Animal Health Board Project No. R-10686

Reducing the Risk of Spillback Infection from Hunter Kills

Ivor Yockney, Grant Morriss and Graham Nugent






Landcare Research
Manaaki Whenua

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Summary

Project and Client

Landcare Research, Lincoln, surveyed North Canterbury pig hunters to collect baseline information before investigating possible ways of reducing the potential risk of spillback tuberculosis (Tb) infection arising from hunter kills, for the Animal Health Board (AHB Project R-10686) between July 2007 and October 2008.

Objectives

- Survey up to 100 pig hunters in North Canterbury to determine the scale of the problem, and to identify what systems, tools, and incentives are most likely to reduce the number of carcasses they dump inappropriately
- Design and evaluate the feasibility, effectiveness, cost and benefits of a depot network aimed at collecting pigs' heads from hunters.

Methods

- One hundred North Canterbury pig hunters were surveyed in late 2007, and asked a standard set of questions that included (among others):
    - The approximate number of pigs they harvested per year, and the number of hunting companions (and dogs) they typically hunted with
    - Distances travelled to hunting areas
    - Their knowledge of VRA boundaries (and the significance of those boundaries)
    - What they did with killed pigs – what number, and in what form, of carcasses were transported long distances from kill sites, and how and where did they dispose of carcass remains after butchering. They were also asked what dumping sites they knew of, regardless of whether or not they used them
    - Their willingness to use rapid decomposition agents or repellents to lessen the risk of spillback
    - Their reactions to the concept of head-collection systems, including where collection depots could be most usefully sited. This information was used to assess the feasibility, design and likely cost of such systems
    - Their thoughts on initiatives that they considered would encourage hunters to reduce the number of pigs' heads they dump
- Information from this survey was used to assess the likely feasibility and uptake by hunters of various methods to reduce the inappropriate dumping of pigs' heads.
- Different means of pig's-head disposal were investigated and where possible costed.
- Establishment of a chiller for pig's-head deposit was costed.
- A broad cost–benefit analysis was carried out to assess the value of setting up head collection depots against the status quo, and the potential risk of new Tb outbreaks.

Results

- The mean (± SE) number of dogs owned by hunters was 3.3 ± 0.2 with a mean (± SE) harvest per hunter per annum of 70.5 ± 5.6 pigs. However, when harvest is analysed by hunting party this decreases to 38.7 ± 4.1 pigs per hunter.
- A *conservative* estimate of total harvest by the hunters surveyed was ~3900 pigs taken in the last year.

- The longest distance hunters travelled to their hunting blocks was 607 km one way (mean ± SE = 154 ± 12 km).
- Eighty-six percent of the hunters surveyed took most of their pigs home with the head attached, and 63% took all of their pigs home with head on.
- The hunters used multiple means of disposing of pigs' heads including open offal pits (39), leaving them at the kill site (37), council rubbish collection (33), capped offal pit (26), retaining them for official necropsy (22), and taking them back to the hunting block after butchering (10). Twenty-eight hunters mentioned other methods of disposal: burying, burning, retaining heads for taxidermy, using as a bait dump to attract pigs, and feeding to the dogs.
- Eight percent of the surveyed hunters admitted dumping pigs' heads in riverbed or roadside locations, and a further 20% knew people who had done that in the last 12 months.
- One hundred and thirty four different riverbed or roadside dumping sites were identified.
- The hunters surveyed agreed that a drop-box system was likely to be used (81%) but with additional incentives of either a prize draw or cash increasing likely uptake to 95%.
- Chemical sanitisation and sterilisation could be used to neutralise potentially Tb-infected pigs' heads.
- A public offal pit or burning of collected pigs' heads are unlikely to be suitable means of disposing of potentially Tb-infected pigs' heads.

Conclusions

- Significant dumping of potentially Tb-infected pigs' heads is occurring
- The agricultural benefits of pig control by pig hunters needs to be qualified by the risk of Tb spread by the inappropriate dumping of Tb-infected pigs' heads.
- There are no legal or social impediments to the use of a pig's-head-collection chiller.
- A single-site pig's-head-deposit chiller would cost in excess of $20,000 to set up with expected annual costs of around $30,000–40,000 for power, lease payment, collection and disposal.

Recommendations

- Because a large proportion of pig hunting in North Canterbury (in particular) is conducted on private land, and because we found many hunters were not well informed about Tb in pigs and how it might be spread to other species, further efforts should be made to educate both hunters and farmers of the risk of spillback infection.
- The AHB should initiate a 2-year pilot trial to determine the number of pigs' heads that could be collected from North Canterbury hunters by establishing a drop-box depot on or near the main highway at Amberley. We recommend that the drop-box consist of large chiller that is serviced weekly, with the contents collected and disposed of by a commercial contractor (unless the heads are required for necropsy). Further, the system should be trialled without cash payment for a 6-month period, followed by 3–4 similar periods in which progressively larger payments are trialled, to determine the effect on the number of pigs collected.
- Depending on what long-term Tb control scenario is adopted for North Canterbury, consideration should also be given to necropsy of the heads collected, with heads disposed of as above after necropsy. This should not include mycobacterial culture of key tissues from every pig. The reliability of the reported locations should be checked by confirming locations of a subset of Tb-positive pigs by requesting the hunter to take an AHB staff member to the kill site in return for a substantial cash payment.

1. Introduction

Landcare Research, Lincoln, surveyed North Canterbury pig hunters to collect baseline information before investigating possible ways of reducing the potential risk of spillback tuberculosis (Tb) infection arising from hunter kills, for the Animal Health Board (AHB Project R-10686) between July 2007 and October 2008.

2. Background

In areas with Tb-infected wildlife, the feral pig is (if present) the most likely species to be infected with Tb (Nugent & Whitford 2008). A review of the role of deer, pigs, and ferrets in the persistence and spread of Tb (Nugent et al. 2003a) concluded that hunter-mediated translocation of 'spillover' hosts such as pigs and deer could easily spread Tb to new areas. This included both transportation and release of live pigs, and the dumping of Tb-infected carcass remains. This project focuses on the latter.

Hunters may dump carcass remains tens or hundreds of kilometres away from where the animal was killed and these carcasses are readily scavenged by ferrets, pigs, and cats and less frequently (but importantly) by possums (Yockney & Nugent 2003; Byrom 2004; Coleman et al. 2005; Nugent 2005). The greatest risk in areas such as North Canterbury is posed by pig-to-ferret transmission. Pigs from within vector risk areas (VRAs) can have high levels of infection (mostly contained in the head) particularly in areas where the primary vectors (possums and ferrets) remain uncontrolled. Hunters routinely carry out pig carcasses whole and butcher them at home. The head and other unwanted parts of the carcass are then sometimes dumped in riverbeds or other scrubby wasteland where ferrets or other vectors may be common. As an example of the potential risk, this potential route of transmission to ferrets arguably provides a more plausible explanation (than does possum-to-possum or ferret-to-ferret transmission) for the rapid geographic spread of Tb south through North Canterbury during the 1990s, and possibly also for the detection of a tuberculous ferret south of the Waimakariri River in 2006 (S. Loefler, pers. comm.).

In this report, we attempt to assess the potential scale of the problem by surveying a sample of pig hunters from North Canterbury to determine how many pigs they killed and what they did with carcass remains. We then explore options for reducing the potential risk, including the possibility of converting the problem into a benefit (by collecting pigs' heads to remove the spillover risk and then using them to provide additional surveillance data).

North Canterbury was selected as the focus for this study for the following reasons:

- The substantial numbers of pig hunters in the area, enabling us to obtain usefully large sample sizes
- The involvement of a significant proportion of urban-based (Christchurch) hunters who have to travel substantial distances to hunting areas, creating potential for long-distance carcass transportation

- The long-standing links between two of the researchers (as big game hunters themselves) with many of those in the North Canterbury pig hunting community, providing a ready means of contact

3. Objectives

To determine ways of reducing the risk of potential new outbreaks of Tb in ferrets and possums as a result of spillback infection caused by Tb-infected pig carcass remains being dumped where vectors can access them, by:

- Surveying up to 100 pig hunters in North Canterbury to determine the scale of the problem, and to identify what systems, tools, and incentives are most likely to reduce the number of carcass remains they dump inappropriately
- Designing and evaluating the feasibility, effectiveness, cost and benefits of a depot network aimed at collecting pigs' heads from hunters.

4. Methods

This project was undertaken in two parts: (1) a survey of a sample of North Canterbury pig hunters and (2) assessing the feasibility, design, and potential benefits of a pig's-head collection system. The pig hunter survey was approved by the Landcare Research social ethics committee for research involving human participants.

4.1 Pig hunter survey

The survey was designed in collaboration with a Landcare Research social scientist, and aimed to assess, in broad terms, the potential for new outbreaks of Tb-infection in wildlife caused by the dumping of potentially infected pigs' heads and other carcass remains at sites accessible to possums or ferrets at sites distant from where the pigs were killed.

As an incentive to optimise hunter participation a lucky-draw prize was offered comprising two dog-tracking collars and a Tracker Maxima receiver (purchased from Sirtrack, Havelock North). Initial interviewees were pig hunters who were known to the authors. In July 2007 the authors attended the Coalgate Hunting Competition and approached individual hunters to encourage participation in the survey. Following this four Canterbury-based pig hunting clubs were contacted (Canterbury, Eastern, Pegasus, and Malvern), and at least one of the authors attended club meetings to present findings from previous research on pig–ferret–possum scavenging, the resulting potential for spillback Tb-transmission, to explain the purpose of the survey, and to obtain contact details of any hunters willing to participate in the survey. We believe that these presentations alone will have helped reduce the spillback risk simply by educating all the attending hunters (even those who did not want to participate in our survey) about the possible consequences of dumping potentially Tb-infected pigs' heads.

The majority of interviews were conducted by phone, but some were conducted face-to-face at club meetings or elsewhere.

In the interview, hunters were asked a standard set of questions (as listed in Appendix 1) that included:

- The approximate number of pigs they harvested per year, and the number of hunting companions (and dogs) they typically hunted with
- The distances travelled to hunting areas
- Their knowledge of VRA boundaries (and the significance of those boundaries)
- What they did with killed pigs – what number, and in what form, of carcasses were transported long distances from kill sites, and how and where did they dispose of carcass remains after butchering. They were also asked what dumping sites they knew of, regardless of whether or not they used them
- The willingness of hunters to use rapid decomposition agents or repellents to lessen the risk of spillback
- Their reactions to the concept of head-collection systems, including where collection depots could most usefully be sited. This information was used to assess the feasibility, design and likely cost of such as systems
- Their thoughts on initiatives that they considered would encourage hunters to reduce the number of pigs' heads they dump. The range of initiatives we suggested included financial incentives, even though the AHB's Technical Advisory Group had indicated that this was unlikely to be an option for operational use. We included this option, because our preliminary assessment was that hunter participation rates were likely to be very low without some form of incentive. Ideally, any incentive would need to be large enough to encourage hunter participation, but not so large as to cause any major change in hunting patterns (such as travelling further to a hunting ground to participate).

4.2 Design and feasibility of pig's-head collection systems

Information gathered from the survey was used to design a depot-based pigs' head collection system, and then assess the likely feasibility, costs and benefits of such as system. To determine legislative constraints on a pig's-head deposit system we contracted consultants to examine both the Hurunui and Kaikoura district council plans; these were the areas where pig's-head collection systems would most likely be set up to cater for the bulk of North Canterbury pig hunters. There are two possible purposes for such a system: the first being aimed solely at reducing spillback risk simply by providing hunters with a convenient way of disposing of unwanted carcass remains; the second having the dual aims of reducing spillback and providing additional Tb-surveillance data.

Reducing spillback risk via a low-cost pig's-head collection system:

This would involve hunters voluntarily depositing pigs' heads at a small number of depots (5–10) strategically located on the main routes to and from hunting areas. Such a system has previously been used to gather, without any payment at all, the jawbones from over half the deer shot annually in the Blue Mountains, Otago, in the late 1980s (G. Nugent, unpubl. data), and in Hawai'i where a one-way drop-in chest freezer was successfully used to collect (and pay cash incentives for) pigs' and deer heads for necropsy (G. Maioho, pers. comm.). The heads collected would then be disposed of in a proper waste-disposal facility from which all wildlife were excluded.

Reducing spillback risk and increasing Tb survelliance through pig's-head collection

To provide additional benefit from collecting the heads as above, some or all of the heads could be necropsied, depending on where they were reportedly taken from. Notwithstanding the likelihood that hunters will sometimes inadvertently or deliberately misreport where pigs were killed, this would provide a highly sensitive measure of the yearly trend in the *regional* levels of Tb in wildlife. It would also give the AHB some quantitative feel for the amount of infected material that may have been otherwise dumped by hunters.

4.3 Cost–benefit analysis

We briefly explore the likelihood that spillback from dumped pig remains could contribute to new outbreaks, and qualitatively assess the likelihood that establishment of a collection system purely for this purpose would be cost-effective. We also explore whether the collection of additional data on Tb prevalence and distribution in wildlife is likely to be worthwhile by exploring how such data might affect the cost and duration of vector control in North Canterbury.

5. Results

5.1 Pig hunter survey

One hundred North Canterbury pig hunters were surveyed between July and November 2007. Hunters took a strong interest in what the researchers were trying to achieve, and appeared to be frank and forthcoming in answering the survey questions. It is the researchers' opinion that the information given by hunters is likely to be a fair and accurate representation of their recreational hunting habits.

General hunting patterns

As in previous studies (Clarke 1991; Nugent 1992) most pig hunters (94%) surveyed in this study hunted with dogs. The mean number of dogs owned by hunters was 3.3 ± 0.2 (SE).

The mean annual harvest reported by interviewees was 70.5 ± 5.6 (SE) pigs, with a total harvest reported for the previous year of 7045. However, these figures undoubtedly include some 'double counting' of participants who hunted together. Although some hunters usually hunted alone, many preferred to hunt with one or two other hunters. Interviewees reported hunting with 1.3 others on average (i.e. mean hunting group size of 2.3). Dividing the reported harvest by this mean group size suggests a mean annual harvest of 38.7 ± 4.1 (SE) per group member. Based on that, a conservative estimate of total harvest by the 100 interviewees is ~3900 pigs. As it was clear that many of the interviewees' hunting companions did not take part in the survey, this estimate will substantially underestimate the true total.

Hunters travelled on average 154 ± 12 (SE) km one way to their hunting destinations. This included some particularly long trips to (for example) the Marlborough Sounds, Central Otago and the West Coast (Fig. 1). This confirms that hunters were travelling distances many

times greater than the scale of natural movement by free-ranging pigs (which are mostly of the order of just a few kilometres). It also showed that although most hunters in North Canterbury hunted in the North Canterbury VRA, many also hunted in at least one other VRA. Overall, it was clear that the majority of hunters were based in or near the larger Christchurch area, but hunted in northern parts of the VRA, creating a substantially southward flow of carcasses to (and beyond) its southern boundary (Fig. 1).

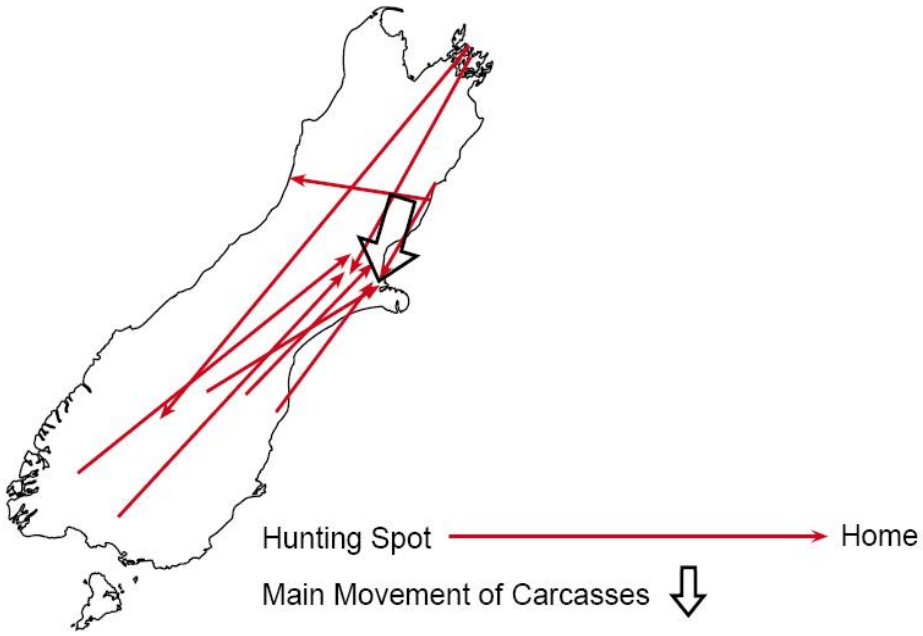

Fig. 1 Movements of North Canterbury pig hunters showing long-distance hunting trips (red arrow) and the main movement of hunters (black arrow) back to their home town (Note: one member of the Eastern Pig Hunting Club based in Kaiapoi was living in Cromwell, Central Otago, and was hunting in the Marlborough Sounds when surveyed).

Pig's-head disposal

Despite the extra weight involved in carrying a carcass from its kill site to a vehicle, Nugent et al. (2003b) found that 87% of hunters transported pig carcasses home with the head attached. We found the same in this survey, with 86% of interviewees taking most of their pigs home with head on, and 63% taking all pigs home with head on. The internal organs are almost always left at the kill site.

The reasons for leaving the head attached are (1) being able to obtain a whole-pig weight that is comparable to that routinely taken in hunting competitions, (2) ease of carrying, and (3) being able to keep the carcass clean until it is skinned and butchered. However, few hunters actually consume pigs' heads, so the head, along with skin and hocks, are almost always discarded once the carcass has been butchered. Unfortunately the head is also the primary site of Tb infection in pigs (Corner at al. 1981; Lugton 1997).

Among those interviewed, the most common method for disposing of pigs' heads was to dump them into either an open or capped offal pit (65% of interviewees; Table 1), either on

the farms where hunting took place, or at the home farm of the respondent or an associate. Twenty-six of these hunters had access to capped offal pits where there would presumably be little risk of scavenging by vectors. In most instances, however, the offal pits were open, and of the 39 hunters who used open offal pits 74% thought that vectors, such as ferrets, would be able to gain access to dumped remains.

The second most common method was to leave heads at the kill site, but only two hunters did this with all the pigs they killed. The majority took home mostly whole pigs (Fig. 2) and heads were typically left behind only when pigs were killed in difficult areas and if it was necessary to reduce the carcass weight. The third most common method of waste disposal was using the official rubbish collection system. Presumably heads disposed of in this way would quickly be covered up in landfill and so would not be available to scavenging vectors.

Twenty-two hunters said they retained pig heads for necropsy. Most of these hunters were paid for the heads by Environment Canterbury (ECan) or the Marlborough District Council (MDC) but some were unpaid (or given ammunition) and collected the heads for 'Locally Initiated Programmes' (LIPs) as part of the Tb control strategy.

Of those interviewed only 8% admitted to dumping carcass remains in areas readily accessible to wildlife (Table 1) (e.g. beside the road, in riverbeds, at roadside rest areas and in neighbours' paddocks). However, 20% of hunters knew of someone else who had dumped carcass remains, and most hunters (76%) knew the locations of commonly used dumping sites near their hunting area or homes. Many of these were reportedly found when exercising their dogs. In total, 134 different dumping sites were identified (see Appendix 2) with the three highest ranking being the Waimakariri riverbed (reported by 26 interviewees), Balmoral Forest straight (Culverden) (*n* = 25) and the Ashley riverbed near Rangiora (*n* = 9).

Table 1 Methods used by 100 North Canterbury pig hunters to dispose of pigs' heads and other waste material after butchering carcasses (some hunters used multiple methods of disposal).

Disposal method	No. hunters using method
Open offal pit	39
Left at the kill site[1]	37
Council rubbish collection	33
Capped offal pit	26
Retained for necropsy	22
Taken back to hunting block	10
Roadside/riverbed	8
Other[2]	28

[1] 37 hunters left at least some of the pigs' heads at the kill sites. Two hunters left all pigs' heads at the kill sites.

[2] Includes burying, burning, retaining heads for taxidermy, using as a bait dump to attract pigs, and feeding to the dogs.

Most hunters (81%) considered that they and their associates would use a pig's-head collection system voluntarily, if it were convenient. With the additional incentive of either a prize draw or cash, 95% of the hunters surveyed indicate a willingness to participate. Other than such incentives, 35 interviewees ranked being able to deposit skins as well as heads as the best way to encourage hunters to make full use of any disposal/collection system, while 22 considered convenient placement of collection depots was likely to be the key encouragement and 11 thought having a tap on site to wash up after dumping animal remains was key.

As regards the convenient location of disposal/collection sites, the three most commonly suggested locations were Amberley (32), Rangiora (18) and Kaiapoi (13).

Fig. 2 Pig hunter returns home from North Canterbury. Papanui Road, Christchurch, July 2004.

5.2 Some options for head collection and disposal

Four potential designs of disposal and/or collection depots were developed, and then assessed in terms of their legality, practicality, cost, user-friendliness, and the ability to collect Tb surveillance data. In North Canterbury, the regional council (ECan) regulates the disposal of waste under the Resource Management Act 1991, including any discharge of solid waste to land and the discharge of contaminants to air, while the local district councils manage the collection of such waste.

Offal pits

Offal pits require the use of a rurally located site and resource consent from ECan. The key points to be considered are distance from the proposed pit to surface water, the implications for ground water, and odour control. An assessment of overall effects on the environment would be required for the resource consent application. There are no known commercial offal pits operating in Canterbury, therefore no cost estimates could be provided.

One likely disadvantage of offal pits, if they are freely open to the general public, is that they might be widely used for waste other than pigs' heads. Another is that there would be no way of assessing the number of pigs' heads deposited, let alone their Tb status, so this option precludes the opportunity for Tb surveillance.

Chillers (or freezers)

Hunters could be asked to place heads (and perhaps other remains) in conveniently located chillers or freezer. Chillers would allow easier handling and removal of the pigs' heads by a collection/disposal contractor than would a freezer, and use less electricity – providing the contents were removed once a week, the material is unlikely to become rotten. A major potential advantage is that the pigs' heads are available for Tb-surveillance (necropsy). This would require that heads be individually identifiable, but this can be easily facilitated by requiring hunters to attach a numbered tag to the pigs' heads they deposit and provide kill location data and their own contact details.

Incineration

Once collected (either in a chiller or freezer or in an unrefrigerated container or dumpster emptied every few days) any material could be disposed of by incineration. Burning of pig remains would be a permitted activity in Canterbury, subject to conditions such as groundwater being at least 3 m below ground surface at the site, and ensuring that the smoke and odour do not cause offence to neighbours. The use of a portable air-curtain incinerator (ACI) as field trialled by MAF (MAF 2005) could be another option if ongoing disposal via other methods are prohibitively expensive and an appropriate site for ACI was available. As there are no commercially operated outdoor incineration services in Canterbury, estimates of cost could not be provided.

Chemical sanitisation and sterilisation

As an alternative to incineration, collected material could be chemically sanitised or thermally sterilised. This would require a contractor to be engaged to transport the goods to the required plant. Sanipac offers a service that sanitises animal waste prior to disposal, to remove pathogens and disease. Likewise Interwaste has a steam sterilisation process and offers a pick-up and disposal service at approximately $2.87 per kilogram, a service charge to take a truck to Amberley would amount to an additional $60 per visit. As with offal pits and incineration there would be no opportunity to use the pigs' heads for Tb-surveillance.

Of the options above, we conclude that the most practical and acceptable method for collection and disposal of potentially Tb-infected pigs' heads would be a network of chillers serviced by a collection/disposal contractor (with or without necropsy for Tb surveillance). Such a system would have less potential for socially or environmentally unacceptable consequences, and less potential for misuse, than would any system of unrefrigerated offal pits or collection depots. In addition it provides the option of collecting additional Tb surveillance data.

5.3 Chiller-based collection and disposal system

Based on the conclusion above, we developed the chiller-based collection and disposal system in more detail, and assessed likely costs and feasibility under two district council plans (for Hurunui and Kaikoura – areas we believe where there is likely to be greatest use of such a system).

Physical characteristics

Based on once-a-week servicing, and depending on the number of chillers established, and where they are located, we considered that any chiller would need to be able to accommodate the remains of up to several hundred pigs at any one time. This-sized chiller should be sufficient to cater for the results of a normal week's hunting (except perhaps during pig hunting competition weekends). That would require dimensions of $2.0 \times 2.0 \times 2.2$ m (see Appendix 3). Each chiller would be placed on a concrete pad designed to facilitate easy pick-up of dumped material by the waste contractor. The inside of the chiller needs to include a large bin on wheels suitable for loading onto the hydraulic tail loader of (for example) the Interwaste freight truck.

Legal implications

A chiller is considered a 'utility building' for the storage of waste and is a permitted activity in both the Hurunui and Kaikoura district plans. Setting up a chiller must comply with the Waste Management Protocol (enforced by ECan) and they should be located in an industrial zone.

The land area on which the chiller is placed would be subject to rental. If this is a roadside (lay-by, roadside verge, rest area) then it is likely to be controlled by either Transit New Zealand or the relevant district council. If it was located on private or other commercial land, a lease arrangement would need to be sought.

A power source would be required to operate the chiller. If a connection is unavailable at the proposed site then a connection to the mains power supply would need to be established, in the worst case a transformer would be required at the nearest power pole.

Costs

A specifically manufactured chiller unit would cost approximately $11,500 + GST including delivery and, once set up, power consumption would be 1600 watts/24-h period, which would cost $182.00 p.a. (Meridian Energy). We assume the chiller would require its own power supply, which might cost a further $10,000, and that fencing, signage, and provision of a water supply and plumbing might add as much again.

Overall, it could cost up to $20,000 to set up each site, and a further $11,500 for the chiller itself. The chiller has an expected minimum lifespan of 10 years and a maximum of 20 years under normal conditions.

Spread over 20 years, the depreciated capital and set-up costs would average $1,500 for each year, while the annual running costs would be <$500 p.a. for electricity, and (assuming a rental of $50 p.w.) rent of $2,500 p.a. The total annual cost per chiller is therefore estimated to be of the order of $4,000 to $5,000.

The cost of disposal obviously depends heavily on the number of chillers, and the amount of material deposited in each chiller each week. Assuming a system of chillers at three key locations in the VRA (Amberley, Kaikoura, and Rangiora), 30 pigs per chiller per week (total of 4500 p.a.) and an average of 5 kg per pig (including skins), the cost of collection to Rangiora would be of the order of $10,000 p.a. ($200 p.w.). Steam sterilisation and disposal (by Interwaste) at c. $15 per pig would cost $67,500 p.a.

The total annual cost of collection-and-disposal-only system would therefore be of the order of $90,000 to $100,000 for a three-chiller, 4500-pig-per annum system, if there was no necropsy of heads, and no direct cash payments to hunters.

Assuming 4500 pigs p.a., adding a cash payment to hunters of (for example) $50 per head would add $225,000 to the annual cost, while adding necropsy costs at $20 per head (R. Corboy, AgriQuality Rangiora, pers. comm.) and culture of all pigs would add $315,000 p.a.

Assuming scenarios of 1000, 4500, and 8000 pigs respectively with $50 per pig cash payment and necropsy, the total costs of a three-chiller system would be of the order of $160,000, $635,000, and $1.1m p.a. respectively. Under any of these three scenarios the chiller costs (power, rental, and depreciated capital and set-up costs) form only a minor part of the total.

These total costs could be reduced in numerous ways.

First the payment to hunters could be set at zero, so that the facility was simply providing a convenient place for disposal of unwanted heads. Hunters indicated in this survey that the level of participation without payment would still be high (81% increasing to 95% with an incentive); however, we believe that the percentage of the pig harvest captured by an unrewarded voluntary system would be lower than indicated (we guess only 1000 pigs p.a.). If so, then the system would cost only $40,000 p.a, but have little impact on reducing the spillback risk, and provide no Tb surveillance information.

The second possibility would be to retain the payment to hunters but simply to dispose of the heads, not necropsy them. Again we have no way of knowing what proportion of the harvest would be 'captured' at the suggested rate of $50 per pig. Given the hunters we surveyed accounted for almost 4000 pigs, and that they were only a subset of the total hunting population, we suggest that the total harvest could feasibly be of the order of 10 000 pigs annually. If so, the 4000 and 8000 pigs p.a. scenarios above would equate to 40% and 80% of the total resulting in equivalent reductions in spillback risk. Put conversely, the system would need to capture at least 4000 pigs annually to have a marked impact in reducing spillback risk. If that were the sole reason for setting up the collection system, then the annual cost would be $320,000 to $540,000 p.a. for 4500–8000 pigs.

The third possibility would be to retain the payment to hunters, and also to necropsy the pigs, but to culture only those few with Tb-like lesions. This would reduce costs by almost $50 per pig, but still provide almost as much surveillance data, as it is rare for Tb to be detected by culture in unlesioned pigs. On this basis, the annual cost would be $400,000 to $700,000 p.a. for 4500–8000 pigs, with both a reduction in risk of spillback and provision of a large amount of surveillance data.

Without any accurate estimate of the numbers of pigs killed annually in North Canterbury, and with no data on how the proportion of heads deposited might vary according to size of payment to hunters, it is not possible to estimate how much it would cost to reduce the risk of spillback by half or three-quarters. However, our survey alone accounted for almost 4000 pigs per year, so it seems clear that over 4000 pigs would need to be collected to have any worthwhile effect on the spillback risk. We think it unlikely that that target would be achieved without any cash payments to hunters, but acknowledge that payments of $10 to $30 per pig might well be sufficient.

The major components of the highest-cost scenarios above are culture and cash incentives. Without those costs, necropsy comprises only one-third to half the total cost, suggesting that heads are being collected for disposal anyway, then the marginal cost of necropsy is relatively minor.

Potential benefits

The benefit of collecting and necropsying pigs' heads as proposed is difficult to assess, particularly in relation to reducing the risk of spillback to ferrets and possums. The size of that risk is not known. Arguably it may have contributed to the comparatively rapid spread of Tb southward through North Canterbury in the 1980s and 1990s, when possums were largely uncontrolled. However, the progressive reduction in numbers of infected cattle herds in North Canterbury since the peak in 1995/96 suggests it is likely that there will have been a reduction of similar size in the level of infection in pigs. Further, the areas to which the disease did spread are now all under intensive vector control, so spillback is less likely (because there are few ferrets or possums available to be infected) and even if it does occur the local vector population should now be too low for it to be sustained. Thus, while the area of southern North Canterbury under vector control remains largely as it is, the risk is mainly related to the possibility of new infection establishing south of the Waimakariri River. That has not occurred previously, and we presume the risk going forward is even lower than the historical risk, which did not result in any known outbreaks. If so, it therefore seems difficult to justify the scale of projected expenditures that we believe would be needed to have any substantial effect in reducing the spillback risk by reducing unwanted disposal of pig remains in Tb-free areas accessible to ferrets and possums. If, for example, there were one case of new infection established by spillback south of the Waimakariri River over 5 years, it seems likely to be cheaper to eradicate the new outbreak than the estimated cost of $320,000 to $540,000 p.a. needed to greatly reduce the likelihood of it happening.

The benefits of the additional surveillance information appear more tangible. On Molesworth Station, Nugent and Whitford (2007) concluded that necropsy of one pig provided the same amount of surveillance information as did skin-testing of approximately 100 cattle. Cattle testing was 5–6 times more expensive than pig necropsy in providing confidence that Tb was not present in possums. However, cattle have been tested not only as sentinels of Tb presence in possums but also to provide data on infection in herds for the purposes of reporting the national Tb status, so cattle testing cannot be abandoned in favour of pig necropsy on cost-effectiveness grounds. Thus, the pig necropsy data available from the proposed collection system would add to, rather than replace the testing data. The question is, therefore, whether the extra data are needed, and if so, are they worth the cost?

The key benefit appears to be additional coverage. Many pigs are taken from areas where there are (or have been) Tb-infected possums but few or no livestock available to confirm Tb absence. Without surveillance data, the only option for managers is to continue to apply vector control for at least 10–15 years and to trust that that is sufficient to break the Tb cycle. With surveillance data, that period can plausibly be shortened to as little as 5–10 years, if there are a sufficient number of pigs to quickly confirm Tb absence within a few years of it having been eradicated from possums (see Nugent & Whitford (2008) for a North Canterbury example). Early cessation of control obviously has the potential to produce a large saving in the total cost of vector control needed to eradicate Tb.

The AHB has as part of a review of the NPMS developed an eradication scenario for North to Mid-Canterbury and the National Disease Control Manager responsible for the area

(K. Crews, pers. comm.) has supplied the following data. Beginning in 2010, the number of infected herds in any 12-month period was projected to decline from 22 to zero over 15 years, with vector control continuing for a further 5 years to 2030. The projected total vector control cost was $54.6m.

Assuming initial annual vector control costs of $5.5m p.a., and adding initial pig surveillance costs of $0.5m, then presuming both decline linearly to zero over the period required to achieve and confirm eradication, the total cost for a 20-year time frame is projected to be ~$60m, $5.5m more than without the pig's-head surveillance. We presume, however, that the pig surveillance data would lead to earlier cessation of control, and on that basis a pig surveillance programme costing $0.5m p.a. initially would break even if it reduced the time frame by only 2 years, and result in a 20% cheaper total cost of eradication if it reduced the time frame by 5 years. If the cost of pig surveillance was maintained at $0.5m p.a. for the whole period (rather than declining), a reduction of only 3 years in the time frame would be sufficient to make added surveillance the lower-cost option.

Is such a reduction of 3–5 years feasible? Assuming that the pig surveillance is based on 4500 pig necropsies per annum, that would provide at least as much power to detect Tb as would the roughly 400 000 cattle-skin Tb-tests currently conducted each year in North to Mid-Canterbury. That suggests that such pig surveillance could halve the period between the last known occurrence of wildlife Tb and any declaration of Tb freedom, a period that is currently presumed to require at least 5 years of continued vector control. Inevitably there will be progressive declaration of Tb freedom across the VRA as the number of remaining sources of infection is diminished, so the effect of early cessation in the areas cleared first will be amplified as those resources are transferred to areas still not free. We conclude that such reductions in time frame are possible, although it would require much more extensive data gathering and modelling than is warranted here to assess how feasible it might be to achieve those potential reductions and savings.

6. Conclusions

Currently recreational pig hunters play an important role in harvesting and controlling feral pigs throughout much of New Zealand. Nugent's (1989) survey of big game hunters estimated that during 1988 over 100 000 pigs were killed by hunters, with 87% of this harvest taken by hunters using dogs (Nugent 1992). Such harvests are likely to substantially reduce threat to agriculture by reducing pasture and crop damage and lamb predation, but offsetting that is the risk of Tb spillback, which we focus on here.

The results of our hunter survey match the finding of a survey of 146 pig hunters in the northern South Island in 1988 (Clarke 1991), in which hunters reported using an average of 4 dogs per pack (cf. 3.2 in our survey) and harvesting an average of 47 pigs per year per hunter (cf. 38 in our survey). In the 1988 survey, hunters hunted for an average of 51 (± 6) days and on average travelled a total distance of 8026 km (± 586 km) – an average of 157 km travelled per day (Clarke 1991). Comparison between the surveys suggests that the level of participation in pig hunting and pig harvest rates have not changed greatly over the last 20 years.

Most hunters surveyed disposed of pigs' heads in ways that would not risk Tb spread, and most were aware of some of the issues surrounding Tb. However, 8% of hunters admitted dumping pigs' heads at sites accessible to scavengers after transporting them long distances, and we strongly suspect that this is an underestimate. Further, a large proportion of hunters used open offal pits, which could also be a risk of Tb-spread when vectors are able to access them. The main reason pigs' heads are dumped in such inappropriate places appears to be the lack of a suitable disposal facility near some (mostly urban) hunters' homes. Education of these hunters (as has been happening in some part during the survey) could have some impact in reducing the frequency with which heads are dumped at risky sites. However, the feedback from hunters indicated that providing facilities for disposal would be far more effective, especially if coupled with some incentive.

Of the options for collection and disposal, we believe that the cheapest option (capped offal pits) is ruled out by the likelihood of misuse. We conclude that some form of refrigerated depot would be the most socially and environmentally acceptable. A chiller, rather than a freezer, is likely to be the most convenient form of refrigerated unit. Regardless of whether a chiller or freezer is chosen, the long-run cost of collection and disposal of heads and skins is far greater than the cost of setting up the system.

If a system is established to collect and dispose of pigs' heads, then the marginal cost of adding necropsy for Tb surveillance would be about one-third to half the total cost, depending on the number of pigs processed annually.

It is not possible to quantitatively assess the size of the spillback risk in North Canterbury, but consider that the intensive vector control of the last decade has substantially reduced the risk of it occurring, and the consequences for Tb spread if it does occur. Nonetheless, the large number of pigs harvested annually, the continued high prevalence of Tb in pigs in some parts of the VRA, and the clear tendency for pigs to be transported long distances southward makes it certain that some spillback risk remains. Collection of pigs' heads would reduce that risk, although how effectively it would do that, and what it would cost to get a large reduction in risk, is unclear.

There is a stronger hypothetical case that collection of pigs for necropsy could be cost-effective by enabling a reduction in the duration of the vector control programme needed to eradicate Tb from North Canterbury. The argument is particularly strong for unfarmed areas where there are few livestock to be tested to confirm Tb absence. The case for pig collection for necropsy is far weaker if eradication is not the goal.

7. Recommendations

- Because a large proportion of pig hunting in North Canterbury (in particular) is conducted on private land, and because we found many hunters were not well informed about Tb in pigs and how it might be spread to other species, further efforts should be made to educate both hunters and farmers of the risk of spillback infection.
- The AHB should initiate a 2-year pilot trial to determine the number of pigs' heads that could be collected from North Canterbury hunters by establishing a drop-box depot on or near the main highway at Amberley. We recommend that the drop-box consist of a large

chiller that is serviced weekly, with the contents collected and disposed of by a commercial contractor (unless the heads are required for necropsy). Further, the system should be trialled without cash payment for a 6-month period, followed by 3–4 similar periods in which progressively larger payments are trialled to determine the effect on the number of pigs collected.

- Depending on what long-term Tb control scenario is adopted for North Canterbury, consideration should also be given to necropsy of the heads collected, with heads disposed of as above after necropsy. This should not include mycobacterial culture of key tissues from every pig. The reliability of the reported locations should be checked by confirming locations of a subset of Tb-positive pigs by requesting that the hunter take an AHB staff member to the kill site in return for a substantial cash payment.

8. Acknowledgements

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Appendix 1 Pig hunter survey form

QUESTIONAIRE
Reducing the Risk of Spillback Infection from Hunter Kills

Introduction

We have been contracted by the AHB to survey pig hunters
There is a possible risk of new Tb outbreaks occurring from pig remains being dumped in Tb-free areas
The guts of the survey is to find out where pigs' heads are being dumped and what could be done to stop it happening
This survey is confidential, names and phones numbers will be recorded separately from survey responses
AHB will not see a list of names only the summarised responses
If uncomfortable answering question don't have to

Benefits to the individual pig hunter:
Chance to win the prize
Possible reduction in VRAs and therefore less pesticide use

Name: Phone No:

HUNTING PRACTICES

1. **Do you own pig dogs?** Yes No How many?
(Explain we may interviewing your mates)
2. **Do you hunt on your own?** Yes No
3. **Do you hunt with a group?** Yes No How many?

4. **How many pigs would you get in a year?**
(Examples based on x/hunt; out every weekend; just winter)
(Don't count piglets killed and not found)

5. How far do you travel to go hunting?
Where do you live (closest town)?
Where do you hunt (closest town/general area)?
List different hunting locations

6. **Of the pigs you take HOME, how many are brought back with HEAD ATTACHED?**

7. **What do you do with your wild pork? Who eats it?**

Family		%
Friends		%
Barter		%
Other		% Specify

8. **How often would you and your family eat wild pork?**

Daily		
Weekly		
Once a month		
Once every three months		
Other		Specify

9. **Do you eat pigs' heads?** Yes No

10. **Do you feed pigs' heads to the dogs/other?** Yes No Specify other

Name other e.g. captive pigs

Raw?

Cooked?

Frozen?

11. **How do you currently dispose of unwanted pigs' heads?** Offal pit Capped

Open

If open could ferrets/possums/cats get access to the remains? Yes No

Take back to your hunting block the following weekend?

Roadside/riverbed?

Rubbish bags?

Other Specify

12. **Have you or do you know of anybody who has dumped carcasses and heads at roadside/rural locations in the last year?**

Yes No

(Identify if you or someone else) Interviewee Other

13. **Can you name any dumping sites you are aware of? Try to name three.**

TB

14. **Have you ever seen Tb in a pig?** Yes No
If so describe where in the pig you saw it
(Need to explain what it looks like if the answer is no here)
(Also need to elaborate that not every pussy lump is Tb)

15. **Do you know what Vector Risk Areas are?** Yes No
(Elaborate on Movement Control??)

16. **Do you hunt in VRAs?** Yes No
(If don't know then explain from what info has been given
re: hunting location above) % time hunting in VRAs

SOLUTIONS

18. **Is a freezer/chemical drop box likely to be used by hunters?** Yes No
(Explain drop box /clothes bins/recycling bin)

19. **Would you use it if you were paid nothing?** Yes No
(Just convenient disposal of waste material)
20. **Would you use it if you went in a prize draw?** Yes No
(Need to give name and phone number)
21. **Would you use it if you were paid? How much?** Yes No $
(Need to give name and ph. no. and location (farm) pig killed)
22. **What sites/towns would make it convenient for you?**
Name sites which would suit you

OTHER OPTIONS

23. **Would you consider burying heads at home?** Yes No

24. **Would you use a rapid decomposition agent that you carry to put on guts and heads left at the kill site?** Yes No

(Explain rapid decomposition agent/scavenge deterrent/sterilization agent)

25. **List any ideas that would make a drop box more attractive to hunters.** Comments

(e.g., scales to weigh pigs)

26. **Any other suggestions to reduce dumping.**
(e.g., offal deposit at local dump)

DEMOGRAPHICS

Sex M F

Age <15 15-19 20-29 30-39 40-49 50-59 60+

Ethnicity European NZer Maori Other (specify):

Hunting experience (years) 1-10 11-20 21-30 31+

Do you belong to a pig hunting club? Yes No

Appendix 2 Identified pig's-head dumping sites in North Canterbury

Identified dumping site	No. resp.	Identified dumping site	No. Resp.
Ashley Forest	2	Kowhai River, Kaikoura	1
Ashley Forest Boundary Rd Gate	1	Kowhai River by golf course, Kaikoura	1
Ashley River	3	Kowhai River rest area, Kaikoura	1
Ashley River near Rangiora ≈ 3 km	1	Lake Janet Walkway, Mt Grey	1
Ashley River, near Rangiora	5	Lewis Pass Hway 5km nth Hanmer turnoff	1
Balcairn-Amberley, Kowhai R. Bridge	2	Little Kowai River, Springfield	1
Balmoral Forest	5	Maces Rd, Bromley	1
Balmoral Forest, Balmoral Stn Rd	1	Mt Mason	1
Balmoral straight – Culverden	13	Okuku Pass Rd	1
Balmoral Forest, Blacks Rd	6	Pahau River near Culverden	1
Browns Rd, Waimak River Nth Side	1	Port Hills above Sumner	1
Burnham Pines (SPB block)	1	Roadside at Broadfields	1
Burnham School Rd roadside	1	Roadside pine block, Waipara–Waikari Rd	1
Coes Ford	1	Roadside, Kaikoura Coast	1
Conway Bridge (Inland Rd)	1	Rogerson River near Hanmer	1
Conway River	1	Selwyn River near Darfield	1
Conway River Rest Area	1	Selwyn riverbed; Selwyn Rd ford	1
Cramptons Bush Rd, Ashley Forest	1	Sewerage ponds, Bromley	1
End of Journeys End Rd, Ashley For.	1	SH1 nth & sth of Kaikoura	1
Eyre River Bridge near Waimak	1	Shale Peak roadside (Lewis Pass)	1
Eyre R. downstream Poyntz Rd Bridge	1	Waiau River	2
Eyre River, Points Rd Bridge	1	Waiau River (Leslie Hills Rd)	1
Greta Valley cutting	1	Waiau River near Waiau	2
Hanmer Forest	1	Waiau River, SH1 sth side	1
Hanmer forest gateway	1	Waimak Gorge Bridge; north side	1
Hawkins River near Darfield	2	Waimak Gorge Bridge; south side	1
Hunderlees rest area	1	Waimak River	6
Hurunui camping area Balmoral Forest	1	Waimak River end of Weedons Ross Rd	1
Hurunui River near Balmoral Forest	1	Waimak River – Eyre River junction	1
Hurunui River rest area, SH1	1	Waimak River near SH1 main bridge	11
Hurunui River SH7, sth bank	1	Waimak River, 5km west SH1, nth bank	1

Jollies Pass Rd	1	Waimak River, McLeans Island	2
Kaiapoi River	1	Waimak River, up to 4–5 km west of SH1	1
Kaiapoi River, west side Kaiapoi	1	Waimak River, West Melton area	1
Kowai River near Springfield	2	Waimak River, Dickies Rd	1
Kowai River sth side, Amberley	2	Waimak River north bank, Downs Rd	1
Kowhai River ford, Kaikoura	2	Waimak south side, Intake Rd	1
		Waitohi River near Hurunui Pub	1

Appendix 3 Drop-box design