ACT Government




PROJECT DESIGN FOR RESEARCH ON KANGAROO IMPACTS IN CANBERRA NATURE PARK

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Research Report 2015/2

January 2015

Cover Photos (left to right)

a) Dingoes like this one in Namadgi can be powerful regulators of the abundance of large mammals such as kangaroos, an ecological process no longer possible in Canberra Nature Park. Elimination of such predation typically causes a decline in biomass at the trophic level two below, i.e. in this case the pasture.
b) Eastern Grey kangaroos are magnificent animals, well adapted to temperate south-eastern Australia, where their populations play a central role in the ecology of grassy ecosystems by altering the habitat of small plants and animals.
c) Reptiles of the grassy ecosystems, such as this legless lizard, require particular habitat structure, which may not be continually available under heavy grazing pressure.
d) Small mammals appear to be a neglected component of the grassland, partly because most species have disappeared. The Common Dunnart shown here is in fact rare but this female with several young in her pouch appears to be doing her part to increase the species.

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RESEARCH REPORT 2015/2

Prepared by staff in the Environment and Planning Directorate,
ACT Government Service.

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CONTENTS

1. GLOSSARY AND ABBREVIATIONS

Detection function	In a survey using the Distance method the Detection function is a mathematical expression of the probability that a counted object will be detected as a function of its perpendicular displacement from the transect. It is estimated from a histogram of observations made in the survey.
Diversity as in 'species diversity'	An index which accounts for the combined abundance and species count of organisms detected in a survey. Diversity is maximised when all species are of equal abundance. Thus a Diversity Index represents both the number of species present as well as the extent to which diversity is reduced by the fact that some species are common and many are rare. Shannon's Diversity Index is the most commonly used diversity index. Also see 'Richness'.
Effective Strip Width (ESW)	In a survey using the Distance method Effective Strip Width (ESW) is the distance either side of a transect line in which half of the counted objects are recorded.
EGK	Eastern Grey Kangaroo *Macropus giganteus.*
EPD	Environment and Planning Directorate (within the ACT Government Service).
Herbage Mass	Synonymous with 'Yield' in agronomic literature, i.e. the dry weight of above ground pasture, excluding unattached dead material; kg/ha. Frequently called 'plant biomass' but biomass should include the roots and exclude dead parts.
KMP	The ACT Kangaroo Management Plan
KMU	Kangaroo Management Unit. A defined area comprising more than one land tenure occupied by one population of kangaroos.
Numerical Response	The Numerical Response is the exponential population growth rate (*r*) of a population of consumer organisms as a function of food availability. It was an aim of the original study to estimate a kangaroo numerical response empirically.
Pasture	Ground layer vegetation which is potentially or actually grazed.
Pasture off-take	The rate at which herbivores reduce pasture (kg/ha/day).
Reptile abundance	The minimum number of reptiles of one species assumed to inhabit a plot (serial captures of single reptiles of the same species under the same tile are treated as one animal).
Richness as in 'species richness'	Commonly used to mean the number of species within a taxon (e.g. plants, reptiles) recorded in a survey and strictly should be corrected to allow for those species not detected in a particular survey, with the uncorrected

	quantum being correctly called the species 'count'. Also see 'Diversity'.
Stratification	The subdivision of a population into sub-sampled components to improve the precision of its measurement. For example, in order to improve counts of plants or animals, survey areas are often stratified by vegetation type or according to attributes (e.g. slope, aspect, elevation) believed to correspond to changes in the density of the counted organisms.
TAMS	Territory and Municipal Services, a Directorate within the ACT Government Service.
Vegetation type	The vegetation structure class (e.g. Forest, Open Woodland, Grassland) based on % canopy cover. Used as the main method of stratification for kangaroo, reptile and vegetation surveys.
WLT	Walked Line Transect, one of the Distance family of methods for estimating the absolute abundance of a population of counted objects. Note: Many other methods of measuring abundance measure only relative abundance and do not account for the number of objects that were not detected. While relative abundance is widely used and extremely useful (e.g. 'the population has halved', it does not reveal the true number or density of the population. See Methods for explanation of the WLT method.

2. OVERVIEW

Large herbivores can act as ecosystem engineers by altering the vegetation structure to the advantage or disadvantage of other species (Neave and Tanton 1989; Diamond 1992; Cote *et al*. 2004; Gordon *et al* 2004; Foster2014). In some cases, including some populations of Eastern Grey Kangaroos in Canberra Nature Park, there are threatened ecosystems requiring protection (ACT Government 2004, 2005). Accordingly, the ACT Kangaroo Management Plan (ACT Government 2010) identified the need to moderate eastern grey kangaroo density within Canberra Nature Park for the conservation of a range of other native species, particularly those resident in the two endangered ecological communities of the ACT lowlands (ACT Government 2004, 2005). Canberra Nature Park is defined in ACT Government (1999).

While the ecology behind the policy to control kangaroo grazing pressure was well understood and subsequent research publications from the ACT have validated the policy in relation to a representative range of organisms (e.g. McIntyre *et al.* 2010 for plants; Barton *et al.* 2011 for beetles; and Manning *et al.* 2012 and Howland *et al*. 2014 for reptiles) there remains a need to better understand the numerical (and temporal) relationships between kangaroo density and biodiversity in order to provide quantitative guidelines for management of kangaroos for biodiversity.

In light of this requirement, a broad scale research project was initiated in 2012 by the Conservation Research Unit of the (then) Environment and Sustainable Development Directorate of ACT Government. The aims of this research project are:

1. To provide management advice based on quantitative empirical assessments to guide the management of grazing pressure, particularly from eastern grey kangaroos, in lowland grassland and grassy woodland areas of conservation value.

2. To facilitate aim 1 by improving the knowledge base for management of local grazing systems by developing a kangaroo numerical response empirically from annual records of green herbage mass and kangaroo population growth rates, and placing the results into the existing ACT population model of kangaroos, vegetation and management treatments; and

3. To monitor the condition of representative lowland native grassland and woodland sites in the ACT in relation to kangaroo grazing pressure, particularly the indicators: reptile species diversity, plant species diversity, and if possible also a measure of invertebrate diversity or abundance (dependent on additional funding).

2.1. Stage 1

Stage 1 of this project was funded for the period June 2012 to June 2014. It involved concurrent assessments of kangaroo density (reserve or KMU level), relative rates of **pasture off-take** by kangaroos and rabbits (plot level), **herbage mass** (plot level), **floristic richness** and **diversity** (plot level), and **reptile richness, diversity** and **abundance** (plot level). Measures of reptile abundance and diversity were conducted within plots also measured for herbage mass so any correlation between

the two could be established. The basic ecological processes examined in this research design are shown in Figure 1.

The selection of research sites in Stage 1 (i.e. individual reserves within Canberra Nature Park, CNP) initially encompassed the range of kangaroo densities commonly observed within CNP (~0.0 EGK/ha to ~3.2 EGK/ha). Except for plots used for measuring floristic diversity, all 1 ha research plots were positioned randomly within reserves and were stratified according to **vegetation type** (an index of canopy cover). Plots used to examine floristic diversity were positioned in the areas considered to possess relatively high grassland or woodland values. Data from each of these elements was collected between summer 2012 and winter 2014. The functional relationships between various measures within Stage 1 are still awaiting statistical analysis, with the exception of the floristic diversity data which has been reported on by Vivian and Godfree (2014).

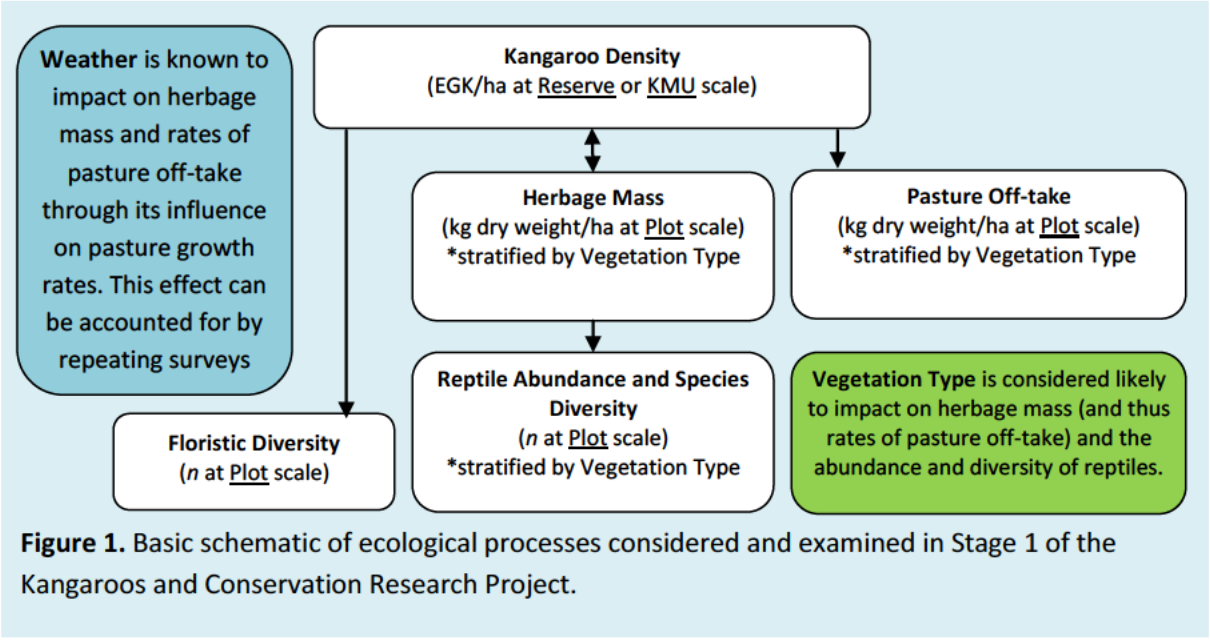

Figure 1. Basic schematic of ecological processes considered and examined in Stage 1 of the Kangaroos and Conservation Research Project.

2.2. Stage 2

Funding for an extension of this project (Stage 2) was granted for the period of June 2014 – June 2016. Whilst the overall aims and data collection techniques are consistent with Stage 1 of the research, improvements to the survey design have been made for Stage 2 (Figure 2). The most apparent change in design will be a shift away from the 'reserve level' assessments (where measurements from up to eight plots were averaged to give a figure for the reserve) with reserves selected to span a range of kangaroo density, and instead the impact of kangaroos at the 'plot level' will be considered. Plots will be selected (and adjusted annually) such that they populate a design matrix includes five levels of kangaroo density (0 – 4 EGK/ha where possible), two levels of vegetation structure (grassland and open woodland) and three classes of grass community (*Austrostipa* and/or *Rytidosperma* dominated, *Themeda australis* dominated and *Phalaris* dominated). Due to the difficulties with measuring kangaroo density at the plot scale, pasture off-take by kangaroos will instead be used as an index of localised kangaroo impact. The relationship between pasture off-take and kangaroo density within different grass community types will be established separately within selected reserves which are not much grazed by livestock and which

are isolated (i.e. where the kangaroo population in the nature reserve is not moving frequently onto and off other land tenures (such as rural grazing properties) so that measured kangaroo density can be reliably associated with grazing pressure on the reserve.

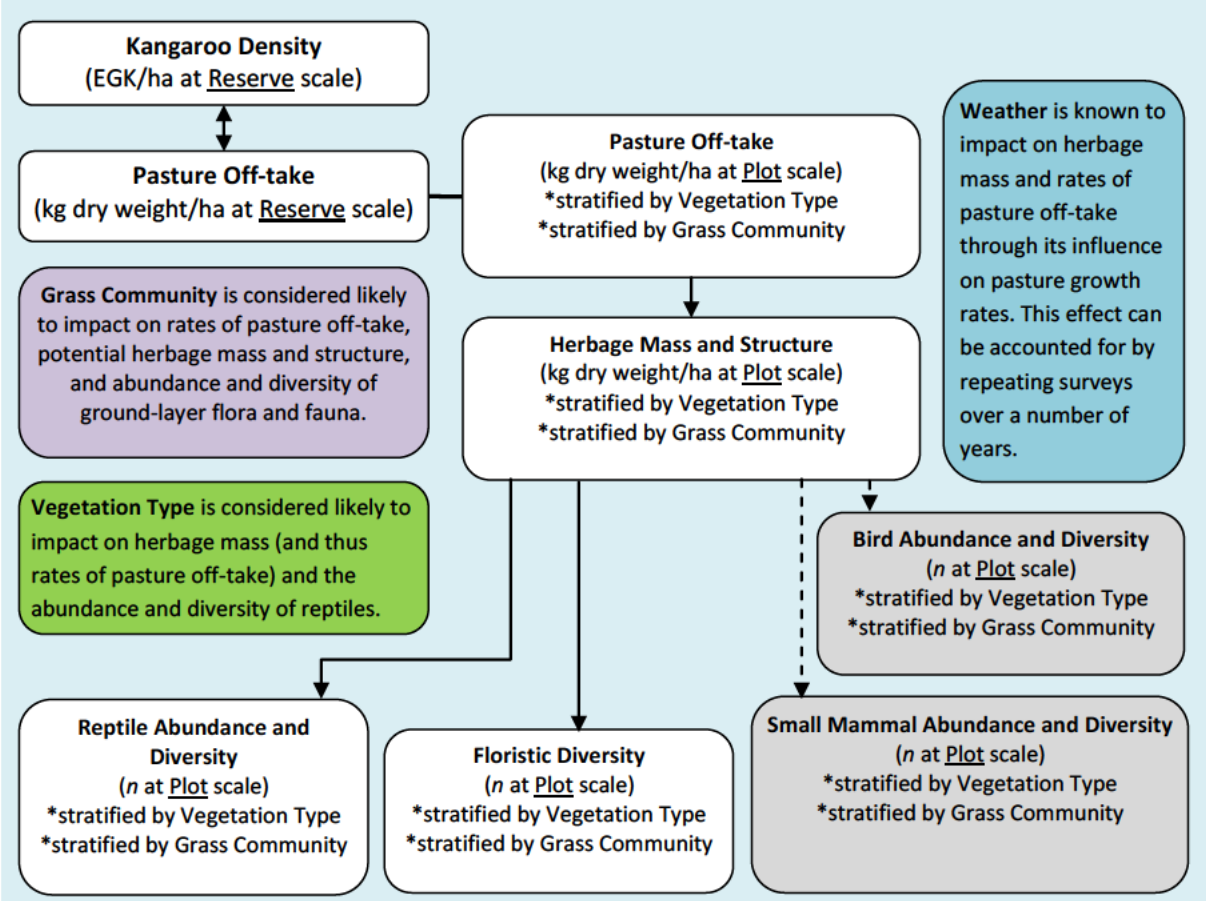

Figure 2. Basic schematic of ecological processes considered and examined in Stage 2 of the Kangaroos and Conservation research project.

Stage 2 of this research project will also involve a trial of the different kangaroo counting methods, in an attempt to establish the relative accuracy, practicality and cost efficiency of different counting techniques in the variety of habitat types encountered in CNP. It should be noted that this trial will be limited by the absence of dedicated funding. Investigations into the impacts of kangaroos (via vegetation structure and pasture biomass) on small mammal abundance and bird diversity will also be considered if funding allows.

This altered design is thought likely to overcome some of the issues encountered during Stage 1. Namely;

- Kangaroo densities were measured at the reserve or kangaroo management unit (KMU) scale (100s – 1000s of ha), which would be too broad for correlations to be observed with plot level (1 ha) measures of pasture off-take, herbage mass, floristic richness and diversity and reptile abundance, richness and diversity. This is especially true where the average kangaroo density for a KMU (which might not reflect spatial variation across the different

land use components) is related to impacts measured in just the reserved portion of the land area.

- Measures of kangaroo impacts were not corrected for the grass community in which they were being measured. Hence when the grassy understorey of a tussocky grass, unpalatable to kangaroos failed to respond to a given level of kangaroo grazing in the same manner as a prostrate, favoured grass species – the statistical power to correct for these effects of grass community type was unlikely to be present.
- Efforts by managers to control kangaroo abundance have increased over the years so that the original spread of kangaroo densities was reduced to a pool of reserves with similar kangaroo density thereby preventing comparison of heavily and lightly grazed areas.

3. PROJECT AIMS

Stage 2 of this research project seeks to describe the impacts of kangaroos on ground-layer biodiversity via a three-step process. Accordingly, it aims to answer the following three questions:

Q1. What is the quantitative relationship between kangaroo density (kangaroos/ha), food availability (grass kg/ha/kangaroo) and rate of pasture off-take (grass kg/ha/day) at a reserve level? (If possible, this will involve consideration of (a) grass community and (b) vegetation type).

Q 2. What is the relationship between rates of pasture off-take and the structure and herbage mass of the ground layer vegetation? How does this differ according to grass community type?

Q 3. What are the general or grass community-specific relationships between ground-layer vegetation structure and herbage mass, and the reptile and floristic (and possibly bird and small mammal) diversity and abundance?

4. ESTIMATING KANGAROO DENSITY

No single method for measuring kangaroo density is ideal across all management areas. Methods used in Australia for counting kangaroos are described in the ACT Kangaroo Management Plan (ACT Government, 2010; Appendix 1) with particular reference to those used in the ACT. On sites where they can be used reliably, Direct Counts and Sweep Counts will be preferred for this research. Both methods seek to enumerate individual kangaroos and their reliability is judged by the consistency between repeat counts combined with the perception of operational success. On other sites, a sampling technique such as the Walked Line Transect or Pellet Count method will be used.

4.1. Direct Counts

Direct Counts are applied in small reserves with open vegetation where kangaroos can be counted directly using binoculars. Reserves are generally bounded by suburbs or high speed roads such that the movement of resident animals is generally restricted to the area being counted. Counts are usually undertaken by 1-3 people travelling around the area to be counted, with individual groups of kangaroos being counted in situ with as little disturbance as possible. Where available, a high vantage point will be utilised to monitor the overall progress of the count and help avoid any double counting. To date, two counts within 10% of one another are considered sufficient for the kangaroo density to be established for an area. In 2014, four repeat counts will be undertaken to better assess the potential for variability between counts. A map demonstrating the use of a Direct Count at Mulanggari Nature Reserve is shown in Figure 3.

4.2. Sweep Counts

Sweep Counts are undertaken in reserves up to several hundred hectares in area, and can be successful across a variety of vegetation types and topographies. They are generally only undertaken in areas surrounded by features limiting kangaroo movement (e.g. suburbs, high speed roads). During a Sweep Count, a line of people spaced at variable intervals move across a reserve, counting kangaroos which pass between them and the person to one side.

Usually the sweep is conducted from opposite directions toward the middle of the reserve to reduce the risk of driving a kangaroo out of the reserve onto a road. As a secondary measure to avoid the movement of kangaroos into suburbs or roadways, people at each end of the line walk ~100m ahead such that they encounter kangaroos first and hence guide animals away from the reserve edges. In general, eastern grey kangaroos are highly faithful to small home ranges and few kangaroos attempt to leave the area in response to sweep counts. To date, two counts within 10% of one another are considered sufficient for the kangaroo density to be established for an area. In 2014, four repeat counts will be undertaken to better assess the potential for variability between counts. A diagram demonstrating progress during a sweep count at Mt Painter Nature Reserve is shown in Figure 4.

The spacing between people is adjusted to adapt to changes in topography and vegetation density; i.e. people moving through dense vegetation must be closer together to maintain visual contact to the next person whilst those in open areas can afford to be further apart. Spacing also aims to allow kangaroos to move through the line relatively undisturbed (and is thus unlike a 'drive' count).

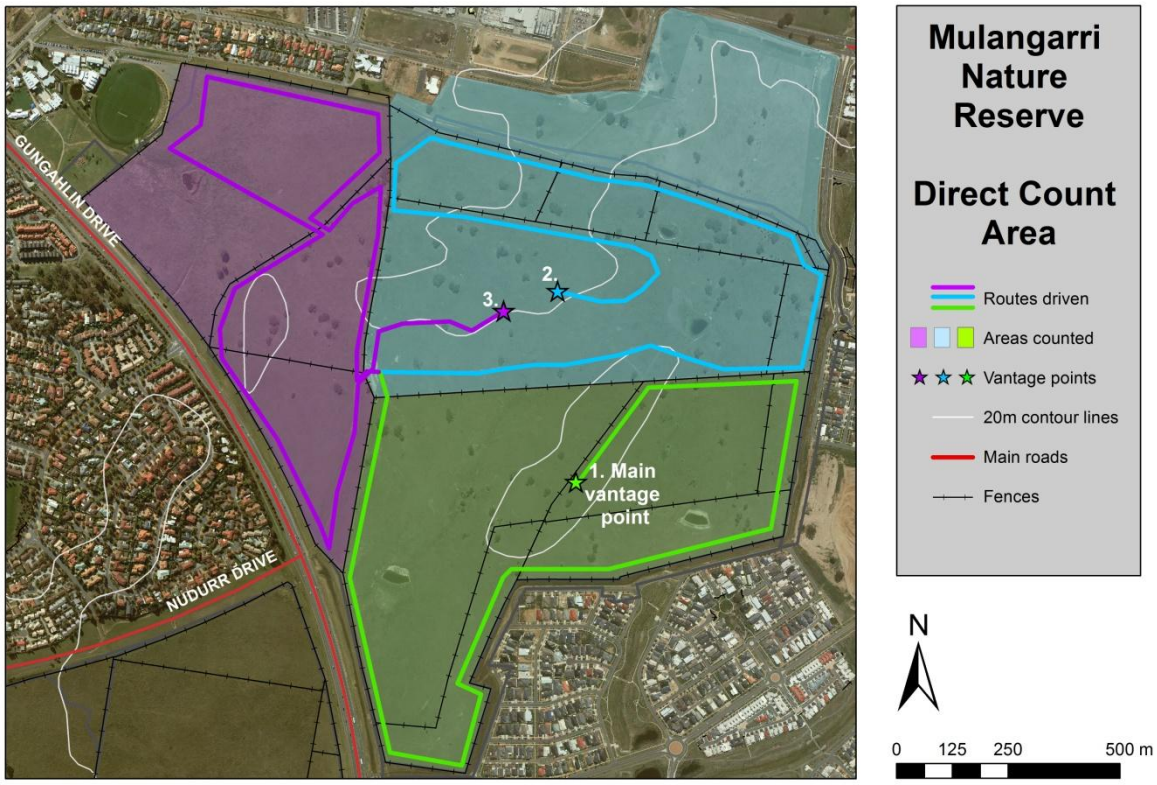

Figure 3. Map showing the process used by three counting vehicles to conduct a Direct Count of kangaroos at Mulanggari Nature Reserve.

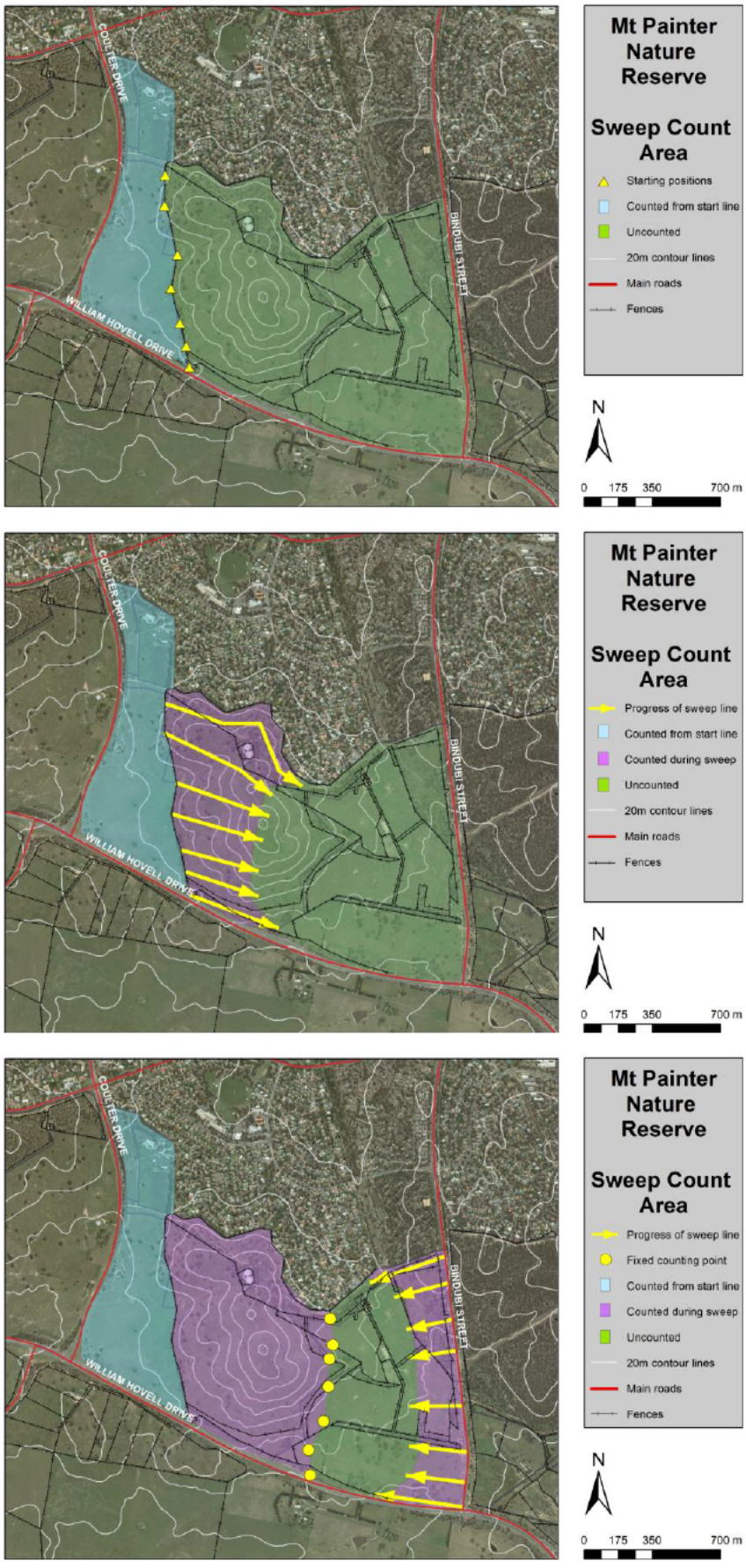

Figure 4. Maps showing the progressive stages of a Sweep Count at Mt Painter Nature Reserve. Stages shown include (i) the initial lining up along the eastern reserve boundary (top). (Such lines would usually start from along the road but in this case any kangaroos in the small paddocks to the left of the line can easily be seen and counted before the line of people move off.) (ii) progress of the first counting line through the reserve (middle), and (iii) placement of stationary counting positions coupled with a secondary sweep from the western boundary to avoid 'herding' kangaroos out of the reserve (bottom). The sweep is complete once the second counting line reaches the fixed positions.

4.3. Walked Line Transect counts

Walked Line Transect counts are one of the methods of 'distance sampling' (Buckland *et al*. 2001, 2004). They can be used in any management area where a sufficient distance of transect lines can be fitted without potential issues surrounding independence (where adjacent transects fall within the '**effective strip width**' of one another) and where visibility (usually determined by vegetation density) allows kangaroos to be observed before they move off in response to the observer.

The defining feature of the Walked Line Transect method is the calculation of a 'detection function' expressing the probability of recording kangaroos as a function of their perpendicular displacement from transects. In our application of the method, 44km of north-west to south-east orientated transects (oriented perpendicular to the winter sunrise so the light is from the side, and approximately the same whichever direction a transect is walked). Transects are walked over 12-16 mornings within three hours of first light before the kangaroos have started to lie down and while many are grazing in open areas away from cover. Only transects more than 600m apart (perpendicular distance) are surveyed on the same morning. As the transect is traversed, the distance and bearing to each group of kangaroos is measured with a laser rangefinder and compass as well as the position of the observer (with a GPS) and the number of kangaroo in the group. From these data, the UTM coordinates of each kangaroo group are calculated then these locations are assigned to the vegetation structure class and land tenure in which they occur. Thus the data are stratified at the observation level prior to being analysed in program *Distance* Ver6. Using the MCDS engine detection functions are estimated for each vegetation stratum and land tenure, enabling more accurate overall estimates of abundance to be obtained with greater precision. An example of a transect layout used for a Walked Line Transect estimate is shown in Figure 5.

4.4. Pellet Counts

Faecal Pellet Counts have been used to estimate the density of a range of species, and have the benefit of representing the number of animals using an area over an extended time period (as opposed to giving a 'snapshot' of density at the time the observer was present as for some other methods). They can also provide density estimates for well vegetated areas where other methods are limited by the potential for kangaroos to react to the observer before being seen. However Pellet Counts are expensive, have wide confidence intervals, and are vulnerable to rainstorms during the 3 week interval between clearing and counting of quadrats. Rain events which wash pellets across the ground require the count to be started again. In our application of the method, pellets are cleared from 15 circular quadrats (2 m diameter) positioned 6 m apart along each of 16 transect lines, which are randomly allocated in pairs 80 m apart throughout the reserve (stratified for vegetation type; Figure 6). A set of reference pellets which were voided on the same day as the quadrats are cleared is left at every transect. Pellets are then allowed to accumulate over approximately 21 days before quadrats are revisited and the fresh pellets counted. The number of pellets detected on each transect is translated into a kangaroo density based on calibration with a comparatively vegetated area with a known kangaroo density where pellet counts have also been conducted.

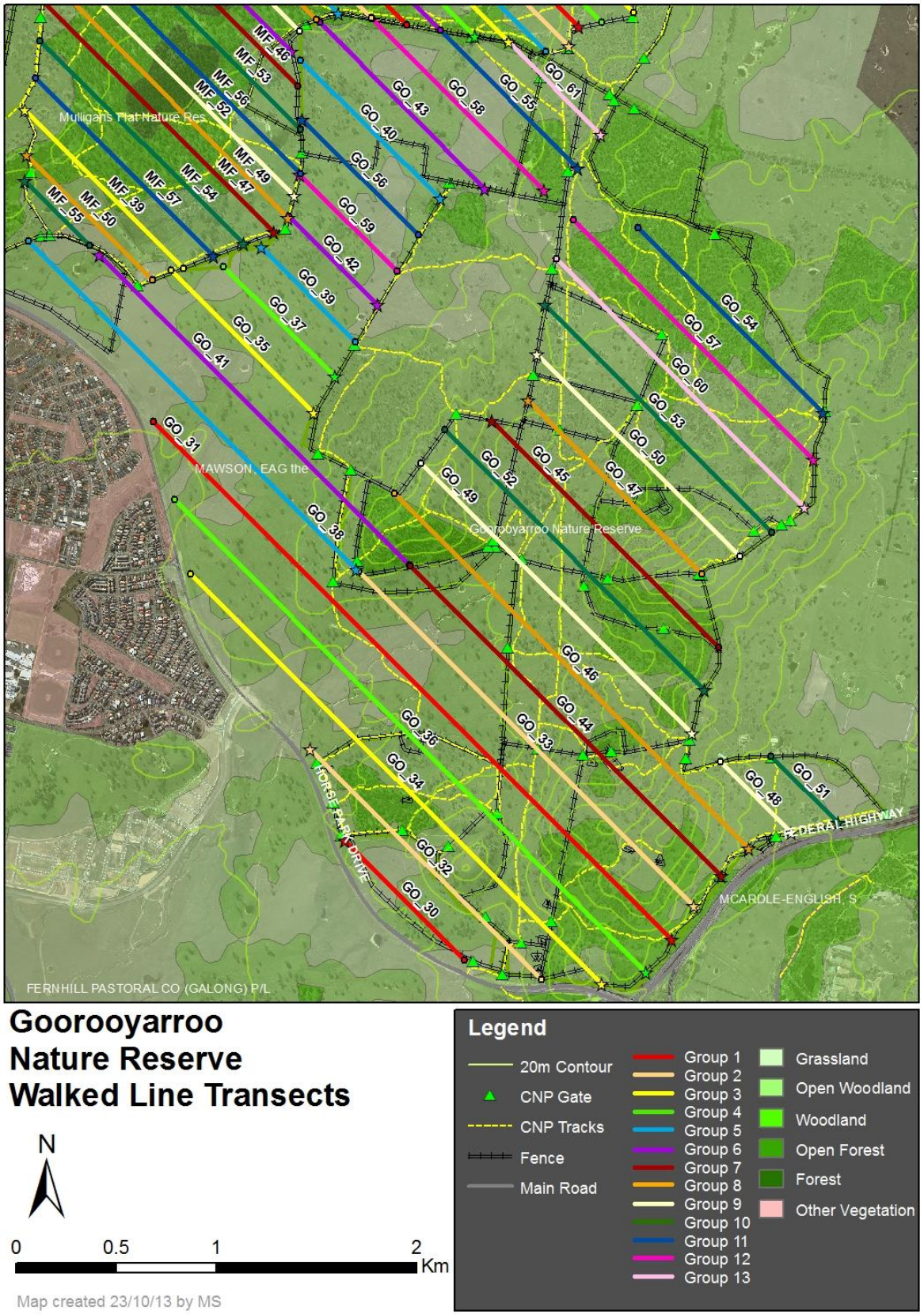

Figure 5. An example of a map used for Walked Line Transect counts. Each colour coded group of transects is surveyed on a different day to avoid observation of animals which have been displaced from a previous transect. Each management area contains approximately 44 km of transects.

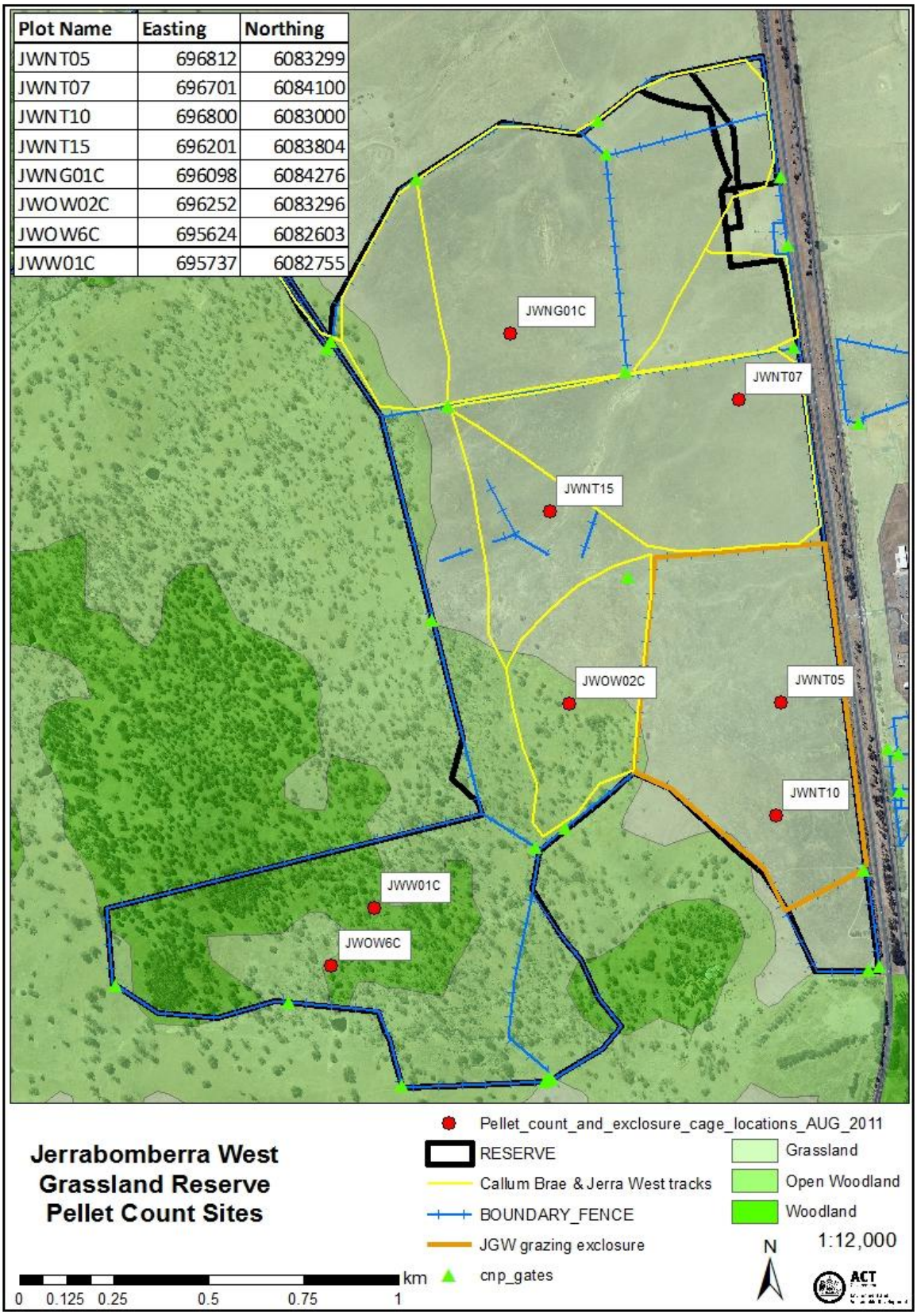

Figure 6. Pellet Count plots at Jerrabomberra West Grassland Reserve. Each point represents the north-west corner of a 1 ha research plot, within which are two parallel 100m transects (running north to south) spaced 80m apart. Pellets are cleared and counted at 15 quadrats along each transect. A defecation rate established from a calibration site is used to determine density.

4.5. Count methods trial

In 2014, a methods trial will be conducted to evaluate the relative cost and accuracy of each of the four count methods. Sites included will encompass a range of kangaroo population densities and both grassland and woodland dominated reserves (Table 1).

Table 1. Research sites for count methods trial in 2014 and methods proposed.

Site Name	Vegetation Type	Approx. EGK/ha	Direct or Sweep Count	Pellet Count	Walked Line Transect Count
Mulanggari NR	Grassland	1	Yes	Yes	Yes
Gungaderra NR	Grassland	2	Yes	Yes	Yes
Farrer Ridge NR	Woodland	3	Yes	Yes	Yes
Wanniassa Hills NR	Woodland	4	No	Yes	Yes
Jerrabomberra East	Grassland	5	Yes	Yes	Yes
Dunnarts Flat Excl.	Woodland	<1	Yes	Yes	No

5. IDENTIFICATION OF RESEARCH PLOTS

In Stage 1 of the research design, up to eight plots (1 ha) were randomly positioned within vegetation structure strata in reserves which spanned a range of kangaroo population densities. The basis of this design was to monitor biodiversity values at a reserve scale and relate these measured parameters to kangaroo density. By 2014, subsequent kangaroo management has resulted in many reserves having similar kangaroo densities (0.5 - 1.5 EGK/ha) which lead to a degree of redundancy in sampling effort and reduced the power of the research in detecting the target relationships.

In Stage 2, research plots will be chosen to encompass a range of kangaroo densities as well as being stratified for vegetation type (grassland or open woodland) and grass community (*Themeda, Austrostipa/Rytidosperma* or *Phalaris* dominated). Plots were chosen either based on the knowledge of grass community type from surveys undertaken during Stage 1, or by locating patches of the targeted grass community types within reserves with appropriate kangaroo densities and randomly choosing the placement of the north-west corner post. Two plots were selected for each combination of kangaroo density, vegetation type and grass community where possible and an effort was made to place each replicate in a different reserve to increase independence and reduce the impact of any reserve-specific stochastic event. A list of plots used in Stage 1 and Stage 2 can be found in Table 2. No *Themeda* dominated plots were identified above 3 kangaroos per hectare and no open woodland plots were established at any kangaroo density for *Phalaris* dominated grass communities.

Table 2. Summary of 1 ha research plots used in Stage 1 and Stage 2.

Surveys conducted for each plot are shown for Stage 1. Additional stratification for grass community is shown for Stage 2 (all surveys at all plots). Details on the number of floristic plots used in Stage 1 are described in Vivan and Godfree (2014). NB: *not surveyed in 2012; G, grassland; OW, open woodland; W, woodland; OF, open forest; F, forest; HM, herbage mass; Au/Ry, *Austrostipa/Rytidosperma* dominated; Them, *Themeda* dominated; Phal, *Phalaris* dominated.

Site Name	Approx. EGK/ha			Veg Type	Stage 1			Stage 2		
	2012	2013	2014		Cages	HM	Tiles	Au/Ry	Them	Phal
BNTS	2	1	-	G	4	-	-	-	-	-
Callum Brae	2	1	2	OW	7	7	4	1	-	-
				W	1	1	-			
Campbell Park	1	3	3	G	-	3	3	1	-	-
Crace*	1	1	1	G	-	6	4	1	1	1
				OW	-	1	1	-	-	-
				W	-	1	-			
Dam Paddock	1	1	-	OW	-	2	2	-	-	-
Dunnarts Flat	1	1	0	G	-	1	1	1	1	-
				OW	-	3	3	1	2	-
Farrer Ridge	2	3	3	OW	3	3	3	1	1	-
				W	4	4	-			
				F	1	1	-			
Forest Carpark	-	-	0	OW	-	-	-	1	-	-
Googong	3	3	3	G	2	2	2	1	2	-
				OW	4	4	4	1	1	-
				W	2	2	-			
Goorooyarroo	1	1	1	OW	5	5	4	1	1	-
				W	3	3	-			
Gungaderra*	-	2	2	G	-	6	6	1	1	1
				W	-	2	-			
Jerra East	2	5	5	G	-	7	4	2	-	2
(Exclosure)	0	0	0	G	-	3	3	1	-	1
Jerra West	0	1	0	G	-	-	-	-	-	2
Kama	1	1	1	G	-	2	2	-	-	-
				OW	-	5	3	-	-	-
				W	-	1	-			
Mt Painter	2	2	2	G	-	2	2	-	-	-
				OW	-	-	-	-	1	-
Mt Majura*	-	1	-	OW	-	2	-	-	-	-
				W	-	2	-			
				OF	-	2	-			
				F	-	2	-			
Mulanggari*	-	1	1	G	-	5	3	1	1	1
				OW	-	3	3	1	1	-
Mulligans Flat	2	1	-	OW	3	3	3	-	-	-
				W	3	3	-			
				F	2	2	-			
North Mitchell	0	0	0	G	2	2	2	-	-	1
NTA	-	-	2	G	-	-	-	1	1	1
Pinnacle*	2	2	2	OW	-	2	2	1	-	-
				W	-	2	-			
Wanniassa*	1	4	4	OW	-	4	4	2	-	-
				W	-	2	-			
				F	-	2	-			
Yarramundi	-	-	0	G	-	-	-	-	1	-

6. ASSESSING HERBIVORE OFF-TAKE

The impacts of kangaroo grazing on local biodiversity are rarely direct (e.g. kangaroos grazing favoured plants species or their flowers and seeds). More generally kangaroo grazing will alter the structure and biomass of the ground level vegetation which will in turn affect flora and fauna abundance and diversity. As kangaroos are likely to vary in their utilisation of specific habitat patches within a reserve, measures of kangaroo density estimated at the reserve scale as a minimum in Stage 1 may not provide a good fit with measures of grazing effect measured at each 1 ha plot. A large number of 1 ha plots would be required to detect the relationship in this way. Instead, kangaroo off-take will be measured at each plot in Stage 2, i.e. at the same scale at which potential secondary impacts (i.e. changes to flora and fauna abundance and diversity) are also measured.

Thus kangaroo off-take will be measured at two scales. Firstly, off-take will be measured at the reserve scale to understand the overarching relationship between kangaroo density and off-take within specific vegetation communities. This aspect will involve setting up 30 individual pairs of quadrats in a systematic design across a small number of reserves where kangaroo numbers are easily quantified and where there is limited kangaroo immigration or grazing by domestic stock (Figure 6). The reserves chosen for this assessment are shown in Table 3. Each pair of quadrats will consist of a 0.25 m^2 'uncaged quadrat' (marked by a buried tent peg) and a matched (in terms of species composition and herbage mass) 0.25 m^2 'caged quadrat' surrounded by a ~1 m high ring of 50mm mesh. Both quadrats will be assessed at 6-monthly intervals for grass height, herbage mass dry weight, % green grass, % bare ground, % grass cover, three most dominant grass species (ranked 1-3) and % contribution to dry weight of non-grass vegetation; before being re-set.

In addition to the reserve-scale measures of kangaroo off-take, plot level measures of kangaroo grazing pressure (off-take) will also be conducted using two pairs of caged and uncaged quadrats (as above) within each 1 ha research plot. Cages will be positioned 9, 15 or 21 m south of the northern perimeter of the plot, on transects 10 m in from the eastern and western perimeters (see Figure 7a). Studies in Stage 1 using cages that exclude kangaroos but not rabbits have demonstrated kangaroos to be the dominant herbivore within research reserves and so the incidental exclusion of any alternative herbivores (e.g. rabbits) is expected to have negligible impacts on our results.

Table 3. Research sites proposed for assessing the relationship between kangaroo density and grass community-specific pasture off-take.

Site Name	Vegetation Type	Approx. EGK/ha	Site Notes
Dunnarts Flat Excl.	Woodland	<1	Kangaroo exclosure
Mulanggari NR	Grassland	1	Isolated nature reserve
Gungaderra NR	Grassland	2	Isolated nature reserve
Googong Foreshore	Mixed	3	Stable kangaroo population
Farrer Ridge NR	Woodland	3	Isolated nature reserve
Jerrabomberra East	Grassland	5	Stable kangaroo population

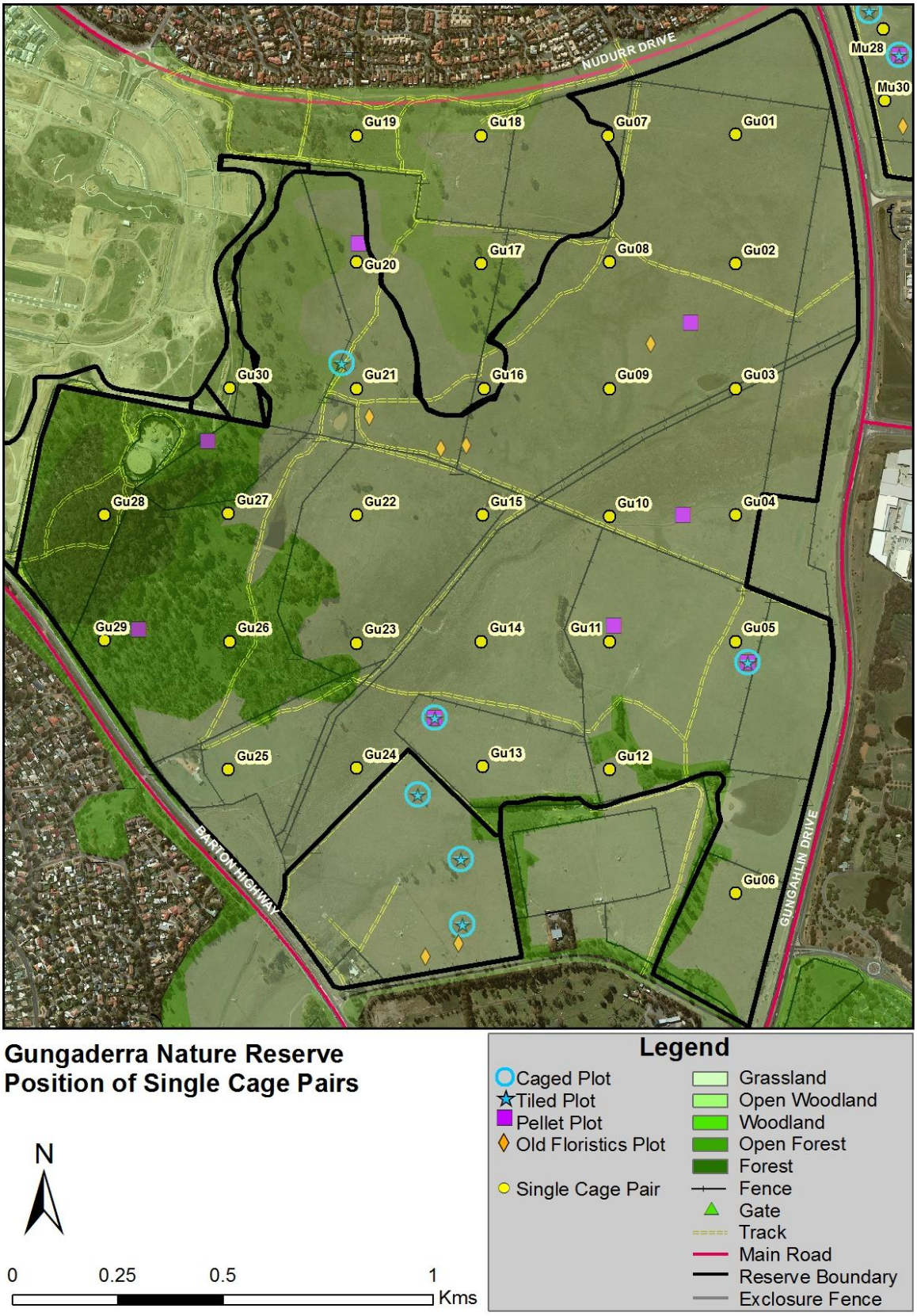

Figure 6. Map showing the systematic layout of 30 paired 'caged' and 'uncaged' quadrats to assess the relationship between kangaroo density and pasture off-take at the reserve level. Points on the map indicate the position of the uncaged quadrat; a matched quadrat is located nearby and caged.

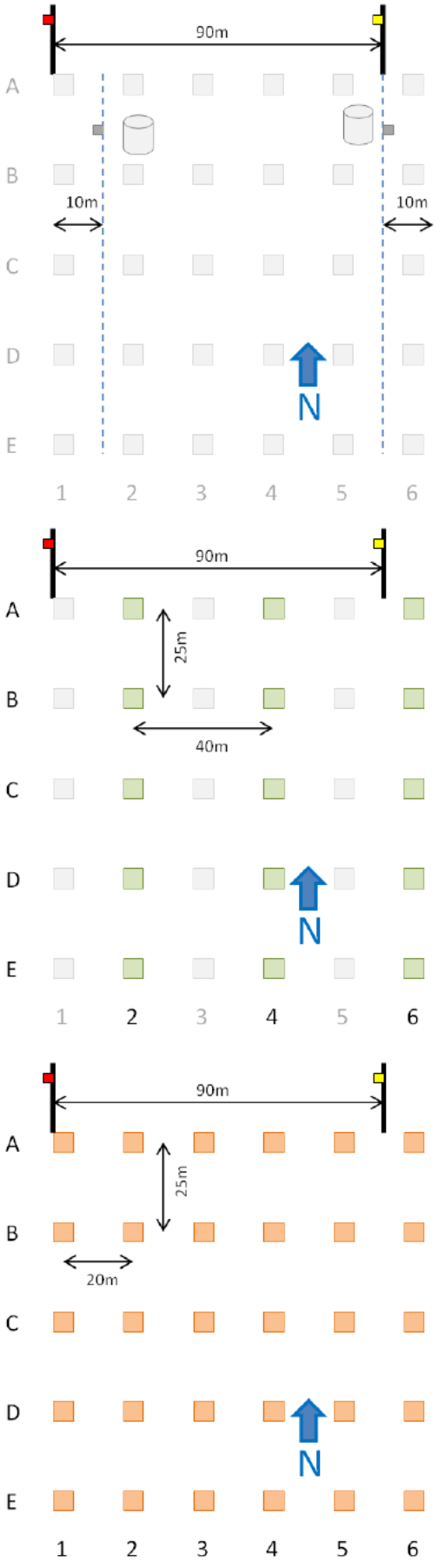

Figure 7. Plot layouts for various survey types

All plots are 1ha (100x100 m) and are marked with labelled star pickets (▮) at the northwest corner and 90 m east of the northwest corner.

TOP: Plot based herbivore exclusion cages
Herbage off-take by herbivores (kangaroos) is assessed at the 1 ha plot level by comparing paired 'caged' (⬭) and 'uncaged' (▪) quadrats which had comparable composition and herbage mass when set up 6 months prior. Two pairs of quadrats are placed on each plot, 9, 12 or 15m south of the northern perimeter on a transect 10 m in from the western and eastern edges of the transect.

MIDDLE: Vegetation structure and biomass
Vegetation structure and biomass are measured at a minimum of 15 quadrats (▪) within each plot (rows 2, 4 and 6). Quadrats are positioned such that the 1 m^2 quadrat surveys the area immediately surrounding the tile placed for reptile surveys. Additional quadrats are surveyed where the associated tile has been known to 'capture' a reptile.

BOTTOM: Reptile diversity and abundance
Thirty roof tiles (▪) are positioned in a grid within the 1ha plot and labelled according the grid positions shown. Tile 1A is at the foot of the north-west post. Tiles are positioned up to three months prior to the start of reptile surveys. During the mid-October to mid-November survey period tiles are checked 5-10 times (budget dependent).

7. ASSESSING VEGETATION STRUCTURE AND HERBAGE MASS

The structure and herbage-mass of ground-layer vegetation will be assessed at each plot and related to kangaroo off-take to quantify relationships with varying degrees of kangaroo impacts. For each plot a minimum of 15 quadrats, each 1 m^2, will be sampled. The quadrats are positioned to survey the area immediately surrounding the reptile survey tiles (See Section 8) in the second, fourth and sixth rows of tiles. Therefore, the quadrats are at 25 m intervals along north-south running transects, which themselves are 40 m apart (20 m, 60 m and 100 m from western edge of plot; see Figure 7b).

Data collected during vegetation structure and biomass surveys will include:

- average grass height (x4), plate meter reading (x4) and height of tallest tussock (x4)
- % contribution to dry weight of top four plants (defined to species for grasses, or as forb sedge/rush, wood)
- % cover of bare ground, grass, litter, non-grass vegetation (should add to 100%)
- % grass which is green
- depth of thatch
- perennial grass reproductive status (number of flowers/seedheads: none, 0-10, 11-50, >50)
- if there is a log, shrub, tree or rock within 2 m

8. ASSESSING FLORISTIC RICHNESS AND DIVERSITY

Ground layer floristic diversity will be assessed in relation to ground-layer vegetation structure and biomass, but is also considered likely to be influenced by both overall vegetation type (grassland/woodland) and ground-layer community (*Themeda, Austrostipa/Rytidosperma* or *Phalaris* dominated). A floristic value score will be determined at two levels within the plot. The first assessment will be made in a 20 x 20 m quadrant placed in the patch considered to be of most value, whilst the second score will be based on the entire 1 ha area. A complete species list will thus be derived for each component. A second assessment of cover will also be completed as part of the floristic diversity survey using a step-point transect to determine inter-tussock distances, % cover and % litter.

9. ASSESSING REPTILE ABUNDANCE, RICHNESS AND DIVERSITY

Reptile abundance and diversity will be assessed in relation to ground-layer vegetation structure and biomass. Reptiles are surveyed using grids of 30 roof tiles, positioned in a 5 x 6 grid within the 1 ha research plots (i.e. tiles spaced 20 x 25 m apart) up to three months prior to the start of the survey season (see Figure 7c). Preliminary surveys used 15 tiles per plot before changing to 30 tiles at 5 m spacing. Tiles 5 m apart were found to be statistically independent for *Delma impar* and *D. inornata*. We assume the tiles 20-25 m apart will be independent for the majority of reptile species we encounter, most of which are smaller than the *Delma* species. From mid-October to the end of November, each tile will be checked 5-10 times for reptiles sheltering under or basking on the tile (budget dependent). In addition, two 15 minute 'active search' surveys will be conducted within the plot during the survey period. Reptiles observed during refuge surveys, active search surveys or

incidentally during the survey period will be identified to species level and recorded, where appropriate, at the tile level to allow microhabitat preferences for individual species to be assessed.

10. ASSESSING SMALL MAMMAL ABUNDANCE

Local researchers had believed small mammals to have virtually disappeared from Canberra Nature Park in recent decades, with some surveys finding even the introduced House Mouse and Black Rat to be rare or absent. The species which have disappeared certainly include Yellow-footed Antechinus, Agile Antechinus, and Bush Rat. There are probably others. Based on bones less than 200 years old left in caves by owls, other local species included New Holland Mouse, Eastern Chestnut Mouse and Tasmanian Long-tailed Mouse.

Exceptions to the absence of small mammals from surveys was the capture of a Common Dunnart at Mulligans Flat before the fox and cat-proof fence was built there, and increasing numbers of both the Dunnart and the House Mouse inside the fence subsequently. Another exception was the discovery during our reptile survey in 2014 of several individual Dunnarts and House Mice including some well out in grasslands away from the wooded areas previously surveyed for small mammals. The grasslands have not previously been considered as small mammal habitat but they appear to have potential to meet the habitat requirements of some species better than areas previously surveyed.

Due to the paucity of small mammals in Canberra Nature Park in recent years, the investigation of the relationship between small mammals and ground layer vegetation will initially be restricted to a small number of sites where large, pre-established grazing exclosures provide an opportunity to compare small mammal relative abundance across grazed and un-grazed treatments. Surveys conducted in spring will use grids of 25 tracking tunnels to compare relative abundance (based on the proportion of traps used) across grazed and ungrazed areas. The number of plots assessed at each site will depend on the site area. A control site where vegetation is comparable despite the presence of a grazing exclosure will be used to determine any effect of the exclosure *per se* on factors such as predation (Table 4).

Table 4. Proposed sites for small mammal surveys.

Treatment	Sites	Approx. EGK Density
Control	Jerrabomberra West *vs.*	<1
	JW Kangaroo Exclosure	<1
Site 1	Jerrabomberra East vs.	5
	JE Kangaroo Exclosure	<1
Site 2	Goorooyarroo NR vs.	1
	Dunnarts Flat Exclosure	1
Site 3	Goorooyarroo NR vs.	1
	Forest Exclosure	<1

11. ASSESSING BIRD ABUNDANCE AND DIVERSITY

A survey of bird abundance and diversity may also be undertaken at the plot level using volunteers. To avoid the issues surrounding the multiple broad scale factors which are known to influence bird abundance and diversity (e.g. distance to urban landscape, distance to water etc.) only birds observed to interact with the plot (and possibly only then the ground layer of the plot) will be analysed after being classified into a functional guilds based on diet and size.

Standard 20 minute surveys will be conducted within 3-4 hours of sunrise or sunset. Data will be collected regarding the species present (and number of individuals), the height strata in which individuals are observed, and the behaviours exhibited (e.g. foraging, territorial, singing, perching). Incidental observations (other species, birds elsewhere on the plot or outside of the plot) can be recorded as a secondary aim if desired – but are of less interest to this study.

12. ASSESSING INVERTEBRATE ABUNDANCE AND DIVERSITY

Pit fall trapping for invertebrates would be a useful adjunct to the planned surveys and could take advantage of the existing design and data collection. Any approaches by students or other researchers to undertake this work will be encouraged.

13. STATISTICAL ANALYSIS

Statistical analyses will be conducted by a statistical consultant using a mixed model approach. Due to the stratification levels included in this research design, analyses should consider the influences of vegetation type and grass community type when assessing the impacts of kangaroos on ground level vegetation and the resulting impacts on ground-layer biodiversity.

14. BUDGET

Details of the project budget can be found in Table 5. A breakdown of the expected costs associated with kangaroo counts specifically is shown in Table 6.

Table 5. An indicative overview of the budget for the Kangaroos and Conservation research.

This incorporates funds for the laying out of research plots, biennial measurements of kangaroo off-take at the plot and reserve level ('Cages'), annual reptile surveys, biennial surveys for herbage mass and structure, annual floristics surveys and a small amount of consumables (mostly field equipment such as compasses, tape measures, steel posts etc.)

The cost of the kangaroo counts is also shown for two years, including a methods trial undertaken in year 1 only (see Section 3). The cost shown for kangaroo counts also includes non-research areas counted as required for the annual conservation cull conducted by TAMS. A breakdown of the relative costs of different counting activities can be found in Table 6.

Survey	No. of Plots	Comments	No. of People	No. of Days	Cost per Day	Cost per Survey	Total Cost
Plot Cages	45	3-4 plots per day	2	14	$630	$8,820	$42,000
Reserve Cages	180	25 cage pairs per day	4	8	$1,260	$10,080	$48,000
Herbage Mass/Structure	45	3-4 plots per day	2	14	$630	$8,820	$21,000
Florstic Surveys	45						$30,000
Reptile Surveys							
Set up	45	4 plots per day	2	11	$630	$6,930	$16,500
Survey	45	5 checks @ 16 plots per day	2	14	$630	$8,820	$17,640
Consumables							$5,000
Statistical Consultant							$15,000
Total for ecological surveys (details above)							**$200,140**
Total for kangaroo counts (incl. methods trial in 2014; see Table 5)							**$97,650**
PREDICTED COST OF PROJECT OVER TWO YEARS							**$292,790**

Count	Person/ Days	Cost PP	Total
METHODS TRIAL			
Sweeps + Direct			
Dunnarts*^	8	$315	$2,520
Farrer Ridge*^	20	$315	$6,300
Gungaderra*^	10	$315	$3,150
Jerra East + Excl.	4	$315	$1,260
Mulanggari*^	4	$315	$1,260
Pellets			
Mulanggari	10	$315	$3,150
Gungaderra	10	$315	$3,150
Jerra East*^	10	$315	$3,150
Dunnarts	10	$315	$3,150
Farrer Ridge	10	$315	$3,150
Wanniassa	10	$315	$3,150
WLT			
Mulanggari	8	$315	$2,520
Gungaderra	8	$315	$2,520
Jerra East	8	$315	$2,520
Farrer Ridge	8	$315	$2,520
Wanniassa*	8	$315	$2,520
OTHERS			
Sweeps			
Crace*	4	$315	$1,260
Mt Painter*	10	$315	$3,150
Pinnacle*	6	$315	$1,890
NTA^	1	$315	$315
WLT			
Googong^	8	$315	$2,520
MFWS*	8	$315	$2,520
Callum Brae*	8	$315	$2,520
Goorooyarroo*	8	$315	$2,520
Cost of counting research sites			**$18,900**
Cost of counting potential culling sites			**$32,760**
Basic annual cost of kangaroo counts			**$35,280**
Additional once-off cost of methods trial			***$27,090***

*Minimum counts required for conservation cull
^Minimum counts required for research
NB. Overlap exists between cull and research counts

Table 6. Breakdown of costs associated with kangaroo counts

This table shows a breakdown of the expected costs for counting each reserve according to a variety of methods. The 'typical' methods used for this reserve are marked as being either required for the conservation cull (*) or the research design (^). The summaries at the base of this table show the annual cost for counting research sites, conducting the methods trial (NB this is in addition to the basic cost of counting research sites), the cost for counting non-research sites (i.e. those counted for the conservation cull) and the total cost of counts required for the conservation cull (NB some overlap with the reserves in which counting is required for research).

15. PROJECT MILESTONES AND DELIVERABLES

June – August 2014:	Establish new plots, set up reptile surveys and off-take surveys. Conduct kangaroo counts at all research reserves.
August – September 2014:	Complete kangaroo counts at potential conservation cull reserves.
October – November 2014:	Conduct surveys for reptiles, herbage mass and structure, and floristic diversity. *(Undertake bird, small mammal and/or invertebrate surveys)*
January 2015:	Review and analyse data. Write progress report.
February 2015:	Measure and re-set off-take cages.
April – July 2015:	Conduct kangaroo counts at all research and potential conservation cull reserves.
June – August 2015:	Set up reptile surveys and measure and re-set off-take cages.
October – November 2015:	Conduct surveys for reptiles, herbage mass and structure, and floristic diversity. *(Undertake bird, small mammal and/or invertebrate surveys)*
January 2016:	Review and analyse data. Write progress report.
February 2016:	Measure and re-set off-take cages.
March – June 2016:	Compile and analyse all data. Write final report.

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Neave H, Tanton M (1989) The Effects of Grazing by Kangaroos and Rabbits on the Vegetation and the Habitat of Other Fauna in the Tidbinbilla Nature Reserve, Australian Capital Territory. *Wildlife Research* **16**: 337-351.

Vivian LM and Godfree RC (2014) Relationships between vegetation condition and kangaroo density in lowland grassy ecosystems of the northern Australian Capital Territory: analysis of data 2009, 2010 and 2013. CSIRO, Australia.

Herbage Mass and Structure Kit

Please ensure this kit contains:

- Paper backup data sheets
- 2 metal rulers
- 2 falling plate meters
- 2 square quadrat markers (1m x 1m)
- Gloves
- Sun cream and wet wipes
- Spare batteries
- Sample bags
- Plot marking kit
    - Spare cattle tags, zip ties and cattle-tag marker
    - Spare post caps

You will need to collect the following from inside:

- Tablet loaded with data sheets (see Mel if you'd like a second tablet)
- GPS and maps
- Keys to reserve and vehicle

Method for measuring herbage mass and structure

We will be measuring herbage mass and structure at each of our research plots. The purpose of these measurements is to be able to relate kangaroo off-take at the plot level to the resulting herbage mass and structure, which in turn will likely influence the ground layer floristic and reptile biodiversity. Within each plot, we will measure the vegetation in a 1m x 1m quadrat immediately surrounding all tiles in rows 2, 4 and 6 (Figure 1). Additional measures of any other tiles which 'capture' a reptile will be completed once reptile surveys are finished.

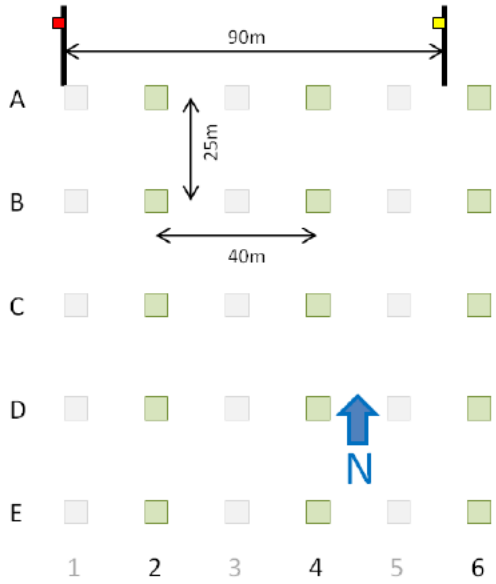


Figure 1. Research plot layout showing tiles which are measured during the initial herbage mass and structure surveys.

At Each Tile

Check the plot ID on the NW or NE corner post to confirm you are where you think you are! The following measurements should then be made around each tile:

- **Average grass height;** measured once on each side of the tile (i.e. four points within quadrat; Fig. 2) to reflect the average height of the quarter being sampled
- **Plate meter reading;** measured once on each side of the tile (i.e. four points within quadrat; Fig. 2)
- **Height of tallest tussock;** measured once on each side of the tile (i.e. four points within quadrat)
- **% Contribution to dry weight of top four plants;** grasses should be identified to species, any non-grass species in the top four can be grouped and classified as 'forbs', 'sedge/rush' or 'wood'.
- **% Cover of grass, non-grass vegetation, rock, log, thatch, bare ground and litter.** Can exceed 100%.
- **% Grass which is green.**
- **Depth of thatch;** (cm). See definition of thatch.
- **Perennial grass reproductive status;** number of flowers/seed heads (None, 0-10, 11-50, >50).
- **If there is a log, shrub, rock or tree within 2m** of the tile.

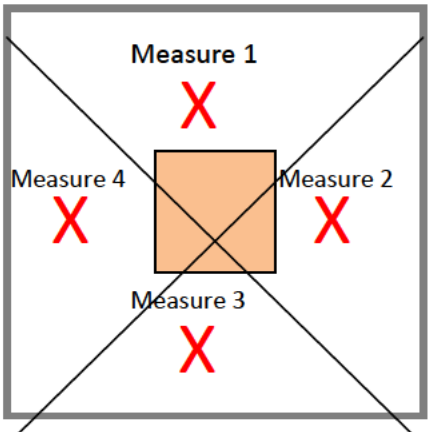


Figure 2. The approximate position at which height measures and falling plate readings should be collected, relative to the tile in the centre.

Measuring the Vegetation

Site and ***Plot ID***

The Site and Plot ID should be chosen from the drop down lists provided. Plot names have been modified to avoid those which were confusingly similar. This change in naming also has great potential to cause confusion. Please ensure you use and carefully quote (including full stops) the new plot name which will have the following structure:

XXX.YY.AAB e.g. 123.GU.GrT

XXX = three digit number, unique to that plot. First two numbers are specific to that reserve.

YY = two letter code for reserve.

AA = two letter code for vegetation type (grassland, Gr; or open woodland, OW)

B = one letter code for grass community type (P = *Phalaris*, S = *Austrostipa*, T = *Themeda*).

Surveyor

Just the person who is doing the measurements initials should be recorded here.

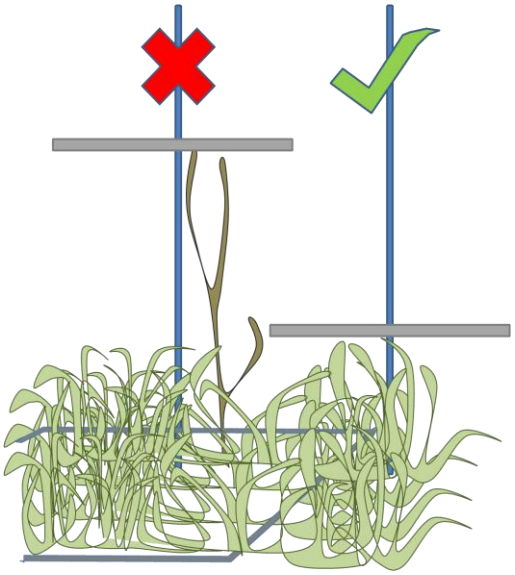
Date

In dd/mm/yyyy format please.

Average height

Mentally divide the quadrat into 4 equal sections (Figure 2). Average height measurements should reflect the average height of the grass across the section of the quadrat being sampled. That is, it should take into consideration any areas where grass height equals zero (e.g. if there is only bare ground or litter). Grass height should not consider flowering stems. Four such measurements should be taken within each quadrat, once on each side of the tile.

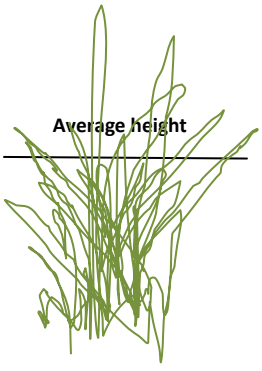
Plate meter



The falling plate meter is designed to give an approximation of the biomass of the grass, with both grass height and density contributing to where it falls. The plate meter should be positioned such that the rod is touching the ground and so that there are no obstacles (such as sticks, woody stems or rocks etc) influencing the reading. If there are obstacles in the quadrat, try to measure a comparable amount of grass of the same species nearby where no obstacles are present. **DO NOT MOVE OBSTACLES OUT OF THE QUADRAT** as this will interfere with the microhabitat for reptiles also being surveyed here. If the ground is steeply sloped, the plate meter should be used perpendicular to the ground (i.e. sloped) so that the plate does not get caught on the ground.

There are two types of falling plate meter, the round one and the square one. They each give a different value depending on the height of the grass and so it is important to specify in the data sheet which one is being used.

Height of tallest tussock



The height of the tallest tussock should be measured on each side of the tile (i.e. four measures per quadrat). Height measures still do not include flowering stems, but instead should reflect the average height of the non-flowering leaves of grass of that single tussock. This is not the highest point reached by any grass blade but rather where the bulk of the vegetation reaches to.

Species composition

For each quadrat, identify the dominant four plants based on their contribution to the dry weight of the herbage mass. Each of the four positions should be either filled with a specific grass species, or grouped 'forbs', 'sedge/rushes' or 'wood'. For example, you might record that 50% of the total dry weight is *Austrostipa scabra*, 30% is 'forbs' (various native and introduced species combined), 15% is *Themeda australis* and 5% is a small sapling ('wood'). Look at the reference photos for a guide to help you know how much different grasses weigh when dried. Use the drop down lists to choose grass species and add extra species if necessary by inserting a cell in the middle of the list (unless you know how named ranges work). Note that it is not necessary to ID *Rytidosperma spp.* to species .

Percent cover of grass, non-grass vegetation, litter, rock, log and bare ground

Record the percentage of the quadrat which is covered by each category. 'Rock' should be of a size that couldn't be dislodged by animal movement. 'Logs' should be >5cm diameter otherwise recorded as litter. Lichen and moss count as 'non-grass vegetation'. 'Bare ground' must be bare dirt. The totals for the quadrat can exceed 100%.

Percent green

This is the percentage of the attached grass (i.e. not unattached thatch, see Glossary) which is green. Note that it is often much lower than you'd think – it often helps to grab a handful that is typical of the dead and live 'grass' mass and then look closely at how many blades are green vs. dried.

Depth of thatch

See Glossary for a definition of thatch. The depth of thatch should be measured using a metal ruler. Thatch shouldn't (in theory) also contribute towards grass height or the falling plate meter reading. It should not be considered as part of the % green measure.

Grass reproductive status

An estimate of the number of flowering stems (perennial grasses only) within the quadrat should be made. Estimates should be categorised as either 'None', '0-10', '11-50' or '>50'. Note this is a measure for the whole quadrat, not for each species. Flowers or seed heads from annual grasses should not be included.

Presence of log, rock, shrub or tree

If there is a log (>5cm diameter), rock (not displaceable by animal movement), shrub (or shrub-like structure) or tree visible within 2m of the tile it should be recorded here.

Glossary

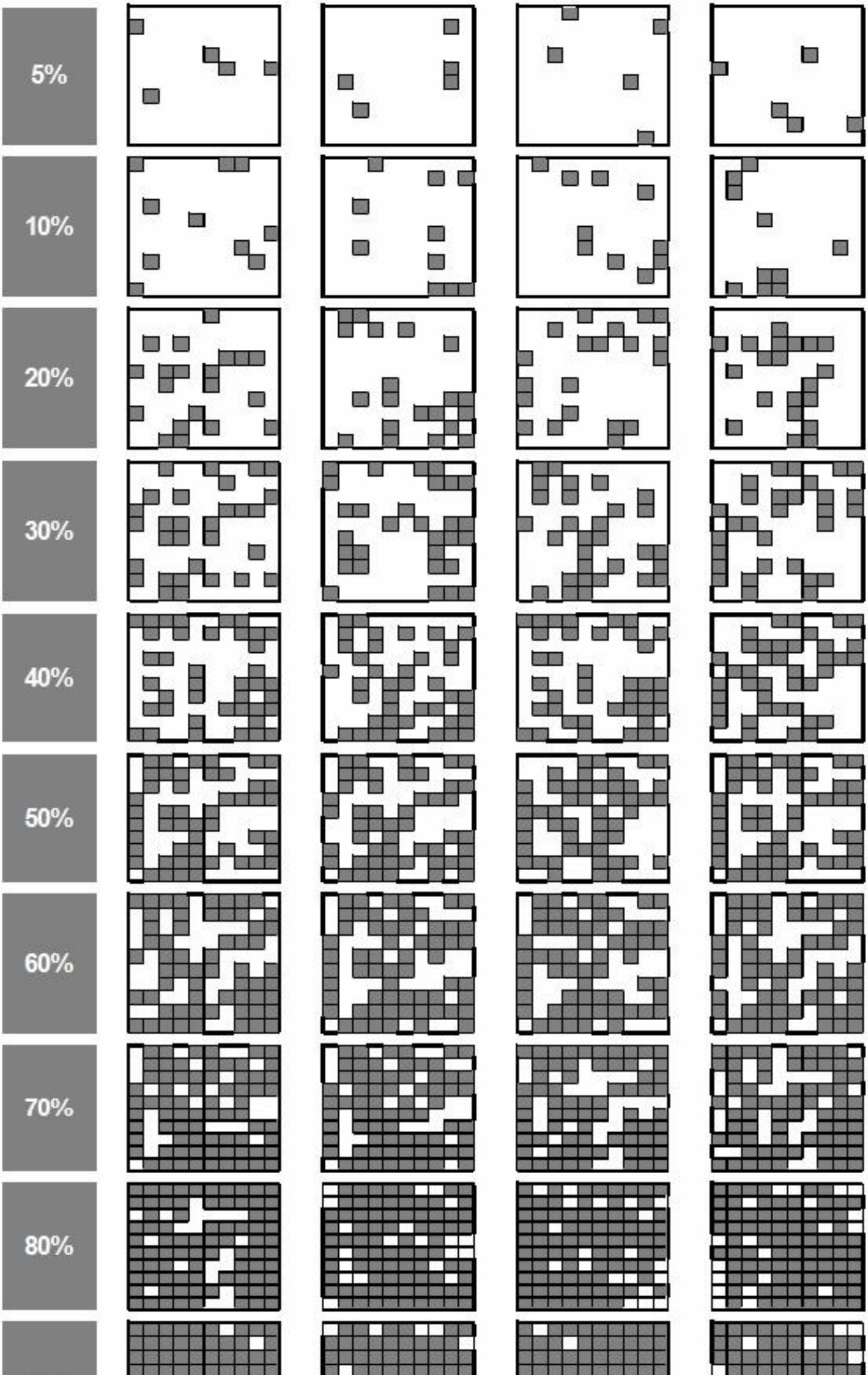
Grass – both the alive and dead portions of tussocky or spreading monocot species, not including sedges, rushes or lomandra, are classified as grass. Dead portions which are still attached (or intricately associated, i.e. woven in with the rest of a tussock) with the rest of the plant are generally counted as 'grass' rather than 'thatch' and contribute to the measures of height, % green and the plate meter reading.

Thatch – the dead, unattached blades of grass which form a mat on the ground are thatch. Thatch does not count towards % green, height or, if you can avoid it, the plate meter measure.

Flowering stem – often stems with flowers on the end will also have a couple of leaves (although the might be different to the bulk). These leaves are fine to include but do not count the top of the flowering stem (usually where the flowers are) towards height measures (including tallest tussock height) and avoid their influence on the plate meter where possible.

Shrub – a shrub can be a legitimate bush/shrub or something that has comparable 'bushy' structure such as a low/dense sapling or a large fern.

Tree – a tree is any upright woody structure that doesn't have much of a base to hide in (i.e. saplings or epicormic growth that provides ground cover should be classified as 'shrub' rather than 'tree').


5%
10%
20%
30%
40%
50%
60%
70%
80%

Off-take Cage Kit

Please ensure this kit contains:

- Paper backup data sheets
- 1 sighting compass
- 1 tape measures (50m)
- 1 or 2 metal rulers
- 1 or 2 falling plate meters
- 3 hula hoops per surveyor
- 50mm mesh
- Rope
- Aluminium pegs and tags
- Tent pegs and hammers
- Tools: pliers, clips, knife, lighter
- Scissors
- Gloves
- Oven bags
- Sun cream and wet wipes
- Spare batteries
- Plot marking kit
    - Spare cattle tags, zip ties and marker
    - Spare post caps
    - Spare wooden pegs
    - Mallet

You will need to collect the following from inside:

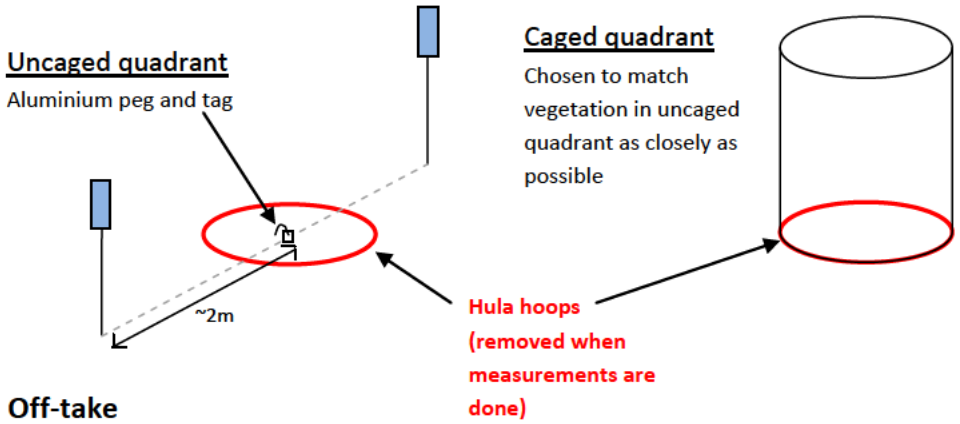
- 1 or 2 tablets loaded with data sheets
- GPS and maps
- Electric shears (should be on charge)
- Keys to reserve and vehicle
- Metal detector (and spare batteries off charger)

Method for measuring kangaroo off-take

We will be measuring kangaroo off-take in two sets of locations. At a number of reserves, 30 single randomly placed off-take cages will be set up and monitored at 6 monthly intervals (Reserve Level Off-take). Two sets of off-take cages will also be set up at each of our monitoring plots (Plot Level Off-take) to be monitored at the same interval. The placement differs for each type of cage set, but the measurements are the same. For each 'set' of cages, there should be one uncaged quadrant (a peg in the ground) and one caged quadrant (50mm mesh).

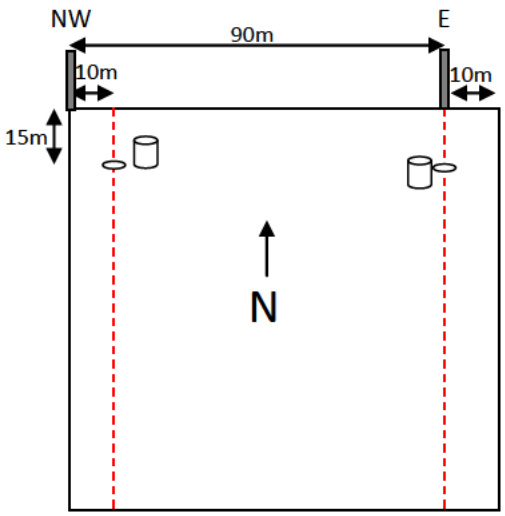
Reserve Level Off-take

Thirty random points will have been loaded into your GPS. Each one of these points should be set up as the 'uncaged quadrant' of a set. Hammer an aluminium tent peg and metal tag into the ground, and place two pin markers approx. 2m either side (such that the peg is on the imaginary line between them). Next place a hula hoop (55cm diameter) around the peg to show the uncaged quadrant and measure the vegetation as described below. Once measured, find a nearby area of vegetation comparable to the uncaged quadrant (in terms of composition and biomass). Measure the vegetation as for the 'uncaged quadrant' before surrounding it with a 50mm mesh cage (~ 85cm diameter) with white trim (plastic mesh or rope). Secure the cage to the ground with at least 6 medium or 8 small tent pegs. Where the ground is soft, more tent-pegs should be used and 'crossed over' where necessary.



Plot Level Off-take

The position of the fixed research plots should be marked in the GPS. Navigate your way to the NW post, and then go east 10m and south 15m to find the 'uncaged quadrant' location (unless otherwise specified on previous data sheets). The second uncaged quadrant for this plot will be 15m south of the 90m E post. It is not necessary to mark the uncaged quadrants with pin markers as they should be easier to find using a compass and metal detector. The position of the caged quadrants should be determined as described for the Reserve Level Off-take cages.



Measuring the Vegetation

Reserve and ***Plot***

The reserve and plot ID should be chosen from the drop down lists provided. Be careful as some plots have very similar names (e.g. GooOW09 and GooW09).

Surveyor

Just the person who is doing the measurements initials should be recorded here.

Date

In dd/mm/yy format please.

Plate meter:

There are two types of falling plate meter, the round one and the square one. They each give a different value depending on the height of the grass and so it is important to specify in the data sheet which one is being used.

Transect:

This refers to you either being on the east or west transect. Please choose from the drop down list.

Timing:

If the quadrant is being measured for the first time, select 'New'. If you are measuring a quadrant after it's been in place for 6 months already select 'Revisited'. In general you will do both in a single visit (unless it's only just being set up which is the case for some).

Uncaged plot placement:

Please specify how many meters south of the northern edge of the reserve the uncaged quadrant was placed. In general this will be 15m but if there is a giant blackberry bush or some other feature in the way it can be placed elsewhere (9m or 21m – remember this line is also used for pellet counts and you don't want the uncaged quadrant to be near a multiple of 6m).

Grass No. 1-3:

For each quadrant, identify the dominant three **grasses** based on their contribution to the dry weight of the herbage mass. Look at the reference photos for a guide to help you know how much different grasses weigh when dried. Please choose the grass species from the list provided. If it's not on the list then make a note in the notes section of what it was and I'll add it to the list for future. Note that it is not necessary to ID *Rytidosperma spp.* to species level.

Percent grass cover:

This is the percentage of the quadrant which is covered by grass (tussock base or overhanging foliage).

Percent bare:

This is the percentage of the ground within the quadrant which is bare dirt. A cover of rock, lichen or any other crust does not count as bare. This measure is to do with erosion potential.

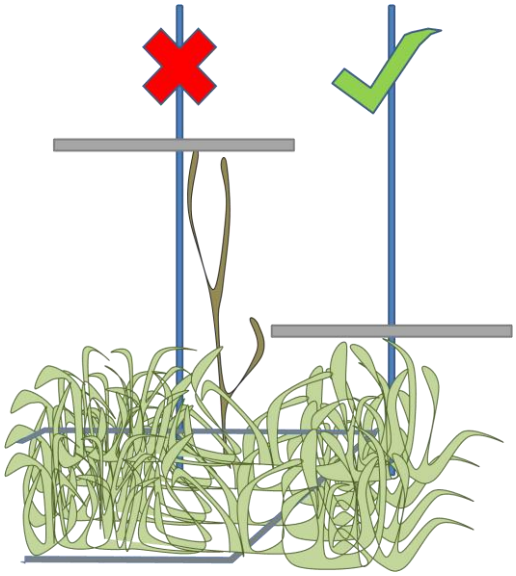
Percent green:

This is the percentage of the attached grass (i.e. not unattached thatch, see Glossary) which is green. Note that it is often much lower than you'd think – it often helps to grab a handful and then look closely at how many blades are green vs. dried.

Average grass height:

The average height of the grass over the plot should reflect just the grass blades, not the flowering stems or any thatch. This is true even of *Aristida* sp. (which is pretty much only stem at some times of year). Where there are patches without any grass, these should be considered as having a grass height of zero. As such, a quadrant with 50% cover of 10cm grass and 50% cover of no grass would have an average height of 5cm. To estimate this measure, place the ruler in a couple of different spots within the quadrant and average each reading to give the overall average to be recorded. With time you'll be able to do this by eye whilst holding the ruler in the centre of the plot.

Falling plate meter:



The falling plate meter is designed to give an approximation of the biomass of the grass (**excluding flowering stems**), with both grass height and density contributing to where it falls. The plate meter should be positioned such that the rod is touching the ground (i.e. penetrates any thatch or litter) and so that there are no obstacles (such as sticks, woody stems or rocks etc) influencing the reading. If there are obstacles in the quadrant they should be removed where possible. Where removing them is not possible try and measure a comparable amount of grass of the same species nearby where no obstacles are present. If the ground is steeply sloped, the plate meter should be used perpendicular to the ground so that the plate does not get caught on the ground.

Percent contribution of non-grass

This measure should also be based on an estimate of dry weight contributions. If the plot has a short covering of grass and lots of woody weeds, then you might enter 90% for woody weeds (hence assuming grass makes up only 10% of the total dry weight). If there are equal amounts of grass and weeds it would be 50% non-grass. Note that this could be anything from woody weeds, to native forbs, to sedges and rushes. Only ground layer plants count so shrubs and trees above about 30cm are excluded. Small saplings contributing to the ground layer are included.

Cutting a plot

When cages are revisited, the grass should be clipped for drying and weighing. As much as is possible, non-grass vegetation, litter, dirt and anything else that isn't grass should be excluded either before the quadrant is clipped or from the clipped material. Note that flowering grass stems and thatch should also be removed prior to the quadrant being clipped. Clipping the plots is the most accurate way of knowing herbage mass (and the most consistent between people), and we will also use this data to calibrate the indirect (height and plate meter) measures. Grass should be clipped as low as a kangaroo can graze, which is about 1cm from the ground and as close as you can really get without losing bits of grass or a finger. **Be really careful with the clippers and wear gloves.** Really short bits of fine grass (such as heavily grazed *Rytidosperma*) can be harvested with scissors instead if more practical. For large tussocks, such as *Phalaris*, you will get to a really dense, unclippable tussock base which you can just leave as is.

Types of cages

At the plots left over from previous years surveys there will be two types of cages, one made of 50mm mesh and one made of hinge joint. The hinge joint cages were to assess the relative impacts of kangaroos and rabbits – there was no evidence of significant rabbit off-take at any of our reserves and thus these cages will not be continued. Once you've measured the 'Revisit' data they can be pulled out and brought back to the office to be dismantled, flattened and stored at the Myky.

GLOSSARY

Grass – both the alive and dead portions of tussocky or spreading monocot species, not including sedges, rushes or lomandra, are classified as grass. Dead portions which are still attached (or intricately associated, i.e. woven in with the rest of a tussock) with the rest of the plant are generally counted as 'grass' rather than 'thatch' and contribute to the measures of height, % green and the plate meter reading.

Thatch – the dead, unattached blades of grass which form a mat on the ground are thatch. Thatch does not count towards % green, height or, if you can avoid it, the plate meter measure.

Flowering stem – often stems with flowers on the end will also have a couple of leaves (although the might be different to the bulk). These leaves are fine to include but do not count the top of the flowering stem (usually where the flowers are) towards height measures and remove them where they influence the plate meter.

Canberra Nature Park Reptile Surveys

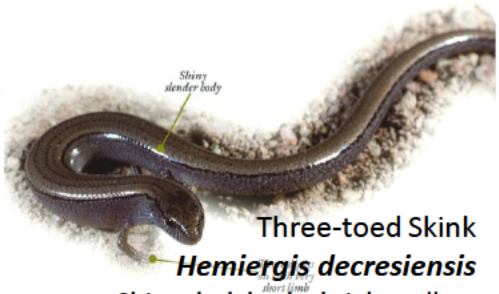
- Only conduct reptile surveys between 5ºC and 20ºC ambient temperature.
- Tilt tile away from you to check underneath and carry a compression bandage to each plot.
- Capture animal only if necessary for identification. Hold animals gently, avoiding the tail end in species which may drop their tail (skinks and *Delma*). **DO NOT CATCH SNAKES.**
- Check tiles in a systematic way to avoid missing tiles or whole rows.
- Record reptiles/frogs/small mammals in association with the tile they were seen **on** or **under**. Animals not directly associated with a tile should be recorded as 'incidental' observations.
- Record species on the data sheet and tick of the wall chart when you finish for the day.

Delicate Skink
Lampropholis delicata
- Dark band on upper sides
- Coppery brown body
- **No dorsal stripe**
- Length <90mm

Boulenger's Skink
Morethia boulengeri
- Reddish tail
- Obscure markings on back
- Clear black and **white stripes along side**
- Length <100mm

Common Dwarf Skink
Menetia greyii
- Elongated slender body
- **Four fingers and five toes**
- Greyer looking than delicate and Boulenger's
- Length <80mm

Garden Skink
Lampropholis guichenoti
- **Speckled back with a central dark line**
- Dark band on flanks +/- white line
- Coppery head (usually)
- Length <90mm



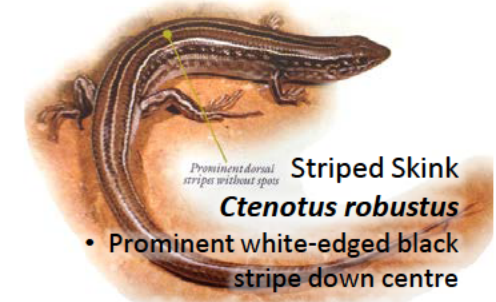
Three-toed Skink
Hemiergis decresiensis
- Shiny dark body, bright yellow underneath
- **Only three digits on each limb**
- Wriggly , burrowing behaviour
- Length <100mm

Olive Legless Lizard
Delma inornata
- Thin white margin around eye
- **Greeny-grey/brown body** with yellow throat
- Coppery head (usually)
- **Length >400mm**

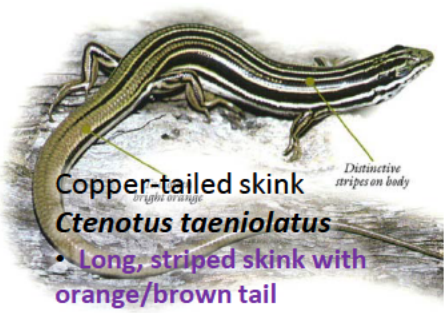
Shingleback
Tiliqua rugosus
- Triangular head
- **Pinecone textured scales**
- Length >400mm

Eastern Blue-tongued Lizard
Tiliqua scincoides
- Grey to pale brown body with dark bands
- **Wedged shaped head with dark bands across eyes**
- Length >500mm

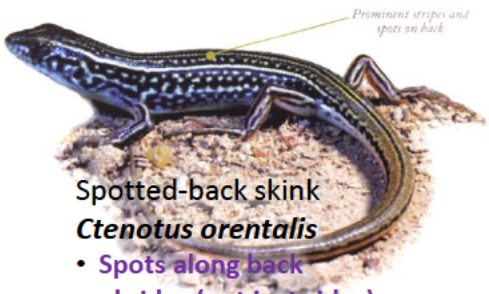
Striped Legless Lizard
Delma impar
- **Browny-pink colour with obvious or faint stripes**
- Dark head
- **Length <200mm**



Striped Skink
Ctenotus robustus
- Prominent white-edged black stripe down centre
- **Dark band spotted with light markings from eye to hind leg**
- Length <300mm



Copper-tailed skink
Ctenotus taeniolatus
- **Long, striped skink with orange/brown tail**
- Length <200mm



Spotted-back skink
Ctenotus orentalis
- **Spots along back and sides (not just sides)**
- Length <300mm

Images from 'Reptiles and Frogs of the Australian Capital Territory' by Ross Bennet. Published by National Parks Association of the ACT Inc (1997). **DO NOT CIRCULATE.**

Common Bearded Dragon
Pogona barbata
- Light to dark grey body.
- Prickly spines, conspicuous on head and 'beard'
- Length <550mm

•Jacky Lizard
•Amphibolurus muricatus
- Variable colour and back pattern, banded tail.
- Longitudinal rows of spines along back, form a central crest.
- Length <400mm

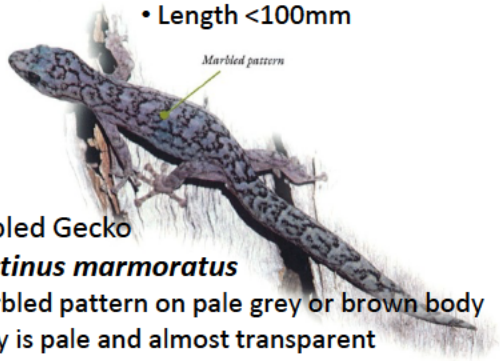
Grassland Earless Dragon
Tympanocryptis pinguicolla
- Very small! Up to 150mm only
- Brightly patterned back
- Tapering curled tail
- Found at Jerra Grasslands

Cunninghams Skink
Egernia cunninghami
- Dark to light brown with greenish tones
- Strongly keeled and spiny scales
- Basks in colonies
- May be > 400mm in length

Pink-tailed worm lizard
Aprasia parapulchella
- Thin, legless lizard which resembles a worm
- Max length 180mm
- Found under rocks or timber

Stone Gecko
Diplodactylus vittatus
- Brownish grey body with irregular pale stripe along back
- •Regenerated tail often has blotches instead of stripe
- Pale dots on flank between vertebral stripe and pale belly
- Length <100mm

Eastern Brown Snake
Pseudonaja textilis - ***DANGEROUS***
- Brown or grey body without patterns. Bullet shaped head
- Length >2m
- Juveniles may be unmarked or strongly banded (above)



Marbled Gecko
Christinus marmoratus
- Marbled pattern on pale grey or brown body
- Belly is pale and almost transparent
- Regenerated tail has different colours and markings
- Length >100mm with tail (if intact)

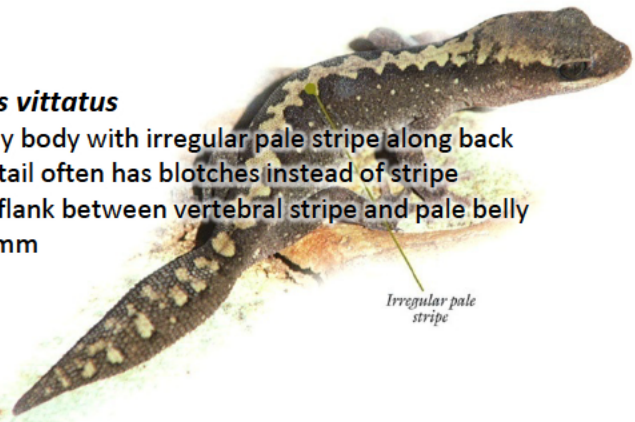
Blind Snake
Ramphotyphlops nigrescens
- Light grey, smooth shiny body
- Blunt head and tail with small spike
- Length ~350mm

Red-bellied Black Snake
Pseudechis porphyriacus
– DANGEROUS
- Length up to 2m

Dwyer's Snake
Parasuta dwyeri - ***DANGEROUS***
- Head is capped with a single dark to black patch
- Length > 500mm

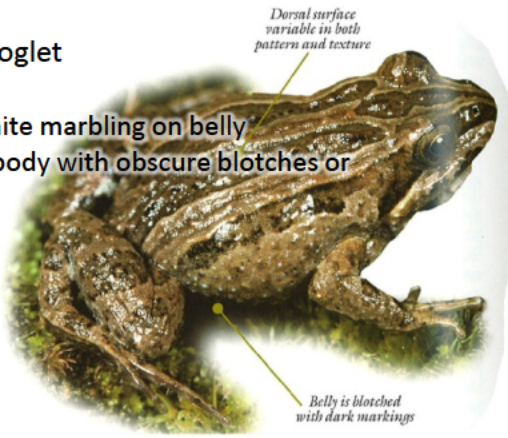
Marbled Gecko
Christinus marmoratus
- Marbled pattern on pale grey or brown body
- Belly is pale and almost transparent
- Regenerated tail has different colours and markings
- Length >100mm with tail (if intact)

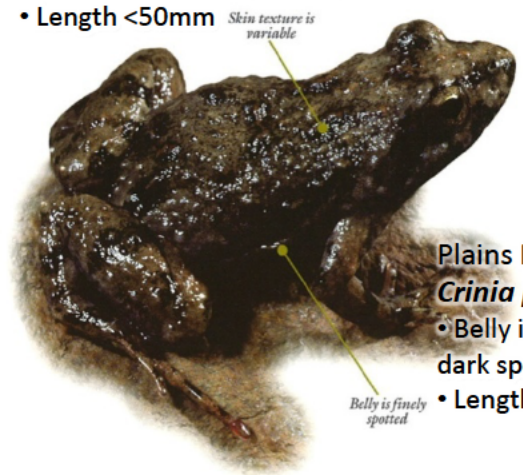
Stone Gecko
Diplodactylus vittatus
- Brownish grey body with irregular pale stripe along back
- Regenerated tail often has blotches instead of stripe
- Pale dots on flank between vertebral stripe and pale belly
- Length <100mm



Spotted Grass Frog
Limnodynastes tasmaniensis
- Sometimes has a thin pale yellow or salmon line from tip of snout to vent
- Body light to dark green with brownish blotches
- Narrow white ridge along side of face below eye
- Length <50mm

Common Eastern Froglet
Crinia signifera
- Coarse black and white marbling on belly
- Grey/green/brown body with obscure blotches or longitudinal bands

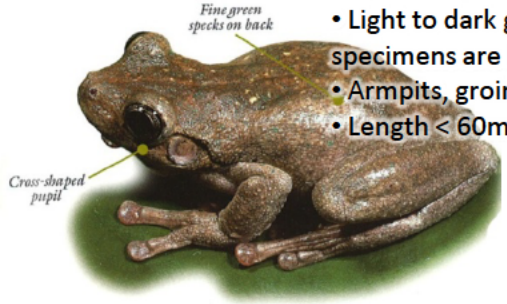




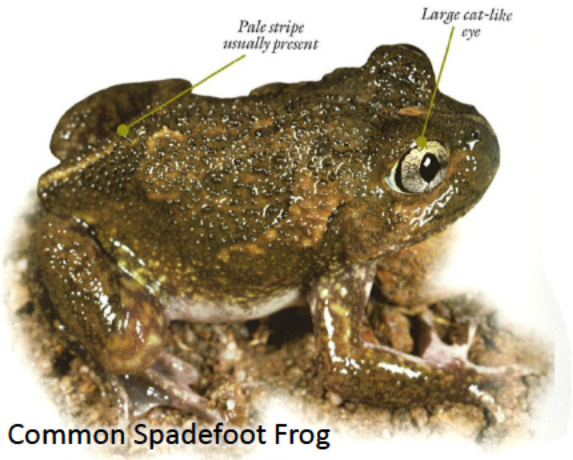
Plains Froglet
Crinia parinsignifera
- Belly is light grey or off-white with fine dark spots, gives a peppered appearance
- Length <30mm

Smooth Toadlet
Uperoleia laevigata
- Triangular pale marking between the eyes and snout
- Prominent swellings on each side of neck
- Rough and warty back
- Small, < 30mm

Peron's Tree Frog
Litoria peronii
- Cross-shaped pupils
- Light to dark grey body, although brown specimens are known
- Armpits, groin and rear surface are yellow
- Length < 60mm



Whistling Tree Frog
Litoria verreauxii
- Dark band extends from should to eye and narrows at snout
- Groins has a yellowish wash with dark blotches
- Length 30-40 mm



Common Spadefoot Frog

Neobatrachus sedelli

- Large cat-like eye
- Pale stripe down middle of back
- Has a hard shiny projection under each hind foot
- Length < 50mm

Eastern Banjo Frog

Limnodynastes dumerilii

- Off-white or pale orange on lower edge of ridge, from behind eye to shuolder
- A broad orange zone is usually visible on each side of body
- Length ~ 70mm

Common Long-necked Turtle

Chelodina longicollis

Yellow-footed Antechinus

Antechinus flavipes

- Slender pointed muzzle, large eyes and ears
- White eye ring and black tip to the tail
- Grey slate coloured head, warm orange-brown sides, belly, rump and feet.
- Head and body length between 76 - 81mm

Fat Tailed Dunnart

Sminthopsis crassicaudata

- Slender pointed muzzle, large eyes and ears
- Thick short tail
- Mouse grey body, white below
- Lots of sharp teeth (do not have incisors as mice do)
- Head and body length 75 mm.

Common Dunnart

Sminthopsis murina

- Slender pointed muzzle, large eyes and ears
- Mouse grey body, white below
- Lots of sharp teeth (do not have incisors as mice do)
- Head and body length 76 – 81 mm.

Images from 'Reptiles and Frogs of the Australian Capital Territory' by Ross Bennet. Published by National Parks Association of the ACT Inc (1997). **DO NOT CIRCULATE.**


Sambar
Rusa
Red Deer


Fallow Deer


Southern Brown Bandicoot


Long-nosed Bandicoot

Name	Description	Leaf Blade	Ligule +/- Auricle	Leaf Sheath	Inflorescence
Austrostipa bigeniculata (Tall spear)	A tufted perennial, 70-150 cm high.	Linear, acuminate, dull green, inrolled, 0 5-1 mm diameter, rarely flat 2-2.5 mm wide, smooth, occasionally scabrous or with bristly hairs.	Truncate, firm, minutely ciliate, 1 mm long.	Outer sheaths paler. Nodes pubescent. Auricles unequal, long ciliate.	
Austrostipa densiflora (Brushtail spear)	An erect, tufted grass to 150 cm tall.	Mid- to blue-green due to a dense covering of very short hairs, 1-5 mm wide, rolled with age.	Truncate, firm, minutely ciliate.	Outer sheaths paler. Nodes pubescent. Auricles unequal, long ciliate.	
Austrostipa scabra (Spear grass)	A tufted perennial, 50-100 cm high.	Linear, dull green, inrolled, 0.5-1 mm diameter, scabrous to softly hairy.	Membranous, truncate, ciliate 0.5-1 mm. Auricle membranous, ciliate ("hairy armpits").	Pale on the outside. Nodes conspicuous, often purplish.	
Avena fatua (Wild oat)	An erect annual, culms stout, smooth or lower ones **softly hairy**, grows in short tufts. 30-120 cm tall.	Broad at base with acute apex, rough, 4-18 mm wide, flat in cross-section.	1-6 mm long, **irregularly dentate**.	Split, smooth or slightly hairy margins, especially in young plants.	
Bothriochloa macra (Red-leg grass)	Slender tufted perennial, 30-100 cm high, often branched above. Young leaves rolled in the bud.	Linear, acuminate, 2-5 mm wide, **flat with scattered tubercle-based hairs**.	Membranous, jagged, 1-2.5 mm long, **auricle ciliate.**	Hairless or with scattered tubercle-based hairs. **Nodes purple.**	
Briza spp. (Quaking grass)	Annual, 10-60 cm high, culms solitary or loosely tufted, erect or bent below.	Green, **hairless**, blades finely pointed, 3-8 mm wide, flat in cross section, finely nerved, **minutely rough on margins**.	Membranous, blunt, **oblong 2-5 mm long**.	Rounded, smooth.	
Bromus spp. (Brome)	Annual or biennial, culms solitary or loosely tufted, **softly hairy on the nodes**.	Greyish green because of the presence of **fine silky hairs**, 2-7 mm wide, flaccid, finely pointed, flat in cross section, rolled at emergence.	Membranous, **toothed**, up to 2.5 mm long, hairy.	Tubular but splitting early, rounded at back, l**ower sheaths hairy, upper tend to be hairless**.	
Chloris truncata (Windmill grass)	A tufted annual or perennial, often growing horizontally with **rooting from the nodes.**	Linear, apex obtuse and **keeled** (boat shaped), flat or folded 1.5-3 mm wide, pale or blue-green, typically hairless.	Minutely ciliate.	**Keeled**, rather loose, broad, margins pale.	
Cynodon dactylon (Couch)	Mat forming perennial, spreading by tough scaly rhizomes, culms erect or slightly bent at the base.	Greyish-green or green, blades narrow to blunt tip, 2-4 mm wide, spreading, flat in cross-section, rolled (rarely folded) in bud, **minutely rough margins**, loosely short-haired or almost hairless.	A **dense row of blunt hairs**, 0.5 mm long.	Rounded and short, with fine **green veins on lighter ground**, 3-4 mm hairs at junction of leaf blade and sheath.	
Dactylis glomerata (Cocksfoot)	A tussock forming perennial up to 1.5 m high. Young leaves folded in the bud.	Long, broad (up to 10 mm), greyish green to green, usually flat but may be folded lengthwise to give a shallow V shaped cross section. Completely hairless, tip gradually tapering to a point. **Margins rough to touch, especially towards tip**. **Indistinct veins except scabrous mid-rib on underside**.	White, transparent, 2-10 mm long. Young ligules usually having a ciliolate fringe. No auricles but a **pale green or yellowish collar at the base of the blade**.	Very much flattened, hairless, **prominent keel**.	
Dichelachne spp. (Plume grasses)	Erect, sparsely tufted grass to 150 cm.	Narrow (2mm), smooth below and often rough to touch above. Usually flat or convolute, scabrous, often pubescent.	Membranous.		
Elymus scaber (Common wheat grass)	Tufted perennial to 1 m high.	Linear, acuminate, grey-green, 2-6 mm wide, flat and loosely in-rolled, **lightly scabrous above, smooth below**. Leaf twists.	Membranous to 0.5 mm long. **Auricles calliper like and almost encircling culm**.	Pale, smoot. **Nodes often purple**.	
Enneapogon nigricans (Nineawn grass)	A tufted perennial, occasionally branching above, to 0.7 m tall.	Linear, acute to acuminate, grey-green. Young leaves rolled in the bud, involute, 0.5-1 mm diameter, rarely flat, pilose with short glandular hairs and long simple hairs; the latter often sparse below.	Minutely ciliate. Nodes densely pilose from simple hairs.	Sparsely pilose.	
Eragrostis brownii (Brown's lovegrass)	A tufted perennial to 0 5 m. Young leaves rolled in the bud.	Linear, acuminate, flat or folded with margins in-rolled 1-3 mm wide, **hairless apart from sparse (tubercle-based) fine cilia along margins near ligule**, continuing along apex of leaf sheath.	Minutely ciliate.	Pale (compared with blade). **Nodes purplish**.	
Eragrostis curvula (African lovegrass)	Large dense, exotic tussocky perennial.	Flat, pale green to blue green, 3 mm wide, distinct parallel veins, rolled when old or frosted. Largely hairless, gently drooping. Leaf tips of larger plants curl distinctively.	Skirt of fine hairs around leaf-sheath junction, 1 mm long.	...	
Fescue elatior (Tall fescue)	A perennial tussock-forming grass up to 2 m high. Young leaves are rolled in the bud.	Usually 3-10 mm wide, green, hairless except on and near the auricle, **pronounced longitudinal grooves on upper surface, lower surface smooth and glossy**. Margins rough to touch.	Membranous and very short. Auricles with a few hairs on them.	Hairless, rounded at back, may be smooth or rough. Mainly green but **can be red to brownish purple at base**.	
Holcus lanatus (Yorkshire fog)	A softly hairy perennial, loosely or compactly tufted, 20-80 cm high, culms erect or bent towards base, rarely hairless, **usually downy** (more so on paler green nodes), purple colouration near base.	Rolled in the bud but flatten on expansion to slightly U-shaped cross section, 3-10 mm wide, upper surface **moderately ribbed, densely covered with short hairs, lower surface densely pubescent with distinct main vein**, blades narrow to a fine point.	White, membranous, **coarsely serrate at top**, 1-4 mm long, hairy. Auricles absent.	Split, rounded at back, prominent **mid-vein** particularly on upper half, covered with downy reflexed hairs. Lower sheaths usually with **red-purple veins against a whitish background**.	
Hordeum spp. (Barley grasses)	Medium sized, leafy and tufted.	Flat, pale-green to blue-green leaves, up to 7 mm wide, scattered with hairs to 1 mm long.	Membranous to 1 mm long, auricles membranous.	...	

Name	Description	Leaf Blade	Ligule +/- Auricle	Leaf Sheath	Inflorescence
Lolium perenne* and *L. annua (Perennial and annual ryegrass)	A tussock-forming perennial up to 60 cm high. Young leaves folded in the bud (perennial) or rolled (annual).	Dark green, hairless, flat, **upper surface evenly ribbed, lower surface smooth and shiny**. Width to 7 mm in perennial, 3-5 mm in annual.	White, translucent, shorter than wide. **Auricles small and narrow**.	Hairless with fine longitudinal ribs as in leaf blades, **base of sheath may be reddish purple**.	
Microlaena stipoides (Weeping grass)	A rhizomic perennial. Culms ascending or erect. Rhizomes are thin and short.	Linear acute, 1-5mm wide, flat or concave, occasionally **undulate** (wavy, corrugated), scabrous or pubescent. Young leaves rolled in the bud. Generally has a pinched tip.	Shortly membranous, **minutely ciliate fringed with a few long cilia**.	Covered in short, soft hairs.	
Nasella trichotoma (Serrated tussock)	A dense tussock with drooping leaves.	Very numerous, rolled in bud, **tightly rolled throughout life**, bleached to a white or pale colour, **harshly scabrid**.	Short and membranous. Auricles absent.	Very short, white towards base, brownish elsewhere.	
Nasella neesiana	Medium to large tussock-forming perennial. **Noxious weed.**	Deep green, coarsely hairy, strongly ribbed on upper surface, flat while growing but roll with age, 2-3 mm wide, margins scabrous.	Ligule almost absent on lower leaves, otherwise truncate to obtuse, 0.5-3 mm long with tufts of hair at sides. Auricles thickened, sparsely haired or hairless.	...	
Panicum effusum (Hairy panic)	A tufted perennial, 20-50 mm high.	Linear, dull or grey-green, 2-5 mm wide. Flat or slightly involute, midrib prominent below with sparse tubercle-based hairs. **Hairs stem from margins**.	To 1 mm long, ciliate.	Generally with sparse tubercle-based soft hairs but often long, soft and **wavy hairs on lower sheaths**.	
Paspalum dilatatum (Paspalum)	A perennial that forms rather open tussocks and spreads slowly by means of short, thick, rhizomes.	7-15 mm wide, flat, green, **hairless except for two tufts of 5 mm long silky hairs near the ligule**. Blade tapers to fine point, margins may be puckered, **blade may have purplish red colouration**. Both upper and lower surface finely ribbed. **Lower surface keel distinct**.	Ligule white and translucent, becoming brown with age, rounded at tip about **as long as it is wide** (3-5 mm). No auricles, a **yellow-ish collar at the base of the blade**.	**Oval in cross-section** and **strongly keeled**, hairless at top, sparsely to very hairy at the base with fine hairs. **Finely ribbed**.	
Phalaris aquatica (Phalaris)	A tussock forming perennial. **Tillers swollen at base**.	Long, broad (4-15 mm), flat, hairless and greyish green. Young leaves rolled in the bud.	White, translucent, longer (3-5 mm long) than wide, **rounded at tip**. Auricles absent. **Pale greenish collar at base of blade**.	Greyish green, hairless, **round in cross-section**. When cut through at base, **excludes a pink sap**.	
Poa annua (Annual poa)	A loosely or moderately compacted annual or short-lived perennial, which is often small (3-4 cm). Culms smooth, erect or prostrate, slender, weak, sometimes branching at lower nodes.	Yellowish green to pale green, crinkled when young, upper surface not ribbed, tramline veins not easily distinguished, midrib rounded and rather indistinct, **tip blunt, often hooded as the bow of a boat**, 1-5 mm wide, folded on emerging, hairless.	Long (2-5 mm), membranous. Auricles absent.	Split, compressed, **keeled**, smooth, not firmly enclosing younger leaves.	
Poa sieberiana* and *P. labillardieri (Poa tussock and River tussock)	A tussock-forming perennial 15-80 cm (sieb) high or larger (lab).	Fine, typically grey-green, 0.3-0.4 mm diameter, in-rolled, surface usually **lightly to strongly scabrous**, occasionally smooth or with bristly hairs. "Shuttle cock" shaped tussock at base.	**Truncate**, minutely ciliate, 0.1-1 mm long.	Outer sheaths usually pale towards base, rarely purplish.	
Rytidosperma pallidum (Red anther wallaby grass)	A tussock forming perennial, 50-100 cm high.	Fine, grey-green, in-rolled, **often 'zig-zagging'**, surface smooth.	**Ciliate to 5 mm long**.	Outer sheaths pale, straw coloured or **quite often purplish towards base**.	
Rytidosperma spp. (Wallaby grasses)	Tussock-forming perennials	Usually fine leaves, can be in-rolled or flat, **distinct parallel veins on surface**, usually prominent hairs along leaf.	**Ciliate to 5 mm long**. (Hairy armpits)	...	
Sorghum leiocladum (Wild sorghum)	A tufted or tussock-forming perennial.	Linear, acuminate, 1.5-7 mm wide, flat or occasionally in-rolled. **Mid-vein prominent below**. Surface hairless or pilose (separate but not sparse hairs) with hairs to 1 mm.	**Dry and thin**, obtuse, to 2 mm long, cilia on adjacent sheath apex up to 3 mm long.	Pale, pilose. **Nodes densely white**, cilia up to 3 mm.	
Themeda australis (Kangaroo grass)	A densely tufted perennial.	Linear with a concave apex, pale green to reddish green, 2-5 mm wide. Flat or **V-shaped in cross-section**, often rolled outwards, occasionally with **tubercle-based hairs on the margins**.	To 0.5 mm long, minutely ciliate.	Often paler than blade, sometimes with long soft wavy hairs.	

Blade Ligule Auricle Sheath Node Culm

Acuminate Acute Obtuse Truncate Pubescent Scabrous Pilose Hirsute

"Tubercle-based hairs" – has small swelling at base.

"Ciliate" – a fringe of hairs

"Sedges have edges, rushes are round, grasses have ligules" Rolled Folded