Methods to monitor the density and impact of hares (*Lepus europaeus*) in grasslands in New Zealand

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ABSTRACT

Three methods to estimate hare densities are described. Faecal pellet recruitment onto plots gives an index of hare density that can be used to estimate relative abundance between areas or measure changes in density over time. Spotlight counts can also be used for these measures, and if line transect methods are included they provide an estimate and measure of precision of true density. Spotlight counts are probably restricted to relatively accessible terrain. The comparative-yield technique is recommended to assess changes in plant biomass due to changes in hare densities. If an estimate of the changes in species composition as well as changes in total biomass is required, the dry-weight-rank technique is recommended. Both methods allow a large number of plots to be surveyed to give a precise estimate whose accuracy relies on a tight regression between the ranking scores and measures of biomass taken on a subset of plots on which the vegetation is clipped, sorted by species, dried, and weighed. The actual methods used to estimate hare densities and their impacts will depend on the aim of any experiment intended. An exclusion experiment is described that would measure the effect of hares on grassland communities.

Keywords: Hares, *Lepus europaeus*, monitoring, density, impacts, vegetation biomass.

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1. Introduction

Landcare Research, Lincoln, undertook to recommend best-practice methods for monitoring hare densities and their impacts for the Department of Conservation (DOC) in June 1999.

2. Background

This report forms part of a project to review the theory of setting target densities in pest control operations that are related to the resource being protected (Choquenot & Parkes 2001). The practice of monitoring pest numbers and impacts has been described in other reports funded under the project for Himalayan thar (Parkes et al. 1999), and for feral pigs (Choquenot & Parkes 1999).

Hares (*Lepus europaeus*) are now widespread in the introduced pastures and indigenous short-tussock and tall-tussock grasslands of New Zealand having been introduced in the 1860s (Flux 1990). Past research to estimate densities and impacts has been limited, but DOC is now reconsidering hares as a potential pest. This is partly because of their potential impact on native grasslands within areas managed as 'mainland islands' (e.g. the South Branch Hurunui 'mainland island', Grant et al. 1998), and the possibility that hare numbers will increase as rabbit numbers decline due to rabbit haemorrhagic disease (Norbury et al. in press).

3. Objectives

- To describe methods to index or estimate hare densities.
- To describe methods to estimate vegetation biomass and species biomass in indigenous grassland.
- To describe an experiment to estimate changes in indigenous grasslands caused by hares.

4. Methods

Past methods used in New Zealand and Australia to monitor hares and rabbits were reviewed and efficient techniques are described.

5. Results and Recommendations

5.1 INDEXING AND MEASURING HARE DENSITIES

5.1.1 Faecal pellet counts

Hares produce between 300 and 700 (mean 434) faecal pellets per day (Flux 1967) which (unless catastrophically destroyed) remain intact for at least 60 days and usually for many years under New Zealand subalpine and alpine climatic conditions (Parkes, unpubl. data; Flux 1990). For example, hare faecal pellets lasted for up to 365 days at Cupola Basin (Flux 1967). Therefore, standing crop densities of pellets in favoured habitats can exceed 100/m^2. This means that the simplest way to estimate relative densities between sites or changes in density over time is by estimating the recruitment of new faecal pellets on plots.

Both plot size and time between measurements can be altered to achieve a sensitive index of hare densities. Parkes (1981) used a small plot of 0.09 m^2 and an interval of 60 days between counts in short-tussock grasslands on river bed flats in the Avoca River catchment, Canterbury. The plot size allowed rapid counting and thus a large number of plots to be counted and cleared of new pellets (up to 1000 plots per person/day) in short-tussock grassland habitat. The interval of 60 days was chosen for experimental reasons, but field tests of marked new pellets showed none disappeared within this period. The recruitment rate in this study was c. 10 ± 1 pellets/m^2 per 60 days, or a modal value of about 1 pellet per plot.

In general, it is recommended that plot sizes be kept small and sample sizes large (= number of transects). In areas with lower hare densities than found in the example given above, the interval between measurements can be extended (e.g. up to a year if pellets last that long in the study area) until a robust recruitment rate is achieved.

The technique recommended is to permanently mark each plot centre with a small bicycle spoke pushed through an aluminium tree-tag. If the spoke is pushed well into the ground, it is inconspicuous and it appears to have no effect on hares' defaecation behaviour (J. Parkes, unpubl. data). However, larger pegs that remain above the ground attract hares and are used as latrine sites (A. Grant, pers. comm.). Plots should be c. 5 m apart along a transect so that they can be easily found. In longer grass, occasional larger marker pegs can assist in retracing the transect and locating the small plot pegs.

A circular wire hoop with its centre located by braces is placed over the spoke and all pellets with any part within the hoop are counted and cleared. All hare faecal pellets should be counted and cleared from the plot at the initial count (the standing crop), and then all pellets recruited are counted and cleared at each subsequent measurement. Parkes (1981, and unpubl. data) found that most recruited pellets were fresh and few old pellets were blown or moved onto the plots despite short vegetation and frequent high winds.

The design of the monitoring will depend on the questions being asked. For example, in the Avoca study, 20 transects (= n) with random start locations and directions, each with at least 50 plots were established over 350 ha, and could be measured (once the initial clearance has been done) by one person in a (long) day. Measuring hares' use of different habitats, or changes between several areas with different management regimes, would require different designs including replication and possible stratification. Managers should consult a biometrician to optimise the experimental design before proceeding.

5.1.2 Spotlight count indices

Hare densities may be indexed using the standard spotlight-count methods developed for rabbits (e.g. Frampton & Warburton 1993). Hares seen in a spotlight are counted along a standard route (usually at least 10 km) over 2 or 3 nights with similar fine weather conditions. The count should not be started until at least an hour after sunset and, ideally, done over the same period on each night. The nightly counts are treated as replicates and the mean number of hares seen per km ± standard errors or confidence limits are used as the index. However, counts on successive nights are not independent, and this method ignores this pseudo-replication unless the transects are replicated.

Generally, hare densities are too low to make this method robust enough to measure anything but large changes in the population size over time (e.g. see Norbury et al. (in press)). For example, the index is usually less than 1 hare/km in the standard rabbit spotlight routes in Canterbury and Otago (J. Parkes, unpubl. data). However, where hare numbers are high and the area is accessible to vehicles, e.g. in some high country valleys in Canterbury, the method may give robust estimates. It has not been tested in such places, and will not work in alpine tall-tussock habitats.

5.1.3 Line transect estimates of density

A line-transect method using spotlight counts can give estimates of absolute hare densities if these are required (Burnham et al. 1980). To do this the right-angled distance from the line of the transect to each hare seen needs to be measured. Usually, the distance is calculated from the observed distance and the angle from the transect, but this is only valid if the transect is approximately straight. Too many bends and convolutions make it impossible to calculate the right-angled distance.

The method assumes only that all animals on the transect, i.e. at zero distance from the line, are counted, and that their visibility decreases with distance from the transect. This decline in visability is measured empirically from the data, and an estimate of density is calculated. Computer programmes to do this are freely available at:

http://nhsbig.inhs.uiuc.edu/wes/density_estimation.html

or Krebs (2000) and the programmes available therein.

5.2 MEASURING TOTAL AND SPECIES BIOMASS IN GRASSLAND COMMUNITIES

The biomass of vegetation (and the individual species) can be measured accurately by clipping all vegetation on plots then drying and weighing it. Because this is extremely time-consuming and budgets are usually limited, the number of plots measured is usually small and precision is sacrificed. An alternative method is to use the comparative yield technique (Haydock & Shaw 1975; Robertson 1987) to estimate total biomass, and the dry-weight-rank technique to estimate species biomass (Mannetje & Haydock 1963; Jones & Hargreaves 1979; Scott 1986, 1995).

These methods improve the precision of the biomass estimates by allowing a large number of plots to be sampled. The accuracy of the estimate of total biomass is assured by the linearity and scatter of the regression between reference measures of biomass and the visual estimates made from the reference plots. The accuracy of the estimate of species biomass relies on the empirical relationship (see section 5.2.2) demonstrated for a large number of grassland types.

5.2.1 Total biomass

The Haydock & Shaw (1975) method estimates total pasture biomass by visually ranking the amount of vegetation on plots using a selection of reference plots to span the range of grassland vegetation types or biomass within each study area, ideally at each sampling time if seasonal changes in vegetation are expected. The range of biomass in the reference plots needs to cover the extreme high and low biomass sites within the study area. The number of intermediate classes is determined by selecting first the midway biomass between the extremes, and then as many midway points between successive classes as required. Generally five or nine ranking classes have been used in past studies.

Validation of the relationship between the score and actual biomass is done by scoring about 40 plots selected to cover the range of biomass in the study area, clipping each, and weighing the dried biomass. Each validation plot is also photographed to act as a reference during the survey of all the plots. Most grassland types give a simple linear relationship (Haydock & Shaw 1975; Choquenot et al. 1998a).

In studies where several people are used to score the biomass on the plots, an initial period of training must be carried out where all observers score the same plots and discuss interpretation of the reference photographs and differences in their scores until there is general agreement about scoring. After this training, one can either cross-check observer scores at the start of each sampling period, or treat each observer's score-biomass relationship independently and revalidate each person by harvesting a set of reference plots at each sampling period. Any changes in the score-biomass relationship with time can be checked for significance by repeating the validation procedure on a smaller subset of reference plots.

5.2.2 Species composition and biomass

The best way to measure the botanical structure of a grassland and its changes will depend on the questions to be answered. At its simplest, a species list might suffice, but more detailed methods are needed if some measure of biomass or changing abundance of species is required.

A quick method to estimate biomass by species is the dry-weight-rank technique (Mannetje & Haydock 1963; Jones & Hargreaves 1979; Scott 1986, 1995). In each plot, all species present are recorded and the observer ranks each species (or at least the first few) according to its abundance in terms of biomass. If no difference in rank is discernable, the observer must allocate first and second, second and third, or first, second, and third, etc. to two or more species. Mannetje & Haydock (1963) recommend ranking three species on each plot, but Scott (1986) recommends ranking the first five species.

The proportion of plots in which each plant species occurred in first, second, to nth rank is calculated and each proportion is multiplied by a coefficient for rank and scaled to 100% as an estimate of the mean percent dry weight for each species. The coefficients have been empirically derived for the first three ranked species as 0.702, 0.211, and 0.087 (Mannetje & Haydock 1963) and updated with new data to 0.705, 0.238, and 0.057 (Jones & Hargreaves 1979). Scott (1986) has pointed out that a log-linear relationship between rank and abundance of the form:

$$P_R = 100\ (1 - k)k^{R-1}$$

where P_R = the proportional contribution to biomass of species of rank R, and k = a constant for each grassland type, which measures the fractional reduction in proportion biomass between successively ranked species,

is almost identical to the empirically derived coefficients when $k = 0.32$ and when scaled to 100%. He recommends using the geometric series with $k = 0.32$, i.e. with weighting coefficients of 0.703, 0.225, and 0.072 if only the first three species are ranked, or 0.68, 0.218, 0.07, 0.022, and 0.003 if the first five species are ranked.

Scott (1986) suggests estimating the proportion of the first-ranked species or the ratio of the proportions between two species by direct measurement on a subsample of plots as a check on the validity of the coefficients.

5.3 MEASURING THE IMPACT OF HARES

The above methods, combined with an open/exclusion plot design are recommended for estimating the effect of hares (or rabbits) on indigenous grasslands. Most studies on hares in New Zealand are likely to aim to survey hare impacts in different habitat types, or measure the effect of control of hares on their impacts. The experimental design to replicate treatments and non-treatments would need to be determined by the questions set.

The following experimental design is given as an example to estimate the change in impacts on a native grassland as hare numbers are controlled. At each sampling time (e.g. quarterly), the biomass of vegetation and the biomass of the plant species are scored using the methods described in 5.2.1 and 5.2.2.

The basic sampling strategy requires a series of sampling points established across a grid of each study area. Choquenot et al. (unpubl. data) found in an Australian study that a grid that gave about 16 sample points per study site was sufficient to limit variation in most estimates of pasture biomass to less than a Coefficient of Variation of 15%.

At each grid point at the first measurement period the pasture biomass and species composition is assessed on three 0.25-m^2 circular plots located at random about the grid point. The plots are then caged to exclude hares. At subsequent measurements three new randomly located plots are assessed and caged, and the previously caged plots assessed to measure vegetation growth in the absence of hares. This system therefore provides an estimate of average vegetation produced under grazed and ungrazed conditions, with the biomass eaten by mammals being the difference between the two. The amount of vegetation growth or decline during the period is estimated from the difference between the plant biomass in the grazed plots with that in the ungrazed plots measured at the next sampling period.

With practice, one person could measure up to 16 grid points in a day in an experiment in New South Wales that used this method.

5.3.1 Complexities

Sympatric herbivores: Distinguishing the contribution of hares to herbivory in places where they are sympatric with other mammalian herbivores will complicate monitoring regimes.

This can be accounted for, in some cases, by additional cage treatments that exclude hares but not the other herbivore. Additional cages need to be included at each sampling point if multiple herbivores are an issue.

For example, possums can be allowed access by fencing a larger area to exclude hares and leaving the plot uncaged within this larger area. Ungulates can be excluded by raising the hare exclosure cages enough to allow access under the wire to hares but not to sheep or deer. Again, a larger exclusion area around the sample plot might be required so as not to affect hare behaviour.

Rabbits are a problem as there is no way to exclude them but not hares. Fortunately, rabbits and hares tend to exclude one another when either species is numerous, so for many ‘hare’ study sites, the effect of rabbits is likely to be minimal (and vice versa). Interpretation of the results in this case is improved by studies of the two species’ diet, when any differences may allow inferences about vegetation structural changes. For hares in short-tussock grasslands, the only diet study is that of Blay (1989), while for rabbits the only study is that of Reddiex (1998).

Effect of grazing on plant growth: The above experiments assume that any differences between plant growth inside and outside the cages is a reflection only of the herbivory, i.e. plant growth is independent of how much grazing occurred. If grazing either increases or decreases plant growth, i.e. the plants either compensate for grazing by growing faster (possible) or they are inhibited and grow more slowly (less likely), then this above experiment will give biased results.

The best way to test for these effects is to conduct a simulation grazing trial where an additional three caged plots would be added to each sample point that were ‘grazed’ by clipping, and the biomass clipped compared with the biomass changes in the normal caged plots.

6. Discussion and Recommendations

Faecal pellet recruitment and spotlight counts have both been used successfully in New Zealand and are suitable for relatively cheap estimates of relative densities and trends in hare numbers. Langbein et al. (1999) assessed methods to survey hare abundance in Europe by counts made during hare drives, various line or belt transect methods, or faecal pellet counts. They recommended line transect counts as the best method to estimate numbers—as a national census for their purposes.

To estimate trends in hare numbers for New Zealand conditions, I recommend faecal pellet recruitment methods in all habitats, or spotlight counts in short-tussock habitats accessible by vehicle. Line transect methods using spotlight counts are recommended where absolute density estimates are required, but this method is again mostly restricted to accessible short-tussock grassland habitats. No easy method exists to estimate hare numbers in alpine tall-tussock habitats.

The methods recommended to assess hare impacts remain untested in New Zealand, but a project using the methods to investigate the impacts of rabbits (J. Parkes, unpubl. data) should test its general validity.

7. Acknowledgements

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8. References

Blay, G. 1989: Food preferences of the European hare *(Lepus europaeus* Pallas) on a fescue grassland. Unpublished MSc thesis, University of Canterbury, Christchurch, New Zealand. 104 p.

Burnham, K.P.; Anderson, D.R.; Laake, J.L. 1980: Estimation of density from line transect sampling of biological populations. *Wildlife Monographs 72*: 1-202.

Choquenot, D.; Parkes, J. 1999: A research programme on feral pigs and their impacts on conservation values. Landcare Research Contract Report LC9899/92 (unpublished), 12 p.

Choquenot, D.; Parkes, J. 2001: Setting thresholds for pest control: how does pest density affect resource viability. *Biological Conservation 99*: 29-46.

Choquenot, D.; Druhan, J.; Lukins, B.; Packwood, R.; Saunders, G. 1998a: Managing the impact of rabbits on wool production systems in the central tablelands of New South Wales: An experimental study and bioeconomic analysis. Pp. 376-374 in Proceedings of the 11th Australian Vertebrate Pest Conference, May 1998, Bunbury, Western Australia.

Flux, J.E.C. 1967: Hare numbers and diet in an alpine basin in New Zealand. *Proceedings of the New Zealand Ecological Society 14*: 27-33.

Flux, J.E.C. 1990: Brown hare. Pp. 161-172 in King, C.M. (Ed.): The handbook of New Zealand mammals. Oxford University Press, Auckland.

Frampton, C.; Warburton, B. 1993: Methods for monitoring rabbit populations: A review. Landcare Research Contract report LC9394/77 (unpublished), 17 p.

Grant, A.; King, W.; Kearvell, J.; van Dijk, A. 1998: South Branch Hurunui "Mainland Island" project 1997/98 report. Unpublished Department of Conservation report, Christchurch.

Haydock, K.P.; Shaw, N.H. 1975: The comparative yield method for estimating dry matter yield of pasture. *Australian Journal of Experimental Agriculture and Animal Husbandry 15*: 663-670.

Jones, R.M.; Hargreaves, J.N.G. 1979: Improvements to the dry-weight-rank method for measuring botanical composition. *Grass and Forage Science 34*: 181-189.

Krebs, C.J. 2000: Ecological methodology. Addison Wesley Longman, USA.

Langbein, J., Hutchings, M.R.; Harris, G.; Stoate, C.; Tapper, S.C.; Wray, G. 1999: Techniques for assessing the abundance of brown hares *Lepus europaeus*. *Mammal Review 29*: 93-116.

Mannetje, L.'T.; Haydock, K.P. 1963: The dry-weight-rank method for the botanical analysis of pasture. *Journal of the British Grassland Society 18*: 268-275.

Norbury, G.; Heyward, R.; Parkes, J. (in press): Short-term ecological effects of rabbit haemorrhagic disease in the short-tussock grasslands of the South Island, New Zealand. *Wildlife Research*.

Parkes, J. 1981: Hare control in the high country. *What's New in Forest Research No. 97*. Forest Research Institute, Rotorua, New Zealand, 4 p.

Parkes, J.; Thomson, C.; McGlinchy, A., Ruscoe, W.; Knightbridge, P. 1999: Best practice monitoring of thar densities and impacts. Landcare Research Contract Report LC9899/51 (unpublished), 17 p.

Reddiex, B. 1998: Diet selection of European rabbits *(Oryctolagus cuniculus)* in the semi-arid grasslands of the Mackenzie Basin, New Zealand. Unpublished MSc thesis, Lincoln University, Canterbury, New Zealand. 107 p.

Robertson, G. 1987: Plant dynamics. Pp. 50-68 in Caughley, G.; Shepherd, N.; Short, J. (Eds): Kangaroos their ecology and management in the sheep rangelands of Australia. Cambridge University Press, Cambridge.

Scott, D. 1986: Coefficients for the dry-weight rank method of botanical analysis of pasture. *Grass and Forage Science 41*: 319-321.

Scott, D. 1995: Vegetation: A mosaic of discrete communities, or a continuum? *New Zealand Journal of Ecology 19*: 47-52.