A case study demonstrates a democratic methodology for making risk based decisions

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Running head: Democratic risk decisions

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1. ABSTRACT

Risk is a subjective notion, but the limits between our role as risk practitioners and decision makers can become blurred. A belief that the public misunderstands risk and the need to control the process are two barriers to effective engagement. We believe that a lack of engagement and the ability to enable citizens to decide their own future can contribute to the controversy we see on important public debates. In our study, using an existing risk assessment and decision, we survey four stakeholder groups in New Zealand in order to determine how they rate the costs and benefits. Our survey methodology incorporates a continuous scale along three axes that represent the biophysical outcomes of economic, environmental and human health. This design enables costs and benefits to be traded-off between individuals, giving them a representative voice. We use these results to investigate whether or not it would be feasible to use such an approach in order to make decisions, and what this may mean. Our results indicate that public decision making is possible, and in this case broadly the public view broadly agrees with the official decision. Such an approach holds promise for expanding the role in the risk assessment process.

Keywords: subjective risk, social weighting, knowledge elicitation, expert opinion, risk assessment

2. INTRODUCTION

Risk assessment is generally perceived as a scientific and technical discipline. That view is slowly changing. Risk assessors have been building tools to incorporate expert scientific and technical opinion (Clement and Winkler, 1999) and to communicate the risk management process more effectively (Fischoff, 1995). Further to this, there have been calls to use public input to help define necessary trade-offs and develop acceptable criteria for risk acceptance or rejection (Renn, 1998). These approaches have achieved some success, for example, water management issues regarding electricity generation (McDaniels et al, 1999).

However, there are many cases where the opposite is true. One reason is that many continue to argue that public participation should be constrained or pursued in order to achieve a particular outcome. For example Rowe and Frewer (2005) argue public participation can be measured by the degree to which relevant information is elicited, then combined into an accurate synthesis. Wang and Wart (2007) also take a similar view in their analysis on whether or not public participation can create trust in citizens, noting that this participation can be viewed as a route to achieving better decisions and raising legitimacy. Other authors concur and note that risk communication has moved from attempts to educate people about risk to a situation of consensus building and conflict resolution (Boholm, 2008). More specific to the field of risk, take the example of Barling et al. (1999) who noted that the incorporation of social impact analysis into risk analysis was to *create* trust. We are yet to see any risk practitioner argue specifically for public participation on moral or ethical grounds. We are therefore left with the impression that risk managers want to engage with the public only if it can practically be used to deflect blame, calm fears and increase acceptance.

Unsurprising perhaps given that previous surveys of experts have shown that they believe the public fundamentally misunderstands many of the issues (Petts and Brooks, 2006). The ultimate outcome of this is that many of the systems and processes developed for eliciting public participation are

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constrained. We may be seeing the effect of such opinions when we hear about the aim to deliberate with only articulate citizens with expertise (Lehoux, Daudelin, and Abelson, 2012), or the design of risk management systems and software's that appear to have the goal of excluding participants (Loosemore, 2010). Such approaches are not new, and generally based on the principle of using frameworks to translate public perceptions allowing the weighting of disparate beliefs. One of the first examples of this was the pioneering work of Thorndike (1937) who in his paper on "Valuations of Certain Pains, Deprivations, and Frustrations" investigated how much we would pay to avoid such deprivations as having a little toe cut off, choking a cat to death or living the rest of our lives on a farm in Kansas ten miles from any town. Clearly, what passes as an experiment has changed, but yet the same focus remains on getting the public to work within our framework. A good example of this comes from Renn et al (1993) who developed a conceptual three part procedure for enabling public participation. This process starts by taking stakeholders who are "valuable resources for eliciting concerns and developing evaluative criteria since their interests are at stake" and experts who are "necessary to provide the data base and the functional relationships between options and impacts". The product that these two groups provide is then used as an input to be tested by citizens panels. Of course one must ensure that they do not see this process as completely open, as Renn et al (1993) put it "The rationality of public input depends, however, on the procedure of involvement. Provided citizens are given a conducive and supportive structure for discourse, they are able to understand and process technical information and to articulate well-balanced recommendations".

It is perhaps needless to say that this layer of translation is a major stumbling block for true public participation. The subjective and emotive nature of risk creates controversy that cannot or perhaps more accurately should not be condensed or translated into a risk analysis framework. A great example of this is the biotechnology sector. There is controversy over the potential of the technology (Pretty, 2001) and it is also clear that people view biotechnology risks and benefit based on their cultural and political dispositions (Kahan et al, 2008) and the public does not trust all sides equally (Lang and Hallman, 2005). We believe that this controversy and complexity is something that should

be embraced rather than hidden or simplified. Risk is a subjective notion (Slovic, 1999) and it is becoming increasingly clear that even coldly rational analyses still need to be guided by emotion (Slovic et al. 2004) or perhaps even more significantly that there is no neurological basis for distinguishing thought from emotion (Damasio, 1994)

We have previously provided a series of case studies that highlight what can happen when value systems conflict, even in the face of objective certainty (Corin et al, 2012). We make the claim that in order to resolve such societal dissonance the only option is to transfer decision making power to citizens so they can determine their own future. This we see as continuing to build on the foundations of our society and democracy.

In this light, we see the role of risk experts as needing to use well established tools and methods to establish the possible biophysical effects of an activity. Citizens are then able to make a decision based on this information and other sources available to them. Of course this leaves open the issue of how we weigh such citizen views. Is everyone treated equally, or are those with greater knowledge the ones to whom we should turn? We believe that many countries have already solved this problem. It is a commonly held belief in democracies that we all have equal right to an opinion and should have the ability to determine our own future. We believe that risk assessment is amenable to such an approach.

In this paper we present a mixed model for helping achieve the goal of incorporating public opinion into risk analysis. We believe that magnitude as a component of risk can only be seen as a subjective topic, in which participants, stakeholders and citizens must directly determine the magnitude of an effect. We therefore provided participants with a biophysical description of a scenario and allowed participants to rate the magnitude of each effect. We surveyed four groups, including the New Zealand regulator, the Environmental Risk Management Authority, and its major stakeholders. The goals were (1) to establish whether the use of a democratically based weighting tool can be used for making decisions on risk; and (2) investigate any differences between the sample groups.

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3. METHOD

3.1 Participants, scenario and survey

Participants were drawn from the New Zealand regulator the Environmental Risk Management Authority (ERMA), and three non-random focus groups comprising people from indigenous tribes - iwi, school teachers and scientists (Table 1). Participants were provided with information on the nature and aims of the project, its methodology, potential benefits of the research, how the researchers will maintain confidentiality of responses and the contact details of the principal investigator, in line with Synapt Consulting ethical guidelines. On consulting to take part in the study, participants were presented with either an online or paper copy of a risk assessment. In this assessment four impacts were presented. These impacts relate to the release of a wasp biological control agent, *Cotesia urabae*, to tackle gum leaf skeletoniser, a caterpillar of eucalypt trees. The risk assessment presented was loosely based on an ERMA decision that had been approved (Table 2) and included descriptions of magnitude but not likelihood. The descriptors for each effect were generated based on the information available in the ERMA assessment and attempted to represent a likelihood of 0.5. However, participants were unaware of this information and were asked to ignore likelihood and accept the descriptions as given.

Participants from ERMA knowledgeable on this case study could have introduced bias into our study design. In an attempt to reduce this bias we ensured that the only staff surveyed were those not knowledgeable about the particular case material. However, our ultimate goal was to test the applicability of this methodology, rather than using a randomised but rigorous approach to look for differences between groups.

3.2 Magnitude assessment

Participants were asked to rate these four physical impacts across three broad categories, human health, economy and environment. Participants were able to compare risks and benefits in any way they desired as measured along a scaleless bar. Three markings were made on the bar, signifying the

midpoint, along with the maximum negative and positive possible. This bar was later translated to a -100 to 100 bar, allowing for statistical analysis.

Participant responses were statistically analysed using a repeated measures ANOVA. Bonferroni post-hoc tests were used to determine the cause of any significant differences. From these omnibus results more specific one-way ANOVAs were used to test whether or not the sample groups rated human health, economic or environmental outcomes differently. The homogeneity of variance's assumption was violated in only the environmental outcome and therefore a Welch ANOVA was used, along with the Games-Howell post-hoc test.

3.3 Decision making

The use of a scaleless bar allowed for post-hoc scaling in order to ensure proportional representation was achieved. This scaling adjusted each participant's score so that all could be considered equal – an important adjustment given the democratic aim of the tool. In order to achieve this we ensured that the largest magnitude response was scaled to the maximum allowable (-100 or 100) and all other scores were scaled using the same factor. We consider this a twist on the Single Transferrable Voting (STV) system. Rather than have people rank preferences we have added in a scale providing for a greater resolution and granularity for participants or 'voters'.

Each of the effects was described at a 50% probability of occurrence. In this instance it meant we did not need to adjust the magnitudes generated by participants in order to weigh risks and benefits. In a more complex example, we would see participants' results having to be scaled proportionally to the likelihood of an outcome. The summation of all scores determined whether or not they considered the positive benefits to have outweighed the negative risks. A positive outcome was associated with a decision to approve the release, and a negative outcome a decline. When benefits and risks were determined as equal a participant was considered to be neutral.

Results were tabulated and a Pearson's chi-squared test was used to determine if the frequency of particular decisions differed from what we would expect. As no post-hoc test is available we used standardised residuals in order to highlight where these differences occurred.

4. RESULTS

4. 1 Magnitude assessment

Statistical differences were found between ratings of each effect ($F(2, 162)=21.521$, $p < 0.001$). A Bonferroni corrected post-hoc test found that economic effects (30.52 ±4.29) were rated significantly higher than human health (6.39 ±4.69, $p < 0.001$) and environment (-2.76 ±4.98, $p < 0.001$).

There were also significant differences in the way in which groups scored the effects ($F(3,81)=3.379$, $p=0.022$). A Bonferroni corrected post-hoc test using the correction revealed that ERMA staff (28.71 ± 6.62) rated effects significantly higher than scientists (0.491 ±7.44, $p=0.035$). Iwi (4.28 ±6.62) also rated effects lower than ERMA although this trend was not statistically significant ($p = 0.064$). There were no significant differences between any of the other groups.

One-way ANOVAs were used to investigate which effect caused this difference. The rating of human health and economic effects did not differ significantly between groups. However, the rating of environmental effect did show significant differences between groups ($F(3, 40.11)=9.76$, $p=0.000058$). A Games-Howell post-hoc test showed that ERMA staff rated the environmental effect (25.29 ±26.172) higher than scientists (-29.58 ±39.47, p= $p < 0.001$) and iwi (-9.29 ±54.81, p= 0.041). There was no significant difference with teachers (2.56, +-56.9, $p=0.412$) or between any of the other groups.

4.2 Decision assessment

In order to make a decision we scaled individual responses in order to ensure they held the same weight (Figure 1). After calculating whether or not an individual's net assessment was of benefit or risk we categorized their responses as approved or declined. Overall it was found that the majority of

participants approved the application, with 57 approvals, 26 declines and 2 neutrals. Under our system we would take this as an overall assessment that the benefits outweigh the risks and that this would provide justification for an approval to be granted.

A comparison of decision making by each group (Table 3) tested with a Pearson Chi-Square statistic showed that the observed frequencies between groups did not match what was expected ($p=0.004$). A comparison of standardized residuals suggests that this result was caused by an under-representation in the ERMA sample of participants who would have declined the application (Standardized residual=-2.3, $p<0.05$).

4.3 Comparison with official decision

On 1 July 2010 the Environmental Risk Management Authority approved the application. In its decision, the Authority provided risk ratings for each component of the assessment undertaken (Table 2.).

As the design through intention of our rating tool does not enable a subjective viewpoint to be directly compared with any of the objective statements, it is difficult to relate participants' scores directly to the much more constrained decision making process undertaken by the Authority. The simplistic nature of the application does however, allow us to make some broad statements. In its official decision, the Authority saw minimal benefits to human health, medium economic benefits and low risks to the environment. Such an outcome matches the broad weighting of participants, with the exception of ERMA staff who rated the environmental benefits as positive.

5. DISCUSSION

Our findings indicate that the use of democratically based weighting tool could be used for making decisions on risk. Although the scenario should be considered simplistic, we found that the tool clearly differentiated viewpoints on benefits and risks, and provided a clear decision. We found that overall participants identified that the positive benefits outweighed the risks with all groups

consistently showing this. Such a result is congruent with the decision made by the Authority. However, this high level result masks substantial inter-group variation. One group, ERMA, was found to be inconsistent with the other focus groups. ERMA consistently scored effects higher than the other three focus groups. In particular the ratings by ERMA for environmental effect were significantly higher than iwi and scientists, who on average rated the effect as negative. This result is suggestive that the ERMA group had few participants rating effects as negative, a finding confirmed by a lower than expected number of ERMA participants declining the application.

5.1 Magnitude assessment

There are a variety of ways of assessing the magnitude component of risk. Though these may seem objective, they all invariably include a subjective valuation of physical effects (ref). Take for example assessment tables, where descriptors are given and users assign their physical assessment to the appropriate category on the table. The question then, of course, becomes who developed the descriptors and how did they avoid biasing the construction of descriptors with their own worldview?

Instead our approach focused on making the magnitude assessment as subjective as possible. To this end we used a survey tool which was devoid of any scales. The results indicated that there were large amounts of variation between participants. Interestingly, we found the ERMA staff who as the regulators are tasked with developing the risk assessment framework were significantly more positive than all the other three focus groups. We cannot rule out that knowledge of the real-world application approval biased some participants from ERMA, but given the consistency of results we feel that it is unlikely to be the only explanatory factor. Furthermore, this result supports existing research which suggests that experts can be biased in their judgements. This research covers a broad range of situations, such as overly optimistic foresight predictions by experts (Brandes, 2009), overconfidence by financial market professionals (Glaser et al. 2005) and even the belief by customs

and police officers that they have greater abilities in lie detection despite evidence suggesting otherwise (Leach et al. 2004).

5.2 Decision assessment

The majority of participants weighed the benefits higher than the risks. This result indicates that the tool can provide a clear outcome that could aid in the decision making process. We ultimately see that a more refined tool could be used in actual decision making, but at this point the tool can be used to highlight to a decision maker a very clear view of public opinion.

The ease of gathering this opinion, either online or in person can enable a greater numbers of the public to respond. For example, the response rate by iwi to this survey was around 20% much higher than the actual number of submissions received during the formal consultation process which had a total of zero respondents from iwi (ERMA, 2010). In fact, as a result of this survey we were approached by a number of iwi and other participants who were unaware of the application, let alone the fact that an approval had been granted (S. Corin, personal observation.). Such an effect is not unexpected. Formal submission processes can often lead to a polarisation of the debate, with few neutral stakeholders taking part, at least according to the perceptions of some risk practitioners (Petts and Brooks, 2006). Furthermore, unlike conventional polling this tool does not provide a simple answer to a simple question, instead it provides a rich overview of what groups think, along three subjective scales and allows respondents to include in their view beliefs, concerns and values for which they may not be able to present reasoned cases (Kaebnick, 2008).

5.3 Comparison with official decision

We found that the decision made by participants was very similar to the official decision. The ranking of effects was consistent, and the overall decision of approval was also in concurrence. We did note that one group, ERMA staff, appeared to rank environmental benefits higher that the decision makers, perhaps reflecting that experts are less concerned about potential risks than the public (Savadori et al., 2004). We believe that this tool could be of use to decision makers. Often these very

public decisions are made 'behind closed doors' after taking into account public input via a formalised process such as submissions or presentation at a hearing. We see the potential benefit of this tool in gathering the views of a much wider swath of society, as well as providing rich contextual data on how people rank the varying benefits and risks to people, the economy and the environment.

The overall aim of the study was to test whether a democratically based decision making tool could be successful. Our results indicate that in a simple scenario the tool is adequate, and allows 'voters' to become directly involved in making the decision.

Further studies could be used to explore voter satisfaction and the utility of the tool in more complex risk environments in order to address the most fundamental question we believe the field of risk assessment faces: can citizens make their own decisions and determine their own future in the field of risk?

6. REFERENCES

Barlinga D, de Vriendb H, Cornelesec JA, Ekstrandd B, Heckere EFF, Howlettf J, Jenseng JH, Langa T, Mayerh S, Staeri KB, Topj R. (1999) The social aspects of food biotechnology: a European view, Environmental Toxicology and Pharmacology 7: 85-93

Boholm Å. (2008) New perspectives on risk communication: uncertainty in a complex society, Journal of Risk Research 11; 1-3

Brandes F. (2009) The UK technology foresight programme: An assessment of expert estimates, Technological Forecasting and Social Change 76:869-879

Clement RT, Winkler RL. (1999) Combining Probability Distributions From Experts in Risk Analysis, Risk Analysis, 19: 187-203

Corin SE, McNeill A, Atapattu A. (2012) Democracy and risk-based decision-making: the next step in public involvement, Journal of Risk Research 15; 1021-1026

ERMA. (2010) Decision on application ERMA200281, Wellington: ERMA New Zealand

Fischoff B. (1995) Risk Perception and Communication Unplugged: Twenty Years of Process, Risk Analysis 15: 137-145

Glaser M, Langer L, Weber M. (2005) Overconfidence of professionals and lay men: Individual differences within and between tasks, Working Paper, University of Manheim

Kahan DM, Braman D, Slovic P, Gastil J, Cohen G. (2008) Cultural cognition of the risks and benefits of nanotechnology, Nature Nanotechnology 4; 87-90

Lang JT, Hallman WK. Who Does the Public Trust? (2005) The Case of Genetically Modified Food in the United States, Risk Analysis, 25; 1241-1252

Leach A, Talwar V, Lee K, Bala N, Lindsay RCL. (2004) "Intuitive" Lie Detection of Children's Deception by Law Enforcement Officials and University Students, Law and Human Behaviour 28; 661-685

Lehoux P, Daudelin G, Abelson J. (2012) The unbearable lightness of citizens within public deliberation processes, Social Science & Medicine 74; 1843-1850

Loosemore M. (2010) Using multimedia to effectively engage stakeholders in risk management, International Journal of Managing Projects in Business 3; 307-327

McDaniels TL, Gregory RS, Fields D. (1999) Democratizing Risk Management: Successful Public Involvement in Local Water Management Decisions, Risk Analysis 19; 497-510

Petts, J, Brooks, C. (2006) Expert conceptualisations of the role of lay knowledge in environmental decisionmaking: challenges for deliberative democracy, Environment and Planning A 38; 1045 – 1059

Pretty J. (2001) The rapid emergence of genetic modification in world agriculture: contested risks and benefits, Environmental Conservation 28; 248–262

Renn O, Webler T, Rakel H, Dienel P, Johnson B. (1993) Public participation in decision making: A three-step procedure, Policy Sciences 26; 189-214

Renn O. (1998) Three decades of risk research: accomplishments and new challenges, Journal of Risk Research 1; 49-71

Rowe G, Frewer LJ. (2005) A typology of public engagement mechanisms. Science, Technology and Human Values 30; 251-290

Slovic P. (1999) Trust, Emotion, Sex, Politics, and Science: Surveying the Risk-Assessment Battlefield, Risk Analysis 19; 689-701

Slovic P, Finucane ML, Peters E, MacGregor DG (2004) Risk as Analysis and Risk as Feelings: Some Thoughts about Affect, Reason, Risk, and Rationality, Risk Analysis 24; 311-322

Thorndike EL. (1937) Valuations of Certain Pains, Deprivations, and Frustration, The Pedagogical Seminary and Journal of Genetic Psychology 51; 227-239

Figure 1. Mean group ratings by effect before and after scaling (error bars are 95% confidence intervals)

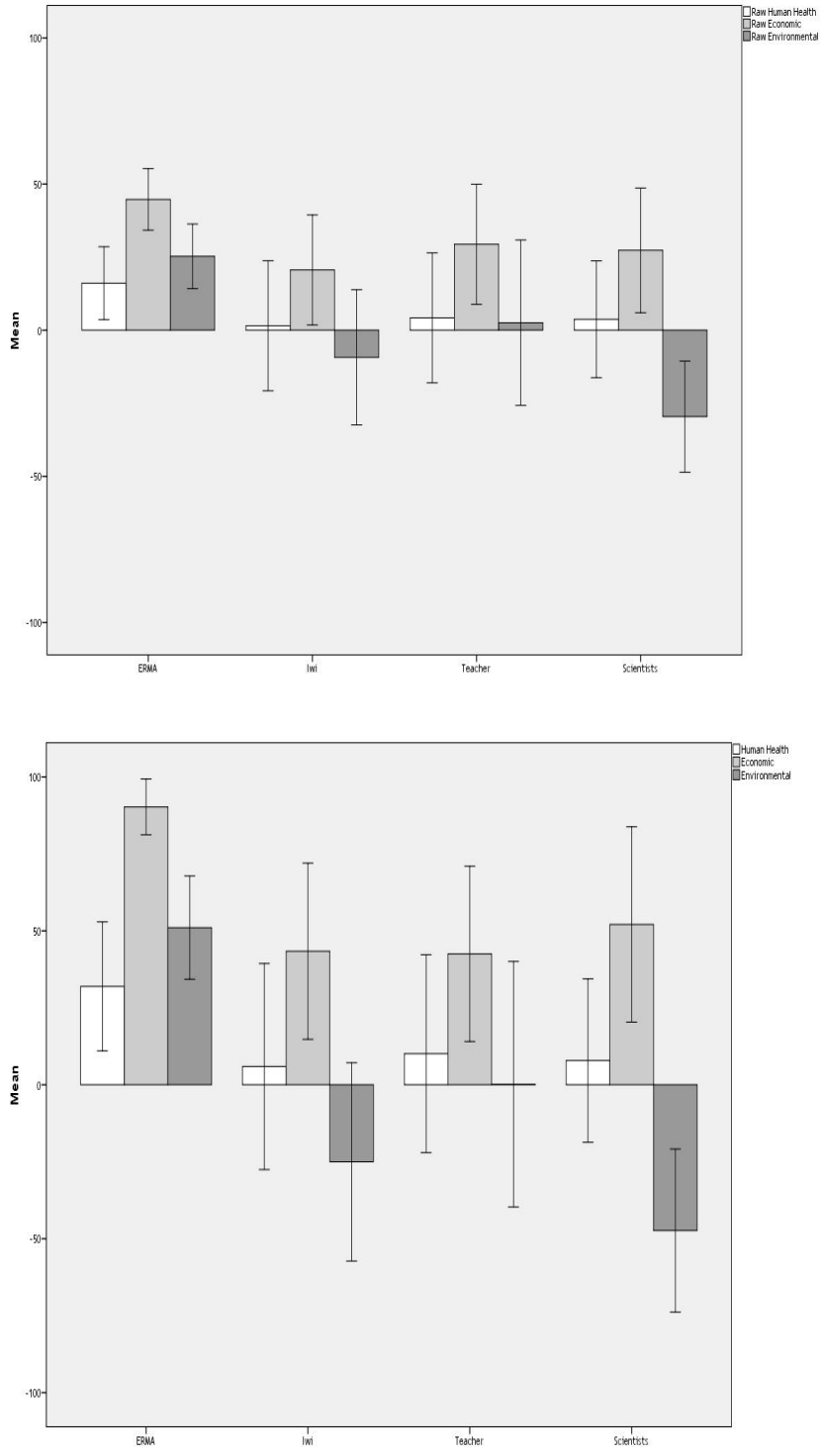

Table 1. Participants groups in the study

Group	Description	Sample size (n)
ERMA	Staff of the Environmental Risk Management Authority whose job it is to assess whether or not new biological control agents should be introduced to New Zealand.	24
Iwi	Picked as an important stakeholder, iwi are the tribes of New Zealand's indigenous people, the Māori. Their participation in the decision making process is recognised statutorily.	24
Scientists	Scientists, in this case primarily ecologists have specialist knowledge on the introduction of new species into an environment and are of use when making a decision on introducing a novel species.	19
Teachers	Primary and secondary school teachers were introduced to give a feel for the opinion of other well educated sectors of the population.	18

Table 2. Risk assessment scenario presented to participants

ERMA impact description	ERMA assessment	Survey impact description
Cotesia urabae causes a significant decline in the population of native or valued moths due to a lack of host specificity	Minor and unlikely and therefore a low risk	The biological control agent will attack a small number of individuals of the native moth (*Celama parvitis*). It will not have any effect on the population, or on visible numbers.
Introduction of *C. urabae* will inhibit the kaitiakitanga responsibility of Māori	Unlikely, no further assessment made	This impact being subjective rather than objective was not provided to participants
Reduction in gum leaf skeletoniser populations reduces the damage to trees and increases eucalypt productivity	Moderate and likely, therefore medium	The release of a biological control agent will reduce populations of the moth, and reduce the amount of damage from $69 to $50 million.
Reduction in gum leaf skeletoniser populations reduces costs for authorities managing amenity trees	Minor and likely, therefore low	The biological control agent will reduce the amount of damage so that only a third of eucalypt trees in urban areas needs to be removed.
Reduction in gum leaf skeletoniser populations	Minimal and unlikely, therefore negligible	The biological control agent will reduce the number

reduces the incidence of serious skin irritations	painful and irritating sting to people from 10 to 5.

Table 3. Decisions made by the participants within each group

	Approve (%)	Decline (%)	Neutral (%)
ERMA	23 (96)	1 (4)	0
Iwi	12 (50)	12 (50)	0
Teacher	12 (67)	5 (27)	1 (6)
Scientists	10 (53)	8 (42)	1 (5)