Measuring the benefits of possum control for pasture production (Envirolink 737-HBRC100)

Phil Cowan






Landcare Research
Manaaki Whenua

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Phil Cowan

Landcare Research
Private Bag 11052, Palmerston North 4442
New Zealand

Landcare Research Contract Report: LC0910/014

PREPARED FOR:
Hawke's Bay Regional Council
Napier

DATE: September 2009

Reviewed by:	*Approved for release by:*
Chris Jones Scientist Landcare Research	Bruce Warburton Science Leader Pest Control Technologies

Contents

Summary

Project and Client

Hawke’s Bay Regional Council sought advice from Landcare Research under the Envirolink programme (Project 737-HBRC100) about robust, cost-effective methods to measure the economic benefits of possum control for mitigating their impacts on pasture production. Demonstration that possum control increases pasture production will help HBRC clarify the economic benefits that ongoing control expenditure delivers, and the extent that this mitigates economic losses to the regions pastoral farmers.

Objectives

To develop a robust and cost-effective methodology to allow Hawke’s Bay Regional Council to measure the benefits of possum control for mitigating their impacts on pasture production at a regional scale.

Methods

Two approaches were used. The first involved re-analysis of the quantification of pasture in the diet of possums and its extrapolation to economic benefit. This was done to check if existing information is sufficient to provide a realistic comparison of costs of possum control and value of production foregone because of possum feeding on pasture. The second reviewed methods for measuring possum impacts on pasture and issues in the design of a regional monitoring programme based on measurements of pasture production.

Results and Conclusions

Available data on possum consumption of pasture, its cost in terms of foregone production, and the costs of possum control to mitigate those losses, suggest strongly that the current HBRC strategy of maintaining possum populations at or below 1 possum/ha is sufficient to mitigate economic costs of possums as pasture pests across the region.

Exclosures and direct or indirect measurement of pasture mass and/or accumulation are appropriate methods if HBRC should wish to undertake assessment of actual benefits to pasture production from possum control. This could, however, be costly at the scale required for a regional assessment.

Development of a possum density/impact relationship using existing and new possum RTC data and one-off measurements of pasture accumulation in the absence of livestock could provide an alternative approach to identify and/or confirm the appropriate possum RTC to mitigate economic losses to possums.

Recommendations

Hawke’s Bay Regional Council should

- reinforce the existing evidence that costs of possum control are roughly equivalent to pastoral production losses to possums by updating the economic information on the value of lost production
- undertake GIS-based consideration of the costs and benefits of limiting possum control on pastoral farmland to those areas most at risk of possum damage as an

alternative to the current strategy of uniform control
- consider exploring the value of using a marginal costs and benefits approach to identify at what stage benefits are maximised
- explore the potential for deriving a possum density/impact relationship using existing and new possum RTC data and one-off measurements of pasture accumulation in the absence of livestock as an alternative to extensive direct measurements of pasture loss
- undertake a formal power analysis of the proposed regional measurement system and work out its costs as an aid to future decision making about outcome monitoring of possum control for economic benefit.

1. Introduction

Hawke's Bay Regional Council (HBRC) spends significant amounts of money on possum control as part of its Regional Pest Management Strategy. One objective of this possum control is to mitigate pasture consumption. Currently, however, it does not quantify directly the economic benefits of such possum control. HBRC therefore sought advice from Landcare Research under the Envirolink programme (Project 737-HBRC100) about robust, cost-effective methods to measure benefits of possum control for mitigating their impacts on pasture production. Demonstration that possum control increases pasture production will help HBRC clarify the economic benefits that ongoing control expenditure delivers, and the extent that this mitigates economic losses to the regions pastoral farmers.

2. Background

The importance of possums as competitors with livestock for pasture is an issue that is raised repeatedly in economic analyses of possum impacts and justifications for possum control. Most of the estimates of possum consumption of pasture and the associated potential economic costs are based on extrapolations from the quantification of pasture in the diet of possums (Butcher 2000). A recent re-analysis of such published information (Cowan 2007) indicates a previous over-estimation arising from confusion in the literature about wet and dry weights. Re-calculation of economic losses from possum browsing of pasture on typical Taranaki and Hawke's Bay dairy farms reduced estimates of economic loss 7.5 fold, down to $3.70 to $5 per hectare per year. Cowan (2007) recommended that direct measures of pasture loss to possums, rather than extrapolations from stomach contents, were needed to resolve their importance as pasture pests, an approach used by Norbury and Norbury (1996) to address a similar question about competition for pasture between rabbits and sheep.

There are two potential approaches to measuring directly the benefits for pastoral farming resulting from possum management – first, measuring changes in pasture production (e.g., wet or dry matter production) and second, measuring changes in grazing livestock production (e.g., body weight, milk production, etc.). The first approach assumes that more pasture translates into increased animal production, while the second assumes that changes in production are attributable solely to changes in pasture production. Both approaches to estimating the economic benefits of possum control must address the issue of attribution since many factors, other than pasture production, also contribute to the economic return from livestock farming, and the value of production may vary significantly from year to year (e.g., the 40% decline in the value of milk solids over the last 12 months). Any economic benefit to pastoral farming also has to be weighed against the costs of possum control, as the issue of concern is the net benefit of possum control.

Changes in pasture production can be assessed by mowing or clipping pasture at intervals using a standard protocol from fixed or random plots of known area from which livestock (but not possums or rabbits) are excluded, and then drying material to obtain an estimate of dry matter production per unit area. Alternatively, production in plots that exclude livestock and pests can be compared with those that exclude only livestock. Replication is important to control for variation between paddocks and sites, as plots are usually small. Exclosures can be constructed that exclude rabbits but not possums and these could be used where both pests were present at a site and only one was controlled.

Only one study, Dodd et al. (2006), has used such an approach. Pasture production was measured at intervals on small plots at six sites in the Waikato region not subject to possum control. Livestock and feral animals were excluded from half the plots and livestock only from the other half. Additional sites were established in areas under possum control (RTC <5%) for comparison. At sites without possum control, pasture accumulation rates on the exclosure plots were significantly higher than on the open plots in both winter and late spring. In areas with possum control, pasture accumulation rates were similar between exclosure and open plots. Dodd et al. (2006) suggested that the additional pasture growth was sufficient to cover the costs of possum control. Because all the paddocks chosen were adjacent to native forest blocks, however, they were likely to be particularly prone to possum impacts on pasture, and so the losses measured are likely to have overestimated impacts at the whole farm level.

Jones (2009) proposed an intervention logic model example based on the HBRC Possum Control Areas (PCA) programme in which the suggested intermediate outcomes were (i) primary production increases by $x/ha over the PCA, and (ii) landowner costs of possum management are lower than pre-PCA programme. The former outcome is directly relevant to the issue of possum impacts on pasture and the suggested outcome indicator was based on kg product/ha (e.g., milk, meat). The difficulty with the proposed indicator in relation to pasture impacts is, however, that of attribution – amount of product could be influenced not just by change in possum impacts but by seasonal and annual variation in climate and changes in a wide range of farming activities. Determining the contribution of possum control to changes in production would therefore be exceedingly complex, even if seasonal and annual variation in climate were controlled for by the use of appropriate measurements in areas without possum control. For those reasons the use of an intermediate outcome indicator based on pasture production (e.g., dry matter/ha/week) is likely to be more practicable.

3. Objectives

To develop a robust and cost-effective methodology to allow Hawke’s Bay Regional Council to measure the benefits of possum control for mitigating their impacts on pasture production at a regional scale.

4. Methods

Two approaches are used. The first involves re-analysis of quantification of pasture in the diet of possums and its extrapolation to economic benefit. This was done to check if existing information is sufficient to provide a realistic comparison of costs of possum control and value of production foregone because of possum feeding on pasture. The second approach reviews methods for measuring possum impacts on pasture and discusses issues in the design of a regional monitoring programme based on measurements of pasture production (largely following the approach outlined by Dodd et al. (2006)).

5. Results

1. Re-analysis of quantification of pasture in the diet of possums

The question of interest is whether existing information is complete and/or robust enough to reliably infer a net economic benefit for the pastoral industry from possum control to minimise feed, and hence production, losses. Previous calculations of the economic costs of pasture loss to possums are based on a series of variables:

a) average dry matter intake of pasture by possums (from diet analysis)
b) possum density
c) standard figure for annual dry matter intake per stock unit
d) economic value of additional production (meat, wool, milk, etc.) derived from additional stock units.

Possum pasture consumption per hectare is converted into stock unit equivalents and hence to $ values. The estimated $ value of lost production is most sensitive to changes in possum pasture consumption and possum density; for example, a halving of either will half the $ value of lost production, and the effects are multiplicative.

The cost of large-scale possum maintenance control on Hawke’s Bay farmland is about $2–5/hectare (C. Leckie, pers. com.). Cowan (2007) calculated the cost of foregone production on the average Hawke’s Bay dairy farm in 2003/4 from possum pasture consumption at about $5/ha. This suggests that such maintenance control is cost-effective – even without taking into account the potential value of any collateral benefits of possum control for bovine TB control and native biodiversity and ecosystem services protection.

Since estimated losses and actual costs of control appear to be roughly equivalent, there is value in examining whether the estimates of loss can be made more robust, and capable of stronger comparison with actual possum control costs. Values of lost production have been calculated at the individual farm level (e.g., Butcher 2000) and at the regional level (Greer 2006). Both these estimates failed to account of spatial variability in the risk of possum feeding on pasture by assuming uniform possum impacts within habitat types. Where pasture is the predominant habitat possum densities are usually around 1 to 3 per hectare, except where there is localised cover, such as shelter belts or streamside willows, when they may be significantly higher (Brockie et al. 1997; Efford 2000). Where there are remnant patches of native forest or woodlots, possum densities will also be higher, and higher again adjacent to major tracts of forest, particularly native forest (Efford 2000).

Possums in remnant vegetation and forest tracts adjacent to pasture often move out onto pasture to forage (Cowan & Clout 2000). While some possums have been recorded moving out onto pasture for > 1 km to feed, most make more limited movements (Brockie et al 1997; Cowan & Clout 2000). This highlights that, even within a farm, not all pasture is equally vulnerable to possums, and so losses to possums may be overestimated if possum foraging patterns are not taken into account. A cut-off distance of 500m into pasture from a pasture-possum habitat boundary is likely to take most of the possum impacts into account.

Thus any regional calculation of possum losses from pasture consumption needs to take into account the land areas of various habitats and their associated habitat-dependent possum densities and foraging ranges. This could be done using GIS analysis and the existing land cover information (e.g., LCDB2), the more detailed information provided by ECOSAT (www.landcareresearch.co.nz/services/informatics/ecosat/about.asp), or the existing HBRC classification of possum habitat in the PCAs (Greer 2006). The area of interest would be all pasture within 500 m of vegetation classes likely to hold >1 possum/ha (i.e. with RTC > 3%). A regional model of possum populations currently under development could also be adapted to map possum risk to pasture (J. Shepperd pers. com.).

Information about current possum densities in the Hawke's Bay region also supports indirectly the cost effectiveness of possum control for mitigating pasture losses to possums at a regional scale. Cowan's (2007) analysis suggests that at a density of about 1 possum/ha the value of foregone production is roughly the same as the cost of possum control. Maintaining average possum densities at 1/ha would therefore effectively mitigate losses from possum consumption of pasture. Based on about 900 monitoring lines in the PCA area of about 400 000 ha, and monitoring of a similar area of AHB control, the mean RTC of all operations across AHB and PCA in the region is between 1 and 1.5% RTC, or about 0.5–0.7 possum/ha (C. Leckie, pers. com.; Ramsey et al. 2005). This could be examined more precisely by mapping control operations and RTC monitoring lines on the land cover map of the region to examine control coverage of pasture and habitat adjacent to pasture, and to identify the subset of RTC lines most closely associated with pasture and adjacent habitats to give a clearer indication of pasture-related RTCs and, hence, likely impact on pasture.

The investigation of Dodd et al. (2006), which is the only study to measure directly pasture losses to possum feeding, supports both criteria suggested above for cost-effective mitigation of damage, namely a possum density of about 1/ha and costs of possum control to achieve that target roughly equivalent to the value of the losses. With regard to target density, sites subject to possum control, where there was no difference in pasture accumulation between open and exclosure plots, had possum densities below 5% RTC (about 1 possum/ha), whereas sites without possum control, where exclosure plots had significantly higher pasture accumulation rates, had possum densities between 17 and 33% RTC (about 3.4–6.7 possums/ha). With regard to offsetting costs of pasture loss, Dodd et al. (2006) calculated that, at 2005 prices, the dollar value of the increase in winter stocking rate resulting from the observed reduction in losses to possum feeding covered the costs of possum control.

A further development of the analysis presented in this section could involve an analysis of marginal costs and benefits to identify the point at which marginal benefits are maximised. Economic theory says that additional units of a good (i.e. pasture) should be produced as long as marginal benefit (i.e. added production) exceeds marginal cost (i.e. possum control). It would be inefficient to produce goods when the marginal benefit is less than the marginal cost. Therefore an efficient level of product is achieved when marginal benefit is equal to marginal cost.

2. Options for measurement of pasture loss or accumulation

The basic design for measuring the direct loss of pasture production from consumption by possums is quite simple – a comparison of dry matter (DM) production in areas from which livestock are excluded compared with similar areas from which livestock and possums are excluded (Dodd et al. 2006). If rabbits are also present, their effects could be separated by additional exclosures that excluded livestock, possums and rabbits. The procedure involves establishing the exclosures, mowing to uniform height at the outset, and then mowing again at a future time to measure pasture DM accumulation (Appendix 1).

At a regional scale a number of other factors could be considered in the design of the monitoring programme:

a) farm type – dairy, beef, sheep, deer (because of potentially different pasture management regimes)
b) regional climate variation (which affects growing season and hence sampling time and frequency)
c) sampling frequency (once at time of severest impact of pasture loss, several times during growing season, or throughout the year)
d) distance of sampling site from nearest significant possum habitat (areas closer to possum habitat are more susceptible to pasture loss).

If possum control was also incorporated in the design (e.g., measurement plots on farms with and without possum control) it would provide another direct measure of the benefit of possum control for DM production. On farms with possum control the differences in DM production between livestock and livestock + possum exclosures should be much less than on farms without possum control. This could be done on a possum control-no possum control basis, or with a more refined design that used possum trap catch index (TCI) measurements (e.g., 0–5%, 5–10%, >10% TCI). In the latter case a much larger set of measurements would be required.

The experiments of Dodd et al. (2006) suggested that the difference in DM accumulation between pasture plots on dairy farms in the Waikato open to or excluding feral herbivores varied seasonally from about 3 kg/ha/day in winter to maximum of about 7 kg/ha/day in late spring, which equated to relative increases from feral grazing exclusion of 43% and 14% in winter and late spring, respectively.

DM production or accumulation is usually measured by mowing, drying, and weighing. There are, however, a number of commercially available devices for measuring pasture mass (e.g., Crosbie et al. 1987; Harmoney et al. 1997), and such devices may enable measurements to be made more cheaply (Crosbie et al. 1987, Lile et al. 2001). Satellite images have also been used to predict paddock average pasture cover (Mata et al. 2007). The rising plate meter (RPM) has been used extensively in New Zealand to measure pasture mass (Lile et al. 2001). Instructions for recommended use of the RPM on NZ perennial ryegrass/white clover pastures can be found at www.dairynz.co.nz/file/fileid/11066 accessed 25 August 2009. The levels of difference in pasture accumulation resulting from possum control that were observed by Dodd et al. (2006) would have been amenable to measurement using the RPM technique (M. Dodd, pers. comm.; Thomson et al. 2001).

The issues with all the indirect methods are (i) whether they have sufficient precision to detect differences of the magnitude suggested from the results of Dodd et al.'s (2006) study, and (ii) the need to calibrate readings, perhaps seasonally, so they can be converted to pasture mass.

An alternative method that involves only livestock exclosures is to measure pasture DM production inside the exclosures and correlate that with information about possum TCI (and possibly rabbit McLean scores) in the vicinity of the exclosures. If sufficient data were available on TCIs, including from sites with a wide range of TCI values and with related information about some of the factors discussed above, a relationship between possum density (TCI) and impact on pasture (DM production) could be derived. This density-impact relationship would then provide the basis for an economic analysis by comparison of value of pasture lost with the costs of possum control to mitigate that loss, as done by Choquenot and Warburton (2000) for wallaby grazing. Because of differences in pasture mass and accumulation rates between farms of different types (e.g., beef vs dairy), pasture accumulation would need to be related to initial standing crop, that is, pasture accumulation over X weeks as a percentage of initial pasture mass.

3. Design issues in implementing a regional assessment of pasture losses

The main issues that need to be taken into account in implementing a regional assessment based on direct measurement of pasture losses are the number of sites to be sampled and their regional distribution. Regional distribution depends on the need to take into account the influence of local factors (e.g., soils, climate) on pasture growth and the need for the inclusion of different farm types (e.g., dairy, beef, sheep, deer). A stratification of the region could be undertaken using, for example, the LENZ classification system combined with information on farm types from AgriBase and the extent of regional council current and future possum control activities. The number of each farm type to be sampled could be identified according to the frequencies of the different farm types and/or the total area of each farm type in each stratum identified from the process above.

The number of sites to be sampled on each individual farm should be at least two exclosure plots and two open plots. Plots should be sampled in late spring when rate of pasture growth is at its maximum (November–December) and left for 6 weeks between initial mowing and removing. A more critical approach would be to measure pasture losses when those losses have their greatest impact on production (i.e. when pasture availability is most limiting for livestock).

Plots on farms could either be positioned to maximise the risk of possum impacts (i.e. adjacent to areas of possum habitat of at least 15 ha) or placed in areas of high and low risk to provide a more realistic assessment of possum impacts. Although this latter approach would require twice as many plots per farm or twice as many farms, it is recommended because spatial factors in production and possum density are likely to be significant.

The design could include measurement sites only in areas with possum control (in which case the hypothesis is that there is no difference in pasture accumulation between exclosure plots and open plots) or it could include sites in areas without possum control as well (in which case the hypothesis is that the difference in pasture accumulation between open and exclosure plots is much less where there is possum control than where there is not).

The trial by Dodd et al. (2006) largely follows such a prescription. They selected 3 areas across the Waikato region, and had 3 sites in each area. Livestock were excluded from each site by electric fencing. Two sites in each area were within possum control operations, and the third was in an area that had had no possum control for at least 3 years. At each site they had six 3 x 3 m plots. Plots were harvested at 4–6 week intervals. For the harvest two of the three plots were excluded from feral grazing using flexinet fences. This design was sufficient to provide a clear demonstration of pasture losses to feral grazing.

Ultimately, the major constraint on the design of a regional system is cost. Cost could be minimised by

- accepting that available evidence indicates that, where possums exist in numbers, there will be pasture loss of economic concern, so the design need not include areas without possum control
- focussing the assessment on areas of highest risk of pasture loss (i.e. areas nearest significant possum habitat)
- sampling once a year in late spring
- minimising the number of strata to be sampled
- using a minimum of 3 farms of the two predominant farm types in each stratum
- using two sets of plots on each selected farm
- undertaking a formal power analysis of the proposed measurement system.

6. Discussion and Conclusions

Available data on possum consumption of pasture, its cost in terms of foregone production, and the costs of possum control to mitigate those losses, suggest strongly that the current HBRC strategy of maintaining possum populations at or below 1 possum/ha is sufficient to mitigate economic costs of possums as pasture pests across the region. The robustness of this conclusion could be strengthened by updating economic information on the value of lost production relative to costs of possum control, and undertaking a consideration of the costs and benefits of limiting possum control on pastoral farmland to those areas most at risk of possum damage rather than the current strategy of uniform control. A GIS-based approach using existing data is suggested as a way to address this latter issue. HBRC have already begun a project to map control success spatially, and this should ultimately allow improved targeting of control (C. Leckie, pers. com.). The issue is partly an economic one – if the sole justification for possum control is related to mitigating economic losses to pasture production across the region then possum control should aim to achieve that by undertaking possum control only to the level required, and so minimise control costs and maximise benefits. Any control of possums beyond that necessary for pasture impact mitigation needs to be justified against a wider set of outcomes. These could include outcomes related to TB control and biodiversity and ecosystem services protection.

Exclosures and direct or indirect measurement of pasture mass and/or accumulation are appropriate methods if HBRC should wish to undertake assessment of actual benefits to pasture production from possum control. This could, however, be costly at the scale required for a regional assessment, and suggestions are provided for ways to minimise cost in the design of a regional system.

A less costly approach to a regional assessment through reduced use of direct measurement of pasture loss may be to develop a possum density/impact relationship using existing and new possum RTC data and one-off measurements of pasture accumulation in the absence of livestock. This information could then be used in a cost-benefit analysis (cf. Choquenot & Warburton 2000) to identify and/or confirm the appropriate possum RTC to mitigate economic losses to possums. The initial step in this approach would be to review existing data on possum TCIs, including sites with a wide range of TCI values, and the availability of related information about factors affecting damage risk and pasture production (section 5.2).

7. Recommendations

Hawke's Bay Regional Council should

- reinforce the existing evidence that costs of possum control are roughly equivalent to pastoral production looses to possums by updating the economic information on the value of lost production
- undertake GIS-based consideration of the costs and benefits of limiting possum control on pastoral farmland to those areas most at risk of possum damage as an alternative to the current strategy of uniform control
- consider exploring the value of using a marginal costs and benefits approach to identify at what stage benefits are maximised
- explore the development of a possum density/impact relationship using existing and new possum RTC data and one-off measurements of pasture accumulation in the absence of livestock as an alternative to extensive direct measurements of pasture loss
- undertake a formal power analysis of the proposed regional measurement system and estimate its costs as an aid to future decision making about outcome monitoring of possum control for economic benefit.

8. Acknowledgements

Thanks are due to Campbell Leckie, Hawke's Bay Regional Council, for helpful advice during the project, to Mike Dodd, AgResearch, for information about his trial design, to Chris Jones and Bruce Warburton for comment on the draft report, and to Anne Austin for editing.

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Appendix 1. Methodology for pasture assessment using exclosures

Exclusion of livestock, possums and rabbits

- Exclusion cages are usually set up within a section of paddock from which livestock have been excluded.
- Livestock can be excluded from areas to be used for pasture measurement using single wire electric fencing, or standard post and wire fences.
- Feral grazers (possums, rabbits) can be excluded from areas to be used for pasture measurement by mesh cages or electrified netting fencing (e.g. Flexinet). Mesh cages used in various studies have been between 0.5 x 1 m and 1.5 x 2 m in size; exclosures using electric fencing may be larger.

Measuring pasture accumulation

- Pasture is normally mown to standard height using hand clippers or lawnmower, left for a fixed period of 4-8 weeks, and then remown. All or part of the plots may be mown.
- The pasture clippings (all or a subsample) are washed and dried to constant weight or for a fixed time period (e.g., 48 h) using an oven set at a value between 60 and100 oC (different studies use different temperature and times).
- Clippings may be separated out before drying into pasture plant types or species if more detailed information is needed
- Indirect pasture accumulation methods can be used instead of mowing; for example, Thomson et al. (2001) used the rising plate meter (RPM) technique to make multiple measurements inside and outside of exclosures. Indirect methods may require calibration, which is usually done by taking multiple readings and correlating them against pasture mass from the same plot measured by mowing. Published correlations may be used instead. Instructions for recommended use of the RPM on NZ perennial ryegrass/white clover pastures can be found at www.dairynz.co.nz/file/fileid/11066 accessed 25 August 2009.