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Economic assessment of using wireless monitoring for managing large-scale trap-networks

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Contents

Summary

Project and Client

- The Hawke's Bay Regional Council (HBRC) contracted Landcare Research to examine the economics of using wireless networks for monitoring trap networks. The report fulfils Landcare Research's contracted Milestone 1.2 and builds on a previous contract report that examined some theoretical aspects of using wireless trap monitoring.

Objective

- To determine the cost-effectiveness of using wirelessly monitored trap networks to optimise control.

Methods

- A pilot trial using 99 live-capture cage traps located over approximately 700 hectares of farmland within the Cape-to-City programme footprint provided data for the analysis.
- Each trap had a wireless node including a sensor that detected when the trap was sprung. Each day the wireless nodes communicated through a hub that the trap was either still set or sprung. This information could then be viewed by the trappers to find out which traps needed to be checked.
- Because the trial was using new, untested technology with an unknown level of faults (i.e. number of incorrect notifications of trap status), all traps were checked daily even though many of the traps were signalled as not having been sprung.
- To measure the potential savings of using wireless trap monitoring, two trappers were used: one inspecting all traps (i.e. to comply with the legal trap inspection requirements), and one checking only those traps signalled as having been sprung.
- The costs of monitoring the trap network with and without wireless notification over 10 years were estimated and expressed as net present value (NPV). The wireless technology costs used in this analysis were: $100 for each node and $3,000 for a hub. As the additional costs of wireless maintenance and the monthly satellite or cellular network fees were not included, the costs of using wireless in these analyses should be viewed as minimum estimates.

Results

- The time to check each sprung trap increased significantly once the proportion of sprung traps declined to below around 0.20.
- The comparison between monitoring costs with and without wireless monitoring and checking traps daily showed that if 10% of the traps were sprung (checked) the savings were $440,323 NPV over 10 years.

- Savings declined as the proportion of sprung traps increased.
- If kill traps are used, use of wireless monitoring only resulted in savings when the proportion of traps sprung was less than 0.1 and traps were checked at least monthly.
- Reducing the node cost had little effect on savings/losses.
- There were more non-target captures than target captures in the Cape-to-City data and, because these increase the proportion of traps sprung, they have the potential to significantly reduce the potential savings from using wireless monitoring.

Conclusions

- Using wireless trap monitoring technology can provide significant savings when live-capture traps that require daily inspections are used.
- As trap checking frequency declines, as it does when kill traps are used, the savings from using wireless monitoring also decline.
- For kill-trap networks, checking frequency will often be governed by the need to refresh bait, and if bait refreshment needs to be done relatively frequently (1–3 months), then using wireless monitoring will add little, if any, value.
- If volunteers or landowners are used to check traps then the potential savings might also be lost and this aspect needs further consideration.
- Because savings are greater when smaller proportions of traps are sprung the number of non-target captures and sprung and empty traps should be minimised to make wireless monitoring more cost effective.
- If savings are re-invested to increase the number of traps being serviced by one trapper, there would need to be a contingency plan in case the wireless system malfunctioned, and sufficient additional staff would need to be available to inspect all traps directly.
- Other benefits (mostly non-monetised) could be accounted for in order to justify the use of wireless systems. Such benefits might include: increased community support and participation in the predator control programme; use of the capture data for monitoring farmer compliance and effectiveness; trap network optimisation; and possibly improved animal welfare.

Recommendations

- Further field testing and trials of using wireless monitoring need to be carried out to determine the effect that wider trap spacing and lower catch rates have on trap checking time and potential savings
- Thought should be given to how best to minimise non-target captures
- Economic comparison of either purchasing or leasing wireless technology should be carried out
- The potential non-monetised benefits from using wireless monitoring should be identified and valued.

1 Introduction

In recent years there has been an increase in the number of vertebrate pest control programmes using permanent networks of traps to maintain pest numbers at low levels and, in parallel, a growing interest in the potential of wireless systems for remote monitoring of these networks to minimise the time and cost associated with checking traps. The Hawke's Bay Regional Council (HBRC) contracted Landcare Research to examine the economics of using wireless networks for monitoring trap networks. The report fulfils Landcare Research's contracted Milestone 1.2 and builds on a previous contract report that examined some theoretical aspects of using wireless trap monitoring (Warburton et al. 2015).

2 Background

Vertebrate pest control in New Zealand has been evolving over the last decade from a paradigm of control applied periodically with intervening periods of no control, to a paradigm of essentially continuous control so that pest numbers are maintained at low levels (presumably below some threshold at which desired values are protected). There has also been a desire to increase the scale of control programmes, with some now covering hundreds of thousands of hectares. This evolution of control programmes has seen the increasing use of permanent networks of live- and kill-traps with a wide range of setting and checking regimes employed. However, irrespective of the implementation details, a common outcome is that pest numbers are held at low density and, especially when having to check live-capture traps daily, the majority of traps checked have no captures. Once a trap network is established (i.e. the initial capital cost is committed), the main cost of running a network is staff or contractor time to check the traps. Current management questions are: can this staff or contractor time be reduced by using wireless monitoring; do the subsequent operational cost savings justify the expenditure of a wireless network; and are there other benefits that remote monitoring might provide additional to the immediate economic benefits?

A previous report (Warburton et al. 2015) examined the likely costs and benefits of using wireless systems, but because of the lack of empirical data this report was necessarily restricted to theoretical analyses. Subsequently, the Hawke's Bay Regional Council has run a pilot trial using wireless sensors to monitor live-capture cage traps for capturing feral cats and data collected during this trial were used to inform the analyses in this report. This report is an interim report and awaits a meeting planned for August with the wireless technology manufacturer, Encounter Solutions, to identify maintenance, satellite or cellular network costs, and potential benefits, such as remote monitoring, volunteer participation, and reduced travel.

3 Objective

- To determine the cost-effectiveness of using wirelessly-monitored trap networks to optimise control.

4 Methods

4.1 Field data collection

Ninety-nine live-capture cage traps were located over approximately 700 hectares of farmland within the Cape-to-City programme footprint (Fig. 1). Each trap had a wireless node including a sensor that detected when the trap was sprung. Each day the wireless nodes communicated via a network hub and satellite network whether each trap was either still set of sprung. This information could then be viewed by trappers to find out which traps needed to be checked. Because live-capture traps were being used, it was a legal requirement to “inspect” the traps daily. Additionally, because the trial was using new, untested technology with an unknown level of faults (i.e. number of incorrect notifications of trap status), all traps were checked daily even though many of the traps were signalled as not having been sprung.

The wireless network used Celium technology (http://www.encounter.solutions/celium/), developed and provided by Encounter Solutions. In this pilot trial 40–50 nodes were used with each hub, although potentially a hub could communicate with many hundreds of nodes.

To estimate what the potential savings might be of using wireless trap monitoring, two trappers were employed: one inspecting all traps (i.e. to comply with the legal trap inspection requirements), and one checking only those traps signalled as having been sprung. Between May and June 2016 both trappers recorded the status of each trap inspected (still set, sprung, species captured) and the time taken to complete their inspection. The locations of all traps were recorded on hand-held GPS units (Fig. 1).

4.2 Relationship between proportion of traps sprung and time to service network

To determine the potential savings in time from using wireless trap monitoring, it was necessary to determine the relationship between the proportion of the network checked and time required to carry out the checking. Although it takes less time to check fewer traps, the relationship is not linear, because, as the number of traps checked declines, the mean spacing and therefore travel time between traps increases. To generate this relationship, the time data collected by both trappers were used – one having checked all traps and one having checked just the traps signalled as sprung. The relationship was generated using least-squares regression in Excel.

4.3 Economic analysis

An economic model was developed accounting for costs (initial capital purchase of wireless technology, and contractor daily rate) with the technology costs depreciated and discounted, and the annual contractor costs inflated by the rates listed in Table 1. The model was run over 10 years. The total expenditure was then expressed as a Net Present Value (NPV). For the scenario using no wireless technology, the NPV was generated only from the contractor costs. When using the wireless technology, the initial capital cost of purchasing the technology was included and the contractor cost reduced, depending on the proportion of traps needing checking (the proportion of the traps sprung (p) ranged from 0.1 to 0.9). This reduction in contractor time was derived using the relation generated from the data shown in Figure 2. The estimated costs (indexed as NPVs) with and without wireless monitoring were calculated and compared to determine the potential savings of using wireless monitoring. The additional costs of wireless maintenance and for the monthly satellite or cellular network were not included, so the costs of using wireless in these analyses should be viewed as minimum estimates.

Table 1. Input values used in the calculation of costs, in terms of net present value, of establishing and monitoring a network of 99 cage traps

Parameter	**Value**
Cost per node	$100
Cost per hub	$3,000
Ratio of nodes to hub	40
Contractor daily rate	$400
Inflation rate	2%
Discount rate	8%
Depreciation rate	20%
Useful life of network (years)	10

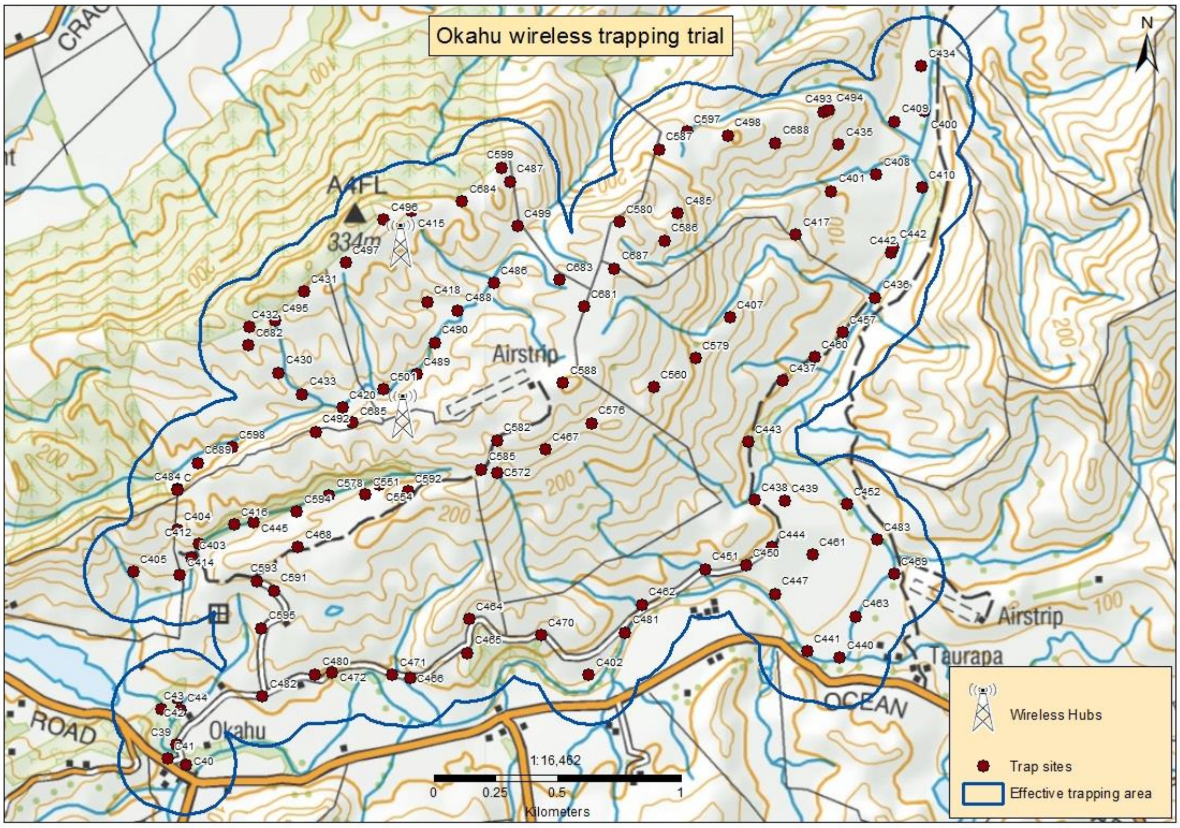

Figure 1. Cage trap locations and the outer boundary of the area trapped.

5 Results

5.1 Relationship between proportion of traps sprung and time to service network

The relationship between the proportion of traps sprung and time showed a significant increase in the mean time taken to check each trap once the proportion of sprung traps is less than about 0.20 (Fig. 2). Because 99 traps (close to 100) were used in the trial, it has been assumed that the relationship generated between traps checked and time is related to the proportion of traps sprung and this relationship stays constant over any number of traps.

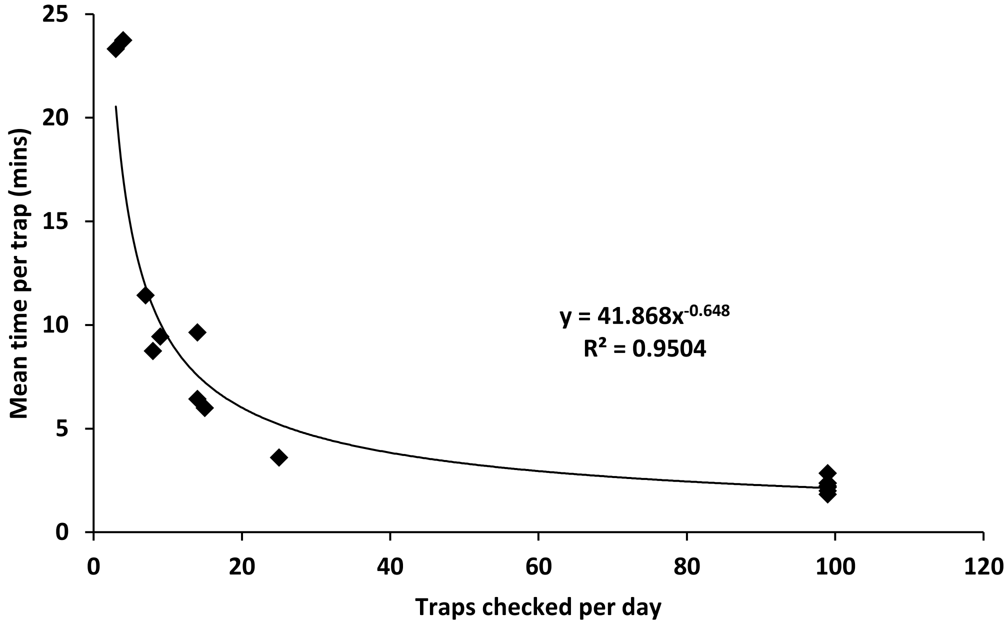

Figure 2. Relationship between number of traps checked per day (total number was 99) and the mean time to check those traps.

5.2 Net Present Value with and without wireless monitoring

5.2.1 Daily trap checking (live-capture traps)

Table 2 below shows an example of the 10 years of expenditure and resultant total costs (expressed as a NPV) when wireless was used and P was 0.1, and when wireless was not used. In this example, the savings were $440,323. Running the model with P ranging from 0.1 to 0.9 shows there were savings when using wireless monitoring for all values of P when traps were checked daily (Fig. 3) with the savings increasing as the proportion of traps needing to be checked declined.

Table 2. Example to demonstrate the effect on 10-year costs of using wireless technology based on a 99 live-trap network. The "with wireless" values indicate when only 10% of traps were sprung

	Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Without wireless	Cost ($)	146,000	148,628	151,303	154,027	156,799	159,622	162,495	165,420	168,397	171,428
	Total costs over 10 yrs (NPV)	**$786,454**									
With wireless & 10% traps sprung	Cost ($) $17.5K*	61,650	62,759	63,889	65,039	66,210	67,401	68,615	69,850	71,107	72,387
	Total costs over 10 yrs (NPV)	**$346,131**									

*This value is for the capital purchase of the wireless technology.

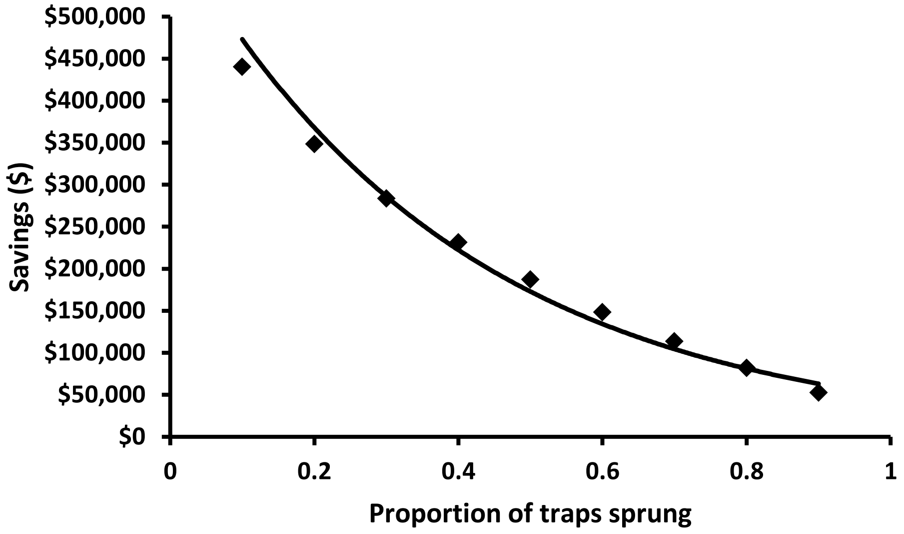

Figure 3. Estimated savings over 10 years, expressed as net present value, of using wireless technology to monitor a network of 99 live traps in relation to the proportion of traps sprung ranging from 0.1 to 0.9. Note: savings should be negative when all traps are checked, but are not on this graph because of the averaging effect of the relationship described in Figure 2.

5.2.2 Infrequent trap-checking (kill traps)

Because kill traps do not have to be checked daily, they can be checked either at some predetermined interval (e.g. 1, 2, 3 months) or when a predetermined proportion of the traps are identified as sprung (e.g. 0.20). Basing the checking frequency on a predetermined interval or sprung rate will lead to cost savings only if those traps that are sprung need to be checked (i.e. the still-set traps do not need their baits replenished). Additionally, even if only the sprung traps need checking, the interval between checks will vary according to target pest and non-target densities and capture rates. Because these rates are not known, the costs for this analysis were calculated for 1-monthly and 2-monthly trap checks. The analysis showed that only if the proportion of traps sprung was 0.1 or less and these traps were checked monthly was there likely to be a cost saving (Table 3). If the proportion of traps sprung was higher than 0.1, or the time between checking was longer than 1 month, there were no economic benefits from using wireless monitoring (i.e. using the costs of the current technology) (Table 3).

Table 3. Estimated cost savings over 10 years, expressed as net present value, from using wireless monitoring of 99 kill traps compared to daily direct observation of each trap. Only when the proportion of traps sprung was 0.1 and traps checked monthly were there minimal savings

Proportion of traps sprung	1-monthly check	2-monthly check
0.1	$2,623	–$7,439
0.2	–$1,441	–$9,470
0.3	–$4,321	–$10,910
0.4	–$6,628	–$12,064
0.5	–$8,586	–$13,043

5.2.3 Effect of node cost on NPV

To determine what effect varying node costs would have on any potential cost savings, the analysis used a 2-monthly trap checking interval (i.e. 6 checks per year) and 0.2 as the proportion of traps needing to be checked to determine if reducing the node cost would result in in savings (i.e. there were no savings when nodes cost $100). Node price was varied from $10 to $100 (Table 4). These data showed that even with node prices as low as $10, if the trap checking was infrequent (i.e. 2-monthly or less frequent) there was no economic advantage in using wireless monitoring.

Table 4. The effect of node price on cost savings over 10 years, expressed as net present value, when checking kill traps with and without wireless monitoring. The analysis assumes that traps are checked 2-monthly and 20% of traps are sprung

Node cost	Savings
$100	–$8,083
$75	–$6,077
$50	–$4,071
$25	-$2,064
$10	–$861

5.3 Non-target captures

Traps can be sprung by target and non-target species and by the malfunctioning of the trap. Trap sensors might also incorrectly notify a trap as being sprung. Given the economic benefits of using wireless monitoring are larger when the proportion of traps sprung is low, it is beneficial to minimise the number of “non-target” sprung traps. In this trial many more non-target species were captured than target species, with the harrier hawk being the most captured species (Table 5).

Table 5. Target, non-target and sprung, empty traps recorded in this trial

Target species			Non-target species and sprung, empty traps				
Cat	Ferret	Stoat	Hedgehog	Harrier hawk	Magpie	Possum	Sprung
18	3	0	26	56	3	2	31

5.4 False negatives and false positives

As the wireless technology used in this pilot trial was being field tested for the first time, the results do not in any way reflect the likely final performance of the technology. Nevertheless, the data on false positives and false negatives were examined to gain some understanding of what challenges the technology might face. False negatives are not critically important if the technology is being used to monitor kill traps (i.e. there is no legal requirement to inspect all traps), but before the technology can be used as the sole "inspection" method for live-capture traps it needs to operate with close to zero false negatives (i.e. a sprung trap is notified as being still set). Both forms of error occurred in this trial, with daily false negatives occurring in 1–12% of traps and false positives occurring daily in 0–14% of traps.

6 Conclusions

Using wireless trap monitoring technology clearly provides significant savings when it is used to monitor live-capture traps that require daily inspections. The more days the wireless technology is used to identify which traps to check, the greater the savings. Similarly, the lower the proportion of traps sprung, the greater the savings. However, as trap checking frequency declines – as it does when kill traps are used – the savings from using wireless monitoring also decline. Assuming current technology costs and contractor daily rates, once the trap checking frequency extends beyond about once per month there is an overall cost from using the technology. Even reducing the price of nodes to $10 did not make the system modelled in this study much more economical, although losses were not large. For kill-trap networks, checking frequency will often be governed by the need to refresh bait, and if bait refreshment needs to be done relatively frequently (1–3 months), using wireless monitoring will not add much, if any, value.

In this analysis the potential savings from using wireless monitoring result from the reduced time necessary to check only sprung traps and therefore the reduced cost of the contractor ($400 per day). If volunteers or landowners are used to check traps then the potential savings are lost. However, if volunteers or farmers were required to check all traps they most likely would not become involved, so although there are no direct contractor costs, having volunteers to check only sprung traps might enable the council to avoid contractor costs altogether. This logic only holds for trap-check frequencies at which the contractor costs are greater than the price of the wireless network, and this will only hold when traps require frequent checking.

The results also showed that the lower the proportion of traps sprung, the greater the savings (i.e. less time is required to check the sprung traps); so, to make wireless monitoring more cost-effective, the number of non-target captures and sprung and empty traps should be minimised.

Potential savings will only be realised if the time saved is used productively doing some other required task. For contractors, this could either be another activity or the service of a greater area and number of traps. Using data from this trial, the 99 traps set were checked in about 3.75 hours with 20% of them (20 traps) checked in about 2 hours. This means a contractor could run about 400 traps in an 8-hour day, which would cover about 2,800 ha. If this scenario was used with live-capture traps, the contractor would need a contingency plan in case the wireless system malfunctioned, and sufficient staff would need to be available to inspect all traps directly.

Although there were losses from using wireless monitoring of kill traps, the losses were not large and therefore arguably cost-neutral. If this is the case, other benefits (mostly non-monetised) could be accounted for to justify any losses. Such benefits might include:

increased community support and participation in the predator control programme; use of the capture data for monitoring farmer compliance and effectiveness; trap network optimisation; and, possibly, improved animal welfare.

The economic analyses carried out here assumed the wireless network was purchased as an asset – that is, there was an upfront capital cost (CAPEX). As an alternative, the network could be leased on an ongoing basis, which would be funded from an annual operating budget (OPEX). The pros and cons of these two options need further investigation.

7 Recommendations

- Further field testing and trials of using wireless monitoring need to be carried out to determine the effect that wider trap spacing and lower catch rates have on trap checking time and potential savings
- Thought should be given to how best to minimise non-target captures
- Economic comparison of either purchasing or leasing wireless technology should be carried out
- The potential non-monetised benefits of using wireless monitoring should be identified and valued.

8 Acknowledgements

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9 References

Warburton B, Jones C, Ekanayaki J 2015. Remote monitoring of traps using wireless-based systems. Landcare Research Contract Report LC2341, 16 p.