Outcome monitoring of pest management

(Envirolink 723-HBRC97)

Phil Cowan






Landcare Research
Manaaki Whenua

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P E Cowan

Landcare Research
Private Bag 11052, Palmerston North 4442
New Zealand

Landcare Research Contract Report: LC0910/080

PREPARED FOR:
Hawke's Bay Regional Council
private Bay 6006
Napier 4142

DATE: January 2010

ISO 14001

Reviewed by:	Approved for release by:
Bruce Warburton	Andrea Byrom
Scientist	Science Leader
Landcare Research	Wildlife Ecology & Epidemiology

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Summary

Project and Client

Hawke's Bay Regional Council (HBRC) requested advice from Landcare Research under the Envirolink programme (Project 723-HBRC97) to assist it to develop a plan for monitoring the outcomes of its pest management activities. This project is one of a series that aims jointly to help HBRC improve its ability to monitor and report on its activities, in this case in relation to pest management. The overall goal of these projects is make more effective, efficient and explicit the linkages between the inputs, outputs and desired outcomes of pest management to enable better measurement of progress and greater certainty of achievement of outcomes. This is being done through the use of intervention logic models (ILMs) that link the goals of the Long Term Council Community Plan (LTCCP) through the Regional Pest Management Strategy to the outputs, activities and inputs specified in the annual and operational plans.

Objectives

- Agree with HBRC on a set of pest programmes for which outcome monitoring methodologies are to be developed
- Suggest appropriate intermediate outcomes and intermediate outcome indicators to be included in an outcome monitoring plan
- Advise on best practice, practicable methodologies for the intermediate outcome indicators selected for each selected programme (covering biodiversity, economic, and social outcomes, where relevant)
- Advise on outcome monitoring of cross-regional pests (e.g., possums, gorse) that may require collective or national funding

Methods

Discussions were held with HBRC biosecurity and agreement was reached on a set of four animal and five plant pests to be used as examples for the project. Information about these pests and the long-term goals and objectives as stated in the 2006 Regional Pest Management Strategy (RPMS) and the Long Term Council Community Plan (LTCCP) were reviewed as a basis for developing appropriate Intermediate Outcomes (IO) and Intermediate Outcome Indicators (IOI). Best practice, practicable methodologies for the IOIs selected for each programme were identified by reviewing methods used by a range of government agencies and relevant publications.

Results

Intermediate outcomes were drafted for each pest case study covering environmental, economic, and social outcomes, as appropriate. Intermediate outcome indicators were suggested for each IO, along with a rationale for their choice and suggested best practice methodologies.

Recommendations

- HBRC should consider the potential implications of the current MAFBNZ projects on the Future of Pest Management and the Performance Management Framework for Pest Management before deciding on its approach to and implementation of outcome monitoring of its pest management activities.
- HBRC should consider the proposed Intermediate Outcomes, Intermediate Outcome Indicators, and rationale for the case studies plant and animal pest used in this project, and accept or modify them accordingly for inclusion in their 2011 RPMS review.
- HBRC should make use of the information and advice provided in defining a set of practicable methodologies for measurement of progress towards achievement of intermediate outcomes for the management of case study plant and animal pests.
- HBRC should consider the development of a structured research programme using case studies to increase understanding of the economic and other outcomes derived from a number of plant and animal pest programmes where the demonstrated link to outcomes is currently unclear.
- HBRC should work with other councils to agree on a set of cross-council pests and common and consistent methodologies for measurement of progress towards achievement of intermediate outcomes of their management.
- HBRC should take into account the place of monitoring for pest management outcomes in any wider plan for regional state of the environment monitoring.
- HBRC should prioritise and seek to act on the research recommendations to strengthen the council’s use of outcome based performance measurement.

1. Introduction

A recent Envirolink-Regional Council-MAFBNZ-funded review of regional council pest management and monitoring (Clayton & Cowan 2009) concluded that there was a significant lack of monitoring of the outcomes of pest management and that this compromised councils' ability to report effectively on the outcome-related benefits of pest management. The report also recommended that councils undertake development of an outcomes monitoring plan for each region. Hawke's Bay Regional Council (HBRC) therefore sought advice from Landcare Research under the Envirolink programme (Project 723-HBRC97) to assist it to implement such an approach.

2. Background

This project is one of a series that aims jointly to help HBRC improve on its ability to monitor and report on its activities, in this case in relation to pest management. The overall goal of these projects is to make more effective, efficient and explicit the linkages between the inputs, outputs and desired outcomes of pest management to enable better measurement of progress and greater certainty of achievement of outcomes. This is being done through the use of intervention logic models (ILMs) that link the goals of the Long Term Council Community Plan (LTCCP) through the Regional Pest Management Strategy to the outputs, activities and inputs specified in the annual and operational plans. These changes are in response to recommendations in the Auditor General's recent report, a recent review of council pest management monitoring (Clayton & Cowan 2009), recent examples of the additional value created by a clearer focus on outcomes (Jones 2009), and the future need of councils to align pest management reporting with the MAFBNZ performance management framework, which is itself ILM based (Jones 2008).

In parallel with the Clayton and Cowan's (2009) review of regional council pest management monitoring and its recommendation of the development of outcome monitoring plans, MAF Biosecurity New Zealand (MAFBNZ) engaged Landcare Research to develop a framework for measuring performance of pest management in New Zealand (Jones 2008). The initial report recommended that pest management agencies should be encouraged to use simple intervention logic models to make explicit the linkages between their programmes and the desired outcomes of pest management (see Appendix 10.1 for definition of terms).

In discussing performance Jones (2009) suggested, "The recommended performance measurement process is, ideally, simple and logical with a hierarchical structure of inputs and activities (or 'interventions') leading to measurable outputs, which in turn influence intermediate and longer-term changes in the state of a system (or 'outcomes'). This structure is commonly described in the form of an intervention logic model (ILM) that consists of a graphical representation of the links between various levels of the hierarchy (Figs 1, 2) and can be accompanied by written details of links to agency goals, methods to be used, and any risks and assumptions associated with the programme in a matrix format."

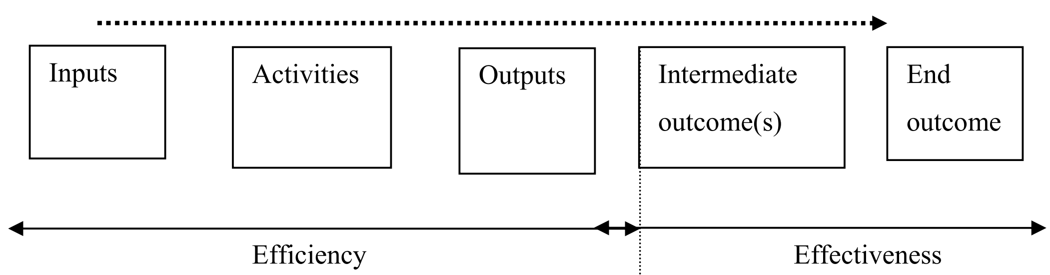

Fig. 1 Simple ILM structure showing the links between a programme's inputs (funding, equipment) and the intended outcomes.

The regional outcomes shown in Fig. 2 are derived from the Biosecurity section of the LTCCP. The definition of these regional outcomes is absolutely critical as they drive the rest of the ILM framework. The process of defining the hierarchical structure below these regional outcomes is a top–down process – that is, once the regional outcomes are defined and agreed, the intermediate outcomes (IOs) that contribute to successful achievement of the regional outcomes can be defined, then the outputs necessary to achieve those IOs, the activities necessary to achieve the outputs, and finally the inputs (resources) to implement the activities. Attached to the outputs and IOs are indicators that are used to measure progress towards achievement.

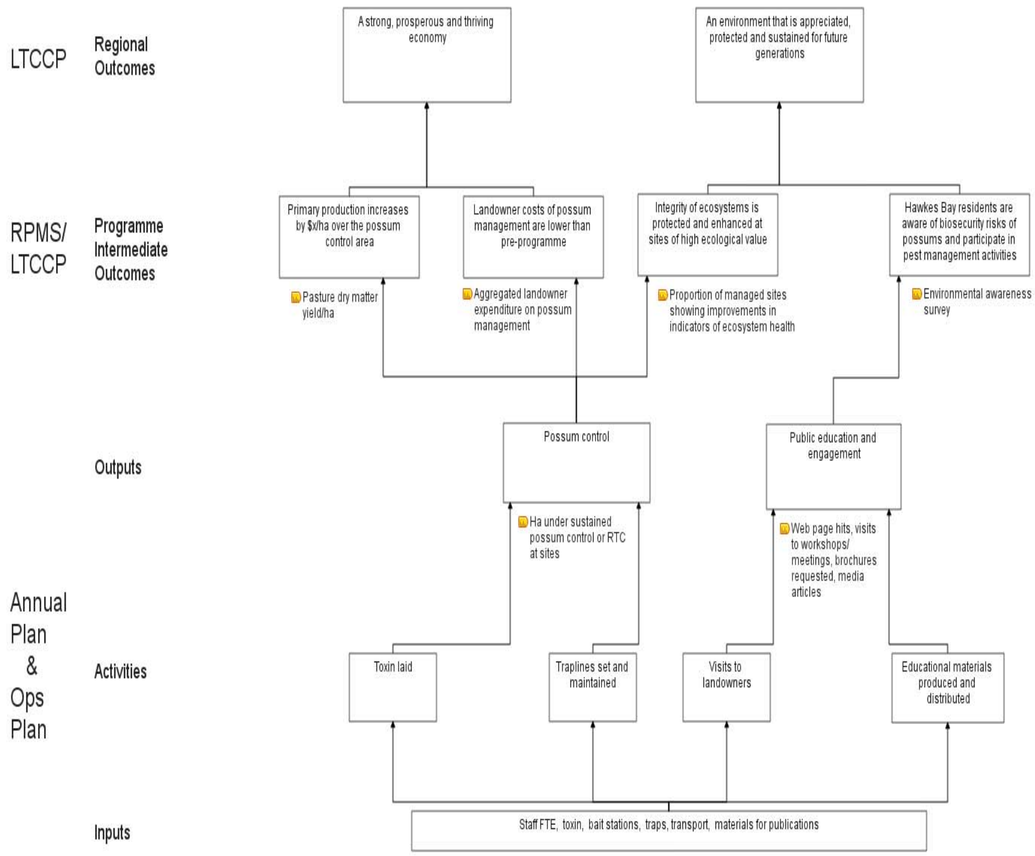

Fig. 2 An example ILM based on Hawke's Bay Regional Council's Possum control programme (from Jones 2009).

To facilitate the uptake of the ILM concept by councils who traditionally use output-based performance measures, Jones (2009) investigated the level of alignment between current pest management agency practices and the ILM concept and trialled the use of the concept by 'retro-fitting' models to a sample of local authority programmes. HBRC was one of the councils involved in the retro-fitting trial, and the intermediate outcomes suggested from that exercise have been used to guide the identification of appropriate intermediate outcome indicators (IOIs) in this project. IOIs measure the difference made by the delivery of outputs, that is *effectiveness*, whereas output measures provide information on *efficiency* of operations and delivery (the ability to do the same work to a consistent standard continually over time and, where possible, save costs). IOIs, to be useful, need to be practicable and cost-effective, as well as measuring a direct relationship between the management action (e.g., possum control) and the desired IO (e.g., increased primary production), and take into account the specific RPMS rules applying to each pest. Because different IOs are likely to vary in their time frame, IOIs will also vary in the immediacy of their ability to measure change.

Indicators of biodiversity health/status pose particular problems because more than one pest may impact on a resource (e.g., native birds, seedlings) but management often only focuses on a single pest. This results in difficulties in attributing change to management of a single pest. For example, possums and rabbits may browse seedlings while Old Man's Beard may suppress seedling germination and growth by reducing light levels under the canopy. Seedling numbers and survival might seem an appropriate indicator of the benefits of control of these species for biodiversity status, but a difficulty arises in attributing benefit where only one of these pest species is controlled, and there may, indeed, be no benefit because of the interactive effects of the multiple pests affecting regeneration or changes in the relative impacts of the different pests when pest numbers change in response to control (e.g., increased rat numbers after possum control). Such problems can be dealt with by use of replicated, matched areas with pest control done in half the areas, while the other half are left uncontrolled to account for natural variation (Clayton & Cowan 2009). That type of approach is expensive, and a compromise is to use output indicators where there is reasonable existing support for a relationship between pest management and change in the impacted resource.

3. Objectives

- Agree with HBRC on a set of pest programmes for which outcome monitoring methodologies are to be developed
- Suggest appropriate intermediate outcomes and intermediate outcome indicators to be included in an outcome monitoring plan
- Advise on best practice, practicable methodologies for the intermediate outcome indicators selected for each selected programme (covering biodiversity, economic, and social outcomes, where relevant)
- Advise on outcome monitoring of cross-regional pests (e.g., possums, gorse) that may require collective or national funding

4. Methods

Discussions were held with HBRC biosecurity and pest management staff and agreement was reached on a set of four animal and five plant pests to be used for the project (see Appendix 10.2). Information about these pests, and the long-term goals and objectives as stated in the 2006 Regional Pest Management Strategy (RPMS) and the Long Term Council Community Plan (LTCCP) were reviewed as a basis for developing appropriate IOs and IOIs, building on the work already undertaken by Jones (2009). Best practice, practicable methodologies for the IOIs selected for each programme were identified by reviewing methods used by a range of government agencies (e.g., Department of Conservation, other regional councils) and various relevant publications.

RPMSs include rules established under sections 52, 53 and 122 of the Biosecurity Act that generally cover actions that people need to take to implement the RPMS. The HBRC RPMS contains rules for the control and management of all the pests included in the Strategy. Because these rules specify actions, they potentially influence the nature of IOs and, particularly, IOIs. This interaction between rules, IOs and IOIs is discussed for each of the test cases to illustrate potential issues.

5. Results

5.1 Case studies for the project, and proposed intermediate outcomes and indicators

The long-term goals in the LTCCP section on Biosecurity and the RPMS for the nine pest examples in this project made reference to the following IOs – economic well-being/prosperity, recreational values, biological diversity, indigenous species and ecosystems, and human health. In addition, both the LTCCP and the RPMS indicate social/community IOs about improved awareness of pest impacts and/or threats, and participation in pest management activities.

Some difficulty was encountered in suggesting IOs and IOIs because the current long-term goals and strategy objectives are not well defined. In most cases they do not have outcomes and targets against which progress could be measured, or these are implied rather than stated clearly. For example, the, weed, saffron thistle, impacts on both agricultural production and recreational values, and the current RPMS aims to mitigate those impacts by limiting the weed to its present sites of infestation, and within those sites to reduce plant density, but without any quantification of the outcome expected within the life of the RPMS. Another difficulty was that measurement of outcomes is often expensive because of the need for sites with and without pest control to account for natural variation in factors unrelated to pest management, and because of the lag in some situations between control and measureable change in the impacted resource (Jones 2008). In such situations, output measures may be the only practicable monitoring methods, and that is reflected below in the suggested indicators for most of the selected pest species. The RPMS rules are also generally output based (e.g., possum control) with associated output performance measures (e.g., RTC <5%). The key issue about the rules is whether the performance measures are sufficient to ensure the desired outcomes – for example, is the specified 5% RTC for possums the appropriate level to mitigate the negative impacts on agricultural production and native biodiversity?

Identifying outcome measures is also constrained for many of the pests controlled for their supposed economic impacts because recent measurements of actual (e.g., saffron thistle) or projected (e.g. rabbits) economic losses are not available – that is, there is no baseline information against which to measure changes resulting from pest management. Clearly there is a need for additional research on the relationship between pest density and pest impacts so that the link between outputs and outcomes can be demonstrated more clearly (i.e. stronger attribution of the contribution of pest management to outcomes).

Intermediate outcomes and IOIs also need to be measurable and time bound. An IOI such as “increase in production or biodiversity” means very little unless the extent and time frame of the desired change are stated – for example, production increased by X% by a set date or an X% increase in fledgling survival rate of tui by a set date. Setting targets and dates was outside the brief of this project, but it is critical that performance measures are quantified and time bound.

Possums (see Cowan 2005)

Possums have impacts on agricultural production in Hawke’s Bay primarily through their role as vectors of bovine TB and through consumption of pasture. Possums have impacts on native biodiversity and ecosystems largely through browsing of preferred plant species resulting in defoliation, reduction of flowering and fruiting and death (for some species), and predation of native insects and birds. At longer time scales, possum-induced plant mortality may change forest composition, with consequences that are not well understood.

The RPMS rule requires land occupiers whose property has had initial possum control by HBRC or AHB to a level of ≤ 5% trap catch to maintain possum densities at or below that level at their own cost. Available evidence suggests this target is appropriate for reducing the risk of TB re-establishing, and mitigating impacts on agricultural production and native biodiversity (Cowan 2005; Clayton & Cowan 2009). Suggested IOs and IOIs for possum control are:

Intermediate Outcome	Intermediate outcome indicator
Primary production increases over the area under HBRC possum control	Pasture dry matter production Costs of possum control to protect pastoral lands Number of herds in PCA area under movement control for TB
Land occupier costs for possum control are reduced over the area under HBRC possum control	Average land occupier expenditure on possum control in PCAs
Biodiversity at HBRC sites of high ecological value is protected and enhanced	Proportion of managed sites showing improvements in indicator(s) of biodiversity status
Hawke's Bay residents are aware of the impacts of possums and participate in their control	Environmental awareness survey and participation measure

Rabbits (see Norbury & Reddiex 2005)

Rabbit grazing on pasture can cause significant reductions in stock carrying capacity, and may reduce pasture productivity in the longer term through soil erosion. The long-term goal of the RPMS is to limit the impacts of rabbits on biodiversity and economic prosperity, but the primary interest is in economic prosperity. HBRC monitors rabbit numbers in rabbit prone areas, and may subsidise rabbit control on rateable land, although the responsibility for control lies with the land occupier.

The RPMS rule requires rabbits to be maintained at or below McLean Scale score 4 from mid-January to mid-August. This score appears to be based largely on a precautionary approach that if rabbits reach a certain trigger level this was sure to lead to even bigger problems if left untreated. Parkes

(2006) notes the unpredictable impact of Rabbit Haemorrhagic Disease has made this logic less certain, and that better information is needed on how rabbits at different densities affect the resources of concern. Such information is needed to better support the appropriate trigger point for control, and so ensure rule-enforced control is sufficient to achieve the IO. Suggested IOs and IOIs for rabbit control are:

Intermediate Outcome	Intermediate outcome indicator
Primary production increases over the area under HBRC rabbit control	Pasture dry matter production Costs of rabbit control to protect pastoral lands
Land occupier costs of rabbit control are reduced over the area under HBRC rabbit control	Average landholder expenditure on rabbit control over the area under HBRC rabbit control
Hawke's Bay residents are aware of the impacts of rabbits and participate in their control	Environmental awareness survey and participation measure

Rooks (see NPCA 2008)

Rooks are controlled to mitigate the damage they cause to pasture and agricultural crops. Unlike possums and rabbits, where the long-term goal is mitigation of damage, the long-term goal of the RPMS is to eradicate rooks from Hawke's Bay. This results in an apparent disjunction between the IO (which is about primary production) and the IOIs (which are about eradication), although progressive reduction of rook numbers en route to eradication will result in the mitigation of impacts on primary production simply from the reduction in rook distribution and numbers. Rook control is carried out by HBRC not by land occupiers. The RPMS rule requires land occupiers to take reasonable steps to ensure no unauthorised action is taken to disturb birds in the rookeries. The key issue for rooks is not the RMPS rule but rather the strategy objectives – by 2011 in the North area to destroy all rookeries, and in the South area to reduce rook numbers to 7000 birds and maintain them at that level. In reality, the objective for HBRC is not rook eradication but local elimination, since sources of immigrant rooks will remain in the adjoining Wairarapa and Wellington regions unless a joint eradication project is undertaken. Eradication of rooks would necessarily achieve the outcome of eliminating agricultural losses, but the costs and benefits of that are unclear. The major constraint on implementing an outcome measure is the lack of baseline information about the economic losses to rooks, regardless of the management strategy adopted.

Intermediate Outcome	Intermediate outcome indicator
Primary production increases over the area under HBRC rook control	Rook distribution and numbers Proportion of landholders reporting rook damage
HBRC costs of rook control are reduced over the area under HBRC rook control	HBRC expenditure on rook control
Hawke's Bay residents are aware of the impacts of rooks and participate in their control	Environmental awareness survey and participation measure

Predators (rodents, stoats, ferrets: see Innes 2005 a, b; King & Murphy 2005; Clapperton &Byrom 2005)

Predators differ from possums, rabbits, and rooks in that their management is site focussed not region wide. The primary impacts of predators are on native animals, both invertebrate and vertebrate. There is no RPMS rule as such, but access to the HBRC subsidy scheme requires an approved management programme that must be undertaken on land deemed by HBRC to have high ecological value or that provides a sufficient protective buffer for an area of conservation value. Approval of a programme implies the proposed extent and intensity of control is deemed sufficient to mitigate impacts on native biodiversity to some unspecified extent. A successful outcome at a site will thus be determined by the level of change specified by the IOI (e.g., X% increase in counts of native birds). Suggested IOs and IOIs for predator control are:

Intermediate Outcome	Intermediate outcome indicator
Biodiversity at HBRC sites of high ecological value is protected and enhanced	Proportion of managed sites showing improvements in indicator(s) of biodiversity status
Hawke's Bay residents are aware of the impacts of predators and participate in their control	Environmental awareness survey and participation measure

Privet (see Roy et al. 1998)

Privet (both species) is considered a risk to human health in urban areas because its leaves and fruits are poisonous. It does not produce wind-borne pollen and so probably does not contribute significantly to allergies and asthma, although information is scanty and complicated by cross-sensitization of people with pollen of related Oleaceae, such as olives (which are increasingly being planted in urban areas). Occupiers of land are responsible for control on their land. The RPMS rule specifies control on land in Napier City, and Hastings, Central Hawke's Bay and Wairoa District Plans, with the long-term goal of removing privet within urban areas. The RPMS rule requires land occupiers not in an approved control programme to destroy all privet plants before they produce hard seed. Currently privet removal by HBRC staff occurs only after a property complaint, and a list is maintained of properties from which privet has been removed (D. Underhill, pers. comm.). This approach seems somewhat at odds with the RPMS goal of eventual eradication, and objective of systematic removal from urban areas. The issue with privet in the RPMS is not so much related to the rule as to the difficulty in relating privet management to human health benefits or reduced risks, and indeed whether the species justifies current control expenditure. Suggested IOs and IOIs for privet control are:

Intermediate Outcome	Intermediate outcome indicator
Risk to human health from privet in Hawke's Bay is minimised	Number of annual complaints received about adverse effects from privet Distribution and abundance
Hawke's Bay residents are aware of the risks of poisoning from privet and participate in its control	Environmental awareness survey and participation measure

Lodgepole pine (see Ledgard 2001)

Lodgepole pine is the most vigorous naturally regenerating introduced conifer, which has led to large areas of unwanted spread or wildings. Wildings threaten native biodiversity through replacement of native vegetation, and recreational values through their impacts on visual landscape and land-use values. Occupiers of land are responsible for control on their land. The current RPMS aims to limit lodgepole pine to its present sites of infestation, and within those sites to reduce plant density. Infestations are recorded in a GPS database. The RPMS rule requires land occupiers not in an approved control programme to destroy all plants before the production of hard seed and to prevent the movement of plants, seeds, and soil likely to contain seeds from the infested site. The rule places no particular constraints on performance measures. However choice of IOI may be influenced by habitat from which lodgepole pine is removed – for example, removal of lodgepole pine in grassland removes habitat for birds that would not be replaced, and so avian biodiversity would presumably decline. Suggested IOs and IOIs for lodgepole pine control are:

Intermediate Outcome	Intermediate outcome indicator
Biodiversity at HBRC sites of high ecological value is protected and enhanced	Proportion of managed sites showing improvements in indicator(s) of biodiversity status Distribution and abundance
Recreational values are restored in the Hawke's Bay region	Environmental awareness survey
Land occupier costs of lodgepole pine control are reduced over the area under HBRC control	Average landholder expenditure on lodgepole pine control over the area under HBRC control
Hawke's Bay residents are aware of the impacts of lodgepole pine and participate in its control	Environmental awareness survey and participation measure

Old man's beard OMB (see Roy et al. 1998)

OMB is a climbing plant with the ability to form a dense canopy that can smother and kill existing vegetation and, by cutting off light, suppress regeneration. It has the potential to impact on both species and ecosystems. Occupiers of land are responsible for its control on their land. The current RPMS specifies control north of the OMB control line, but HBRC can also use its power under the Biosecurity Act to require control of OMB south of the line where it is threatening specific ecological values or causing nuisance on properties in its vicinity. Current monitoring consists of checking all known infestations in the north area and some in the south area once yearly for compliance and identifying any new infestations (locations of all infestations recorded using GPS). The RPMS rule requires land occupiers not in an approved control programme to destroy all plants before the production of hard seed and to prevent the movement of plants, seeds, and soil likely to contain seeds from the infested site. The rule places no particular constraints on performance measures. Suggested IOs and IOIs for OMB control are:

Intermediate Outcome	Intermediate outcome indicator
Biodiversity at HBRC sites of high ecological value is protected and enhanced	Proportion of managed sites showing improvements in indicator(s) of biodiversity status Area of OMB infestation
Hawke's Bay residents are aware of the impacts of OMB and participate in its control	Environmental awareness survey and participation measure
Land occupier costs of OMB control are reduced over the area under HBRC control	Average landholder expenditure on OMB control over the area under HBRC control

Saffron thistle (see Roy et al. 1998)

Saffron thistle is a weed of pastures and crops that has the ability to form virtually impenetrable stands. It impacts on both agricultural production and recreational values. It currently occurs as local, scattered infestations. Land occupiers are responsible for the control of saffron thistle on their land. The current RPMS aims to limit saffron thistle to its present sites of infestation, and within those sites to reduce plant density. Current monitoring consists of checking all known infestations once yearly for compliance and identifying any new infestations (locations of all infestations recorded using GPS). The RPMS rule requires land occupiers not in an approved control programme to destroy all plants before the production of hard seed and to prevent the movement of plants, seeds, and soil likely to contain seeds from the infested site. The rule places no particular constraints on performance measures. Suggested IOs and IOIs for saffron thistle control are:

Intermediate Outcome	Intermediate outcome indicator
Primary production is sustained over the area of HBRC saffron thistle control	Regional distribution of saffron thistle Area and density of saffron thistle infestation
Hawke's Bay residents are aware of the impacts of saffron thistle and participate in its control	Environmental awareness survey and participation measure
Land occupier costs of saffron thistle control are reduced over the area under HBRC control	Average landholder expenditure on saffron thistle control over the area under HBRC control
Recreational values are restored in the Hawke's Bay region	Environmental awareness survey

Chilean needle grass (CNG; see Bourdot & Hurrell 1989)

Chilean needle grass is a weed of pastures. Although generally palatable to livestock in early spring it becomes less palatable as it matures and it replaces more productive and palatable pasture species causing economic losses to livestock farmers. Land occupiers are responsible for the control of CNG on their land. The current RPMS aims to limit CNG to its present sites of infestation, and within those sites to reduce plant density. Current monitoring consists of checking all known infestations once yearly for compliance and identifying any new infestations (locations of all infestations recorded using GPS). The RPMS rule requires land occupiers not in an approved control programme to destroy all plants at or before the early flowering before seed development and to prevent the movement of plants, seeds, and soil likely to contain seeds from the infested site. The rule places no particular constraints on performance measures. Suggested IOs and IOIs for CNG control are:

Intermediate Outcome	Intermediate outcome indicator
Primary production is sustained over the area of HBRC CNG control	Regional distribution of CNG Area and density of CNG infestation
Hawke's Bay residents are aware of the impacts of CNG and participate in its control	Environmental awareness survey and participation measure
Land occupier costs of CNG control are reduced over the area under HBRC control	Average landholder expenditure on CNG control over the area under HBRC control

5.2 Best practice, practicable methodologies for IOIs

Possums

Intermediate outcome indicator	Rationale
Pasture dry matter production	Possum eat pasture and so reduce food available for livestock. The increased food available after possum control would be expected to translate into increased production (e.g., kg milk solids, wool, or meat). Production is, however, affected by a wide range of factors (e.g., weather, farming practice) so it would be difficult to identify how much possum control contributed to a change in production. Direct measure of change in pasture production is therefore recommended as a practical, if costly, alternative, and suitable methods are detailed in Cowan (2009). This involves measuring changes in pasture dry matter production before and after possum control or using cages to exclude possums from pasture plots.
Costs of possum control to protect pastoral lands	There is a possum density (threshold) at which the cost of possum control to reduce possums to that level equals the value of the increased production resulting from the additional pasture expected to be produced after possum control, not including ancillary benefits (Cowan 2009). The costs of possum control to achieve that threshold are thus an indicator of the benefits of control. For example, it currently costs on average about $ 3.50 /ha to maintain (initial control is more expensive than maintenance) possums at a 1% RTC – this is less than the estimated $4 direct loss in production. Comparison of the annual average cost of possum control and estimated benefits of control provides an indirect means of measuring performance.
Number of herds in PCA area under movement control for TB	TB infection in herds is an economic cost to cattle and deer farmers. If Tb is eliminated from the PCA area by AHB control, the PCA programme should prevent its re-establishment, and this

	should be reflected in numbers of infected herds. Once TB is eradicated from Hawke's Bay, this will cease to be a useful indicator.
Average land occupier expenditure on possum control in PCAs	If the HBRC possum control programme is successful, average land occupier control costs will be reduced because most properties are being controlled so population recovery through breeding and immigration is minimised and ongoing control effort reduced. Information is probably best derived by direct interview using a standard questionnaire, and standard rates for costing time spent on control activities, if not done by contractor.
Proportion of managed sites showing improvements in indicator(s) of biodiversity status	Possums impact on biodiversity through browsing and predation so indicators of biodiversity status should relate to those impacts. Changes in native animal abundance would be an obvious indicator for predation but rodents and stoats also prey on many of the same species as possums, and so attributing change to possum control would be very difficult if other predators occurred at a site and they remained uncontrolled. Browsing on plants is the most commonly used approach to measuring the benefits of possum control, with the Foliar Browse Index (FBI) being the most commonly used method. Best practice for FBI is described by Payton et al. (1998) and in DOC's inventory and monitoring toolbox (McNutt et al. 2007).
Environmental awareness survey	Public awareness of the biodiversity and agricultural impact of possums and satisfaction with HBRC performance should be measured by periodic survey. Best practice survey design is described in NZ Statistics (2005).
Public participation in possum control	Public participation in possum control should be assessed by the number of complaints and/or reports received, or the number of surveyed properties exceeding the RPMS threshold level for control.

Rabbits

Intermediate outcome indicator	Rationale
Pasture dry matter production	Rabbits, like possums, eat pasture and reduce food for livestock. The increased food available after rabbit control would be expected to translate into increased production (e.g., kg milk solids, wool, or meat). Production is, however, affected by a wide range of factors (e.g., weather, farming practice) so it would be difficult to identify how much rabbit control contributed to a change in production. Direct measure of change in pasture production is therefore recommended as a practical, if costly, alternative, and methods for possum are detailed in Cowan (2009) and could be easily adapted for rabbits. This involves measuring changes in pasture dry matter production before and after rabbit control or using cages to exclude rabbits from pasture plots. Where possums and rabbits are feeding on the same pastures, a more complex design would be required, as described in Cowan (2009).
Costs of rabbit control to protect pastoral lands	If the gain in economic value can be shown to exceed the costs of rabbit control to achieve the threshold for mitigation of pasture loss (in terms of an index of rabbit numbers (e.g., McLean score 4), then the costs of rabbit control may be able to be used as an indicator of increased primary production (as indicated above for possums). Information is probably best derived by direct interview using a standard questionnaire, and standard rates for costing time spent on control activities, if not done by contractor.
Average landholder expenditure on rabbit control over the area under HBRC rabbit control	If the HBRC rabbit control programme is successful then the long-term cost of rabbit control to the land occupiers should be less than it was pre-programme. Information is probably best derived by direct interview using a standard questionnaire, and standard

	rates for costing time spent on control activities, if not done by contractor.
Environmental awareness survey	Public awareness of the impact of rabbits and satisfaction with HBRC performance should be measured by periodic survey. Best practice survey design is described in NZ Statistics (2005).
Public participation in rabbit control	Public participation in rabbit control should be assessed by the number of complaints and/or reports received, or the number of surveyed properties exceeding the RPMS threshold level for control.

Rooks

Intermediate outcome indicator	Rationale
Distribution and numbers of rooks	Rooks damage pasture and crops, but because the RPMS goal for rooks in the North area is eradication, progress should be measured against that outcome. The appropriate indicators therefore measure rook distribution and numbers, as damage will decline to zero as rooks are eliminated. If the strategy of eradication is revisited in the future in a cost/benefit framework, there will be a need to estimate economic losses due to rook damage. The mitigation of those losses will provide a more direct method to measure progress against the IO – primary production increases over the area under HBRC rook control.
Number and proportion of land occupiers reporting rook damage	Land occupier reports of damage would provide a direct measure of effectiveness in reducing economic losses to rooks. In the South area the goal is to maintain a fixed number of rooks, a number that presumably results in an acceptable level of economic losses. The number and proportion of land occupiers

	reporting rook damage would be appropriate indicators for success in meeting both the RMPS goal and maintaining acceptable damage levels.
Cost of rook control	If the HBRC rook control programme is successful then the long-term cost of rook control should decline.
Environmental awareness survey Public participation in rook control	Public awareness of the economic impact of rooks and satisfaction with HBRC performance should be measured by periodic survey. Best practice survey design is described in NZ Statistics (2005). Public participation in rook control should be assessed by the number of complaints and/or reports received.

Predators

Intermediate outcome indicator	Rationale
Proportion of managed sites showing improvements in indicator(s) of biodiversity status	Predators impact on native vertebrate and invertebrate populations and regeneration through seed predation. At managed sites, birds (5-min counts, distance sampling) and commonly eaten invertebrates (pit-fall traps, weta houses) could be monitored by a variety of methods. Regeneration (e.g., seedling numbers) could be measured using cages that exclude rodents. There may be difficulty at small sites in achieving a sufficient number of independent sampling locations (e.g., 5-min bird counting sites are usually 200 m apart).
Environmental awareness survey	Public awareness of the biodiversity impact of predators and satisfaction with HBRC performance should be measured by periodic survey. Best practice survey design is described in NZ

	Statistics (2005).
Public participation in predator control	Public participation in predator control could be assessed by

Privet

Intermediate outcome indicator	Rationale
Annual number of cases of privet poisoning and privet allergy per 1000 people in the Hawke's Bay region	Privet is controlled because of its perceived risk to people. The number of poisoning and allergy cases provides a direct indicator of success in minimising that risk. So few cases from HB have been reported to National Poisons centre in the last 7 years (<5; M Clear, pers. comm.), however, that this is probably not a useful indicator. People may also be sensitized to privet pollen by reaction to pollen from other members of the Oleaceae, so numbers of people with allergic responses may also not be a useful IOI.
Distribution and abundance of privet in areas of control specified in the RPMS	The next best measure is of risk of contact with privet, which could be indexed by periodic surveys of the extent and abundance of privet in urban areas. As the risk from privet pollen is likely to be greatest where privet density is high, such areas should be high priority for control.
A reduction in the number of public complaints based on the perceived health related impacts of privet	All privet-related complaints are recorded by HBRC and therefore a downward trend in the number of public complaints is a potential indicator of the success in achieving the community perceived health outcomes for this plant pest programme.
Environmental awareness of privet as a weed	Public awareness of the impact of privet of human health and satisfaction with HBRC performance should be measured by periodic survey. Best practice survey design is described in NZ Statistics (2005).

Public participation in weed control	Public participation in privet control should be assessed by the number of complaints and/or reports received.

Lodgepole pine

Intermediate outcome indicator	Rationale
Proportion of managed sites showing improvements in indicator(s) of biodiversity status	Removal of lodgepole pine impacts is most likely to result in replacement of affected areas by native vegetation. That could be measured directly using standard vegetation survey methods (see Partridge et al. 2002).
Distribution and abundance of lodgepole pine	Alternatively, the distribution and abundance of lodgepole pine could be used as indicators, on the assumption that replacement with native vegetation occurs. Partridge et al. (2002) provide decision trees to assist with method selection.
Average landholder expenditure on lodgepole pine control over the area under HBRC control	If the HBRC lodgepole pine control programme is successful, the average cost of control to the land occupiers should reduce with time.
Environmental awareness survey	Public awareness of the biodiversity and recreational impacts of lodgepole pines and satisfaction with HBRC performance should be measured by periodic survey. Best practice survey design is described in NZ Statistics (2005).
Public participation in weed control	Public participation in lodgepole pine control should be assessed by the number of complaints and/or reports received.

Old man's beard

Intermediate outcome indicator	Rationale
Proportion of managed sites showing improvements in indicator(s) of biodiversity status	Removal of OMB impacts is mostly likely to reduce native plant mortality and increase regeneration, but only in the absence of other pests that have similar impacts. At sites where only OMB is controlled this may limit indicator choice to weed-focussed rather than biodiversity-focussed options.
Aggregated landholder expenditure on OMB control over the area under HBRC control	If the HBRC OMB control programme is successful, the long-term cost of OMB control to the land occupiers should reduce with time.
Environmental awareness survey	Public awareness of the biodiversity impact of OMB and satisfaction with HBRC performance should be measured by periodic survey. Best practice survey design is described in NZ Statistics (2005).
Public participation in weed control	Public participation in OMB control should be assessed by the number of complaints and/or reports received.

Saffron thistle

Intermediate outcome indicator	Rationale
Regional distribution of saffron thistle	The desired outcome of saffron thistle control is to prevent further spread, sustain production by preventing further conversion of pasture to thistle, and increase production by reducing density of thistle. Measuring changes in production is difficult for reasons

	noted in the possum section, and the alternative approach of measuring pasture dry matter production is likely to be costly. Measures of saffron thistle distribution and extent are, therefore, appropriate indicators.
Area of saffron thistle infestation	The area of thistle infestation will also be an appropriate indicator if the RMPS changes from containment to control.
Density of saffron thistle	The best method for measuring plant density depends on its distribution pattern (e.g., aggregated or not) and density (low, moderate, high). Partridge et al. (2002) provide decision trees to assist with method selection.
Average landholder expenditure on saffron thistle control over the area under HBRC control	If the HBRC saffron thistle control programme is successful then the long-term cost of saffron thistle control to the land occupiers should reduce with time.
Environmental awareness of saffron thistle as a weed	Public awareness of the impact of saffron thistle on agricultural and recreational values and satisfaction with HBRC performance should be measured by periodic survey. Best practice survey design is described in NZ Statistics (2005).
Public participation in weed control	Public participation in saffron thistle control should be assessed by the number of complaints and/or reports received.

Chilean needle grass

Intermediate outcome indicator	Rationale
Regional distribution of CNG	The desired outcome of CNG control is to prevent further spread of CNG, sustain production by preventing further conversion of pasture to CNG, and increase production by reducing density of

	CNG. Measuring changes in production is difficult for reasons noted in the possum section, and the alternative approach of measuring pasture dry matter production is likely to be costly. Measures of CNG distribution and extent are, therefore, appropriate indicators.
Area of CNG infestation	The area of CNG infestation will also be a good indicator if the goal of the RPMS changes from containment to control.
Density of CNG	The best method for measuring plant density depends on its distribution pattern (e.g., aggregated or not) and density (low, moderate, high). Partridge et al. (2002) provide decision trees to assist with method selection.
Average landholder expenditure on CNG control over the area under HBRC control	If the HBRC CNG control programme is successful then the long-term cost of CNG control to the land occupiers should reduce with time. This programme is by necessity long term, as seed may survive in the soil for up to 25 years. This means, however, that land occupier costs may not be a suitable indicator in the short to medium term, unless the RPMS changes from containment to control.
Environmental awareness of CNG as a weed	Public awareness of the impact of privet and satisfaction with HBRC performance should be measured by periodic survey. Best practice survey design is described in NZ Statistics (2005).
Public participation in weed control	Public participation in CNG control should be assessed by the number of complaints and/or reports received.

6. Discussion

6.1 General comments

A potential difficulty facing HBRC in implementing measurements of progress towards outcomes at this time is uncertainty about the MAFBNZ performance management framework and future of pest management projects, both of which have implications for future measurement of progress towards outcomes through likely recommendations for standardisation of methodologies. It would be unfortunate if these projects required HBRC to change systems established as a result of its own forward-looking initiatives, and it may therefore pay HBRC to delay implementation of the recommendations of this report until details of the proposed framework become clear.

Suggestions have been made for appropriate IOIs and, where they exist, sources of best practice methodology have been identified. Specific methodologies and protocols have not been provided because indicator methodology is a trade off between statistical robustness, cost, practicality, and the characteristics of the site to be monitored (e.g., size), and such decisions rest ultimately with HBRC. The need for SMART (specific, measureable, achievable, realistic and timebound) performance measurement statements is also critical (Jones 2008) but was outside the brief of this report. References have been provided to appropriate sources of information to aid decision making.

6.2 Research gaps

Defining outcomes and outcome indicators would benefit from additional information on:

- quantification of the impacts of pests and weeds across all dimensions – economic, environmental, social, and cultural. For example, what are the recreational impacts of saffron thistle infestation, how are they viewed by the Hawke’s Bay community, and how does one best measure these?
- characterising the relationships between pest and weed density/distribution and impacts, so that adequate bio-economic analysis can be done as part of the decision making process. One approach to achieving this would be adoption of an adaptive experimental management (AEM) approach, which could lead ultimately to optimized monitoring effort. Morgan and Warburton (2007) indicated how this could be done for possum control in Hawke’s Bay.
- the links between pest management outputs and outcomes, particularly the biodiversity outcomes of single vs multiple pest management where perverse outcomes may occur under some circumstances in terms of net biodiversity benefit.

Overseas experience suggests that well structured research case studies can provide quality insight into the potential impacts of a range of pests on economic and other outcomes. A number of the pests listed in Hawke's Bay's RPMS could benefit from additional insight into likely outcomes from the preparation of a structured series of case studies with appropriate analysis.

6.3 Consequences of single pest control

There is increasing evidence, at least for possums, rodents, and stoats that these species interact with each other in ways that influence their population dynamics. For example, control of possums alone in native habitats often results in increases in numbers of rats (Sweetapple & Nugent 2007). Similarly, control of rats alone, or rats and possums, often results in increases in mouse numbers. Control of single mammal pests such as possums and rabbits may also exacerbate some weed problems. For weeds, control of a single species may result in its replacement by other weeds in the absence of additional site management. These interactions are particularly relevant for biodiversity outcomes, and they, and issues of net benefits of pest management, are active areas of research.

Where these perverse responses occur, the desired outcome (e.g., status of biodiversity) may be partly or wholly put at risk. For example, increased rat numbers resulting from control of possums alone may have a greater impact on native bird numbers through increased predation than the original population of possums and rats, or the reduced population of possums. A desired outcome of increased numbers of native birds may, thus, not be achieved.

There may also be other layers of complexity. For example, possums have impacts both through browsing and predation. Possum control alone may be an effective approach to mitigating browsing damage to canopy and sub-canopy species and to prevent canopy collapse, so the benefits of those outcomes would also need to be weighed against the potentially negative impacts of increased rat numbers. However, control of possum impacts alone is likely to be insufficient to ensure long-term sustainability of the habitat even in the absence of browsing pressure if regeneration is impeded by seed predation and seedling browsing by rodents and ungulates.

The key implications of these interactions are first, that multiple pests will often need to be managed to increase the likelihood that a desired biodiversity outcome is achieved; second, there may be difficulties attributing the outcome depending on the relative impacts of various pests on the outcome indicator chosen; and third, the consequences of (particularly) single pest management need to be factored into decision making. In the last case this needs to involve consideration of the full range of pests that are impacting on the resource in question, and their known and potential interactions. A useful tool for doing that is an interactive web diagram, of which food webs are the most well-known and researched (see for example, Innes & Barker 1999, Ramsey & Veltman 2005).

An increasing response to the need to control multiple pests is site-based management. In such situations outcomes are often described in terms of ecosystem health and/or biodiversity protection and enhancement, with progress measured using a set of indicators that together account for key aspects of the responses to mitigation of pest pressure.

6.4 Cross-council programmes and metadata

A number of species are identified as pests in several, sometimes all, Regional Pest Management Strategies. There would therefore be value and, perhaps, cost efficiencies in coordinating outcome monitoring of these species across councils. Additional emphasis is likely to be given to coordinated monitoring across regions by the proposed MAFBNZ Performance Management Framework, particularly so that progress towards national outcomes can be demonstrated (Jones 2008). The design of appropriate cross-council monitoring will present some challenges. Sites where pest control is undertaken both within and between regions are, however, likely to vary in ways that potentially influence the outcomes of pest control. For example, there are site differences in the susceptibility of fuchsia and kamahi to possum browsing and whatever is responsible for these site differences (e.g., soil fertility) may influence the pattern and rate of recovery of foliage after possum control. Such variation between sites is usually poorly understood, but it may be sufficient, when added to all the other sources of variation, to preclude the development of cross-region outcome monitoring programmes because of the costs in establishing robust monitoring systems, or limit monitoring to identification of trends (Clayton & Cowan 2009). These risks could be evaluated through statistical modelling as a precursor to the design of cross-council monitoring programmes. Opportunities for cross-council collaboration in outcome monitoring may be easier to achieve, however, for economic and social/cultural outcomes than for biodiversity ones, because of the potential difficulty for controlling for site differences in biodiversity responses. Identifying and prioritising opportunities for cross-council collaborative biosecurity efforts might best be done by the biosecurity managers group.

If councils were to agree on a set of cross-council pests for outcome monitoring, the next step would be the design and costing of a monitoring programme to meet council needs. This would need to take into account the extent to which agreement between councils on best practice for methodologies for outcome monitoring for pests of common interest (e.g., possums, predators, gorse) would influence the design and costs of monitoring. Common and consistent methodology could provide the basis for the application of meta-analysis to cross-council data, and so potentially provide greater statistical robustness to outcome monitoring. Meta-analysis is a statistical technique for amalgamating, summarising, and reviewing quantitative measurements from similar projects (see http://wilderdom.com/research/meta-analysis.html accessed 18 December 2009). Alternative monitoring designs would need to be evaluated for both costs and statistical power, based on agreement across councils about the magnitude of change that was considered significant, and the certainty with which such change had occurred (e.g., 95% certainty that the condition of a resource had improved by 20%).

Information on social outcomes is collected by all councils, often in the form of customer satisfaction surveys or systems that assess performance against specified standards for responses to enquiries. These data, if collated across councils, could be used to identify ratepayer understanding of pest issues and existing and developing concerns, and guide the focus of future information gathering.

6.5 Observations and anecdotes

Pest management is a topic that generates much public discussion, much of it involving personal experiences or anecdotes, about people's perceptions of the positive and negative outcomes. Volunteer schemes that make use of public interest to observe and record biological information are becoming increasingly common at local and national levels; for example, the Hamilton Halo tui project (http://www.ew.govt.nz/Projects/Hamilton-Halo/ accessed 17 December 2009), the New Zealand garden bird survey (http://www.landcareresearch.co.nz/research/biocons/gardenbird/ accessed 17 December 2009) and the New Zealand Biodiversity Recording Network (http://www.nzbrn.org.nz/index.aspx accessed 17 December 2009). Such projects are web based and often use free software (e.g., Artportalen).

Similar approaches may be useful as contributions to assessing the outcomes of pest management, with appropriate treatment and consideration of the information provided. For example, sightings by members of the public of pest species for which the management aims is to reduce in range or density, or for which information is required about changes in range or new infestations, may provide useful information to HBRC managers. For some species this would merely formalise what HBRC pest managers currently do through visits and personal contacts.

In contrast, anecdotes are stories, influenced by internal and external factors and so need to be treated with caution (http://www.sciencebasedmedicine.org/?p=33 accessed 17 December 2009). But there are two approaches by which such information may be rendered useful. The first is that anecdotes should be recorded as carefully as possible so that all the relevant information is carefully documented and any confounding variables are noted. The second is that anecdotes should be thought of only as preliminary – as a means of pointing the way to future research or formal data collection. They should never be considered as definitive or compelling by themselves.

6.6 Non-market valuation (NMV) of environmental and social/cultural benefits

While people's concerns about pest impacts can be assessed by surveys designed to evaluate factors such as the ranking of various pests, acceptable action, and satisfaction with HBRC performance, other techniques can provide alternative insights into the value people place on the outcomes of pest management and the underlying "ecosystem-based" goods and services (Philcox 2007; Kaval et al. 2009). Because these goods and services, for example ecosystem services, are not traded in a market, they are often referred to as non-market goods or services. Incorporating non-market values into the policy or decision-making process requires a suitable valuation framework that captures all values (market and non-market). The most common framework for aggregating the value of ecosystem goods and services (including non-market goods and services) is total economic value (TEV), in which the value of ecosystem-based goods and services is classified into use values and non-use values (Philcox 2007).

A number of methodological approaches can be used to measure the value of non-market goods and services. The methodologies are broadly classified into two categories: revealed preference methodologies (e.g., hedonic and travel cost methodologies), and stated preference methodologies (e.g., contingent valuation and contingent choice modelling methodologies). Valuations based on revealed preferences are derived from prices paid for goods or services. Those based on stated preferences reflect willingness to pay for a good or service expressed in terms of a stated choice in hypothetical scenarios presented to respondents. Other methodologies that are not as well grounded in economic concepts of value include the benefit transfer methodology, and cost based methodologies (replacement cost, avoided cost, and opportunity cost).

These approaches, particularly contingent valuation, have been applied to a range of biodiversity and threatened species issues in New Zealand (e.g., Kaval et al. 2007, 2009), but less so to environmental and social issues round management of vertebrate pests. Lock (1992) and Kerr and Cullen (1995) studied the benefits from the control of the common brushtail possum (*Trichosurus vulpecula*), while Greer and Sheppard (1990) valued the benefits from the control of the weed, Old Man's Beard (*Clematis vitalba*).

Non-market valuation and decision-making tools including dialogue process (Hayes et al. 2004), multi-criteria (Proctor & Dreschler 2006) and analytic hierarchical process methodologies (van den Belt 2004) are relatively new approaches that can be helpful to measure value and assess the willingness of the public and management agencies to trade off various values and develop agreed priorities in relation to the management of, for example, key invasive species, key pest control methods, and key sites for biodiversity protection and restoration. HBRC would benefit from a better understanding of where and how such techniques can be applied effectively to give insight into its social, cultural and environmental mandates, not just for pest management but also more widely.

6.7 State of the Environment Biodiversity Monitoring

Legislative requirements to report on the status of biodiversity at a regional level require appropriate monitoring of state and change in regional biodiversity. Given that one of the key pressures on native biodiversity is introduced weeds and pests, regional council pest management will contribute to the outcomes set for regional biodiversity. Some councils (e.g., Auckland) are currently formulating monitoring programmes to meet the requirements for the biodiversity component of state of the environment reporting. If HBRC were to adopt a similar approach it is pertinent to ask whether or not HBRC's needs in terms of measuring and reporting on progress towards its desired outcomes of pest management could be met as part of a wider programme of environmental monitoring and reporting. The main risk of such an approach is the attribution of effects – that the contribution of pest management to outcomes may not be able to be separated from other actions that improve biodiversity as clearly as by doing specific monitoring for benefits of pest management. The ability of HBRC to justify expenditure on pest management would not be as strong in the former case. The main advantage would be reduced cost from lesser amount of monitoring that might have to be done for pest management outcomes – i.e. the information is collected once and used for two purposes.

7. Recommendations

- HBRC should consider the potential implications of the current MAFBNZ projects on the Future of Pest Management and the Performance Management Framework for Pest Management before deciding on its approach to and implementation of outcome monitoring of its pest management activities.
- HBRC should consider the proposed Intermediate Outcome, Intermediate Outcome Indicators, and rationale for the case studies plant and animal pest used in this project, and accept or modify them accordingly for inclusion in their 2011 RPMS review.
- HBRC should make use of the information and advice provided in defining a set of practicable methodologies for measurement of progress towards achievement of intermediate outcomes for the management of case study plant and animal pests.

- HBRC should consider the development of a structured research programme using case studies to increase understanding of the economic and other outcomes derived from a number of plant and animal pest programmes where the demonstrated link to outcomes is currently unclear.
- HBRC should work with other councils to agree on a set of cross-council pests and common and consistent methodologies for measurement of progress towards achievement of intermediate outcomes of their management.
- HBRC should take into account the place of monitoring for pest management outcomes in any wider plan for regional state of the environment monitoring.
- HBRC should prioritise and seek to act on the research recommendations to strengthen the council's use of outcome based performance measurement.

8. Acknowledgements

Thanks are due to Campbell Leckie and HBRC staff for guidance of and input to the project and for willingness to answer questions and provide information. Bruce Warburton commented on the draft report, which was edited by Anne Austin.

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Appendix 10.1 Definitions approved by the MAFBNZ Performance Management Framework Working Group (from Jones 2009) and used in this report for consistency.

Term	**Definition**
National Outcomes	Desired end state from pest management in New Zealand and linked to high level governmental priorities, e.g., for DOC "New Zealand's natural and historic heritage is protected and people enjoy it and are involved with the Department in its conservation".
Outcomes	The results experienced by the community from a combination of agency interventions and external factors. Outcome is a general term used to describe the *state* or change in state of a condition of significance to the community resulting from a combination of agency interventions and external factors. Information about outcomes provides a rationale for agency outputs.
Outcome Indicators	These measure the prevailing state in a given period for a specific group. They do not show causal links between outputs and outcomes.
Intermediate Outcomes	A more specific intermediate state that feeds into an outcome. Intermediate outcomes are expected to lead to a desired outcome, but are not the ultimate end result sought. Intermediate outcomes are often used to inform operational or management decisions, and are especially useful when delays in measuring outcomes are significant or limit timely response.
Intermediate outcome indicators ("impact measures")	These indicators measure the difference we have made by the delivery of outputs – the impact that we are having. These measures focus on *effectiveness*.
Outputs	The goods or services that are produced by a department/agency.
Output performance measures	These focus on delivery in the field. They provide information on *efficiency* of operations and delivery (the ability to do the same work to a consistent standard continually over time)
Inputs	The resources (such as capital, personnel, accommodation, equipment, information and time) used to produce outputs and to achieve outcomes
Activities	Actual interventions undertaken by agencies to achieve specified outputs. An output is made up of a number of activities, e.g., in DOC, the activity of 'Animal Pest Ground Control' when combined with the other activity of

Term	Definition
	‘Animal Pest Aerial Control’ makes up the output of ‘Possum Control’.
Methods	Activities are made up of a number of methods, e.g., trapping, hand-laid bait, and bait-stations in the DOC activity of ‘Animal Pest Ground Control’.
Monitoring	Monitoring is the measurement of change in a natural environment, e.g., the abundance and condition of weed and pest populations over time. Monitoring enables staff to evaluate progress and success of programmes.

Appendix 10.2 Agreed list of animal and plant pests used for development of outcomes and an outcome monitoring plan. Primary impacts are taken from the long-term goals of the Hawke's Bay Regional pest Management Strategy 2006.

PEST	DESIGNATION	PRIMARY IMPACTS
Possum (*Trichosurus vulpecula*)	Region wide control	Native biodiversity, economic prosperity
Rabbit (*Oryctolagus cuniculus*)	Region wide control	Economic prosperity
Rook (*Corvus frugileus*)	Region wide control	Economic prosperity
Predators (Rodents, stoats, ferret)	Site specific control	Native biodiversity
Privet (*Ligustrum sinense & lucidum*)	Total control (occupier responsibility)	Human health
Lodgepole pine (*Pinus contorta*)	Total control (occupier responsibility)	Native biodiversity, recreational values
Old man's beard (*Clematis vitalba*)	Total control (occupier responsibility)	Native biodiversity
Saffron thistle (*Carthamus lanatus*)	Total control (occupier responsibility)	Economic prosperity, recreational values
Chilean needle grass (*Nasella neesiana*)	Total control (occupier responsibility)	Economic prosperity