Supporting Documents for the Evaluation and Review report on Application ERMA200599

Prepared for the Environmental Risk Management Authority

Contents

Appendix 1: Risk Assessment Framework

Qualitative descriptors for risk/benefit assessment

This section describes how the Agency staff and the Authority address the qualitative assessment of risks, costs and benefits. Risks and benefits are assessed by estimating the magnitude and nature of the possible effects and the likelihood of their occurrence. For each effect, the combination of these two components determines the level of the risk associated with that effect, which is a two dimensional concept. Because of lack of data, risks are often presented as singular results. In reality, they are better represented by 'families' of data which link probability with different levels of outcome (magnitude).

The magnitude of effect is described in terms of the element that might be affected. The qualitative descriptors for magnitude of effect are surrogate measures that should be used to gauge the end effect or the 'what if' element. Tables S4.1 and S4.2 contain generic descriptors for magnitude of adverse and beneficial effect. These descriptors are examples only, and their generic nature means that it may be difficult to use them in some particular circumstances. They are included here to illustrate how qualitative tables may be used to represent levels of adverse and beneficial effect.

Table S4.1 Magnitude of adverse effect (risks and costs)

Descriptor	Examples of descriptions - Adverse
Minimal	Mild reversible short term adverse health effects to individuals in highly localised area Highly localised and contained environmental impact, affecting a few (less than ten) individuals members of communities of flora or fauna, no discernible ecosystem impact Local/regional short-term adverse economic effects on small organisations (businesses, individuals), temporary job losses No social disruption
Minor	Mild reversible short term adverse health effects to identified and isolated groups Localised and contained reversible environmental impact, some local plant or animal communities temporarily damaged, no discernible ecosystem impact or species damage Regional adverse economic effects on small organisations (businesses, individuals) lasting less than six months, temporary job losses Potential social disruption (community placed on alert)
Moderate	Minor irreversible health effects to individuals and/or reversible medium term adverse health effects to larger (but surrounding) community (requiring hospitalisation) Measurable long term damage to local plant and animal communities, but no obvious spread beyond defined boundaries, medium term individual ecosystem damage, no species damage Medium term (one to five years) regional adverse economic effects with some national implications, medium term job losses Some social disruption (e.g. people delayed)

Major	Significant irreversible adverse health effects affecting individuals and requiring hospitalisation and/or reversible adverse health effects reaching beyond the immediate community Long term/irreversible damage to localised ecosystem but no species loss Measurable adverse effect on GDP, some long term (more than five years) job losses Social disruption to surrounding community, including some evacuations
Massive	Significant irreversible adverse health effects reaching beyond the immediate community and/or deaths Extensive irreversible ecosystem damage, including species loss Significant on-going adverse effect on GDP, long term job losses on a national basis Major social disruption with entire surrounding area evacuated and impacts on wider community

Table S4.2 Magnitude of beneficial effect (benefits)

Descriptor	Examples of descriptions - Beneficial
Minimal	Mild short term positive health effects to individuals in highly localised area Highly localised and contained environmental impact, affecting a few (less than ten) individuals members of communities of flora or fauna, no discernible ecosystem impact Local/regional short-term beneficial economic effects on small organisations (businesses, individuals), temporary job creation No social effect
Minor	Mild short term beneficial health effects to identified and isolated groups Localised and contained beneficial environmental impact, no discernible ecosystem impact Regional beneficial economic effects on small organisations (businesses, individuals) lasting less than six months, temporary job creation Minor localised community benefit
Moderate	Minor health benefits to individuals and/or medium term health impacts on larger (but surrounding) community and health status groups Measurable benefit to localised plant and animal communities expected to pertain to medium term Medium term (one to five years) regional beneficial economic effects with some national implications, medium term job creation Local community and some individuals beyond immediate community receive social benefit.
Major	Significant beneficial health effects to localised community and specific groups in wider community Long term benefit to localised ecosystem(s) Measurable beneficial effect on GDP, some long term (more than five years) job creation Substantial social benefit to surrounding community, and individuals in wider

	community.
Massive	Significant long term beneficial health effects to the wider community Long term, wide spread benefits to species and/or ecosystems Significant on-going effect beneficial on GDP, long term job creation on a national basis Major social benefit affecting wider community

The likelihood applies to the composite likelihood of the end effect, and not either to the initiating event, or any one of the intermediary events. It includes:

- the concept of an initiating event (triggering the hazard), and
- the exposure pathway that links the source (hazard) and the area of impact (public health, environment, economy, or community).

Thus, the likelihood is not the likelihood of an organism escaping, or the frequency of accidents for trucks containing hazardous substances, but the likelihood of the specified adverse effect1 resulting from that initiating event. It will be a combination of the likelihood of the initiating event and several intermediary likelihoods[2]. The best way to determine the likelihood is to specify and analyse the complete pathway from source to impact.

Likelihood may be expressed as a frequency or a probability. While frequency is often expressed as a number of events within a given time period, it may also be expressed as the number of events per head of (exposed) population. As a probability, the likelihood is dimensionless and refers to the number of events of interest divided by the total number of events (range 0-1).

Table S4.3 Likelihood

Descriptor	Description
Highly improbable	Almost certainly not occurring but cannot be totally ruled out
Very unlikely	Considered only to occur in very unusual circumstances
Unlikely (occasional)	Could occur, but is not expected to occur under normal operating conditions
Likely	A good chance that it may occur under normal operating conditions
Highly likely	Almost certain, or expected to occur if all conditions met

Using the magnitude and likelihood tables a matrix representing a level of risk/benefit can be constructed.

In the example shown in Table S4.4, four levels of risk/benefit are allocated: A (negligible), B (low), C (medium), and D (high). These terms have been used to avoid confusion with the descriptions used for likelihood and magnitude, and to emphasise that the matrix is a tool to

1 The specified effect refers to scenarios established in order to establish the representative risk, and may be as specific as x people suffering adverse health effects, or y% of a bird population being adversely affected. The risks included in the analysis may be those related to a single scenario, or may be defined as a combination of several scenarios.

2 Qualitative event tree analysis may be a useful way of ensuring that all aspects are included.

help decide which risks/benefits require further analysis to determine their significance in the decision making process.

For negative effects, the levels are used to show how risks can be reduced by the application of additional controls. Where the table is used for positive effects it may also be possible for controls to be applied to ensure that a particular level of benefit is achieved, but this is not a common approach. The purpose of developing the tables for both risk and benefit is so that the risks and benefits can be compared.

Table S4.4 Level of risk

	Magnitude of effect				
Likelihood	**Minimal**	**Minor**	**Moderate**	**Major**	**Massive**
Highly improbable	A	A	A	B	B
Very unlikely	A	A	B	B	C
Unlikely	A	B	B	C	C
Likely	B	B	C	C	D
Highly likely	B	C	C	D	D

Figure 1
Decision path for applications to import for release or release a new organism from containment (NO and GMO)

Context

This decision path describes the decision-making process for applications to **import for release or release a new organism from containment**. These applications are made under section 34 of the HSNO Act, and determined under section 38 of the Act. Section 38 requires consideration of the criteria specified in section 36 (whether the organism meets the minimum standards) and section 37 (ability of the organism to form an undesirable self-sustaining population and ease of eradication).

Introduction

The purpose of the decision path is to provide the Authority with guidance so that **all relevant matters** in the HSNO Act and the Methodology have been addressed. It does not attempt to direct the weighting that the Authority may decide to make on individual aspects of an application.

In this document 'section' refers to sections of the HSNO Act, and 'clause' refers to clauses of the ERMA New Zealand Methodology.

The decision path has two parts –

Flowchart (a logic diagram showing the process prescribed in the Methodology and the HSNO Act to be followed in making a decision), and

Explanatory notes (discussion of each step of the process).

Of necessity the words in the boxes in the flowchart are brief, and key words are used to summarise the activity required. The explanatory notes provide a comprehensive description of each of the numbered items in the flowchart, and describe the processes that should be followed to achieve the described outcome.

For proper interpretation of the decision path it is important to work through the flowchart in conjunction with the explanatory notes.

Figure 1 FLOWCHART

Decision path for applications to import for release or release a new organism (NO and GMO) from containment (application made under section 34 of the Act and determined under section 38 of the Act)

For proper interpretation of the decision path it is important to work through the flowchart in conjunction with the explanatory notes

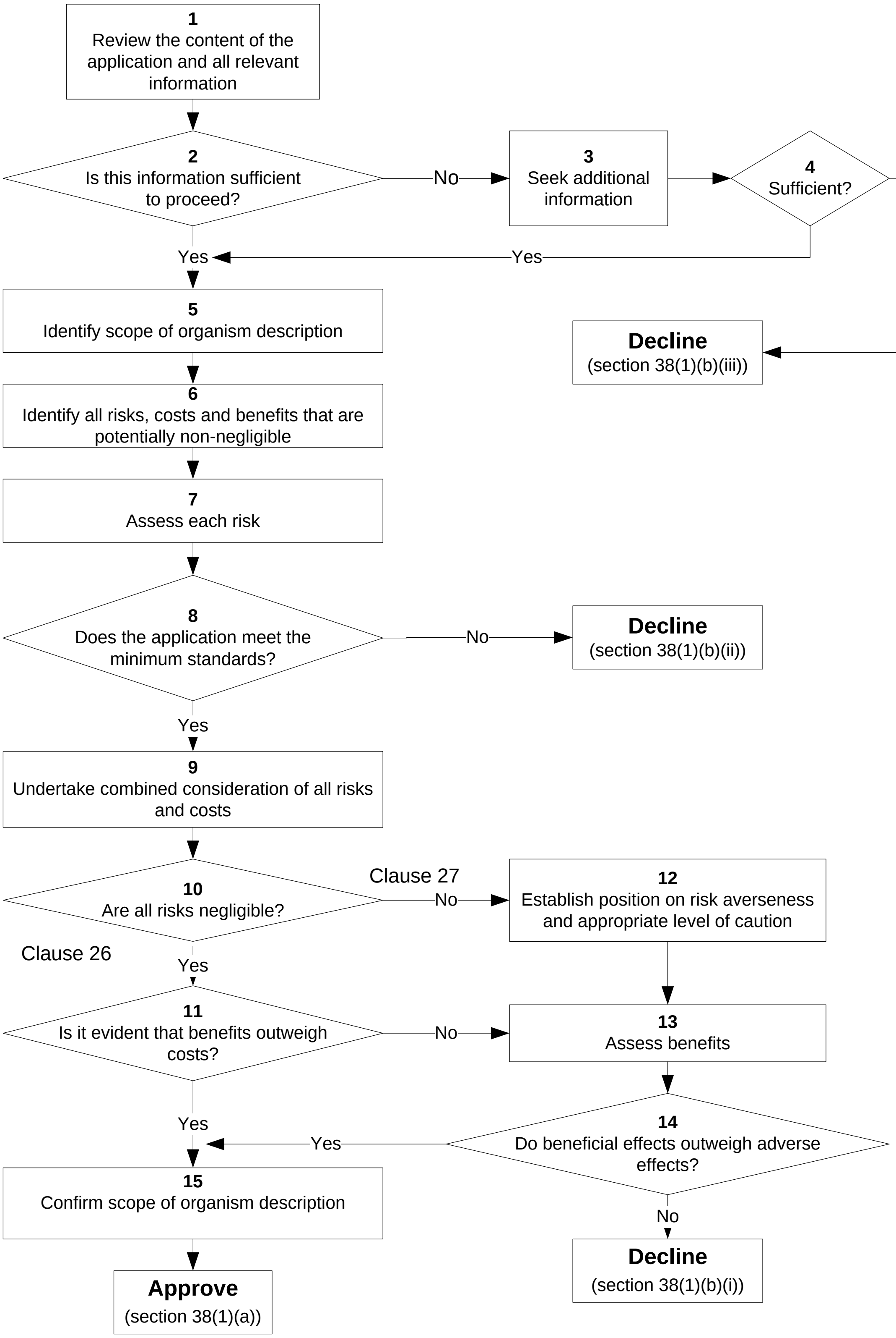

Figure 1 EXPLANATORY NOTES

An application may be for a single new organism, or for a variety or range of new organisms where the boundaries of the extent of modifications envisaged are well defined (see ERMA New Zealand Protocol: *Interpretations and Explanations of Key Concepts* interpretation 'Identification of New Organisms'). In both of these cases organisms having similar risk profiles should be grouped into categories. Each category should be considered separately via the path below.

Section 38B of the Act allows the Authority, with the agreement of the applicant, to treat an application for release under section 34 as if it were an application for conditional release (made under section 38A). This will in most circumstances be determined prior to public notification of the application (see Policy[3]). Accordingly a switch to conditional release is not included in this decision path.

Item 1: Review the content of the application and all relevant information

Review the application, the E&R Report (or draft decision and Agency advice), information received from experts and that provided in submissions (where relevant) in terms of section 38A(2) of the Act and clauses 8, 15, 16, 20 and 23 of the Methodology.

Item 2: Is this information sufficient to proceed?

Review the information and determine whether or not there is sufficient information available to make a decision.

The Methodology (clause 8) states that the information used by the Authority in evaluating applications shall be that which is appropriate and relevant to the application. While the Authority will consider all relevant information, its principal interest is in information which is significant to the proper consideration of the application; ie information which is "necessary and sufficient" for decision-making.

Item 3: (if no) Seek additional information

If there is not sufficient information then additional information may need to be sought from the applicant, the Agency or other parties/experts under section 58 of the Act (clause 23 of the Methodology).

Item 4: Sufficient?

When additional information has been sought, has this been provided, and is there now sufficient information available to make a decision?

If the Authority is not satisfied that it has sufficient information for consideration, then the application may be declined under section 38(1)(b)(iii).

[3] Protocol Interpretations and Explanations of Key Concepts: Conditional release of New Organisms ER-PR-03-22

Item 5: **Identify scope of organism description**

Clearly identify the scope of the organism description. Particular attention should be paid to whether the application is for a single new organism or a variety of new organisms as referenced in the Introduction to these notes. Exclusions may be used to sets bounds on the scope of the organism description where a range or variety of new organisms is being considered.

Item 6: **Identify all risks, costs and benefits that are potentially non-negligible[4]**

Costs and benefits are defined in the Methodology as the value of particular effects (clause 2). However, in most cases these 'values' are not certain and have a likelihood attached to them. Thus costs and risks are generally linked and may be addressed together. If not, they will be addressed separately. Examples of costs that might not be obviously linked to risks are direct financial costs that cannot be considered as 'sunk' costs (see footnote 2). Where such costs arise and they have a market economic effect they will be assessed in the same way as risks, but their likelihood of occurrence will be more certain (see also item 12).

Identification is a two step process that scopes the range of possible effects (risks, costs and benefits).

Step 1: Identify all risks and costs (adverse effects) and benefits (beneficial effects) associated with the approval of the organism(s), and based on the range of areas of impact described in clauses 9 and 10 of the Methodology and sections 5 and 6 of the Act[5].

Relevant costs and benefits are those that relate to New Zealand and those that would arise as a consequence of approving the application (clause 14).

Consider short term and long term effects.

Identify situations where risks and costs occur in one area of impact or affect one sector and benefits accrue to another area or sector; that is, situations where risks and costs do not have corresponding benefits.

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[4] Relevant effects are **marginal effects**, or the changes that will occur as a result of the organism(s) being available. Financial costs associated with preparing and submitting an application are not marginal effects and are not effects of the organism(s) and are therefore not taken into account in weighing up adverse and positive effects. These latter types of costs are sometimes called 'sunk' costs since they are incurred whether or not the application is successful.

[5] Effects on the natural environment, effects on human health and safety, effects on Maori culture and traditions, effects on society and community, effects on the market economy.

Step 2: Document those risks, costs and benefits that can be readily concluded to be negligible[6], having regard to the characteristics of the organism and the circumstances of the application, and eliminate them from further consideration.

Note that where there are costs that are not associated with risks some of them may be eliminated at this scoping stage on the basis that the financial cost represented is very small and there is no overall effect on the market economy.

Item 7: Assess each risk

The assessment of potentially non-negligible risks and costs should be carried out in accordance with clauses 12, 13, 15, 22, 24, 25, and 29 to 32 of the Methodology. Most of these risks and costs will relate to matters in sections 5 and 6 of the Act. In undertaking this assessment the Authority must take into account the principles of the Treaty of Waitangi (section 8, and clause 9(c)(iv)).

Assess each potentially non-negligible risk and cost estimating the **magnitude** of the effect if it should occur and the **likelihood** of it occurring. In estimating the **magnitude** of the adverse effect take into account the extent to which the risk might be mitigated by how or whether it might be possible to eradicate the organism if a significant adverse effect eventuated. When estimating the **likelihood** of the effect occurring, consider the full pathway, that is, all the possible steps that must occur before the final identified effect is realised. Estimating the likelihood requires combining (multiplying) all of the individual likelihoods for each link in the chain of events.

Where there are non-negligible financial costs that are not associated with risks then the probability of occurrence (likelihood) may be close to 1. Relevant information provided in submissions should be taken into account.

The distribution of risks and costs should be considered, including geographical distribution and distribution over groups in the community, as well as distribution over time. This information should be retained with the assessed level of risk/cost.

The assessment should consider the following matters:

Self sustaining population

Section 38C(3)(c) requires the Authority to consider the ease with which the organism could be recovered or eradicated if it formed a self-sustaining population considering whether the organism meets the minimum standards (item 7)

[6] Negligible effects are defined in the Annotated Methodology as “Risks which are of such little significance in terms of their likelihood and effect that they do not require active management and/or after the application of risk management can be justified by very small levels of benefits”.

In assessing the adverse effects, Section 38(1) of the Act requires the Authority to regard to the ability of the organism to establish a self sustaining population and the ease of recovery or eradication should it establish an **undesirable** self-sustaining population (section 37).

Thus whether the organism(s) can form a self sustaining population is addressed in two parts of the decision process.

"Undesirable" is interpreted as being (in effect) able to create significant risks because of the reference to significant effects in section 36 (minimum standards).

Approach to risk and approach to uncertainty

Consider the Authority's **approach to risk** (clause 33 of the Methodology) or how risk averse the Authority should be in giving weight to the risk.

The risk characteristics set out in clause 33 are:

(a) Exposure to the risk is involuntary;

(b) The risk will persist over time;

(c) The risk is subject to uncontrollable spread and is likely to extend its effects beyond the immediate location of incidence;

(d) The potential adverse effects are irreversible; and

(e) The risk is not known or understood by the general public and there is little experience or understanding of possible measures for managing the potential adverse effects.

Consider each non-negligible risk in terms of the factors listed and decide whether to be risk averse by giving additional weight to that risk. This may be done as part of estimating the magnitude of the effect or where this is not relevant, it may be done separately.

Where the Authority chooses to be risk averse, and there is uncertainty as well, the approach to risk may be consolidated with the approach to uncertainty by adopting a conservative approach such as the worst feasible case scenario.

See the ERMA New Zealand report 'Approach to Risk' for further guidance[7].

The assessment includes consideration of how cautious the Authority will be in the face of **uncertainty** (section 7 and clauses 29-32). Where there is uncertainty, it may be necessary to estimate scenarios for lower and upper bounds for the adverse effect as a means of identifying the range of uncertainty (clause 32). It is also important to bear in mind the materiality of the uncertainty and how significant the uncertainty is for the decision (clause

[7] http://www.ermanz.govt.nz/resources/publications/pdfs/ER-OP-03-02.pdf

29(a)).

For each component (magnitude and likelihood) consider the degree of uncertainty associated with the estimation of each component. In some cases it may be clear that the uncertainty could be reduced by gathering further information (undertaking more scientific tests, or extending the literature search). Before requesting or seeking further information it is important to consider how important the uncertainty is in terms of the decision (clause 29(a) – materiality), and to essentially consider the cost-effectiveness of gathering further information.

Another approach to addressing uncertainty is to look at a range of scenarios and consider a best feasible-worst feasible scenario range. However, where there is a large degree of uncertainty, this may not be particularly meaningful for calculating the level of risk. In other cases, calculating the level of risk for each end of the range may result in a fairly similar level of risk. Where this does not occur, rather than presenting a wide range in the level of risk it may be better to concentrate on analysing why the uncertainty occurs and whether or not there is any obvious way of resolving it.

Item 8: Does the application meet the minimum standards?

If an organism does not meet the minimum standards set out in Section 36 the Authority must decline the application. To meet the minimum standards an organism must not be likely to cause **any** of the following:

(a) any significant displacement of any native species within its natural habitat;

(b) any significant deterioration of natural habitats;

(c) any significant adverse effects on human health and safety;

(d) any significant adverse effect to New Zealand's inherent genetic diversity; or

(e) any disease, be parasitic, or become a vector for human, animal, or plant disease, unless the purpose of that importation or release is to import or release an organism to cause disease, be a parasite, or a vector for disease.

The organism is tested against the minimum standards after the assessment of adverse effects because the information from the assessment and in particular the analysis of pathways is an input to this evaluation.

Item 9: Undertake combined consideration of all risks and costs

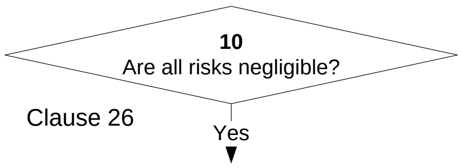
Once the risks and costs have been assessed individually, if appropriate consider all risks and costs together as a 'basket' of risks/costs. This may involve combining groups of risks and costs as indicated in clause 34(a) of the Methodology where this is feasible and appropriate, or using other techniques as indicated in clause 34(b). The purpose of this step is to consider the interactions between different effects and determine whether these may change the level of individual risks.

Item 10: Are all risks negligible?

At this point the decision path branches. Looking at individual risks in the context of the 'basket' of risks, consider whether all of the residual risks are negligible. Consider also the cumulative effect of the assessed risks.

Where all risks are negligible, and the cumulative effect of the risks is considered to be negligible then take the **clause 26** option and move to item 10. If one or more of the risks is considered to be non-negligible, or the cumulative sum of the risks is non-negligible, then take the **clause 27** option and move to item 11.

Item 11:



(from item 9 - if 'yes') Is it evident that benefits outweigh costs?

Risks have already been determined to be negligible (item 9), therefore the decision must be made under clause 26 of the Methodology. In the unusual circumstance where there are non-negligible costs that are not associated with risks they have been assessed in item 6.

Costs are made up of two components: internal costs or those that accrue to the applicant, and external costs or those that accrue to the wider community.

Consider whether there are any non-negligible external costs that are not associated with risks.

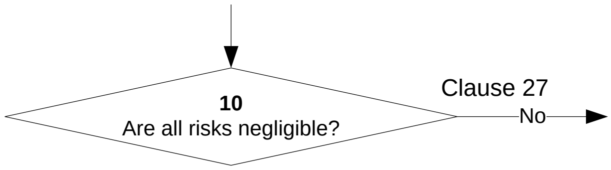
If there are no external non-negligible costs then external benefits outweigh external costs. The fact that the application has been submitted is deemed to demonstrate existence of internal or private net benefit, and therefore total benefits outweigh total costs[8]. As indicated above, where risks are deemed to be negligible, and the only identifiable costs resulting from approving an application are shown to accrue to the applicant, then a cost-benefit analysis will not be required. The act of an application being lodged will be deemed by the Authority to indicate that the applicant believes the benefits to be greater

[8] Technical guide 'risks, costs and benefits' page 6 - note that, where risks are negligible and the costs accrue only to the applicant, no explicit cost benefit analysis is required. In effect, the authority takes the act of making an application as evidence that the benefits outweigh the costs. See also protocol series 1 'general requirements for the identification and assessment of risks, costs, and benefits'.

than the costs.

However, if this is not the case and there are external non-negligible costs then all benefits need to be assessed (via item 12).

Item 12:



(from item 9 - if 'no') Establish position on risk averseness and appropriate level of caution

Although 'risk averseness' (approach to risk, clause 33) is considered as a part of the assessment of individual risks, it is good practice to consolidate the view on this if several risks are non-negligible. This consolidation also applies to the consideration of the approach to uncertainty (section 7).

Item 13: (from item 11, or from item 10 if 'no') Assess benefits

Assess benefits or positive effects in terms of clause 13 of the Methodology.

Since benefits are not certain, they are assessed in the same way as risks. Thus the assessment involves estimating the magnitude of the effect if it should occur and the likelihood of it occurring. This assessment also includes consideration of the Authority's approach to uncertainty or how cautious the Authority will be in the face of uncertainty (section 7). Where there is uncertainty, it may be necessary to estimate scenarios for lower and upper bounds for the positive effect.

An understanding of the distributional implications of a proposal is an important part of any consideration of costs and benefits, and the distribution of benefits should be considered in the same way as for the distribution of risks and costs.

The Authority will in particular look to identify those situations where the beneficiaries of an application are different from those who bear the costs[9]. This is important not only for reasons related to fairness but also in forming a view of just how robust any claim of an overall net benefit might be. It is much more difficult to sustain a claim of an overall net benefit if those who enjoy the benefits are different to those who will bear the costs. Thus where benefits accrue to one area or sector and risks and costs are borne by another area or sector then the Authority may choose to be more risk averse and to place a higher weight on the risks and costs.

[9] This principle derives from Protocol Series 1, and is restated in the Technical Guide 'Risks, Costs and Benefits'.

Item 14: Do beneficial effects outweigh adverse effects?

In weighing up positive and adverse effects, consider clause 34 of the Methodology. Where possible combine groups of risks, costs and benefits or use other techniques such as dominant risks and ranking of risks.

Where this item is taken in sequence from items 11 and 12 (i.e. risks are not negligible) it constitutes a decision made under clause 27 of the Methodology.

Where this item is taken in sequence from items 10 and 12 (i.e. risks are negligible, and there are external non-negligible costs) it constitutes a decision made under clause 26 of the Methodology.

Item 15: Confirm scope of organism description

At this step the scope of the organism description for generic applications should be reviewed. If changes are made to the organism description, items 4-13 above should be repeated for the revised organism description. Then the weighing up process in this item for the revised organism description should also be repeated.

The scope of the organism description has been identified in item 4. This step in the decision-making process confirms the scope of the organism description in such a way that the risk boundaries are defined.

Appendix 2: Consolation with Department of Conservation

Department of Conservation
Te Papa Atawhai

DOC comments on ERMA new organism for release application

Application number: ERMA200599
Applicant: The Dung Beetle Strategy Release Group
Application purpose: to import and release up to 11 species of dung beetles to overcome the many adverse effects caused by animal dung in New Zealand pastures

Thank you for the opportunity to comment on this application. The Department of Conservation **does not** wish to be heard at a public hearing in support of our comments.

<u>The generalised approach</u>
It is the opinion of the Department that this application is too general to enable an accurate assessment of the individual characteristics of each species. The application fails to provide sufficient detailed information on each species to determine the risks or benefits associated with the 11 species.

While we acknowledge that these species of dung beetles possess similar traits in some respects (as the applicant states), there are also a number of areas where they differ such as climate suitability, soil preference, etc. The information provided gives the impression that the applicant is building the case for dung beetles in general, as opposed to the specific 11 they wish to import. While we acknowledge that there is some of that information contained in the various appendices, it is fragmented and spread through a number of documents. We consider it would have been of greater benefit to the Authority making this decision, if the information had been clearly provided on each of the species. Only then can the merits or potential adverse effects be addressed to justify the introduction of each species.

Despite all the supporting information provided for dung beetles in general, it is of considerable concern to read the statement by Dr Ridsdall-Smith that "we don't really know what niches they occupy in their native environments" on page 7 of Appendix 1.

<u>Need for further information</u>
The Department considers that there is a general need for further explanation of the information provided on these dung beetles. For example, the climate suitability rating in Table 1 (page 9) is not clear – what are the thresholds that are being worked to? What makes a 1 rating, or a 3 rating? How different are they? Similarly, the table in Appendix 3 on soil preferences (para 25) would have provided more benefit if it was compared with the New Zealand soil conditions – where are each of these beetles most likely to establish in NZ based on soil preferences etc?

<u>Other habitat types and associated species</u>
The application seems to be solely focussed on the introduced dung beetles 'staying' in open pasture/grasslands, while native dung beetles are deep forest dwellers. However, there is little to no mention of other habitats that may result in interaction – native grasslands, forest fragments or margins, open land above the bush line, etc.

A significant proportion of the endemic scarab beetles in the *Prodontria* genus are found only in areas above the bush line of the lower eastern South Island (see work by Brent Emerson), areas that are still being farmed. These native *Prodontria* live in the open country, and there is the potential for interaction if these introduced dung beetles established in this South Island high country. Importantly, a number of these particular *Prodontria* species are on the threatened species classification list.

Another aspect of these dung beetles establishing in the high country is whether, through the utilisation of dung, they could permanently alter the structure and nature of the soils in this area. This could have a negative impact on the native decomposer organisms, and community. Another potential effect could be that this soil alteration enables further increased stocking of that landscape, resulting in greater pressure on the native ecosystems.

The information provided with the applications indicates that a number of the European species can occur at altitudes up to 1700m. Yet there is no discussion on the potential for (or likelihood) the sorts of interactions detailed above.

<u>Quantifying benefits and costs</u>
It is the Department's opinion that the generalised information provided makes it difficult to quantify the risks and benefits associated with each of the 11 species proposed for release. We note that the applicant has not even attempted to quantify the risks or benefits for each. Further to this, we consider that the information supporting the tables in Section 4 (page 11 onwards) should not be in an appendix, but needs to be in the full application.

The Department of Conservation recommends that the Authority **does not** approve this application, but instead that they request the applicant provides more detailed and specific information on the 11 species proposed. The application, as it stands, is inadequate in the information provided on each species to assess the risks associated with their importation for release

Comments co-ordinated on behalf of the Department of Conservation by:

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***Agencies response**: We acknowledge the Department of Conservation recommendations and comments. The Agency believes that the information provided by the applicant was sufficient to do a risk assessment on all 11 species. It is our opinion that as each of the beetles were sufficiently identified, detailing their taxonomy, seasonality and nesting preference, with the included reference of their potential geological preferences, based on New Zealand's climate (Edwards, 2010). Moreover the reason that the eleven species were picked by the applicant was because of their collective obligate reliance on herbivore dung, and open pasture habitat, each are critical features to assess when evaluating these organisms for release in New Zealand.*

Appendix 3: Identification and assessment

1.1 The first step in the decision-making process is to identify the effects associated with the organism(s), and to undertake a scoping exercise to determine which effects are potentially significant. Identifying adverse effects requires identification of the sources of effect (eg, the hazards), the pathways for exposure, and the areas of impact (outlined below), as well as the likelihood and magnitude of effect. In accordance with clauses 9 and 10 of the Methodology and sections 5 and 6 of the Act, the project team has categorised adverse and beneficial effects in relation to the following areas of impact: the environment, human health and safety, relationship of Māori to the environment, the market economy, and society and the community.

1.2 The second step is to assess the effects that have been identified as being potentially significant. Those effects that are deemed to be not potentially significant are described, but are not assessed. Assessing effects involves combining the magnitude and likelihood resulting in a level of effect. In this instance the process used is a qualitative assessment described in Decision Making: A Technical Guide to Identifying, Assessing and Evaluating Risks, Costs and Benefits (ERMA New Zealand, 2007). A summary of this qualitative approach is included in Appendix 1.

1.3 The sources of effects are associated with the characteristics of the organism(s) and the type of application, in this case an application to import 11 species of dung beetle to be released into New Zealand. As this is a release application, the primary sources of effects are therefore the characteristics of the dung beetles.

1.4 Below we outline the potential adverse and beneficial effects (risks, costs and benefits) on human health and safety, the environment, society and community, Maori culture and traditions and the market economy.

1.5 All the adverse and beneficial effects are ultimately mentioned in the main Evaluation and Review (E&R) report. Below is a breakdown of the individual potential effects that have been identified by the applicant, submitters and ERMA New Zealand staff.

Our approach

1.6 The benefits identified by the applicant could be assessed individually and as such are likely to be only minor and easily dismissed. However it is our view they should be seen as an inseparable whole benefit which is likely to occur and significant because the effects are additive and not discrete, therefore we have considered them individually to be **non-negligible**, and discuss them in context in the E&R. As a collective we regard the magnitude of the benefits to be **major**, and are **highly likely** to occur, and therefore the composite benefit to be **high.**

Adverse effects on the Environment

Tunnelling action allowing runoff leading to eutrophication of ground water

1.7 Environmental Waikato and others stated there was potential that the deep tunnelling from dung beetles could lead to increased drainage of pollutants into groundwater reserves.

1.8 Furthermore submitters pointed out that dung is a relatively small component contributing to nutrient waste, namely excess nitrogen, when compared to urine. This excess nitrogen could flow via the tunnels made by the dung beetles into ground water.

1.9 The Agency regards the likelihood of the tunnelling actions of dung beetles leading to an increase in ground water pollution to be **very unlikely**. The dung beetles in this application beetle burrow into the ground only as deep as earthworms currently do (Springett and Gray, 1998), and there is no evidence that earthworm tunnelling leads to increased groundwater pollutants. Furthermore, tunnels are not permanent, and are essentially filled in as soon as they are made. It is this process of tilling the soil by the beetles that leads to improved soil aeration and structure.

1.10 It is this Agency's opinion that the schematic diagram of the tunnels from dung beetles (pg 7 of the application) has given a false interpretation of the size and depth of the tunnels.

1.11 It is acknowledged that urine is a major source of nitrogen, when compared to dung. But it is the delayed presence of the dung on the surface- especially over the warmer months, which lead to the problems associated with runoff into streams and lakes. Improved soil structure through the cooperative actions of earthworms and dung beetles will boost the biodiversity in soil to better cope with both dung and urine waste from herbivores, therefore the magnitude of this effect is **minimal**.

1.12 The Agency therefore concludes that the level of adverse effect is **negligible.**

Exotic dung beetle killing off native dung beetles

1.13 Concern was raised by submitters of effects on unknown native organisms in the environment. Their concerns were that these yet unknown organisms might be affected now or in the future if dung beetles were introduced.

1.14 Grassland environments are the grazing grounds of vast herds of animals. These herbivores produce huge volumes of dung. Depending on the climate this dung can break down slowly, over many weeks or months. Dung beetles have evolved to become specialised in using this dung, which means that the dung can be processed quickly, in days.

1.15 The same cannot be said of forests. Forests generally are darker, damp and humid resulting in a more rapid breakdown of dung through microbial action. Without this accumulation of dung there is no equivalent niche for specialist true-dung beetles. Specialist dung beetles that use the open grasslands will not enter forests. The dung beetles we have recommended for approval have been demonstrated to be pasture specific, and will not, unless attracted by dung availability, to enter darkened forested areas.

1.16 New Zealand does have native beetles in the Family Scarabaeidae which live in forested areas. However, they are not true or functional dung beetles. Rather they have a broad range of food sources of decaying material. Which may include but is not dependent on the dung of bird, reptile and insect dung.

1.17 It has been demonstrated that these native beetles can eat cattle and sheep dung, yet they are rarely found in open pasture (Seldon, 2002). The species recommended for introduction are **very unlikely** to compete over the same food resource. Should any impacts occur it is estimated to be **minimal**; therefore the level of risk is **negligible**.

1.18 One species, from the application *Geotrupes spiniger*, was not considered a true dung beetle but a 'dor' beetle, triggered a **non-negligible** risk when evaluating the HSNO Act 1996 minimum standards, and as such is not recommended for importation as stated in Section 3 of the E&R.

1.19 A study by Spector and Ayzama (2003) demonstrated that dung beetle species present in a community can completely change within the space of just a few meters. Research looking at the three species of dung beetle already introduced into New Zealand has found similar results (Pawson et al, 2008), demonstrating that multiple species live in very close proximity without impinging on each other.

1.20 All the species of true dung beetles in the application have been extensively studied overseas to understand their biology. All have been demonstrated to be pasture specific, with a dislike to shaded areas, as well as being specific to large grazing animal dung (Duraes et al, 2005, Klein, 1989).

1.21 All the dung beetles in this application do have the ability to fly. Therefore there is a possibility that these exotic dung beetles entering a forest. This could occur if the beetle has been attracted by the scent of fresh dung. However, these dung beetles are equally driven to move away from the shade of the forest to the bright light of open grasslands.

1.22 The beetles proposed for release cannot hybridise with native beetles, as they are phyllogenetically too distant.

1.23 It is **unlikely** that an exotic dung beetle would enter the forested habitat of the native beetles and the effect of such would be **minor** because if attracted by the presence of large herbivore dung it would be equally compelled to move out of the forest and into the light, and it is also impossible for the beetles to hybridise with native species. The level of risk is therefore **negligible**.

Exotic dung beetles damaging native habitats.

1.24 Submitters also commented on the variety of habitat these true-dung beetles may populate, beyond native forests, and for example into highland tussocks and urban forest fragments.

1.25 It is the Agency's opinion that the dung beetles will only be present where large graving herbivores and their dung are to be found. We have also taken the view that land that is farmed with grazing cattle or sheep has been extensively modified by their grazing, and by the introduction of fodder and weed species to a point where it could not be considered a truly native habitat. Thus it is **very unlikely** there will be any displacement of native species from its natural habitat, and such an effect would be **minor,** therefore the risk of any of the exotic dung beetle on native habitats is **negligible.**

Beneficial effects on the Environment

Reduced runoff improves water quality

1.26 Many submitters declared in their support of the application that a benefit would be the reduction in runoff, leading to an improvement in water quality, which was beneficial to the environment.

1.27 Eutrophication of waterways in New Zealand is a problem, as detailed in a recent Ministry for the Environment report[10]. It leads to the degradation of ecosystems and death of pets[11]. The government, councils and organisations are all looking into ways to help solve this problem. Dung beetles are a cost effective, low maintenance tool that while not being a total solution can be a proven (Doube BM, 2005) link in the final answer.

1.28 It is the Agency's opinion that the improvement of the aeration of the soil will lead to an increased water capacity of soils due to better top soil composition, reducing runoff into streams and lakes. This is a significant long term benefit, and effects the farming community, animal welfare, and the wider community that rely on a quality water supply, therefore this benefit is **non-negligible** and needs to be taken in context together with all the other non-negligible benefits as stated in the E&R in Section 4.

Increased earthworm biomass and activity

1.29 A submitter, who researched New Zealand earthworms and supports the application, did criticise some of the methods and presentation of data and reference material in the application, therefore doubting all the results when it was demonstrated that earthworm biomass increased when dung beetles were present compared to if they were not present (Doube 2006).

1.30 There is no doubt that earthworms play an important role in the breakdown of livestock dung, in the reduction of forage contamination, in nutrient cycling, and in the productivity of New Zealand pastures.

[10] http://www.mfe.govt.nz/publications/ser/lake-water-quality-in-nz-2010/lake-water-quality-in-nz-2010.pdf Retrieved 18 November. 2010
[11] http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=10625272 Retrieved 18 November. 2010

1.31 Earthworm activity in New Zealand is spatially and climatically limited. In drier months, there is very little earthworm activity due to the soil being too difficult to borrow through. The majority of earthworms in New Zealand are also exotic species and are unevenly distributed throughout the country. Many of the dung beetles proposed are active in the months when earthworms are not active. Therefore, with the introduction of dung beetles, year round benefits are achieved.

1.32 Earthworms also are affected when soil is compacted, this occurs either through natural means or farming practises. Less compacted soils enables earthworms to move more freely throughout the soil and possibly increase the length of earthworms seasonal activity as a result of dung beetle activity.

1.33 A considerable quantity of data produced in New Zealand, which focuses on earthworms, is similar to what has been demonstrated by dung beetles and earthworms produced overseas. We are confident this data can be extrapolated to dung beetles in New Zealand at a very basic level, which all point to beneficial effects.

1.34 Most earthworms present in New Zealand are exotic species and originate from Europe. Many of the proposed dung beetles to be imported also originate from Europe. Earthworms and dung beetles coevolved in the European grasslands and are living communally with no evidence of one adversely affecting another.

1.35 The Agency considers that the activity of dung beetles; tunnelling increasing soil aeration, bringing nutrients below the surface, leading to increased earthworm vigour is **likely**. The benefits would be localised and short term but are still considered to be **non-negligible** and needs to be taken together with all the other non-negligible benefits as stated in the E&R in Section 4.

Adverse effects on Human health and Safety

1.36 There were no adverse effects on human health or safety suggested by submitters or the Agency.

Beneficial effects on Human Health and Safety

Reduced runoff improves water quality

1.37 Many submitters declared in their support of the application stating a benefit would be the reduction in runoff, leading to an improvement in water quality, which was beneficial for human health.

1.38 As stated earlier eutrophication of waterways in New Zealand is a recognised problem. Many communities in New Zealand still rely on water catchments, next to farms which are not always treated in a way similar to major metropolitan centres before being used.

1.39 It is the Agency's opinion that the improvement of soil structure will lead to increased water retention, reducing runoff into streams and lakes. This has a significant long term benefit, and effects the farming community, and the wider community that rely on quality water, therefore this benefit is **non-negligible** and needs to be taken together with all the other non-negligible benefits as stated in the E&R in Section 4.

Adverse effects on the relationship of Māori to the environment

A degradation of mauri disempowering the role of kaitiakitanga

1.40 In performing a kaitiakitanga role, iwi/Māori are concerned with ensuring and maintaining the sustained and enhanced health and well-being of the environment, particularly in relation to native flora and fauna. Further, it is well acknowledged that Māori culture is inextricably linked with the land and that their health and well-being, both physically and spiritually, reflects the health and well-being of the land. Regardless of ownership, the kaitiakitanga role of Māori includes responsibility to care for the land both physically and spiritually.

1.41 Submitters to this application raised concern about the potential for negative impacts to native species and a general overall impact from introducing a new exotic species to a native New Zealand ecosystem. Also, the Te Rūnanga o Ngāi Tahu HSNO Policy Statement 2008 states three primary concerns including the potential effects to native ecosystems, how well the risks are understood, and whether appropriate consideration has been given to identifying measures to address issues should something go wrong.

1.42 It has been assessed elsewhere in this report that the potential for adverse effects to native species is negligible. However, the concern raised by Māori goes beyond the immediate biophysical risk of attack or hybridisation with native species, to recognising a potential degradation of mauri[12]– vital to sustaining health and well-being.

1.43 The report provided by Ngā Kaihautū also raises this concern. They note that the applicant's assertions that the dung beetles will only affect pastures supporting herbivores, does not recognise the Māori understanding of the complexity of our land, vegetation and biological populations. They note that this complexity is expressed as *ki uta ki tai* (from the mountains to the sea – and all in-between).

1.44 Assessments for previous applications of this kind have acknowledged the difficulty in measuring effects to mauri. For this reason one submitter recommended caution when considering the introduction of a new organism because of the uncertainty relating to the potential for adverse effects to mauri and therefore whakapapa. In response submitters such as Ngāti Kahu and Rangitaane o Manawatu requested that adequate monitoring and reporting be undertaken after the release, to ensure there are processes in place for caring for mauri and tapu associated with transfer and release. This is also supported in the Ngāi Tahu HSNO Policy Statement. In addition Rangitaane o Manawatu signalled their willingness to participate in the breeding and release programme if the dung beetles were released in their area. The Agency notes that this measure has been undertaken for previous applications and considers it

[12]Active life-giving principle or form of energy present in all animate and inanimate things.

provides affected iwi/Māori groups, to continue to fulfil their role as kaitiaki. We would therefore encourage the applicant to work with iwi/Māori groups to this end.

1.45 As noted above the Agency recognises that assessing the potential for adverse effects to mauri is difficult. However, given the information provided elsewhere in this report, and that provided by submitters, consultees, and the applicant, we consider the magnitude of any adverse effect to mauri and kaitiakitanga to be **moderate**. Given the lack of significant adverse biophysical effects to native species and ecosystems noted elsewhere in this report we consider the likelihood to be **highly improbable,** and therefore a **negligible** effect.

Beneficial effects on the relationship of Māori to the environment

Improved water quality empowers the role of kaitiakitanga

1.46 The assessment and information provided elsewhere in this report indicates that the release of the dung beetle species will contribute to improved water quality. In addition both the applicant and submitters have noted that with the expected water quality improvement all aspects of Māori health and well-being should improve. With regard to the role of kaitiakitanga, submitters noted that improved water quality would lead to the enhancement and protection of mauri as well as better food quality (including through improved mahinga kai).

1.47 Given the information provided, the Agency considers a **moderate** beneficial effect to the mauri of the environment and hence the ability of Māori to exercise their role as kaitiaki to be **likely,** which is a **medium** benefit.

Effects to the Principles of the Treaty of Waitangi

1.48 In accordance with the requirements of section 8 of the HSNO Act 1996 the Agency has considered any potential impact posed to the principles of the Treaty of Waitangi (Te Tirīti o Waitangi). Of particular relevance to this application we have considered the principle of active protection identified by the Court of Appeal decision in New Zealand Māori Council v Attorney General 1987.

1.49 Active protection has been defined as “not merely passive but extends to active protection of Māori people in the use of their lands and waters to the fullest extent practicable” (Cooke, 1987). The assessments provided in this section and in other parts of the report, indicate a negligible adverse biophysical effect to lands, native species and ecosystems, though notes the existence of uncertainty relating to mauri and kaitiakitanga. In addition the report identifies a significant beneficial effect to water quality and the potential for improved kaitiakitanga outcomes.

1.50 On considering the information provided we do not anticipate any significant effect to the principle of active protection from the release of the species of dung beetle outlined in this application.

Adverse effects on society and community

1.51 There are no specific effects brought to the Agency’s attention by submitters or the applicant on society and community, which do not overlap assessment elsewhere.

Beneficial effects on society and community

1.52 There are no specific effects brought to the Agency's attention by submitters or the applicant on society and community, which do not overlap assessment elsewhere.

Adverse effects on the Market Economy

Land usage

1.53 Submitters were concerned that an increasing amount of land being available for forage, would lead to increased land intensification.

1.54 This effect is beyond the scope of the HSNO Act 1996, and ERMA New Zealand has no mandate to dictate how a farm should manage their stock.

Increased parasites

1.55 Submitters refer to a report by Dr David Leathwick and associates at AgResearch who observed that the success of nematode eggs survival becoming larvae, doubles with dung burial, potentially increasing the abundance of infectious stages on forage, and increasing the probability of re-infection of stock through ingestion (Waghorn et al, 2002).

1.56 While Dr David Leathwick's observations are meaningful, they did not use dung beetles to bury the dung, and therefore not taking in the possibility that the nematodes eggs being damaged by dung beetle feeding, or that actions in the dung pile breaking up the dung to take under the ground or that the majority of the dung would be transported deeper than used in his study.

1.57 We also reviewed the observations of many reports and dung beetle expert opinions demonstrating that dung beetles have been shown to reduce nematode numbers (Waterhouse, 1974; Bryan, 1976; Holter et al, 2002) by the chewing action, some of the eggs and nematode larvae would be physically destroyed. Also, by lining their tunnels with the processed dung material nematode larvae would be exposed to other predatory soil organisms and thus further reducing their numbers.

1.58 The effects of using veterinary medicinal products, such as drenches on grazing animals to control for parasitic organisms eg, nematodes, lungworm and lice, can be detrimental to dung beetles and earthworms, thus affecting the magnitude of all effects.

1.59 The Agency notes that it is estimated that most farms in New Zealand use drenches, and thus would expect any program set up by the applicant (if the Authority approves this application) would need to take this in account. If all the dung beetles do not establish, there would be no beneficial or adverse effects.

1.60 It is therefore the Agency's opinion that published data directly looking at dung beetles and nematodes interactions, demonstrate that it is **very unlikely** that the nematode population will increase because of dung beetles, and the effect would be **minor**, consequently the risk is **negligible**. The E&R discusses this in more detail.

Beneficial effects on the Market Economy

Increased farm productivity

1.61 There are multiple possible pathways dung beetles could add to New Zealand's farm productivity. The biggest impact is from dung being buried, increasing the amount of grazing land being available for farming. It has been calculated from the average amount of dung produced by cattle, the area of a dung pile, plus the immediate surrounding area which grazing cattle will not eat, that at any time it is estimated up to 5% of pastoral land is spoilt by dung deposits. This increased feed will allow mean faster growth and better condition for the forage animals, therefore increased farming productivity.

1.62 The burial of dung increases the availability of nutrients to earthworms, soil biota and the pasture itself, which reduces the dependency on fertilizers to stimulate pasture growth. There is both published laboratory and field work demonstrating that the effects of returning dung (nutrients) from the surface by dung beetles increases the availability of essential compounds that improve pasture vigour, including ryegrass the predominate pasture grass in New Zealand (Jørgensen and Jenson 1997, Yokoyamae et al. 1991).

1.63 The reduction of the availability of dung to nuisance insects like flies, which use dung as both an energy source and to lay eggs in, will help in reducing their numbers, which leads to increased livestock health. This was postulated when exotic dung beetles were introduced into Australia, and was considered a great success.

1.64 New Zealand does not have a problem to the scale that Australia did, but there are many flies that use dung as source for nutrients and moisture, and its swift removal by dung beetles would likely have flow on effect on fly's fitness.

1.65 Furthermore, dealing with the dung problem before any future incursion will reduce the likelihood of an establishment of a pest fly species. If the dung is not dealt with and establishment occurs it is likely to be dealt with by chemicals which may be unsustainable and with a high social cost that will come from the potential use of chemicals to either eradicate or manage an establishment.

1.66 Another benefit from the actions of dung beetles removing dung from the surface is that they would have a negative effect on nematode populations. As part of its lifecycle, the eggs of nematodes are released with the dung; larvae are later ingested by cattle. Through the normal action of dung beetles, transporting the dung under the ground, mechanical action of their mouth parts potentially may reduce the final count of infective nematode larvae. This could lead to improved livestock health and a reduction on the reliance of drenches in farm management, although it is difficult to quantify this in dollars.

1.67 Taking into consideration that mixed populations of dung beetles establish on New Zealand pastures, the removal of dung from the surface of the soil is considered to be highly likely. There is overwhelming evidence to support this both within the Agency's review, the application and comments from submitters and international experts.

1.68 It is our opinion that the importation of the dung beetles will bring significant long term benefits to famers, reducing effort and cost to current farm management practises. It is our view that this multi-faceted benefit is **non-negligible** and together with all the other non-negligible benefits as stated in the E&R in Section 4.

Summary Table

Adverse risk	**Effect**	**Benefit**	**Effect**
Runoff leading to eutrophication of ground water	Negligible	**Improved water retention in soil, reduction in eutrophication**	Non-Negligible
Native beetles displacement	Negligible	**Improved earthworm biomass and activity**	Non-Negligible
Native habitats destroyed	Negligible	**Improved water quality for human consumption**	Non-Negligible
Degradation of mauri	Negligible	**Increased farm productivity**	Non-Negligible
Increased parasites	Negligible		

Appendix 4: Invited International Expert opinion

1.1 We contacted five recognised dung beetle experts with a list of questions, in which we used to increase our background knowledge, and risk assessment.

- Professor Wes Watson, Veterinary Entomology, North Carolina State University, Raleigh, NC, USA
- Professor Liz Nichols, Centre for Biodiversity and Conservation, American Museum of Natural History, USA
- Professor Clarke Scholtz, Scarab Research Group Department of Zoology & Entomology, University of Pretoria
- Dr Kevin Floate, Research Scientist, Insect Biocontrol, Lethbridge Research Centre, Agriculture and Agri-Food Canada
- Professor Jean-Pierre Lumaret, Centre d'Ecologie Fonctionnelle et évolutive Laboratoire de Zoogéographie Université Paul Valéry Montpellier III route de Mende Montpellier

1.2 We unfortunately did not receive a final response from Professor Jean-Pierre Lumaret in time to include in our report.

1.3 The questions ERMA put to the experts:

We are currently evaluating an application to import 11 species of Dung beetle (listed below).
We would value your opinion reflecting on the questions below. You do not need to answer all the questions.
Your information will be added with our report that helps a panel make a decision on the safety of importing these species. Only brief comments are required.

1. In your experience have you observed dung beetles improving nutrient cycling in the soil? Do you think this change is dramatic enough to change farm management practice (ie lower fertiliser use)?

2. Taking in consideration that the majority of NZ pasture is ryegrass and clover. In your experience do know of any potential effects regarding these Dung beetles and this pasture type?

3. One concern about this introduction has been that dung beetles will have a negative impact on the abundance of earthworms. In your experience have you ever observed this?

4. Another concern we have had raised is the impact on native dung beetle species. Native dung beetles live exclusively in forested areas, and rely on the dung of birds and other insects. Of the eleven species of dung beetle proposed for release, have you ever known them to enter forests or are they restricted to pasture like conditions? In your opinion will any of the eleven species be a danger to our native dung beetles?

5. Another concern raised is the possibility of increased nematode numbers affecting farm animal health. The fear is that through the burial of nematode eggs, the eggs will

be protected from desiccation and environmental conditions. In your opinion have you seen evidence that this can or will occur?

6. Another concern is that the dung beetle will be a vector of disease, have you seen evidence of such an effect?

The 11 species of dung beetle are:

Onthophagus binodis
Onthophagus gazella
Onthophagus vacca
Onthophagus taurus
Euoniticellus fulvus
Onitis alexis alexis
Bubas bison
Bubas bubalus
Copris hispanus hispanus
Copris lunaris
Geotrupes spiniger

2.1 Response from Professor Wes Watson:

1. In your experience have you observed dung beetles improving nutrient cycling in the soil? Do you think this change is dramatic enough to change farm management practice (ie lower fertiliser use)?

We studied the effect of dung beetle activity on soil nutrition in two distinct soil types, Cecil red clay and sandy loam, respectively, these soils are commonly found in the piedmont and coastal plains of North Carolina. For comparison, we selected commercially available play sand as a minimal nutrient standard.

Two tunnelling dung beetles, Onthophagus gazella and Onthophagus taurus, were allowed to incorporate cattle dung for brood production, into the respective sol filled pots. Controlled treatments included soil alone and soil exposed to dung only. Soils were tested for primary nutrients (Phosphorus and Potassium), secondary nutrients (Calcium and Magnesium) and micronutrients (Manganese, Zinc, and Copper), as well as other soil characteristics. Comparisons were made within soil type not between soil types. These results were published in the accompanying paper (Bertone et al. 2006).

The re-treatment soil analyses of the red clay piedmont soil and sandy loam costal soil provide the base line nutrient levels of these soils. Commercial play sand was selected for comparison because it lacked the nutritional value of natural soils. The additional of dung and dung plus beetles to sand allowed us to measure the basic contribution of dung beetles with minimal pre-existing inherit nutrient value. In most cases the addition of dung and dung beetles plus beetles increased the nutrient values relative to the pre-treatment analysis of the test soil. These data also indicate that the addition of dung beetles significantly increased the soil nutrient level over dung alone. Farmers advocating a more holistic organism approach to pasture management may recognize the benefits of dung beetles for soil fertility, however, for others, the immediate result of fertiliser application is likely to outweigh the former. Applications of ammonium nitrate at rates exceeded those acquired by manure application.

2. Taking in consideration that the majority of NZ pasture is ryegrass and clover. In your experience do know of any potential effects regarding these Dung beetles and this pasture type?

   We studied the impart of the most common North Carolina dung beetles Onthophagus taurus Schreber on sol richness and plant yield in an experiment that was designed to mimic rotational pasture grazing system. Two native soil types were used: North Carolina piedmont cecil red clay, costal plain sandy loam and for commercially available play sand as a nutrient deficient standard. In this pot study, we examined plant yield of warm season grass Sorghum bicolour and cool season grass Lolium multiflorum grown in pots containing the three test soil types with and without dung beetles. Treatments include; dung plus five pairs of O. taurus, dung only, fertilizer, and an untreated control...
   ...Soil analysis was performed to measure the amount of Potassium and Phosphate and Nitrogen in the underlying soil for all treatments. Dung beetle activity increased the amount of total nitrogen (NH_4 and NO_3) measured in all three soils over the dung only treatment and the untreated control. Ammonium-nitrate fertilizer significantly increased NH_4 and NO_3 over the other treatments. Fertilizer treatments clearly exceeded nitrogen contributions of dung and dung beetles.
   O. taurus activity significantly increased the yield of sudan grass the ryegrass over the dung-only treatment and control. Ryegrass yield was higher in the dung beetle treatments relative to the fertilizer treatment for all soil types except in sandy loam.

3. One concern about this introduction has been that dung beetles will have a negative impact on the abundance of earthworms. In your experience have you ever observed this?

   I do not have any experience with potential competitions between earthworms and dung beetles.

4. Another concern we have had raised is the impact on native dung beetle species. Native dung beetles live exclusively in forested areas, and rely on the dung of birds and other insects. Of the eleven species of dung beetle proposed for release, have you ever known them to enter forests or are they restricted to pasture like conditions? In your opinion will any of the eleven species be a danger to our native dung beetles?

   In North Carolina O. taurus is occasionally found in woodlots where cattle aggregate. Their abundance is significantly lower than in the pasture. I have not observed O. gazella in the woodland areas. We have not conducted any scientific studies on dung beetle abundance or species richness in wooded areas.

   The question of displacement of native species is an important consideration when evaluation the prospects of introduced organisms. Of the dung beetles found in North Carolina pastures, 95% are imported species. Most have been in the US for decades. Two native species, Onthophagus pennsylvanicus and

Onthophagushecate coexist with the imported species but at a relatively low frequencies (4% and 2% respectively). We do not have adequate data to conclude the potential displacement impact of the non-native species on the native beetles.

5. Another concern raised is the possibility of increased nematode numbers affecting farm animal health. The fear is that through the burial of nematode eggs, the eggs will be protected from desiccation and environmental conditions. In your opinion have you seen evidence that this can or will occur?

   We have not specifically studied the potential of dung beetles to disseminate nematode eggs. However several researchers have side the impact of dung beetles on helminthes of livestock. Results have been mixed. Studies focused in the tunnelling beetles suggest that dung burial negative impacts endoparasites (Bryan 1973, Fincher 1975). These authors observed a reduction in parasites in dung pates were disrupted by dung beetle activity...
   ...The digestive tract of an insect is a hostile environment for most parasites, but some eggs may survive(Mathison and Ditrich 1999)). It is reasonable to say that under certain conditions sung beetles can be beneficial in reducing worm numbers, while under other circumstances they can have a neutral or even negative effect on worm transmission to cattle.

6. Another concern is that the dung beetle will be a vector of disease, have you seen evidence of such an effect?

   I have not studied the potential of dung beetles to transmit disease agents. I am relatively confident the enteric bacteria such as Escherichia coli present in the dung would also be found the digestive tract of the beetle. Presumably many other bacterial agents would also be found in the digestive tract. This would not be any different for dung beetles, flies or any other organisms that may frequent a dung pat for moisture or sustenance.

3.1 Response from Professor Liz Nichols:

1a. In your experience have you observed dung beetles improving nutrient cycling in the soil?

Yes. The laboratory evidence linking dung beetles to improvements in critical soil nutrients is overwhelming positive, from elevated N mineralization rates to higher levels of P, K, N, Ca and Mg. This has been answered in the affirmative by a range of lab studies (Bertone, 2004; Galbiati et al., 1995; Lastro, 2006; Yamada et al., 2007). While there are relatively fewer field studies from which to address this empirically (simply because these questions have been asked less often under field conditions), there is no reason to believe that lab results do not translate into real effects in pasture systems.

1b. Do you think this change is dramatic enough to change farm management practice (ie lower fertiliser use)?

Dung beetles can improve the availability of necessary nutrients to forage *grass, and do so above and beyond the rate of (i) dung being left on the ground surface alone, and (ii) fertilizer rates in some cases. The authors of the application made a strong presentation of the existing evidence in both cases.*

I think the weight of the evidence suggests that the incorporation of feces into the soil by dung beetles will have a strongly positive effect on forage quality and quantity, and I believe dung beetles could be used to reduce the amount, or number of applications of fertiliser. This answer is conditioned on the assumption however –that dung beetles are both present, and highly throughout the year. This will require the farm-level, and preferably landscape-level reduction in the use of endectocides (wormer agents).

2. Do you know of any potential effects regarding these Dung beetles and ryegrass and clover?

   No I do not. However, there is a paper by Jørgensen and Jensen (Plant and Soil ***196:*** *133–141, 1997) that outlines the differential effects of dung on clover and ryegrass grown in mixture, which suggests that the elevated nitrogen mineralization rates brought about by beetle action in dung would be beneficial to both pasture species.*

3. Do dung beetles have a negative impact on the abundance of earthworms?

   I have never seen evidence that dung beetles have any negative impact on the abundance of earthworms. If anything, I believe their interactions are broadly positive for earthworm populations. The application's review of this subject was robust. I would add, that I do not know of any introduced pasture system in which earthworms are sufficient removers of cattle waste.

4a. Of the eleven species of dung beetle proposed for release, have you ever known them to enter forests or are they restricted to pasture like conditions?

I strongly believe that these species will not colonize forest, and that they are restricted to pasture like conditions. Dung beetles are often extremely habitat specific. In my opinion, this specificity arises much more because of basic thermoregulatory sensitivities than resource use. So, though cattle or sheep for example may occupy these forest patch fringe or border areas, the likelihood of dung beetle occupation of forest edges remains extremely low.

4b. In your opinion will any of the eleven species be a danger to our native dung beetles?

I really do not believe they will, not for resource competition reasons, nor hybridization concerns, nor for disease ecology reasons. I very much doubt they will even come into contact with native dung beetles.

5. Another concern raised is the possibility of increased nematode numbers affecting farm animal health. The fear is that through the burial of nematode eggs, the eggs will be protected from desiccation and environmental conditions. In your opinion have you seen evidence that this can or will occur?

I believe that the burial action of tunneling dung beetles has a strongly negative impact on the emergence of infective L3 nematode larvae, and that these effects are related to dung burial depth. The empirical evidence suggesting that dung burial increases nematode emergence centers on the study by Waghorn et al (Veterinary Parasitology 2002. 104:119-129), who simulated the action of dung beetles by placed infected sheep dung at a depth of 5cm. This depth is far shallower than the shallowest burial depth recorded by any of the 11 tunneling dung beetle species proposed here.

That beetles will occasionally bury more shallowly and permit the escape of some nematodes should also be expected. The risk of this occurring should be weighed not against a baseline of zero, but rather against current levels of nematode reinfection under existing drenching protocols. The replacement in part or in whole, of nematicidal treatments with a non-toxic dung beetle approach ultimately is a much more sustainable system over longer time frames.

6. Another concern is that the dung beetle will be a vector of disease, have you seen evidence of such an effect?

    No – dung beetles are not known to be the vector of any reported disease. I wonder however if the spirit of this question was targeted at their role in disease ecology, rather than specifically as a disease vector (narrowly defined as an organism that transmits a pathogen from reservoir to host).

    Dung beetles have been considered various times for their role as intermediate hosts – a host which acts as a required stage between the vector and the definitive host in a transmission cycle. Parasites have often been documented within the gut tract of dung beetles (see Nichols et al. 2008 for a short review), however simple presence of infectious or non-infectious larval stages within adult dung beetles is a highly insufficient demonstration of a dung beetle's role as host in a parasite's development cycle. In short - the evidence that dung beetle species are obligate, intermediate hosts of known parasites is weak, and demonstration of their role in the transmission cycle of known livestock nematodes non-existent. I think it is also worth noting that other coprophagous invertebrates (e.g. earthworms) have been investigated for their role as endoparasite hosts as well, typically also with inconclusive results (Roepstorff et al., 2002).

4.1 Response from Professor Clarke Scholtz:

1. In your experience have you observed dung beetles improving nutrient cycling in the soil? Do you think this change is dramatic enough to change farm management practice (ie lower fertiliser use)?

    Definitely

2. Taking in consideration that the majority of NZ pasture is ryegrass and clover. In your experience do know of any potential effects regarding these Dung beetles and this pasture type?

    Not aware of any

3. One concern about this introduction has been that dung beetles will have a negative impact on the abundance of earthworms. In your experience have you ever observed this?

   Not aware of any. Functional effects are quite different.

4. Another concern we have had raised is the impact on native dung beetle species. Native dung beetles live exclusively in forested areas, and rely on the dung of birds and other insects. Of the eleven species of dung beetle proposed for release, have you ever known them to enter forests or are they restricted to pasture like conditions? In your opinion will any of the eleven species be a danger to our native dung beetles?

   Absolutely not

5. Another concern raised is the possibility of increased nematode numbers affecting farm animal health. The fear is that through the burial of nematode eggs, the eggs will be protected from desiccation and environmental conditions. In your opinion have you seen evidence that this can or will occur?

   On the contrary, dung beetle activity destroys eggs

6. Another concern is that the dung beetle will be a vector of disease, have you seen evidence of such an effect?

   No

5.1 Response from Dr Kevin Floate:

1. In your experience have you observed dung beetles improving nutrient cycling in the soil?

   Yes. In the absence of the activity of dung beetles and other dung-breeding insects, cattle dung on pastures in southern Alberta can remain intact for 3+ years. By scattering and fragmenting dung pats, nutrients that otherwise would remain on the soil surface (bound within the dung pat), more rapidly cycle in the pasture ecosystem. This process is very evident to even the casual observer.

   Do you think this change is dramatic enough to change farm management practice (ie lower fertiliser use)?

   Yes, depending upon the number of beetles and type of species that colonize the dung pat.
   For example, I currently have a program to introduce O. taurus into Canada. Most species of dung beetles in cattle dung in southern Alberta are of European origin and are 'dwellers' that only slowly degrade the pat. Dwellers develop from egg to adult within the pat as it lies on the soil surface. Degradation of the pat occurs from larval feeding, and occurs over a period of several weeks to months. Dung-burying species incl. O. taurus are much more desired because

degradation occurs over a period of days by the action of adults arriving at the pat. By burying manure, these species also move nutrients from the dung pat directly back into the soil within the root zone of plants. The amount of fresh cattle dung buried by O. taurus with each broodball is about 1.6 g with a pair of beetles producing about 23 broodballs in 14 days (Hunt and Simmons 2002). The larger D. gazella, produces broodballs of 4-5 cc (ca. 3.2-4 g) with a pair of beetles burying perhaps 180 cc (ca. 144 g) of fresh dung during their lifetimes (Bertone et al. 2006). In moist sandy soils, brood balls of O. taurus and D. gazella may be buried up to 10 and 20-25 cm deep, respectively (Tyndale-Biscoe 1990).

In addition to accelerating the cycling of nutrients through the pasture ecosystem, other benefits associated with the activity of 'tunnelling' dung beetle species include the formation of tunnels that increase aeration of the soil and the soil's ability to trap water and reduce run-off.

2. Taking in consideration that the majority of NZ pasture is ryegrass and clover. In your experience do know of any potential effects regarding these Dung beetles and this pasture type?

   I have no experience regarding the effect of dung beetles on these types of pastures. Of possible interest, Macqueen and Beirne (1975) showed in a pot experiment that burial of dung by Onthophagus nuchicornis improved growth of beardless wheatgrass, Agropyron spicatum.

3. One concern about this introduction has been that dung beetles will have a negative impact on the abundance of earthworms. In your experience have you ever observed this?

   No. We rarely observe earthworms in cattle dung pats in our region, probably due to our low rainfall.

4. Another concern we have had raised is the impact on native dung beetle species. Native dung beetles live exclusively in forested areas, and rely on the dung of birds and other insects. Of the eleven species of dung beetle proposed for release, have you ever known them to enter forests or are they restricted to pasture like conditions? In your opinion will any of the eleven species be a danger to our native dung beetles?

   I would assess this risk as extremely low.
   Dung beetles are habitat specialists. Cattle dung (large wet deposits) has a complex of species distinct from that of dung from deer or small rodents (pellet type dung). Given the even more extreme difference between cattle and bird dung (plus the general reliance of 'cattle' dung species for open habitats), it is exceedingly unlikely that species that have evolved to breed in cattle dung would be able to complete development using (let alone be attracted to) bird dung.

5. Another concern raised is the possibility of increased nematode numbers affecting farm animal health. The fear is that through the burial of nematode eggs, the eggs

will be protected from desiccation and environmental conditions. In your opinion have you seen evidence that this can or will occur?

The activity of dung beetles should reduce the overall survival of nematodes in cattle dung.
Beetle activity scatters the manure to accelerate dung desiccation and reduce nematode survival. True – some nematode eggs may be protected from desiccation if buried with manure by dung beetles. However, these eggs would represent only a small fraction of the total number of nematode eggs in the pat.

6. Another concern is that the dung beetle will be a vector of disease, have you seen evidence of such an effect?

   I have no first-hand knowledge that dung beetles can vector diseases. Lonc (1980) reports the possible role of dung beetles in spreading beef tapeworm, which can infect humans as well as cattle. I have not read the original paper, but the abstract indicates results were based on study of Aphodius fimetarius, A. fossor, and Sphaeridium scarabaeoides.

Annex 1: References for Appendix 3 and 4

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