

Economic Costs of Pests to New Zealand

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Preface

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Authorship

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Executive Summary

BACKGROUND

This study complements the development of a national performance measurement framework (PMF) for pest management for use by all pest management agencies. A better understanding of the national costs of pests will support the results of the PMF work contributing to the evaluation of the effectiveness of pest management programmes, and provide context for future resource allocation decisions.

METHOD

The objective of this project is to assess the current economic costs of pests to New Zealand by collecting information on economic costs from previous studies rather than conduct new analyses on individual pest species. Key outputs of this project include an understanding of how economic information is used by pest management agencies (Section Two) and guidance on developing a repeatable methodology for future national assessments (Section Three). Previous national assessments are updated in today's dollars for a selection of important pests and comments made on the use of a macroeconomic indicator (Section Four). We have consulted with regional authorities, key industry organisations and government to canvas views on this use of economic information for pest management and future needs of economic analysis.

REVIEW OF PREVIOUS ANALYSES – SECTION 1

Cost Benefit Analysis (CBA) is the key economic assessment tool used by pest management agencies to decide on how to allocate resources for pest control. CBA provides decision makers with useful information to compare the merits of programmes but is only one aspect of the decision making process. CBA quantifies the economic impacts of a pest as a baseline and thereafter estimates the net-benefits of individual and public control options.

THE CURRENT USE OF ECONOMIC ANALYSIS IN PEST MANAGEMENT – SECTION 2

A range of issues are highlighted with respect to the use of economic information representing views from key pest management agencies and recent relevant literature is also reviewed presented. The points below summarise conclusions from the review:

1. Smaller regional authorities would generally like to have access to more economic information but lack the resources to pay for the analysis.
2. In some cases Section 72 (of the Biosecurity Act) CBA is used only to demonstrate due process and to mitigate the risk of legal challenge.
3. Section 72 CBA could be presented in a more user friendly form in Regional Pest Management Strategy documents and as a tool to consult with stakeholders.
4. There seems to be limited resources devoted to understanding economic implications of different control options although a number of agencies expressed an interest in this.
5. The Biosecurity Act (BSA) has become outdated and regional councils refer to the difficulty in justifying the benefits of site led programmes given the requirement to demonstrate species by species pest control benefits under the BSA.
6. There is strong interest in CBA that includes non-market values of biodiversity benefits of pest management although the cost of this analysis is a barrier.

7. There are gaps in the quality of inputs used in economic evaluations, particularly in the understanding of the links between control activities and pest management outcomes.

Other findings from our review of the current use and needs for economic information found that:

- Monitoring pest management outcomes is becoming increasingly important, particularly with respect to environmental and biodiversity outcomes.
- Economic indicators have an important role in monitoring performance although existing knowledge (e.g. CBA held by regional councils) and methods (e.g. non-market valuation) are not well utilised.
- Causal links between pest management operations and outcomes are not well known requiring further biological based and economic research.
- Pest management agencies will need to include economic measures and indicators in monitoring outcomes although economic indicators for biodiversity pests need to be developed.
- A need for simple tools that can be applied by agencies and industry organisations to develop data for economic analysis.

We do not recommend that simple tools be developed for agencies and industry organisations to conduct their own economic analysis unless completed by qualified economists due to the risks of pest management decisions being based on poorly conducted analyses.

A REPEATABLE METHODOLOGY FOR UPDATING THE ECONOMIC COSTS – SECTION 3

A reporting framework for monitoring and reporting economic costs requires two key tasks; ongoing monitoring and collection of data by MAF Biosecurity New Zealand (MAFBNZ) and, assessment of pest management performance through CBA. Ongoing monitoring will improve updates of the costs of pests and CBA will help decision makers allocate resources to the programmes with the highest net benefit. Section Three sets out the type of information needed and provides guidance on the collection and use of economic information.

ASSESSMENT OF THE CURRENT ECONOMIC COST OF PESTS – SECTION 4

We have reviewed analyses undertaken on the most significant pests to the New Zealand primary sector and adjusted these values based on changes in pest management programmes and inflation (to 2008 dollars). This provides an indicative assessment and highlights areas of uncertainty. Given that only a selection of pests is included, the estimates made in this study are likely to understate the total costs of pests to New Zealand.

The measurable economic cost of pests has two major components (Bertram 1999):

- **defensive expenditures:** the financial cost of resources devoted to restricting pest populations; and
- **output losses:** the economic output lost each year as a result of the existing level of infestation.

Other costs can also be measured in economic terms such recreational losses and environmental impacts (e.g. biodiversity loss) although the methods to measure these impacts need further application in the New Zealand context.

Defensive expenditure was estimated from the public sector including central and local government expenditure on quarantine and border control, surveillance, research, pest control, and eradication programmes. Private sector defensive expenditure includes an estimate of primary sector spending and annual household expenditure. The table below summarises these findings.

New Zealand's Total Defensive Expenditure

Total Annual Defensive Expenditure (\$ million)	
Regional Councils	36.9
Central Government	418.6
Private Sector	407.0
Total (GST exclusive)	862.5
Total (GST inclusive)	970.3
Defensive expenditure as a % of GDP (2008)	0.55%

Output losses measured in this study focus on only significant pests with available data and are therefore likely to understate total production losses. In reviewing economic data on the costs of pests, care was taken to include only the actual losses currently being incurred. In addition to adjusting values for inflation we have also updated cost information based on changes to pest related losses in recent literature. The table below summarises these costs.

Total Output Losses by Sector

Total Output Losses (\$ million)	Plant	Animal & invertebrate	Total Impacts
Agriculture	202	635	837
Horticulture		25	25
Forestry	37	227	264
Marine		15	15
Other	63	88	151
Total Output Losses	302	885	1292

Total economic costs of pests to New Zealand's primary sector (based on a selection of significant pests) is therefore estimated to be roughly \$2,262 million per year of which \$970 million (45 percent) are defensive costs and \$1,292 million (55 percent) is the value of output losses. Multiplier effects account for losses incurred by up and downstream services and industries and mean that the actual economic impact could be as high as \$2,454 million¹ or total costs to \$3,424 million (1.93 per cent of GDP).

Total economic cost of pests to New Zealand including multipliers

Area of impact	2008 \$ million
Defensive Expenditure	970
Production Losses (with multiplier)	2,454
Total	3,424
Total Costs as a % of GDP	1.93%

¹ This potential economic cost may be somewhat offset by increased employment in the Biosecurity sector.

The cost of pests and weeds to indigenous biodiversity have not been included in our estimate as current estimates are based on overseas data and more widespread application of non-market valuation methods is needed.

Use of macroeconomic indicators other than GDP – development of economic indicators that include pest management outcomes and societal welfare would improve our understanding of how well we are doing at reducing the impact of pests. GPI (Genuine Progress Indicator) is an indicator that incorporates not only the value of economic output but also takes stock of changes to New Zealand's social and natural capital and may have application in the future.

CONCLUSION

Estimating the total cost of pests is difficult as an accurate assessment requires impact evaluations at individual species level. There are positive signs in the area of pest management and the linkages that this project has with the national PMF for pest management are important. The reduced costs of some major pests such as argentine stem weevil, rabbits, giant buttercup are positive examples of pest management programmes delivering positive economic outcomes. While there has been some progress, the total economic costs of pests (both defensive expenditure and output losses) are increasing and likely to continue to do so.

MAFBNZ also plans other work on improved co-ordination of biosecurity programmes and closer co-ordination with regional councils, industry, central government departments and others, which will also help improve the effectiveness of resources invested in this area.

Steps for a repeatable methodology

The steps below are provided to guide MAFBNZ in collating better quality information to be used in economic analysis.

1. Assemble data on annual expenditure (GST inclusive) from annual reports.
2. Survey regional council and unitary authorities on annual pest control expenditure
3. Update FRST data on biosecurity related research funding and include as a defensive expenditure.

DEFENSIVE EXPENDITURE – PRIVATE SECTOR

1. Gather MAF Farm Monitoring data on annual farm weed and pest expenditure (sheep and beef, dairy, deer, arable, horticulture).
2. Estimate total primary sector private sector defensive expenditure by extrapolating MAF per hectare data against relevant farm type areas.
3. Gather pest control expenditure from industry organisations such as the AHB.

PRODUCTION LOSSES

1. Review all existing economic analyses for individual pest species (including MAFBNZ data) and identify annual production losses within analyses. Adjust for inflation and relevant changes to pest infestation (taking into account pest management outcomes).

Recommended tasks to improve information gaps over five years

1. Further develop private sector expenditure on weed and pest control monitoring by utilising MAF Farm Monitoring data and incorporating household and commercial sector expenditure overtime by using surveys.
2. Work with industry economics organisations (i.e. Meat and Wool Economic Service, DairyNZ, HortNZ) to improve data on primary sector labour expenditure on weed and pest control.
3. Develop national database of economic output losses by reviewing all Section 72 CBA information held by regional authorities so that annual production losses are collated in a data base for each region and species.
4. Develop links between pest control operations and outcomes so that in time relationships between pest prevalence, distribution and density (stored in a national database) can be used to estimate production and control costs.
5. Update primary sector industry economic multipliers (using input-output tables released in 2009) so that impacts on employment and GDP output can be incorporated in the national costs.
6. Work more closely overtime with the marine farming industry to develop impact assessments of potential harmful organisms so that rapid responses to incursions can be made.

1. Review of existing economic impact assessments

1.1 BACKGROUND

MAF Biosecurity New Zealand (MAFBNZ) is currently developing a national performance measurement framework for pest management for use by all pest management agencies. There are a number of data needs to support this project. One identified gap is a lack of current information on the true costs of pests to New Zealand. The true cost of pests is the focus of this study. This information will complement the results of the performance measures work undertaken, thereby contributing to the evaluation of the effectiveness of pest management programmes, and providing context for future resource allocation decisions.

Establishing the costs of pests is necessary for comparative analysis of the effectiveness and efficiency of pest management across a range of sectors.

Decisions on whether the public sector should undertake pest management are based around the theory of market failure. In theory, market failure occurs when people and organisations (i.e. a market) will not allocate resources (goods and services) in a manner that is economically efficient². In regards to pest management this occurs when individuals (e.g. landowners and occupiers) only spend on pest control up to a point where the marginal benefits (to themselves as beneficiaries) equal their marginal costs. The problem occurs where the benefits of control are received by wider society (i.e. freedom from pests is a public-good) and therefore, private individuals will “under-provide” public goods or alternatively under-control public detriments. In these cases there is a strong argument for public expenditure for pest management.

1.1.1 Method

The objective of this project is to assess the current economic costs of pests to New Zealand by collecting information on economic costs from previous studies rather than conduct an in-depth analysis of the cost of individual pest species. There is a general lack of economic information on the costs of pests. We have reviewed major New Zealand based studies and one international analysis on the economic impacts major pests. The review of existing studies has allowed an identification of gaps in information and methods and also allowed an update of past estimates.

The study has also involved consultation with key pest management agencies to collate their views on use of economic information, identify project relevant issues, opportunities or needs that are important to future assessments of economic costs.

Section Four of this report updates previous estimates of economic costs by identifying relevant costs within the studies and adjusting the values for inflation. Account is also taken of changes to pest incursion by adjusting the prevalence rate.

MAFBNZ was consulted with throughout the project in regard to information emerging from the consultation and issues around the number of pests included in the updates and range of impacts.

² Situation in which it is impossible to generate a larger benefit from the available resources, alternatively, the situation where some people cannot be made better-off by reallocating the resources or goods, without making others worse-off.

1.1.2 Scope and Limitations

This study focuses mainly on pests to the primary sectors (agriculture, forestry, fisheries, horticulture). This study considers issues around the assessment of economic impacts to the environment but due to the complexity of such analyses no updates are made. Given the range and scope of pests in the primary sector, no assessment of impacts is made on human health and lifestyle (such as private households) or commercial business (other than farming). Pests are also limited to major plant and animal pests and do not include diseases such as Bovine TB (although the control of TB vectors is included) and/or microbial pests such as nematode worms in livestock or fungal diseases in forestry. The update of economic costs focuses on pests already established in New Zealand, rather than potential impacts of future incursions.

1.2 INTRODUCTION

Section 1 of this report provides a critical analysis of a selection of economic impact assessments of mainly New Zealand pests. It also includes analyses of the impact of new pests to inform incursion responses. The analysis in Section One is based on the table contained in Appendix 1. This table identifies common features of robust analyses, discusses methodology, and makes recommendations on how to improve the collation and use of economic information for MAFBNZ. Most of these analyses are also used in Section Three to update estimates of the total economic impact of pests.

There are six key areas considered in the analysis of economic impact assessments (EIA) in Appendix 1:

1. summary of pest impact and objective;
2. the suitability of the economic methods used;
3. the applicability of the methodology for today's pest management and economic context;
4. likely future applicability and robustness of the analysis;
5. the robustness of the result and adequacy of assumptions used; and
6. gaps in the coverage of pests, costs identified, reporting and/or modification for future updating of the analyses.

As well as a critical analysis, Section 1 also contains observations about the economic analyses used by regional councils in the preparation of Regional Pest Management Strategies (RPMS) and previous literature on best practice cost-benefit analysis for pest management.

1.3 COMMON FEATURES OF REVIEWED ANALYSES

A number of features made some of the studies more robust than others. These features include:

- testing the effect of more than one scenario (usually low, medium and high impact) to improve the reader's understanding of the potential costs;
- use of a technical advisory group to ensure that assumptions made on pest impact and biology are valid;
- the use of probabilities against various scenarios (weighting of) to provide an understanding of risks (risk analysis);
- identification of constraints and limitations of the analysis including identification of the impacts that do not have estimated costs (quantified) and justification for not quantifying these impacts;
- review of other relevant analyses that provide reference points for assumptions made about pest impacts;
- the estimate of private and public sector investment in controlling the pests;

- inclusion and assessment of the full range of impacts across all sectors- commercial, environmental, social, human health and well being and Maori cultural and spiritual values.

In undertaking economic analysis an understanding of the relevant economic and environmental conditions that prevailed prior to the incursion/response is needed and is usually called a baseline. Baseline information may also include existing impacts and is essential for formulating appropriate pest management. Baseline data for new pests relies heavily on international analyses and assumptions are generally based on incursions that have occurred overseas. Where there is no data from a New Zealand experience with the pest, the limitations and interpretation of data need to be made clear. For new pest incursions particular care is needed to verify key assumptions used to estimate costs with technical experts.

In a study conducted by the New York Sea Grant to estimate the economic impacts of zebra mussels in North America (O'Neill, 1995) a detailed survey was mailed to a random sample of 766 infrastructure owners/operators in 35 states to illicit economic impact data. This approach is expensive although direct contact through targeted surveys is the best method of collecting impact information. Where financially feasible and where pests are already established sample surveys of control costs (public and private sector) and production losses are the best method of collecting reliable data for analyses. Sample sizes should be at minimum the square root of the total population and expert input should be sought in structuring survey questions so that responses can be analysed reliably.

1.4 METHODS USED

Economic cost-benefit analysis was used for all of the economic impact assessments reviewed. Briefly, Cost Benefit Analysis (CBA) is an economic assessment tool. By quantifying all costs and benefits in monetary terms, and discounting these values to today's dollars, it is possible to determine the net benefits (or costs) of a proposed intervention (or project) (New Zealand Treasury 2005). The net benefits are the sum of a future cashflow and the term used for using future discounted cashflows in this way is Discounted Cashflow analysis (DCF). These net benefits/costs can then be used to quantitatively rank alternative proposals:

- between a given proposal and the status quo; or
- between competing proposals.

Decision-makers can thus be provided with a consistent basis for assessing proposals and can be better informed about the implications of resource allocation. CBA can also be used to test the effectiveness of a proposal after it has been implemented. Social CBA assesses the net benefits of a project to society. Recently, CBA has been used in economic evaluations of ecosystem services (e.g. Butcher, 2006³). Ecosystem services are also included in a limited way for CBA of RPMS, although robust valuations of the relevant ecosystems are rare (the Auckland Regional Council have made a rough estimate). In a Section 72 analysis for Environment Waikato the annual cost of pest control operations are given on a per hectare basis and the council is required to make a subjective judgement as to whether the ecosystem being protected is more valuable (supported by data from other relevant studies).

Cost Benefit Analysis can be used to analyse many different types of proposals, is flexible and can be applied to assess most pest management proposals. However, it has some

³ Department of Conservation (DOC) commissioned an analysis on the value of water from a property purchased through the pastoral lease tenure review (Rocklands 22,000 Ha) and retired from farming (now called Te Papanui Conservation Park). The objective was to investigate the value of existing water and look at the potential change in value if the land was not retained in the conservation estate.

limitations (e.g. it is often not possible to assign a monetary value to all costs and benefits) that mean it is not suitable for assessing every proposal. In such situations, alternatives such as Cost Effectiveness Analysis (CEA) and Cost Utility Analysis (CUA)⁴ can be used.

CBA quantifies the impacts of a pest as a baseline and thereafter estimates the net-benefits of individual and public control or eradication options. A common indicator, of the merit of the proposal, used in CBA is Net Present Value (NPV). NPV represents the sum of all future net-benefits estimated in every year of a proposal and shown as a cashflow. Timelines for proposals vary depending the expected timing of costs and benefits, although 10 – 30 years is common for pest management CBA. Because costs and benefits in the future are worth less (in today's dollars) than they are today, all future cashflows are “discounted” to account for this using a discount rate.

Another indicator of project merit is the net-benefit to cost ratio which is calculated by dividing the net benefits by the total cost of the project. The net-benefit to cost ratio is used to rank projects when funds are limited.

1.4.1 Choosing an appropriate discount rate

As stated above, DCF analysis assumes that benefits or costs incurred in the future have less value than the same benefit or cost incurred now. Future values are reduced for each year that they are delayed using the discount rate (expressed as a percentage, e.g. 8 percent). There is considerable disagreement as to what an appropriate discount rate is. The factors that affect the selection of discount rate are the rate at which people are willing to trade today's consumption of a good for consumption in the future (private and social rates of time preference), the opportunity cost of capital (the rate of return one can expect from the next best investment alternative), views on risk and uncertainty, and the interests of future generations—all have environmental dimension that relate to pest management.

There are two approaches to selecting discount rates: the social rate of time preference and the opportunity cost of capital. The social discount rate measures the rate at which a society would be willing to trade present for future consumption (Lopez 2008), while the opportunity cost of capital is the pre-tax rate of return that can be expected from private sector investments that have the same risk (e.g. a combination of returns from investing in a business, purchasing company shares, bank deposits or government bonds). Choosing an appropriate discount is close to the 10 year bank bill rates (the risk-free rate) plus a premium for risk.

Selecting an appropriate discount rate is important as cost-benefit analysis based on high discount rates tends to favour those projects with short-term benefits over those with longer term payoffs. Where economies are growing slowly discount rates chosen tend to be lower (i.e. 2–4 percent) than those in high growth scenarios (5-7 percent). Discount rates should also take into account the time horizon of the project where longer-term projects (e.g. environmental or climate change projects) have a lower rate than short-term projects (Lopez 2008). Given this uncertainty, MAFBNZ should seek guidance from New Zealand Treasury on selecting discount rates for individual CBA. A recent guidance document (New Zealand Treasury 2008) on choosing public sector discount rates was undertaken by Treasury suggests the following real opportunity costs of capital for various projects⁵.

4 Cost Effectiveness Analysis (CEA) is similar to Cost Benefit Analysis except that it compares the costs of alternative ways of producing the same or similar outputs/benefits (and does quantify benefits). CUA is a variant of CEA that measures the relative effectiveness of alternative interventions in achieving two or more given objectives.

5 Since this document was written the risk free rate has reduced because of the financial crisis beginning in October 2008, so advice is recommended from Treasury at the time of undertaking the CBA.

Table 1.1 Treasury Recommended Discount Rates

Discount rate	Applications
6.0%	Buildings
8.0%	Default
8.0%	Infrastructure
9.5%	Technology

1.4.2 Treatment of costs and benefits

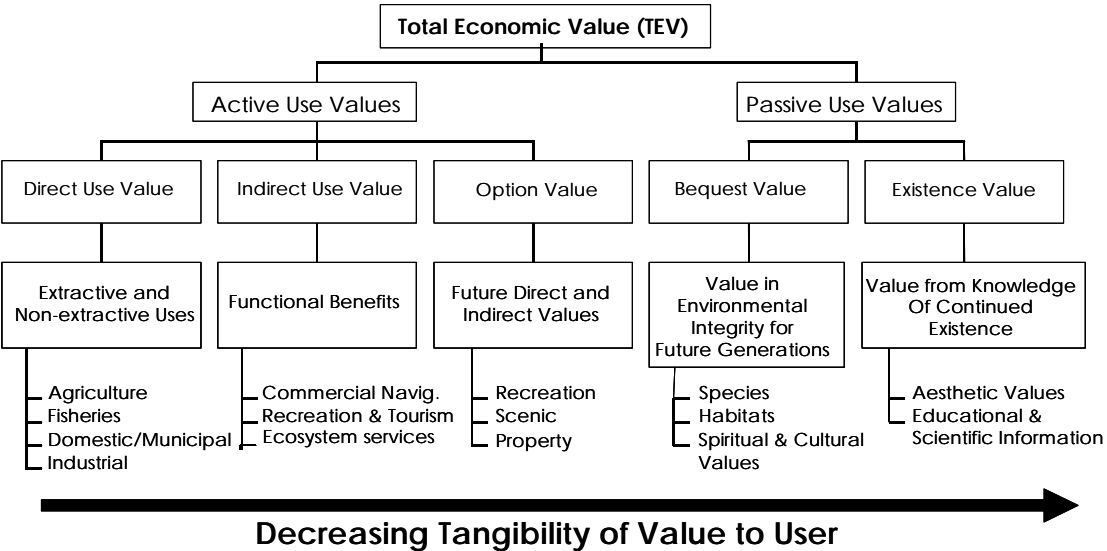
Economic costs relate to actual resource use in the economy and reflect the next best alternative use that the resources could be used for. CBA that consider the impact of pests on primary sector production estimate farm gate losses by identifying lost production, or changes in prices from reduced quality and/or increases in inputs (e.g. pest control). Economic benefits are gains in the welfare of society (or relevant group/industry) from the proposal being considered.

By breaking costs and benefits down by sector, regional and climatic variation differences can add important information to the analysis. The impact of pests can be different in different regions (even for the same sector) and under various climatic conditions. Some costs and benefit do not have a easily recognisable monetary value (such as gains in biodiversity) and a referred to as non-market values.

1.4.3 Methods for valuing environmental values

The chart below shows the breakdown of total economic value into those that are more likely to have a market (active use values) and those less tangible values without accessible markets (passive use values). Economic methods that use stated preference techniques (i.e. surveys where people state preferences on given options) are used to estimate non-market passive values which include bequest values (value in environmental integrity for future generations – species, habitats and spiritual and cultural values) and existence values (the value of knowledge of continued existence – aesthetic values and education and scientific information).

Figure 1: Total Economic Value framework



Source: Environment Canada (The Environmental Valuation Reference Inventory (EVRI) Database).

To date, stated preference techniques (contingent valuation and choice modelling) have found little application in New Zealand for estimating changes to passive values (including environmental values) due to the impacts of pests. The main reason is the relatively high cost of undertaking such analysis, but a lack of understanding of the advantages and limitations of the techniques are also factors. However, recent developments in software to design the experiments and analyse the results of stated preference surveys mean that such techniques are becoming more accessible.

The estimate of the total costs of pests to the economy in Section 4 refers to Bertram (1999) as a benchmark study. Since the Bertram study there have been major advances in the methodology for estimating values for non-market goods and services such as indigenous biodiversity. Contingent valuation has largely been superseded by choice modelling. Choice modelling allows the analyst to estimate individuals' willingness to pay for a number of attributes of an ecosystem at the same time, whereas contingent valuation could only address one attribute. So far, however, these advances in methodology have not been directed much to valuing indigenous biodiversity rather the emphasis has been on the values of recreational activity.

A current study led by Nimmo-Bell (Bell, 2007) aims to estimate dollar values for predicted loss of indigenous biodiversity from potential incursions of invasive weeds or pests. It will set up a database of values of indigenous biodiversity and populate this with data from four New Zealand ecosystems. The ecosystems, invasive species and native fauna and flora impacted on are set out in the table below:

Table 1.2: Biodiversity Values

Ecosystem	Invasive species	Indigenous biodiversity impacted
South Island high country	Wilding pines	Hebe cupressoides, Robust grasshopper, Bignose galaxias
Coastal marine	European shore crab	Native shellfish and crabs
Freshwater	Alligator weed (Hydrilla)	Charophytes, native fish, mussels and shags
Beech forest	Wasps	Native birds and insects

Information from these case studies will be available to enable quantitative estimates to be made of the non-market costs of pests and weeds impacting on indigenous biodiversity. This is done using the benefit transfer technique where surveys are conducted to estimate individual's Willingness to Pay (WTP) for changes in biodiversity values and are transferred from a study site (where the values were originally estimated) to a policy site (where values are needed). In order for the transfer to have credibility there needs to be a high degree of similarity between the study site and the policy site both in terms of the environmental values and the characteristics of the communities.

More sophisticated versions of benefit transfer are function transfer where functional relationships are transferred and meta analysis where values from many sites are combined and then transferred. Rolfe and Bennett (2006) provide a thorough review of the issues with examples of choice modelling and the transfer of environmental values. A manual is currently being prepared for Biosecurity New Zealand by Nimmo-Bell which sets out the practical steps for estimating the benefits of pest management and incorporating these into cost benefit analysis. The manual is expected to be available by the end of 2009.

1.4.4 Gaps in previous analyses and recommended improvements

The review of MAFBNZ supplied CBA has highlighted some gaps in the analyses that if addressed will improve future CBA work:

- Discussion on the impact that the discount rate has on the NPV. Given that pest management impact assessments and natural resource projects often require cashflows with long time horizons, the results are highly sensitive to selection of the discount rate (see discussion on discount rate in Section 1.4.1).
- Non-quantifiable downstream industry impacts are considered in some analyses where primary sector impacts are significant (such as non-quantified trade impacts). Non-quantifiable impacts would be helpful for decision makers' understanding of all the impacts of a pest.
- The inclusion of environmental impacts whose value do not have a market (non-market values). Some analyses would benefit from inclusion of non-market valuation of environmental impacts and are currently discussed in the "non-quantified" impacts of the analysis.
- The quantification of private sector defensive expenditure⁶ (e.g. the investment made by the private sector in pest control). This investment should be part of economic impact assessments.

Accounting for risk would improve analyses. Various risk modelling tools could be used to account for the uncertainty that arises in making estimates of important variables (e.g. population spread). Most analyses provide low, medium and high impact scenarios. Risk modelling provides decision makers with better information on the range of possible outcomes⁷.

For MAFBNZ it is important that a consistent analysis framework is used when a number of different species are being evaluated so that impacts can be compared and, if necessary, projects ranked (using NPV/response cost ratio) to assist in prioritising resources.

Cost-benefit analysis also relies on an accurate description of the baseline or counterfactual (the scenario that would occur without any public funded intervention). A number of the studies have failed to fully explore the likelihood or capability of the private sector to innovate in response to a pest threat. The development of a baseline should involve input from a TAG as it can be difficult to predict how the private sector is likely to respond to a pest threat.

⁶ Defensive expenditure is made by both private and public sector and refers to the costs of mitigating pest impacts, controlling spread, preventing incursions and monitoring species distribution.

⁷ The most tested method that Nimmo-Bell uses to compare projects with different risk profiles is the QuRATM approach. QuRATM (Quantified Risk Analysis) is a cost-benefit analysis tool developed and used extensively by Nimmo-Bell in resource allocation decisions for agribusiness and environmental projects. Using this approach it is up to the decision maker to decide between projects based on the probability distributions of the NPV taking into account their own level of risk aversion.

2. The current use of economic analysis in pest management

This section builds on the analysis in Section One by presenting a range of views from key agencies with a responsibility for pest management. It also reviews recent work that has considered the full spectrum of issues facing future pest management in New Zealand. This understanding is important as it identifies what stakeholders need from economic analysis and provides direction for future changes to best practice EIA. Face to face and telephone interviews were used to gather the range of views. A series of questions helped guide the interviews (Appendix 2).

The Section ends by pulling together the findings of the review of earlier analyses and stakeholder consultation (in Sections One and Two) and proposing a repeatable methodology for future assessment of the national economic costs of pests.

2.1 CURRENT ISSUES RELEVANT TO THE USE OF ECONOMIC ANALYSIS

Recent literature has identified key issues in pest management. Those of relevance to economic analysis were identified in a report by Hackwell and Bertram (1999) commissioned by the New Zealand Conservation Authority. This report aimed to inform the public of the costs of pests, weeds and pathogens to New Zealand as a blue print for action to halt the damage. It was critical of efforts to prevent new incursions and manage/eradicate existing pest species. Recommendations included:

1. Increased funding for research, border control, surveillance, eradication and control
2. Improved co-ordination of pest incursion response, pest control, and research
3. Advocacy for the inclusion of the precautionary principle into biosecurity provisions of international trade agreements
4. Greater resources needed for pre-border Biosecurity and border controls
5. Increased effectiveness of control of pests that threaten conservation values on both public and private land and
6. Improvement of Biosecurity measures to uphold New Zealand's international obligations as a potential country of origin for pest species in other countries.

All of these recommendations require improved allocation of existing resources and/or increased resources devoted to biosecurity. Decision makers invariably require both quantitative and qualitative information to make funding decisions so that resources are directed to the highest priorities. Establishing priorities requires balancing strategic fit, costs and technical resources, socio-economic, biodiversity, recreation, health and cultural impacts. The importance of non-market values (e.g. environmental benefits of pest control) has been recognized and therefore the importance of quantifying them.

A think piece report commissioned by the Regional Council Pest Management Steering Group⁸ identifies seven key pest management challenges facing New Zealand in the years ahead, these are summarised below:

1. Greater pest threats due to more successful incursions of new pests and extensions to the range of many existing pests.
2. Evolution of the strategic direction of pest management at the regional level, primarily in the form of the traditional driver of protecting primary production giving way to a principal concern for impacts of pests on environmental quality, such as indigenous biodiversity. This in turn is changing the business of pest management from a focus on

⁸ The Future of Pest Management in New Zealand: A Think Piece. Gerard Willis, Enfocus Limited.

- single species management to multi-pest, site-led management requiring a difference set of management and operational skills.
3. The changing nature of local government with regional councils now having a broader mandate than they had previously and a high urban representation. Regional councils will face challenges in sustaining increases in pest management funding.
 4. The special risks and greater complexity of managing marine and freshwater pests. These are likely to grow in line with other pest incursions. The difficulties are compounded by the highly complex jurisdictional arrangements of management agencies in marine and freshwater environments.
 5. Land use change brought about in a number of ways including re-vegetation of marginal farmland and rural repopulation will create new pest pathways and vulnerabilities. In addition, continued expansion of the Crown conservation estate will increase pressure on Crown contributions. A growing public estate will also increase the duality of the current system with, effectively, two separate pest management systems operating according to land ownership with the challenges for strategic integration that that entails.
 6. The prospect of more limited pest control tools brought about by community resistance to traditional pest control methods, and the declining efficacy of some biological controls (such as RCD) with implications for rabbit control (in particular) and future management options and costs.
 7. The potential wind down of the Tb vector control programme having successfully eradicated Tb from herds in several parts of the country and reduced infection rates in other parts. This will significantly reduce off-conservation estate public expenditure on possum control. The challenge is how to maintain, where warranted, the biodiversity gains achieved through the Tb Strategy that have come at a cost in excess of regional budgets.

Willis (2008) highlights a number of key findings, including that tenure neutrality is a prerequisite for an effective pest management system such that Crown land and other land is treated similarly. The implications are that the Crown is required to internalise current externalities of landownership (i.e. act as a good neighbour) and that there be a statutory duty on landowners/ occupiers (including the Crown) to pay for the external costs of pests. A stronger focus on the externalities of pests would require improved information on the impacts (both market and non-market). Progression of pest management along these lines will require landowners and MAFBNZ (as implementer of the Biosecurity Act 1993) to ensure they have reliable qualitative and quantitative information in order to fairly allocate the costs of these externalities.

Willis (2008) also calls for a proactive approach to management and a mechanism that allocates scarce public funding that achieves maximum results for dollars spent and accounts for multiple outcomes to be achieved over a sustained period.

Additional pest management challenges are identified in a separate review commissioned by MAFBNZ (Hellstrom *et al.* 2008) including:

- **Funding and prioritisation for pest management** – a key challenge is current levels and principles of funding which are inadequate to achieve the goals of the Biosecurity Strategy and fund ongoing research. There are perceived to be opportunities to increase funding by linking funding to exacerbators and beneficiaries.
- **Retain capability and improve understanding about species and pests** – this refers to the currently declining capability in science, physical pest control, and at policy level. Additional capabilities are needed in modelling techniques, information sharing, new research and practical on-ground knowledge of pest management.

In addition to pressures on funding for pest management, New Zealanders are placing increasing emphasis on environmental impacts of pests relative to output losses from primary industries, driven to some extent by an increasing urban voice in society⁹. Essentially, there will be a greater need for economic analysis, because more pest control will have to be done, funds will be scarce and resources should be allocated to highest priority (or value) and identifying these values (or priorities) is important. A challenge in this regard is how to deal with changing priorities if there are new established pests. Given pest control will often need to be sustained, better quality information (including economic values for CBA) will need to be used to decide what programmes to stop and what to continue.

2.2 REGIONAL COUNCILS

Sixteen regional authorities (Regional Councils and Unitary Authorities) throughout New Zealand have adopted Regional Pest Management Strategies (RPMS) that provide strategic and statutory frameworks to manage plant and animal pests in their regions. Strategies are usually written to cover intervals of five years but can be longer to reflect the long-term management needed for many pest species. RPMS must be reviewed at least every five years and can only be adopted following review and public consultation. When operative, RPMSs empower regional authorities to exercise the relevant enforcement and funding provisions made available under the Biosecurity Act (1993) (BSA). Together with the RMA (1991) and the Local Government Act (2002), these are the main pieces of legislation governing pest management activities by regional authorities.

Pest management programmes follow a hierarchy that provide for differing levels of regional intervention with Total Control and Eradication programmes providing the highest level of pest control. RPMSs should contain:

- programme objectives;
- details of the means by which the council will achieve the objectives;
- any rules and statutory obligations that apply;
- how the council will monitor its performance;
- summarised financial information; and
- any further relevant information.

Economic information is an important part of developing RPMS for individual species. Biosecurity Managers from eight regional councils were interviewed in this study to gather information around how economic information is currently used and emerging trends on future economic information needs.

2.2.1 Current needs for and uses of economic information

Economic information on pest management is usually outlined in cost-benefit analysis (CBA) and is used by regional councils to assist in decision making or consultation for the following purposes:

- 1) reviews of the RPMS (as a statutory requirement);
- 2) major changes to the operating environment e.g. new pest incursion; and
- 3) industry and stakeholder consultation as a tool to gain political or community support for control operations or policy shifts.

Economic information on the costs and benefits of pest management is an important part of how councils prepare RPMSs. Section 72 of the BSA requires that regional councils consider

⁹ Paradoxically the weediest places are often those closest to towns (DOC 2002). Over 70% of invasive weeds were originally garden plants. People continue to spread invasive weeds by growing them in their gardens, dumping rubbish from gardens or fish tanks, or accidentally spreading seeds and fragments.

the costs, benefits and externalities of pest management. Economic theory suggests that private landowners will usually carry out pest control up to a point where the marginal costs equal the marginal benefits (to themselves) and therefore, there can be spill-over costs that warrant a collective approach. Understanding the implications of public and private approaches is a requirement of the BSA which is described below.

The Biosecurity Act (1993)

Regional Councils have powers to undertake pest management in their respective regions under the Biosecurity Act (the Act). The guiding principle of the Act in relation to surveillance and pest management operations is to provide for monitoring and effective management or eradication of pests and unwanted organisms. In preparing RPMS, regional councils must take into account the Act's relevant statutory and planning requirements. An important requirement is Section 72 which contains the criteria for assessing candidate pests and determines whether a Strategy is necessary, appropriate and the most cost-effective means of managing those organisms. These criteria say that a council must be satisfied that:

- The net benefits (monetary and non monetary) of the Strategy outweigh the costs.
- There should be net benefits to the wider community in addition to private landowners (those who would normally be expected to control the pest).
- Those who pay for the Strategy must either receive benefits which exceed their costs or be exacerbators.
- A collective approach to controlling the pest is more effective than individual landowner action.
- The pest is having actual or potential environmental effects of regional significance. These effects may be broad in nature and include economic matters, as well as natural, physical and cultural impacts.

As well as adverse impacts, councils consider whether the pest's distribution is limited, restricted or widespread with respect to its potentially suitable habitat. Its distribution will have a bearing on the type and level of management considered appropriate.

Under the wording of the Act there is no legal obligation for a regional council to take on the role of managing pests unless it chooses to do so. Any council involvement is discretionary and is undertaken subject to the preparation of RPMS. Once operative, a Strategy empowers councils to exercise the appropriate enforcement and funding provisions of the Act.

As a starting point, regional councils use the infestation curve¹⁰ to guide the level of control for each pest included in the RPMS¹¹. Cost-benefit analysis (CBA) is then used either on groupings of pests or on an individual basis for major pests.

There is a range of ways in which regional councils use economic information. Some rely on the results of CBA analyses when there is a risk of being challenged by rate payers. CBA can be important in mitigating legal challenges from landowners that dispute council priorities. The most common approach is a specialist model developed for pest response CBA (the "Harris Model"). This model assesses the costs of individual pest species and uses a common framework for evaluating the benefits of publicly funded intervention programmes. Others

¹⁰ The invasion pattern of many species tends to follow an 'S-shaped' pattern (Appendix 3). The important characteristics of the curve are a long tail at the beginning of a species' invasion as the pest establishes itself, a steep rise as the pest finds suitable habitats, and then a flattening off as these habitats reach carrying capacity.

¹¹ While this is a starting point for councils, there are limitations in this approach as infestation does not necessarily have any relationship with impacts. Unless the relationship between infestation level (density) and impact is known, infestation alone is of limited use.

simply use CBA information to demonstrate to stakeholders that due process for the inclusion of pests in a RPMS has been followed. While economic information is considered important, CBAs are generally only relied upon, in preference to council opinion, when proposed programmes are particularly contentious e.g. gorse. Justifying inclusion in the RPMS usually means that councils have weighed-up the least cost way to achieve regional pest management outcomes.

Economic analysis generally determines the approach taken (i.e. whether council/collective approach or individual led). Smaller sized regional councils (in terms of funding resources) generally only commission CBAs on a small number of high priority individual pests (2-3). A lack of funding for external consultants is a constraint to wider use of CBA for smaller councils.

In regard to economic capabilities, some of the larger councils have in-house economists although these are generally used for planning decisions rather than to undertake CBA for pest management (water use being a high priority). Councils almost always engage external consultants to provide CBA for a range of pests included in RPMS.

Regional council funding of external consultants for CBA is proportionate to the level of pest impact and budget for control operations. Some councils also note that they do not have access to the economic analyses that meet their needs or are unaware of such studies. The perceived value of economic analyses is twofold:

- a description of the nature and quantitative assessment of costs to the region; and
- description and analysis of qualitative factors that decision makers should be aware of in considering the overall impact.

CBA studies are usually peer reviewed, some times by technical advisory groups, if intended for use in public consultation.

2.2.2 Type and form of Cost-Benefit Analysis

A mix of public and private costs and benefits are included in CBAs used by regional councils. This information is usually presented in the form of regional production costs and may be separated out by sector. While recognising that pest management has benefits for both the private sector and for wider society, an agreement on pest management outcomes between these two groups is critically important. Other quantified economic costs include health costs, impacts on leisure and the costs of control by individuals. Higher level macro-economic costs to the community are only occasionally produced in CBAs, such as changes to employment or added value components of Gross Domestic Product (GDP) (DOC, 2006). Losses in amenity or impacts on leisure are usually expressed using willingness to pay methods but only as an output of more substantive previous studies.

CBA reports prepared for Section 72 analyses are publicly available documents but generally only on request. Economic information is generally not used by councils in consultation documents or indeed in most proposed RPMS documents. It is generally perceived that economic information is not of interest to the public unless challenging a decision. Some councils, however, felt that if economic information could be presented in a form that was easily understood by the general public then it would add value to public consultation. This could be achieved by expressing values in a metric that the public can relate to, such as dollars of economic benefit per council dollar invested or production losses per hectare.

2.2.3 Future needs and trends

There is a view among regional councils that environmental values are becoming more important as a driver of pest management activities than traditional production losses. This trend reflects:

- an increased awareness of environmental values from ratepayers;
- an increasing urban voice on rural land use; and
- a perceived declining importance of agriculture as the main driver of regional economic wellbeing.

This trend towards environmental outcomes is also reinforced at a regional level by the 2003 amendment to the RMA which gave councils the express function of “*the establishment, implementation and review of objectives, policies and methods for maintaining indigenous biological diversity*”. This is a function that cannot be achieved without an increased focus on pest management (Willis, 2008).

Views from regional councils also suggest that the framework for prioritising pest management, under Section 72 of the BSA, on market drivers alone is out of date. A fresh approach is needed that includes how rate payers value the conservation/ biodiversity benefits of pest management. Operating within the current statutory environment requires improved economic information that measures the value that communities place on the environmental benefits of pest control. Currently economic analyses for biodiversity protection are limited to cost analysis where councils consider whether the estimated costs of protecting key native environments are warranted for a subjective estimation of the benefits. There is also no monitoring of outcomes and so no current measures for benefits (without additional survey work). Economic analysis that employs more advanced methods to quantify how communities value changes to the region’s natural environment (e.g. changes to indigenous biodiversity from pest damage) is expensive and beyond the reach of most regional council budgets.

The need for biodiversity values to be included in economic analysis is linked to an increasing need for the BSA to cater for site based prioritisation rather than a focus on single species led programmes. The requirement for CBA on a species basis excludes some pests from the regional strategies because, on an individual species basis, the economic benefits do not outweigh the costs. However, economic evaluation that includes non-market values of pest control (e.g. biodiversity gains) for a number of interrelated pest species at valued sites is likely to support pest management outcomes that reflect society’s changing values. While a council can still undertake this type of pest management, it is often done despite the Act rather than because of it. There is also a willingness of councils to collaborate to share information on site led pest management. Despite the interest in non-market valuation shown by regional councils, MAF and DOC, this has not manifested into support for analysis of this type.

Other future trends identified during stakeholder consultation are linked with related programmes being developed by MAFBNZ on performance measurement frameworks for pest management. Councils that manage pests using a “managing for outcomes” framework, find that their focus on pest management outcomes (seen as best practice) cannot be supported by robust economic information. An area where councils believe they lack access to reliable information is in the outcomes of pest management activities. Causal links between control activities and outcomes require robust relationships between these levels to have been demonstrated or monitoring of the outcomes following pest management activities. Once these links are established outcomes can be measured in a range of ways, an important measure for prioritising resources is the ability to measure outcomes in economic terms (dollar values) which can be done using non-market valuation and CBA.

Other areas identified as being important to regional councils include:

- a lack of data on what landowners spend individually on pest control as this would assist in understanding the total costs of species control;
- a lack of accurate data for some species on distribution and density, because for a number of pests council officers generally only visit properties when there is a non-compliance (usually brought to their notice by a neighbour);
- a view that economic analysis could be used more effectively if combined with technical data on species distribution and density to forecast where the pest could spread to within a region without action and the costs of control at various scenarios¹².
- Social research to understand the drivers behind landowner pest control would help councils communicate priorities to landowners. For example, in regions where landowners have a legacy of controlling certain weeds (e.g. gorse and broom) landowners have a “weed ethic” and are insistent that councils control weeds, despite a negative cost-benefit analysis. In these cases, landowners feel obliged to control weeds as a duty to continue the efforts of past generations and political pressure they exert can affect council priorities.

A national weeds database has been put forward as a necessary part of future pest management, although the same is also true of other pests. A national weeds database could be anchored with national experiences on managing weeds for the benefit of various regional pest management agencies. This information could include economic impact information and provide analysts with a reference point for making technical assumptions in other regions. MAFBNZ would be the logical host for a national weeds database although it may lack the resources to do so. The benefits of spatial information on weed distribution, is that this information would provide:

- an overview of national weed distribution and spread within and between regions,
- vital data for predictive tools on future spread;
- information that would lead to a more co-ordinated national approach to weed priorities and improved allocation of resources;
- information that could be incorporated with climate data to improve predictive tools.

While the above has been called for by some regional councils as a necessary part of future pest management, it is only useful if it is resourced to collect and update on a regular basis. Our review of economic information used by various local and central government agencies indicates that existing information on economic impacts could be utilised more effectively. Regional councils, for example, commission external consultants to prepare cost benefit analyses to justify the inclusion of pests in RPMS under Section 72 of the Biosecurity Act (1993). These analyses contain estimates of regional species-based economic impacts as a baseline to quantify the benefits of region council intervention. This information rarely makes it into the public domain (although it is available) and is generally not utilised by other agencies with similar pest challenges.

We make two recommendations to improve the utilisation of regional council “Section 72” analyses. These recommendations require MAFBNZ to co-ordinate with regional council biosecurity managers to:

- a) ensure that Section 72 analyses use a standard methodological framework;
- b) ensure that all analyses are held in a central MAFBNZ database on species impacts to help provide a more accurate understanding of a national assessment of impacts (developed over time) rather than a number of separate, unco-ordinated regional assessments.

¹² An example of progress in this area is Environment Southland’s use of predictive monitoring and modelling data to develop scenarios of pest spread to improve processes for prioritising invasive weeds.

This process is likely to take at least five years (over the time of RPMS reviews) but will improve the understanding of economic impacts and serve as a resource for all agencies. An important benefit of a national pest impact database is that MAFBNZ will have an improved national and regional view of the economic impact of pests which will assist with national prioritisation across sectors and regions.

Incorporating economic information into a weeds database by collating and analysing all Section 72 analyses undertaken at a region level would also improve the outputs of a national database.

2.3 GOVERNMENT DEPARTMENTS AND RELATED ORGANISATIONS

MAF Biosecurity New Zealand

MAF Biosecurity New Zealand (MAFBNZ) is the government agency responsible for managing pest incursions at the national level. MAFBNZ's pest management team deals with pests of national significance and with established organisms i.e. pests that are past the point where they can be dealt with as an incursion response. The process is guided by an Integrated Risk Management Framework (IRMF), based on formal risk management standards (AS/NZS 2004).

Economic information is produced using CBA to prioritise resources by assessing options for long term management. CBA also helps decide who is best placed to lead a long term management programme and is used as a part of MAF Biosecurity New Zealand's decision framework criteria. These criteria includes strategic fit, opportunities and barriers, available resources and economic benefits.

The IRMF is an interdisciplinary process with a strong economic focus. MAFBNZ's challenge with the IRMF is to balance economic, social/cultural and environmental aspects in their decisions to maximise net social benefit. The wider economic implications of pests and their management are also important to MAFBNZ and this information is used in tracking indicators in the MAF Performance Measurement Framework (e.g. economic output, Tb impacts on trade).

In assessing the costs and benefits of response options there is relatively good information about market impacts, but relatively poor information about environmental values, particularly how society values impacts on indigenous biodiversity. Quantitative information seems to receive greater weight than qualitative information and thus the imbalance is likely to result in decisions that under invest in areas where the benefits are difficult to quantify.

Currently MAFBNZ analyses economic information of pest impacts and interventions on a species basis although acknowledge that this approach has its limitations where a site-led approach maybe more useful. In this case non-market values are needed to evaluate site-led programmes. A review of the BSA is likely within the next two-three years. MAFBNZ expect the review to include revision of the species-led approach that is the current focus of the BSA.

While MAFBNZ generally takes a national perspective to industry specific economic impacts, it is also mandated to take into account risks to socio-cultural, environmental and human health values and interactions with other organisms (e.g. balancing biodiversity impacts of possums with economic and animal health impacts of Tb). Like other agencies MAFBNZ is interested in analysis methods that provide non-market valuations. This information is useful

to understand changes to the value of externalities generated by the sector's pest management interventions.

Department of Conservation (DOC)

DOCs pest management operations are driven by protection of biodiversity and conservation values rather than reducing the impact of pests on economic activity. As such it does not have a requirement for traditional (market value based) economic information, at least not to justify its pest management expenditure. In addition, DOC as manager of the conservation estate, is not bound by various RPMS, but endeavours to act as a "good neighbour" despite this. DOCs pest management operations are undertaken under its Natural Heritage Management System (NHMS) and mainly on the conservation estate to minimise the impacts of weeds and pests. Its operations are driven by the "managing for outcomes" based framework established under NHMS.

Aligned, but not directly related to the impact of pests on agricultural production, DOC is interested in the impact of pests on biodiversity and "ecosystem services" which are defined as services provided by the natural environment that benefit people (DEFRA 2007). DOC recognises that some ecosystem services are utilised for economic activities (e.g. tourism, drinking water supply) and DOC has recently undertaken analysis of this type on water supply near Dunedin (Butcher, 2006) and on the economic benefits of conservation (DOC 2006) using a series of case studies. These studies were commissioned by DOC as there is a growing realisation that ecosystem services actually underpin sustainable development and economic growth, and thus have a significant economic value, even though technically they don't have to be paid for. These types of studies also recognize that while ecosystem services are not paid for, they would be very difficult and very costly to remediate or replace.

The types of economic analyses undertaken to value ecosystem services are often based on regional population surveys to quantify the economic activity (in value added, house hold income) that is directly related to the conservation estate asset. In the case of the value of water supplies from a protected catchment (Butcher, 2006), values were based on the lower of either replacing the resource or finding an alternative water supply.

Understanding the value of DOCs pest management operations unrelated to tourism activities to quantify the "intrinsic" value of ecosystems is more complex and requires stated preference non-market valuation techniques (such as contingent valuation or choice modelling). DOC has expressed an interest in methods to understand the non-market value of pest management related conservation gains, although no major studies have been undertaken for DOC of this type yet.

Land Information New Zealand (LINZ)

LINZ manages biosecurity on Crown land under its administration and works with landowners, regional councils and other agencies to do this. LINZ is the lesser of a number of large landholdings although lessees generally have the pest management responsibilities (e.g. Crown pastoral leases and Crown forest licenses). Most of LINZ pest management operations are carried out on lake and river beds for aquatic pests. LINZ is not bound by a strategy but seeks to comply with the BSA where it can. Pest management operations are generally prioritised on a historical basis. With a relatively small budget (\$2 - 3 million) and mainly conservation values that are protected by pest management, no quantitative economic analysis is used to develop national priorities.

2.4 INDUSTRY ORGANISATIONS

Animal Health Board (AHB)

The Animal Health Board is an Incorporated Society and a Pest Management Agency with specific legal powers under the Biosecurity Order 1998 (National Bovine Tuberculosis Pest Management Strategy) or NPMS. The AHBs members represent the pastoral sector, as the main beneficiary of the AHBs mission -*the eradication of bovine tuberculosis from New Zealand* and local government. In the course of implementing the current strategy, AHB has developed effective capacity and systems for strategic disease and vector control planning, databases and information systems, contract management, research management, financial planning and management of contributors' funds, communications and stakeholder relations. AHB's skills, knowledge and capability to deliver a national pest management strategy are now at a very high level and are arguably unique in New Zealand (AHB, 2009).

AHBs pest control operations are funded by the Crown, industry and regional councils for the control of possums and ferrets as vectors of Tb. Under the BSA, the AHB is required to analyse the direct and indirect costs and benefits of all vector control operations. Analysis of the costs and benefits of the NPMS are required to be as broad as possible including social, economic and environmental aspects. The BSA sets out a number of requirements for economic analysis of a proposal to amend a national pest management strategy. The key requirements are:

- The actual or potential effects, beneficial or detrimental, that the implementation of the strategy might (in the proposer's opinion) have on the environment and the marketing overseas of New Zealand products.
- An analysis of the benefits and costs of the strategy and the reasons why a national strategy is more appropriate than a regional strategy or regional strategies.
- The anticipated costs of implementing the strategy.
- The basis, if any, on which compensation is to be paid by the management agency in respect of losses incurred as a direct result of the strategy.

The AHB places a high importance on sound economic information for its NPMS development and monitoring. Economic information is used to guide decisions on both strategic and operational levels. Operational activities are mainly driven by the NPMS itself. Economic costs and benefits of the NPMS are particularly important for the AHB in its consultation with the public and in justifying its strategy to government and levy payers.

Cost-benefit analysis including direct industry benefits and biodiversity benefits supports the adoption of either a sustained control or eradication strategy assuming a small degree of trade risk is associated with a TB control failure. Four potential options are modeled in AHB analysis including a "without" or ad-hoc response to TB spread scenario in the absence of an NPMS as the base case. This option must make assumptions on the response of the pastoral sector and regional authorities to undertake control activities on a regional or ad-hoc basis. Disease costs are estimated for the "without" scenario and the impact of national strategy in reducing these costs are then viewed as benefits (in the CBA) of the NPMS. Economic analysis undertaken by the AHB also estimates the allocation of benefits of the NPMS to stakeholders to justify proposed distribution of funding obligations (e.g. Crown, industry, regional authorities).

External consultants are engaged by the AHB for technical and economic analysis and economic costs and benefits are produced on a national basis rather than on a regional level.

The Aquaculture Industry

Aquaculture New Zealand is the combined industry organisation representing the views and membership of the individual species bodies, the New Zealand Mussel Industry Council, the New Zealand Salmon Farmers Association and the New Zealand Oyster Industry Association. Aquaculture NZ was also formed to implement the industry strategy released in 2006 which outlines the industry's vision and goals to 2025. The organisation is mainly industry funded and is focused on legislative reform and the creation and implementation of research and development and market development strategies. The Marine Farmers Association (MFA) was also consulted as the regional organisation representing mussel and finfish producers in the Marlborough- Tasman region.

The response of the MFA to the incursion of *Didemnum Vexillum* is an example of an excellent use of economic impact information (provided by NZIER 2008) for the industry to make a decision on whether or not to continue spending industry funds on controlling the organism. Unfortunately the analysis was undertaken following over two years of largely industry led and funded control and farmers made the decision to cease control efforts. Industry funded control also included benefits to the wider community as well as farm specific control.

There appears to be a need for improved economic impact information of potentially harmful pests that if found in the industry would need a rapid response to control or eradicate an organism. There was a call for a number of "off the shelf" theoretical analyses or economics based decision tools that would allow the industry to respond quickly to incursions. The speed of response to potential harmful organisms is critical for the marine industry.

While there are pests that have the potential to cause economic losses the main economic impacts of pests and disease for the aquaculture industry are due to efficiency losses (such as slower harvesting of green shell mussels) and increased processing costs and control measures rather than production losses. Other gaps in economic information for the marine industry are in quantifying pest related increased processing costs and reduced operational efficiency (e.g. bio-fouling of mussel lines and fin fish structures).

2.5 CONCLUSION

There are a number of findings that came from discussions with stakeholders on issues around developing and using economic information for making pest management decisions. The key findings are:

1. Smaller councils generally would like to have access to more economic impact assessments for prioritisation of pest management programmes but lack the resources to pay for the analysis.
2. While most regional councils value the economic information they get, in some cases councils commission CBA merely to demonstrate to stakeholders that due process has been followed in order to mitigate the risk of legal challenge.
3. The results of CBA work undertaken under Section 72 of the BSA are generally not presented in summarised form in the RPMS. This work is only available to the public on request.
4. There seems to be limited resources devoted to understanding economic implications of different control options although a number of agencies expressed an interest in this. Where organisations do have access to adequate economic impact assessment studies and CBA (e.g. in the case of MAFBNZ) comparative case studies on the economic implications of different control options are rarely carried out.

5. The BSA has become outdated and often regional councils act despite the Act rather than because of it. In particular councils refer to the difficulty in justifying the benefits of site led programmes given the requirement to demonstrate species by species pest control benefits under the BSA. Site led programmes are aimed at protecting places with significant environmental rather than economic values. This is relevant because the general public is becoming increasingly interested in the environmental and conservation benefits of pest management. This finding is aligned with previous think-piece work (LECG 2008 and Willis 2008).
6. There is strong interest in CBA that includes non-market values of biodiversity benefits of pest management. The expense of such research is a major barrier, and most agencies do not have the resources to fund such work.
7. Most regional councils interviewed were generally happy with the quality of CBA work although some were unaware of economic analysis work that had been undertaken for other councils. The benefit of sharing analyses is that biosecurity managers are able to consider the type of analysis being utilised by other councils and to frame questions for analysis that will meet their own needs.
8. That there are gaps in the quality of inputs used in economic evaluations, particularly in the understanding of the links between control activities and pest management outcomes. Once these links are established it will be possible to measure economic outcomes as an input in prioritising resources.

There is a call for simple tools to be developed for economic analysis by pest agencies and industry organisations. We do not recommend that simple tools be developed for the purpose of conducting in-house estimates of economic impacts and CBA unless completed by qualified economists. The risks of this approach are that high level estimates of pest impacts (and the benefits of intervention) are that these analyses will lead to poor decision making and economic information in general will be discredited. As a minimum measure to ensure data integrity, we recommend that an independent peer review process be applied to in-house analysis.

A challenge for policy makers is that the need (identified by councils) for site based pest management decisions cannot be supported with quantitative data until economic evaluation of environmental values is used more widely. This would seem to be a priority for further research.

Improved effort is also needed to identify key economic information from CBA analysis that the general public can easily understand to improve the value that regional councils derive from economic information.

The use of intervention logic and “managing for outcomes¹³” type approaches are varied amongst pest management agencies (Jones 2008). Despite this it will become increasingly important for pest management agencies to have the ability to monitor progress towards pest management outcomes. Often this will require the use of economic indicators. Developing causal links between pest management operations/outcomes and economic benefits (conventional and non-market) will become more important for all agencies. This is likely to lead to increased need of this type of economic information.

¹³ Programme introduced by the State Services Commission to encourage improved performance measurement and monitoring by local and central government departments and organisations.

3. A repeatable methodology for updating the economic costs of pests

The terms of reference for this work calls for a repeatable methodology for updating national economic costs of pests over five years including an assessment methodology and reporting framework that can be developed and updated in the future. This section presents a methodology and reporting framework for estimating the primary sector production losses and defensive expenditure committed by pest management agencies and funding organisations. Where aspects of the methodology cannot be carried out due to a lack of available data, recommendations are made to gather further data.

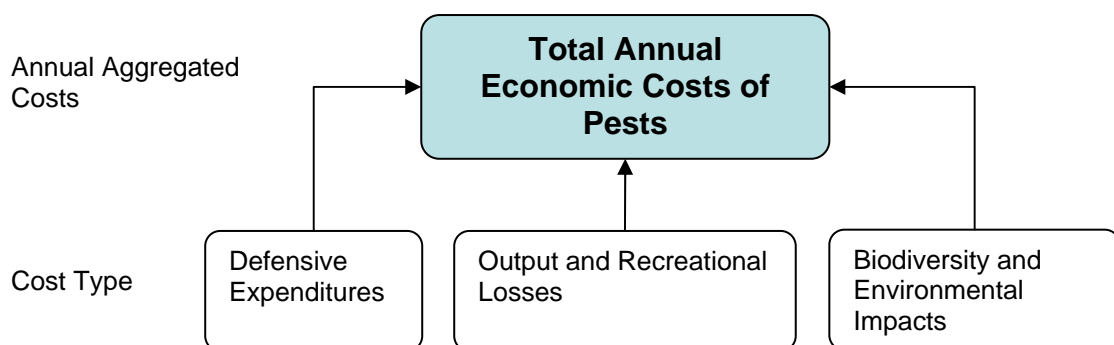
In making recommendations on a monitoring and reporting framework there are two key functions to be undertaken. The first is ongoing monitoring and collection of data by MAFBNZ to be included in updates of the economic impacts of pests. Ongoing monitoring will improve updates of the costs of pests. The second is undertaking CBA of pest management programmes aimed at reducing this cost, so that the decision makers allocate resources to the programmes with the highest net benefit. This section deals with both functions by setting out a framework for ongoing collection of data by MAFBNZ and then builds on the theory of economic impact and CBA provided in Section One to provide recommendations on undertaking CBA for pest management programmes. It is helpful to deal with each separately because collecting and maintaining good quality impact data will improve the outputs of CBA.

As outlined in Section Two CBA is mostly undertaken by contractors for pest management agencies. There may be potential for individual pest impact assessments to be carried out by unitary authorities, industry organisations and other pest management agencies, provided they have the in-house expertise and the resources. Collation of national aggregated data should be done by MAFBNZ and the framework set out in this section provides guidance on how to do that. Impacts also include multiplier impacts on employment and economic output, although there is a lack of recent data on these types of impacts.

3.1 ONGOING MONITORING AND COLLECTION OF IMPACT DATA

The diagram below sets out the three main types of cost information that MAFBNZ needs to collect in ongoing updates of the economic costs of pests.

Figure 2: Components of Annual Economic Costs



The table below sets out the type of information needed and assumptions to be made so that ongoing monitoring of economic information can be undertaken and linkages made with the performance of pest management.

In linking economic information with pest management performance it is important that pest management agencies include economic measures and indicators in their logic models and performance measurement frameworks. Economic indicators should be included under intermediate economic outcomes. Examples of intermediate economic indicators for a pasture weed pest such as buttercup are product output per hectare (e.g. milk solids, meat) or pasture dry matter yield per hectare. Economic indicators for biodiversity pests need to be developed overtime using non-market valuation techniques such as choice modelling (see Section One). In this way it would be possible to put economic values on changes in indigenous biodiversity enhanced by pest control and described to participants in a choice modelling survey. Before economic indicators could be reliably linked with changes in biodiversity, more research is needed to develop causal links between pest management activities and changes to biodiversity or other desirable environmental outcomes.

Table 3.1 Economic data gathering framework

Cost Type	Data Sources	Steps and Assumptions
Defensive Expenditure Central government Industry organisations Total Annual Economic Costs of Pests	Annual Plans and Reports	Collect annual expenditure (GST inclusive) by category from key agency annual reports. Use following categories: <ul style="list-style-type: none"> • Border Control- Customs • Quarantine- MAFBNZ • Pest Surveillance and Response- MAFBNZ • TB vector control- AHB • Pest control on conservation estate-DOC • LINZ- lake and river bed • Policy advice- MAFBNZ • Standards, enforcement, approvals- MAFBNZ • MAFBNZ Other¹⁴ • FRST Research
		Verify expenditure figures with managers from MAF, MFish, DOC, LINZ, FRST, MoH and any other relevant public sector organisations.
		Review annual expenditure from industry organisations (e.g. AHB)
		Update FRST data on biosecurity related research funding and include as a defensive expenditure.
Regional Unitary Authorities	RPMS, LTTCP and Annual Reports	Populate table based on annual expenditure from regional council and unitary authorities on annual pest control expenditure using annual reports and verify with Biosecurity managers. Ensure that AHB payments for TB vector control operations are not double counted with AHB expenditure.
Private Sector	MAF Farm Monitoring Pest Expenditure Data	Gather MAF Farm Monitoring data (contained in Sector Monitoring Reports with budgets) on weed and pest expenditure for the following farm types: <ul style="list-style-type: none"> • Sheep and Beef • Dairy

¹⁴ Select committee financial review (2008). In addition, since 2005, MAFBNZ have provided all biosecurity services for the Ministry of Fisheries.

Cost Type	Data Sources	Steps and Assumptions
Output and Recreational Losses	Regional and national economic output statistics	<ul style="list-style-type: none"> • Deer • Arable • Horticulture <p>Match regional weed and pest control expenditure per hectare with total hectares by farm type in each region. This will give total estimated primary sector private sector defensive expenditure. Required data is held by MAF to estimate total annual farm expenditure on weed and pest control (note this doesn't include cost of labour). See Appendices for example tables.</p> <p>Work with industry economics organisations (i.e. Meat and Wool Economic Service, DairyNZ, HortNZ) to improve data on primary sector labour expenditure on weed and pest control.</p> <p>Gather household and commercial private sector expenditure on weed and pest control overtime and incorporate into the primary sector data.</p>
	Economic literature of pest impacts	<p>Review all existing economic analyses for individual pest species (including from MAFBNZ data) and identify annual production losses as done in this analysis. Collate production losses by sector and include the year it was estimated. Adjust production losses for pest management programmes and pest spread since time of analysis. Expressed dollar values today's values (i.e. the year the estimate is made).</p> <p>Update primary sector industry economic multipliers (using input-output tables released in 2009) so that impacts on employment and GDP output can be incorporated in the national costs.</p>
	Reduced production of goods and services	
Reduced amenity and recreational use	S.72 analyses on regional output losses	<p>Develop a national database of economic output losses by collecting and reviewing all Section 72 CBA information held by regional authorities so that annual production losses are collated in a data</p>

Cost Type	Data Sources	Steps and Assumptions
Biodiversity and Environmental Impacts	Linking pest control operations with costs	<p>base for each region and each species. Specific information needed from each CBA is outlined below.</p> <p>As better quality inputs become available that can develop links between pest control operations and outcomes, use this information to develop relationships between pest prevalence, distribution and density (stored in a national database) and estimates of production and control costs.</p>
	Other important information	<p>MAFBNZ should wherever possible invest in improving the knowledge on both impact of pests and the effect of control measures as even if a standard methodology is developed the results will be limited by the quality of inputs.</p>
	Results of non-market valuation projects that estimate the economic value of environmental benefits and link this to pest management outcomes.	<p>Work more closely overtime with the marine farming industry to fill the gaps in knowledge on economic impacts of pests to the sector. Keep abreast of developments in non-market valuation.</p> <p>As outlined in Section one there is a lack of reliable New Zealand based data in this area. MAFBNZ should work with other agencies interested in this type of information and to commission non-market valuation research.</p>

Table 3.2 Template for gathering species information from Section 72 analyses
The table below sets out template for recording Section 72 analysis data into a database.

Data	Information	Assumptions
Pest type	Plant or animal. Vertebrate/ invertebrate Freshwater Marine Terrestrial	Break data down by species where possible.
Sector impacted	Agriculture Land recreation Biodiversity	Some species may have impacts in more than one sector.
Current spread	Within the region analysed.	Hectares
Public sector control costs. Estimated cost of control	RUA expenditure. Central government expenditure.	Ensure that private sector expenditure does not double up on MAF Farm Monitoring estimate.
Annual private sector control costs	Annual expenditure per hectare.	Ensure that this estimate is not double counted with national estimate of private sector expenditure, i.e. this value will be useful for verification with MAF national estimate and as a cost per species.
Estimated output losses	\$ per hectare	Use existing measures of output loss. This is most likely to be weighted average gross margin, or economic farm surplus per hectare. Update inputs for key variables, such as: product prices (10-20 yr real ¹⁵ average) and inputs.
Rate of spread/ years to infest TAPI	Estimate spread without control over period of the analysis (e.g. 20 years).	Hectares per year.
Total area potentially infested (TAPI)	Area within the regional council region.	Hectares
Any benefits provided by infestation.	E.g. suppression of other weeds	In dollars
Discount rate	Use default Treasury assumptions to calculate appropriate discount rate.	Use the discount rate calculations and assumptions provided by the Treasury.
Annual Costs		Section 72 CBAs will have estimated costs on an annual basis. Include costs in relevant year to quote annual cost.
Value of losses prevented by landholder control	Estimate of reduction in losses	Reduction in total costs assuming that landholders will take some action against further spread.

¹⁵ Ensure that all product prices or relevant input costs use either current government returns (gross margin/EFS) or are 10-20yr average prices adjusted for inflation.

Use of collated CBA information

Once Section 72 data is collected we recommend that the data is stored in a database that records the above information by region and species. Database assumptions should be able to be updatable every time MAF undertakes an assessment of the annual cost of pests and should be kept current with reviews of Pest Management Strategies.

3.2 IMPORTANT ASPECTS OF A REPEATABLE METHODOLOGY FOR CBA-RECOMMENDATIONS FOR FUTURE ECONOMIC ANALYSES

In recommending a consistent approach to undertaking CBA, we reviewed previous work on recommending best practice in CBA by Mumford (1999). Mumford listed some common criticism of CBA for pest incursion responses and we have highlighted those that are relevant to developing a repeatable methodology and are not identified earlier in Section One. For each common criticism we have outlined what we recommend to address these gaps. An example CBA is provided as an update to a previous impact assessment on clover root weevil (NZIER, 2005) to draw together identified gaps and recommended best practice and is included in the Appendix 7.

- a) Time scales used in analyses are often inappropriate (generally too long on benefits, given the risks of reinvasion and other uncertainties);*

We recommend that 15 – 25 years is long enough to assess the impacts and relevant costs of benefit publicly funded pest interventions.

- b) Discount rates are inappropriate (generally too high, especially for irreversible invasions of natural environments and for health impacts)*

Discount rate calculations should be undertaken for each analysis. This way an appropriate discount rate is used for the type of investment and accounts for changes in the Crown's weight average cost of capital.

- c) Spatial resolution is inadequate and does not reflect variability or localisation of impacts*

All analyses should at least have some input or peer review from technical specialists familiar with pest distribution and spread for the regions analysed.

- d) Distribution issues need to be included separately from CBA and are not addressed adequately and appropriate allocation of benefits are not taken into account, nor is moral hazard represented in recovering costs (e.g. state intervention discouraging people from taking reasonable steps to reduce their own exposure to risk).*

As outlined in Section One, the analyst needs to make appropriate consideration of how costs may be transferred between sectors (private and public, agriculture and recreational landusers) and decide whether this is material to decision makers. For example, if a pest management intervention is being used to justify and quantify the imposition of a levy on a group of landusers, then distributions issues (e.g. identifying exacerbators and beneficiaries of a proposed pest management programme) need to be addressed.

- e) Market and price impacts are not included adequately such that pest affected production causes changes in product prices or trade shocks or change in disease status (although predicting trade impact can require complex modelling).*

For simple cost-benefit analysis to be undertaken by Regional Councils and Unitary Authorities (RUAs) and low level MAFBNZ analyses, accounting for impacts on trade should be left. For pest and disease outbreaks that have major trade implications, (e.g. a FMD outbreak) then analysts with specialist trade models should be used.

f) Environmental values and other intangibles are covered inadequately (generally ignored).

Including environmental values is problematic without robust non-market valuation data. Where decision makers are prepared to invest in project specific non-market valuation, including environmental values would enhance CBA, otherwise attempts to quantify environmental values are likely to be erroneous.

g) Analyses do not include dynamic variables adequately (they often assume all variables remain constant).

Flexibility in dynamic variable values (such as control costs per unit of pest and product prices) should be accounted for where this can be done with certainty (i.e. where pest control costs are likely to increase per unit, meaning that the last possum in a region will be a lot more expensive to kill than the first, then this should be accounted for in cashflows). Historical averages (adjusted for inflation) should be used when using product prices. Where the impact of pest management on a population is used in a CBA, a range of values should be used an modelled using risk simulation.

h) Too often cost benefit analysis is used as a post-event justification rather than as a pre-event decision aid

CBA is most useful prior to decisions are made on resource allocation and is a requirement for regional and national pest management strategies.

Cost-benefit analyses should contain a number of key elements. A repeatable methodology for undertaking cost-benefit on pest management decisions should include the steps below which are adapted from earlier recommended CBA steps (Mumford, 1999). New Zealand Treasury also has a guidance document that provides basic guidance on steps in undertaking CBA¹⁶. These steps relate specifically to conducting cost-benefit analysis of one or more options for the control of an unwanted organism or pest.

1. Define the problem including background on infestation and previous control responses and determine the desired outcome of the proposal.
2. Select the control options- likely to involve consultation with a TAG as it can be a complex task.
3. Specify the baseline scenario and period of the analysis.
4. Estimate control costs for the control options.
5. Identify the effects of the control options (i.e. what benefits will arise from the control options).
6. Quantify the magnitude of these benefits and set these out in a cashflow over a defined period (15-25 years) by considering the timing of the costs of the pest and when pest management benefits will take place.
7. Discount annual costs and benefits so that these are presented as present values (today's dollars).
8. Consider the effect of any intangible costs and benefits that could not be reliably assigned monetary values.

¹⁶ New Zealand Treasury (2005). Cost Benefit Analysis Primer

9. Perform sensitivity analysis to account for risk and uncertainty.
10. Report on the CBA

In practice these steps may also require: setting the scope and limitations of the analysis; forming a technical advisory group to verify assumptions; identifying uncertain variables and apply risk analysis; and presenting results in plain language, briefly explaining methodology, limitations and basis of important assumptions.

While having technically robust analyses is critical for decision makers, expressing economic information in a user friendly manner is also important. Nimmo-Bell has found that expressing the benefits of public funded intervention as a ratio against dollars spent is a useful measure. The hypothetical example below illustrates:

Regional council annual expenditure on Weed A	\$0.5 mill
Benefits of Weed A control	\$2.0 mill
Net-benefit of intervention	\$1.5 mill
Net-Benefit/Cost ratio	$(1.5/0.5) = 3.0 / 1.0$

This can also be expressed “*as every \$1.00 spent by the council controlling weed A produces net regional economic benefits of \$3.00.*”

The next section reviews and updates existing work on the national economic costs of pests on the economy.

4. Assessment of the current economic cost of pests to New Zealand

4.1 INTRODUCTION

New Zealand has a large number of introduced species. Some have provided positive economic impact such as sheep and cattle. Others have turned out to be harmful to the economy and/or for indigenous ecosystems and are considered pests.

An indicative estimate of the economic costs of pests to New Zealand is not possible without individually assessing the large number of introduced plant and animal pests and the complex interactions these have on New Zealand's primary production systems, health, cultural and amenity values. There are very few studies that have estimated the economic costs of animal and plant pests to the economy. Bertram (1999) is considered as a benchmark study. This study estimated that the directly quantifiable impact of pests on the New Zealand economy was \$840 million each year. This estimate was the sum of output losses from agriculture (\$400 million) and defensive expenditure spent by the private and public sectors on pest control.

In a subsequent study that analysed the status and potential solutions to pastoral weeds, Bourdot *et al.* (2007) estimated total aggregate costs of pastoral weeds to the economy of \$1.2 billion per annum. This may be compared with a recent estimate of the impact of weeds in Australian agriculture of A\$3.5–4.5 billion (Sinden *et al.* 2004). Quantifying the economic costs of biodiversity impacts of pests has only been undertaken on a limited basis in New Zealand.

Bertram divided the measurable economic costs of pests in New Zealand into two major components: defensive expenditure (the costs of controlling pests) and production losses (foregone economic output). Bertram also noted, but did not quantify, a third category of costs refers to the damage caused by pests to New Zealand's indigenous biodiversity and environmental values. These losses can also be referred to "welfare losses" and can only be measured in dollar terms indirectly through non-market stated preference techniques including contingent valuation and choice modelling. In estimating the total costs of pests to the New Zealand economy, it is important to distinguish between revealed willingness to pay for control activities and damage for which individuals and society as a whole have a stated willingness to accept.

Some costs are able to be assessed with a reasonable level of certainty. These are mainly control costs by key agencies including:

- regional councils;
- industry organisations, such as the AHB
- government ministries with an interest in pest management (Ministry of Health, Ministry of Fisheries, MAFBNZ)
- government agencies with a role in control and management of land assets such as DOC and LINZ.

Other significant costs include production losses. The next section reviews analyses undertaken on the most significant pests to the New Zealand primary sector and conducts a brief analysis of shifts in economic impacts. Previous impacts are adjusted for inflation to

2008 dollars. This provides an indicative assessment and highlights areas of uncertainty where known.

The analysis below quantifies the economic costs of defensive expenditures and production losses by updating data from previous analyses. In addition, MAF farm monitoring data is analysed to estimate private sector expenditure. We have used estimates contained in existing analyses and have identified gaps in the economic cost literature later in this section. A full list of analyses is included in Appendix 8.

The classification of economic costs into defensive expenditure and output losses is the most appropriate classification with current data. These two broad groupings can also capture losses that occur as a result of damage to assets and recreational impacts. In some instances a control programme (e.g. Tb control) may result in output losses for an individual (e.g. movement control) although it may result in a transfer when considered on a national basis. In cases where a single programme covers both types of costs, we have attempted to separate the costs.

4.2 ECONOMIC COSTS OF PESTS

4.2.1 Defensive expenditures

Defensive expenditures include quarantine and border control costs, surveillance, research, pest control, and eradication programmes. MAFBNZ operates a formal system for decision making regarding management response to new incursions. Once established, however, pests present the dilemma of whether to control their numbers and/or spread or to eradicate them. Eradication is not an option for many widespread and long-established pests, primarily because it is not cost-effective, and so sustained pest control is a major feature of public-sector activities to minimise the negative impacts of pests on society.

Central and local government

A survey of annual reports from central government agencies and regional councils was undertaken to estimate the total value of expenditure on biosecurity (policy, surveillance, quarantine etc.) and pest control operations. Not all biosecurity expenditure is able to be clearly identified from annual reports and so total expenditure is probably an under-estimate.

Regional council Biosecurity Managers were contacted for this study to supply data and verify estimates. Regional council annual reports have been used as the primary basis for estimating annual pest expenditure by local government. The table below shows that the estimated regional council expenditure on pest management is around \$41 million per year. The figures are GST exclusive as is reported in annual reports and LTCCPs (Long Term Council Community Plans). A GST inclusive figure is shown so that it can be added to other expenditure and compared to GDP which is measured using GST inclusive market prices.

Table 4.1: Annual Weed and Pest Expenditure by Regional Councils

	Plants	Animals	Total
Regional Council	\$000 (2008)		
Northland	600	600	1,200
Auckland	2,700	2,350	5,050
Waikato	3,104	2,634	5,738
Bay of Plenty	1,620	1,080	2,700
Hawkes Bay	639	1,647	2,286
Gisborne DC	414	414	828
Manawatu- Wanganui	1,721	1,787	3,508
Taranaki	403	1,671	2,074
Greater Wellington	1,065	1,296	2,361
Tasman	473	229	702
Marlborough	827	238	1,065
West Coast	5	5	10
Canterbury	2,294	1,461	3,755
Otago	500	300	800
Southland	2,400	2,400	4,800
Total Annual Expenditure	18,765	18,112	36,877
Total GST Inclusive	21,111	20,376	41,487

Source: Annual Reports & RPMS

Central government expenditure on pest control is concentrated in two areas: Biosecurity and Department of Conservation. The pest expenditures are categorised in the table below into major groups from the annual reports of MAF, DOC, MFish and LINZ. Reviews of these organisation's documents cover public defensive expenditure across the main primary sectors including, pastoral agriculture, arable, horticulture, forestry and fisheries.

The current annual investment in biosecurity science in New Zealand is broadly estimated at \$37 million¹⁷. Approximately 60 percent of this funding is provided by central government through The Public Good Science and Technology Fund managed by FRST. Another 30 percent is delivered through research funds provided by those agencies with biosecurity responsibilities. A small amount of funding is also provided by regional councils and by industry directly and indirectly through in-kind support, although this is difficult to quantify. An estimate of Foundation for Research Science and Technology (FRST) contestable funds signalled has been made by MAFBNZ and is approximately \$15 million (MAFBNZ, 2009 pers comm.). This research includes identifying, assessing and responding to pest threats to native biodiversity and environmental integrity, natural resources and facilitating shifts in society's understanding and values.

Table 4.2 FRST Investment in Biosecurity Contestable Funding

	Funds per year (\$000)
Resilient, Functioning and Restored Ecosystems (ECO)	5,556
Sustainable Productive Systems (SPS)	7,168
Production, Quality and Assurance (PQA)	1,500
Maintaining Environmental Integrity for Sustainable Resource Use (SRU)	674
Total	14,898

Source: MAFBNZ

¹⁷ A Biosecurity Science Strategy for New Zealand, October 2007

The Department of Conservation manages eight million hectares of native forests, tussock lands, alpine areas, wetlands, dune lands, estuaries, lakes and islands. This is about 30 percent of New Zealand's land area. DOC is responsible for preserving and protecting these areas, including managing threats to them from invasive weeds and pests. In 2006/07 DOC estimated that it spent approximately \$74 million in pest management and \$2 million on meeting the Crown's obligations as a "good neighbour" by undertaking work consistent with regional council RPMS (Hellstrom 2008).

The table below shows the central government expenditure broken down by function and department.

Table 4.3: Total annual weed and pest expenditure by central government

Central Government	Annual Costs (2008) \$mill
Border Control- Customs	119.0
Quarantine- MAFBNZ	65.4
Pest Surveillance and Response- MAFBNZ	45.3
Pest control on conservation estate-DOC	76.0
LINZ- lake and river bed	2.5
Policy advice- MAFBNZ	10.9
Standards, enforcement, approvals- MAFBNZ	28.5
MAFBNZ- Other	34.0
Biosecurity science research- FRST	22.2
Biosecurity science research- Other	14.8
Total Central Govt Expenditure	418.6
Total Central Govt Expenditure (GST Inclusive)	470.9

Source: Annual Reports and government statistics

Private Sector

The private sector also undertakes substantial expenditure on animals and plant pests. An analysis of average farm expenditure on "Weed and Pest Control" was undertaken using MAF Farm Monitoring Report data from 2007/08 and forecast figures for 2008/09 across the sheep and beef (and deer), dairy, horticulture (including pipfruit and viticulture), arable and vegetable sectors. These data were extrapolated up to regional and national levels using corresponding MAF sourced farmed areas. Weed and pest control does not fluctuate a great deal in most sectors, although with recent low income levels in the sheep and beef sector, the average spend is likely to be understated. Table 4.4 summarises average expenditure on pest control by sector. The data aligns with the inflation adjusted estimates by Bertram (1999) of \$242 million and Hellstrom *et al.* (2008) of \$350 million.

Household pest related expenditure lies below the household economic survey conducted by Statistics NZ (roughly 0.1-0.2 percent of expenditure) and for this reason was not included in the Bertram study. A telephone survey was conducted of hardware and garden centre stores to estimate the percentage of national sales on weed and pest control. These estimates were combined with Statistics NZ data on household expenditure by store type so that an estimate of total household expenditure could be. This survey indicates that household expenditure on pest and weed control is likely to be around \$28 per year or annual aggregate total of around \$42 million. Data on business expenditure (outside the primary sectors) could not be sourced and is an area for further research.

Table 4.4: Estimated private sector cost of on-farm weed and pest control (\$mill)

Sector	2007/08	2008/09
Sheep & Beef	59	64
Dairy	44	48
Deer	21	21
Arable	45	52
Horticulture	126	125
TB vector control -AHB ¹⁸	52	55
Household expenditure	40	42
Total (GST exclusive)	388	407
Total (GST inclusive)	437	458

Source: MAF Monitoring Reports, See Appendix 6- Tables- Primary Sector

The cost of weed and pest control included in MAF Farm Monitoring models does not include the cost of labour (as this is included in wages). Therefore the true cost of controlling animal and plant pests for the private sector is likely to be higher than indicated above. Research on the impacts of weeds conducted in Australia, for example, estimated the financial cost of controlling 15 different weeds in seven crops at AU\$1,182 million in 1998-9 (Jones *et al.*, 2005). About one-half of the financial cost was the cost of herbicides to control the weeds (*ibid.*). A similar estimate was calculated by the Cooperative Research Centre for Australian Weed Management (Sinden *et al.*, 2004). This would suggest that the actual cost of controlling weeds and pests could be up to twice the cost stated above i.e. up to \$600 million per year, when labour costs are included¹⁹.

Williams and Timmins (2002) assumed that the proportion of private sector expenditure on plant pests was similar to the share of regional council proportional expenditure. This was estimated (by Williams and Timmins, 2002) at 14.7 percent based on a survey of regional councils and exclusive of bovine Tb. Our own survey indicates that the amount spent on plant pest control is roughly 50 percent and we have chosen to take a mid point of 32 percent. Therefore, we estimate that of the total \$458 million spent on weed and pest by the private sector approximately \$311 million is spent on animal pests and \$147 million on plant pests.

Private expenditure on recreational deer hunting has been estimated at \$20 million in the past (Nugent and Fraser, 1993) and might be considered as part of the cost of deer control. However, this expenditure type was not included in Bertram (1999) and is not included here as it does not represent a diversion of resources from other valued uses for the purpose of pest control, since the primary reason for hunting is recreational. The \$20 million estimated as the private expenditure in 1993 (\$27 million in 2009 values) represents the value of recreational hunting itself rather than the value of control.

Total Defensive Expenditures

Table 4.5 estimates the total defensive expenditure costs of pests and weeds to New Zealand. Previous studies have estimated the total value of defensive expenditures at approximately \$440 million dollars or 0.46 percent of GDP (Bertram 1999). The 2008 National Accounts show that New Zealand's GDP was \$177 billion. The total defensive expenditure of \$970 million represents 0.55 percent of GDP and is therefore similar to Bertram's earlier estimate.

¹⁸ AHB operations are approximately 55% funded by the pastoral sector, other funders include the Crown (35-40%) and regional councils (5-10%).

¹⁹ The 2007/08 season was affected by a severe drought in both islands. Costs of weed and pest expenses in 2007/08 is likely to understate the ongoing annual costs weed and pest control as farmers tend to spend less in this area during periods of low prices or drought.

Table 4.5: New Zealand's Total Defensive Expenditure

Total Annual Defensive Expenditure (\$ million)	
Regional Councils	36.9
Central Government	418.6
Private Sector	407.0
Total (GST exclusive)	862.5
Total (GST inclusive)	970.3
Defensive expenditure as a % of GDP (2008)	0.55%

4.2.2 Output losses

The direct economic costs in terms of loss of production in agriculture, horticulture, and forestry were estimated by Bertram (1999) as \$358 million for a range of significant animal and plant pests²⁰. Inflation adjusted to today's values, this figure equates to \$407 million in 2008 dollars.

We have analysed a number of previous studies and estimated annual production losses have been estimated from these studies by adjusting output loss related costs and excluding non-primary sector costs. Annual output losses (including future losses) have been estimated by identifying relevant values in earlier studies and adjusting for inflation into 2008 values. A total of eight animal and plant pests were analysed at a national level in addition to those in Bertram (1999).

Table 4.6 summarises the annual costs of a selection of pest related production losses incurred by the agriculture, horticulture and forestry sectors from selected pests. Due to the lack of more robust monitoring of pest losses and review of only significant pests with available data, this is likely to understate the production losses. In reviewing the economic analyses on the costs of pests, care was taken to include only the actual losses currently being incurred, rather than potential losses used to justify a pest management programme.

Total production losses are at least \$1,292 million in 2008 dollars. The figure compares to previous estimates of \$407 million by Bertram (1999), however, the number of invasive pests has increased and the new figure contains the losses related to nine new invasive species. Care was taken to use the actual production losses estimated in each study without including the costs of defensive measures already estimated in the analysis above.

Table 4.6: List of common invasive species and associated annual production loss

Species	Reference	Annual Cost in 2008 dollars (million) ²¹
Clover Root Weevil	(NZIER, 2005)	312
Forestry Sector	(MAF/NZFOA 2006)	214
Argentine Stem Weevil	(Bertram, 1999)	160
Giant Buttercup	(Boudot et al. 2003)	177
Rabbits	(Bertram, 1999)	50
Possums	(Bertram, 1999)	52
Bird Losses- Viticulture	(FAR, 2008)	10
Bird Losses- other crops	(NZIER, 2007)	33

²⁰ Argentine stem weevil, rabbits, possums, Californian thistle, clover root weevil, gorse and blackberry, rose grain aphid, powdery mildew, wasps and other (10%).

²¹ Annual costs were derived from the key references stated. The method for calculating the annual cost differed depending on the available information in each report. See appendix for more detail.

Species	Reference	Annual Cost in 2008 dollars (million) ²¹
Didymo	(NZIER, 2006)	24
Californian Thistle	(Bertram, 1999)	26
Gorse	(Williams and Timmins 2002)	31
Sea Squirt	(NZIER, 2005)	15
Varroa	(MAF 2000; Varroa EIA Model 2008)	15
Gum Leaf Skeletoniser	(MAF, 2003)	13
Rose grain aphid	(Bertram, 1999)	12
Powdery Mildew	(Bertram, 1999)	9
Lucerne Aphid	(Goldson et al., 2005)	8
Blackberry	(Bertram, 1999)	6
Wasps	(Bertram, 1999)	2
Didemnum Vexillum	(NZIER, 2008)	1
Other (guess 10%)	(Bertram, 1999)	125
Total	(GST Inclusive)	1,292

4.2.3 Gaps in our knowledge of pests

The animal pests listed in Appendix 9 are those for which are included in RPMS as a potential starting point for identifying priority pests. It also provides MAF BNZ with a useful reference point to prioritise investment in valuing economic costs for pests not included in this assessment. Most have regional economic impact information although few (the main exception being possums) have national costs estimates. Developing national costs estimates for pests included in RPMS should be achievable using the method of analysing Section 72 CBA analyses (of the BSA) outlined in Section Three. National cost estimates for the seven most common (i.e., common to RPMS) should be a priority for future updates of the national economic costs of pests. The animal pests that are most commonly included in RPMS by regional councils are:

Pest	Included in RPMS
Possums	13
Rook	13
Rabbit	11
Feral cat	9
Goat	7
Magpie	7
Mustelids	7

These are listed by pest management agencies as either serious threats to indigenous flora and fauna or cause significant costs to New Zealand primary sector or recreational amenity values. A consolidated list of environmental weeds in New Zealand (Howell 2008) notes that it is impossible to produce a top 100 nationally worst weeds from the list of environmental weeds produced because of the difficulties in describing taxa and because of their range of habitats and coverage. Incorporating market and non-market economic values into a list of potentially worst weeds would clearly make it easier to rank weeds, as well as animal pests.

Appendix 9 contains a list of pests included in RPMS. To justify inclusion in RPMS each pest will have some level of economic impact information and is a logical starting point for MAF BNZ to gather further information on national economic costs as outlined in Section Three.

4.2.4 Total economic costs of pests

The total economic cost of pests to New Zealand's primary sector by reviewing a selection of significant pests is therefore estimated to be roughly \$2.26 billion per year (although the actual cost is likely to be higher). Of which \$970 million (45 percent) is defensive costs and \$1,292 million (55 percent) is the cost of output losses.

Table 4.7: Total economic value of pests in New Zealand

Area of impact	2008 \$ million
Defensive Expenditure	970
Production Losses	1,292
Total	2,262

Multiplier effects of production losses

Including the up and downstream impacts of pests on primary sector output accounts for the economic impacts on GDP and employment. This is done using multipliers. The multiplier effect indicates the relationship between some observed change in the economy and the amount of economic activity that this change creates throughout the economy. Multiplier analyses are often used to estimate the impact on the New Zealand and regional economies of various projects and events. In this case a multiplier assessment is used to analyse the flow on effects of reduced revenue in the primary sector due the loss of production caused by invasive pests. It is likely that the true economic costs are much greater than the production losses alone.

We have reviewed two previous studies that estimated the multiplier impacts of changes to agricultural output. Butcher (1993) found the multiplier effect of output throughout New Zealand's primary sectors in the early 1990s ranged from 2.5 to 2.9. This analysis assessed the trends in primary sector economic multipliers and found that multipliers had been declining since 1976/77. With continued on-farm factor productivity improvements over the past decade we have estimated that downstream economic impacts from pest related output losses are likely to range from 1.8 to 2.0. Therefore applying a multiplier of 1.9 to the calculated cost of pests (\$1,292m) increases the economic cost of invasive pests to \$2,454 million. This potential economic cost may be somewhat offset by increased employment in the Biosecurity sector.

This would bring the total costs of defensive expenditure and production losses to \$3.424 billion or 1.93 per cent of GDP²². The total cost excluding multiplier impacts is \$2.262 billion or 1.40 percent of GDP.

Table 4.8: Total economic cost of pests to New Zealand including multipliers

Area of impact	2008 \$ million
Defensive Expenditure	970
Production Losses (with multiplier)	2,454
Total	3,424

4.2.5 The cost of pests and weeds to indigenous biodiversity

A 1999 study suggested that the total annual value provided by New Zealand's indigenous biodiversity could be more than twice that of New Zealand's gross domestic product (GDP)²³

²² The total cost excluding multiplier impacts is \$1.801 billion or 1.02 percent of GDP

(although this estimate relied mostly on overseas data). The annual value of indigenous biodiversity on land in 1994 was estimated at \$46 billion made up of \$9 billion from direct uses (including food and raw materials from agriculture and horticulture and timber from forests), \$30 billion from indirect uses of ecosystem services, and only \$7 billion came from passive values, namely existence value (value from knowledge of continued existence) and bequest value (the value of preservation for future generations). GDP for the same year was \$84 billion. In 2006 DOC commissioned a study to estimate the value of biodiversity to the New Zealand economy. The work used a number of case studies²⁴ to measure the total dollars spent by tourists and economic activity generated by national parks/conservation area. This value came to \$920 million per year. This study expressed economic impacts in ways that are familiar to non-economists: jobs created; household income: value added; and total output.

An assessment undertaken by Williams and Timmins (2002) used the conservation component of the value land-based biodiversity developed by Paterson and Cole (1994) (\$26 billion of a total of \$43 billion) to estimate that weeds cause a loss of native biodiversity worth \$1.8 billion. Adjusting for inflation this represents a value of \$2.04 billion in 2008 dollars and would bring combined economic costs of pests to \$5.2 billion per year or approximately 3 percent of GDP. We have not included these costs in our estimate as the values are based on overseas data and more widespread application of non-market valuation methods is needed before these costs can be included.

4.2.6 Use of a macroeconomic indicator and the limitations of GDP

The previous section compares today's costs of pests to GDP as the Bertram study did in 1999. Choosing a macro economic indicator is difficult because the non-market costs of pests are not easily captured in existing measures of economic performance. For example, GDP measures an economy's total value of output. Using this measure a pest incursion that has an impact on indigenous biodiversity and requires government resources to control or eradicate the pest (and jobs created by this) may in fact increase GDP. The same situation occurs in response to crime or health problems. For this reason GDP has its limitations as a declining effectiveness of pest management programmes may result in short term increases in GDP.

There are currently few, if any, reliable alternatives to GDP to measure the costs of pests against. Using GDP as a macroeconomic indicator, we have estimated that the costs of pests to New Zealand equates to 1.4 – 1.93 percent of GDP depending on whether the up and downstream impacts of production losses in the primary sector are included in the estimate. Percentage of GDP accounts for changes in the value of output losses and also accounts for defensive expenditure by central and local government as a proxy for society's 'willingness to pay' for pest management outcomes. Despite its limitations using current economic information this is an adequate indicator. In the future as more sophisticated information on the non-market costs of pests are more fully understood, MAFBNZ will be able to explore new measures. An indicator linked to a Genuine Progress Indicator (GPI) is likely to be the most appropriate future measure.

GPI is a progress or wellbeing indicator that incorporates not only the value of economic output but takes stock of changes to New Zealand's social and natural capital. The concept of a GPI is based on the sustainability of society in general and recognises that there may be costs to continued growth in economic output that need to be measured. For example, a GPI would account for the value of New Zealand's ecosystem services that are used in the process

23 Patterson M and Cole A 1999. Assessing the Value of New Zealand's Biodiversity. Occasional Paper Number 1, School of Resource and Environmental Planning, Massey University, February 1999. In The New Zealand Biodiversity Strategy, 2000. Department of Conservation with the Ministry for the Environment.

24 West Coast of the South Island, Fiordland National Park, Abel Tasman National Park, Queen Charlotte Track, Tongariro National Park including the Mt Ruapehu skifields, Southern Lakes Ski Areas, Te Papanui Conservation Park, and Cape Rodney – Okaraki Pt marine reserve.

of food production, water supply, recreation etc. Traditionally GDP is used as a measure of a nation's wellbeing and this assumption is being questioned by economists. Also GDP does not account for the impact on indigenous biodiversity which is an increasingly important aspect of the costs of pests.

A GPI has not been fully developed for New Zealand yet and further economic research is needed to develop values that are acceptable to society. In this regard, the New Zealand Centre of Ecological Economics²⁵ (NZCEE) has been undertaking research that is aimed at enabling cities and regions to progress towards sustainable development by providing decision makers with information that will link economic, social and environmental dimensions of sustainable development. The development of progress indicators that “uncouple economic growth from social progress from environmental harm” is one of three linked objectives of this research.

The NZCEE website notes that an improvement in well-being for a nation can be interpreted as genuine progress. This research is answering to increasing demand for indicators that take into account a broader range of factors than national income captured by GDP. It was never intended GDP be used as a measure of welfare for a nation, but it has assumed this role by default. The need for a meaningful measure of national well-being has led many countries to construct indicators such as the GPI or the Index of Social and Economic Welfare (ISEW). With these measures, well-being is seen to consist of both economic and non-economic factors.

The box below sets out the different components of the GPI being developed by NZCEE. Improvements in pest management outcomes and the value of these outcomes could be measured under the heading of Terrestrial (loss or damage caused by invasive pests to New Zealand ecosystems).

Components of the New Zealand Genuine Progress Indicator

Air quality – Loss of air quality – calculated by weighing the cost of loss of life years and reduced activity days for 2004 by an air pollution index

Climate change – Covers all greenhouse gas emissions (GGE) from NZ, calculated by multiplying annual GGE by an estimate of the marginal social cost of emitting an additional tonne of CO₂ into the atmosphere.

Commuting – Incorporates the direct (e.g. vehicle purchase, bus/train fares) and time costs of commuting to work

Crime – Private-sector property loss, property damage, and preventive expenditure including associated administration costs borne by insurance companies.

Household and community work – Non-leisure time spent on household and community work; time-series estimates converted to dollars using median wage rate.

Health – Cost of private defensive expenditure on health, from Statistics New Zealand time series data.

Noise pollution – Increase in number vehicle kilometres travelled and associated noise used as proxy for loss of amenity from noise exposure

Non-renewable – Loss of non-renewable resources – calculated using El Safary method

25 The Sustainable Pathways and Ecological Footprint Plus projects are being undertaken by the New Zealand Centre for Ecological Economics which is a joint venture between Massey University and Landcare Research Ltd and in conjunction with Market Economics Ltd.

Overwork – Loss of leisure time – calculated as hours overworked per week multiplied by total employment and average wage rate.

Ozone depletion – Loss of life years from death from melanoma cancer (due to higher exposure New Zealanders have to impact of damage in ozone layer).

Personal Consumption – Personal consumption (household spending on consumer goods and services, and non-capital items by private non-profit organisations serving households), adjusted for income inequality.

Public Capital- Services rendered by government-owned capital stocks, with allowances for non-defensive and non-market services. Estimated as depreciation of capital stocks and opportunity cost of such investment.

Soil – Tonnes of annual soil loss (mainly from erosion), valued at 1998 costing.

Public consumption – Non-defensive public expenditure – using a time series of input-output tables to establish public consumption by category.

Solid Waste & Contaminated Sites – Based on estimated costs of remediation of contaminated sites in NZ and tonnes of waste going to landfills.

Terrestrial – Loss and damage to terrestrial ecosystems, which is mainly caused by invasive pests.

Underemployment – Indirectly values involuntary leisure time that underemployment brings. Total part-time employees seeking full time jobs, x average hours wanted to work per work, x average hourly rate.

Unemployment – Indirectly values involuntary leisure time that unemployment brings. Total unemployed hours per week, x cost per hour (min wage rate \ 40 hours). Allowances made for full and part-time employment.

Water Quality – Loss of water quality calculated by cost of riparian planting lowland river margins and planned restorative work on eutrophic lakes.

If a GPI were to be developed where genuine sustainability and progress were measured in dollar terms, an increase in GPI (e.g. improved value of ecosystem services or gains in indigenous biodiversity) may be the result of more effective pest defensive expenditure. The simplified example below depicts how the value that an increase in spending on biodiversity related pest control (in this example) adds to our national welfare is not accounted for by GDP, but could potentially be captured by GPI. The simplified example shows that a \$500 million increase in biodiversity related pest control increases the costs of pests by 13 percent and the value of GPI by 10 percent. Where as using GDP, only the value of increases in expenditure is captured.

Table 4.9: Comparison of GDP and GPI as Economic Indicators.

Values in billions (\$)	GDP		GPI	
	Yr 1	Yr 2	Yr 1	Yr 2
Economic Output	\$ 180	\$ 180	\$ 180	\$ 180
Prevented losses in Biodiversity	N/A	N/A	\$ -	\$ 20
Value of Biodiversity	N/A	N/A	\$ 10	\$ 30
National Wealth/Welfare	\$ 180	\$ 180	\$ 190	\$ 210
Costs of Pests				
Biodiversity Defensive Expenditure	\$ 1.00	\$ 1.50	\$ 1.00	\$ 1.50
Output losses and other costs	\$ 1.00	\$ 1.00	\$ 1.00	\$ 1.00
Total Economic Costs of Pests	\$ 2.00	\$ 2.50	\$ 2.00	\$ 2.50
Costs as % of GDP/GPI	1.1%	1.4%	1.1%	1.2%
Change in costs of pests as % of wealth		25.0%		13.1%
Change in National Wealth/Welfare	(no change)	0.0%	(plus)	10.5%

4.3 CONCLUSION

The economic cost of pests to New Zealand is significant and the selection of significant pests reviewed in this report is likely to be under-estimate of the total costs. This study has estimated that the total costs are at least \$2.26 billion or 1.3 percent of GDP and could be as high as \$3.5 billion if including multiplier effects. Estimating the total costs is difficult as an accurate assessment requires impact evaluations at individual species level. This cost also does not include losses to indigenous biodiversity. The total cost of pests is therefore likely to be understated, although no reliable New Zealand based data is available to include this cost. Section 3.2 makes recommendations on how to improve the reliability of data in estimating losses of indigenous biodiversity.

Our review of current economic cost related issues in the field of pest management indicates that this cost is likely to rise significantly as the “pest threat” to New Zealand increases. For example, invasive weeds numbers have been growing steadily. On average four new species naturalise each year (Esler 1988, In. Paynter *et al.* 2003) in the Auckland region alone, where over 615 species were known to have naturalised by the 1980s (Esler & Astridge 1987). Furthermore, lag times are common between the introduction, establishment and spread of environmental weeds (e.g. gorse and broom were first recorded as naturalised in 1867 and 1872) and indicates that more recently established species are likely to become serious weeds in the future.

At increasing levels of pest threat, defensive expenditure will have to rise to keep pace with this threat in order to achieve today’s equivalent pest management outcomes. Society’s changing values (more importance to environmental benefits, relative to production benefits and further restrictions on control methods) mean that public expenditure will likely focus on improved environmental outcomes and the burden of control measures affecting industry increasingly shift to the private sector.

As more sophisticated economic methods are able to capture the costs of pests on New Zealand’s social and natural capital, our understanding of the total costs of pests to the economy will improve.

There are positive signs in the area of pest management and the linkages that this project has with the national performance measurement framework for pest management are important. MAFBNZ also plans other work on improved co-ordination of biosecurity programmes and

closer co-ordination with regional councils which will also help improve the effectiveness of resources invested in this area.

Glossary of Terms

Economic analysis – Systematic approach to determining the optimum use of scarce resources, involving comparison of two or more alternatives in achieving the same objective under given assumptions and constraints. It takes into account the costs of resources used and attempts to measure in monetary terms the private and social costs and benefits of a project to the community or economy.

Economic costs – The estimated monetary costs of a project or change in an industry measured for a cost-benefit analysis. For pest management these costs include the cost of reduced production, the cost of preventing further losses, costs on recreational use and non-human related costs such as reduced biodiversity where it has no impact on people. Some losses to biodiversity have an impact on people and these are included in the definition of ecosystem services.

Economic Impacts – Economic impacts are effects or “shocks” to an economy caused by an intervention or climate or market related change. Where cost-benefit analysis focus on costs and benefits within a sector, economic impacts consider the economy as a whole and therefore focus on total economic outputs. For example, impacts account for the value of shifting resources from one use to another (e.g. the opportunity cost of moving labour to a less productive sector). Impact analysis simulates impacts with mathematical equations (such as input-output models) that show linkages among various industries, economic sectors, and external factors including effect on income, employment and value-added GDP.

Net Present Value – NPV is an indicator of how much value an investment or project adds to a firm or society (if investing public funds). In theory, if there is a choice between two mutually exclusive alternatives, the one with the higher NPV should be selected.

Opportunity cost of capital – The opportunity cost of capital is the return (e.g. 10 percent) foregone by investing in one project rather than in an alternative project (i.e. the cost of a project is the value of the next best alternative foregone). Examples of alternatives are investment in the share market, or a combination of company shares, bank deposits or government bonds.

Social rate of time preference – The rate for which society is willing to trade today’s consumption for future consumption, assuming that consumption today is worth more than consumption of the same good tomorrow.

Cost Benefit Analysis (CBA) – An economic assessment tool used to quantify all costs and benefits of a proposed project or intervention in monetary terms, and discounting these values to today’s dollars to determine the net benefits. The net benefits are the sum of a future cashflow.

Non-market values – Goods or services that are consumed by people but have no established market for trade or common understanding of value in monetary terms. Most environmental goods and services, such as clean air and water, and healthy fish and wildlife populations, are not traded in markets. Their economic value is not revealed in market prices. The only option for assigning monetary values to them is to rely on non-market valuation methods (such as choice modelling).

Ecosystem services – The services provided by the natural environment that benefit people. Examples include catchments that provide drinking or irrigation water to a city or farming area, indigenous forest and vegetation that reduce hillside erosion, wetlands that purify water or reduce the risk of tidal floods.

Moral hazard – Intervention discouraging people from taking reasonable steps to reduce their own exposure to risk, other examples include insurance companies reducing the incentive to guard against a risk by protecting insurance holders against it.

RUA – Regional Council or Unitary Authority.

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Appendix 1- Critical Analysis of existing Economic Impact Assessments

Pest and EIA National	a) Summary of pest impact and objective	b) Methodology used	c) Applicability for that pest/knowledge/stage of incursion
1. Varroa in New Zealand: Economic Impact Assessment. MAF Policy, 2000	To evaluate the potential economic impacts of Varroa on New Zealand agriculture in the absence of government intervention. EIA data to be used as baseline data for evaluation of control options designed to avert some or all of the costs of Varroa. Forms baseline for cost-benefit analysis of control options.	Analysis estimates value of costs at the farm gate through lost production, reduced quality impacts and increased costs of pollination charges (passed on by bee keepers) and increased costs of actions taken to mitigate reduced pollination activity (e.g. increased N fertiliser use in the pastoral sector and clover reseeded). Production losses valued at the farm gate, no multiplier impacts modelled for downstream economic impacts. Cashflows developed over 35 year time horizon and all values expressed in 2000 values. Government bond rates used as the discount rate. Losses for each sector were developed using an expert reference group that were used to develop and verify assumptions used by the analyst/s. Analysis accounts for farm type per sector, regional (three regions), and climatic variation differences. Economic costs are shown across four sectors (horticulture, arable, pastoral and beekeeping) and by region using three scenarios of possible pest spread. Three scenario cases are modelled (worst, middle, best cases).	Year 2000 at first sign of incursion in the Northland. Little was known of how to manage and the potential impacts in New Zealand at the time. Knowledge has built up considerably with HortResearch leading research into management options for bee keepers.
2. Clover Root Weevil Economic impact assessment, report to Biosecurity New Zealand, Ministry of Agriculture and Forestry, August 2005	To evaluate to cost of Clover Root Weevil (CRW) on New Zealand Agriculture and Apiculture sectors including the cost of greenhouse gas emissions from increased use of synthetic fertilisers. The analysis assumes no control of CRW is available.	Analysis estimates costs to farmers at farm gate through estimating the cost to replace nitrogen in pastoral systems that is reduced through the CRW reducing natural nitrogen fixation. Analysis also considers the cost of purchasing supplementary feed. Costs to the apiculture sector are estimated by looking at the reduction in clover content of honey and corresponding reduction in price. Costs of greenhouse gas emissions are considered for the additional synthetic fertiliser used. For all costs, three rates of spread and establishment are considered. No multiplier impacts modelled for downstream economic impacts. Cashflows were developed over a 35 year time horizon and a discount rate of 10% used.	The analysis notes that the cost is highly sensitive to the estimates of nitrogen fixation by white clover and the reductions in this caused by CRW. This has been accounted for through using three scenarios. Methodology is applicable for this pest at the stage of incursion at the time it was completed.
3. <i>Didymosphenia adiate</i> (didymo) economic impact assessment- NZIER 2006	The objective of this assessment is to model the potential impacts of Didymo New Zealand in the absence of government intervention under three distribution and impact scenarios (low, medium and high). A technical advisory group has used to verify assumptions and a range of mainly New Zealand-based studies are used in governing assumptions.	The economic impacts (covering both market and non-market values) are modelled using three scenarios of high, medium and low impact and distribution. The study uses a technical advisory group to identify sectors where significant impacts will appear and the regional spread of these impacts over time. The study acknowledges limitations on the availability of data and likely significance of economic impacts for non-quantified impacts (e.g. cultural values, alluvial gold-mining and human health).	Given that Didymo was discovered in two Southland rivers in October 2004 preliminary data and technical understanding could be called upon for the analysis and the level of analysis was appropriate.

Pest and EIA National	a) Summary of pest impact and objective	b) Methodology used	c) Applicability for that pest/knowledge/stage of incursion
	A relatively succinct and clearly written report provides a high-level understanding of the nature of impacts and how the economic values are estimated.	<p>In assessing the impacts and likely response of the private sector, private sector stakeholders will consult with to verify assumptions and understand likely response.</p> <p>Discounted cash flows are used to express values in real terms (June 2000 five New Zealand dollars) and both for annual impacts and present values are shown. It is not clear how the discount rate (10%) was chosen.</p>	
4. An economic analysis of the impacts of equine influenza on New Zealand, Report to Biosecurity New Zealand, NZIER, December 2007	<p>Equine influenza (EI) is a highly contagious respiratory disease of horses which could result in significant economic and social costs to the New Zealand horse industry (racing and other).</p> <p>The objective of this work was to establish the likely costs for New Zealand of an incursion in Australia and a possible incursion in New Zealand. Specifically four questions were examined around incursion in Australia and New Zealand, different responses, and pre-emptive vaccination.</p>	<p>Costs were assessed over a 10-year period to provide a net present value of the discount rate of 10%. The approach focuses solely on one sector and does not consider flows between sectors, i.e. whether land, labour or capital would be used for other purposes.</p> <p>The impact of incursion in New Zealand is based on a specific incursion scenario. A range of spread possibilities are considered alongside do nothing, containment and eradication response options.</p>	<p>Analysis considered the impact in Australia and the potential for this and an incursion into New Zealand to impact on the horse industry in New Zealand.</p> <p>The level of analysis and detail was entirely appropriate for the pest and level of knowledge held.</p>
5. Painted Apple Moth: reassessment of potential economic impacts, MAF, May 2002	This assessment updates an initial piece of work by MAF with a refined methodology incorporating projected expansions in key sectors and providing a range of potential impacts.	<p>The analysis models the impacts of PAM on urban households, urban golf courses and school grounds, public land in urban areas, plantation forestry (radiata pine) and horticulture (apples). The report notes other possible impacts as being too uncertain to quantify or relatively minor.</p> <p>Costs are considered over a 20 year period and are expressed in 2002 dollars using a discount rate of 10%.</p>	<p>The analysis estimates costs associated with additional spraying to control PAM and in the case of forestry a reduction in production.</p> <p>It appears the report considers the cost of PAM assuming no further government intervention.</p>
6. The potential economic impacts of the RED IMPORTED FIRE ANT in New Zealand (2001)	This study estimates the potential impact of the red imported Fire ant in the North Island and the South Island under minimal government intervention. The study (2001) uses mainly US data to assess the economic impact on a range of sectors so that an evaluation of control options could be undertaken in the event of an infestation. Red	A study assesses the economic impact of prevention and treatment costs, damage to infrastructure and crops, medical costs and loss of outdoor amenities on three broad groups. These are; household impacts, infrastructure impacts and agricultural impacts. US data is relied upon to estimate economic impacts and a 25 year cash flow is used. Annual impacts of \$311 million are expressed in \$2001 at full range expansion and consolidation by 2023/24. The present value of total impacts over the period 2001/02 – 2023/24 (\$665 million) is also estimated. All assumptions are referenced (mainly US-based studies on economic impacts) and	The limited information available on the economic impacts of red fire ants make point estimates difficult. The level of analysis is generally adequate for the stage of incursion (i.e. pre-incursion). Further discussion on the implications for agriculture particularly beef and dairy farming sectors would be useful.

Pest and EIA National	a) Summary of pest impact and objective	b) Methodology used	c) Applicability for that pest/knowledge/stage of incursion
	fire and is not currently established in New Zealand.	limitations are generally identified. It is not clear what discount rate is used.	

Pest and EIA	d) Likely future applicability/robustness of the analysis	e) Robustness of the result/adequacy of the assumptions	f) Gaps in the analysis
1. Varroa in New Zealand: Economic Impact Assessment. MAF Policy, 2002.	Analysis was updated in 2002 and methodology was robust enough for this to be done by updating production loss assumptions, mite spread rates and prices based on improved data. The methodology and analysis was clearly stated and made update simple to complete.	<p>Method was appropriate for estimating the economic impacts of Varroa without any government control. It did not account for industry research to mitigate impacts as part of the counterfactual but this was not stated.</p> <p>The method was appropriate for the purpose and all technical and economic assumptions seem well tested and verified with relevant experts.</p> <p>Sensitivity of various scenarios are discussed, in addition to the application of the results as baseline data for use in CBA of control options.</p>	<p>The majority of economic impacts in the pastoral sector occur after 2020 and are therefore heavily discounted given that they are 20 years from the start of the cashflow. More discussion is required to analyse the effect of discount rate on the NPV.</p> <p>Un-quantified downstream industry impacts and multiplier affects are acknowledged and although could capture the costs more accurately, but would make it more difficult to update.</p>
2. The potential economic impacts of the RED IMPORTED FIRE ANT in New Zealand	<p>Analysis was conducted in 2001 and an update would be appropriate given changes that have occurred in agriculture and the very broadbrush approach used for the horticulture and cropping sector impacts.</p> <p>An update on losses and recreational amenity values would also be appropriate for this analysis.</p>	It is likely that these costs are understated given the gaps in relevant information for assumptions. This limitation is not clearly recognized in the report. The overall approach is adequate and an update with review of current assumptions could be useful.	<p>Improved analysis on the impact of red imported fire ants on horticulture and cropping industries is required.</p> <p>Non-market values on recreation area losses would improve the analysis.</p> <p>A closer analysis of any potential predation benefits would be useful to guide further research.</p> <p>The use of different infestation scenarios would improve the understanding of the potential costs. Further discussion on the likelihood of these scenarios would also improve the analysis.</p>

Pest and EIA	d) Likely future applicability/robustness of the analysis	e) Robustness of the result/adequacy of the assumptions	f) Gaps in the analysis
3. <i>Didymosphenia adiate</i> (didymo) economic impact assessment- 2006	<p>This analysis is likely to be able to be kept updated on the future given the method of developing values. The study acknowledges that improvements could be made in capturing economic value to non-market impacts, this would be a logical improvement on the existing methodology.</p> <p>Improved assessment of existence values would also be possible with new information developed on the value of indigenous biodiversity.</p>	<p>The assumptions used are mostly clearly stated and have been verified by relevant technical and commercial experts. The results of the NPV analysis appear to be robust.</p> <p>A very simplistic approach is taken to valuing biodiversity losses and study acknowledges that values may not accurately represent the public's willingness to pay to prevent biodiversity loss or cumulative species losses due to didymo.</p>	<p>Commercial eel fishing industry losses are estimated although no account is made for the effort that the eel fishing industry would take to reduce the impact (and potential benefits).</p> <p>The discount rate of 10% is likely to be at the other end of a suitable range of discount rates for environmental impact assessments. It is not clear the number years used for the discounted cash flow analysis.</p> <p>It is important that tables are described clearly for readability.</p>
4. Clover Root Weevil Economic impact assessment, report to Biosecurity New Zealand, Ministry of Agriculture and Forestry, August 2005	<p>The analysis assumes no effective control over the 35 years which the costs are considered. It establishes a baseline against which to consider any mitigation strategies such as biological control. The methodology used lends itself to being updated as improved information is available. With some additional work the benefits of any mitigation strategies could be determined through estimates of the saving in cost.</p>	<p>The report acknowledges uncertainty around key assumptions and presents low, medium and high impact scenarios.</p> <p>Assumptions are clearly stated and impacts determined with the support of an extensive technical advisory group. The analysis acknowledges uncertainty in some key assumptions</p> <p>Results were provided by region and sector.</p>	<p>The analysis appears very thorough and well researched.</p> <p>It does not consider downstream industry or multiplier effects and these would likely make the cost of CRW significantly greater than that quantified.</p> <p>The total cost assumes no control of CRW, which has now proven possible through the introduction of a parasitic wasp.</p>
5. Painted Apple Moth: reassessment of potential economic impacts, MAF, May 2002	<p>Approximately three quarters of the assessed cost are related to production losses and spraying costs to plantation forestry. While robustness of this analysis is difficult to determine, it highlights the key area of focus for future analysis.</p>	<p>The robustness of the result/adequacy of the assumptions is difficult to determine. Many of the assumptions appear to be based on previous assessment of the economic impact of the white spotted tussock moth.</p> <p>Detailed explanation of the methodology used as lacking in the report.</p>	<p>The analysis lacks a concise summary of the impact of PAM.</p> <p>While a number of the assumptions are discussed, report has not clearly defined the methodology used. For example, high, medium and low impacts are considered however it is not clear how these are calculated.</p>

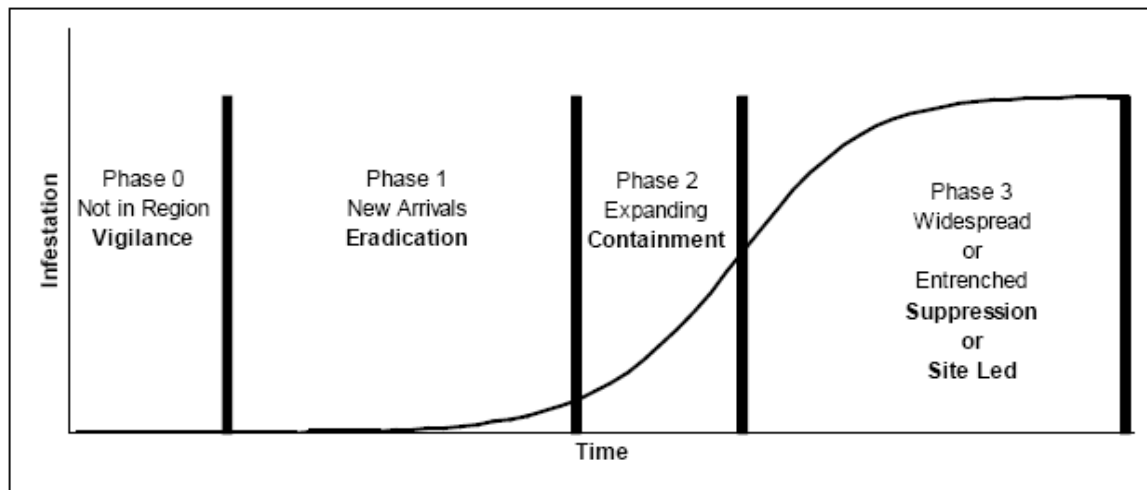
Pest and EIA	d) Likely future applicability/robustness of the analysis	e) Robustness of the result/adequacy of the assumptions	f) Gaps in the analysis
6. An economic analysis of the impacts of equine influenza on New Zealand, Report to Biosecurity New Zealand, NZIER, December 2007	<p>The analysis was robust given the current state of knowledge, particularly around possible incursion path and spread rates.</p> <p>The analysis is likely to be relatively easily updated given an actual incursion.</p>	Assumptions used appear reasonable. Sufficient detail is provided to support these. A range of scenarios are considered, presenting information to consider a range of response options.	Analysis may have benefited from an increased focus on uncertainty and provision of a sensitivity analysis.

Appendix 2 – Questions for Stakeholders in Pest Management

1. How do you use economic information in your pest management resource allocation decisions?
2. What type of economic information do you find most useful?
3. What is the main source of economic information?
4. What value do you get from economic impact information on pests that your agency has a responsibility to manage?
5. What resource do you have for undertaking economic impact assessments in-house?
6. Do you communicate economic information to external stakeholders- if so who?
7. How do you assess the significance of pests (e.g. unwanted organism status) and what role does economic information play in this assessment?
8. Which pests are a priority for your organisation in terms of economic impact assessment?
9. Which pest species need to be included in assessing production losses from pests?
10. What information does your organisation hold on pest-impact relationships (e.g. assumptions, qualitative and quantitative estimates)?
11. What requirements do you have for ongoing economic impacts?
12. What reporting requirements do you have for economic impact assessments?

Appendix 3 – The Infestation Curve

As well as considering impacts, costs and benefits, the location of a pest on the curve helps determine its appropriate management. The curve is divided into the four sections, or “**phases**”. These phases, and the preferred management policies associated with them, are summarised in the figure below.



Conceptual phases of a pest through time in relation to its appropriate management. Modified from P. Williams, 1997, *Ecology and Management of Invasive Weeds*, Department of Conservation.





Appendix 4 – Key outputs to be specified for a cost benefit analysis







Mumford (1999) suggested that the key outputs to be specified for a cost benefit analysis are:






- a time series of expected impacts without intervention;
- technical management options for proposed actions;
- a cost profile of each of the management actions;
- a time series of expected impact with intervention;
- a time series of benefits resulting from the management action;
- a distribution of benefits [geographic, sector, land type];
- economic criteria for selecting options [net present value, benefit cost ratio, payback period, internal rate of return];
- a data table indicating the technical and economic assumptions;
- examples of cost and benefit profiles based on sensitivity analysis for key variables [a key variable being one that is likely to change the outcome of the decision over its assumed range].

Appendix 5 – Production Losses: Adjustment Assumptions

All output costs have been adjusted for the impact that each pest is having on economic output in 2008 due to changes in pest populations or control programmes. Adjustments have also been made for inflation. The treatment of output losses set out in the table below are only for those pests that are currently in New Zealand causing economic losses (e.g. potential losses from incursions are not included and it is assumed that the cost of preventing incursion are captured by public expenditure on border security).

Forestry Sector	 0%	<p>Estimated costs of forest sector pests were based on a MAF/NZFOA 5th Annual Forest Health Workshop, working on Biotechnology Solutions for Forest Biosecurity Problems. The estimate of \$200 million per annum does not include pests and disease estimated separately (painted apple moth, fall webworm). The \$200 million estimated in 2006</p>
Argentine Stem Weevil	 25%	<p>There have been two releases of commercial ryegrass cultivars that reduce the cost of ASW and endophyte alkaloid side effects (AR1 and AR37). High endophyte ryegrasses offer protection against root and foliar feeding insects with the most significant of these being the Argentine stem weevil (ASW). High endophyte levels are therefore likely to result in improved pasture persistence, particularly in dryland situations and areas where pest levels are higher. Historically farmers have had to choose between high endophyte grasses where pasture persistence may be improved and accept some negative impact on livestock performance, and low endophyte grasses with poorer pasture persistence however increased livestock performance. Trial work undertaken by Dexcel has shown that cows grazing AR1 infected ryegrasses produced 9% more milksolids than those grazing wild-type endophyte-infected ryegrasses, while total pasture production was little different. Uptake by seed merchants and farmers has been significant with estimates that as much as 70% of all seed now sold into the dairy industry is AR1 endophyte treated.</p> <p>Despite the fact that annual regrassing amounts to between 2-3% of total area in pasture, we have assumed that with the benefit of new developments in ryegrass cultivars we have reduced the cost of ASW by 25% from the estimate include in Bertram (1999).</p>
Clover Root Weevil	 88%	<p>A full update of the NZIER report is presented in separate Appendix has adjusted all prices and introduced impact of biological control (Irish Wasp).</p>
Californian Thistle	 0%	<p>A study quoted by Lincoln University indicates that the cost to sheep farms in Otago and Southland was \$34 million per year although output losses were around up to a million per year. The national impact of bio-controls since the 2000 study are unknown so we have left the costs unchanged.</p>
Unchanged	0%	

Rabbits	 22%	Otago Regional Council experience of rabbit number declines following the release of RHD indicates that kill rates of 50-09% were achieved. The values included in Bertram were based on 2.0 million sheep being displaced at a value of \$25 per head. Using 2008 IRD livestock values of \$50 per head and reducing the impact of rabbits by 50% gives a new value of \$50 million (in 2008 dollars).
Giant Buttercup	 5%	CBA undertaken by Nimmo-Bell on the benefit of bio-control using myco-herbicides is broken into three affected regions (Taranaki, Tasman and the rest of NZ) and estimated that this technology would reduce output losses by approximately \$6.0 million per annum. With the adoption of this biocontrol we have adjusted total losses down by this amount.
Possums	 0%	We have used output loss data from the cost of TB under the current AHB control programmes at \$4.5 million per year (this includes on-farm testing and mustering, TB reactor and slaughter costs, and grazing damage). An estimate of \$30 - \$60 million was also made (Cowan 1996, <u>In</u> Bertram 1999) of the cost of damage to forestry production and erosion control plantings. Given the increased programme of possum control as a vector for TB undertaken by the AHB since the Bertram study we have not increased the output losses caused by possums in addition to inflation adjustment.
Bird Pests- Other crops	 0%	The Foundation for Arable Research ^{advised} in 2008 that losses from sparrows and finch cost the country around \$30 million annually. This estimate was made as an input to a falcon control programme and FAR has indicated that this cost hasn't changed.
Bird Pests- Other crops Viticulture	 850%	We have also included costs of bird damage to the grape growing industry. In 1998 a Marlborough based study estimated that the region suffered losses from birds of approximately 3% of total grape production despite growers bird control efforts (Boyce <i>et al.</i> 1999). It is also estimated that without bird control, approximately 25% of grape production would be lost or damaged by birds. We have used the technical assumptions made in Boyce <i>et al.</i> (the main one being 3% loss per hectare above existing) and extrapolated this across New Zealand using 2008 vineyard areas and MAF Cash Operating Surplus per hectare values. These adjustments increase the annual losses to \$9.7 million and adjusts the costs up by 850%.
Didymo	 25%	The annual estimated losses included in the report are based on analysis undertaken by NZIER (2006). The results of this modelling indicates that under a medium scenario annual impacts from didymo were likely to be around \$24 million. Discussions with MAFBNZ indicate that Didymo economic impacts are tracking closer to the low impact scenario rather than the medium impact scenario (for the year 2008). We have therefore reduced annual costs by 25%. It should be noted however that the modelling undertaken by NZIER that annual impacts could increase to between \$20 million and over \$120 million per annum.

Varroa	 10%	Discussions with the CEO of the National Beekeepers Association indicate that Varroa has spread faster than was originally expected with movement control operations ceasing in 2008. A MAFBNZ CBA (2008) analysed the benefit of maintaining movement control for additional years. It found that the impacts of Varroa increased substantial from 2028 onwards with the major impacts felt by the pastoral sector NPV of impact over \$300 million over 35 years. We increased estimated impacts in 2008 by 10% to around \$15 million per year.
Gorse and Blackberry	 30%	Williams and Timmins (2002) cite work by Richardson and West (1993) that estimates output losses from forestry as a result of reduced growth and in radiate pine forests at \$20.6 million per year. The area of plantation forest has increased 30% since 1993 to 1.81 million hectares and we have adjusted forest sector impacts up by 30% to account for increased area. We have not increased the cost of gorse and blackberry on pastoral farmland from the estimate made by Bertram given that most of this cost occurred on marginal land that if expected to pose significant additional costs were likely to have been retired.
Sea Squirt Varroa Gum Leaf Skeletoniser Rose grain aphid Powdery Mildew Lucerne Aphid Wasps	 0%	No adjustment in output losses has been made for these pestbx of a lack of information on changes in their impact on the economy (although costs have been adjusted for inflation from the most recent estimate).
Didemnum Vexillum	 0%	Output losses in the honey sector are based on Bertram's assumptions of 2% loss in honey production. The value of the New Zealand industry has doubled since the 1999 estimate was made so an adjustment was made in impact (accounting for inflation).
Other (10% guessed)	 0%	At the time of reviewing the NZIER (2008) analysis on options for controlling DV no decision had been made on the likely response. We have chosen the mid point of output losses ranging from \$250,000 - \$750,000 per annum.
		The Bertram study included an estimate for output losses from other pests where the costs have not been quantified as 10% of the total cost of all quantified pests. To maintain consistency with this estimate (as a benchmark study) we have also included a cost of 10% to account for the losses incurred by other pests.

Appendix 6 – Tables: Primary Sector Costs

Estimated private sector cost of controlling weed and pests on farm (\$mill)

Sector	2007/08	2008/09
Sheep & Beef	59	64
Dairy	44	48
Deer	21	21
Arable	45	52
Horticulture	126	125
Total	296	310

DAIRY	2007/08			2008 /09 ^f			Stocking Rate	Per Hectare (\$)	Number of farms	Average Size of farms	Total Area	Total Cost (\$)	
	Whole farm (\$)	Per cow (\$)	Per kg of milksolids (\$)	Whole farm (\$)	Per cow (\$)	Per kg of milksolids (\$)						2007/08	2008/09
Regions													
Northland	4288	16	0.05	4,200	16	0.05	2.24	36	1200	121	145200	\$5,145,600	\$5,040,000
Waikato	2826	9	0.03	2,859	10	0.03	3.03	30	5140	106	544840	\$14,525,640	\$14,695,260
Taranaki	2100	8	0.03	2,500	9	0.03	2.86	26	1800	96	172800	\$3,780,000	\$4,500,000
Lower North Island	4300	12	0.04	5,000	14	0.04	2.75	39	1086	130	141180	\$4,669,800	\$5,430,000
Canterbury Dairy	5720	8	0.02	5,980	8	0.02	3.25	26	770	210	161700	\$4,404,400	\$4,604,600
Southland Dairy	6442	12	0.03	6,440	12	0.03	2.72	33	660	178	117480	\$4,251,720	\$4,250,400
Other Dairy Regions	4279	11	0.03	4497	12	0.03	2.8	32	780	201	156,800	\$3,337,880	\$4,939,723
Dairy Support Land		14							15		302,242	4,231,388	\$4,533,630
Total									11436	149	1,742,242	44,346,428	\$47,993,613

^f = forecast expenditure

Source: MAF Pastoral Monitoring Report 2008, LIC Dairy Industry Statistics, Statistics New Zealand

SHEEP AND BEEF	2007/08			2008/09f			Number of farms	Average Size of farms	Total Area	Total Costs 2007/08	Total Costs 2008/09
	Whole farm (\$)	Per ha (\$)	Per stock unit1 (\$)	Whole farm (\$)	Per ha (\$)	Per stock unit1 (\$)					
Farm types by Region											
Northland	4193	13	1.3	4 744	15	1.45	984	314	308,976	4,016,688	\$4,634,640
Central North Island	4171	7	0.77	4 442	7	0.9	1,272	635	807,720	5,654,040	\$5,654,040
Waikato	4320	14	1.4	4 549	15	1.41	300	722	216,600	3,032,400	\$3,249,000
Gisborne	5952	7	0.85	6 166	8	0.85	600	821	492,600	3,448,200	\$3,940,800
Hawkes Bay/ Wairarapa	4243	7	0.75	4 400	7	0.82	1,165	624	726,960	5,088,720	\$5,088,720
Eastern Lower North Island	4000	12	1.19	4 500	13	1.24	840	347	291,480	3,497,760	\$3,789,240
Western Lower North Island	3108	15	1.16	3 334	16	1.41	420	208	87,360	1,310,400	\$1,397,760
Canterbury/Marlborough Hill Country	9081	7	1.63	9 500	7	1.81	425	1,397	593,725	4,156,075	\$4,156,075
Canterbury/Marlborough Breeding and Finishing	9099	25	2.42	9 899	27	2.97	1,630	365	594,950	14,873,750	\$16,063,650
South Island High Country	12554	1	1.16	14 468	1	1.45	220	10,212	2,246,640	2,246,640	\$2,246,640
Otago Dry Country	10626	5	1.62	11 180	6	1.89	400	2,000	800,000	4,000,000	\$4,800,000
Southland/South Otago hill country	6431	9	1.06	7 267	10	1.28	720	723	520,560	4,685,040	\$5,205,600
Southland/South Otago Intensive	2100	11	0.79	2 050	11	0.83	1,600	194	310,400	3,414,400	\$3,414,400
Total							10,576		7,997,971	59,424,113	\$63,640,565

f = forecast expenditure

Source: MAF Pastoral Monitoring Reports 2008

DEER	2007/08			2008 /09f			Opening deer SU	Total Deer	Average Size of farms	Total Area	Total cost 2007/08	Total cost 2008/09
	Whole farm (\$)	Per deer (\$)	Per Stock unit (\$)	Whole farm (\$)	Per deer (\$)	Per Stock unit (\$)						
Region												
North Island Deer	1 600	11	1	1 792	13	1	2,194	430,171	140	4,731,881	\$5,592,223	
South Island Deer	3 018	17	1	2 800	16	1	2,812	965,852	180	16,419,484	\$15,453,632	
Total								1,396,023	160	364,473	21,151,365	\$21,045,855

f = forecast expenditure

Source: MAF Pastoral Monitoring Report 2008

ARABLE	2007 /08		2008 /09f		Total Area	Total Cost 2007/08	Total Cost 2008/09
	Whole Farm (\$)	Per Hectare	Whole Farm (\$)	Per Hectare			
Region							
New Zealand	79 750	275	91 060	314	165002	\$45,375,550	\$51,810,628
Total					165002	\$45,375,550	\$51,810,628

f = forecast expenditure

Source: MAF Pastoral Monitoring Report 2008

HORTICULTURE	2007 /08		2008 /09f		Total Area	Total Cost 2007/08	Total Cost 2008/09
	Whole Farm (\$)	Per Hectare	Whole Farm (\$)	Per Hectare			
Kiwifruit	6 750	1350	6 750	1350	13092	\$17,674,200	\$17,674,200
Hawkes Bay Pipfruit	55682	2531	53,746	2443	5408	\$13,687,648	\$13,211,744
Nelson Pipfruit	86643	3209	77,193	2859	2722	\$8,734,898	\$7,782,198
Other Pipfruit	71,163	2,870	65,470	2651	1556	\$4,465,720	\$4,124,956
Malborough Viticulture	24 705	915	27,405	945	17169	\$15,709,635	\$16,224,705
Hawkes Bay Viticulture	9 640	1004	9 300	1057	4930	\$4,949,720	\$5,211,010
Other Viticulture		959.5		1001	10467	\$10,043,087	\$10,477,467
Vegetables		1010		1010	40381	\$40,784,810	40,784,810
Others		750		750	13,333	\$9,999,750	9,999,750
Total					109,058	\$126,049,468	\$125,490,840

f = forecast expenditure

Source: MAF Pastoral Monitoring Report 2008

Weed and Pest Expenditure for Agricultural and Horticultural Sectors

SHEEP AND BEEF	2007/08			2008/09 forecast			Number of farms	Average Size of farms	Total Area	Total Costs 2007/08	Total Costs 2008/09
	Whole farm (\$)	Per ha (\$)	Per stock unit1 (\$)	Whole farm (\$)	Per ha (\$)	Per stock unit1 (\$)					
Farm types by Region											
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Gisborne	5952	7	0.85	6 166	8	0.85	600	821	492,600	3,448,200	\$3,940,800
Hawke's Bay/ Wairarapa	4243	7	0.75	4 400	7	0.82	1,165	624	726,960	5,088,720	\$5,088,720
Eastern Lower North Island	4000	12	1.19	4 500	13	1.24	840	347	291,480	3,497,760	\$3,789,240
Western Lower North Island	3108	15	1.16	3 334	16	1.41	420	208	87,360	1,310,400	\$1,397,760
Canterbury/Marlborough Hill Country	9081	7	1.63	9 500	7	1.81	425	1,397	593,725	4,156,075	\$4,156,075
Canterbury/Marlborough Breeding and Finishing	9099	25	2.42	9 899	27	2.97	1,630	365	594,950	14,873,750	\$16,063,650
South Island High Country	12554	1	1.16	14 468	1	1.45	220	10,212	2,246,640	2,246,640	\$2,246,640
Otago Dry Country	10626	5	1.62	11 180	6	1.89	400	2,000	800,000	4,000,000	\$4,800,000
Southland/South Otago hill country	6431	9	1.06	7 267	10	1.28	720	723	520,560	4,685,040	\$5,205,600
Southland/South Otago Intensive	2100	11	0.79	2 050	11	0.83	1,600	194	310,400	3,414,400	\$3,414,400
Total							10,576		7,997,971	59,424,113	\$63,640,565

DAIRY	2007/08			2008/09 forecast			Stocking Rate (\$)	Per Hectare	Number of farms	Average Size of farms	Total Area	Total Cost (\$) 2007/08
	Whole farm (\$)	Per cow (\$)	Per kg of milksolids (\$)	Whole farm (\$)	Per cow (\$)	Per kg of milksolids (\$)						
Regions												
Northland	4288	16	0.05	4,200	16	0.05	2.24	36	1200	121	145200	\$5,145,600
Waikato	2826	9	0.03	2,859	10	0.03	3.03	30	5140	106	544840	\$14,525,640
Taranaki	2100	8	0.03	2,500	9	0.03	2.86	26	1800	96	172800	\$3,780,000
Lower North Island	4300	12	0.04	5,000	14	0.04	2.75	39	1086	130	141180	\$4,669,800
Canterbury Dairy	5720	8	0.02	5,980	8	0.02	3.25	26	770	210	161700	\$4,404,400
Southland Dairy	6442	12	0.03	6,440	12	0.03	2.72	33	660	178	117480	\$4,251,720
Other Dairy Regions	4279	11	0.03	4497	12	0.03	2.8	32	780	201	156,800	\$3,337,880
Dairy Support Land		14						15			302,242	4,231,388
Total									11436	149	1,742,242	44,346,428

DEER	Whole farm (\$)	Per deer (\$) Per Stock unit (\$)	Whole farm (\$)	Per deer (\$) Per Stock unit (\$)	Opening deer stock units	Total Deer	Average Size of farms	Total Area	Total cost 2007/08	Total cost 2008/09
Region										
North Island Deer	1 600	11	1 792	13	2 194	430,171	140		4,731,881	\$5,592,223
South Island Deer	3 018	17	2 800	16	2,812	965,852	180		16,419,484	\$15,453,632
Total						1,396,023	160	364,473	21,151,365	\$21,045,855

	2007 /08		2008 /09		Total Area	Total Cost 2007/08	Total Cost 2008/09
ARABLE	Whole Farm (\$)	Per Hectare	Whole Farm (\$)	Per Hectare			
Region							
New Zealand	79 750	275	91 060	314	165002	\$45,375,550	\$51,810,628
Total					165002	\$45,375,550	\$51,810,628

	2007 /08		2008 /09		Total Area	Total Cost 2007/08	Total Cost 2008/09
HORTICULTURE	Whole Farm (\$)	Per Hectare	Whole Farm (\$)	Per Hectare			
Kiwifruit	6 750	1350	6 750	1350	13092	\$17,674,200	\$17,674,200
Hawke's Bay Pip fruit	55682	2531	53,746	2443	5408	\$13,687,648	\$13,211,744
Nelson Pip fruit	86643	3209	77,193	2859	2722	\$8,734,898	\$7,782,198
Other Pip fruit	71,163	2,870	65,470	2651	1556	\$4,465,720	\$4,124,956
Marlborough Viticulture	24 705	915	27,405	945	17169	\$15,709,635	\$16,224,705
Hawkes Bay Viticulture	9 640	1004	9 300	1057	4930	\$4,949,720	\$5,211,010
Other Viticulture		959.5		1001	10467	\$10,043,087	\$10,477,467
Vegetables		1010		1010	40381	\$40,784,810	40,784,810
Others		750		750	13,333	\$9,999,750	9,999,750
Total					109,058	\$126,049,468	\$125,490,840

Regions & Area	Vegetables	Grapes	Kiwifruit	Olives	Subtropicals	Pip fruit	Citrus & summer fruit	Avocados	Berry Fruit	Summer Fruit
Northland	1512	121	634				324	1325		
Auckland	5354	411	309	290	251	215	153			
Bay of Plenty			10249		2,348		119	2210		
Waikato	5053	133	782			268			340	
Gisborne	4267	1812	284				1003			
Manawatu-Wanganui	3871					107				
Hawke's Bay	5821	4930	220	317		5408				895
Wellington	294	860		254		151				
Nelson-Tasman	432	805	614			2722			925	
Marlborough	1811	17169		240		41				67
Canterbury	11410	4683		437		279			736	122
Otago	556	1642				495				977
Southland										
Totals	40381	32566	13092	1538	2,599	9686	1599	3535	2001	2061

Source: Statistics NZ

Regions & Area	Milling Wheat	Other Wheat	Barley	Oats	Maize	Grain	Other Cereals	Field Peas	Herbage Seeds	Vegetable Seeds	Other Crops
Northland						550					
Auckland						1,217				112	
Bay of Plenty						3,133				117	
Waikato						5,515				374	
Gisborne						2,654					215
Manawatu-Wanganui	353	380	2900			2,021				140	
Taranaki			132								
Hawke's Bay			1428			1,295			164		
Wellington			1261					539	122	118	
Nelson-Tasman											
Marlborough			599					223	959		116
Canterbury	15940	19361	36869	2925		432	2129	5063	25420	5537	5739
Otago	279	1556	5012	863					175	196	702
Southland			3136	1818				187	304	412	
Total	17216	23321	51481	5773		17,030	2267	6273	27329	7330	6982

Source: Statistics NZ

Appendix 7 – Example CBA (See separate appendix)

Appendix 8 – List of analyses reviewed in study

A list of all analyses reviewed (in addition to the reference list) in quantifying economic impacts was requested as part of this study and is provided below.

Title	Pest/Topic	Author/Reference
Review of the National Bovine Tuberculosis Pest Management Strategy, February 2009.	Bovine Tb	Animal Health Board (2009).
An economic framework for biosecurity decision making in New Zealand. Contributed paper, AARES 51 st Annual Conference, Queenstown, New Zealand, February 2007.	Pest management decision making	Bell, B. A. (2007).
The impact of introduced pests on the New Zealand economy	Economic Impact Assessment: <ul style="list-style-type: none"> • Argentine Stem Weevil • Rabbits • Possums • Californian Thistle • Gorse and Blackberry • Rose grain aphid • Powdery Mildew • Wasps 	Bertram, 1999
An Economic Analysis of Bird Damage in Vineyards of the Marlborough Region	Pest Birds – Economic Impact Analysis	Boyce <i>et al.</i> (1999)
The economic impact of <i>Didemnum Vexillum</i> . Report to Marine Farming Association. NZIER, Wellington, New Zealand.	Didemnum Vexillum	New Zealand Institute of Economic Research. (2008).
Pastoral weeds in New Zealand: status and potential solutions. New Zealand Journal of Agricultural Research, 50, 139-161.	Pastoral weeds	Bourdot, <i>et al.</i> (2007).
Analysis of trends in the economic impacts of agriculture. MAF Technical Paper 93/20. Retrieved on April 9 2008 from http://www.Maf.govt.nz/mafnet/rural-nz/profitability-and-economics/trends/econ_omic-trends/anal1.htm#E13E1	Economic multiplier analysis	Butcher, G. V. (1993)
Economic Benefits Of Water In Te Papanui Conservation Park Inception Report, Department of Conservation (June 2006)	Conservation report	Butcher, G. V. (2006)
Ecological and economic costs of alien vertebrates in New Zealand In Pimentel, D. (ed). Biological Invasions, 2002. Boca Raton, Florida. CRC Press. Pp. 185–193.	Alien vertebrates	Clout, M.N. (2002)
Summary of the Department of Conservation's Strategic Plan for Managing Invasive Weeds (SPMIW). The Science Publications Unit, Department of Conservation, Wellington.	Managing Invasive Weeds	Department of Conservation (2002).

Title	Pest/Topic	Author/Reference
Review of the National Bovine Tuberculosis Pest Management Strategy, February 2009.	Bovine Tb	Animal Health Board (2009).
An economic framework for biosecurity decision making in New Zealand. Contributed paper, AARES 51 st Annual Conference, Queenstown, New Zealand, February 2007.	Pest management decision making	Bell, B. A. (2007).
The value of conservation: why does conservation contribute to the economy?	Economic value of conservation	Department of Conservation (2006).
The impact of invasive invertebrate pests in pastoral agriculture: a review. New Zealand Journal of Agricultural Research 48: 401-415.	Economic impacts of pests on pastoral agriculture	Goldson, S. L.; <i>et al.</i> (2005).
The economic benefits of the possum control are programme. Agribusiness and Economics Research Unit. Research Report No. 282. May 2006. Lincoln, Canterbury.	CBA- Possum Control	Greer, G. (2006).
Media Release- Pest Birds result in \$30 million loss to New Zealand Arable Growers.	Economic impacts of pest birds	Foundation for Arable Research (2008)
Varroa in New Zealand: Economic impact assessment. MAF policy. November, 2000.	Economic impact assessment of Varroa	Ministry of Agriculture and Forestry. (2000).
Painted apple moth: reassessment of the potential economic impacts. May, 2002.	CBA- Painted apple moth programme	Ministry of Agriculture and Forestry. (2002).
Economic assessment on the impact of the gum leaf skeletoniser, <i>Uraba lugens</i> in New Zealand. MAF Policy, Hamilton, New Zealand.	Economic impact assessment- Gum leaf skeletoniser	Ministry of Agriculture and Forestry. (2003).
MAF/NZFOA 5 th Annual Forest Health Workshop: Biotechnology Solutions for Forest Biosecurity Problems. 28 February – 1 March 2006, Rotorua. http://www.nzfoa.org.nz/file_libraries/workshop_reports/5th_annual_maf_foa_health_workshop	Forest Health Workshop	MAF /New Zealand Forest Owners Association (2006)
Clover Root Weevil: economic impact assessment. Report to MAF Biosecurity. August, 2005.	Economic impact assessment- Clover Root Weevil	NZIER. (2005).
Sea squirt alert: economic impact assessment of <i>Styela clava</i> . Report to MAF Biosecurity New Zealand. NZIER, Wellington, New Zealand.	Economic impact assessment- Sea squirt	NZIER (2005).
<i>Didymosphenia geminata</i> economic impact assessment. Final report to Biosecurity New Zealand. NZIER, Wellington, New Zealand.	CBA- <i>Didymosphenia geminata</i> programme	NZIER (2006).
An economic analysis of the impacts of equine influenza on New Zealand. Report to Biosecurity New Zealand. NZIER, Wellington, New Zealand.	Economic impact assessment – Equine influenza	NZIER. (2007).
Cost Benefit Analysis Primer December 2005, Prepared by the Business Analysis Team. URL http://www.treasury.govt.nz/publications/guidance/costbenefitanalysis .	Cost benefit Analysis Guidance 2005	New Zealand Treasury (2005).
Public Sector Discount Rates for Cost Benefit Analysis July 2008, URL http://www.treasury.govt.nz/publications/guidance/costbenefitanalysis/discount rates	Cost benefit analysis Guidance 2008	New Zealand Treasury (2008).

Title	Pest/Topic	Author/Reference
Review of the National Bovine Tuberculosis Pest Management Strategy, February 2009.	Bovine Tb	Animal Health Board (2009).
An economic framework for biosecurity decision making in New Zealand. Contributed paper, AARES 51 st Annual Conference, Queenstown, New Zealand, February 2007.	Pest management decision making	Bell, B. A. (2007).
Causes, Prevention and Cure of Invasive Weed Problems in New Zealand: Cytisus Scoparius, a Case Study. Landcare Research New Zealand Ltd	Invasive weeds	Paynter, Q., <i>et al.</i> (2003).
The economic impact of weeds in Australia. Adelaide, CRC for Australian Weed Management. In Bourdot et al. 2007.	Economic impact assessment – Weeds in Australia	Sinden J, <i>et al.</i> 2004.
Economic impacts of weeds in New Zealand. In Pimentel, D. (ed). Biological Invasions (2002). Environmental and economic costs of alien plant, animal and microbe invasions. Boca Raton, Florida. CRC Press. Pp. 175–184	Economic impact assessment – Weeds in New Zealand	Williams P, <i>et al.</i> (2002)

Appendix 9 RPMS Pests

Pests included in the various RPMS that are included in RPMS and actively managed by RUA. Their inclusion in RPMS mean that some form of economic information will be available under the BSA and is a logical starting point gather national costs by region and species.

RPMS PEST ANIMALS

Northland DC	Taranaki RC	Env Southland	Env BOP	Grtr Wellington	Gisborne DC	Hawkes Bay RC
Ferret	Argentine ant	Ant	Argentine ant	Argentine ant	Feral Cat	Feral cats
Hare	Brown hare	Cattle tick	Eastern rosella	Feral cat	Feral Cattle	Feral deer
Magpie	Feral cat	Chamois	Feral cat	Feral goat	Feral Goat	Feral goat
Myna	Feral deer	Chinchilla	Feral deer	Feral pig	Feral Pig	Feral pig
Possum	Feral goat	Feral cat	Feral goat	Feral rabbit	Ferret	Mustelid
Rabbit	Feral pig	Feral deer	Magpies	Ferret Mustela	Magpie	Possum
Rat	Hares	Feral goat	Mustelid	Hare	Chinchilla	Rabbit
Rook	Magpie	Feral pig	Mynah	Hedgehog	Possum	Rat
Stoat	Mustelid	Hedgehog	Possum	Mice	Rabbit	Rook
Wallaby	Possum	Himalayan thar	Rabbit	Magpie	Rook	
Weasel	Rabbit	Magpie	Rat	Norway rat	Stoat	
	Rook	Mustelid	Rook	Possum	Wallaby	
		Possum	Wallaby	Rook	Wasp	
		Rabbit	Wasp	Ship rat	Weasel	
		Rodent		Stoat Mustela	Willow Sawfly	
		Rook		S.Crested Cockato		
		Wallaby		Wasp		
		Wasp		Weasel		
		Whitetail deer				
Auckland RC	Env Waikato	Marlborough DC	Tas DC	Env Canterbury	Otago RC	Horizon MW
Argentine ant	Possum	Rook	Argentine Ant	European wasp	Hare	Possum
Bearded dragon	Rook	Darwin Ant	Darwin's Ant	Feral cat	Rabbit	Rabbit
Blue-tongue skink	Wallaby	Possum	Feral Cat	Feral goat	Rook	Rook
E.water dragon		Rabbit	Hare	Ferret	Wallaby	
Feral cat			Magpie	German wasp		

Possum	Possum	Possum
RE slider turtle	Rabbit	Rook
Shingle lizard	Rook	Stoat and Weasel

RPMS PEST FISH

Northland DC	Taranaki RC	Env Southland	Env BOP	Grtr Wellington	Gisborne DC	Hawkes Bay RC
	Brown bullhead catfish	Catfish	Koi carp	Brown bullhead catfish	Catfish	
	Goldfish	Gambusia	Catfish	Goldfish	Koi Carp	
	Koi Carp	Koi carp		Koi Carp	Perch	
	Mosquito fish	Orfe		Mosquito fish	Rudd	
	Rudd	Rudd		Rudd		
	Tench	Tench		Tench		
Auckland RC	Env Waikato	Marlborough DC	Tasman DC	Env Canterbury	Otago RC	Horizon MW
Brown bullhead catfish			Koi Carp			Catfish
Gambusia			Rudd			Koi Carp
Gudgeon						Perch
Koi carp						Rudd
Marron						
Orfe						
Perch						
Rudd						

RPMS PEST PLANTS

Env Waikato	Taranaki RC	Hawkes Bay RC	Marlborough DC	Env Canterbury	Otago RC	Horizon MW
African Feather Grass	Australian sedge	African Feather Grass	African Feather Grass	African feather grass	African Feather Grass	African feather grass
Chilean Flame Creeper	Brush wattle	Apple of Sodom	Bathurst Bur	African love grass	African Love Grass	grass
Chocolate vine	Chilean rhubarb	Australian Sedge	Boneseed	Baccharis	Bomarea	African love grass
Climbing Spindleberry	Climbing spindleberry	Chilean Needle Grass	Broom and Gorse	Banana passionfruit	Boneseed	Australian sedge
Equisetum	Darwin's barberry	Chinese Privet	Boundary Control	Bell heather	Broom	Blackberry
Evergreen Buckthorn	Giant reed	Cotton Thistle	Broom and Gorse	Bennett's wallaby	Bur Daisy	Broom
Gunnera spp.	Gorse	Goats Rue	upper Awatere	Boneseed	Cape Ivy	Chilean needle
Horse nettle	Japanese walnut	Japanese Honey Suckle	Broom and Gorse	Broom	Contorta Pine	Chinese penisetum
Hydrilla	Mignonette vine	Nassella Tussock	upper Wairau	Bur daisy	Gorse	Gorse
Kikuyu grass	Old man's beard	Old Mans Beard	Bur Daisy	Coltsfoot	Lagarosiphon	Johnson grass
Kudzu vine	Oxygen weed	Pinus Contorta	Chilean Needlegrass	Darwin's barberry	Montpellier Broom	Nassella tussock
Manchurian wild rice	Oxygen weed	Saffron Thistle	Chinese pennisetum	Egeria	Nassella Tussock	Nodding thistle
Marshwort	Pampas – Common	Spiny Emex	Climbing Spindleberry	Entire marshwort	Nodding Thistle	Ragwort
Nasella tussock	Pampas – Purple	Tree Privet	Eel Grass	Gorse	Old Man's Beard	Skeleton weed
Noogoora bur	Ragwort	White Edge Nightshade	Giant Needlegrass	Hieracium	Perennial Nettle	Tutsan
Old Man's Beard	Senegal tea	Wolly Nightshade	Kangaroo Grass	Lagarosiphon	Ragwort	Variiegated thistle
Pampas	Spanish heath	Yellow Water Lily	Maderia Vine	Lodgepole pine	Spartina.	Woolly nightshade
Purple loose strife	Thistle – Nodding		Moth plant	Nassella tussock	Spiny Broom	
Reed sweet grass	Thistle – Plumeless		Nassella tussock	nightshade	White-edged Nightshade	
Senegal Tea	Thistle – Variiegated		Nodding thistle	Nodding thistle		
Spartina	Wild broom		boundary control	Old Man's Beard		
Taiwan cherry and Rum cherry	Wild ginger – Kahili		Ragwort Boundary Control	Phragmites		
Variiegated thistle	Wild ginger – Yellow		Saffron Thistle	Possum		
Water poppy			White edged nightshade	Rabbit		
White bryony				Ragwort		
				Saffron Thistle		
				Variiegated thistle		
				White-edged		
				Wild thyme		

Env Southland	Grtr Wellington	Grtr Well (cont'd)	Env BOP	Gisborne DC	Tasman DC	Northland DC
African club moss	African club moss	Gunnera	African Feather Grass	African feather grass	African Feather Grass	African Feather Grass
Aluminium plant	African feather grass	Hawthorn	Alligator Weed	Australian sedge	Banana Passion Vine	Alligator Weed
Angelica	Artillery plant	Himalayan	Apple of Sodom	Banana passion fruit	Bathurst Bur	Bathurst Bur
Banana Passionfruit	Banana passionfruit	honeysuckle	Asiatic Knotweed	Barberry	Blackberry	Broom
Barberry	Barberry	Hornwort	Banana passion Fruit	Bathurst bur	Boneseed	Californian Thistle
Bittersweet	Bathurst bur	Japanese honeysuckle	Blackberry	Blackberry Moth Plant	Boxthorn	Eel Grass
Blackberry	Blackberry	Lagarosiphon	Blue morning glory	Blue morning grass	Broom	Entire Marshwort
Bomarea	Blue morning glory	Manchurian wild rice	Boneseed	Boneseed	Broom (Howard – St	Fringed Water Lily
Boxthorn	Blue passion flower	Marram grass	Bushy Asparagus	Boxtham	Arnaud)	Gorse
Broom	Boneseed	Mexican daisy	Cathedral bells	Buddleia Smilax	Buddleia	Houttuynia
Buddleja	Boxthorn	Mignonette vine	Cestrum spp	BurDOCK	Cathedral Bells	Hydrilla
Californian thistle	Broom	Mile-a-minute	Chilean rhubarb	Californiam stinkweed	Chinese Pennisetum	Lantana
Cape honey flower	Brush wattle	Mist flower	Climbing asparagus	Chinese mugwort	Climbing Spindleberry	ManchurianRice
Cherry laurel	Buddleia	Moth plant	Climbing spindle	Climbing sindleberry	Egeria	Grass
Chilean fire bush	Cape honey flower	Nodding thistle	berry	Common pampus	Entire Marshwort	Mothplant
Chilean flame	Cape ivy	Old man's beard	Darwin's barberry	Gorse	Fireblight	Nardoo
creeper	Cathedral bells	Pampas grass	Gorse	Hawthorn	Gambusia	Nassella Tussock
Collomia	Chilean flame creeper	Parrot's feather	Heather	Holly leaved senecio	Gorse	Needlegrass
Common Ivy	Chinese and tree	Perennial nettle	Houttuynia	Japanese honey	Hornwort	Nodding Thistle
Contorta pine	privet	Periwinkle	Italian buckthorn	suckel	Madeira Vine	Old mans Beard
Cotoneaster	Climbing DOCK	Plectranthus	Japanese walnut	Mignonette/Maderia	Nassella Tussock	Oxygen Weed
Crack willow	Climbing spindleberry	Purple ragwort	Jasmine	Vine	Nodding Thistle	Pampas
Egeria	Cotoneaster	Ragwort	Kudzu vine	Nodding thistle	Old Man's Beard	Parrots Feather
Elderberry	Darwin's barberry	Saffron thistle	Lantana	Old mans beard	Parrot's Feather	Privet
European	Eelgrass	Smilax	Lodgepole pine	Periwinkle	Perch	Ragwort
spindleberry	Egeria	Spanish heath	Marshwort	Purple pampus	Phragmites	Rhamnus
German ivy	Elaeagnus	Stinking iris	Mexican devil	Ragwort	Pinus contorta	Senegal Tea
Giant hogweed	Evergreen buckthorn	Sweet pea shrub	Mexican feather grass	Red Cestrum	Purple Loosestrife	Skeleton Weed
Gorse	German ivy	Sycamore <i>Acer</i>	Mignonette vine	Spartina	Purple Pampas	Spartina
Green daphne	Gorse	Variegated thistle	Mile-a-minute	Spiny emex	Ragwort	Water Poppy
Grey willow	Great bindweed	Velvet groundsel	Mist flower	Star thistle	Reed Canary Grass	Wild Ginger
Hawkweeds	Wild ginger	Wandering jew	Moth plant	Sweet briar	Reed Sweet Grass	
Hawthorn	Wild onion		Nassella tussock	Thorn Apple	Saffron Thistle	

Env Southland	Grtr Wellington	Grtr Well (cont'd)	Env BOP	Gisborne DC	Tasman DC	Northland DC
Hemlock	Wilding conifers		Old man's beard	Tree & Chinese Privet	Senegal Tea	
Himalayan honeysuckle	Wilding pines		Pampas	Undaria Montpellier broom	Tench	
Holly	Woolly nightshade		Parrots feather	Variegated thistle	Variegated Thistle	
Hornwort			Privet	Variegated thistle	White-edged	
Ice plant			Purple loosestrife	Variegated thistle	Nightshade	
Japanese honeysuckle			Purple nutsedge	White edged	Wild Ginger	
Lagarosiphon			Ragwort	nightshade	Yellow Flag <i>Iris</i>	
Montbretia			Royal fern	Wild broom		
Mountain pine			Senegal tea	Wild Ginger		
Nassella tussock			Snow poppy	Woolly Nightshade		
Nodding thistle			Spartina			
Old man's beard			Tree of heaven			
Pampas grasses			Variegated thistle			
Periwinkle			Water poppy			
Potato wart			White-edged			
Purple loosestrife			Nightshade			
Ragwort			Wild ginger			
Reed sweet grass			Wild greengoddess			
Scotch thistle			lily			
Siberian lyme grass			Wild kiwifruit			
Smilax Spanish heath			Woolly nightshade			
Spartina			Yellow flag iris			
Stonecrop						
Sweet brier						
Sycamore						
Tradescantia						
Tutsan						
Wild turnip Pests						

Auckland RC 1	Auckland RC 2	Auckland RC 3	Auckland RC 4	Auckland RC 5	Auckland RC 6
African club moss	Bur daisy	Eel grass	Japanese spindle tree	Oxylobium	Smilax
African feather grass	BurDOCK	Egeria	Jasmine	Palm grass	Snow poppy
African love grass	Bushy asparagus	Elaeagnus	Johnson grass	Pampas grass	Spanish heath
African pig's ear	Buttercup bush	Elephant's ear	Kangaroo acacia	Paperbark poplar	Spartina
Agapanthus (large forms)	Californian bulrush	English ivy	Khasia berry	Parrot's feather	Spiny broom
Alligator weed	Cape honey flower	False tamarisk	Kudzu vine	Pennisetum species	Strangling fig
Aristea	Cape ivy	Fire tree	Lagarosiphon, oxygen weed	Perennial nettle	Sweet briar
Arum lily	Cape sundew	Fi rethorn	Lantana	Periwinkle	Sweet pea shrub
Asiatic knotweed	Cape tulip	Formosa lily	Lizard's tail	Phoenix palm	Sweet pittosporum
Asparagus species	Carex	Fringed water lily	Lodgepole pine	Phragmites	Tasmanian ngaio
Australian sedge	Castor oil plant	German ivy	Madeira vine	Pitted crassula	Tradescantia
Baccharis	Cat's claw creeper	Giant hogweed	Male fern	Plectranthus	Tree of heaven
Balloon vine	Cathedral bells	Giant reed	Manchurian wild rice	Plumeless thistle	Tuber ladder fern
Banana passionfruit	Caulerpa	Goat's rue	Marshwort	Port Jackson fig	Tutsan
Barberry	Chilean flame creeper	Gorse	Mexican daisy	Privet	Variegated thistle
Bartlettina	Chilean glory creeper	Great reedmace	Mexican feather grass	Purple loosestrife	Velvet groundsel
Bathurst bur	Chilean needle grass	Green cestrum	Mexican water lily	Pyp grass	Water hyacinth
Blackberry (wild aggregates)	Chilean rhubarb	Grey willow	Mickey Mouse plant	Queensland poplar	Water lettuce
Bladderwort species	Clasped pondweed	Guinea grass	Mile-a-minute	Ragwort	Water poppy
Blue morning glory	Clematis flammula	Gypsywort	Mist flower	Reed sweet grass	Water primrose
Blue passion flower	Climbing asparagus	Hawkweed	Monkey apple	Reynoutria japonica	White bryony
Blue spur flower	Climbing DOCK	Hawthorn	Montbretia	Rhamnus	White-edged nightshade
Bog bean	Climbing gloxinia	Heather	Montpellier broom	Rhus tree	Wild broom
Bolivian fuchsia	Climbing spindle berry	Hemlock	Moth plant	Rough tree fern	Wild ginger
Bomarea	Coast banksia	Himalayan honeysuckle	Nardoo	Royal fern	Wild kiwifruit
Boneseed	Coltsfoot	Hornwort	Nassella species	Saffron thistle	Woolly nightshade
Boxthorn	Cotoneaster	Horsetail	Nassella tussock	Sagittaria species	Yellow flag
Brazilian pepper tree	Crack willow	Houttuynia	Needle grass	Salvinia	Yellow water lily
Broomsedge	Darwin's barberry	Hydrilla	Nodding thistle	Scrambling lily	
Brush cherry	Devil's fig	Iceplant	Noogoora bur	Senegal tea	
Brush wattle	Devil's tail	Italian arum	Norfolk Island hibiscus	Sexton's bride	
Buddleia	Drooping prickly pear	Italian jasmine	Nutgrass	Sheep's bur	
	Dusky coral pea	Japanese honeysuckle	Old man's beard	Skeleton weed	

