Field manual for assessing deer density and impacts on forested vegetation

This field manual is designed to assist land managers to easily implement surveys for assessing deer impacts on forested vegetation as described in *Ecological Management & Restoration* 2021. This field manual includes detailed, step-by-step information to enable a wide range of people with varying expertise to undertake the survey.

Overview of method

This method can be undertaken by anyone with a basic knowledge of native tree and shrub species in the survey area in question. One transect can be undertaken by two surveyors in approximately 1–2 hours. The method involves survey of unmarked 150-m transects (**Figure 1a**). At 5-m intervals along the transect (total 30 survey points) within a 1-m radius (3.14 m^2) circular plot, the number of deer faecal pellet groups and total pellets are counted, in addition to the pellet groups and total pellets of other sympatric herbivores that can cause similar impacts to vegetation which cannot be separated from that of deer in the field (e.g. swamp wallaby). At 10-m intervals along the transect (total 15 survey points) within a 5-m radius (78.54 m^2) circular plot, impacts on vegetation are assessed by selecting the closest understorey tree or shrub to the central survey point within each quadrant of the plot for assessment (**Figure 1b**).

Plants are included in the assessment if they are a tree or shrub species, >10 cm in height and <10 cm diameter at breast height (DBH; 1.3 m). For each plant, record the species, distance from the centre of plot (this can be used to determine understorey density) and total height of the plant and assess the plant for deer impacts. Because deer and swamp wallaby browsing cannot be reliably separated in the field we apply two impact assessments to each plant over 1 m in height; one <1 m, which we assume to be a combination of deer and swamp wallaby browsing and one >1–3 m, which we assume to be almost entirely attributable to deer. Vegetation impact is scored using a rapid assessment (scale 0–4, **Table 1**). In total, 60 trees or shrubs are assessed at each site.

Although woody trees and shrubs are the focus of the survey, tree ferns are included because they are known to be impacted by deer (Bennett 2002; Forsyth and Davis 2011) and in some forest types are a relatively common component. Tree fern species (e.g. *Cyathea australis*, *Dicksonia antarctica* and *Todea barbara*) may therefore be included in the impact assessment but because tree ferns are usually >10 cm DBH regardless of height, and produce new fronds annually, all tree ferns >10 cm height but of any DBH are included in the assessment. And, as is typical in other studies (e.g. Fedrigo*, et al.* 2019), the height of tree ferns is measured to the top of the caudex, not to the top of live foliage as for all other plant species.

In addition, within a 20-m wide belt transect (centred on the 150-m line transect; **Figure 1a**), we record the presence of any signs of deer and deer damage including the presence of faecal pellets (not located in survey plots), trails, creek crossings, tracks and pugging (hoof-prints), rubbing, thrashing and wallows. While this is not an essential element of the survey, it is included here to identify the presence of deer (Gormley*, et al.* 2011) in locations where density is extremely low and no faecal pellets are recorded in the survey plots.

We used faecal pellets counts as an index of abundance (Forsyth 2005; Forsyth*, et al.* 2007), which persist in the environment for approximately a year (Davis and Coulson 2016), and similarly, browsing damage,

the most common impact observed, mostly occurs on the new growth from the current growth season. Therefore, repeat surveys to examine changes in density and impact using this method should not be conducted with greater frequency than annually. Additionally, this method cannot separate the impacts of different deer species where they co-occur, or similarly that of other native or feral browsing species of a similar size, such as goats (*Capra hircus*).

Equipment and preparation

The equipment and preparation tasks required to complete a transect survey are listed in the ***Check list for Preparation and Equipment***. One 150-m transect survey constitutes one sample and each site will require multiple transects. The survey design, including stratification, number and location of sites is not described here and will vary depending on the site and management requirements.

CHECK LIST FOR PREPARATION AND EQUIPMENT

Tasks before field assessment

- Check requirements for permits or obtain permissions from private land holders to conduct surveys. Where necessary apply for permits; note permit applications may take several months ☐
- Design the survey and distribution of transects according to site and management requirements ☐
- Organise staff and volunteers to conduct the surveys (teams of 2 people / transect) ☐
- Load site GPS coordinates onto GPS unit ☐
- Print method (or save to mobile device) ☐
- Print field data sheets (or organise a digital data collection program) ☐
- Assemble survey pegs (2 large plastic sand pegs and 5m of non-stretch cord) ☐
- Charge GPS batteries ☐
- *Optional* – prepare a plant identification 'cheat sheet' for the site area if surveyors are unfamiliar with plant species at the site ☐
- *Optional* – download plant identification app onto mobile device to assist with plant identification at the site ☐

Assemble equipment for field survey

- Site map ☐
- List of survey sites, GPS locations and random bearings ☐
- Field method ☐
- Data sheets, clipboard, pencils ☐
- GPS and spare batteries ☐
- Sighting compass ☐
- 1 × 5 m retractable builder's tape measure (recommend also to carry a spare) ☐
- 1 × assembled survey pegs (consists of 2 large plastic sand pegs and 5m of non-stretch cord) ☐

Vegetation survey data management

Use of a digital data collection method can save significant time transferring information from field data sheets and reduce mistakes (e.g. we used a mobile phone app ProofSafe; www.proofsafe.com.au to digitally record data). Alternatively, record the information on the field data sheets into the digital database. It is recommended that this data entry occurs as soon as possible after the field surveys in case details need to be clarified by surveyors. Each separate element (deer faecal pellets, swamp wallaby faecal pellets, vegetation assessment of the survey is to be entered into separate worksheets. Ensure that only **one** piece of information is entered into any one cell of the worksheets.

References

Bennett A. (2002) An assessment of sambar deer (*Cervus unicolor*) browsing on tree ferns in Victorian wet sclerophyll forests. M. Qual. Env. Sc. (Res.) Thesis. Monash University, Clayton, Victoria.

Fedrigo M., Stewart S. B., Kasel S., Levchenko V., Trouvé R. and Nitschke C. R. (2019) Radiocarbon dating informs tree fern population dynamics and disturbance history of temperate forests in southeast Australia. *Radiocarbon* **61**, 445-460. doi: 10.1017/RDC.2018.119.

Forsyth D. M. (2005). Protocol for estimating changes in the abundance of deer in New Zealand forests using the Faecal Pellet Index (FPI). Landcare Research New Zealand Ltd. (New Zealand Department of Conservation: Wellington, New Zealand.)

Forsyth D. M., Barker R. J., Morriss G. and Scroggie M. P. (2007) Modeling the relationships between fecal pellet indices and deer density. *The Journal of Wildlife Management* **71**, 964-970. doi: 10.2193/2005-695.

Forsyth D. M. and Davis N. E. (2011) Diets of non-native deer in Australia estimated by macroscopic versus microhistological rumen analysis. *Journal of Wildlife Management* **75**, 1488-1497. doi: 10.1002/jwmg.179.

FIELD MANUAL: Deer density and impact transect survey

This survey involves assessment of 30 survey plots along a 150-m transect (**Figure 1A**). The survey is to be undertaken by two people, and will take approximately 2–3 hours. One surveyor will undertake the measurements, the second surveyor will record data and carry spare equipment. The second surveyor can of course assist with faecal pellet identification, plant species identification and assigning deer impact scores.

! Note: **The second surveyor should not walk ahead on the transect line in case faecal pellets are accidentally disturbed or stand in proximity to the peg when it is being pulled out to avoid injury.**

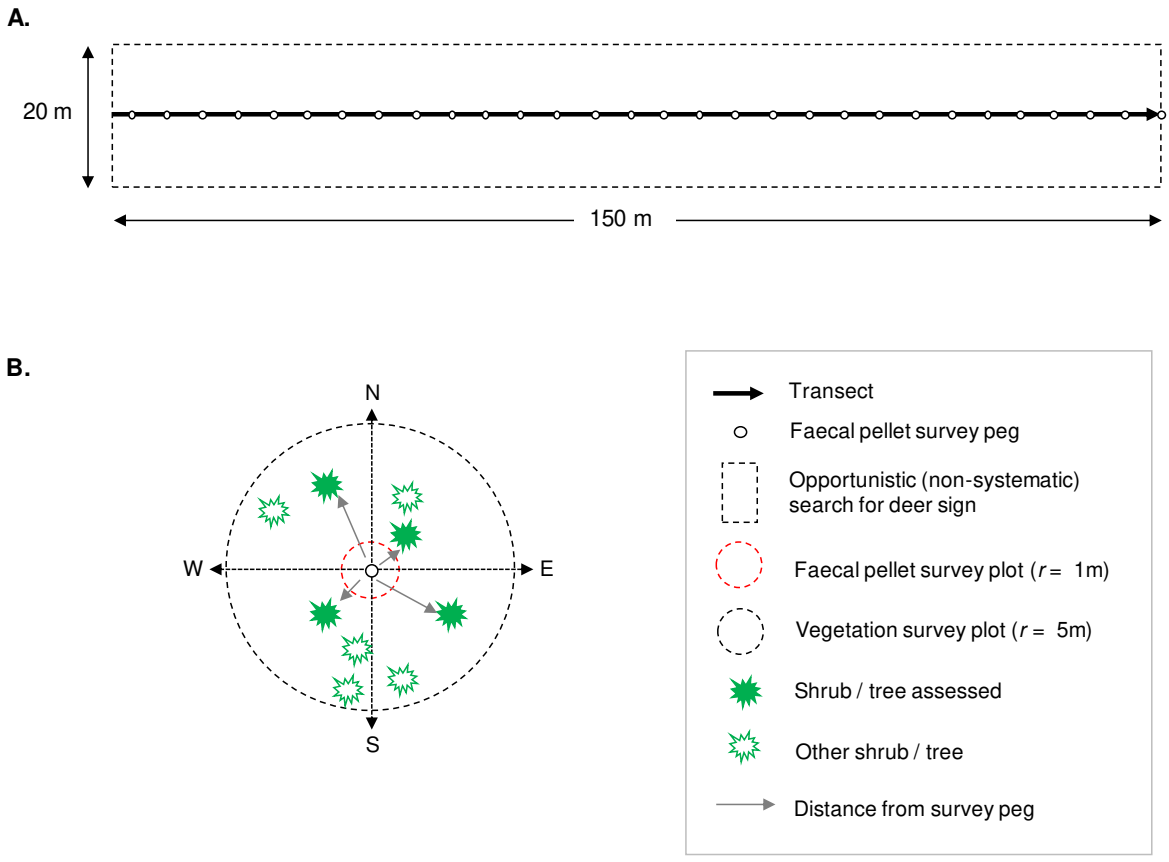

Figure 1. *Schematic of field survey protocol. A: 150-m transect along which 30 plots are surveyed for faecal pellets and 15 plots are surveyed for vegetation impacts, with deer signs recorded along a belt transect centred on the transect line (20×150m). B: One survey point along the transect in which faecal pellets are counted within r=1m circular plot (3.14 m^2; red circle) at 5-m intervals along the transect and vegetation impact assessments conducted within r=5m circular plot (78.54 m^2; black circle) at 10-m intervals along the transect.*

1. Navigate to the start location using the GPS.
2. Push one peg into the ground at the start location, but do not survey at this location. Use the sighting compass to determine the direction of the transect bearing (**Box 1**). Walk along the bearing in as straight a line as possible, extending the cord attached to the pegs until it is taught, 5 m from start location. Place the second peg firmly in the ground.

BOX 1: USING A SIGHTING COMPASS

- Look through the eye piece. You will see a vertical line, large numbers and small numbers. The vertical line is the bearing, the large numbers are the direction forward and the small numbers are the back-bearing (180° behind you).
- Stand with both feet planted on the ground so that you are stable and can stand quite still.
- Hold the compass up to your eye and ensure it is level, so that the dial is able to move freely.
- Line up the vertical line and the allocated bearing of your transect.
- Hold the compass slightly away from your eye so that you can simultaneously see the bearing through the eye piece and an object in the distance (such as a distinctive tree, fence post) that you can use as your target.
- Walk straight towards your target. This will ensure you remain on your allocated transect bearing.

3. Give the cord a sharp tug to pull the first peg out of the ground, and gather in the cord and first peg. This is the location of the first survey plot.
4. Locate the knot positioned 1 m from the peg in the ground and use to delineated the faecal pellet plot boundary (r=1m). Systematically survey in a series of concentric circles the 1-m radius plot for deer faecal pellets, following the rules for inclusion (**Box 2**), and record the number of pellet groups and the total number of pellets in each group.

BOX 2: FAECAL PELLET RULES

- A **pellet group** is the collective of all the individual pellets that are voided in a single defaecation.
- A **pellet** is the individual unit that make up a pellet group.
- A pellet group is determined based on the size, shape, colour and texture of the pellets.
- A pellet group must contain at least 1 pellet (≥1).
- When searching for pellets, you may brush aside low vegetation such as ferns, but the leaf litter should not be disturbed. If you locate a pellet group which is partially obscured e.g. by a leaf, you may move the leaf to count the number of pellets.
- Only count pellets that are intact, regardless of whether they are covered in moss or fungi. If the pellet is cracked but has not lost material it is also counted. Do not count pellets that have lost material.
- If a pellet group is located on the boundary of the plot, count the pellets located inside the plot and do not count the pellets located outside the plot boundary.
- If a pellet group is found in a clump, tease apart the individual pellets using a stick to allow the number of pellets to be counted and recorded.
- If your survey plot contains an object or obstacle e.g. tree or log, survey the available area of the plot. Do not move the plot.

5. Repeat Step 4 for survey of swamp wallaby (or other sympatric herbivore) faecal pellets and record the number of faecal pellet groups and total number of pellets in each group on the data sheet.
6. Use the compass to determine the location of the four quadrants (i.e. 1=NE=1–90°; 2=SE=91–180°; 3=SW=181–270°; 4=NW=271–360°). In the NE quarter (1–90°), select the plant that is closest to the centre peg for assessment (*r*=5m; **Figure 1B**). To qualify for assessment, the plant must be a tree or woody shrub species, >10 cm in height and <10 cm DBH (diameter at breast height = 1.3 m from the ground). An exception are tree-ferns, which should also be recorded (e.g. *Cyathea australis*, *Dicksonia antarctica*, *Todea barbara*). If there are no plants that fulfil these criteria, record 'No plant' in the species column.
7. Record the plant species and measure the total plant height (to nearest cm for plants ≤250 cm, estimated to nearest 10 cm for plants >250 cm) and distance (cm) from centre peg using the builders tape measure. Plant height is measured as the plant stands, so if it is growing on an angle, measure vertically from ground beneath the highest point. Similarly, if foliage at the top of the plant is drooped, do not stretch out the foliage. Tree-ferns are measured to the top of the caudex (tree-fern 'trunk') and not to the top of foliage. Distance from the centre peg is measured to the base of the trunk or stem where the plant is rooted in the soil, not to the closest branch.
8. Assess the plant for deer impacts according to **Table 1** giving separate scores for sections of plants <1m and >1–3m and record on the data sheet.

Table 1. *Categories used to assess deer impact on understorey trees and shrubs.*

Score	Description	
0	No impact	NA
1	Low impact	1–25% foliage browsed
2	Low–moderate impact	25–50% foliage browsed, stem breakage or rubbing damage
3	Moderate–high impact	51–75% foliage browsed, multiple stem breakage or severe rubbing damage
4	High impact	76–100% foliage browsed or extreme rubbing damage

9. Repeat steps 6–8 for plants in the SE, SW and NW quadrants.
10. Leaving the survey peg in the ground, use the compass to again determine the transect bearing (Step 2) and repeat Steps 3–5 (faecal pellet count at 5-m intervals) and steps 6-9 (vegetation impact assessment at 10-m intervals i.e. every second plot) until 30 survey plots (total transect distance 150 m) have been assessed.
11. As the survey is being conducted, take note of any deer sign within a 20-m belt transect (10-m either side of transect line; **Figure 1A**) and record on the data sheet. Deer sign may include presence of faecal pellets (not located in survey plots), trails, creek crossings, tracks (hoof-prints), pugging (deep hoof-prints in mud), rubbing, thrashing, wallows and deer sightings.