of material obtained through each mode of feeding depends on habitat and often varies temporally and spatially (Chapman and Chapman 1997). Duncan (1987) found that introduced grasses such as *Holcus lanatus* and *Vulpia* spp. as well as the native *Danthonia* spp. and *Poa* spp. made up the majority of the diet of fallow deer in Tasmania's Midlands. In New Zealand they readily graze introduced pasture species and also occur in native forest where grasses are relatively scarce (Davidson and Nugent 1990).

Rumen content analysis conducted on animals taken in New South Wales found that the proportion of grazed material varied from 99% in animals taken from agricultural land to 66% in animals taken from more densely wooded areas where diets were supplemented with browsed native vegetation (Calleja 2001). A similar study of deer shot in the Blue Mountains of New Zealand suggest fallow deer in native forested habitats there feed on a wide variety of plants (Wodzicki 1950).

Social Organisation and Behaviour

Fallow deer are gregarious, forming groups that often vary in size seasonally and geographically. Seasonal variation in group size has been observed in fallow deer herds in Britain (Chapman and Chapman 1997). Females (does) and their current offspring (fawns) and sub-adult followers (yearlings) form groups known as doe herds while the mature males (bucks) form bachelor groups. For a considerable part of the year the doe herds live separately from the bachelor groups with the two groups coming together for the autumn rut. While this pattern of social organisation is perhaps the general rule, fallow deer display great social plasticity and the pattern can vary from place to place and seasonally (Chapman and Chapman 1997; Statham and Statham 1996; Vincent 2001).

According to Vincent (2001) fallow deer display a crepuscular pattern of grazing with peaks of activity during dusk and dawn. Chapman and Chapman (1997) describe situations where fallow deer herds display diurnal behaviour, where they are active during the day as well as other situations where the deer display nocturnal behaviour with most activity occurring after dark. This variation in behaviour is evident between populations of fallow deer in different areas, but can also occur in a population in response to disturbance or availability of resources (Chapman and Chapman 1997; Statham and Statham 1996).

Reproduction

Fallow deer have an annual breeding season. The period when fallow deer are fertile and able to conceive is longer than the period of heightened sexual activity known as the rut, which occurs during April in Tasmania. Females can cycle up to seven times during the breeding season. However, if sufficient males are available they usually conceive during the first cycle during the rut. Gestation is 230 ± 4 days and most births in Tasmania occur during December/January (Griffiths and Campbell 1993).

The mating strategies of fallow deer can vary from non-territorial to different levels of territorial behaviour in males (Vincent 2001). Langbein and Thirgood (1990) described seven broad categories of mating behaviour in fallow deer some of which include harems, dominance groups, stands, temporary stands and leks. Population density and habitat structure were identified as the main factors in determining which mating strategies were adopted.

Home Range and Dispersal

Chapman and Chapman (1997) describe a home range as the area to which an individual animal confines itself during the course of its day to day activities. According to Litvaitis *et al.* (1994) habitat structure, competition, social factors and distribution of food and cover play important roles in determining an individual's home range size and shape.

Mature female fallow deer usually have a single home range smaller than that of mature males and tend to favour areas providing feed and cover. Male fallow deer have at least two seasonal home ranges; one during the rut when they join with the female groups and one for the remainder of the season when they form bachelor groups. According to Chapman and Chapman (1997) it may be more useful to consider the concept of lifetime range for a male fallow deer which would include seasonal home ranges, excursions for mating and routes of movement.

Seasonal influences may also play a role in defining the home ranges of fallow deer. In New Zealand there appears to be a tendency for fallow deer to inhabit valley sides and river flats during the colder months but to move to higher, more exposed habitats during the warmer periods (Forsyth, D.M. Arthur Rylah Institute for Environmental Research, Victoria, pers. comm. 2005; Wodzicki 1950). This movement in response to seasonal conditions is perhaps to take advantage of a food resource and represents a temporal variation in home range.

In Tasmania, Statham and Statham (1996) found that fallow deer had home ranges of 870 ha for males and 590 ha for females representing larger home ranges than reported in other countries like Britain where home ranges are often under 100 ha (Chapman and Chapman 1997). In New Zealand, Nugent (1994) found that fallow deer occupy relatively small home ranges (66ha for females and 189ha for males) and sub-adult female dispersion appeared to take the form of a range extension rather than a discrete whole range shift. Adult female dispersion was almost non-existent. In contrast most sub-adult males shifted their range but the distances between range centres was always less than 2.6km. Given that the density of the study population was high, Nugent (1994) argues that this suggests a relatively slow rate of natural dispersal for fallow deer and makes them easier to control than other deer species in New Zealand.

1.1.3. Impacts on natural and agricultural environments

Populations of fallow deer are thought by some people to have a considerable negative impact on ecological communities, primary production and sometimes public safety (Chapman and Chapman 1997; Moore *et al.* 1999). Others argue that there is insufficient evidence to conclude that they have any significant negative impacts and that they would be better viewed as a resource to be managed sustainably for human benefit (Caughley 1983). While some of the popular ideas regarding the impacts of fallow deer are explored briefly, it is not within the aims of this report to draw conclusions about the impacts of fallow deer except to say that it seems further research is required in this area in Australia.

<u>Ecological Impact</u>

In Illinios, USA, fallow deer caused a distinct browse line by denuding leafy vegetation below 1.5m high. Worn trails and some stream bank erosion, thought to be caused by the deer's habitual movements were also observed (Gray 1983). It has been suggested that deer can change the floristic composition of a community by targeting palatable species thereby favouring non-palatable species. In a New Zealand study, Nugent (1990) claimed that regeneration of sub-canopy broadleaf species was minimal while fallow deer densities remained at or above 0.1 deer ha^{-1}. Wodzicki (1950) suggested the ecological impact of high concentrations of fallow deer in the Blue Mountains of New Zealand was considerable but would require more investigation. Smale *et al*. (1995) recommended that a major reduction in the fallow deer population at South Kaipara Spit in New Zealand should be a conservation priority to allow natural ecosystem succession to occur.

The parallel expansion of eutherian ruminants (such as deer) and the macropods (kangaroos and wallabies) occurred at the same time as the development of widespread grasslands during the Miocene and Pliocene. This required both groups to develop adaptations for digesting structural carbohydrates like cellulose and hemicellulose (Hume 1982). In Australia macropods occupy the same ecological niche that would be occupied in part by deer on other continents. It may be reasonable to suggest that in Australia where deer populations are present in natural environments they may represent some degree of competition with macropods. However, the nature and degree of the competition is largely unknown.

Duncan (1987) investigated the diets of fallow deer and forester kangaroos in Tasmania's Midlands. The study found that both species ate grasses and that fallow deer ate more shrub species than the kangaroos. The study also found that the overlap of deer and kangaroo diets is greatest during winter when food is most scarce. Further research is required before accurate conclusions could be drawn and at this stage any effect fallow deer have on native herbivores remains speculative.

The view that deer cause harm to Australian ecological communities is evidenced by the fact that degradation, herbivory and habitat loss caused by deer species has been nominated for listing as threatening processes under the threatened species legislation of both Victoria and New South Wales. While the New South Wales nomination was successful, in the case of Victoria, the nomination was rejected by the Scientific Advisory Committee on the basis that it lacked credible scientific evidence supporting the claims of deer impacts. This disparity in the status of deer between States reflects the current range of views and the lack of scientific knowledge on the ecological impacts of deer in Australia. Finally, the Bureau of Rural Sciences (Hart 2002) did not even list deer as a 'minor or non-pest' in a review of pest animal management in Australia.

<u>Agricultural Impacts</u>

Fallow deer are reported to have significant impacts on agricultural and forestry operations in Britain (Moore *et al*. 1999). Chapman and Chapman (1997) state;

> '*Fallow have a pronounced effect on the countryside…….damaging the farmer's crops and the forester's trees.*'

Wodzicki (1950) considered grazing pressure on pasture in New Zealand '*not a serious concern*' but that fallow deer could significantly affect crops. Primary producers in Tasmania have expressed concern in the past that large numbers of fallow deer cause damage to crops, trees, pastures and fences, and regularly request and obtain permission to cull large numbers of deer to control crop damage (Hocking, G. Department of Primary Industries Water and Environment, Tasmania, pers. comm. 2005). When considering the grazing pressure that fallow deer may exert on agricultural land it is important to consider that an adult female fallow deer's average energy requirement is 2.1 Dry Sheep Equivalents (DSE) and that of an adult male is 3.1 DSE (Tuckwell 2003).

According to Calleja (2001) fallow deer are susceptible to most of the diseases and parasites which occur in farmed ruminants. Statham and Statham (1996) suggest that wild deer populations must be considered as possible vectors of dispersal in the event of an exotic disease outbreak. The Agriculture and Resource Management Council of Australia and New Zealand (2000) provides a list of major emergency diseases which may affect wild animal populations in Australia. The following diseases from the list have been identified as potentially affecting wild deer:

- Bluetongue
- Foot and mouth disease
- Screw worm fly
- Vascular stomatitis
- Transmissible spongiform encephalopathy, particularly chronic wasting disease

It is important to note that the epidemiology of these pathogens is greatly dependent on the density of the host population. As density increases the likelihood that the disease pathogen will be contracted, maintained and spread also increases. According to the Agriculture and Resource Management Council of Australia and New Zealand (2000) the fact that deer are gregarious and that they travel long distances, have cryptic behaviour and can be difficult to control may increase the risk of them contracting, maintaining and spreading disease. However, where fallow deer populations are localised, and where dispersal is limited by lack of suitable habitat then they are unlikely to play an important role in an emergency disease outbreak. A survey of wild fallow deer in Australia found that they were relatively free from infectious diseases (English 1985).

Taking wildlife including fallow deer illegally (poaching) has been and remains a problem in Tasmania, although owing to the covert nature of the activity it has not been quantified (G. Hall, Game Management Services Unit, DPIW, Cressy, pers. comm. 2005). Poaching on agricultural land can lead to damage to property infrastructure like gates, fences, and tracks and can also interfere with domestic stock and cropping. Poaching also has the potential to interfere with the management goals for public reserved land. The presence of highly prized game species like fallow deer in an area may lead to an increase in the likelihood of poachers to target the area. (D. Higgins, Wildlife Operations Unit, DPIW, Prospect, pers. comm. 2005).

<u>Loss of Wilderness Quality</u>

Caughley (1983), when reflecting on the harvesting of wild red deer (*Cervus elaphus*) from Forest Service administered land in New Zealand states;

> *'There is no wilderness left to restore the soul. The calm and quiet of what used to be wild and remote country is now shattered every twenty minutes by foraging helicopters,….The commercial benefits of wild deer,…. have not been won without appreciable retribution and social cost.'*

The Tasmanian Wilderness World Heritage Area Management Plan, (1999) recognises that there is a continuum of wilderness quality from high to low based on certain wilderness characteristics including apparent naturalness and biophysical naturalness. If a sufficient population of a large exotic species like fallow deer establish in any wilderness area then they have the potential to reduce the naturalness and so the wilderness quality of the area.

1.1.4. Commercial and recreational value

Harvesting for Human Consumption and Farm Stock

According to Ramsay (1994) wild deer have been a valuable source of breeding stock for the deer farming industry in Australia during its early years. Dependence on wild captures has since declined with the emphasis now on farm breeding and importing stock. Harvesting wild deer for the purpose of human consumption including from areas of reserved land has been an important industry in New Zealand since the 1960s.

Hunting

According to Bentley (1995) recreational deer hunting in Tasmania is more readily accepted and ingrained in tradition than on mainland states. This is reflected by Tasmania having the longest history of government management of deer, over and above simple protection, of any Australian state. A 1990 survey estimated that around $60 million is spent annually on recreational deer hunting in Australia (Cause 1990 cited Calleja, 2001). The study estimated the number of recreational deer hunters in Tasmania to be around 4000 and that around $3 million is spent annually in Tasmania on licences, food, accommodation, travel and other goods and services related to deer hunting. Since the 1990 study this figure is estimated to have grown as high as $5 million (G. Hall, Game Management Services Unit, DPIW, Cressy, pers. comm. 2005). Recreational hunting groups have been used successfully to control other introduced ruminants such as feral goats on reserved land in South Australia (Parkes *et al*. 1996).

1.2. Monitoring Deer Populations

The effective management of wildlife populations, whether for the purposes of preservation, sustainable use, control or eradication requires knowledge of the target population's distribution, abundance, and rate of change (Caughley 1977; Lancia *et al*. 1994; Mayle *et al*. 1999; Forsyth and Scroggie 2003).

1.2.1. Distribution

The distribution of a species is defined in Strahan (1995) as referring to the overall area in which a species occurs. Knowledge regarding the distribution of wildlife species is useful in order to make informed management decisions (Caughley 1977; Litvaitis *et al*. 1994; Ramsay 1994).

Methods to detect the presence or absence of deer in an area are described in Mayle *et al*. (1999) and include direct methods such as observation, capture and radiotelemetry and indirect methods such as detecting animal sign. Using reported sightings has also been used to map the distribution of deer (West and Saunders 2003).

1.2.2. Abundance

Wildlife biologists describe abundance as a measure of the number of animals in a population (Lancia *et al*. 1994). Abundance can be measured and expressed in a number of ways described below.

Absolute Abundance

When an estimate is made of the actual number of animals in a population then this is a measure of absolute abundance. Absolute abundance can be expressed as the number of animals in the entire population (population size) or as the number of animals per unit of area (population density) (Lancia *et al*. 1994). An attempt to count all the individuals in a population is known as a census. While a census may be possible in some situations for some species (Lancia *et al*. 1994), Chapman and Chapman (1997) claim any census of a fallow deer population would probably result in an underestimate even when dealing with a relatively small isolated area. A more commonly used method of obtaining population size is using a population estimate. This is where an approximation of the true population size is made based on methods that sample a proportion of the population (Lancia *et al*. 1994).

A variety of methods are available for estimating the absolute abundance of a target population of animals like deer (Caughley 1977; Lancia *et al*. 1994) but these require making a set of assumptions which can sometimes be difficult to meet in field situations without undertaking costly calibrations to determine bias. Mayle *et al*. (1999) suggest that knowledge of the absolute abundance of deer species is useful but possibly not worth the effort required to achieve a robust survey. Vincent *et al*. (1996) tested three absolute density estimators for fallow deer based on direct observations of an enclosed population of known size. The study concluded that the methods may prove useful in determining trends in population density only when the environment is relatively homogeneous and the survey avoids the autumn rut.

Relative Abundance

Relative abundance compares the abundance of populations by using indices. An index of relative abundance is a statistic that is related to population size but where the exact relationship between the index and the true population size is not known, (Lancia *et al*. 1994). Indices are commonly used to compare the abundance of two populations or to measure trends in a single population over time. Caughley (1977) suggests that for most ecological problems an index of relative abundance is sufficient, describing absolute estimates as unnecessary luxuries. For most species of wildlife, including deer species, obtaining an index of relative abundance is also the most cost-effective and practical option for detecting changes in the target population (Caughley 1977; Lancia *et al*. 1994; McCullough *et al*. 1994; Parkes *et al*. 1996; Mayle *et al*. 1999).

1.2.3. Baseline data and monitoring

Wildlife biologists use baseline data to quantify populations at a given point in time to provide a benchmark against which future data can be compared. In this way they can monitor trends in the target population. When the abundance of a deer population is measured as part of a repeatable monitoring program then data from future surveys can be compared to baseline data and will be useful in determining whether the population is increasing, stable or in decline (Mayle *et al*. 1999). When coupled with an investigation of distribution this information will help to identify new areas being colonised by deer.

1.3. Fallow Deer in Tasmania

1.3.1. History

The European form of fallow deer was introduced into Tasmania by private landowners and the Acclimatisation Society of Victoria from around 1829 for the purpose of having deer on estates for visual pleasure and providing game for hunting. Another species, Axis deer *(Axis axis*) was introduced into Tasmania at around the same time but is considered extinct (Wapstra 1973).

Commercial farming of fallow deer has been permitted in Tasmania since the 1980s (Griffiths and Campbell 1993). Government policy on deer farming in Tasmania was developed by the then Parks and Wildlife Division of the Department of Environment and Land Management. Other stakeholders that were consulted included the then Department of Primary Industries and Fisheries, the Tasmanian Deer Advisory Committee and prospective deer farmers. One of the goals of the policy was to prevent deer from becoming established in sensitive natural habitats and to minimise the risk of deer escaping or being released from captivity.

1.3.2. Distribution

Wapstra (1973) describes the distribution of fallow deer in Tasmania at the time as consisting of three separate main populations as well as several small isolated populations. The total area inhabited was estimated at around 430 000 ha. This pattern of distribution is also presented in Griffiths and Campbell (1993). The distribution of fallow deer in Tasmania has expanded significantly since Wapstra's study in 1973. Coleman *et al*. (2001) suggests that escapes and releases from deer farms have played a role here and places the number of wild fallow deer in Tasmania at around 15 000 – 18 000 animals. Staff from the Game Management Services Unit as well as others involved in the management of wild fallow deer in Tasmania provide the current view of fallow deer distribution covering around 2.1 million ha and illustrated in Map 1.

1.3.3. Current fallow deer management and legislation

Fallow deer are a partly protected under the Tasmanian *Nature Conservation Act 2002*. This means that deer can be taken by licensed hunters during a declared open season. In addition landholders can be issued with a crop protection permit to cull a specified number of deer on their properties during a specified period of time. The Wildlife Management Branch of DPIW administers the management of game species in Tasmania including fallow deer by assisting landholders to develop Game Management Plans for their properties. In reference to deer the plans aim to reduce any agricultural impact by reducing the overall numbers while enhancing the quality of the 'trophy' males. This is achieved by increasing the number of females taken and decreasing the number of immature male deer taken thereby increasing the male/female ratio of the remaining population.

In order to farm deer in Tasmania, farmers need to comply with the *Wildlife Regulations 1999* (Part 3A) which provides fencing standards and procedures aimed at preventing escapes and/or releases and outlines certain conditions that apply in the event that this does occur. A permit is required under the *National Parks and Reserved Land Regulations 1999* to take deer on land reserved under the *Nature Conservation Act 2002*.

1.4. Tasmanian Wilderness World Heritage Area

1.4.1. History and current management

The Tasmanian Wilderness World Heritage Area (hereafter WHA) was inscribed on the world heritage list in 1982 and expanded in 1989. It covers approximately 20% of the State and includes four large National Parks as well as other smaller reserves. According to Tasmanian Wilderness World Heritage Area Management Plan (1999), the WHA contains some of the best wilderness areas in south-eastern Australia. The WHA has been and remains a highly valued area for tourism and recreational opportunities.

The Tasmanian Parks and Wildlife Service Division of the Department of Tourism, Arts and the Environment (DTAE) is the primary agency responsible for management of the WHA. Other agencies such as the Resource Management and Conservation Division of the Department of Primary Industries and Water (DPIW), the Tasmanian Heritage Office, and the Aboriginal Heritage Office (DTAE) also contribute. As part of a Commonwealth and State Government arrangement the management of the WHA is based on the implementation of the Management Plan prepared in 1992 and revised in 1999. The WHA Consultative Committee provides the forum for ongoing community involvement in the management of the WHA.

1.4.2. Central Plateau Conservation Area

The Central Plateau Conservation Area (CPCA) together with some other smaller reserves make up the north-eastern part of the WHA. The majority of the CPCA is identified as ‘self-reliant recreation zone’ under the WHA Management Plan and is subject to minimal management so as to retain a relatively unmodified natural setting. Some areas of the CPCA are identified as ‘recreation zone’ under the WHA Management Plan and these areas are generally where vehicular access is maintained and visitor use is higher. A ‘hunting area’ overlays a large portion of the CPCA where wallaby and rabbit hunting can occur under permit.

1.4.3. Fallow deer in and near the CPCA

A fallow deer population exists in the central highlands of Tasmania including areas around Bronte Park, Lake Echo, Steppes, St Patrick Plains, Bothwell, Interlaken and Poatina (P. Austin, Gunns Ltd, Longreach, pers. comm. 2005; R. Hill, Forestry Tasmania, Hobart, pers. comm. 2005; Wapstra 1973). The management of deer (further to that provided by legislation) on land adjacent to the CPCA ranges from little to no management in some areas, to well established quality deer management regimes as part of game management plans in other areas. Forestry Tasmania manages land adjacent to the CPCA and manages game including fallow deer by allowing access to hunters under permit. Rod Hill from Forestry Tasmania indicated that in 2005 the fallow deer population on land managed by Forestry Tasmania that is adjacent to the CPCA west of the Marlborough Hwy is very low and is not subject to management further to that imposed by the normal deer hunting seasons under the *Nature Conservation Act 2002*. Gunns Ltd also manages land adjacent to the CPCA west of the Marlborough Hwy. Phil Austin, Game Management Officer from Gunns Ltd indicated that it is the company’s intention to manage the fallow deer population at around the 2005 abundance levels on its land in this area by implementing a game management plan. Adult males as well as females are taken during the hunting seasons and information is gathered from hunters regarding deer numbers.

There is a belief that the fallow deer population has expanded to areas adjacent to the CPCA over the past decade and that the deer may be expanding their distribution to include parts of the reserve. This has been supported by an increase in the frequency of deer sightings as well as an increase in group size observed in the area around Liawenee and extending west to areas within the CPCA. The observations include sighting reports made by recreational anglers and bushwalkers and observations made by Parks and Wildlife Service staff, Inland Fisheries Service staff, Police Officers and other people who live or work in the area.

The Parks and Wildlife Service acknowledges deer as a potential threat to the WHA particularly where reserved land adjoins agricultural land and it has a policy of controlling deer in the CPCA (Parks and Wildlife Service 2005). Under the section of the WHA Management Plan regarding introduced animals one of the specific prescriptions is to prevent the establishment of deer populations in the WHA. To make informed management decisions regarding the fallow deer population in the CPCA the current fallow deer distribution needs to be mapped and their abundance quantified.

1.5. Aims and Objectives

Aim 1: To establish baseline information regarding the distribution and relative abundance of fallow deer in the CPCA and adjacent areas.

Objectives:

- To seek information from stakeholders regarding fallow deer in the CPCA and adjacent areas.
- To investigate and assess appropriate methods for fallow deer population monitoring.
- To trial selected monitoring methods in areas of known populations of fallow deer.
- To develop and implement appropriate methods to provide baseline data on the distribution and abundance of fallow deer in the CPCA and adjacent areas.

Aim 2: To provide recommendations for on-going management and monitoring of fallow deer in CPCA and adjacent areas.

Objectives:

- To investigate options for fallow deer management in the CPCA.
- To provide recommendations in the light of results from the baseline survey.

2. Methods and Results

This section defines the study area and describes:

(a) The process undertaken to investigate the possible methods that could be used to monitor the abundance and distribution of fallow deer in the CPCA;
(b) The methods and results of several pilot studies to investigate the usefulness of various methods;
(c) The results of baseline surveys.

All location co-ordinates that appear in this report use the Australian Geodetic Datum 1966. All surveys were conducted between 15 March and 8 July 2005.

2.1. The Study Area

This study focused on the area within the CPCA illustrated in Map 2, as well as the areas adjacent to the reserve particularly to the south (including parts of the catchments of the Little Pine, Pine, Little and Nive Rivers and Kenneth Creek) and east (around Liawenee and Miena). These areas are where populations of fallow deer are known to exist. The northern boundary of the CPCA is mostly defined by a considerable escarpment forming in part the feature known as the Great Western Tiers. This area is rugged, steep and mostly heavily forested. Although it is possible for fallow deer to move up to the CPCA following trails from the north, it is considered unlikely at least in the short term. Although some ground searches were conducted in this northern part of the CPCA the area was not given high priority in this study and received a relatively low level of survey effort. The area of the CPCA east of Great Lake that is outside the WHA was not surveyed because it lies within the known fallow deer range and because of the rugged terrain.

2.2. Potential Survey Methods

Methods for measuring the distribution and relative abundance of fallow deer were investigated through a literature search and by seeking information from other agencies involved in deer research and management. The methods for measuring the abundance and distribution of deer that would be best suited for a particular situation will depend on several factors including:

- Project objectives;
- Geography of the study area;
- Project timeframe and resources;
- Density of the target population.

The available methods were evaluated in the light of these factors. Table 1 lists the methods that were considered for the project and provides a rationale for each method's subsequent inclusion in, or omission from field trials.

Method	Brief Description	Feasible?	Rationale
Aerial counts	Deer are counted from a moving observation platform such as a helicopter or a fixed wing aeroplane. Observers systematically search for deer along a predetermined flight path.	Yes	Well-documented method of achieving population estimates as well as relative abundance indices. Suitable for extensive areas with relatively flat topography and good visibility like most of the CPCA.
Spotlight counts	Deer are counted from a vehicle at night using a spotlight. A predetermined route is followed and each side of the road is searched systematically.	Yes	This is a commonly used method to obtain population estimates or indices. It has questionable precision unless extreme sampling intensity is applied. However, even at the sampling intensity afforded by this study, it may provide a quick, easy method to determine relatively large temporal changes in abundance.
Sighting reports	Gathering information from management staff, locals and visitors regarding the presence of deer.	Yes	Deer are a relatively unmistakable species in the CPCA. This method may provide an inexpensive source of information to gain a picture of present and future distributions.
Walked transect counts	Transects through the study area are walked and the number of deer observed is recorded.	No	Population abundance in the study area is probably not high enough. It is a relatively labour intensive method probably not suited to the CPCA.
Vantage point counts	A direct observation method where deer are counted from a high feature that overlooks a study area.	No	Population abundance in the study area is probably not high enough. It is a relatively labour intensive method probably not suited to the CPCA.
Ground searches for deer sign	Detecting evidence of deer presence in an area by identifying sign (pellet groups, hoof prints, tree-rubs, cast antlers).	Yes	Thought to be reliable method to detect the presence of deer.
Pellet group clearance plot density index	Quantifies the accumulation rate of pellet groups using semi-permanent bounded plots. Requires at least 2 site visits.	No	May be too time consuming and labour intensive and would require a longer timeframe than this project affords (Mayle *et al.* 1999).
Pellet group standing crop density index	Quantifies the density of pellet groups on the ground at any one time using temporary plots or transects. Requires only 1 site visit.	Yes	A popular method. Considered a highly suitable method for achieving an index of relative abundance for detecting temporal changes in population size (Forsyth and Scroggie 2003; Mayle at al. 1999).
Passive activity index	An indirect method for obtaining an index based on monitoring the number of animal tracks made across a pad of sand.	No	There may be too much non-target 'background noise' in CPCA. It would be undesirable and labour intensive to introduce large sand plots to WHA.
Mark/recapture	An estimate based on catching a sample of deer and measuring the proportion of the sample that has been captured previously.	No	Labour intensive. Requires capture of animals, which is not practical in extremely low-density populations like CPCA.
Infrared-triggered cameras	Cameras capture images of deer and female:fawn and male:female ratios are used to determine a population estimate.	No	Is expensive and may be difficult to apply in low population densities. Little is known regarding population composition in the study area.

Table 1: Feasibility of methods considered for measuring abundance and distribution of fallow deer on the CPCA and adjacent areas.

2.3. Aerial Counts

No field trial was conducted for this method due to the considerable cost involved. A literature review on aerial survey of deer was conducted and the advice of experts including Dr Graham Hall of the GMSU, Cressy and staff from the Vertebrate Pest Research Unit, Orange, NSW and Michigan State University was sought. It was decided that an aerial survey would be a useful method to detect deer presence in the study area and to provide an additional index of relative abundance.

An aerial count was conducted from a Robinson 44 helicopter, with doors removed, flying at a speed of approximately 50 knots, and at a height of approximately 90m above the ground. A systematic pattern of transects across the study area was used for the survey and the transects are shown in Map 5. Route coordinates are provided in Appendix 1. Two observers (one on each side) scanned an area from directly below to an angle of approximately 45^0 from the side of the aircraft. Following consultation with staff from the Vertebrate Pest Research Unit in Orange NSW, it was decided not to enforce search distance brackets during this survey although they are commonly used in aerial population surveys. This was to maximise the search area and to avoid having to discard sightings that may have fallen outside the distance brackets. As long as surveys methods are standardised in terms of speed, height and route then a count of all deer observed would be a useful index of deer abundance. The aerial survey was conducted on the 27th April 2005.

No deer were recorded during the aerial count. The weather on the day of the survey was fine and mild with very light winds. The observer to ground visibility was very good as evidenced by the observer's ability to clearly see Bennett's wallabies, Tasmanian pademelons, wombats and trout. Two counts over the same transects were planned to improve the precision of the index. However, following the results of the first count and due to cost constraints it was decided to abandon the second count.

Caughley (1979) suggests observers conducting aerial surveys count only a proportion of the animals being searched for and that the proportion is commonly considerably lower than the true population. De Young (1985) found that aerial survey from a helicopter estimated the density of white-tailed deer at between 36% and 65% of the true density. It is presumed that the population density must reach a certain level before animals can be counted dependent on the level of bias. The result of no observations of fallow deer during the aerial count cannot therefore be interpreted as meaning that there are no fallow deer in the survey area but that the current population density must be lower than the level that can be detected by aerial survey methods in the CPCA.

2.4. Spotlight Counts

Spotlight counts used an adaptation of methods described in Hocking and Driessen (1992). Spotlighting commenced around 1hr after sunset and was conducted from a four-wheel drive vehicle with the height of the observers head approximately 1.6m above ground. A speed of approximately 20km/hr was maintained during the count. The beam from a 100W Lightforce® spotlight was swung in an 180^0 arc in front of the vehicle by the driver and any deer observations were recorded. No other visual aids were used to detect deer but once an animal was detected a pair of 10 X magnification binoculars were used to determine the sex and age class of the animals where possible. Due to the gregarious behaviour of fallow deer the sample unit was a group of animals and for each observation the group size, group composition (males, females, spikies, fawns), perpendicular distance from the road and location was recorded. A rangefinder was used to measure the perpendicular distance from the transect to the centre of the group.

There may be a bias in the spotlighting data related to the visibility or landuse of an area. Therefore, the spotlight counts are not intended to compare the abundance of fallow deer between sites but to detect temporal changes in abundance at each site. For the purposes of the baseline survey and future surveys the spotlight counts assume there will be no significant changes in the landuse or visibility of the study sites between surveys.

2.4.1. Spotlight counts pilot study

The aim of this trial was to determine the practical feasibility of achieving an index of relative abundance with an acceptable level of precision based on spotlight counts. Spotlight counts were conducted in the area between The Steppes and Liawenee. Route A (Steppes/St Patrick's plains) was an area of reported high deer abundance. Route B (Barren Tier/Miena) was an area of reported medium deer abundance while route C (Miena/Liawenee) was an area of lower reported abundance. Each of the routes used for the trial were 10 km in length. Spotlight counts were repeated over three nights.

Route	No. Groups observed	No. Individuals observed	Mean group size
A (Steppes to Barren Tier)	10.7± 1.45	67.3 ± 13.38	6.3 ± 0.62
B (Barren tier to Miena)	3.3 ± 0.67	15.7 ± 7.69	4.6 ± 1.67
C (Miena to Liawenee)	0.7 ± 0.33	5.3 ± 4.84	8 ± 7

Table 2. Means and associated standard errors for the data from the three nights of spotlighting.

Three variables from the spotlight counts were analysed; number of groups, number of individuals and mean group size (Table 2). The variable providing the most precise data (ie. lowest coefficient of variation: [SE/mean]*100) from spotlighting varied between routes. However, Number of Groups Observed was the only variable with a coefficient of variation <50% for all routes (Table 2), and this variable may provide the best measure for detecting changes in fallow deer numbers over time. At the sampling intensity of one 10 km route counted on three nights for each site, spotlighting may be useful to determine relatively crude temporal changes in abundance. It was decided that this method be included in the baseline survey to provide more than one method as suggested in Forsyth and Scroggie (2003) and to provide at least some data in areas where other methods were not practical.

2.4.2. Spotlight counts baseline surveys

The spotlight counts for the baseline survey were repeated over five nights in an attempt to increase the precision of the data obtained. Four routes were established for baseline surveys and are shown in Map 4. Routes 1, 2 and 3 were chosen because they are in areas close to the CPCA where deer are known to exist while route 4 was chosen because it is within the CPCA and in an area where deer sightings have been reported. Route 3 was identical to route C used for the pilot study. On each night the routes were surveyed in the order 1,2,3,4. Appendix 2 provides the data recording sheet that was used during the spotlight counts. Five counts were completed for routes 1, 2 and 4 while eight counts of route 3 were completed including the three counts completed during field trials. The counts were completed during late May/early June 2005 apart from the three route 3 counts from field trials, which were completed in late March 2005.

Route	No. Groups observed	No. Individuals observed	Mean group size
1	0	0	0
2	0	0	0
3	0.4 ± 0.18	2.1 ± 1.85	5.7 ± 4.6
4	0	0	0

Table 3: Mean and standard error for baseline spotlight counts.

No deer were seen on three of the four routes used for the survey suggesting that deer were either not present or that the deer abundance in those areas was too low for deer to be counted using this method (Table 3). These spotlight surveys will provide a useful baseline from which to monitor any large increases in fallow deer abundance over time.

2.5. Sighting Reports

The distribution of deer in the CPCA based on sighting reports was investigated by consulting with DTAE and DPIW staff in the area as well as landowners and other people who live or work in the area. People were questioned in an informal manner on the frequency of deer sightings, group size and composition (male:female:juvenile ratios). In addition to reporting recent sightings of deer, people were encouraged to provide information on the history of deer in the area.

In order to gather information from people during the baseline survey and to encourage future reporting, user groups were targeted and encouraged to report sightings of deer in the CPCA. Presentations were given to walking clubs that use the area and a notice was posted at several fishing tackle stores and prominent places around the Central Highlands. A media release was also issued to encourage reporting of deer in the CPCA. Sighting reports were directed to DTAE staff at Liawenee, Mole Creek or Lake St Clair where they will be stored in a deer sighting register (see Appendix 3).

Sightings of female and male fallow deer have been reported close to and within the CPCA. Most sighting reports within the CPCA have been of male deer. Table 4 provides a summary of sighting reports collected during the baseline survey. Only sighting reports that were within or close to the CPCA are shown. A consistent trend that was revealed following discussions with stakeholders was an increase in the frequency of sightings and group size in the Liawenee area over the past 5 years indicating a relatively rapid increase in the population in that area. DPIW and DTAE staff as well as the general public reported groups of up to 20 female and male deer in the Liawenee area in recent years whereas previously no such large groups were observed. In contrast, according to reports by locals and land managers the deer population in the Bronte Park area has increased slowly over the past 20 years and in that time some occasional sightings have been reported within and close to the CPCA in the area north-west of Bronte Park.

Location/Area	Female(F) male (M)	Group size	Proximity to CPCA	Source
Talinah Lagoon	M	2	Within	DPIW staff
Olive Lagoon	F/M	<10	Within	DTAE staff
Clark's Timber	M		Within	General public
Lake Augusta			Within	DTAE staff
Sandy Lake	M		Within	General public
Lake Baillie	M		Within	DPIW staff
Lake Ada	M		Within	General public
Halfmoon Creek	M		Within	DTAE staff
O'Dell's Lake	M		Within	General public
Pillan's Lake	M	1	Within	DPIW staff
Woolshed Swamp	F/M		Within	General public
Lake Paget	F/M	3	Within	DTAE staff
Skittleball Hill	F/M		~2km	DPIW staff
Lake Fergus	M		~1km	General public
Mother Lord's Plains			~1km	DPIW staff
Doctor's Point	M	1	~1km	General public
Johnson's Lagoon	F/M	<5	~1km	General public
Lake Ina	F/M	<5	~1km	Land manager
Nive Plain			~12km	DTAE staff/General public
Laughing Jack Marsh			~9km	DTAE staff
Gowan Brae	F/M	Up to 20	~3km	Land manager/general public
Reynold's Neck	M	16	~1km	DPIW staff
Meander Area	F/M		~5km	DPIW staff/general public
Jackey's Marsh Area	F/M		~6km	DPIW staff
Little Pine Lagoon	F		~5km	DPIW staff
Liawenee Moor	F/M	Up to 20	~4km	DPIW staff/ DTAE staff/police/general public
Cameron's Lagoon	M	<5	~9km	DPIW staff

Table 4: Summary of reported sightings of fallow deer.

2.6. Ground Searches for Deer Sign

In order to establish the distribution of fallow deer in an area, methods to detect the presence/absence of deer in an area are required. This is often not difficult where the population density is moderate to high. However in extensive areas of low to very low population density, deer may be more difficult to detect. It is also sometimes difficult to distinguish between the sign of fallow deer and that of other ruminants of similar size like sheep and goats. In the present study, ground searches assumed the absence of sheep and goats from the CPCA.

Ground searches for deer sign involved walking in an area and looking for hoof prints, tree rubs and faecal pellet groups. Training in the detection of fallow deer sign was achieved through observing deer hoof prints and pellet groups in a captive population at Cressy Research Station. Experience in recognising fallow deer sign in a natural bush setting was gained during a site visit accompanied by Phil Austin, Game Management Officer from Gunns Ltd and keen deer enthusiast. Advice on detecting fallow deer in the area was also obtained from Wayne Turale, local deer enthusiast and Rod Hill, Forestry Tasmania representative on the Game Management Liaison Committee. Appendix 4 provides a guide to identifying the sign of fallow deer.

During initial site visits to Little Pine Marsh, Bens Marsh, Circular Marsh and several unnamed marshes further west, it became apparent that detecting fallow deer sign is a practical method to determine deer presence, particularly in grassy areas judged by the observer as likely to be targeted by deer for grazing. Ground searches for deer sign were conducted in open grassy/marshy areas in the CPCA because it is believed that deer would target these areas for feeding and because these areas are relatively accessible on foot. Furthermore, the ground cover in these areas is such that the observer has a reasonable chance of finding deer sign, in contrast to the more densely vegetated alpine scrub and sub-alpine forests where movement and ground visibility are restricted.

To identify areas that should be targeted for survey, 1:25 000 topographic maps were used to identify grassy/marshy areas along with information gathered during consultation with DTAE and DPIW staff. Selected areas were placed into groups according to their proximity to each other so they could be practically searched during one excursion into the field and these site groups are referred to in this report as forays. Maps 3a –3i show the locations of forays.

During ground searches observers walked at a normal walking pace, scanning the ground for pellet groups and hoof prints as well as checking shrubs and low tree branches for rubs. The location of observations of deer sign were recorded using a GPS. The search pattern was subjectively chosen by the observer to provide the highest likelihood of finding deer sign. Trails formed by native herbivores were followed where possible and edges of lakes and creeks and patches of grass were targeted. The search effort for each foray is expressed in terms of the time interval from when the observer set out from the vehicle to when the observer returned to the vehicle.

Ground Search Foray	Effort (person/hours)	Evidence of deer presence.				
		Pellet groups	Hoof prints (number of sets of prints)	Tree rubs	Sightings (number of individuals)	Cast antlers
1. Ibbots Rivulet/Stoney Plain	3	0	0	0	0	0
2. First, Second and Double Lagoons	3	2	0	0	0	0
3. Alison's hut	3	0	0	0	0	0
4. Lake Kay/Double Lagoon	5	2	0	0	0	0
5. Lake Botsford/East Rocky Lagoon	3	2	0	0	0	0
6. Ada Lagoon/O'Dells Lake/Lake Flora	7	13	0	0	0	2
7. Ada Lagoon/Halfmoon Marsh	16	4	1	0	2	0
8. Ada Lagoon/Sandy Lake	3	0	0	0	0	0
9. Ada Lagoon/Bernes Valley	16	2	1	0	0	0
10. Kenneth Lagoon/Skullbone Plains	4	0	0	0	0	0
11. Unnamed Marsh/Nive River	1.5	0	0	0	0	0
12. Breona Tier	4.5	0	0	0	0	0
13. Staggs Creek	8.5	0	0	0	0	0
14. Westons Rivulet	8	0	0	0	0	0
15. Circular Marsh/Woolshed Swamp/Pine River	10	Many *	5	2	0	0
16. Olive Lagoon/Curena Creek	4	0	0	0	0	0
17. Johnson's Lagoon	4	0	0	0	0	0
18. Kerrison's Hut/Lake Illa	7.5	0	0	0	0	0
19. Open Grassland Lake Field Track	3	0	0	0	0	0
20. Balmoral Moor	3.5	0	0	0	0	0

* Areas where more than five pellet groups were found in any one hundred metre distance during a ground search triggering that area to be targeted for a pellet group standing crop density index.

Table 5: Locations where ground searches for deer sign were conducted and evidence found.

Maps 3a - 3i show the location and type of evidence of deer presence found during ground search forays. Table 5 provides a summary of the search effort expended and the evidence found for each ground search foray. Evidence of deer presence was observed at a number of sites within the CPCA. Evidence of fawns (very small hoof prints and pellets) was found adjacent to the CPCA at Flexmore's Marsh and Circular Marsh. All other evidence found during the ground searches appeared to be related to fully-grown deer judging by the size of hoof prints and pellets.

The ground searches were able to detect deer sign where other methods like spotlighting and aerial counts failed to detect any deer. It is important to recognise that the presence of fallow deer sign in an area does not mean that the deer must be present at the time the sign is found. This is because fallow deer sign may persist for some time in the environment. However, the presence of sign does provide evidence that fallow deer have inhabited an area previously.

2.7. Pellet Group Standing Crop Density

A pellet group standing crop density is a targeted method of survey which can provide a quantitative index of the relative abundance of deer at a particular site. A pellet group standing crop density method is based on the premise that the density of faecal pellet groups in an area will depend on the density of the deer population, the defecation rate and the rate of pellet group decay.

2.7.1. Pellet group standing crop density pilot studies

Distance method

Initially, a pilot study was conducted at a site of high pellet density (Little Pine Marsh) and low pellet density (Circular Marsh) using a distance method adapted from Bacheler (1975). This method uses a number of points that can be randomly or systematically selected at a site. At each point the observer searches for the nearest faecal pellet group and the distance from the point to the nearest pellet group is recorded. At each site a maximum search distance is set so that a distance is recorded for at least 50% of points. Bacheler (1975) used this method to calculate a population estimate using a complex equation that requires knowledge of pellet group decay rate and defecation rate. Since this survey aims to obtain a measure of relative abundance only, the analysis was simplified by using the mean distance from point to nearest pellet group as a pellet group standing crop density index.

The distance method produced relatively precise data for Little Pine Marsh (Mean distance from point to nearest pellet group was 1.6m with a standard error of 0.2m). However, when applied to an area of lower pellet density (Circular Marsh), it was found to be too time consuming with a considerable number of points from which no pellet group could be located within the maximum search distance of 10m. This made analysis of data difficult. Extending the search distance greater than 10m would have made the searching too time consuming.

Strip transect method

A strip transect method based on Mayle *et al*. (1999) was trialed at the same sites as the distance method. This method involved commencing a transect on the margin of a marsh and traversing the marsh at a slow pace while identifying any pellet groups one metre either side of the centre line (see Section 2.7.2 for more details of method). Pellet groups were counted along 20m transect sections, which could then be summed to obtain 100m or 200m subtotals that are more useful when surveying areas where pellet group density is relatively low.

Mayle *et al*. (1999) suggested a method for estimating absolute abundance, requiring knowledge of defecation rate and decay rate. However, if all that is required is an index and no inference is made about the absolute density of the population then it is sufficient to assume that the defecation rate and decay rate will remain constant through time. As long as the surveys do not attempt to compare sites and the time interval between surveys is greater than the time it takes pellet groups to decay, then the density of pellet groups will be a useful index to measure population trends.

Some knowledge of the rate of pellet group decay for a survey area during a particular time interval is required so that the surveyor can be confident that a subsequent pellet group count will not be confused by pellet groups still present since the time of the previous count (Parkes *et al.* 1996). The rate at which faecal pellet groups decay is influenced by several environmental variables and has been proven to be site specific and sensitive to seasonal variation (Batcheler 1975; Massei *et al*. 1998; Mayle *et al*. 1999). Massei *et al*. (1998) found that 88% of fallow deer pellet groups had disappeared one month after deposition during autumn in a Mediterranean climate. According to Mayle *et al*. (1999) the rate of decay for fallow deer pellet groups in Great Britain varies between 42 and 434 days depending on the type of habitat and climatic zone.

To determine the approximate rate of pellet group decay within the study area fresh pellet groups were obtained from Little Pine Marsh and translocated to four sites across the study area. The pellet groups were placed on the ground and a protective cage made from galvanised steel mesh with apertures of 6mm. The cages were pegged over each pellet group to prevent them from being moved by runoff while still allowing small insects access to the pellets. The pellet groups that were placed under each of the cages consisted of pellets that were judged to be from a single defecation of an adult fallow deer (i.e. the pellets were relatively large in size and formed a discrete pellet group of approximately 40-60 pellets). Approximately 50% of the pellets under each cage were clumped together and approximately 50% were loose pellets. The exact location and establishment date of the pellet cages is shown in Appendix 5.

Pellet cage	Deposition date	Observations as at 13/08/2005	Observations as at 19/02/2006	Observations as at 03/09/2006
1	11/04/2005	Not decayed	Not decayed	Decayed
2	11/04/2005	Not decayed	Decayed	
3	12/04/2005	Not decayed	Decayed	
4	12/04/2005	Not decayed	Decayed	

Table 6: Results of observations on the decay of caged pellet groups.

The caged pellets groups were checked four months after deposition and caging date, at which time none of the pellet groups had decayed (Table 6). After 10 months, three of the four pellet groups had decayed, while after 17 months all pellet groups had decayed to the point that none of the pellet groups would have been included in the pellet group density index (Table 6). Therefore, an interval of at least 1.5 years between pellet group density index surveys at a site should be sufficient to ensure there is no recounting of pellet groups.

The strip transect method was found to be a more suitable method than the distance method, requiring less effort whilst still providing a relatively precise index of relative abundance. For Little Pine Marsh the mean number of pellet groups counted along a 20m long strip transect was 6.1 with a standard error of 0.51 (n = 40). For Circular Marsh where the distance method proved troublesome, the mean number of pellet groups counted along a 100m strip transect was 3.2 with a standard error of 0.71 (n = 18). This method allows the length of transect to be increased to suit the pellet density at each site. Increasing the length of transect for sites with low pellet density has the effect of improving the precision of the data by reducing the number of transects where no pellets were counted. No comparison between sites is intended. Rather, it is intended to compare the data taken from each site during the baseline survey with that taken at the same site in the future. Future surveys will therefore use the same transect length that was used during the baseline survey. It was decided the strip transect method of determining a standing crop pellet group density index would be implemented during the baseline survey at suitable sites.

2.7.2. Baseline pellet group standing crop density surveys

When applying pellet group standing crop density surveys in low density fallow deer populations, it is suggested that an assessment of the area is undertaken to identify areas likely to be favoured by deer for grazing and these areas targeted for pellet group counts (Calleja 2001). During this study, foray areas in which five or more pellet groups were found in any one hundred metre distance during ground searches for deer sign were chosen for a pellet group standing crop density survey. Map 6 shows the location of areas targeted for a pellet group standing crop density index. Site 5 is within the CPCA whereas sites 1, 2, 3 and 4 are on adjacent land. The sites were surveyed between 13 April and 5 May 2005.

Once an area had been identified for a pellet group standing crop density index the boundary of the area had to be identified. For the areas targeted during this baseline survey this was a matter of stratifying according to vegetation cover and surveying only within the grassy/marshy areas and stopping transects short of scrub or forest. Beginning at one end of the area, the observer identified a straight line across the area by choosing a feature on the far side. Once identified, the transect was walked by the observer at a pace slow enough so that, without stooping, the observer was confident of identifying any pellet groups one metre either side of the centre line. A 20m length of cord lightly anchored at one end with a tent peg was used to measure out each section of the strip transect while a 1m cane was used to identify the width of the strip transect.

The number of pellet groups lying within one metre of the centre line was recorded for each 20m section. The process was repeated until the pattern of traverses extended the full length of the marsh and at least 800m of transect had been completed. For large sites, fewer traverses were required (i.e. larger angles between traverses) than for smaller areas where more transects were required to gather enough data (i.e.

smaller angles between traverses). The data recording sheet used during the pellet group strip transect counts are provided in Appendix 6.

For the purposes of this survey a pellet group is defined as a cluster or assemblage of six or more intact pellets judged to be produced by a single defecation at the place where they were observed. Pellets that had obviously been redistributed by water are not counted. This definition of a pellet group is close to that described in Batcheler (1975) and Mayle *et al.* (1999). Initially a distinction was attempted between pellet groups that were relatively new (dark in colour) and those that were obviously old (pale in colour). However, it appears that there exists a continuum of pellet colour from dark to very pale and when the colour of a pellet group lay somewhere midway on the continuum it was difficult to decide whether to include or disregard them. Due to this possible source of bias, all pellet groups matching the above definition were included regardless of colour.

Site	Length of transect (m)	Number of Transects	Total length of all transects (m)	Total pellet groups counted	Mean ± standard error (number of pellet groups per transect)
1. Little Pine Marsh	20	40	800	243	6.1 ± 0.51
2. Bens Marsh	100	44	4400	319	7.3 ± 0.83
3. Circular Marsh	100	18	1800	58	3.2 ± 0.71
4. Unnamed Marsh	200	4	800	20	5.0 ± 0.91
5. Unnamed Marsh	200	4	800	5	1.25 ± 0.95

Table 7: Mean, standard error and total counts for baseline pellet group standing crop density surveys.

Due to differences in the attractiveness of sites relative to the surrounding area and other site specific factors such as the size of the stratified habitat, it is not possible to compare pellet group standing crop density surveys between sites. The pellet group standing crop density indices (Table 7) will be used to detect changes in abundance at each site over time.

3. Discussion

3.1. Distribution and Abundance of Fallow Deer in and near the CPCA.

It is possible to distinguish between areas that contain established fallow deer populations in which deer are resident year-round, and areas that have a seasonal presence in which deer are present for only a part of the year. Female fallow deer usually have a single home range in areas providing suitable cover and food. In contrast, male deer have at least two seasonal home ranges which may extend well beyond the range of female deer during the non-breeding season (Chapman and Chapman 1997). Therefore, in the present study a distinction is made between areas where female deer have been recorded (fallow deer in these areas are considered to be established), and areas where fallow deer occur but little or no evidence of female deer can be found (occurrence of fallow deer in these areas is considered seasonal).

Immediately to the east of the CPCA, established fallow deer populations occur in the areas between Miena and Bronte Park (Map 7). More recently, the fallow deer distribution has extended to include the area around Liawenee immediately adjacent to the CPCA (Map 7). Fallow deer appear to have established in areas immediately adjacent to the boundaries of the CPCA along the Pine River as far west as Flexmore's Marsh and along the Nive River valley as far west as Gowan Brae (Map 7). Isolated records of primarily male deer, suggesting a seasonal presence of fallow deer, occur west of Liawenee around the area known as the Nineteen Lagoons and as far west as the area around Talinah Lagoon. At least some seasonal occurrence is also evident within the CPCA as far west as Olive Lagoon and Halfmoon Marsh. Areas of the CPCA further to the west and north do not appear to be used regularly by fallow deer.

Conclusions on the relative abundance of fallow deer within and adjacent to the CPCA are based on an informed judgement rather than a comparison of data due to the difficulty of eliminating bias when comparing between sites. In areas that are close to the CPCA around Liawenee and along the Nive and Pine Rivers fallow deer appear to be less abundant than in areas further east around Miena, St Patrick's Plains and Lake Echo. Generally, abundance seems to decrease in a westerly direction where less suitable habitat, higher elevations and more exposed conditions occur.

There is some anecdotal evidence that fallow deer have recently extended their range westward and into the CPCA. Based on available data it is not clear whether the current containment of fallow deer within the eastern-most fringes of the CPCA represents the most westward extent to which the species can establish, or whether fallow deer can and will move further west and north into the CPCA. The adaptability of fallow deer, as evidenced by the fact that they can establish populations in a wide range of habitats throughout their range, suggests that the remainder of the CPCA may be able to support some level of establishment by fallow deer. The data collected during this survey within and close to the CPCA will provide a baseline against which future surveys can be compared in order to indicate changes in fallow deer distribution and abundance in these areas over time.

3.2. Possible Sources of Fallow Deer in the CPCA

The presence of fallow deer within the CPCA west of Great Lake may be a result of one or more of the following processes;

1. Adult Males from nearby populations around Miena and Bronte Park occupying a seasonal home range that includes parts of the CPCA. This appears to be the most likely reason that fallow deer occur within the CPCA, particularly north of the Great Pine Tier where most reported sightings of fallow deer have been of male deer (Map 7).

2. Yearling males (spikies) dispersing west to the CPCA. Some of the reported sightings of deer in the CPCA have been of yearling males. Yearling male fallow deer are known to disperse in more cases than yearling females. (Chapman and Chapman 1997; Nugent 1994). According to Nugent (1994) in most cases the dispersal distance is relatively small (1-2km). It may be possible that some yearling males from nearby populations around Miena and Bronte Park are dispersing over greater distances into the CPCA.

3. Females from nearby fallow deer populations around Miena and Bronte Park occupying a seasonal home range that includes parts of the CPCA. In some situations populations of fallow deer including doe herds have been observed to display seasonal variation in home range (Forsyth, D.M. Arthur Rylah Institute for Environmental Research, Victoria, pers. comm. 2005; Wodzicki 1950). Few sightings of female deer were reported within the section of the CPCA west of Great Lake and north of the Great Pine Tier. However, it is possible that female deer and fawns from nearby populations around Miena and Bronte Park have a seasonal home range that includes part of the CPCA.

4. Females and males from nearby populations around Miena and Bronte Park undertaking a range extension or a whole-range shift due to hunting or population pressure and spreading westward to the CPCA. Yearling female fallow deer have been known to disperse over small distances (Nugent 1994). According to sighting reports, the fallow deer population including females have extended their range westward from the Barren Tier to Miena and towards Liawenee over the past 15 years indicating their ability to spread. Few sightings of female deer were reported within the section of the CPCA west of Great Lake, and it is unlikely that groups of female deer and fawns have established within this section of the CPCA at this stage.

3.3. Management Options.

3.3.1. Local eradication/exclusion

Local eradication is the permanent removal of all individuals from an area. When describing feral goat management Parkes *et al*. (1996) outlines three conditions that must be met before eradication is possible:

- The likelihood of reinfestation must be close to zero.
- The eradication methods must place all individuals in the population at risk.
- The rate at which individuals are removed must be greater than the rate of increase at all densities.

It is assumed that the deer that are present in the CPCA have immigrated from or are a part of nearby populations outside the CPCA. Therefore, a deer proof barrier would need to be erected to exclude deer from the CPCA before local eradication could be considered. The initial and ongoing costs and practical difficulties of such a measure would be considerable and make this option impractical.

3.3.2. Strategic management

Strategic management reduces the population to a level where damage is kept at an acceptable level through an initial knock-down control program. The population is then sustained at the low level through periodic maintenance control programs preventing recovery. The main aim of strategic management is to reduce the damage caused by the pest population to an acceptable level. It is not known if the fallow deer population that currently exists in the CPCA is causing significant ecological damage. An understanding of the damage caused by fallow deer at different abundances would be needed before strategic management would be warranted. Furthermore, since the fallow deer in the CPCA are likely to be associated with nearby populations on adjacent land, any effective strategic management of the fallow deer in the CPCA would need to be extended to include these adjacent areas.

3.3.3. On-going monitoring/watching brief

It is uncertain whether the fallow deer population at the current low abundance level in the CPCA causes significant damage. It is also uncertain whether fallow deer are likely to extend their range westward within the CPCA. Monitoring the fallow deer population in the CPCA will provide a means to detect increases in abundance in the areas where deer currently exist and to detect any extension of their current distribution. If the abundance of fallow deer increases in the CPCA then the question of strategic management may need to be revisited and the damage caused by fallow deer would need to be investigated.

3.3.4. Do nothing/*ad hoc* management

To engage in little or no management of fallow deer in the CPCA would be a low cost but risky option. An unmanaged animal population will reach carrying capacity with births equalling natural deaths. The carrying capacity will depend on food, water and other requirements as well as mortality agents such as predators and disease (Parkes *et al*. 1996). The impacts of an un-managed fallow deer population in the CPCA which is allowed to reach its carrying capacity are unknown.

3.4. Recommendations

1. A fallow deer sighting report register should be kept at the Liawenee, Lake St Clair and Mole Creek Parks and Wildlife Service Field Centres and at the Liawenee/Great Lake Inland Fisheries Service Research Station. Sightings of fallow deer made within or adjacent to the WHA, including the CPCA, should be recorded in the register. Sightings made by staff as well as those reported to staff by visitors should be recorded. These sighting registers will be useful sources of data for future surveys to monitor the fallow deer population in these areas so that any significant expansion of distribution may be detected. Information from the sighting report registers from each of the field centres should be collated each year by the WHA Zoologist and the information kept on the Natural Values Atlas. Visitors to the CPCA should be made aware of the issue of deer and encouraged to

report sightings through the placement of a small sign at the vehicle access road near Liawenee. Future surveys should also seek information from Gunns Ltd and Forestry Tasmania regarding the number of deer taken each season on their land west of the Marlborough Hwy.

2. A repeat of the spotlight counts should be completed in 3-5 years.

3. A repeat of the pellet group density survey should be completed in 3-5 years.

4. The ground searches for deer sign should be repeated in 3-5 years at all Ground Search Foray sites within the CPCA to determine whether evidence for deer activity is increasing at these sites. Where future ground searches reveal the presence of sufficient pellet groups (ie. 5 pellet groups in any 100m) at sites where the present surveys detected insufficient levels of deer activity for pellet group density survey, then a baseline pellet group density index should also be obtained for these sites.

5. Where there is evidence from sighting registers for an expansion of fallow deer within the CPCA, this information should be used to select additional areas to be targeted for ground searches for deer sign within the CPCA.

3.5. Further Research

During this baseline survey very little obvious damage caused by fallow deer was observed within the CPCA. Prior to undertaking costly management of fallow deer further studies investigating the impacts caused by fallow deer at various levels of abundance would be useful to help set management goals and quantify the benefits of fallow deer management.

Further studies investigating the movements of fallow deer in populations close to and within the CPCA would be useful to answer questions related to the nature of fallow deer occurrence (seasonal or permanent) in the CPCA and to aid with any future strategic management.

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