Animal pests: night counts for rabbits

Version 1.0

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Contents

Department of Conservation
Te Papa Atawhai

Synopsis

Night-time counting using spotlights along fixed routes or transects is a standard method for assessing rabbit populations in New Zealand and Australia (Williams et al. 1995; Fletcher et al. 1999). It is a rapid and simple approach to estimate whether the relative abundance of rabbits has increased to or beyond some predetermined threshold where control needs to be done. It is used to estimate relative changes in rabbit numbers (i.e. percentage kill) following control operations (NPCA 2012). It also can provide population trend data that can be compared over time or between areas (NPCA 2012).

The monitoring design for night counts can differ depending upon the management or research question and the level of rigour required for management purposes. Qualitative information about the effectiveness of a control operation can be obtained from a single unreplicated night count route conducted before and after control (Williams et al. 1995; NPCA 2012). To obtain statistically defensible quantitative results, yielding 95% confidence intervals, additional independent routes will need to be monitored (Latham et al. 2012; NPCA 2012).

In addition to the methods described in this report, a monitoring and control good practice guidelines document for rabbits has been produced by the National Pest Control Agencies (NPCA) and is freely available online.[1] The methods in the NPCA document, which were developed in collaboration with the New Zealand Rabbit Coordination Group, provide a standardised approach to monitoring rabbit populations in New Zealand.

Assumptions

This method makes the following assumptions (see 'Full details of technique and best practice' for further details):

- Observer bias is negligible.
- All spotlight counts are done under good weather conditions.
- A constant fraction of individuals are counted along routes over time.
- The relationship between the index (rabbits counted per route) and actual abundance or density is linear.
- The population of rabbits within the area surveyed remains demographically closed throughout the survey period, i.e. there is no movement of rabbits into or out of the survey area.
- Temporal changes in vegetation structure or other features (such as presence or absence of livestock) do not bias counts.
- If not explicitly assessed, then it must be assumed that the number of routes sampled provides sufficient statistical power to detect a desired effect size, e.g. a percentage kill of 95% or a 20% increase in the relative abundance of rabbits over 5 years.

[1] http://www.npca.org.nz/images/stories/NPCA/PDF/a5%20rabbits%202012-11.pdf

Advantages

- Relatively quick and simple method for estimating percentage kill after control and providing population trend data at fixed sampling locations if the effect size is large (Fletcher et al. 1999; Latham et al. 2012).
- Not all rabbits along night count routes need be counted, i.e. night counts provide an index of rabbit numbers that can be compared over time and/or between locations.
- Comparatively cheap method of surveying a large geographical area.
- Data analysis is relatively straightforward, and if multiple routes are monitored, variance can be estimated.
- Night counts, data entry and data analysis can be done by managers / extension professionals who may not have the skills required for alternative, more complicated survey and analytical methods for estimating changes in rabbit numbers. However, it should be noted that managers and extension professionals must understand relevant statistical concepts, particularly determining a biologically meaningful effect size and sample sizes necessary to achieve acceptably high power. If they do not, assistance should be sought from experts (Greene 2012).

Disadvantages

- Method does not adjust for imperfect detectability.
- Observed reduction in counts may underestimate percentage kill because the spotlight count index saturates (i.e. inability to count all individuals) at high rabbit density (Fletcher et al. 1999).
- Counts of rabbits may not indicate long-term trends in rabbit abundance unless several years of data are available. This occurs because not all factors that can affect detectability can be standardised across surveys / years.
- Requires experienced personnel (operating off-road vehicles in rough terrain at night and previous use of spotlights for night counts).
- The method may not be feasible in terrain that is too rugged or scrubby to ride or walk routes. In this instance, monitoring methods such as vantage counts conducted in the evening or camera traps may be alternatives to night counts using spotlights (Latham et al. 2012).

Suitability for inventory

It is appropriate to use this method in the following situations for inventory:

- Night counts can be used to establish whether some control threshold has been reached (NPCA 2012). That is, a one-off night count survey will provide a minimum estimate of rabbit abundance and can thus provide an indication of whether control is necessary.
  - The threshold determining when control should occur must be predefined, will likely vary according to the conservation values of the area being surveyed, and should ideally have been correlated with rabbit impacts. A one-off survey of rabbit abundance will in itself not yield information about the impact that rabbits can have in an area.
  - Similarly, variance cannot be estimated from a one-off survey of one single route. However, if more than one route is sampled during the one-off survey (i.e. the one-off survey is replicated), then confidence around the mean rabbit abundance can be estimated.
  - The Modified McLean Scale is similarly a one-off survey, and is often the preferred method for ascertaining whether some predefined threshold of rabbit relative abundance has been reached (NPCA 2012).
- A one-off night count survey may be useful to qualify areas of low, moderate or high rabbit relative abundance, i.e. describe their distribution across a landscape or property.

Suitability for monitoring

It is appropriate to use this method in the following situations for monitoring:

- To monitor the relative abundance of rabbits (i.e. population trends) over time along fixed routes. So long as the same methodology has been applied, these trends can also be compared between areas.
  - This approach can provide a robust assessment of whether some predetermined control threshold has been reached. However, high variability between night counts across years due to imperfect detectability means that several years of data are required to determine trends in the relative abundance of rabbits. This is particularly important when effect sizes are not large, e.g. attempting to quantify inter-annual changes of 5–10%.
- To determine percentage kill, i.e. the relative reduction in rabbit numbers pre- versus post-control.
  - This can usually be done with high statistical confidence because effect sizes associated with control operations are large, i.e. a reduction in rabbit numbers of > 70% (usually > 90%; e.g. Latham et al. 2012). However, percentage kill can be underestimated at high pre-control rabbit densities because of saturation (Fletcher et al. 1999).

- Ideally, an *a priori* statistical power analysis should be done to determine what sample size (no. of routes) is required to estimate percentage kill or changes in relative abundance (i.e. effect sizes) with acceptable precision (Fletcher et al. 1999; Greene 2012; Latham et al. 2012).

Skills

- Staff should be capable of preparing field plans and health and safety plans, and entering and analysing results using Excel, geographic information systems (GIS) or similar software.
- Field staff will require skills in:
  - Navigating in the field at night using spotlights, maps and GPS
  - Operating quad bikes (i.e. the primary method of conducting night count routes) along transects of between 10–20 km in length
  - Traversing and conducting night counts on foot in rugged terrain when quad bikes are unsafe to use (i.e. walking transects on foot may be an alternative to quads in some areas / situations)

Resources

This method requires the following resources (NPCA 2012):

- Personnel to conduct night counts. A route should be surveyed by a single observer. An observer can survey more than one route per night, so long as they do not exceed 3–4 hours surveying per night (i.e. eye strain and decreased concentration can influence results). To avoid observer biases, personnel changes should be kept to a minimum and, if possible, routes should be repeated by the same observer before and after control and/or over subsequent years.
- Night counts are easier to conduct if reflective markers are followed, as opposed to only a GPS track (although ideally the latter should be kept as a backup). Sufficient pegs (wooden stakes or Waratah® standards) and section markers (red and white reflective tape) will be needed to mark routes, and these should be laid out during daylight before counts are conducted.
- Hammer.
- Night count description forms and night count recording forms (see 'Minimum attributes').
- Maps and GPS with appropriate features displayed, e.g. waypoints, route/s, treatment block or property boundaries.
- A minimum of one sheep tally counter mounted on the quad (or handheld if route is walked) to record rabbit numbers. An additional sheep tally counter may be useful to record non-target animal numbers; however, this can distract observers from counting rabbits in areas with high rabbit numbers.
- A spotlight (usually 30 or 55 watts) and usually attached to a motorbike helmet when routes are done on a quad bike. Alternatively, night counts can be conducted using night vision equipment (see 'Full details of technique and best practice').

- A power source: either a quad bike battery (connected to the quad bike electrics or independent from it) or if the area to be monitored is too small or rugged to use quad bikes, sufficient 12-volt batteries must be available to observers walking night count routes.
- A quad bike.
- Safety equipment for quad bike use, plus any additional safety equipment outlined in organisational health and safety plans.

A full description of preparation for night-counting rabbits using these resources is available in NPCA (2012, pp. 30–32; also see 'Full details of technique and best practice').

Minimum attributes

Consistent measurement and recording of these attributes is critical for the implementation of the method. Other attributes may be optional depending on the objective. For more information refer to 'Full details of technique and best practice'.

DOC staff must complete a 'Standard inventory and monitoring project plan' (docdm-146272).

Attributes to record are shown in Table 1 below. Minimum attributes to record at the beginning of the survey include:

- Route
- Property or block
- Observer (or counter)
- Date
- Start time
- Weather conditions

At the end of the survey, the finish time should be recorded, as well as weather conditions (particularly if they have changed over the course of the survey).

The minimum attributes to record at the end of each route section include the number of rabbits and non-target animals seen. Other information, such as vegetation and visibility, is also collected by some authorities (NPCA 2012); however, collecting information on too many factors can distract observers from the primary objective of counting rabbits.

Note that the length of a section along night count routes conducted using a quad is usually 1 km. However, this could vary depending on the area being surveyed.

Table 1: Example night count recording form for rabbits. Abbreviated headings include: wind conditions, temperature, cloud cover, section number and non-target animals seen. Note that additional rows should be added to the table to meet the requirements of the route to be surveyed (i.e. the number of sections that it is divided into).

RABBIT NIGHT COUNT RECORD CARD				
ROUTE I.D.				
PROPERTY/BLOCK				
OBSERVER			DATE	
TIME	Start			
	Finish		WIND COND.	
ODOMETER	Start		TEMP.	
	Finish		CLOUD COV.	
MONITORING EQUIPMENT USED			MOON	
			RAIN	
Section No.	Rabbits seen	N-T animals	Notes	
COMMENTS:				

Data storage

Original data records should be retained along with any explanatory information (metadata) necessary to understand the dataset. The final report should state where the original data and any associated analysis material are stored.

Forward copies of completed survey sheets to the survey administrator, or enter data into an appropriate spreadsheet as soon as possible. Collate, consolidate and store survey information securely, also as soon as possible, and preferably immediately on return from the field. The key steps here are data entry, storage and maintenance for later analysis, followed by copying and data backup for security.

Summarise the results in a spreadsheet or equivalent. Arrange data as ‘column variables’—i.e. arrange data from each field on the data sheet (date, start time, finish time, route ID, section, number seen, species identity, etc.) in columns, with each row representing the occasion on which a given route section was sampled.

If data storage is designed well at the outset, it will make the job of analysis and interpretation much easier. Before storing data, check for missing information and errors, and ensure metadata are recorded.

Storage tools can be either manual or electronic systems (or both, preferably). They will usually be summary sheets, other physical filing systems, or electronic spreadsheets and databases. Use appropriate file formats such as .xls, .txt, .dbf or specific analysis software formats. Copy and/or backup all data, whether electronic, data sheets, metadata or site access descriptions, preferably offline if the primary storage location is part of a networked system. Store the copy at a separate location for security purposes.

Analysis, interpretation and reporting

Standardised analysis and interpretation allows comparisons to be made at different sites and at different times. Follow the instructions below when analysing and interpreting data (also see NPCA 2012). The methods are relatively straightforward; however, seek statistical advice from a biometrician or suitably experienced person if required (Greene 2012).

Calculating trend assessment

- Trend assessment is easily calculated and graphed using Excel.
- First, calculate the mean number of rabbits seen per km for each route (mean $route_i$ = total number of rabbits seen / total length of the route in km).
- Second, calculate the mean number of rabbits seen per km for all routes surveyed (MEAN = sum [mean $route_i$] / number of routes).
- If the routes have been divided into strata (see 'Full details of technique and best practice'), the mean number of rabbits seen per km per stratum can be calculated.
- Third, calculate the standard error (SE = STDEV [mean $route_i$] / (N^0.5) and 95% confidence intervals (CI = 1.96 × SE) for each stratum mean.
- This can be done by using the 'Descriptive Statistics' function under the 'Data' tab, 'Data Analysis' in Excel.
- Present the results as the mean number of rabbits seen per km over time (e.g. annual winter surveys) by strata. This approach is consistent with that used by most extension professionals and results are easily compared across regions and agencies.

Calculating percent kill assessment

- Percentage kill assessment is easily calculated and graphed using Excel.
- Enter pre- and post-control rabbit data from routes within the same stratum in columns. At a minimum, enter route number, pre-control rabbits seen per km and post-control rabbits seen per km (see NPCA 2012, p. 33 for an example).
- Calculate percentage kill for routes within the same stratum. This is done by dividing the average number of rabbits seen per km 'post' by 'pre' and multiplying by 100. This provides 'percentage rabbits remaining'. To obtain percentage kill, subtract 'percentage rabbits remaining' from 100.
- Calculate the standard error of the percentage kill and 95% confidence intervals.

In some instances, there may be a need to correct for observer biases or some other form of bias.

Case study A

Case study A: spotlight counts for assessing abundance of rabbits (*Oryctolagus cuniculus* L.)

Synopsis

Fletcher et al. (1999) used night counts conducted from a motorcycle for assessing abundance of rabbits pre- and post-control in the Mackenzie Basin, South Island. The authors found that at practical levels of effort, night counts could not provide an accurate estimate of actual rabbit densities, especially when these densities were high. Night counts were an imprecise index of relative rabbit abundance, but they might be useful to detect very large differences / trends in rabbit numbers. Night counts could estimate percentage kill with acceptable precision if the kill rate was at least 80%.

Objectives

The authors described the statistical relationship between night counts and actual numbers of rabbits per hectare and the precision of night counts for estimating percentage kill following a poisoning operation.

Sampling design and methods

Rabbits were surveyed along a total of 17 km (divided into two routes of 9 and 8 km) of farmland in the Mackenzie Basin. Routes were marked with reflectorised stakes. Counts were made from a motorcycle travelling at about 7 km/h. The observer used a 30-watt spotlight mounted to a motorbike helmet that was swung in an arc 90° to each side of the direction of travel. Rabbits were counted 50 m either side of the routes pre- and post-control (conducted following standard 1080 control methods; Nugent et al. 2012).

The predicted components of variability in log-transformed counts of rabbits were estimated using a linear model. The components of variability were then used to predict the precision of any future night counts and ultimately their utility for monitoring trends in rabbit abundance and percentage kill.

Results

Fletcher et al. (1999) found that rabbit counts were highly variable and affected by observer, night the count was conducted on, weather and unknown (residual) sources. They concluded that regardless of the precision of the field counts, the wide confidence intervals around the predicted absolute abundance suggested that night counts are an inaccurate estimate of actual rabbit densities. However, they may be suitable for detecting major regional differences in actual rabbit abundance if the differences are very large (e.g. low versus medium versus high).

Night counts were found to have greater utility for estimating percentage kill along fixed routes, but only at high kill rates (estimated effect size of ≥ 80%). The precision of estimates of percentage kill increased with the number of times the counts were repeated before and after poisoning (although the improvement was small, especially when percentage kill was high).

Limitations and points to consider

- Precision of night counts for estimating changes in rabbit numbers may be unacceptably low because of high variability in the number of rabbits counted in different spotlight routes. Impracticably large numbers of routes and counts would be needed to appreciably increase precision. Thus, caution should be used when assessing trends in rabbit numbers over a small number of surveys and if differences in observed rabbit numbers are small.
- Estimates of percentage kill can be affected by saturation at high rabbit densities. This is likely to underestimate the reduction in actual rabbit densities. However, night counts can be used to estimate percentage kill with acceptable precision if the effect size is large (Fletcher et al. 1999; Latham et al. 2012).

References for case study A

Fletcher, D.J.; Moller, H.; Clapperton, B.K. 1999: Spotlight counts for assessing abundance of rabbits (*Oryctolagus cuniculus* L.). *Wildlife Research 26*: 609–620.

Latham, A.D.M.; Nugent, G.; Warburton, B. 2012: Evaluation of camera traps for monitoring European rabbits before and after control operations in Otago, New Zealand. *Wildlife Research 39*: 621–628.

Nugent, G.; Twigg, L.E.; Warburton, B.; McGlinchy, A.; Fisher, P.; Gormley, A.M.; Parkes, J.P. 2012: Why 0.02%? A review of the basis for current practice in aerial 1080 baiting for rabbits in New Zealand. *Wildlife Research 39*: 89–103.

Case study B

Case study B: alternative approaches for monitoring rabbit populations

Synopsis

The primary method of monitoring rabbit populations in New Zealand is along fixed night count routes of between 10–20 km and conducted by an observer riding a quad. Latham et al. (2012) advocate using this approach where it is feasible and to use a quad in areas where there is sufficient space to survey long night count routes. However, some areas might be too small or rugged to use this method, but it might be critical to quantify the relative abundance of rabbits (population trends and percentage kill) within these areas. The authors evaluate alternative methods for monitoring rabbits, compare their statistical power for detecting medium to large effect sizes and provide recommendations relating to their application and use.

Objectives

Latham et al. (2012) evaluated alternative methods (camera traps, vantage point counts and spotlight transects conducted on foot) for estimating the percentage of rabbits killed in a poison control operation.

Sampling design and methods

Latham et al. (2012) conducted pilot trials in Central Otago to estimate the power to detect changes in the relative abundance of rabbits before and after a control operation. Trials were done in 100-ha blocks that were stratified qualitatively into high and low density rabbit areas based on the Modified McLean Scale. Distributed within these strata, nine camera traps were erected, five vantage points were identified and four 800-m spotlight transects were delineated. Data on percentage kill was obtained using each method by surveying the relative abundance of rabbits before and after control. Using this data, Latham et al. estimated the power to detect a reduction in rabbit numbers of 50%, 90% and 95% (i.e. the effect size) with 2–4 replicates for vantage point counts and transects and 2–12 replicates for camera traps.

Results

Latham et al. (2012) found that the changes in the relative abundance of rabbits (i.e. percentage kill) was comparable for all three survey methods. These methods had low power to detect an effect size of 50% (i.e. demonstrating a halving of the rabbits within this population following control) when four replicates encompassed high and low density rabbit areas. All methods had good statistical power to detect 90% and 95% reductions in rabbit numbers when four or more replicates were used.

Limitations and points to consider

- Camera traps, vantage point counts and spotlight transects conducted on foot at fixed sampling locations may be effective alternatives to night counts conducted along long routes using a quad.
- Alternative monitoring methods were most effective when effect sizes were large (90–95%).
- Similar to previous studies (e.g. Fletcher et al. 1999), the authors found that the precision of estimating changes in rabbit numbers was unacceptably low for all three methods in areas where there was high variability in rabbit numbers, effect size was comparatively small (50%) and number of replicates used was small (< 4 vantage point counts and walked spotlight transects, and < 6 camera traps).
- If 12 camera traps were used, they had reasonable power to detect an effect size of 50%.
- If these requisites are met, these alternative monitoring methods may be preferable to conventional monitoring methods for estimating changes in the relative abundance of rabbits where there is insufficient space to ride long transects or in areas where terrain is too rugged or scrubby to safely ride transects using a quad.

- Alternative methods for estimating percentage kill may similarly be affected by saturation at high rabbit densities (Fletcher et al. 1999). This is likely to underestimate the reduction in actual rabbit densities.

References for case study B

Fletcher, D.J.; Moller, H.; Clapperton, B.K. 1999. Spotlight counts for assessing abundance of rabbits (*Oryctolagus cuniculus* L.). *Wildlife Research 26*: 609–620.

Latham, A.D.M.; Nugent, G.; Warburton, B. 2012. Evaluation of camera traps for monitoring European rabbits before and after control operations in Otago, New Zealand. *Wildlife Research 39*: 621–628.

Full details of technique and best practice

Details of technique and best practice for this method are briefly explained here. Full details of the method can be found in *Pest Rabbits: Monitoring and Control Good Practice Guidelines* (NPCA 2012) which is freely available online.[2]

Best practice methodology

- Night counts are widely used to estimate percentage kill and provide population trend data (Williams et al. 1995; Fletcher et al. 1999; NPCA 2012).
- Usually a number of separate night count routes are assessed to allow 95% confidence intervals to be estimated. Ideally the number of routes needed to provide sufficient power to detect a desired effect size should be determined by conducting an *a priori* power analysis (e.g. Greene 2012; Latham et al. 2012).
- Night counts for rabbits are primarily done using a quad bike. Observers count rabbits illuminated by the beam of a spotlight along routes of between 10–20 km. Night counting for more than 20 km along a route does not appear to appreciably increase precision. The NPCA (2012) recommends that at least five independent routes of this length are required for a sample size sufficiently large to quantify percentage kill or population trends with confidence.
- Where the area of interest is too small to be assessed using long survey routes conducted using a quad bike, shorter, replicated transects can be walked. For example, Latham et al. (2012) found that four 800-m long transects that were walked in control blocks of 1 × 1 km provided high statistical power to detect large reductions in rabbit numbers following control. This approach may have utility in small areas of high conservation concern or on other small properties where robust, statistically defensible results are needed.
- If rabbit control is done using different methods (e.g. 1080 versus Pindone poison) in two or more areas, then monitoring routes should be separated into strata corresponding to each of these treatments so that percentage kill can be estimated for each treatment individually.

[2] http://www.npca.org.nz/images/stories/NPCA/PDF/a5%20rabbits%202012-11.pdf

Similarly, in areas with different rabbit-proneness and/or habitat characteristics, stratification by habitat, elevation, etc., is recommended (NPCA 2012).

Use of night vision equipment

- An alternative approach to using spotlights to conduct night counts is night vision equipment.
- The efficacy of night vision equipment versus spotlights has not been quantitatively assessed. Night vision equipment may yield marginally higher rabbit counts compared to those obtained using spotlights; however, the variability in rabbit numbers is expected to be similar for both methods. This means that statistical power to detect a desired effect size should also be comparable for both methods. Alternatively, night vision methods may increase sensitivity at low rabbit numbers.
- If observers use night vision equipment to monitor pre-control rabbit numbers along routes in a given area, then night vision equipment must be used on the same routes for post-control monitoring; the same principle applies to assessing population trends.
- Unless assessed and shown to be otherwise, we do not recommend comparing rabbit indices obtained using night vision equipment with those obtained using spotlights.
- If significantly higher rabbit counts are consistently obtained using night vision equipment, then thresholds of when control should be done will need to be redefined based on the higher number of rabbits observed per km using night vision equipment.

Assumptions

Many of the assumptions listed below will not be met. Where possible, we have provided solutions to minimising the effect of not meeting these assumptions. Assumptions include:

- Assumption 1: Observer bias is negligible.
  - This assumption can be met by minimising personnel changes on long-term monitoring routes, or can be accounted for statistically if observer biases are quantified in the field.
- Assumption 2: All spotlight counts are done under good weather conditions.
  - A number of factors can affect the proportion of rabbits that venture above ground from one night to the next, e.g. wind speed and direction, nebulosity, temperature and relative humidity (Rowley 1957). If night counts are not conducted under similar environmental conditions, the proportion of rabbits above ground that are available to be counted can differ between nights and consequently bias estimates of percentage kill and changes in relative abundance.
- Assumption 3: A constant fraction of individuals are counted along routes over time.
  - This assumption would be violated if observers surveyed during suboptimal environmental conditions; if land use practices altered rabbit behaviour from one sampling period to the next, e.g. time of emergence from burrows differed post-control compared to pre-control because of increased hunting pressure; or annual monitoring to determine changes in relative abundance was repeatedly conducted at different times of the year.

- Prior to conducting night counts, all disturbance such as secondary control / recreational shooting should cease. Similarly, the presence of stock can affect rabbit counts. Clearly all stock should have been removed from a control area prior to toxic bait being sown; however, stock should also not be present during pre-control night counts because their presence could affect rabbit behaviour and ultimately the proportion of rabbits counted pre- versus post-control.

- Assumption 4: The relationship between the index (rabbits counted per route) and actual abundance or density is linear.
- Assumption 5: The population of rabbits within the area surveyed remains demographically closed throughout the survey period, i.e. there is no movement of rabbits into or out of the survey area.
- Assumption 6: Temporal changes in vegetation structure or other features (such as presence or absence of livestock) do not bias counts.
    - This assumption would be violated if, for example, grass was significantly longer on night count routes when post-control counts were conducted compared with when pre-control counts were done (or vice versa). This could result in percentage kill being overestimated if there was a high proportion of survivors that were not counted because they were not visible in denser vegetation. Similar biases may occur when assessing the relative abundance of rabbits across years. Other than noting that conditions did or did not differ between surveys—and that these differences may have over- or under-estimated changes in relative abundance—it will probably be impractical to account for violations to this assumption.
- Assumption 7: The number of routes sampled provides sufficient statistical power to detect a desired effect size, e.g. a percentage kill of 95% or a 20% increase in the relative abundance of rabbits over 5 years.
    - Ideally, *a priori* power analysis should be conducted to determine the number of replicates required to detect a given effect size (Latham et al. 2012). Additionally, existing documents can provide estimates of required sample sizes for quantifying changes in rabbit relative abundance (e.g. NPCA 2012).
- For additional guidance on sampling techniques refer to NPCA publication code A1, *Possum Population Monitoring Using the Trap-Catch Method*.[3]

References and further reading

Ballinger, A.; Morgan, D.G. 2002: Validating two methods for monitoring population size of the European rabbit (*Oryctolagus cuniculus*). *Wildlife Research 29*: 431–437.

Barrio, I.C.; Acevedo, P.; Tortosa, F. 2010: Assessment of methods for estimating wild rabbit population abundance in agricultural landscapes. *European Journal of Wildlife Research 56*: 335–340.

[3] http://www.npca.org.nz/images/stories/NPCA/PDF/a1_monittrapc_201110_web.pdf

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Williams, K.; Parer, I.; Coman, B.; Burley, J.; Braysher, M. 1995: *Managing vertebrate pests: rabbits*. Australian Government Publishing Service, Canberra.

Appendix A

The following Department of Conservation documents are referred to in this method:

docdm-870579	A guideline to monitoring populations
docdm-146272	Standard inventory and monitoring project plan