"Achieving Outcomes by Building Capability"

The AgriBusiness Group™

Trojan Female Project

User Needs Analysis

Prepared for: Landcare Research
Prepared by: The AgriBusiness Group
May 2015

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Executive Summary

Background

This report contributes to The AgriBusiness Groups involvement in the Landcare Research project named The Trojan Female Project. It is in completion of Objective 1.4.3 User Needs Analysis: A User Needs Analysis has been conducted for the six top terrestrial vertebrate and invertebrate pest issues (in terms of economic impact).

The purpose of this piece of work is to carry out the user needs analysis on each of the six species by reference to previous work that has been carried out on each of them in terms of the Cost Benefit Analysis (CBA) of potential control measures. Then three of them will be chosen for 'pathway to application' construction. Note that although varroa mite was initially identified as one of the six pests to consider, feasibility studies identified it would not be conducive to control by the Trojan Female Technique. It was thus replaced with pest wasps, recently identified as having greater economic impacts to New Zealand than previously realised, for consideration here.

In a CBA there are three possible measures reported. Net Present Value (NPV) is the difference between discounted benefits and discounted costs, Benefit Cost Ratio (BCR) is the ratio of discounted benefits to discounted costs, and Internal Rate of Return (IRR) calculates the discount rate that results in discounted benefits being equal to discounted costs.

In this case it is our opinion that the first two (NPV and BCR) are the two measures which are relevant. The purpose of carrying out CBA is to create measures which projects can be compared between to determine which is the best investment. It is our understanding that this project wished to have these comparative measures to compare the worth of the Trojan Female Project.

Results

The results of the financial analysis carried out on the six specified species are shown in Table 1.

Table 1: Results of Analysis of Six Species

	NPV ($m)	Comments
Argentine Stem Weevil	$878 to $2,825	Costs to the productive sector. No inclusion of the impact of endophyte or parasitic wasp.
Clover Root Weevil	$1,092	Costs to the productive sector. No inclusion of the impact of the parasitic wasp.
Wasps	$1,350	Cost to the productive sector.
Possums	$250	Full CBA factored against the counterfactual. Partial in that it doesn't include DOC expenditure.
Rabbits	$107	Cost of control to the land based sector only.
Pest Birds	$373	Cost to the Arable sector.

The things to take from the analysis of the six species are:

- Only one, possums, was a full CBA on control costs.
- The majority of the rest were economic impact statements of the cost to the productive sector.
- Several were relatively early in the incursions of the pests and severely overestimated the impacts of them.
- Many of them were done too early in the life of the pest which meant that they were not able to estimate the impact of control measures, particularly the biocontrol measures.
- Only one of them had a counterfactual which meant that it was impossible to calculate a BCR.

Recommendations for the next stage

It is our recommendation that 'pathways to application' be constructed for the control of Argentine Stem Weevils, Clover Root Weevils, and wasps. We also recommend that a full CBA be done on Argentine Stem Weevil in relation to the impact of the parasitic wasp and the use of endophyte, Clover Root Weevil on the impact of the parasitic wasp and Wasps into the potential impact of the range of treatment methods being developed. From these studies we will be able to calculate both NPV and BCR in order for the project to compare the potential value and benefit cost ratio of the Trojan Female Project.

1. Background

The AgriBusiness Group will contribute to a two year Landcare Research led research project (October 2013 to September 2015) that aims to develop a novel and cost-effective technology platform for the specific, persistent, non-lethal and non-GMO control of vertebrate and invertebrate pests. Overall project research aims are (1) proof-of-concept in invertebrates, (2) proof-of-utility in vertebrates, (3) assessment of social acceptability, and (4) pathways to market.

Objectives:

In collaboration with the Science Leader, other Key Researchers and a project Advisory Group, The Agribusiness Group will lead Critical Steps 1.4.3 and 1.4.4 of the MBIE contracted programme of work:

<u>1.4.3 User Needs Analysis:</u> A User Needs Analysis has been conducted for the six top terrestrial vertebrate and invertebrate pest issues (in terms of economic impact).

<u>1.4.4 Pathways to application:</u> Detailed pathways to application have been developed for three of the target pest species through considerations of the feasibility studies (1.4.1) and the User Needs Analysis (1.4.3), under guidance from the Advisory Group, and considering likely application scenarios, Trojan Female Technique (TFT) development and application costs, and technological, logistical, policy and social hurdles to application (and the probabilities of surmounting them).

The Agribusiness group will also assist the Science Leader with Critical Step 1.4.5 of the MBIE contracted programme of work:

<u>1.4.5 Industry and research partner engagement</u>: End-user and service provider relationships have been developed as appropriate (with reference to 1.4.1 – 1.4.4).

Methods:

In was initially intended that the User Needs Analysis (1.4.3) would be conducted for clover root weevil, Argentine stem weevil, rabbits, possums, pest birds, and varroa mite. The analysis will quantify the scale of economic benefit that could be realised by new control approaches.

The detailed pathways to application (1.4.4) will be constructed for three of the target pest species, as determined by the Advisory Group and Science Leader, through application scenario simulations (i.e. the logistics of what, how and when, in relation to both costs and benefits, and other available tools), consideration of likely TFT development and application costs on a species-by-species basis, and assessment of the likely technological, logistical, policy and social hurdles to application (and the probabilities of surmounting them), all linking into the on-going development of the MBIE-funded Sustainability Dashboard.

2. Methodology

As a result of early mathematical modelling feasibility research for TFT application to insect pests, Tompkins (2015) identified that:

- For varroa mite populations, the high level of brother / sister mating which occurs would negatively impact the inclusive fitness of females carrying TFT mitochondrial DNA haplotypes, resulting in the rapid loss of the TFT impact from the population. Therefore Pest Wasps were substituted for varroa mites in this analysis.
- For field pasture weevil populations greater results were achieved by trickle release of TFT individuals and releases into overwintering adult populations. Increasing male fertility of the TFT individuals increased the release effort required.

2.1 Cost Benefit Analysis

In Treasury (2015) they specify the main steps in creating a cost benefit analysis as:

- Define the project options and the counterfactual.
- Identify the gainers and the losers.
- Identify the costs and benefits
- Quantify costs and benefits (ideally in terms of ranges).
- Calculate Net Present Value, Benefit Cost Ratio and / or Internal Rate of Return.
- Identify equity (distributional) issues.
- Report.

The counterfactual is the situation which would occur if the project did not proceed. It is often called the "do nothing" scenario. It is vitally important to have the counterfactual calculated correctly because the benefits and costs of the project are measured against the counterfactual.

In a CBA there are three possible measures reported:

- Net Present Value (NPV) is the difference between discounted benefits and discounted costs. The discounting requires that they are set out over a long time period of approximately thirty years and this is then discounted at a given discount rate which in this case is 8%.
- Benefit Cost Ratio (BCR) is the ratio of discounted benefits to discounted costs.
- Internal Rate of Return (IRR) calculates the discount rate that results in discounted benefits being equal to discounted costs.

In this case it is our opinion that the first two (NPV and BCR) are the two measures which are relevant. The purpose of carrying out CBA is to create measures which projects can be compared between to determine which is the best investment.

It is our understanding that this project wished to have these comparative measures to compare the worth of the Trojan Female Project.

3. Results

3.1 Argentine Stem Weevil

3.1.1 Background

Argentine Stem Weevil (ASW) has been a pasture pest in New Zealand for over 100 years. It is mainly a pest in improved pastures and some crops and has been recorded as doing up to 50% damage to new pasture species. As detailed in the Taranaki Regional Council article (2009) ASW damage to pastures result in:

- Lower stocking rates.
- More frequent resowing of pastures.
- Reduced cultivar suitability.
- Lower weight gains.
- Lower milk production.
- Higher incidence of dags and flystrike.
- Animal health problems due to relying on high endophyte species.

Biological control by the Parasitoid Wasp was expected to result in the following outcomes:

- Increased persistence of high producing ryegrass species.
- Increase in Dry Matter production.
- A resultant increase in productivity.

As explained by Jackson(2009) one of the greatest breakthroughs in insect control in New Zealand has been through the distribution of fungal endophytes in ryegrasses, particularly in terms of resistance to ASW attack. However there is a cost in lower stock productivity because of animal health problems caused by the presence of these endophytes. Selected endophytes have the potential to provide protection from insect attack and marked improvement in animal performance. The AR1 endophyte gives both of these advantages.

The biological control has given mixed results and in Goldson (2014) there is discussion on its ultimate efficacy which may cast doubt on its ultimate success.

3.1.2 Analysis

In Prestidge (1991) he details his attempt to quantify the cost to the New Zealand economy of ASW. This work should be regarded as an economic impact assessment rather than a CBA. He does not create or compare the result of his work with a counterfactual.

It is the only work that we could locate which attempted to put an economic value on ASW.

In it he quotes a possible range of values. He calculates values for:

- Reduced animal production and re grassing.
- Reduced Animal Health due to pasture quality.
- Facial Eczema.
- Bloat.

He comes up with annual values of between $78 m and $251m in terms of the annual cost of ASW.

If these figures are put through a CBA analysis they come up with an NPV of between $878m and $2,825m. This has been updated to the value expressed for the last quarter of

2014 using the Producers Price Index (PPI). Because no control methods are calculated there is no way of calculating a BCR.

It should be noted that no financial analysis has been done on the impact of either the use of endophytes or the parasitic wasp.

3.2 Clover Root Weevil

3.2.1 Background

Clover Root Weevil (CRW), *Sitona lepidus*, feeds exclusively on clover and has spread rapidly since its arrival and identification in New Zealand around 1996.

It spread initially through Waikato, Bay of Plenty and Northland. By 2004, CRW had been found on dairy farms throughout the North Island. In early 2006 it reached the South Island and has since migrated as far as Southland.

White clover is its preferred host, with all cultivars susceptible, although more vigorous varieties show a level of tolerance. Both white clover and CRW go through seasonal cycles. CRW populations will tend to rise and fall with fluctuations in clover growth.

CRW can completely remove clover from pastures, decreasing pasture quality and negatively affecting nitrogen fixation.

When CRW feeds on clover roots, they reduce the amount of nitrogen that can be provided by clover, and this must be supplemented with nitrogen fertiliser to maintain productivity.

In pastures CRW damage can result in a substantial loss of productivity due to reduced clover levels and nitrogen fixation. These losses in nitrogen fixation can only be offset at this stage by applying nitrogen fertiliser, and drawing on existing soil organic nitrogen reserves, which vary with soil type, fertility and climate.

In 2006, AgResearch introduced a small parasitic wasp (Microctonus aethiopoides) as a biological control agent against clover root weevil. It lays an egg inside the adult CRW, which immediately stops the weevil from being reproductive. After a major release programme by AgResearch with support from DairyNZ, this biological control agent is now present in most areas of the North and South Islands. The wasp is also spreading naturally from release points at the rate of 15-20 km per year.

The way that CRW spread and the proportion of infested pastures was quiet spectacular with the initial shock causing quite widespread reduction of clovers in the pastures. As the population settles down it now seems that the amount of damage is much less than what was first experienced and it is expected that damage will occur in cycles as numbers wax and wane.

No attempt has been made to assess the impact of the parasitic wasp on CRW.

3.2.2 Analysis

In 2005 the NZIER reported an economic impact assessment of the impact of CRW in New Zealand. They calculated the cost of CRW assuming that farmers were able to replace the loss of nitrogen fixation with the addition of artificial nitrogen and additional supplementary feed. Therefore there was no counterfactual created in this analysis.

They also calculated the costs related to the cost of production of extra N fertiliser, atmospheric nitrogen pollution and the costs to the Apiculture industry of the impact of CRW. In their report they noted that;

There is considerable uncertainty over the likely impacts of clover root weevil. The rate of spread through New Zealand, the relationship between levels of infestation, reductions in soil nitrogen and clover foliage, and the response by farmers in adapting their management practice are notable areas of uncertainty. The following three scenarios are modelled to assess the level of uncertainty around these core assumptions mentioned above:

- *A medium impact scenario using best judgement of the likely spread of clover root weevil and its impacts on soil nitrogen and white clover foliage. In this scenario clover root weevil spreads nationwide by 2010. Nitrogen fixation and pasture coverage of white clover would be reduced by 50 percent.*
- *A low impact scenario using optimistic assumptions for rates of spread and impacts on soil nitrogen and white clover foliage. In this scenario, clover root weevil spreads nationwide by 2015. Nitrogen fixation and pasture coverage of white clover would be reduced by 20 percent.*
- *A high impact scenario using combinations of pessimistic assumptions for rates of spread and impacts on soil nitrogen and white clover foliage. In this scenario, clover root weevil spreads nationwide by 2008. Nitrogen fixation and pasture coverage of white clover would be reduced by 80%.*

In retrospect it seems that their medium and high impact scenarios were far too aggressive particularly in relation to the amount of pasture reduction of clover. Therefore the analysis that we have done relates only to the low impact scenario.

What we have done is taken their estimates of the urea usage and the extra supplementary feed costs and have put them through an NPV analysis and updated the result to the last quarter of 2014. This gives us an NPV value of $1,092 m of the cost of CPW using the assumptions used in the NZIER report. There is no way of calculating a BCR because no estimation of control costs has been made.

3.3 Wasps

3.3.1 Background

The following information on wasps is taken from the Landcare website.

There are no native social wasps in New Zealand – a very unusual situation compared with other parts of the world. However, there are four introduced species of social wasps established: two introduced species of paper wasps (Polistes) and two Vespula species.

The German wasp (Vespula germanica) is native to Europe and northern Africa. It was first found at an air force base near Hamilton, in 1945. Although considerable efforts were made to eradicate nests, German wasps spread very quickly, and within a few years were found in most of the North Island and parts of the upper South Island.

The common wasp (V. vulgaris) is native to Europe and parts of Asia (e.g. Pakistan and northern China). Single specimens of the common wasp were recorded in New Zealand in 1921 and 1945 but these apparently did not establish. The common wasp was confirmed as established in Dunedin in 1983, although, examination of museum specimens showed that queens had been collected from Wellington as early as 1978. It rapidly spread throughout

New Zealand and almost completely displaced the German wasp from beech forests in the upper South Island because of its superior competitiveness.

In general, wasp populations are large in New Zealand because of the mild climate, lack of natural enemies, and very abundant food sources (especially honeydew). However, recent reviews of invasive invertebrates continually point to social insects as one of the top problems around the world because of their high level of 'ecological plasticity' (i.e. flexibility to adapt and utilise resources). Factors such as nest size and longevity, a very wide diet range, feeding at different trophic levels, and ability to reach very high densities, all contribute to the successful invasion of social wasps.

Both the German and common wasp are now widespread throughout New Zealand. In some habitats, they can be some of the most common insects encountered. As a result, wasps have had detrimental impacts on native ecosystems, and human health, cause economic losses for beekeepers, and disrupt recreational activities.

Ward (2013) in traversing the various possible control options lists the following potential controls:

- Nest Destruction: highly effective; no non-target effects; toxicity is high however, nests are currently very difficult to find.

- Trapping/Attractants: no evidence to support its effectiveness; some non-target effects can be high, dependingon the attractant used.

- Baits (general): proven method of rapidly reducing and eliminating wasps; control over a relatively limited scale; toxicity high but benefits currently seen to out-weight costs. Baits (with fipronil): currently unavailable because of chemical patent/legal issues and future availability very uncertain. Baits (with other toxins): yet to be fully tested and registered but may be available in the near future.

- Pheromones (to disrupt nest activities): largely unproven but great potential; no non-target effects; no toxicity; control over a relatively limited scale.

- Biological control: potential to suppress numbers of workers and reduce nest densities; however, current agents ineffective

- New DNA technology: the method known as "RNA interference".

Ward (2014) in traversing the options for biological control of wasps identified from the literature that there are few promising options for biocontrol of wasps in NZ. He did identify that in New Zealand, one species is known to attack *Vespula* wasps: the parasitoid *Sphecophaga vesparum vesparum*; and a species of *Pneumolaelaps* mite is currently suspected of attacking *Vespula* wasps. Ward felt that the recent discovery of *Pneumolaelaps* mites warrants further research to determine their potential as classical biological control agents.

Ward also noted that we should wait for results of the Marsden funded study (Nov. 2013-Nov. 2016) awarded to Prof. P. Lester (Victoria University) which will search for pathogens in the native range of V. vulgaris. If potential agents are found, then follow-up work will be needed to develop these into biocontrol agents.

3.3.2 Analysis

Sapere (2015) have recently published their evaluation of the costs of pest wasps in New Zealand. They divided their analysis up into Use Impacts and Non Use Impacts.

Use impacts incorporated:

- Direct impacts, which included impacts on beekeepers, agriculture, human health and forestry which they calculated to have a total value of $75 m per annum.
- Indirect Impacts: which included impacts on tourism and recreational value of which they stated that the total value is unknown.
- Option values which included the potential future values should wasps be better controlled. In this section they valued the net value of honeydew at $58 m per annum.

Non Use Impacts incorporate:

- Bequest values for which they give the example of wasps removing our ability to pass on a nuisance free biodiverse environment. They have not quantified any values for this section.
- Existence values for which they give the example of damage done to biodiversity as wasps compete with indigenous species.

They calculate that for the things that they have been able to value that wasps create a cost of NPV $1,350. As there is no counterfactual calculated it is not possible to calculate a BCR.

3.4 Possums

3.4.1 Background

Possums are widely spread throughout New Zealand. One estimate made in 2009 was that there were 30 m of them in New Zealand. They are the cause of two major sources of harm. One is to our native forests, and the biodiversity which they contain, where they are particularly destructive and can cause the trees to die if they are present in sufficient numbers. They are also known to feed on the nests and young of many of our native birds. The second is that they are the major vector for Bovine Tuberculosis (TB). Therefore there are two sets of people who are keen to either control or possibly eradicate possums in New Zealand. The first is those people who are charged with maintaining our native fauna and flora, this group is led by the Conservation Department. The second is the national body which is responsible for controlling TB which is the Animal Health Board (AHB).

The main means of control used by both groups is the use of 1080 poison which is dropped across the infected areas. Apart from this control method other options are other poisons and individual animal trapping and shooting.

3.4.2 Analysis

The AHB has a five yearly review of its strategy and funding. Because it is partly funded by the Government it is required to do a Cost Benefit Analysis of its proposed programme. The following information is taken from MAF’s Review of the National Bovine Tuberculosis Pest Management Strategy 2010.

The counterfactual that they use is called the No Strategy and Ad Hoc Control option whereby there would be no national body responsible for TB control and therefore control programmes in each region would be managed by land owners, industry and regional councils on an ad hoc basis. It was decided that this was a more realistic option than the do nothing option because under that option the country would be riddled with TB in a relatively short time and it would not be able to trade.

This counterfactual was compared to a preferred option that tested the ability to eradicate TB. This option would maintain and continue to seek measured reductions to the disease rate and vector risk areas from status quo levels, and would test assumptions about, and projected costs for, eradicating Tb from vector risk areas.

In the CBA the counterfactual had costs associated with vector control and testing costs for TB which totalled an NPV of $356 m. The preferred option had benefits of Carcass Value Saved, Productivity saved, Clinical diagnosis costs saved and Biodiversity benefits (DOC costs saved) of $369 m. the preferred option had costs of Management, disease control and testing, vector control and on farm costs to have a total of costs of NPV $950 m. The deduction of the counterfactual from the preferred option leaves a marginal net cost of the preferred strategy before trade risks of $225m.

Expressed in 2014 dollars this is a total cost of the difference between the strategies of $250m. In the analysis this is written off as the Net trade benefit based on the costs avoided.

No attempt has been made to put a financial value on the efforts made by DOC to kill possums.

3.5 Rabbits

3.5.1 Background

Rabbits have been a significant pest across New Zealand for over one hundred years. Their impact is particularly significant in the semi arid lands across the High Country of New Zealand. With the illegal introduction of rabbit haemorrhagic disease (RHD) in 1997 the rabbit population was devastated. Landholders were encouraged to target survivors of RHD with other control techniques to maintain low rabbit numbers and to avoid resistance to RHD building up. This has been done very successfully on some properties but on others rabbit numbers have built up sufficiently to justify costly wide spread poisoning programmes.

In Lough (2009) he states that:

Rabbits pose a significant threat to production values – they compete with livestock for grazing and provide a staple diet for vectors of bovine tuberculosis. Along with farmed livestock, particularly sheep, they have modified vegetation cover and composition. At higher numbers they can cause significant soil damage and soil erosion, with subsequent effects on water values. The costs incurred in their control can be very high and, where toxins are used, there can be major disruption to grazing management because of the need to keep the land clear of livestock.

Together with farmed livestock, rabbits also damage natural ecosystems, plant communities with specific conservation values, threatened species and their habitats. Rabbits can also pose indirect risks to valued fauna by supporting resident populations of predators such as ferrets and cats. One hundred and fifty years of pastoral farming and repeated 'explosions' in *rabbit populations have modified the original vegetation to the extent that, in large areas of the semi-arid lands, the most extensive environmental threat posed by rabbits is to the soil. By the time significant soil erosion occurs productive values will largely have been lost.*

Rabbits are still controlled by Regional pest management strategies which are helping to limit the amount of unacceptable population increases.

3.5.2 Analysis

Reddiex and Norbury (2005) concluded that *"there is no way at present to assess the marginal costs and benefits of rabbit control"* this is confounded by the inability to differentiate between the combined effects of sheep grazing and rabbits. This is further confounded by the inability to accurately account for the environmental impacts of rabbits. This has meant that no one has attempted an overall CBA on rabbit control.

In Lough (2009) he details the impacts of rabbits on land based industries as:

- Short term direct grazing losses (otherwise available to livestock)
- Longer term grazing losses through modification of vegetation cover and composition
- Financial costs of rabbit control
- The major disruption to grazing management associated with the need to spell from grazing any land treated with 1080 until sufficient rain has fallen to make it safe to livestock
- Loss of soil (at high densities)
- High rabbit populations assist in maintaining high predator numbers. 'This can lead to significant costs being incurred in situations where predators carry bovine tuberculosis' (ECan RPMS).

Brown Copeland and Co (cited in RCD Applicant Group, 1996) estimated the annual costs of rabbit control to landholders and regional councils to be 'a minimum' of $12.6 million. The Applicant Group suggested that $22 million was a more realistic assessment. Nimmo-Bell (2009) estimated the current annual production losses due to rabbits at $50 million, citing an earlier report by Bertram (1999) in which it had been estimated that 2.0 million sheep were being displaced by rabbits (at a 1999 value of $25 per head). In reaching this estimate, Nimmo- Bell assumed that by 2009 rabbit populations had halved and that livestock values had doubled.

In our assessment we took all of the land classified as over the minimum value for rabbits and therefore requiring control and valued the cost of that at the average cost detailed in Lough. We then applied the average cost of secondary control detailed in Lough across the area detailed as subject to extreme pressure from rabbits and included the detailed annual costs to each of the Regional Councils of rabbit monitoring and control. This figure should be considered to be the annual control costs of rabbits and totals $8.4 m.

When this figure is run through our NPV model and adjusted to last quarter of 2014 values it results in an NPV of $107 m. Again because we do not have a counterfactual we cannot calculate the BCR.

3.6 Pest Birds

3.6.1 Background

FAR 2010 states that:

- Introduced bird species, predominantly house sparrows and green finches, are the key species causing damage in arable crops.
- In the breeding season (summer) areas which had high populations of problem birds in one year had high populations in the following year. High populations were associated with hedgerows and shelter belts.
- In the winter the population densities were not related to the summer population or the previous winter population densities. Winter populations were associated with supplementary feed and the presence of stubble.
- Birds foraged and moved over significant distances in both winter and summer.
- A strategy to control birds needs to focus well beyond the farm boundary and winter control on a local scale may have little effect on summer populations.
- Reducing or removing winter food sources may be an effective control measure.
- Effective bird management is expected to require a collaborative approach on a large scale to reduce winter bird survival.

They explain that netting crops is relatively effective against house sparrows and greenfinches, it is also very expensive and is impractical for many large scale crops of lower value. It is used in some specialist high value crops such as carrot seed etc.

3.6.2 Analysis

FAR estimate that pest birds may cost the industry in excess of $30m per annum. When this is calculated through our NPV model and adjusted to bring it to the last quarter of 2014 it results in an NPV of the cost to the industry of $373m. However the lack of a control strategy makes it impossible for us to calculate a BCR on pest birds.

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