

PROTOCOL



**For Possum Monitoring
using the WaxTag[®] Method**

April 2008

This protocol has been produced for use by agencies and contractors involved with vertebrate pest control to provide a standard methodology for possum population monitoring. The protocol may be updated from time to time, so please check whether your version is current by checking the publications section on www.npca.org.nz, or contacting NPCA direct.

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INTRODUCTION

Purpose

This Protocol outlines a method for estimating an index of possum abundance based on sampling populations by means of interference with WaxTags®. The index derived depends for its statistical robustness on meticulous adherence to the concept of random systematic selection of survey sites, consistency and accuracy in its application, and 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 WaxTags® should be used on each line and how these should be deployed. It details the required norms and standards of design considerations and field-work involved.

The data obtained from the lines is used to calculate Bite Mark index (BMI). The BMI represents the percentage of WaxTags® which recorded possum interference on each WaxTag® line. This is calculated as a mean figure with associated statistics such as range and confidence limits

Scope of the protocol

The Protocol describes how a standardised possum population monitoring programme should be set up when using WaxTags®. This will provide management agencies with sound estimates of an index of relative population densities, and/or a technique for mapping the distribution of possums in the landscape (presence/absence). 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, behaviour or ethics of those doing the monitoring.

The nature of any use of the WaxTag® monitoring method to measure contractor performance is a matter of agreement between management agencies, and control contractors.

Updated edition

This edition of the Protocol is an update of the earlier July 2005 edition. To assist readers who have been using the earlier edition, a summary of the amendments in this 2008 edition is contained in Appendix 1.

Layout of the protocol

The protocol is divided into three parts:

1. **Design of a monitoring programme.** The requirements of management agencies are determined and a suitable monitoring programme put together. This involves stratification, measuring areas of potential possum habitat, deciding the number of WaxTag® lines that are necessary and randomly selecting the start points of those lines.
2. **Carrying out the fieldwork.** Information is provided so that field operatives can locate the start points of WaxTag® lines, deploy WaxTags® according to the prescribed standards and record the outcomes.
3. **Managing the results.** Methods are provided to collate and analyse data and interpret the results.

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 tools.

In practice, various blends of manual and electronically assisted techniques are used, dependent on resources.

This Protocol establishes appropriate methodologies, principles and standards. You may implement these by either manual methods, or some electronically assisted process.

PART 1: DESIGN OF A MONITORING PROGRAMME

1.1 Define the management boundary

Draw on a map (no less detailed than 1:50,000) the boundary of the management area in which bite mark index (BMI) is to be determined. 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 the management area.

1.1.1 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. 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.

1.2 Define strata boundaries

Stratification is carried out either to increase the statistical precision of the 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 the treatment area has parts that vary significantly in possum density or control techniques (e.g. aerial and ground control), then sampling can be made more efficient by stratification. 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.

Stratification is often included for management reasons, to ensure adequate monitoring information is available the client from specified areas, for reasons such as differentiating disease risk status, or establishing progress payment blocks.

There are three default classes on which to base stratification;

- Continuous habitat (e.g. large forest or tussock areas),
- Farmland (other areas characterised by patchy habitat)
- Bush-pasture margins (i.e. the interface between large areas of forest, and farmland). This category may also include other linear habitats such as river corridors.

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

1.3 Define possum habitat area

You will need to calculate the hectares of possum habitat for each stratum, or the entire management area if unstratified. This habitat area will be used to determine how many WaxTag® lines are required.

Potential possum habitat is defined as those areas where possums may potentially nest. Major habitat areas e.g. forest, tussock etc, may form separate areas but smaller habitat patches will generally be part of farmland. Potential habitat includes but is not restricted to:

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

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

1.3.1 Continuous habitat area

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

Aerial photographs are the best source for identification of bush or forest habitat. The Land Cover database (LCDB) or ECOSAT can also be used. As a minimum, 1:50,000 topographical maps are necessary.

1.3.2 Farmland habitat area

Calculating the area of farmland habitat is more challenging. two approaches depending on the habitat information 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 Land Cover Database (LCDB) to estimate total habitat area.

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

The only 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 total 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.

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

1. Habitat area (ha) = 10% + 5% points = 15%
2. 15% of 10,000ha = 1,500ha expected habitat area
3. Subtract the cumulative habitat area of habitat patches greater than 16 ha to create separate >16ha and <16ha strata.
4. Add the area of known tussock country on to the total habitat area estimate.

1.3.3 Bush-pasture margin habitat area

Aerial photographs or ECOSAT are good sources of information for identification of bush-pasture margins. As a minimum, 1:50,000 topographical maps plus 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 200m apart, such as a tongue of forest or indentation of pasture into forest, then **only one side** should be included.

The bush-pasture area is taken to be a strip of 200m back into the bush. Therefore to calculate the area, multiply the length of the margin above (in km) by 20 to obtain the area in hectares.

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.

1.4 Number of WaxTags® and WaxTag® lines

1.4.1 WaxTags® per line and duration

Twenty WaxTags® are normally spaced at 10m intervals along a line, and left for a period of 7 nights. Sometimes lines may be left for only 3 nights, although this provides an index different from the default 7 nights.

The main reason which justifies the use of the 3 night option is 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.

In some cases it may be advantageous to obtain both a 3 and 7 night estimate of possum density but the extra line check required will increase the costs of the monitoring operation.

1.4.2 Number of WaxTag® lines – no stratification

Table 1 gives the minimum number of lines that should be established in unstratified areas based on the total habitat area.

In areas that are considerably less than 500 ha, fewer than 10 lines can be used if that is all that can be fitted into the area.

The same number of lines are to be used for both 3 and 7 night monitoring. Where shorter lines of 10 tags are used, double the number of lines. Where improved precision is desired, sample size can be increased. Doubling the recommended sample size will improve precision, at a cost approximately equivalent to half the number of trap-catch lines.

Table 1. Minimum numbers of WaxTag®-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.

When monitoring **bush-pasture** margin as a stand alone monitor, then the number of WaxTag®-lines required is half the number of kilometres (i.e. 1 WaxTag® 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.

1.4.3 Number of WaxTag® lines – with stratification

When an area has been stratified, each stratum is allocated its share of lines on the basis of habitat area as follows;

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

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 Table 1 (option1) we determine the total line requirement is 15 lines. Then allocate these among the strata;

- Forest stratum $880/1500 \times 15 = 8.8$ hence **9** lines.
- Farmland stratum $500/1500 \times 15 = 5$ lines
- Bush-pasture stratum $120/1500 \times 15 = 1.2$, observe minimum, hence **5** lines

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.

1.5 Placement of lines

For sampling to be unbiased, all potential possum habitat has to have an equal chance of being sampled. Systematic sampling ensures sampling is established in a random fashion, and creates an effective spatial sampling pattern over the landscape.

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

1.5.1 Line placement in continuous and farmland strata

The steps for systematically placing lines in continuous or farmland habitat are;

1. Calculate the required grid spacing.

Grid spacing is measured in kilometres. The required spacing = $1/\text{square root}$ (line density), where line density is lines/km². For example, say a stratum has a management area of 3000 ha, with 2100 ha of habitat area. Then from Table 1, the minimum number of lines is 18. The management area is 30 km² (3000 ha/100). Hence the line density is $18/30 = 0.6$ lines/km² and thus the required grid spacing is $1/\text{square root}(0.6) = 1.29$ km.

2. Create a grid of the calculated spacing to encompass the entire stratum.

3. Generate one random point within the stratum (using the technique described in 1.5.1 for instance). Place an intercept of the grid on this random point with the grid lines aligned in true North/South and West/East directions. This ensures the sampling grid is randomly placed.
4. Finally, mark the start points for monitoring lines in the **CENTRE** of each grid square where that grid square falls within the stratum boundary (**NOT** on the intercepts).

Depending on the shape of the stratum boundary, and how the grid is randomly placed, you may find that slightly more or less than the calculated minimum number of lines are actually mapped. This does not matter.

In discontinuous habitat, the field operator may not find habitat at the mapped point. In that case, the operator must travel to the nearest habitat within the grid square and commence the line. Once a line is started within a grid square it may finish outside that square.

If there is no habitat within the grid square, the line is to be abandoned.

1.5.2 Line placement in bush-pasture margin strata

Calculate the number of 100m intervals (n) in the margin by multiplying the length of the margin (km) by 10. The intervals are numbered from 0 to "n". If one was to face the bush from the pasture, point #0 is at either the left-hand or right hand end of the margin, whichever the designer decides is the most practical.

Then, generate the systematic spacing variable "x" by dividing "n" by the number of lines required. Generate a random number between zero and "n-1". The first line starts at this point. Additional lines are mapped every "x" intervals.

For example: say the length of a margin has been measured as 20 km and ten (10) lines will be deployed. The number of 100m intervals (n) is therefore $20 \times 10 = 200$. The range from which to randomly select lines is 0 to 199. Assume point #0 is at the left hand end of the margin. If the random process selects point #126, that line would start 12.6km from the left-hand end of the margin, and the line path will be left to right. Further lines are mapped at intervals of $x = 200 \text{ intervals} / 10 \text{ lines} = 20$. Hence line starts are at interval numbers 126, 146, 166, 186, - but at this point there is not enough pasture margin left to accommodate any more start intervals, so one has to start again at the left hand end of the margin, so the next interval is at 6, and subsequent intervals are at 26, 46, 66, 86, 106.

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. If the line happens to go around the end of the forest projection or forest indent, continue to lay WaxTags even if these are close to ones that have already been laid.

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

1.6 Trend monitoring

Trend monitoring is used to track the change in possum populations over time. Typically these are populations not subject 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. Using the BMI from 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.

1.7 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 Map Grid (NZMG) co-ordinates
- Number of WaxTags® per line, and whether sampling is over 3, or 7 (or both 3rd and 7th) nights.
- Topographical map (1:50,000) showing line starts and paths and the sampling grid.
- The orientation of bush-pasture margin lines.
- 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
- Detailed written instruction for getting to line starts, and escape routes

PART 2: CARRYING OUT THE FIELD WORK

2.1 Deploying WaxTags®

New 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.



Ensure all WaxTags® can be relocated, uniquely identified, and interference outcomes recorded accurately. As a minimum, write the date, line number and tag number (e.g. 1 to 20) on the back of the WaxTag® with a permanent waterproof marker.

To assist with relocating the WaxTag®, a suggestion is to use colour plastic cruise tape as a marker. If markers are used, do not place them directly above the WaxTags® where they may act as an additional attractant.

2.2 Laying WaxTag[®] lines

Navigate to the line start points using GPS, or orienteer there using maps, compass and hip chain. It is necessary to start a line within 50m of the mapped start point of the line.

It may be that at the mapped start point, there is not any possum habitat, dependent on the quality of information that was available to the designer. In this circumstance, the procedures are;

- When monitoring bush pasture margin, move on a bearing north, south, east or west, whichever gets to the margin in the shortest distance. Providing that point is 100m or more from a previously laid line, start at that point. If it is within 100m of another line, start the new line at least 100m from the previously laid line.
- In any other stratum, face north and turning in a clockwise direction select the first possum habitat within the grid square for that line. Once you have started a line, you can continue outside the grid square to complete the line on the prescribed bearing. If there is no possum habitat within the sampling grid square, then abandon the line.

The first WaxTag[®] on a line should be 10 m from the start point. WaxTags[®] should be placed at 10m intervals on the nearest suitable site. Hip-chains must be used for measuring the distance between WaxTags[®]. All hip-chain cotton must be retrieved to prevent the entanglement of birds. Lines are required to be +/- 10% of the designed length (i.e. 20m for a 20 tag line; 10m for a 10 tag line).

If a line is being laid on a compass bearing and a WaxTag[®] site is not on the line of the compass bearing then return onto the line before proceeding to next WaxTag[®] site. Where a line is laid according to its planned bearing, it is required to be +/- 10 degrees of its planned bearing. Where a line has no pre-determined bearing (e.g. farmland) then the line must be laid in a straight direction at the default of zero degrees magnetic, if the habitat allows.

When following a compass bearing, small barriers that can be walked around in the space of 100m or less, should be traversed placing WaxTags[®] at the standard 10m 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 vertical bluffs that extends 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 WaxTag[®] sites e.g. logs within the clearing, continue to deploy WaxTags[®] at 10m intervals and on the compass bearing. If, however there are no suitable sites, treat it the same as an obstacle i.e. go around the clearing deploying WaxTags[®] at 10m intervals until the compass line can be resumed. If roads or creeks are encountered, select the nearest suitable site on one side or other of the road or creek.

When laying lines around bush-pasture margins, each line should be placed on or as near as possible to, the margin as possible. Lines should follow the general line of the forest edge not individual trees or shrubs. If stock are likely to interfere with WaxTags[®] placed along the margin, then lines should be placed inside the margin.

2.3 Checking WaxTag[®] lines

WaxTag[®] lines are retrieved after either 3 or 7 nights (as specified in the design), and do not need to be checked in the interim. For 7 night monitoring periods, weather effects are expected to be variable, and do not need to be taken into account.

Where however, the monitoring is over a period of 3 nights only, then these must be fine nights. Fine nights are defined as those 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 WaxTags[®] 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 WaxTag[®] 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 100m either side of the current lines. 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.

Recording outcomes

There are five possible outcomes for each WaxTag[®]:

1. Includes possum bite marks (P).
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. WaxTag[®] lost or damaged beyond interpretation (L).

The operator must be sure bite marks originate from a possum before recording it as such¹.

Results must be recorded standardised forms (Figure 1 shows an example, but alternative layouts are acceptable). For practical convenience reduce the form to note-pad size (preferably wet-notes).

Concluding activities

On completion, supply all WaxTags and records of outcomes to the designer. Also include a written summary of any relevant issues and problems encountered during the monitoring. This would include reasons for any deviations from planned line paths for instance, and weather conditions.

Tags are required to be safely stored and available for audit for a minimum of 2 years following the monitoring.

¹ The WaxTag[®] monitoring methodology is pivotal on trained operators correctly interpreting bite marks in the wax. Approved operators will be required to undertake an examination and meet the following standards. Of 40 bitten tags of known (caged animals) origin, comprising approximately 50% possum bitten tags. The examinee may record no more than 4 as unknown, and must identify at least 90% of the possum bitten tags correctly, and may not identify more than one non-possum bitten tag as a possum.

Figure 1 - WAXTAG[®] 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.		
11.		
12.		
13.		
14.		
15.		
16.		
17.		
18.		
19.		
20.		

There are five possible outcomes for each WaxTag[®];

1. Includes possum bitemarks (P).
2. No possum bitemarks, but identifiable non-target bite mark (NT, record species).
3. No possum bitemarks, but unknown bitemarks (U).
4. No bitemarks (leave record blank)
5. WaxTag[®] lost, or damaged beyond interpretation (L).

PART 3: MANAGING THE RESULTS

3.1 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 important operational information, monitoring information and results, and be presented in an easily understood way.

Retain all raw data records, and bitten WaxTags[®], in case of disputes regarding analyses and their interpretation. WaxTags are required to be safely stored and available for audit for a minimum of 2 years following the monitoring, either by the field operative, or the designer.

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:

- Number of WaxTag[®] lines.
- Number of WaxTags[®] per line.
- Period of exposure (3 or 7 nights).
- For 7 night exposures, whether checked at 7th day only or both 3rd and 7th day.
- Weather (particularly rainfall) over the duration of the monitoring.
- BMI results by line, stratum, and combined strata with confidence intervals
- Habitat for each line.
- Approved operators who were involved with the monitoring.
- Map with WaxTag[®] lines marked.
- Discussion of reasons for any non-conformances or deviations.
- If data are to be used for determining population trends, provide description of starting points and compass bearings of lines.

3.2 Analysing stratified Bite Mark Index (BMI)

Follow the steps below for calculating the BMI. Some statistical assumptions may be violated, so accept that 95% confidence intervals are approximations.

1. For each line, count the total number of WaxTags[®] with possum bite marks.
2. Divide the total number of WaxTags[®] with possum bite marks on each line by 20. This will give you the proportion of WaxTags[®] with possum bitemarks for the line.
3. Using the line values calculated in 2(above) calculate mean proportion of WaxTag[®] with possum bitemarks for all lines in each stratum i.e. the sum of the proportion of WaxTags[®] with possum bite marks calculated from each line /number of lines. Multiply by 100 to get the BMI.

4. Calculate a weighted mean BMI, using the BMI per stratum, and the proportion of total habitat area each stratum contributes to the total. [(habitat area stratum #1/total habitat area x BMI stratum 1) + [(habitat area stratum #2/total habitat area x BMI stratum 2) etc to “n” strata].
5. Calculate the standard error (SE) for each stratum i.e. standard deviation of the BMI/square root of the number of WaxTag® lines.
6. Calculate the combined SE for all strata. This is the square root [(habitat area stratum #1/total habitat area x SE stratum 1) + (habitat area stratum #2/total habitat area x 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 500 ha, and the farmland stratum is 200 ha. (See Table 2 below).

Table 2. Example BMI Data and Analysis

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	BMI
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				BMI	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				BMI	29.0%
						SE	11.4
	Combined Result					BMI	27.6%
						SE	8.9
						95% CI	+/- 17.8

Some of the calculations in the above table are;

- BMI forest stratum = $(20 + 40 + 10 + 0 + 65)/5 = 27.0\%$
- SE forest stratum = standard deviation $(0.2 + 0.4 + 0.1 + 0.0 + 0.65)/\text{square root}(5) \times 100 = 11.5$
- Combined BMI = $500/700 \times 27.0 + 200/700 \times 29.0 = 27.6\%$
- Combined SE = square root $((500/700 \times 5.2)^2 + (200/700 \times 5.1)^2) = 8.9$
- Combined 95% CI (approx.) is the combined mean BMI $\pm 4.0 \times 2 = 27.6\% \pm 17.8$

An Excel spreadsheet for entering and analysing data is available for free download from www.npca.org.nz

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.
Strata	Parts of the treatment area that have clearly different possum densities, or require individualised monitoring data for management reasons.
WaxTag [®]	A plastic tag containing a wax block specifically designed for possum monitoring.
WaxTag [®] -site	A tree, fence post, log, stake or backing board or other attachment site that will allow a WaxTag [®] 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.
Index (population)	A number that relates to population density but is not the actual density.
Bite Mark Index (BMI)	The mean proportion of WaxTags [®] bitten by possums over a 3 or 7 night period for a sample of lines. Reported as a percentage.

WAXTAG[®] MONITORING PROTOCOL EVALUATION AND FEEDBACK

Name: Date:

Contact Details:

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The NPCA welcomes any feedback and comment you might have on the WaxTag[®] Protocol, and sees this as an important part of the continuous improvement and development of this best practice.

Please quote the page and reference that your comment(s) relates to, provide a short comment and return to:

NPCA,
 Fax: (04) 473 1603
 Email: [npca@xtra.co.nz](mailto:nzca@xtra.co.nz)

Note: This form can be downloaded from the website: www.nzca.org.nz.

Page, Reference	Comment

APPENDIX 1: SUMMARY OF AMENDMENTS TO THE PREVIOUS EDITION

The first edition of this Trap Catch Protocol was published in July 2005. It was reviewed and updated for this second edition. The amendments incorporated into this April 2008 edition are summarised below.

1. The PAI terminology is replaced with BMI (Bite Mark Index).
2. All reference to the TLI is deleted in favour of the BMI.
3. Flour lure is included in the specification.
4. A cautionary note is included regarding the potential for bite shyness confounding results, particularly where cyanide paste has been used.
5. Justification for the use of the 3 night option, rather than the default 7 nights, is clarified.
6. Waxtag methodology is justified for population densities up to 10% RTC equivalent.