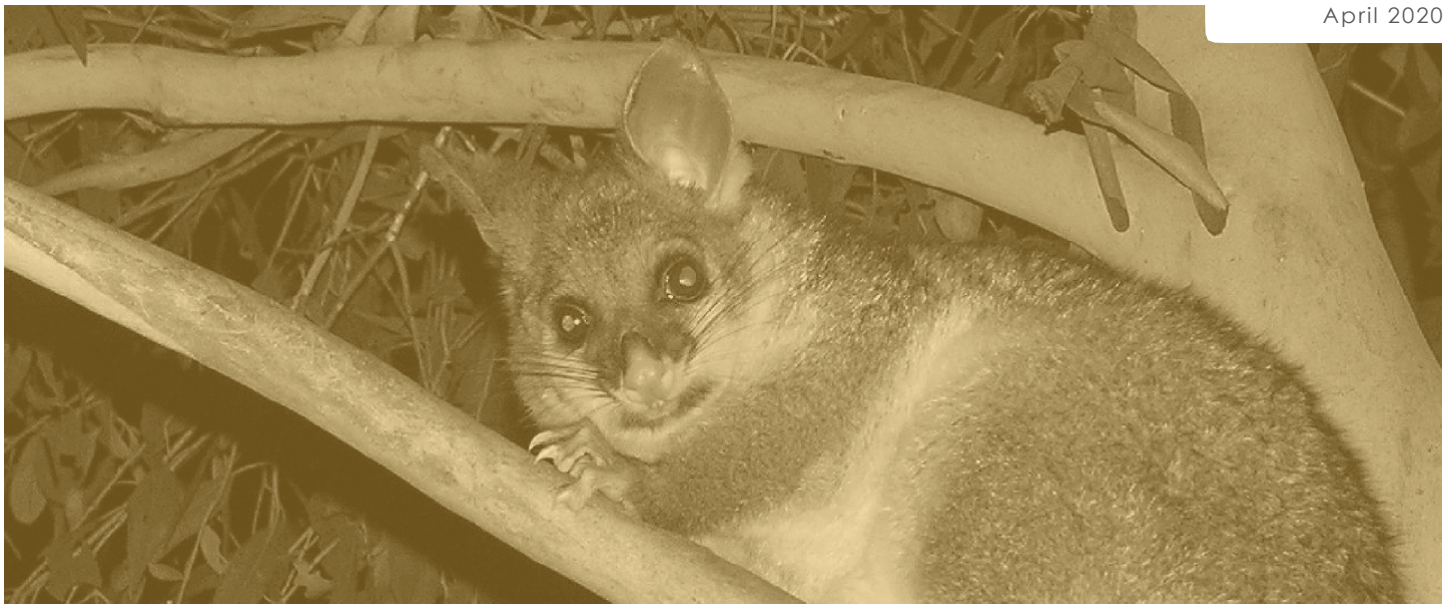
April 2020



A1

POSSUM POPULATION MONITORING

USING THE TRAP-CATCH, WAXTAG AND CHEWCARDMETHODS

PRODUCED BY

Bionet.NZ

National Pest Control Agencies

ABOUT NPCA AND BIONET

This document was published by NPCA (National Pest Control Agencies) which, until part way through 2018, provided a co-ordinating forum for agencies and stakeholders to address vertebrate animal pest control in New Zealand. In 2018 its role was transferred to the Ministry for Primary Industries under its Bionet brand.

PUBLICATIONS

Most of NPCA's publications on animal pest control were partially updated in April 2018 and transferred to the library section of the Ministry for Primary Industries' 'Bionet' online portal. The updates reflect the transfer and also acknowledge the change in the regulatory regime during 2017 and 2018, while not fully incorporating these changes in the interim, pending further reviews of the publications. Written by experienced practitioners, the main titles cover:

- best practice guidelines on controlling and monitoring vertebrate pests; and
- information about relevant regulations.

The transferred publications can be found at www.bionet.nz/library

PRODUCED BY

Bionet.NZ

National Pest Control Agencies

A1 POSSUM POPULATION MONITORING

USING THE TRAP-CATCH, WAXTAG AND CHEWCARD METHODS

Published April 2020

Bionet and National Pest Control Agencies (NPCA)
c/o Bionet Portal (Ministry of Primary Industries)
www.bionet.nz/contact-us/

ISBN: 978-0-473-52335-0

The guide may be updated from time to time, so please check that your version is current by checking the publications section on www.bionet.nz

SUMMARY OF AMENDMENTS IN THIS EDITION

This publication updates and combines two former NPCA publications: *Protocol for Possum Population Monitoring using the Trap Catch Method* (October 2010) *and Possum Population Monitoring Using the Waxtag® Method* (October 2010). It also contains new material about Chewcard monitoring. To assist readers who have been using the earlier editions, a summary of the amendments is contained in Appendix 2.

Contents

PART 1. INTRODUCTION

1.1 Background

Prior to 2015, two separate possum monitoring protocols were maintained by the NPCA: the trap-catch protocol since the mid 1990's and the Waxtag protocol since 2006. Both were developed as a result of TBfree New Zealand, Regional Councils (RCs) and the Department of Conservation (DOC) wishing to have standardised methods for estimating relative possum population densities.

This Possum Monitoring Protocol (this Protocol) integrates into one document the two previous methodologies and includes a further monitoring device, Chewcards.

1.2 Purpose

This Protocol outlines a method for estimating indices of relative abundance of possum populations. It is based on sampling populations using various detection devices (traps, Waxtags or Chewcards). The indices derived depend for their statistical robustness on meticulous adherence to the concept of random selection of survey sites and consistency and accuracy in its application, recording of results and analyses of data. Basically, the Protocol describes how many monitoring lines are to be used and how they should be located, how many devices should be used on each line and how the devices should be deployed. It details the required standards of design considerations and field-work involved.

The data obtained from the monitoring lines are used to calculate a Relative Abundance Index (RAI). The respective RAI's for the various devices are:

- Traps – Residual Trap Catch Index (RTCI)
- Waxtags – Waxtag Index (WTI)
- Chewcards – Chewcard Index (CCI).

RAI's are calculated as a mean figure, with associated statistics, such as range and confidence limits.

RAI's from before and after a control operation can be used to estimate percent kill of a population, with associated confidence limits.

1.3 Scope of the Protocol

The Protocol describes how a standardised possum population monitoring programme should be set up to provide management agencies with estimates of relative population densities. It is not a training manual for people involved in monitoring operations. Nor does it address issues such as occupational safety and health, public relations, legal access to lands, or behaviour and ethics of those doing the monitoring.

RAI estimates, associated statistics or individual line capture data may be used as performance criteria in possum control contracts. Contract performance criteria based on monitoring information are set by a management agency such as TBfree New Zealand or DOC. Such performance criteria are not prescribed in the Protocol nor are they directly

derivable from it. Management agencies may demand programmes that increase the sensitivity of monitoring by means of stratification e.g. of areas with difficult access or habitat; or by increasing the sampling intensity by using more lines than would normally be the case e.g. in areas with a high TB risk. Either requirement may result in a greater likelihood of some individual lines with index means exceeding maxima that have been set by management agencies. Agencies and their contractors need to work through these issues before contracts are agreed to.

All three monitoring devices described can also be deployed for the purpose of detecting pest presence rather than assessing relative abundance. In this case deployment patterns can be quite variable subject to management objectives, and resulting rates of detection are not directly comparable to the relative abundance indices resulting from the nationally standardised indices described here. Similarly, where monitoring of extremely low population densities is proposed and existing tools are perceived to be sub-optimal, alternative methodologies outside this protocol may be considered[1]. Alternative, pest detection survey designs and data analyses are not included in this protocol.

1.4 Layout of the Protocol

The Protocol is divided into three parts:

1. **Design**. The requirements of management agencies are determined and a suitable monitoring programme put together. This involves selecting an appropriate detection device, stratification, measuring areas of potential possum habitat, deciding the number of monitoring lines that are necessary and randomly selecting the start points of those lines.
2. **Field Work**. Field operatives locate the start points of lines, deploy devices according to the prescribed standards and record the outcomes.
3. **Information management**. This involves collation, analysis of data and interpretation of results.

1.5 Application of manual and digital techniques

Design, planning, data analysis and reporting can be achieved either manually or with the aid of various software and digital data. In practice, various blends of manual and electronically assisted techniques are used, dependant on resources.

This Protocol establishes appropriate methodologies, principles and standards. These may be implemented by either manual methods, or some electronically assisted process.

For example, drawing management boundaries on a map, calculating habitat area, and randomly selecting line start points may be achieved either on a paper map or with a GIS package.

[1] For example, based on Nugent et. al 2019.

PART 2. DESIGN OF A MONITORING PROGRAMME

2.1 Select a Monitoring Device

Three devices can be used to estimate a relative abundance index (RAI) of possum population: no.1 double coil spring traps, Waxtags and Chewcards.

All devices are deployed at 20 m spacing typically along 200 m lines (10 devices per line). Nights deployed and the resulting indices are variable, as follows.

	Nights deployed
Traps	3 (RTCI[2]) or 2 (2 night RTCI)
Waxtags	7 (WTI[3]) or 3 (3 night WTI)
Chewcards	7 (CCI[4]) or 3 (3 night CCI)

While there is flexibility to alter line length (described later), it is important that the respective device spacing and deployment times are adhered to. A key objective of nationally consistent methodology to estimate RAI's is that results can be compared between different areas and over time. Changing device spacing or deployment time will significantly alter the resulting RAI, negating any comparisons. For example, if a 200 m line of 20 Waxtags recorded possum interference with 1 Waxtag, then the WTI would be 5% (1/20). If, instead, only 10 Waxtags had been used spaced at 20 m, again recording possum interference with 1 Waxtag, than the WTI would double to 10% (1/10) even though the actual possum population density is the same.

To treat both outcomes as equivalent measures of WTI would be misleading.

RTCI is the longest established possum index and remains the benchmark RAI within the sector. The WTI has become more used over the past 10 years, while the CCI is standardised as a new method (2015) and subject to further validation. It should be noted that all three methods only provide an estimated RAI, subject to significant inherent variability. An RAI is a relative index of population abundance, not a measure of the actual possum abundance (possums/hectare).

The following compares the attributes of the devices to assist selection.

[2] RTCI – Residual trap catch index
[3] WTI – Waxtag index
[4] CCI – Chewcard index

Traps	Waxtags	Chewcards
For comparative purposes, most existing possum RAI data are RTCI. The sector overall has a significant degree of experience and comfort with RTCI.	Much less existing data expressed in terms of WTI. Lesser clarity about what the WTI means c.f. RTCI.	New method, very little existing data expressed in CCI (as standardised here). Subject to further research.
Physical evidence of possum in trap, and no possibility of 'double-counting[5]' individual possums.	Unpalatable device. Evidence that 'double counting' is inconsequential as evidenced by good accuracy including at relatively high population density (up to 20% RTCI equivalent, Warburton and Forrester 2008) and a tendency for cumulative interference rate to decline to asymptote relative to population density and RTCI (Thomas et. al. 2007, Sakata 2011).	Chewcards differ from Waxtags in that a palatable food bait (peanut butter) is incorporated. Evidence of double-counting as interference does not appear to tend to asymptote over time (Kavermann et.al. 2013), and leading to CCI saturation especially at higher population densities (Sweetapple and Nugent 2011, Ruffell et. al. 2014).
Traps relatively heavy, not always practical to carry the required number.	Small lightweight device.	Small lightweight device.
Modest capital cost of traps, reusable	Un-bitten Waxtags can be reused.	Reusable unless fresh bait required.
Can capture native birds and companion animals. Additional effort of raised sets may be required.	No non-target captures. No possums removed from the population.	No non-target captures. No possums removed from the population.
Regulatory restrictions on use (e.g. need permission within 150 m of dwelling, traps must be cleared daily within 12 hours sunrise, etc).	No specific regulatory constraints.	No specific regulatory constraints.
Most labour intensive method for a given sample size of monitoring lines. Traps are heavy and take longer to set, daily checking requires 4 visits for the duration of 3-night monitoring.	Significantly less effort required for a given sample size c.f. traps. Lightweight device, rapidly deployable, only 2 visits required.	Significantly less effort required for a given sample size c.f. traps. Lightweight device, rapidly deployable, only 2 visits required.

[5] In this context double counting refers to the scenario where a possum is detected more than once, e.g. biting 2 or more separate Waxtags or Chewcards. Where this occurs, accuracy may be compromised, especially at higher densities where saturation of the RAI can result.

Accuracy[6] is perceived to be acceptable, with evidence in support. (Henderson et. al. 2007 reports R=0.82 for 3 night RTCI, and R=0.88 for 2 night RTCI. Monks and Ramsey 2006[7] report R^2 = 0.5)	Accuracy is perceived to be acceptable, with evidence in support[8]. (R^2 = 0.97 from Thomas et al 2007, R = 0.85[9] Henderson et. al. 2007).	No data available at this time. Device saturation at higher population densities (>10% RTCI equivalent) may compromise accuracy.
Relative accuracy[10] does not apply to RTCI as it is the industry benchmark.	Relative accuracy appears acceptable. One study directly comparing RTCI to WTI, R^2 = 0.9 (Thomas and Meenken 2010).	Relative accuracy is modest c.f. RTCI and WTI at low density populations (R^2 = 0.6-0.8) and poor at higher population densities due to CCI saturation (Ruffell et. al. 2014).
Sensitivity[11] of the RTCI is generally less than for Waxtags (Thomas Meenken 2010).	Sensitivity of the Waxtag and Chewcard methodologies are similar (Sweetapple and Nugent 2011, Ruffell et. al. 2014).	Sensitivity of the Waxtag and Chewcard methodologies are similar (Sweetapple and Nugent 2011, Ruffell et. al. 2014).
Precision[12] is not considered directly in terms of RTCI, as it is the industry benchmark against which other systems are compared.	Precision was found to be similar to traps in one study (Henderson et. al. 2007). If, however, advantage is taken of the opportunity to increase sample size for the same effort/cost c.f. trapping, then precision can be significantly improved compared to the RTCI.	No specific information available. Presumably, the benefit of increased sample size for a given effort compared to RTCI applies, as is the case for Waxtags.

[6] Accuracy in this context means the ability of the RAI to reflect changes in the 'true' possum population density in a linear fashion. As indicated by regression coefficient (R), described Henderson et. al. 2007.

[7] As reported in Jones and Warburton 2011.

[8] Although Warburton and Forrester 2008 caution that while Waxtags are sufficiently correlated to support their use, the Thomas et al 2007 study used Waxtags placed in cruciform arrangement rather than lines, so the indices derived may differ.

[9] No flour lure was used with the Waxtags in this study. Available information indicates this substantially reduces interference rates (P=0.0001) c.f. where flour lure is used (S Henderson unpublished data reported in Thomas and Meenken 2010). A study where corflute blaze was substituted for a food lure in one treatment group (non-forest) also suggest predictive ability of the Waxtag method is compromised where no food lure is used (Forsyth et.al. 2018).

[10] Relative accuracy in this context means the relationship (correlation) between an RAI in question versus an established RAI (typically RTCI).

[11] Sensitivity in this context means the ability to detect possum presence. At very low population densities it becomes important to minimise 'false negatives'.

[12] Precision in this context means that the methodology provides reasonably tight confidence intervals that genuinely reflect sampling variation. Precision can be estimated from CV's (coefficient of variation). From Henderson et. al 2007.

2.1.1 Cautionary note: bite shyness

Waxtags require that a possum actively chooses to bite the device. Consequently, if a possum population has been exposed to control techniques which have resulted in a significant number of possums becoming bait averse, or wary of novel objects, then those animals may be less inclined to bite the Waxtags. There is evidence from research that possums from areas treated with cyanide paste are less likely to bite the Waxtags (summarised in Thomas and Meenken 2010). In areas where cyanide paste has been recently used, or there is some other compelling reason to believe the population is bait shy, monitoring using the Waxtag method is not recommended. Presumably a similar caveat applies for Chewcards.

2.2 Define the management boundary

Draw on a map (no less detailed than 1:50,000) the boundary of the management area in which possum density is to be assessed. Calculate the total management area hectares.

This Protocol presumes monitoring lines may be placed up to the boundary of a management area. However, some managers may choose to incorporate a buffer to allow for possum immigration. If this is the case, then the reduced area becomes your management area.

2.3 Define strata boundaries

We may need to divide our management area into various strata. Stratification is carried out either to increase the statistical precision of the RAI estimate, or to ensure lines are allocated to specific areas of interest or concern. Try to keep stratification to a minimum, as it adds complexity and often additional lines (cost) to the monitoring.

If parts of the treatment area vary significantly in possum density or control techniques (e.g. aerial and ground control), then simple random sampling can be made more efficient by stratifying the sampling. However, to stratify effectively on this basis (i.e. to improve statistical precision) it is necessary to know something about the relative density of possums in each stratum. In most cases, this information is not known with any confidence. If the management area has clearly identifiable strata in which possum densities are likely to be different, then stratification is warranted. Where very low residual populations are expected, e.g. less than 2% RTCI, there is little point in stratification for statistical reasons.

We may also need to stratify for management reasons, to ensure adequate monitoring information is available for the client from specified areas. Stratification could be for a number of reasons, such as differentiating disease risk status, or establishing progress payment blocks.

Stratification guidelines include;

a) **High Risk Strata** Minimum line numbers may be increased for any operation, and/or within any stratum, where enhanced confidence in information requirements is de sired. Any risk factor may dictate a “High Risk” stratum. For example, areas of unique ecological value or under particular threat, or high risk in terms of Tb history, or areas where control techniques are historically less consistently effective – such as aerial exclusion zones. Very low density populations may also increase variation and skewness (larger proportion of zero interference lines) in the data, and increasing sample size will ameliorate that to some extent, together with increasing line lengths to 400m/20 devices (refer Table 1) to reduce incidence of zero points in the dataset.

b) **Low Risk Strata** Any stratum may have minimum line numbers reduced where management information requirements have less importance, or where or where management knowledge already exists sufficiently. Any factor may dictate a “Low Risk” stratum. For example, habitat areas which are known to have an acceptably low intrinsic carrying capacity for possum populations. (See also “Exclusion Strata” below).

c) **Exclusion Strata** Some strata may be left entirely unsampled. (For example, “Exclusion” strata). Any factor may dictate an “exclusion” stratum. For example, they may be areas treated by aerial control and known to be prohibitively difficult to monitor. While a corresponding more feasible stratum within the same aerial control operation can be feasibly monitored. The assumption is made, on balance of probability, that the results from the monitored stratum can be extrapolated to the non-monitored stratum with reasonable confidence.

d) **Small Strata** Any “spatially limited” stratum, or sub-stratum, may have minimum line numbers reduced to whatever is able to be accommodated. This may be just one line, or even one reduced line of say 5 detection devices. However, device spacing on a line must remain at 20m, and minimum separation of 200m between lines must be observed. While reduced monitoring effort is unavoidable in such areas, that does not really compromise management information quality, as effectively all of the available area is monitored. However, if a stratum only has a sample size of one, it can no longer contribute to the estimated weighted mean for the operational area. For a weighted mean to be calculated (if of any interest to management), at least 2 lines per stratum are required. One solution may be to combine several small areas into a “non-contiguous stratum” (see below), ensuring the technical requirement for 2 line minimum can be met.

e) **Non-contiguous Strata** Any individual stratum may be spatially “non-contiguous”. (For example, a series of separate exclusion zones for an aerial operation can be treated as one stratum). To ensure non-contiguous stratum are adequately monitored, they may be treated, for the purpose of line allocation, as if each spatially distinct polygon is a sub-stratum. With number of random line start points allocated pro-rata based on polygon size accordingly, and each polygon receiving a minimum of one line. Where a polygon is too small to fit one line, a shorter 100m line of 5 monitoring devices may be specified.

Additionally, there are three habitat classes on which to base stratification IF required for management purposes. Often a separate bush-pasture margin stratum will not be necessary:

- Continuous habitat (e.g. large forest or tussock areas, typically > 1000ha),
- Farmland (other areas characterised by patchy habitat),
- Bush-pasture margins (i.e. the interface between large areas of forest and farmland)

Draw on a map (no less detailed than 1:50,000) the boundaries of the strata. Calculate the management area of each stratum.

2.4 Define possum habitat area

Calculate the hectares of possum habitat for each stratum, or the entire management area if un-stratified. This habitat area will be used to determine how many monitoring lines are required.

Potential possum habitat is defined as those areas where possums may potentially nest. Major habitat areas, e.g. forest, tussock, will often be large areas of continuous habitat but on farmland habitat will often be in smaller isolated patches. Potential habitat includes, but is not restricted to:

- Native or Exotic Trees
- Bush – Forest Patches
- Scrub Patches/Gorse
- Flax/Cabbage Trees
- Orchards
- Alpine (altitude at Managers discretion)
- Shelter Belts/Tree Lines
- Willows/Riverbeds and Banks
- Hay Bales
- Tussock
- Isolated Trees
- Fern Patches
- Gardens
- Buildings
- Rocky Outcrops/Piles
- Hedgerows
- Swamps
- Unused/Abandoned Machinery.

The approach and tools required to determine habitat area depends on the default stratification class: continuous habitat, farmland or bush-pasture margin.

2.4.1 Continuous habitat area

If a management area or stratum is continuous possum habitat (e.g. forest or tussock areas typically > 1000 ha) then the possum habitat area is the same as the management area.

Aerial photographs are a good source for identification of bush or forest habitat and this imagery may be available online (e.g. Google Earth). The Land Cover database (LCDB) or ECOSAT or similar databases may also be used. As a minimum, 1:50,000 topographical maps are necessary.

2.4.2 Farmland habitat area

Calculating the area of farmland habitat is more challenging. You can take one of two approaches depending on the habitat information you have available. One approach is to map all habitat patches and directly calculate their total area. Alternatively, if adequate habitat information is not available, then use the most recent version of the Land Cover Database (LCDB) to estimate total habitat area. The approach you take here will affect the line selection methodology and field operator responsibilities later.

To map all the habitat patches and calculate their area directly, you must be able to identify areas of habitat 30 m by 30 m or larger and any linear features, such as hedgerows > 2 m wide. Mapping and area calculation can be achieved by either manual or digital means.

Examples of data sources that can currently identify habitat to this degree of resolution are:

a) Aerial photographs (colour or black & white) with a scale of 1:25,000 or better and photographed within the last 5 years, or

b) Satellite imagery (e.g. ECOSAT) combined with aerial photography. ECOSAT does not have the capability of identifying 2 metre linear features (e.g. shelter belts) or non-woody habitat (e.g. patches of bracken), so it is necessary to use 1:25,000 aerial photos as well.

In the absence of high resolution habitat data, use the LCDB to map larger habitat patches directly and estimate the remaining habitat area as follows.

- Calculate the total farmland management area in hectares.
- Identify the total habitat area in hectares using the LCDB (excluding tussock) and express this as a percentage of the management area.
- Calculate expected % habitat area by adding 5 percentage points if the percentage habitat area is less than 50% of the management area. If more than 50% of the management area is defined as habitat by the LCDB, then use the LCDB estimate directly.

For example, if the management area is 10,000 ha and the LCDB indicates that 1000 ha, or 10%, is potential possum habitat area, then:

1. Habitat area (ha) = 10% + 5% points =15%
2. 15% of 10,000ha = 1,500 ha expected habitat area

2.4.3 Bush-pasture margin habitat area

Aerial photographs, Google Earth, or ECOSAT are good sources of information for identification of bush- pasture margins. As a minimum, 1:50,000 topographical maps and the Land-Cover Data Base (LCDB) should be used.

There are two measures of habitat pertaining to bush-pasture margins:

(i) the length of the margin, and

(ii) the area of the bush-pasture margin.

Measure the length of the margin (using a map wheel, digitiser or similar). When two sides of an area are less than 200 m apart, such as a tongue of forest or indentation of pasture into forest, then **only one side** should be included.

For the purpose of stratification, an area-equivalent is required for the bush-pasture habitat. This is presumed to be a strip 200 m wide and the length of the bush pasture margin long. Therefore, to calculate the area-equivalent, multiply the length of the margin (in km) by 20 to obtain the area in hectares. However, margin lines should be planned and deployed only along the margin, not in the 200 m strip back from the margin.

If your monitoring design includes the adjacent forest as a monitoring stratum, then subtract the bush-pasture margin area-equivalent from the forest habitat area for the purpose of calculating the relative habitat proportions among strata. However, the entire original area of the forest stratum will be available for forest stratum line placement.

2.5 Number of devices, nights and lines

2.5.1 Devices per line and nights

Each line will normally be deployed as follows, depending on which device is selected.

	Device spacing	Nights deployed	Default line length
Traps	20m	3 (RTCI) or 2 (2 night RTCI)	200m (10 traps)
Waxtags	20m	7 (WTI) or 3 (3 night WTI)	200m (10 Waxtags)
Chewcards	20m	7 (CCI) or 3 (3 night CCI)	200m (10 Chewcards)

The **default** nights deployed are 3 for traps and 7 for Waxtags and Chewcards. Where the 3 night option is selected for WTI or CCI, these results will not be directly comparable to the default 7 night indices. However, because the RTC is calculated on a "per night" basis, the 2 night and 3 night options are accepted as being comparable.

The 3-night option for Waxtags and Chewcards should generally be avoided as it gives RAI's different to the default 7 nights, and the sensitivity of the monitoring will be reduced. There are two main reasons to justify using 3 nights only. Where the cost of a second helicopter visit to check remote lines after 7 nights is prohibitive, and the 3-night option allows operators to stay on site. Or where populations are relatively high, and device saturation is likely to occur, particularly when using Chewcards if relative population density is expected to exceed 10% RTCI.

RTCI is less affected by nights deployed because the index is calculated on a per night basis. Therefore there is scope to select alternative combinations of line, trap and night numbers that will give precision similar to the default combination, as follows.

Table 1. Alternative combinations of traps per line and trap-nights[13]

10 traps/line		5 traps/line		15 traps/line		20 traps/line	
3 nights	**2 nights**	**3 nights**	**2 nights**	**3 nights**	**2 nights**	**3 nights**	**2 nights**
10	13	18	25	8	9	6	7
15	18	26	35	11	13	9	10
20	25	35	48	15	18	12	14
25	31	44	59	19	22	16	17
30	37	53	71	22	28	18	21
35	43	60	81	26	30	21	23
40	50	70	94	30	34	25	27
45	55	79	106	33	38	27	30
50	62	88	118	37	43	31	34

[13] Based on data from – Webster et. al. 1999.

Line length may also be halved for Waxtags and Chewcards, in which case the sample size (number of lines) should be doubled. Or line length may be increased (for example) to 400m and 20 devices for improved precision monitoring low population densities. In which case minimum sample size should be at least maintained.

The rest of this Protocol is written assuming the default arrangements described above. Where different line length or nights deployed are used, the text in other parts of this Protocol will have to be interpreted accordingly.

2.5.2 Number of trap lines – no stratification

Table 2 gives the minimum number of lines that should be established in unstratified areas based on the total habitat area. More lines may be used to improve accuracy and precision in the RAI estimate if required.

In the case of Waxtags and Chewcards, the same number of lines may be used for both 3 and 7 night monitoring.

Plan additional contingency lines in case some planned lines are not able to be monitored, for whatever reason.

In areas that are considerably less than 500 ha, fewer than 10 lines can be used if that is all that will fit. A 200 m separation distance between lines must always be maintained.

Table 2. Minimum numbers of lines in unstratified areas

Habitat area (ha)	**Option 1** Where ground control has been applied	**Option 2** Where aerial control has been applied
0-500	10	10
501 or greater	For every additional 200 ha add one more line up to a combined total of 60 lines. e.g. Treatment area = 5500 ha First 500 ha = 10 lines Additional 5000 ha = 5000/200 = 25 lines Total lines required = 35.	For every additional 300 ha add one more line up to a combined total of 40 lines.

If monitoring **bush-pasture** margin as a stand-alone monitor, then the number of lines required is half the number of kilometres (i.e. 1 line for every 2 km of bush-pasture margin). No fewer than 5 lines should be used except when it is physically not possible to fit 5 lines in the space available. A maximum of 30 lines is sufficient, so a bush margin of 60 km would have 30 lines, as would a margin of 100 km.

2.5.3 Number of lines – with stratification

If an area has been stratified (optional), each stratum is allocated its share of lines on the basis of habitat area as follows:

1. Add together habitat area from all strata (reduce the habitat area of forest strata by the area equivalent of the bush pasture margin).
3. Use this total habitat area to determine the total lines required using Table 2.
4. Allocate lines to each stratum according to its percentage of total habitat area.

5. If a stratum gets less than 5 lines then increase the number of lines to the minimum of five, except where there is not enough space to fit in 5 lines. A 200 m separation distance between lines must be maintained.

For example, consider an operation comprising a 1000 ha forest strata, 2000 ha of farmland of which 500 ha is habitat, and 6 km of bush-pasture margin (120 ha habitat area equivalent). First, we correct the forest habitat area by subtracting the bush-pasture margin: 1000-120 =880 ha. Then our total habitat area is 880+120+500=1500 ha. From (option1) we determine the total line requirement is 15 lines. Then allocate these among the strata:

- forest stratum 880/1500 * 15= 8.8 hence **9** lines;
- farmland stratum 500/1500 * 15 = **5** lines;
- bush-pasture stratum 120/1500*15 = 1.2, observe minimum, hence **5** lines.

Note: * means 'multiplied by'

When interpreting data, it should be noted that the unit for which monitoring results are valid is any one stratum and not for any smaller or different area. Where significant management decisions will be applied to an individual stratum based on the monitoring information, it is recommended the minimum number of lines per stratum be increased to 10. One instance might be where information is used to determine payment to control contractors.

2.6 Placement of lines

For sampling to be unbiased, all potential possum habitat must have an equal chance of being sampled. However, the sample area may need to exclude some possum habitat because of the requirement that no leg-hold traps can be used within 150 metres of a dwelling without the express permission of the occupier, or in any area where there is a probable risk of catching a pet animal (Animal Welfare (leghold traps) Order 2007), or because of safety hazards.

Techniques for line placement depend on default strata (i.e. continuous, farmland or bush-pasture margin).

If possible, avoid using line start points falling within 100 m of a line used in previous monitoring within the past 12 months.

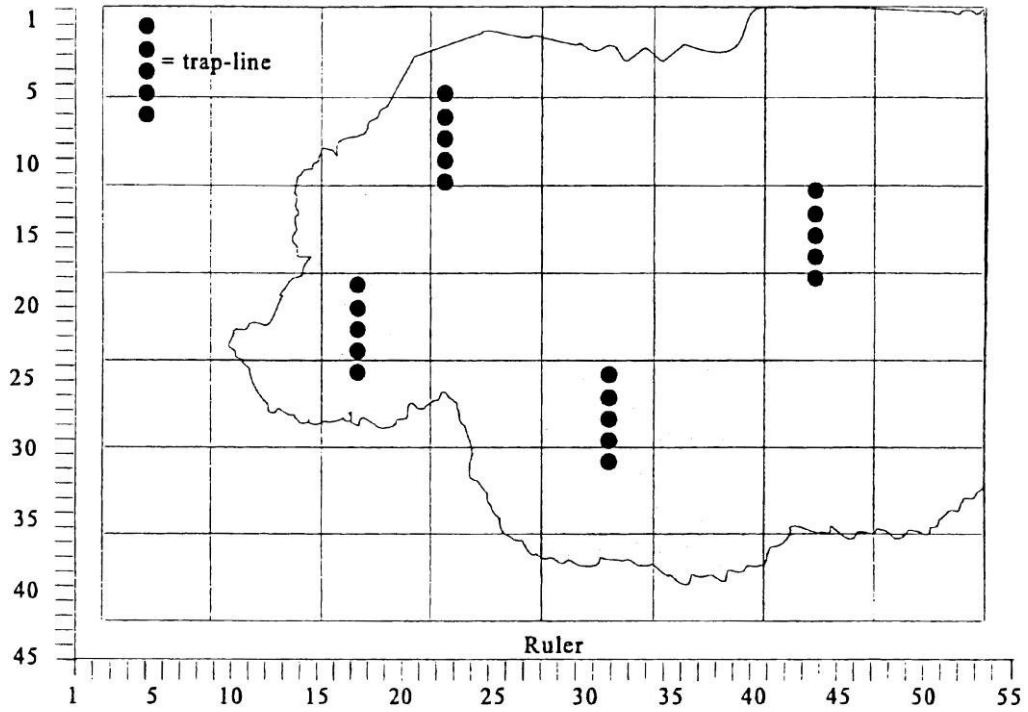
2.6.1 Random placement in continuous habitat strata

In continuous habitat, overlay a numbered grid (intervals no greater than 100 metres) over the sampling area. Then use random[14] northings and eastings to generate random coordinates. Mark in the lines from the random start points at zero degrees magnetic.
Discard any line that falls either wholly or partly outside the sampling area, or within 200 metres of any previously selected line in the same or adjoining strata.

Figure 1. provides an example.

[14] Systematic sampling may also be utilised in place of random sampling for all techniques described in this protocol. For further information on random systematic sampling consult a biometrician.

Figure 1.



To select random starting points, select one number between 1 and 45 for the north-south axis, and one number from 1 to 55 for the east-west axis. For example, the numbers generated were: 12, 22, 25, 17, 32, 32, 18, 43 etc. The starting points for the first two lines are therefore 12 north-south and 22 east-west, and 25 north-south and 17 east-west (see diagram). In Excel you would use the function =randbetween(1,45) to return a random number between 1 and 45.

The F9 key will calculate the next random number. If an error message is returned, you will need to install the analysis toolpack, Tools/add-ins/analysis toolpack/OK.

Alternatively, a GIS can be used to select random co-ordinates in a given area.

A quasi-random sampling strategy may be employed to reduce travel time in remote or difficult country. Randomly generate points numbering a quarter of the required number of lines. Draw a 1 km square (minimum) centred about each point, ensuring at least 200m clearance between adjacent sampling squares. Each square then has a monitoring line (200 or 400 m) commencing at a corner and laid along one side of the grid square. Larger squares or rectangles may be used to increase distance between lines and hence improve coverage of the management area somewhat. While this clustered sampling approach will reduce operational cost, coverage of the operational area will be compromised, as will the statistical requirement of independence. Accordingly, this approach is not recommended for the purpose of performance monitoring.

2.6.2 Random placement in bush-pasture margin strata

This method can also be used for monitoring other linear habitat types such as riparian corridors.

Mark out the bush-pasture margin at 100 m intervals, numbered from 0 to ‘n'.

Then, randomly select the required number of start points for lines from the range 0 to [n-1], (because if point “n” were selected, it would not be possible to fit in a line).

For example: if the length of a margin has been measured as 34.4 km. With a 100-m interval between points, the number of potential start points is therefore 34.4 * 10 = 344. The range from which to randomly select lines is 0 to 343. Assume point #0 is at the left-hand end of the margin. If the random process selects point #3, that line would start 300 m from the left-hand end of the margin, and the line path will be from left to right.

Once a line is started it should follow the edge, even when the edge turns sharply and travels either out into the farmland or into the forest.

Discard any line which falls directly adjacent to any previously selected line, i.e. ensure a minimum distance of 100 m between line ends is maintained.

Where the bush-pasture margin is part of a stratified monitoring operation, allocate lines to the bush-pasture margin first and then to the farmland and/or forest strata. Reject any line in the farmland or forest if any part of it is within 200 m of a line already selected for the bush-pasture margin.

2.6.3 Random placement in farmland strata – all habitat mapped

If all habitat in farmland strata has been accurately mapped, then random start points can be allocated directly into areas of habitat. Discard any line that falls within 200 m of a previously selected line.

A GIS can randomly allocate line start points into known habitat. Once random start points are selected, draw line paths in available habitat. In the first instance, attempt to lay the line path on a zero-degree magnetic bearing. If there is no viable path on magnetic north, then search clockwise around the compass for the first opportunity to map a straight line. Where a straight line is not possible, the line paths may follow available habitat incorporating straight sections of line where habitat allows. You may need to connect consecutive patches of habitat to allocate the required number of monitoring devices There is no minimum distance once a line is commenced, though it needs to remain within the stratum boundary and at least 200 m away from any other line. If no habitat is available within 200 m of the designated start point, then discard the line and randomly select another start point.

Lines can also be selected using manual techniques, typically using photos as follows:

- Mark all potential trap-lines on the photo and where patches are too small to fit in lines of 10 traps, link two or more patches until 10 traps can be fitted.
- If there are large patches of habitat in which several lines would fit, then place a 200 m x 200 m grid (the required size of a trap-line) over the patch and mark each grid cell as a potential trap-line. In addition, identify potential trap-lines around the edges of the patches.
- Number each potential line from one to the maximum and then select which lines to monitor using a random selection process.

2.6.4 Random placement in farmland strata – habitat estimated

Where we have estimated the habitat area using the LCDB, we cannot allocate all lines directly into habitat, because we don't know where all the habitat is. So allocate random points directly into the management area using an xy grid system (refer figure 1). The field operative has rules to travel to the nearest available habitat (refer Part 3).

2.7 Trend monitoring

Trend monitoring is used to track the change in possum populations over time. Typically, these are populations have not been subjected to control. It is preferable to use the same lines over time so that each line is only measuring the change over time without the additional variation of changes in location as would happen if lines were shifted. Lines should not be monitored more than once every 12 months.

Using the RAI on each line, the change over one or more years is calculated using regression analysis. The change from each line is then used to calculate an overall mean change for the monitored area along with its standard error and confidence limits. Results cannot be extrapolated outside the survey area and it is recommended that a biometrician be consulted before trend analysis is undertaken.

Trend monitoring in this context does not refer to pre-control monitoring. However, recent trend monitoring data can be used as a pre-control estimate where control is proposed. Any post control monitoring will then require a new set of lines to be selected.

2.8 The field plan

The final stage of the design process is preparing a field plan for the field operators. The minimum information that needs to be provided is:

- uniquely numbered lines, their stratum and New Zealand Transverse Mercator (NZTM) map coordinates. It is important that the designer specify clearly which default habitat stratum applies (i.e. continuous habitat, BP margin, or farmland habitat), as that will affect the expected requirements of field operatives.
- contingency lines, their stratum, and NZTM co-ordinates. Specify that where contingency lines are used the one nearest to the rejected line must be used.
- suitably scaled map showing operational and strata boundaries, line starts and paths. Where design is by electronic means, and operators are using GPS/PDA or similar technology, then it is recommended that all the foregoing information is delivered electronically;
- the direction in which bush-pasture margin lines will be laid (default is right when facing the margin from the farmland side);
- device type and number of devices per line;
- number of nights deployed;
- if traps are used, set type and height (ground, leaning board, or other raised set);
- if traps are used, whether back riders are classified at the default 800 gram weight or some other specified weight;
- time frame for completion.

Additional information may also be provided, such as:

- property boundaries included in map;
- orthophotos in addition to 1:50,000 topographical maps;
- occupier names, addresses, phone numbers.

PART 3. CARRYING OUT THE FIELD MONITORING

3.1 Trap ground sets

No. 1 double-coil spring traps are to be used. The triggering weight should be approximately 500 grams. **Operators must ensure all traps used are consistently maintained and that their traps operate at near new performance levels.** Use of any type of protective coatings or oils is not recommended. It should be noted that some makes of traps may deteriorate faster than others.

Traps must be lured with a mixture of plain white flour and icing sugar (5 kg flour/1 kg icing sugar). No flavours should be added. Spread flour behind the trap up the trunk of the tree, stump, log or backing board from the ground to a target height of 50 cm (in any case between 40-60 cm high) to make a white blaze (figure 2). The blaze should be approximately 10 cm wide, though it may be less if the backing is too narrow. If using a log as a backing for the trap, smear the flour along the log behind the trap, creating a horizontal blaze of 50 cm (+/- 10 cm) directly above the trap (figure 3. However, a vertical blaze must be used if the nearest trap site permits that, with the horizontal blaze only applied as a last resort.

Bark must NOT be removed from trees to aid application of flour lure under any circumstances. Best efforts to minimise any lure spillage in excess of the specified application must be made. Where lure is inadvertently spilt on the ground or trap, it should be removed or scuffed into the substrate.

Figure 2. Traps should be bedded into the substrate, approximately one hand width from the trunk of the tree, and with the trap dog nearest the tree.

Figure 3. If using a log (or tree root) that is less than 50cm high as a backing for the trap, smear the flour along the log behind the trap, creating a horizontal blaze of 50cm (+/- 10cm) directly above the trap.

Figure 4. Traps should be set fine (i.e. trap dog just under the trigger latch) with the trigger plate at the same level as the jaws.

Wire or nylon cord can be used to secure traps to soft or small sites that cannot hold a staple securely (e.g. punga). In areas such as open tussock country and flax areas where there are no suitable anchor points for traps and/or no backing for lure, then stakes or backing boards must be used. The stakes/boards must be 50 cm long and 10 cm wide. They must be white on both sides, either white corflute or a painted board or similar. If a road marker is used it must not incorporate any reflective material. The white board creates the visual ‘blaze’.

attractant and a small handful of flour and icing sugar lure is placed at the base of the board to encourage the possum to spend time at the trap site as for a tree set.

Set traps with dog towards the backing and approximately 10 cm or about one hand width out. The distance away from the backing may be a little closer or further where the backing leans towards or away respectively. The purpose of the hand width clearance is to increase the chance of back leg captures, so consider the distance from the blaze. The same judgement applies for buttressed trees.

Do not cover traps or fence them on the sides with sticks or rocks. The trap site should be disturbed as little as possible. However, for welfare reasons, clearance of any vines or saplings to prevent captured possums from entangling the chain and increasing the risk of injury is required. Traps must be firmly bedded, but with no more soil disturbance than necessary.

Ground set traps should be set as horizontally as possible and, in any case, within 10^0 of horizontal. This may occasionally require digging a platform in steep terrain.

Ensure all traps can be relocated and recorded accurately. A suggestion is to use colour plastic cruise tape as a marker. If markers are used place them at least 1 m away from the trap so as not to be an additional attractant.

3.2 Trap raised sets

A standardised methodology for raised sets using a leaning board is presented below. In some cases, such as remote forest locations, resource limitations may not enable leaning boards to be used. Alternative raised sets using some type of platform or bracket can then be used[15]. The Field Plan will specify the set type you are to use.

The default standards for raised sets specified by the Department of Conservation are;

"When working in an area where kiwi and/or weka are present, traps must be set so they cannot be accessed by the respective species. For excluding kiwi: traps must be set at least 70 cm above ground and any accompanying ramp must be sloped at least 55 degrees. For excluding weka: leghold traps must be raised at least 100 cm above ground; kill traps must be at least 130 cm above ground; any accompanying ramp must be sloped at least 55 degrees."

Leaning boards must be of wood[16] or be wood-based (e.g. plywood). Boards must be 100 cm or 1400 cm long, for 70 cm and 100 cm sets respectively[17], 50–80 mm wide, and rigid.

[15] Research consistently shows that a raised set other than a leaning board set (i.e. not in contact with the ground) is likely to result in a reduced RTCI estimate compared to ground sets or leaning board sets. From Henderson et. al. 2007, unpublished Research Report to Animal Health Board (now TBfree New Zealand) R–80660 Configurations of leg-hold traps that were not effective were 'raised' leg-holds……'Raised' leg-holds have historically had low capture efficiencies relative to leg-hold traps set on the ground during previous field trials (Thomas & Brown 2001, Nugent et al 2001, Henderson et al. 2004). However, where platform type sets are used, any type of platform or bracket is acceptable, as long as the required specifications are met, being:

- bracket holds trap firmly and horizontally, against the tree, with the trap dog towards the tree.
- trap is 70 cm (kiwi present) or 100 cm (weka present) above ground (as for leaning boards);
- trap is able to disengage from the platform and trap chain is of adequate length and fastened so trapped animal can easily reach the ground;
- lure blaze placed from the trap up the trunk 50 cm (+/- 10 cm) and a small handful of flour is placed at the base of the tree also.

[16] Leaning boards can be made from pawlonia or cryptomeria (Japanese cedar). Both timbers are light and very strong and, when cut into 2 lengths, are readily stowed in a back-pack. A short section of channeling attached to either side of one half of the board allows the other section of board to readily slide into the side-supports and thus provide a board that is 1.2 m long. Another option is to join 2 sections of timber with short lengths of dowel. Anecdotal evidence suggests that boards hinged in the middle are inclined to collapse after a possum has been caught and this can result in injuries to possums if the trap chain gets entwined around the board.

[17] For perfect right angled triangles lengths of the leaning board would be 85 cm and 123 cm respectively. A modest margin has been added to allow for cases whether the ground level slopes away from the tree.

Adequate rigidity is determined by supporting the board at both ends so that it is horizontal and then placing a 3-kg weight in the centre – the centre of the board should not be displaced more than 10 mm. Boards may be hinged or otherwise joined, but they must be straight when set. The surface of the board should be rough in texture (i.e. rough-sawn not dressed) and the material should not be painted. If treated timber is used for the boards, they should be weathered for a minimum of 1 month before being used. There can be a 15 mm-deep notch (i.e. saw cut) in one side of the board (for the trap chain) 50 mm from the (top) end. The top of the board should also have two holes drilled for locating the nails used to attach the board to the tree (these holes will help to prevent the board from splitting and will allow for easier fixing and removal). A V-shaped notch cut in the top of the board will help the board rest securely against the tree.

The board should be placed against the nearest suitable tree at an angle of $\geq 55^0$ so that the trap when set is ≥70 cm or ≥100 cm up the trunk of the tree. The top of the board must be firmly attached to the tree using nails, wire or cord so that the board is stable and will not wobble when a possum climbs it. The trap must be firmly attached at the top of the board using two bands of rubber so that it does not move. The bands for attachment can be either commercially available heavy-duty rubber bands (e.g. Dixon No. 104, 15.9 · 102 mm) or strips of rubber inner tube tied into bands. Traps should be fine-set with the trigger plate horizontal (in relation to the trap) and the dog towards the tree.

The trap chain should be attached directly below where the board meets the tree and at a height such that the chain is not loose. The point of attachment must be low enough so that when a possum is captured and the trap dislodges from the leaning board, the possum and trap are not left hanging. The trap site should be cleared of any vines or saplings to prevent captured possums from entangling the chain and increasing the risk of injuries.

While not considered habitat, fence posts can be used as ‘trees’ for raised sets provided they are the nearest trap site to the 20 metre point, are tall enough for raised sets to be set according to this Protocol and are within 30 metres of any habitat.

For luring raised sets, spread the flour and icing sugar lure up the trunk of the tree, from the trap to a point about 50 cm (+/- 10 cm) above this and also place a small handful of flour at the base of the board on the ground. No lure should be placed on the leaning board. In areas where suitable sites for deploying raised sets are scarce, 50 mm x 50 mm wooden battens may be driven into the ground to provide for a raised set to 700 mm. White corflute 50x10 cm is nailed to the batten to extend above the trap for a visual blaze. The same nails can be used as hold the leaning board to the batten. A small handful of flour lure is placed at the base of the leaning board on the ground.

Figure 5. Raised set. Raised trap set on a leaning board at approximately 450 and showing the position of the chain (directly under the trap), the rubber band holding the trap to the board, the trap dog towards the tree, lure extending upwards 50 cm.

3.3 Waxtag and Chewcard Deployment

Waxtags incorporating a luminescent strip are to be used. Waxtags and luminescent strip are nailed to a tree or post (using a flat-head nail) so that the wax part of the Waxtag is approximately 30 cm above the ground. A blaze of flour and icing sugar (5:1 ratio) is applied from the ground up to the Waxtag. No other lure or attractants are to be used.

The photographs below show how a Waxtag, luminescent strip and flour blaze should be placed.

Chewcards are placed similarly, except that no luminescent strip or flour and icing sugar lure is used. The standard design is a 9 x 18-cm card made of 3-mm white plastic coreflute. Smooth peanut butter or similar bait[18] is applied to the internal channels at either end of the card. Cards are applied to tree trunks, 30 cm above the ground. Fold the card in half then push a 50 mm flat-head nail through the top half of the card, about 10 mm back from the fold. Then push the nail through the bottom half about 5 mm from the fold. This offset nail placement helps hold the card in a right-angled position when placed on the tree. Finally nail to the tree with the nail angled up at about 30 degrees.

Ensure all Waxtags or Chewcards can be relocated and are uniquely identified. As a minimum, write the date, line number and tag number (e.g. 1 to 10) on the back of the Waxtag or Chewcard with a permanent waterproof marker.

If colour plastic cruise tape markers are used, place them at least 1 m away from devices so as not to act as an additional attractant.

3.4 Laying monitoring lines

Navigate precisely to the planned line start coordinates using a GPS.

If a GPS fix cannot be obtained, then navigate to the line start as accurately as possible using maps, compass and hipchain. In this instance, your navigational accuracy must place you with 50 m of the planned line start coordinates.

If, when you get to the planned start coordinates, there is no suitable habitat to monitor, or you cannot access the start point, then:

- If you are in continuous habitat (e.g. bush or tussock), but the start point is in habitat unsuitable for monitoring (either because it is inaccessible or there is a patch of no habitat), then move to the nearest habitat within 200 m of the start point. If there is no suitable habitat within 200 m of the start point then select the nearest contingency line.

[18] A range of other commercially available baits are also acceptable, for example Connovation's "smooth in a tube", or Trappers Cyanide 'possum dough'. Trial data indicates these various products have comparable effect (B Warburton, Landcare Research, pers. comm.)

- If you are monitoring bush pasture margin, move directly to the margin in the shortest distance and start at that point (applies regardless of whether the planned start point falls in farm or bush habitat). However, if you are within 100 m of another line, walk along the margin to ensure the start point is 100 m from the previously laid line. If there is no margin habitat within 200 m, the nearest contingency line is selected.
- If you are monitoring a farmland stratum, or any other stratum which is not continuous habitat, select the first available habitat within 200 m. If no habitat is available within 200 m, the nearest contingency line is selected. If the habitat selected proves to be too small to complete the line, then when you emerge from that patch of habitat, select the nearest suitable habitat to continue the line (this can be any distance away but must remain within the stratum boundary and at least 200 m from other lines).
- Contingency lines must only be used in place of planned lines where there is genuine need, for example a lack of habitat or safety reasons.

Lines must not be within 200 m of each other at their closest approach (or 100 m between ends of lines in bush pasture strata. If a previously established monitoring line is about to be approached within 200 m, or a stratum boundary is about to be breached, treat this as an obstacle and turn the line 90^0 to ensure 200 m minimum clearance is maintained. Similarly, the line may be turned 90^0 at the commencement of a line where the operator knows a boundary or other line will be approached within 200 m during line deployment.

The first device on a line should be 20 m from the start point. Subsequent devices should be set at 20 m intervals on the nearest suitable site. Hip-chains must be used for measuring the distance between devices. All hip-chain cotton must be retrieved to prevent the entanglement of birds.

For ground-set traps, a suitable site is the nearest tree or fence post that will hold a fence staple or to which a trap can be secured by alternative means. For raised sets select the nearest site that provides adequate height. Waxtag and Chewcard sites require sufficient height and provide for the device to be nailed or screwed on.

Lines are required to be within 10% of their overall design length. For instance, a 10 trap line must be 200 m long, +/- 20m (i.e. from 180 to 220 m long).

If a line is being laid on a compass bearing and a required site is not on the line of the compass bearing then, after setting the device, return onto the line before proceeding to the next site. Where a line is laid on a bearing, it is required to be +/- 10 degrees of the bearing specified in the plan. Where a line has no pre-determined bearing (e.g. farmland) then deploy the line, in order of priority, as follows;

1/ If a straight line can be laid at 0 degrees magnetic, then do so. Else;
2 If habitat allows lay the line straight on the first available bearing going clockwise from 0 degrees magnetic. Else;
3/ The line must be laid following available patches of habitat, making best attempt to achieve straight sections of line where possible.

Doubling back around the margins of small habitat patches, or following margins when a straight line can be laid through the habitat, shall be avoided.

When following a compass bearing, small barriers that can be walked around in the space of 100 m or less should be traversed, placing devices at the specified intervals whilst making the traverse, and the line then continued on the designated compass bearing. If a barrier is encountered that cannot be traversed (e.g. perpendicular sides on a gorge, or steep bluffs that extend for 100m either side) then turn the line 90 degrees from the original bearing either to the right or left and follow this new bearing until the line is completed.

If a clearing is encountered whilst laying a line and there are acceptable sites e.g. logs within the clearing, continue to deploy devices on the compass bearing. If, however there are no suitable sites, treat it the same as an obstacle (refer previous paragraph). If roads or creeks are encountered, select the nearest suitable site on one side or other of the road or creek.

Whenever a deviation has had to be made from the original direction of a line being laid on a compass bearing, you must ensure that the trap line will not encroach within 200 m of another line and include your deviation with your report.

When laying lines around bush-pasture margins, each line should be placed on or as near as possible to, the margin. Lines should follow the general line of the forest edge, not individual trees or shrubs. If the line happens to go around the end of the forest projection or forest indent, continue to lay devices along this margin even if these devices are close to ones that have already been laid. If stock are likely to interfere with devices placed along the margin, then lines should be placed just inside the margin.

A plan may specify that lines are to be laid along river banks or other situations resembling bush pasture margins.

No leg-hold traps can be used within 150 metres of a dwelling without the express permission of the occupier or in any area where there is a probable risk of catching a pet animal. Refer Animal Welfare (leghold traps) Order 2007. If you cannot get permission, abandon the line and select the nearest contingency line.

A trapping permit will be required from DOC if working on conservation estate.

3.5 Weather considerations

Traps must normally be run for three fine nights i.e. with weather unlikely to significantly lessen possum activity. If you know rain started 4 hours or later after dark, that night can be accepted as a fine night. Although it is not always possible to predict stable fine weather, long-range forecasts should be used to maximise the chances of achieving this requirement.

If traps are already placed on lines and on the second or third day rain is predicted, close traps and reopen them when the weather clears.

If rain falls on the **third** night and traps are set, then pick up the line as normal and include the fact in your report. The designer can calculate an RTCI based on only 2 nights, although this should be avoided if possible (i.e. if you expect heavy rainfall on night 3, then close the traps as per above).

If it rains heavily on the first or second night, and catch rate is likely to be significantly reduced (but some possums were caught), then monitoring should be started again using a new set of monitoring lines. In forest, shift lines 100 m either side of the current line. On farmland or bush

pasture margins, use contingency lines. However, if no possums were caught at all, the same lines can continue to be used until a total of three fine nights is achieved.

In the case of Waxtags or Chewcards, for 7 night monitoring periods, weather effects are expected to be variable. However, monitoring should only be commenced on a reasonable forecast. However, if monitoring is over a period of 3 nights, then these must be fine nights as for traps. In the case of three-night monitoring only, if Waxtags or Chewcards are already placed on lines and on the second or third day rain is predicted, remove the Waxtags and reinstate them when the weather clears. If heavy rain occurs, and interference rates are likely to be significantly reduced (but some interference occurred), then monitoring should be started again using a new set of monitoring lines, shifting lines 100 m either side of the current lines in continuous habitat, or using contingency lines in farmland or bush pasture margin habitat. However, if no interference is recorded on a line, the same lines can continue to be used until a total of three fine nights is achieved.

3.6 Checking trap-lines

Traps must be checked within 12 hours of sunrise, as required by the Animal Welfare (leghold traps) Order 2007. It is an offence not to do so as well as not dealing humanely with any captured animals whether or not they are euthanised.

Remove all fur off jaws of traps when setting them to enable you to clearly identify an escape when checking traps the following day.

Replenish lure daily or as required to maintain the original white blaze.

All possums and non-target introduced species (rats, hedgehogs, etc) must be killed as quickly and humanely as possible and removed from the traps. Any dependant juveniles (e.g. pouch young) must also be humanely euthanised. Leave carcasses at least 5 m from the trap-site, either on the ground or in trees (or as directed for audit purposes). However, never leave carcasses in stocked areas as this creates a risk of Bovine tuberculosis transmission to stock. In this case the carcass should be left as close to the line as possible and away from stock access. If you bleed stunned possums do so at least 5 m away from the trap site.

If native birds are caught uninjured or with only minor injuries (i.e. no broken limbs), then release them. Seriously injured or dead native birds should be taken to the nearest DOC office if possible. Contact your local DOC Species Protection Officer to obtain information on how to handle injured wildlife.

Possible trap outcomes are shown in table 3. A possum weighing 800 grams or less is regarded as a ‘backrider’ and must be recorded as such (a backrider is not counted as possums caught when the data are analysed). To ensure uniformity of ‘backrider’ classification, operatives must carry with them scales that are capable of measuring the weight of 800 grams within 50 grams of accuracy. It is especially important, for the avoidance of doubt, that any possum recorded as ‘backrider’ must have its weight recorded. In some cases, a manager may specify some weight other than 800 grams for backrider classification. Check your field plan.

It is important that possum escapes (ESC) are clearly evidenced. If there is any doubt at all, then the outcome must be recorded as sprung and empty (S).

Trapping results must be recorded daily on standardised forms (figure 6 shows an example but alternative layouts are acceptable). For practical convenience, reduce the form to note-pad size (preferably wet-notes).

Alternatively, data may be captured in the field by electronic means.

When trapping is completed, supply all trap records to the designer.

Also include a written summary of any relevant issues and problems encountered during the trapping. This would include reasons for any contingency lines used, exceptional weather events, or deviations from planned line paths for instance.

Table 3. Possible Trap Outcomes

Description	**Record**
Possum caught	Male or female, i.e. M or F.
Possum caught with kitten (backrider or pouch young)	Possum caught (only one) i.e. F
Backrider (animal less than 800 grams)	Backrider i.e.BR
Trap still set with flour on tree	Still set i.e. SS
Trap still set with flour removed by rats or possums	Still set i.e. SS
Trap sprung and empty, chain extended to full length, unclear which species responsible	Trap sprung and empty i.e. S
Trap still set but effectively disabled (e.g. up side down, fell off leaning board etc)	Trap sprung and empty i.e. S
Trap not found, but no clear evidence of a possum	Trap sprung and empty i.e S
Trap sprung, caught non-target species	Non-target i.e. Rat, kiwi, heg (hedgehog), ferret, stoat etc.
Trap not found, but clear evidence of a possum	Possum escape i.e. ESC
Trap sprung with clear evidence of a possum (e.g. fur or claw in jaws).	Possum escape i.e. ESC

Figure 6. Trap-Catch Data Record Sheet

Field Operative:_____ Location:_____

Monitoring period:_____

Line:_____ Stratum:_____ Habitat:_____

Survey: pre-control / post control / maintenance (circle one)

	DATE...../...../.....	**DATE...../...../.....**	**DATE...../...../.....**
Trap No.	**Rain:**	**Rain:**	**Rain:**
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			
16.			
17.			
18.			
19.			
20.			

Possum caught = Male/Female, i.e. M or F. Animals weighing 800 grams or less (unless specified otherwise) = BR

Possum with backrider = F

Traps still set = SS (for ease of recording and processing the results, trap numbers with no notation, or a dash can be assumed to be SS)

Trap sprung and empty = S

Non-target species caught = Rat, kiwi, hedgehog, ferret, stoat etc

Possum escape = ESC

3.7 Checking Waxtag and Chewcard lines

Waxtags and Chewcard are retrieved after either 7 or 3 nights (as specified in the design), and do not need to be checked in the interim.

There are five possible outcomes for each Waxtag or Chewcard device.

1. Includes possum bite marks (P). Only clear evidence of incisor bite marks should be considered.
2. No possum bite marks, but identifiable non-target bite mark. (NT, and record species).
3. No possum bite marks, but unknown bite marks (U).
4. No bite marks (leave record blank).
5. Device lost or damaged beyond interpretation (L).

Results must be recorded on standardised forms (the following figure shows an example, but alternative layouts are acceptable). For practical convenience, reduce the form to notepad size (preferably wet-notes).

Alternatively, data may be captured in the field by electronic means.

The operator must be sure bite marks have been made by possums before recording it as such. If in doubt, record as unknown, and double check the device with co-workers or other competent persons later. The methodology relies on trained operators correctly interpreting bite marks.

Detailed guides on interpreting bite marks are available online.

- For Waxtags at https://www.traps.co.nz/Content/Images/uploaded/Malcolm/bitemark%20identification.pdf
- For Chewcards at https://www.landcareresearch.co.nz/science/plants-animals-fungi/animals/vertebrate-pests/pests-in-forests/chew-track-cards

Approved operators will be required to undertake an examination and meet the following standards. Of 40 bitten devices of known (caged animals) origin, comprising approximately 50% possum bitten devices: the examinee may record no more than 4 as unknown, and must identify at least 90% of the possum bitten devices correctly, and may not identify more than one non-possum bitten device as a possum.

When transporting or storing Waxtags in a vehicle, or in any case where high temperatures may occur, Waxtags must be kept in a chilli bin to prevent melting. Waxtags and Chewcards should be stored for at least two years in case a later audit is required.

On completion, supply all records to the designer, and also Waxtags or Chewcards if required. Include a written summary of any relevant issues and problems encountered during the monitoring. This would include reasons for any contingency lines used, exceptional weather events, or deviations from planned line paths for instance.

Figure 8. Data Record Sheet

Field Operative:_____ Location:_____

Monitoring period:_____

Line:_____ Stratum:_____ Habitat:_____

Survey: pre-control / post control / maintenance (circle one)

WAXTAG NUMBER	**DATE OUT...../...../..... DATE IN...../...../.....**	**NON-TARGET SPP (IF KNOWN)**
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

PART 4. INFORMATION MANAGEMENT

4.1 Reporting requirements

Collection, recording, collation and analysis of data from monitoring surveys should be carried out in an ordered way to ensure that all relevant information can be reported. The report should include relevant operational information, monitoring information and results, and be presented in an easily understood way.

Retain all original data records, together with sufficient explanatory information (metadata) to describe the dataset. The report itself should identify where the original data and any associated analysis material are stored. Where interpretation of Waxtags or Chewcards is liable to dispute, it is recommended they are safely stored and available for audit for a minimum of 2 years following the monitoring.

Operational information

- Location or name. This will allow the monitoring report to be cross-referenced to the report of the control operation.
- Size of the management area.
- Size of possum habitat area.
- Control method(s).
- Dates of start and completion of control operation.

Monitoring information

- Weather on each night.
- Device type.
- Number of lines.
- Nights deployed.
- If traps were used, weight below which possum classified as back rider.
- RAI results by line, stratum and combined strata, with confidence intervals. In light of typical confidence intervals, it is recommended that final reported RAI results be truncated to one decimal point (e.g. 1.073% would be reported as 1.0%).
- Habitat for each line.
- If traps were used, set type and height (ground, leaning board or other raised set).
- Approved operators who were involved with the monitoring.
- Map with lines marked.
- Discussion of reasons for use of contingency lines and any non-conformances.
- If data are to be used for determining population trends, provide description of starting points (i.e. GPS coordinates) and compass bearings of lines.

4.2 Analysing stratified Residual Trap-Catch Index

Follow the steps below for calculating the Residual Trap-Catch Index. Some statistical assumptions may be violated, so 95% confidence intervals are approximations.

1. For each line, count the total number of possums.
2. Determine which escapes will contribute to the possum total and which ones will be treated as Sprung and empty records. An escape will be counted as a sprung and empty record if there is a possibility that the escapee was subsequently captured on the **same** line and, therefore, double-counted. Some examples of which escapes would be excluded/included under this principle are:
    - If only one escape is recorded on a line, with no other captures on the same or subsequent nights, then the escape is included in the possum total.
    - If an escape occurs after having caught a possum on a previous night, then the escape is included in the possum total.
    - If the escape on the first or second night is followed by a possum capture or further escape on that line, then the escape is treated as a Sprung-and-Empty (S) trap.
    - If there are two or more escapes on the same or subsequent nights, and there are no possum captures, then it may be the same animal that has escaped twice (or more). One escape will be included in the possum total and the remainder will be treated as sprung trap.
    - If a possum claw is found in a sprung trap, subsequent captures on the line should be checked and, if no possum with a missing claw is found, the escape is counted as a possum.
3. Calculate the corrected trap-nights by multiplying the number of trap-nights by the number of traps on the line and subtracting half a trap-night for each non-target (NT), backrider[19] (BR) or sprung but empty (S) trap.
4. Divide the total number of possums (include both possums caught and escapes) on each line by the corrected trap-nights on the line. This will give you the mean number of possums captured per trap-night (total possums/corrected trap-nights).
5. Using the possums captured per trap-night from each line, calculate the mean possums captured per trap-night for each stratum i.e. sum of mean possums captured per trap-night/number of lines. Multiply by 100 to get the % RTC.
6. Calculate a weighted mean based on the mean catch rate per stratum and the proportion of total habitat area each stratum contributes to the total [(habitat area stratum 1/total habitat area * mean RTC stratum 1) + (habitat area stratum 2/total habitat area * mean RTC stratum 2) etc to n strata].
7. Calculate the standard error (SE) for each stratum. i.e. standard deviation of the mean possums per trap-night/square root of the number of trap-lines.
8. Calculate the combined SE for all strata. = square root [(habitat area stratum 1/total habitat area * SE stratum 1)+(habitat area stratum 2/total habitat area * SE stratum 2)+ etc to stratum n]

[19] In some regions of New Zealand, mean adult possum weight is relatively low and in such areas an 800 gm possum may be old enough to survive independent of its mother. It is within the manager's discretion to specify a lower target weight for backriders or to treat all caught possums as adults, effectively ignoring the backrider provision. It is not recommended that this discretion is applied in the case of performance monitoring; however, that is a matter of agreement between the parties to any contract.

9. Multiply the combined SE by 2 to calculate the approximate 95% confidence interval.

An example of the analysis will help. You have 10 trap lines, trapped for 3 nights. The forest stratum is 500 ha and the farmland stratum is 200 ha. Escape records have already been allocated into the appropriate columns for these examples (escapes or sprung/empty).

Line	Stratum	Possums captured	Possum escapes	Non-targets	Sprung but empty	Corrected trap-nights	Mean possums per trap-night
1	Forest	1	0	1	0	29.5	0.0339
2	Forest	2	0	1	1	29	0.0690
3	Forest	0	0	0	0	30	0.0000
4	Forest	1	0	2	0	29	0.0345
5	Forest	1	0	1	0	29.5	0.0339
	Forest	**Stratum**				**Mean RTC SE**	**3.43% 1.05**
6	Farmland	5	1			29.5	0.1695
7	Farmland	1	1			29.5	0.0339
8	Farmland	10		1		29.5	0.3390
9	Farmland	4				30	0.1333
10	Farmland	3			2	29	0.1034
	Farmland	**Stratum**				**Mean RTC SE**	**15.58% 5.09**
	combined result					**Mean RTC SE 95% CI**	**6.9% 1.64 + or - 3.3**

Some of the calculations in the above table are:

- Mean RTC forest stratum = (0.0339+0.0690+0.0+0.0345+0.0339)/5 * 100=3.43%
- SE forest stratum = standard deviation(0.0339+0.0690+0.0+0.0345+0.0339)/square root(5) * 100 = 1.05
- Combined RTC = 500/700 * 3.43+200/700 * 15.58 = 6.9%
- Combined SE = square root$((500/700 * 1.05)^2+(200/700 * 5.09)^2)$ = 1.64
- Combined 95% CI (approx.) is the combined mean RTC +or– 1.64 * 2 = 6.9% +or- 3.3

Excel data entry and analysis spreadsheet are available for free download from https://www.bionet.nz/library/tools/ This spreadsheet automatically allocates escapes correctly in the calculation of the RTCI.

4.3 Analysing percent kill

Follow the steps below for calculating the estimate of the percent kill from pre- and post-control trap-catch monitoring data.

- Calculate the mean catch rate and SE for both the pre-control lines and the post-control lines (using methodology in previous section).
- Calculate the estimate of the percent kill

$$\%kill = \left[1 - \left(\frac{Mean_{post}}{Mean_{pre}}\right)\right] * 100$$

Corrected pre-control trap-catch data

Line	Corrected trap-nights	Possums captured	Mean number of possums captured per trap-night
1	30	11	0.3667
2	29.5	22	0.7458
3	29	12	0.4138
4	28	12	0.4286
5	29	13	0.4483

Corrected post-control trap-catch data

Line	Corrected trap-nights	Possums captured	Mean number of possums captured per trap-night
1	29.5	1	0.0339
2	29	2	0.0690
3	30	0	0.0000
4	29	1	0.0345
5	29.5	1	0.0339

	Total	Divide by number of lines	Mean
Pre-control	2.4032	2.4032 / 5	0.4806
Post-control	0.1713	0.1713/ 5	0.0343

%kill = (1-(0.0343/0.4806)) * 100 = 92.9%

- Next, calculate the standard error for the percent kill estimate. There are two options for calculating the confidence limits.

  a) When the post-control monitoring lines have been selected independently of the pre-

control monitoring lines (i.e. both the pre- and post-control lines have separate random starting points), the standard error of the %kill =

$$\%kill_{se} = \sqrt{(1-kill)^2 * \left(C_{pre}^2 + C_{post}^2\right)} * 100$$

Where C^2 and C^2 = coefficient of variation for the pre and post estimates. For example, the coefficient of variation for the pre-control mean is: ***se*** pre/***mean*** pre. Kill is the proportional kill (e.g., 0.896, not 89.6).

Example:

	Pre-control	**Post-control**
Mean	0.4806	0.0343
Standard error	0.0676	0.0109
Coefficient of variation	0.1407	0.3184

Standard error of the kill	0.0248

b) When the pre- and post-control monitoring lines have been paired (i.e. in parallel sets), then the SE of the kill estimate is:

$$\%kill_{se} = \sqrt{(1-kill)^2 * \left(C_{pre}^2 + C_{post}^2 - 2C_{pre} * C_{post} * Correlation\left(ppnt_{pre}, ppnt_{post}\right)\right)} * 100$$

Where pptn = possums per trap-night on each line, and correlation is the correlation coefficient between the pre- and post-control lines (use a spreadsheet to obtain this coefficient).

Example (assuming the above pre- and post-control lines were paired)

Correlation coefficient	0.7817
Standard error of the kill	0.0161

- The approximate 95% confidence limit is then the standard error times 2.

Example using the unpaired monitoring lines

Kill	0.929
Standard error of the kill	0.0248
Approximate 95% CL	0.049

- If an estimate of the kill for multiple strata has been obtained, an estimate of the overall kill for the total control area can be calculated by weighting each stratum estimate by the proportion that each stratum contributes to the total area. For example, if there were three

strata (1,2,3) contributing 0.2, 0.3 and 0.5 to the total area, and the percent kills within each stratum were 80%, 90%, and 40% respectively, the kill estimate for the total area would be (80 x 0.2) + (90 * 0.3) + (40 * 0.5) = 63%.

The approximate 95% confidence limit for this example is:

$$\pm 2 * \sqrt{(0.2 * se_1)^2 + (0.3 * se_2)^2 + (0.5 * se_3)^2}$$

4.4 Analysing Waxtag and Chewcard data

Follow the steps below for calculating the RAI (WTI or CCI). Some statistical assumptions may be violated, so accept that 95% confidence intervals are approximations.

1. For each line, count the total number of devices with possum bite marks.
2. Divide the total number of devices with possum bite marks on each line by the total number of devices per line. This will give you the proportion of devices with possum bite marks for the line.
3. Using the line values calculated in 2 (above) calculate mean proportion of devices with possum bite marks for all lines in each stratum i.e. the sum of the proportion of devices with possum bite marks calculated from each line/number of lines. Multiply by 100 to get the RAI.
4. Calculate a weighted mean RAI, using the RAI per stratum, and the proportion of total habitat area each stratum contributes to the total. [(habitat area stratum #1/total habitat area * WTI stratum 1) + [(habitat area stratum #2/total habitat area * WTI stratum 2) etc to "n" strata].
5. Calculate the standard error (SE) for each stratum i.e. standard deviation of the RAI/square root of the number of lines.
6. Calculate the combined SE for all strata. This is the square root [(habitat area stratum #1/total habitat area * SE stratum 1) + (habitat area stratum #2/total habitat area * SE stratum 2) + etc to stratum "n"]
7. Multiply the combined SE by 2 to calculate the approximate 95% confidence interval.

An example of the analysis will help. Say you have 10 Waxtag lines. The forest stratum is 1000 ha and the farmland stratum is 400 ha. (See Table 4 below).

Table 4. Example WTI or CCI Data and Analysis.

Note: Note this example presumes 20 waxtags per line, based on the historical 10m spacing of Waxtags. However, the same principle applies for lines of 10 devices at 20 m spacings.

Line	Stratum	Waxtags with Possum Bite marks	Waxtags with Non-target Bite marks	Waxtags with Unknown Bite marks	Waxtags Lost or Damaged	Waxtags without Bite marks	WTI
1	Forest	4	1	1	0	14	20%
2	Forest	8	0	0	0	12	40%
3	Forest	2	5	0	0	13	10%
4	Forest	0	3	0	0	17	0%
5	Forest	13	0	0	0	7	65%
	Forest	**Stratum**				**WTI**	**27.0%**
						SE	**11.5**
6	Farmland	0	1	1	2	16	0
7	Farmland	10	0	0	1	9	50%
8	Farmland	12	5	0	0	3	60%
9	Farmland	2	3	0	0	15	10%
10	Farmland	5	0	0	0	15	25%
	Farmland	**Stratum**				**WTI**	**29.0%**
						SE	**11.4**
	Combined Result					**WTI**	**27.6%**
						SE	**8.9**
						95% CI	**+/- 17.8**

Some of the calculations in the above table are:

- WTI forest stratum = (20 + 40 + 10 + 0 + 65)/5 = 27.0%
- SE forest stratum = standard deviation(0.2 + 0.4 + 0.1+ 0.0 + 0.65)/square root(5) * 100 = 11.5
- Combined WTI= 500/700 * 27.0 +200/700 * 29.0 = 27.6%
- Combined SE = square root$((1000/1400 * 5.2)^2 + (400/1400 * 5.1)^2)$ = 8.9
- Combined 95% CI (approx.) is the combined mean WTI+/– 4.0 * 2 = 27.6% ± 17.8

An Excel spreadsheet for entering and analysing data is available for free download from https://www.bionet.nz/library/tools/

Appendix One – Glossary of Terms

The following terms are used in this Protocol:

Management area	The total area within which possums are to be managed. It may include areas other than typical possum habitat (e.g. areas of developed pasture).
Possum habitat	Areas where possums may potentially nest. Specifically NOT developed pasture.
Strata	Parts of the treatment area that have clearly different possum densities or require individualised monitoring data for management reasons.
Trap-site	A tree, fence post, log, stake or backing board or other attachment site that will hold a fence staple or allow a trap to be wired on or set on a sloping board. There must be sufficient backing for the lure.
Trap-night	Trapping effort represented by one trap set for one night.
Lure	A mixture of flour and icing sugar (5 kg flour to 1 kg icing sugar).
Relative Abundance Index - RAI	A number that relates to population density but is not the actual population density.
Percent kill	The percentage of a population killed during a control operation (100 minus percent survival).
Percent survival	The percentage of a population surviving a control operation.
Waxtag	A plastic tag containing a wax block specifically designed for possum monitoring.
Waxtag or Chewcard site	A tree, fence post, log, stake or backing board or other attachment site that will allow a Waxtag or Chewcard to be attached.
Luminescent strip	An aluminium strip coated with a photo luminescent pigment that absorbs light during the day and emits the light at night.
Waxtag Index (WTI) or Chewcard Index (CCI)	The mean proportion of Waxtags or Chewcards respectively bitten by possums over a 3 or 7 night period for a sample of lines. Reported as a percentage.

Appendix Two – Summary of amendments

Consequential changes made in this 2020 edition from the 2015 edition are summarised as follows;

1. Document rebranded to reflect the 2018 stewardship transfer from NPCA to Bionet (Ministry of Primary Industries).
2. Section 1.3. Further information regarding monitoring of very low population densities.
3. Section 2.3. Further guidance regarding stratification.
4. Clarification that the three “default” strata do not necessarily impose a requirement on designers to include them in any design.
5. Continuous habitat or “forest” strata recommended to be minimum 1000 ha. Smaller areas can be included as habitat patches in “non-continuous” habitat. This does not apply to operational areas less than 1000 ha total if they are properly characterised as continuous habitat.
6. Re-monitoring of the same line coordinates increased to 12 months in all cases where possible to do so. And specified as any point within 100 m of the original line coordinates.
7. Horizontal blaze to be avoided where a vertical blaze is achievable at a site. The requirement to set device on nearest available site still takes priority.
8. Default established directing use of nearest contingency lines.
9. Default direction established for BP margin lines – to right facing the bush habitat.
10. New raised set heights specified by Department of Conservation incorporated.
11. Clarify that dependant juveniles (e.g. pouch young) must also be humanely euthanised together with the mother.
12. Reporting of mean RAI is to be truncated, rather than rounded, to one decimal place.
13. Field data recording simplified given that “backrider” outcome effectively displaces historical “immature” possum category. Now have “M” and “F” for male or female adult possum caught.
14. References Appendix is now included.

Appendix Three – References

Forsyth D. M., Perry, M., Moloney, p., McKay, M., Gormley, A. M., Warburton, B., Sweetapple, P., Dewhurst, R. 2018. Calibrating brushtail possum (Trichosurus vulpecula) occupancy and abundance index estimates from leg-hold traps, wax tags and chew cards in the Department of Conservation's Biodiversity and Monitoring Reporting System. New Zealand Journal of Ecology (2018) 42(2): 179- 191.

Henderson, R; Commins, P.; Frampton, C.; McGaw, S. 2007. Best practice for monitoring low-density possum populations. Pest-Tech Contract report 2007/03 (unpublished) 47p.

Kavermann, M. J., Paterson, A. M. Ross, J. G. 2013. Sensitivity of audio-lured versus silent chew-track-cards and WaxTags to the presence of brushtail possums (Trichosurus vulpecula). New Zealand Natural Sciences (2013) 38: 1-8.

Nugent, G., Whitford, J., Gormley, A. Freedom without TB surveillance: Can good control and density monitoring be enough? 2019. Contract Report: LC3606 Manaaki Whenua – Landcare Research (OSPRI report – R-10804).

Ruffell J, Innes J, Didham R. K. 2015. Efficacy of chew-track card indices of rat and possum abundance across widely varying pest densities. New Zealand Journal of Ecology 39: 87–92.

Sakata, K. 2011. Forensic Approaches to Monitoring and Individually Identifying New Zealand Vertebrate Pests. A thesis submitted in partial fulfilment of the requirements for the Degree of Doctor of Philosophy. Lincoln University.

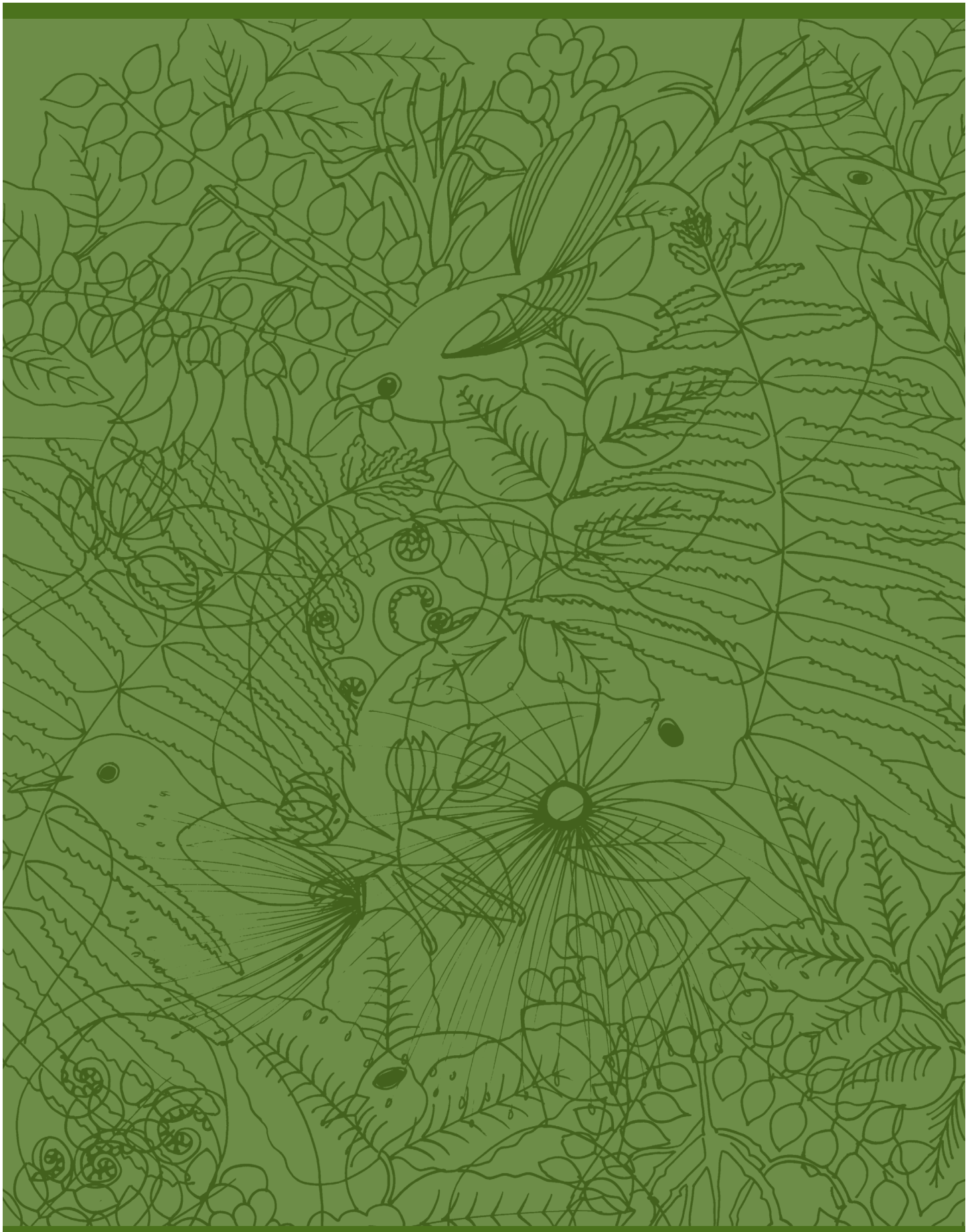
Sweetapple P, Nugent G. 2011. Chew-track-cards: a multiple-species small mammal detection device. New Zealand Journal of Ecology 35(2): 153-162.

Thomas M, Meenken D. 2010. Effects of Prefeeding on Ground and Leaning-board Trap Sets, and the Relationship between WaxTag and Trap-catch Possum Monitoring Indices. A Partial Replication of Animal Health Board Project R-80660 "Best Practice for Monitoring Low Density Possum Populations". Animal Health Board Project No: R-80660-01.

Thomas M. D.; Morgan D.R.; Maddigan, F. 2007. Accuracy of possum monitoring using WaxTags. Animal Health Board Contract Report No: R-80621-01 (unpublished) 50 p.

Warburton, B., Forrester, G. 2010 Southland Regional Council Possum Monitoring Programme. Landcare Research Contract Report: LC0809/04

Webster, R.A., Ruscoe, W.A., Warburton, B. 1999. Optimising the Trap-Catch Method for Monitoring Possum Populations. Landcare Research Contract Report: LC9899/141. For Animal Health Board.



PRODUCED BY

Bionet.NZ

National Pest Control Agencies