Gap analysis for risk assessment and decision making in the biosecurity system

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Summary

- The research programme "He Tangata, He Taiao, He Ōhanga[1]" (Strategic Outcome 3, Bioheritage National Science Programme) aims to incorporate information from a holistic set of values into a biosecurity risk assessment framework.

- This study is the first part of that research programme, aiming to describe the current state of decision making based on risk assessment in the biosecurity system.

- Twenty six decision makers who work in biosecurity and use risk assessments to support their decisions were interviewed for this study. The interviews were analysed using thematic analysis methodology.

- Three main themes were identified:
  - Structured frameworks are not widely used for biosecurity decision making
  - A wide range of values are considered in making decisions, although values aren't considered in a consistent or systematic way
  - Trust is central to participants' views on risk assessment quality and usefulness

- Overall, this study does support the need to incorporate information from a holistic set of values into a new biosecurity risk assessment framework, to help inform better biosecurity decisions.

- This study also suggests that such a framework, even if available, may not be used.

- In determining whether any new framework is used, how the framework is developed may be as important as the content of the framework. In particular, the framework needs to be developed in a way that builds trust between those developing the framework and those using the framework.

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[1] The people, the environment, the economy

Contents

"biosecurity is all about values and… we need to be clear whose values we are prioritising because we're constantly prioritising somebody's values" (L5)

Introduction

Biosecurity and the biosecurity system

"Biosecurity" is a term that is defined in different ways by different organisations and in different places. In New Zealand, biosecurity is defined as "*the exclusion, eradication or management of pests and diseases that pose a risk to the economy, environment, cultural and social values, including human health*" (MPI 2016). However, there are other definitions that need to be considered. The Food and Agriculture Organisation (FAO) Biosecurity Toolkit defines biosecurity as "*a strategic and integrated approach that encompasses the policy and regulatory frameworks (including instruments and activities) for analysing and managing relevant risks to human, animal and plant life and health, and associated risks to the environment*" (FAO 2007). This definition is useful because it highlights the strategic nature of biosecurity, and the risk-based nature of decisions. "Biosecurity" is also used in relation to laboratory biosafety, to mean security measures that are applied to prevent theft, loss or release of pathogens and toxins from containment (WHO 2018); this definition of the term is not relevant to this project and is not considered further in this report.

The definitions of biosecurity are broad, and encompass not just the statutory responsibilities of central and local government, but activities such as pest and weed control undertaken to protect and mitigate ongoing damage to agriculture, horticulture and biodiversity. The Ministry for Primary Industries (MPI) is the lead agency for New Zealand's biosecurity system, administering the legislation and advising the Minister for Biosecurity (MPI 2020). However, the biosecurity system also includes a wide range of other organisations that participate in and contribute to biosecurity. These organisations include the Environmental Protection Authority, the Department of Conservation, regional and district councils, industry groups, iwi and hapū, community conservation groups and research organisations.

A diagram of the biosecurity system, showing the different participants, the different decisions that are made and how risk assessment fits in, is given in Figure 1.
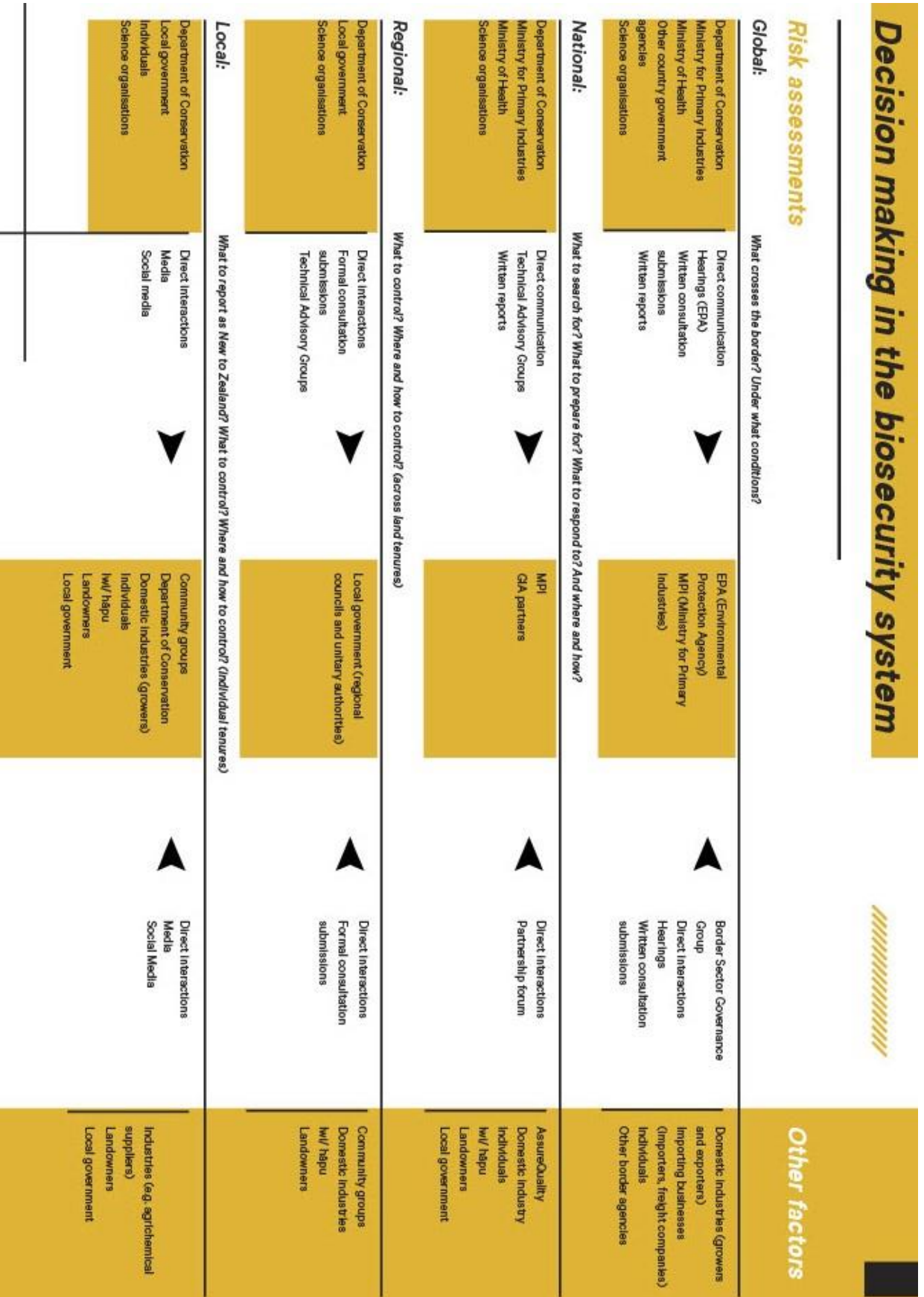
Decision making in the biosecurity system

Risk assessments

Global:

Department of Conservation
Ministry for Primary Industries
Ministry of Health
Other country government agencies
Science organisations

What crosses the border? Under what conditions?

Direct communication
Hearings (EPA)
Written consultation submissions
Written reports

▼

EPA (Environmental Protection Agency)
MPI (Ministry for Primary Industries)

▲

Border Sector Governance Group
Direct Interactions
Hearings
Written consultation submissions

Domestic Industries (growers and exporters)
Importing businesses (importers, freight companies)
Individuals
Other border agencies

National:

Department of Conservation
Ministry for Primary Industries
Ministry of Health
Science organisations

What to search for? What to prepare for? What to respond to? And where and how?

Direct communication
Technical Advisory Groups
Written reports

▼

MPI
GIA partners

▲

Direct Interactions
Partnership forum

AssureQuality
Domestic Industry
Individuals
Iwi/ hāpu
Landowners
Local government

Regional:

Department of Conservation
Local government
Science organisations

What to control? Where and how to control? (across land tenures)

Direct Interactions
Formal consultation submissions
Technical Advisory Groups

▼

Local government (regional councils and unitary authorities)

▲

Direct Interactions
Formal consultation submissions

Community groups
Domestic Industries
Iwi/ hāpu
Landowners

Local:

Department of Conservation
Local government
Individuals
Science organisations

What to report as New to Zealand? What to control? Where and how to control? (individual tenures)

Direct Interactions
Media
Social media

▼

Community groups
Department of Conservation
Domestic Industries (growers)
Individuals
Iwi/ hāpu
Landowners
Local government

▲

Direct Interactions
Media
Social Media

Community groups
Domestic Industries
Iwi/ hāpu
Landowners
Industries (eg. agrichemical suppliers)
Landowners
Local government

Other factors

Figure 1. Decision making in the biosecurity system

Biosecurity risk assessment and risk analysis

Like biosecurity, the terms "risk assessment" and "risk analysis" are defined in different ways in different organisations.

In the FAO Biosecurity Toolkit, risk assessment is described as "*a scientific process to estimate risks to* [human, animal and plant] l*ife and health that may be associated with a particular food, animal, plant or specific organism*" (FAO 2007). Risk assessment is one of three components that make up "risk analysis"; the other two are risk management[2] and risk communication[3]. Risk assessment and risk analysis are defined in a similar, but not identical, way by the international bodies concerned with animal health (World Organisation for Animal Health), food safety (Codex Alimentarius) and plant health (International Plant Protection Convention). All three of these bodies have their own risk analysis framework. One important difference is that under the plant health framework, the step of making a decision is specifically excluded from the risk analysis process. Under the animal health and food safety frameworks, the decision-making step is included as a part of the risk analysis process. The differences between these risk analysis frameworks are discussed further in the accompanying review of risk assessment and decision making frameworks (Newfield 2021).

Because MPI works with the three international bodies mentioned above, the definitions from these bodies are often used within MPI. However, because of the differences between how the three bodies use terminology, there is still some variation in how the terms are applied.

Differences in terminology become more significant where the risk management framework (ISO 31000) from the International Standards Organisation (ISO) is used. Under the ISO, the term "risk management" rather than "risk analysis" is used for the whole set of components. Risk assessment is defined as the overall process of risk identification, risk analysis, and risk evaluation. Risk identification and risk analysis are steps for identifying risks, and describing the nature and level of risks. These two steps are equivalent to the way the term "risk assessment" is used in the FAO toolkit and in the international organisations concerned with animal and plant health.

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[2] Defined as "the process of "weighing" control measure alternatives by government in consultation with interested stakeholders, taking into account scientific information on risks to health and life and legitimate values-based inputs, and then choosing and implementing control measures as appropriate" (FAO 2007)
[3] Defined as "the interactive exchange of information and opinions throughout the risk analysis process, with explicit consideration given to communicating the decision criteria applied in risk management" (FAO 2007)
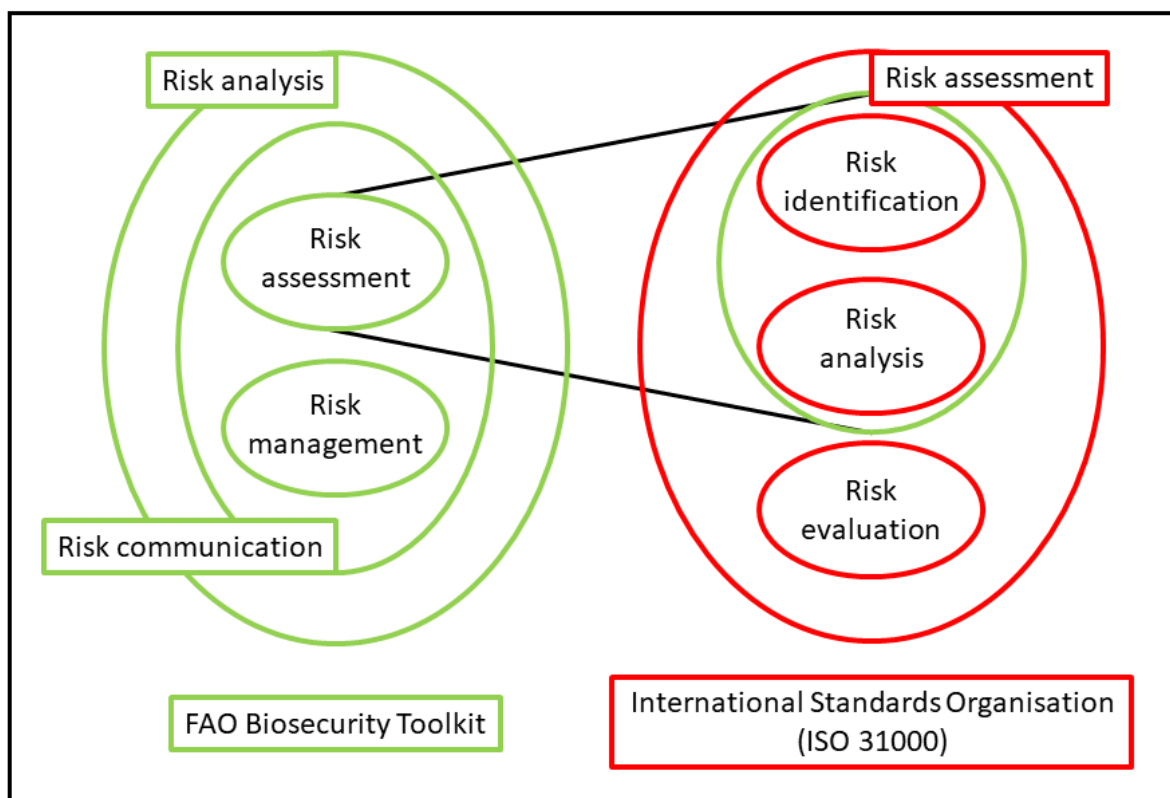
Figure 2. Differences in use of the terms risk assessment and risk analysis

Crucially, under the ISO, the term "risk evaluation" is defined as the "process of comparing the results of risk analysis with risk criteria to determine whether the risk and/or its magnitude is acceptable or tolerable" (ISO 2009). Judgements about whether a risk is acceptable or tolerable are not scientific or technical judgements, they are "acceptable risk problems" (Fischhoff et al. 1980, Pharo 2004). Acceptable risk problems are value-laden, and don't lend themselves to simplistic solutions (Fischhoff et al. 1980). They are highly situation-specific – in different situations, different options, values and information may be relevant. And with the same situation and information, different people will still draw different conclusions, depending on their values, beliefs or decision methods. Determining acceptable risk, that is, deciding on a course of action in response to a risk, is a political process, requiring a participatory approach and determined on a case-by-case basis (Pharo 2004). The assumption under the ISO definition is that there are established risk criteria that can be used to determine what is acceptable. Fischhoff et al. (1980) illustrated that this assumption had serious limits for the kinds of situations they were considering[4].

In this report, the term "risk assessment" explicitly excludes any form of risk evaluation as defined by the ISO. Nonetheless, even with the risk evaluation step as defined by ISO excluded, risk assessment is still value-laden (Elliott 2019). Therefore the definition in the FAO Biosecurity Toolkit, which describes risk assessment as a scientific process, is also problematic.

In this report, risk assessment is defined as "**the process of identifying risks[5] and describing the nature and level of risks**", that is, equivalent to the risk identification and risk analysis steps of ISO

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[4] For example the safety of electricity generation plants.
[5] The term "hazard" is sometimes used in this context, but "risk" is seen more often in common usage.

31000. This definition is consistent with the definition in the FAO Biosecurity Toolkit and with those used by the international organisations concerned with animal and plant health.

He Tangata, He Taiao, He Ōhanga

The research programme "He Tangata, He Taiao, He Ōhanga[6]" (Strategic Outcome 3, New Zealand's Biological Heritage National Science Challenge) aims to enable biosecurity system participants, and particularly mana whenua, to be actively engaged in the identification and prioritisation of biosecurity risks.

The overall goal of this research programme is to incorporate information from a holistic set of values into a new fit-for-purpose biosecurity risk assessment framework[7]. This framework will be one of the main outputs of the research programme. It aims to be based on the holistic values of society and culture (he tangata), the environment (he taiao), and the economy (he ōhanga). These values intersect with those of kaitiakitanga, manaakitanga, whakapapa, whanaungatanga and tikanga Māori. The framework aims to be dynamic and adaptable to work at national, regional and local scales, and account for changes in biosecurity risk to NZ through external influences such as climate, trade and tourism. The research programme aims to have transformative impact in particular on the extent to which Māori voices and values are taken into account in biosecurity risk assessment.

The programme has research focussed around delivering in three key areas (Figure 3):
RA1: Participation. Mana whenua and key participants in the New Zealand biosecurity system are active in identifying and prioritising existing, emerging, latent and recurring risks.
RA2: Values. We understand and prioritise biosecurity risks according to Māori values of kaitiakitanga, manaakitanga, whakapapa, whanaungatanga, and tikanga Māori; within the context of environmental, economic, mana whenua, and social/cultural values.
RA3: Impact. Decision making by mana whenua and key participants is driven by a dynamic and adaptable biosecurity risk assessment framework that accounts for multiple influences (such as changes in climate, demographics, land use, trade and tourism).

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[6] The people, the environment, the economy
[7] The term "framework" is defined in different ways. One definition is that of United States National Academy of Sciences (2013): their definition is "conceptual structures and principles for integrating the economic, social, ecological, and legal/institutional dimensions of decisions". For further definitions of decision frameworks, see the accompanying literature review (Newfield 2021).
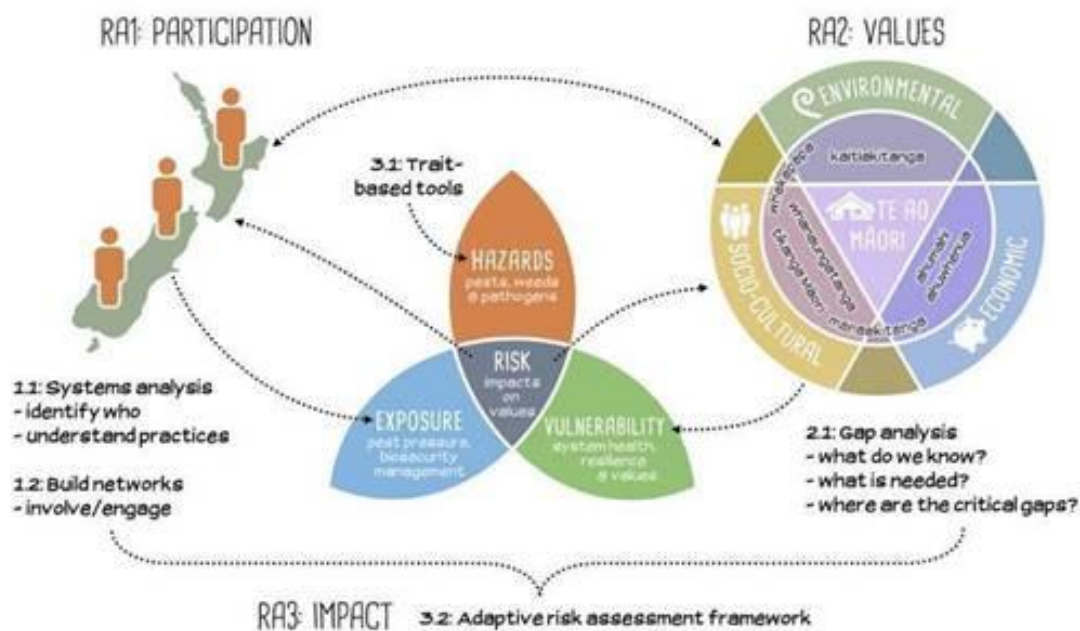
RA1: PARTICIPATION

RA2: VALUES

ENVIRONMENTAL

kaitiakitanga

TE AO MAORI

SOCIO-CULTURAL

ECONOMIC

3.1: Trait-based tools

HAZARDS
pests, weeds & pathogens

RISK
impacts on values

EXPOSURE
pest pressure, biosecurity management

VULNERABILITY
system health, resilience & values

1.1: Systems analysis
- identify who
- understand practices

1.2: Build networks
- involve/engage

2.1: Gap analysis
- what do we know?
- what is needed?
- where are the critical gaps?

RA3: IMPACT   3.2: Adaptive risk assessment framework

Figure 3. of New Zealand Biological Heritage National Science Challenge project SO3: He Tangata, He Taiao, He Ōhanga

Gap analysis for risk assessment and decision making

The first stage of work under He Tangata, He Taiao, He Ōhanga is to describe the current state of decision making based on risk assessment in the biosecurity system. The purpose of this current state description is to show the gaps in current knowledge and therefore the research required to achieve the overall programme goals. The current state description uses information gathered from talking directly with some of those who use risk assessment to make decisions about managing biosecurity risks in different parts of the biosecurity system.

This report is the outcome of those conversations with decision makers. Using the method of thematic analysis (Braun and Clarke 2006), it analyses the conversations for key themes that provide insights into the following areas:

- Who in the biosecurity system makes decisions and uses risk assessment?
- Who is included and who is excluded?
- How do biosecurity system participants connect?
- What decisions do they make, and for what purposes?
- What frameworks do they use?
- What data are available/required/excluded?
- What do they need?
- What barriers and enablers exist to both participation in the decision-making process and implementing good practice in risk assessment and decision-making?

An overview of decision making in the biosecurity system is provided in Figure 1.

Methods

Study participants

We used semi-structured interviews to talk to decision makers working within the biosecurity system about their experience of making decisions, with a focus on how they used risk assessment to inform their decisions. Because of the very limited pool of individuals using risk assessments for their biosecurity decisions, we aimed to reach as many as possible within the time available rather than trying to get a random sample. We recruited participants for the study by:

- directly approaching those we knew
- approaching people that we knew who advised decision makers and asking them to suggest people
- approaching organisations via their public websites
- asking decision makers that we interviewed to suggest further candidates (a form of snowball sampling approach).

Our main intention with this project was to interview decision makers in the biosecurity system who used formal biosecurity risk assessments or other forms of advice about pest and disease risks. However, in many cases, participants acted as decision makers under some circumstances and advisers under other circumstances. As advisers, they sometimes did risk assessments or interpreted risk assessments for other decision makers, rather than being users of risk assessments. This meant that they sometimes answered questions from the perspective of a decision maker, but at other times answered questions from the perspective of an adviser or risk analyst.

For reasons of confidentiality, we have not given the names of participants or the specific organisations that they work for. Participants are identified by the type of organisation that they work for (central government, local government or industry) and a number. There are slightly more central government participants than local government or industry participants, but they represent fewer organisations. This reflects the fact that the central government agencies were larger and had more diverse biosecurity roles than local government and industry organisations.

Organisation type	Number of participants	Scope of organisations
Central government	12 participants (10 interviews)	2 organisations across 4 geographical locations
Local government	7 participants	6 organisations: 4 North Island, 2 South Island
Industry	7 participants	7 organisations, representing 5 industries across agriculture, horticulture and forestry

We did not collect specific demographic information such as age, ethnicity and gender. However, approximately two thirds were male, and there were female participants from all 3 organisation types. Many participants had at least 10 years working in the biosecurity system, some much longer[8]. These demographics are consistent with our knowledge of current decision makers in the biosecurity system.

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[8] Based on knowing participants personally over a number of years.

We had ethical approval from the ethics committee of AgResearch and obtained informed consent from all participants.

Interviews

The questions we used for the semi-structured interviews are given in appendix 2. Interviews ranged from 35-80 minutes in length. We did 9 interviews in-person, 13 by video call and 2 by phone. We recorded all but one interview and then had them transcribed[9]; for one phone interview only written notes were possible. All but 2 interviews were one-on-one; in 2 of the in-person interviews there were 2 participants as well as the interviewer. Both interviewers conducted interviews; 20 were done by the first author and 4 by the second author.

Analysis

I (Melanie Newfield) analysed the interview transcripts using the thematic analysis methodology outlined in Braun and Clarke (2006). This methodology uses 6 phases:
1. familiarisation with the data
2. generating initial codes
3. searching for themes
4. reviewing themes
5. defining and naming themes
6. producing the report

Although there are 6 phases, the process is recursive rather than linear. For phases 2-5 of the analysis I used the Quirkos software package.

Braun and Clarke (2006 and in subsequent publications) intend thematic analysis, as they describe it, to be a fully qualitative research method. This means not only that the method uses qualitative tools and techniques, but also that it is underpinned by a qualitative research paradigm (Braun and Clarke 2018). For example, they see researcher subjectivity as a resource rather than a problem to be managed and reflexivity[10] as important to the analysis process.

Braun and Clarke (2006) outline a number of choices which need to be made as part of a thematic analysis. I chose to attempt a description of the whole dataset rather than focusing on a specific question of interest, and to take an inductive approach, that is, driven by the data, rather than a theoretical or deductive approach. I used this approach because there is relatively little research on the link between risk assessment and decision making, and none, to my knowledge, specifically for biosecurity. However, because of the size of the data set, it was not possible to cover the full breadth of themes within the timeframe of this project. So I narrowed our focus to themes that I considered would be most useful to those using the research to help develop risk assessment tools in future.

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[9] I transcribed 9 interviews myself using Otter transcription software and then correcting the transcript. Emma Hall transcribed 15 interviews.
[10] Reflexivity is "an awareness of the researcher's role in the practice of research and the way this is influenced by the object of the research, enabling the researcher to acknowledge the way in which he or she affects both the research processes and outcomes" (Haynes 2012).

For any quotes used, I have removed any details that might identify participants, including names, organisations and reference to specific locations or control programmes. For each decision maker, I have identified them only by a letter indicating the type of organisation that the participant worked for, and by a number. The letter C indicates the decision maker was from a central government agency, L indicates a local government agency and I indicates an industry organisation. This approach ensures that individuals are not identified but demonstrates that the quotes used come from diverse decision makers. In the quotes, I have removed words that are irrelevant, extraneous or might identify the participants – these omissions are denoted by an ellipsis. If we have altered words or added clarifying details, these are given in square brackets. The removal of identifying details and extraneous words was done late in the process to ensure that context to the quotes was retained during the analysis process.

Study authors

In this study, both authors, (Melanie Newfield and Christine Reed) identified study participants and conducted interviews, but only the first author did the analysis and wrote this report. Therefore some sections of this report refer to "we" while others refer to "I", depending on whether one or both of us did the work.

We have both worked in organisations that are part of the biosecurity system, particularly the Ministry for Primary Industries, for a combined total of more than 40 years. For most of that time, we have been managers of people doing risk assessment, or risk assessors ourselves. Our work meant that we spoke with and advised decision makers in the biosecurity system frequently, mostly in MPI, but not exclusively. We experienced the frustration of sometimes having our advice disregarded and worked hard to build the kinds of working relationships necessary to being a trusted adviser. One or both of us knew more than half of the participants in this study. Where we did not, we often had mutual contacts.

We have therefore approached this work with the status of "insiders". This status undoubtedly made it easier for us to get access to people, as we knew whom to ask. Another clear advantage was that our experience gave credibility to the project's goals – we were not speaking as people with only an academic interest, but as people who really understood risk assessment and what was involved in providing advice. Our backgrounds also meant that we understood much of what decision makers said without needing to ask for clarification – something with both advantages and disadvantages. In particular, our familiarity with the topic meant that we may have assumed meanings based on our own experiences rather than really listening to what was said. We may not have asked followup questions where someone who was less familiar would have, and may have missed some insights as a result.

For analysis methodology guidance, I relied on reading relevant literature, especially that recommended by the University of Auckland[11], and discussions with Susanna Finlay-Smits from AgResearch.

Because of the size of the data set, I chose to focus on three main themes that I considered most relevant to people using this research. Two of these three main themes coincide with areas of interest from my work in the biosecurity system – trust and process. However, I also found a number of the findings unexpected.

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[11] Available at this link https://www.psych.auckland.ac.nz/en/about/thematic-analysis.html

Results

This report is focused on three themes as defined by Braun and Clarke (2018):

- Structured frameworks are not widely used for biosecurity decision making
- A wide range of values are considered in making decisions, although values aren't considered in a consistent or systematic way
- Trust is central to the value that participants place on risk assessment

Structured frameworks are not widely used for biosecurity decision making

The decision makers interviewed for this project (participants) described risk assessment and decision making in a number of different ways. However, only a minority described their decision making process in terms of steps or frameworks. This could indicate that participants aren't using structured processes or frameworks; it could mean that they are, but that the frameworks are unconscious or unstated; or it could mean that participants look at the process in a different way.

The participants who described using structured frameworks for decision making had different processes that they used. Two used specific frameworks developed for biosecurity. One was a central government framework, the Biosecurity Decisions Framework[12]. The other was a local government framework developed as part of the Marlborough District Council's Biosecurity Strategy[13]. Some other participants described more general process steps or questions that they asked themselves, questions such as "*can we afford it?, should we do it?, can we do it?*" (C10) or "*what are the risks?, what are the opportunities?, what are the mitigation measures?*" (C7). No framework appeared to be used across multiple organisations or types of decision. A few participants also referred to risk assessments being done using frameworks or models, but again, there was nothing used across different organisations or for different types of decision in the same organisation[14].

A few participants were conscious of the lack of a structured process in their or their organisation's decision making, and raised that as a concern. For example, one local government decision maker said: "*we haven't had much sort of formalised structure around stuff. We've often been a bit organic and people are making risk assessments and making decisions but it's possibly…it's an unconscious process to some extent, or sort of variably documented process*" (L5). One decision maker noted that some situations were "*chaotic in the beginning*" but then added that "*you're supposed to get some order, so if that [chaos] continues, I would say, well, that will be not a successful attempt to do something*" (C6). One decision maker put it more bluntly:

- "*What I have learned in this job is that where you need to make a proper professional decision, you should follow a structured process. There are many decision making frameworks. I think they all are conceptually very similar. So I don't really mind which framework you want to follow. But you should follow one*" (C1)[15].

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[12] Described in more detail in the accompanying literature review (Newfield 2021).

[13] https://www.marlborough.govt.nz/repository/libraries/id:1w1mps0ir17q9sgxanf9/hierarchy/Documents/Environment/Biosecurity/Marlborough_District_Council_Biosecurity_Strategy_14_December_2017.pdf

[14] One possible exception was a reference to "team process" in the Department of Conservation. However this was not described as a structured process but in terms of bringing together different people to advise on a decision.

[15] *This participant wasn't specific about why they thought a framework should be used. However they did note that policy frameworks had the benefit of being "about good problem definition, being clear about your*

In contrast, a few participants identified reasons that they might not always follow structured processes. For example, one said that "*Ideally, all projects and all decision making should go through a process, but we're all busy people under the pump, and sometimes for those quicker things you just make a decision based on experience*" (L1). Some indicated that the frameworks that they had only addressed part of decision making.

However, the majority of participants referred neither to a structured process, nor to a lack of structured process. That was despite us asking the question "*Can you run through your decision-making process for me from start to end – the steps, who is involved and where does risk assessment fit in*". How did the decision makers that we interviewed conceptualise their processes if not as a series of steps?

I identified three distinct ways that participants thought about decision processes, apart from structured process steps. The first of these is that participants see the process as collaborative, in terms of people. The second is that they see decision making as adaptive, where decisions are reviewed as new information comes in, and sometimes changed in response to the new information. The third is that they see decision making as intuitive, as a matter of judgement.

Decision making is a collaborative process

Many participants talked about people when they talked about decision making processes. A number of them spoke about "*getting the right people in the room*" (C8), or "*around the table*" (C6). The "*right people*" were often those who made similar types of decisions – those with "*shared experiences*" (L2) – and people with technical expertise related to the problem they were dealing with. However, there were other people and groups from which participants sought and valued input. In one case, the term "right people" was very broad – "*anybody that is a stakeholder in that issue*" (C8) [16]. Participants did comment that sometimes their decisions were counter to information or advice that they had received, acknowledging that "*you've still got to make a decision and some of those decisions will be impactful on your relationship*" (C8). However, they didn't speak about the need to involve others in decision making as a constraint.

Decision making is an adaptive process

The concept that the decision making process is adaptive was another minor theme. A number of participants noted the importance of continuing to get information and changing the decision if the information warranted it. As one decision maker described it "*Decisions need to only stand as long as information they're based on is true*" (C3). The need to change decisions related to the need to make decisions quickly and in the face of uncertainty.

- "*Sometimes you don't have a lot of time to make a decision so your decisions are made with the acknowledgement that there is uncertainty and that you can come back to revise a decision when more information becomes available*" (I1).
- "*We have to be able to go back and change our decisions once we've got more information and we need people to understand that that's part of risk and it's part of biosecurity and I think that's really important*" (I2).

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objectives. weighing up the costs and benefits, both in a broad sense, not just the immediate direct costs, but some of the implications" (C1)

[16] The participants gave no information on who they might consider to be the "wrong" people.

Although a number of participants talked about the importance of responding to new information and changing decisions, I noticed one particular area where participants raised concerns about being unable to change decisions. In particular, they raised this concern in relation to pest or weed control programmes where they thought that there was no longer any value in the programme – as one decision maker said, with regard to long-running control programmes, "*it's easy to get into something, it's harder to get out of it*" (C4). In some cases, participants thought that the reasons that programmes were hard to stop were external – for example, community attachment to a programme. However sometimes the reason was that people doing the work were themselves committed to it.

- "*I've seen a lot of things where we're… really the only reason that we are still doing something is because somebody thought it was a good idea some time ago and now people in the team are emotionally committed to it and it's quite hard to stop. So I think if you make the wrong decision then potentially you're on a path for spending some money for quite a while before it's reviewed*" (L5).

There was one notable exception to the participants who talked about the difficulty in stopping ineffective control programmes. One local government decision maker highlighted, more than once, the decision to pull out of some ineffective programmes as an example of a good decision that they and their council had made.

Decision making is an intuitive process

The theme of decision making as an intuitive process was dominant, having been mentioned by almost all of the participants in various ways. Words such as "*gut*", "*intuition*", "*experience*" and "*judgement*" were common. Participants also talked about feelings, instincts and senses such as smell to describe making decisions. In general, participants were confident about using their own intuition, for example, one said "*If it feels right, it usually is. If it doesn't feel right, it's usually not*" (C7), while another spoke of "*trusting your instincts*" (I1).

Even though participants commonly spoke of decision making as intuitive, this didn't mean that they disregarded other ways of thinking about decision making, such as structured processes. In particular, participants didn't usually describe the whole process as intuitive. Rather, they noted that certain aspects were intuitive, that intuition should be used at a certain point in the process, or that intuition fitted with other ways of viewing the process, such as collaboration. For example, one said "*risk assessment… or decision making is a process but you've got to bring in your own gut feel, your own personal experience, advice from your colleagues*" (I6). Although they didn't state specifically why they thought intuition should be used, they were very clear about how intuition should fit into a decision process, stating that "*if you're unsure or you feel that possibly you are making the wrong decision and your gut really tells you that… it requires you to then to get a second opinion or run it by a committee*" (I6).

In a couple of cases, participants directly said that they went against advice based on their intuition. For example, one gave a specific example, then noted that "*no assessment framework is going to be perfect either and if something smells a bit funny then it just could be*" (I4). While this wasn't something that was common in the data, it may be more prevalent than the data indicate. My own experience is that people making decisions sometimes go against advice for reasons that they can't clearly articulate. It is also my experience that scientists or people in advisory roles commonly state that decision makers already have an answer in their head and ignore advice that contradicts that

answer. A decision maker once told me that the results of a risk assessment that I presented to them "*passed the sniff test*". These experiences may relate to decision makers using intuition.

A wide range of values are considered in making decisions, although values aren't considered in a consistent or systematic way

I found a clear theme that the decision makers interviewed for this project thought about different values when making their decisions. While a small number mentioned the values that they considered only in a very general sense, for example naming "environmental, economic, social, cultural" without further expansion, most gave some detail about how they took the values into account. Mostly, they described how they took economic and environmental values into account, although a few talked about social and cultural values. A few mentioned taking social impacts into account when considering control methods for pests. However, I found little sign of a pattern in the approaches that they used to take the values into account.

There were two approaches to taking values into account used by a reasonable number of participants. These approaches were considering a value (mostly economic and environmental) in terms of more detailed factors, and getting input from others. For example, in considering economic values one decision maker said that "*the economic impact is split into production potential impacts and then overseas trade formal access and then customer preference*" (I5). For environmental values, one decision maker talked about "*environmental protections that align to our biodiversity outcomes around species and ecosystem protection*" (L5). Another noted "*it's maintaining those biodiversity outcomes, especially birds*" (L2), and then went on to talk about the ways that their organisation monitored that their programmes were achieving specific objectives, something that was quite unusual among the decision makers we interviewed.

A few participants acknowledged that they weren't in the best position to understand values, and that input from others was therefore an important part of understanding impacts on values. For example, one said "*What the industry people will quite often bring to the table, they'll give us some of the direct insights in terms of potential trade impacts, size of markets that they might be sending… product to, that kind of thing* (C4). Another said "*We certainly lean on our community, our stakeholders and those partners that have a really good idea around that value set*" (L3). That same decision maker also talked about the way that discussions were framed when taking social and cultural values into account.

- "*when you're looking at things that may affect cultural or sociocultural and those kind of values and factors, we basically flip it around and say look, intervening might cost X, do you…are you concerned from those value points enough that you believe that that's justified in terms of an intervention cost, which is all you can really do if you can't quantify something*" (L3)

Overall, it was clear that participants found it more difficult to take social and cultural values into account. However a few had ways by which they did so, mostly by improving links with local iwi and hapū, and then taking their advice. One said that:

- "*I'd sit there and say that we haven't necessarily been good at doing that in the past but we are rapidly getting better at that and have some very good forums now… where we've got good strong partnership relationships with those groups*" (L7)

While I found no clear pattern in how participants took values into account, nor the weight that different values received, there were two themes in the way the different organisation types approached values. As expected, industry organisations focused on economic values related to their industries. However they didn't focus exclusively on these values to the exclusion of all others. Most talked about considering broader social or environmental values, such as animal welfare or ecosystem services, as well as the impacts of control measures for pests. Local government participants usually emphasised the importance of environmental values to their organisations. One said "*our delivery is very focused on environmental protections*" (I5) while another said "*councillors have set up, you know, improvement in… or stopping the deterioration of native biodiversity many, many years ago, as one of the council priorities*" (L2). Participants from central government organisations didn't show a pattern of emphasising any particular value over another.

Overall it appeared that participants were considering organisational rather than personal values in their decisions. When speaking of values, participants mostly used "we" rather than "I", and often referred specifically to organisational policies and objectives.

When asked more widely about legislation and policy that shaped decisions, participants most often referred to the Biosecurity Act (1993), sometimes mentioning specific sections of the Act that related to their work. In addition to the Biosecurity Act, participants referred to a range of other pieces of legislation that were part of the context for their decisions: the Forest Act (1949), the Wildlife Act (1953), the Wild Animal Control Act (1977), the Conservation Act (1987), the Public Finance Act (1989), the Commodity Levies Act (1990), the Resource Management Act (1991), the Hazardous Substances and New Organisms Act (1998), the Civil Defence Emergency Management Act (2002), the Local Government Act (2002) and the Public Service Act (2020). The legislation that applied to each decision depended both on the organisation the participant worked for and that specific decision.

As well as legislation, participants also referred to regulations and policy that further influenced their decisions. An important policy document that local government participants mentioned was the National Policy Direction for Pest Management (2015). Specific policy outcomes, such as for biodiversity, also influenced some local government participants. Industry participants referred to Government Industry Agreement Deed and work under that deed such as operational agreements or working groups. Industry and government participants involved in international trade referred to the World Trade Organisation Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement).

Difficulty considering Maori cultural values

Although there was no pattern in how participants consciously weighted different values, many described having difficulty in dealing with social and cultural values. In many cases, this difficulty is likely to result in certain values being de-emphasised, even if unintentionally.

This difficulty was particularly prevalent when participants talked about taking Māori cultural values, as well as mātauranga Māori, into account. Participants spoke of their own lack of knowledge, their difficulty in understanding how Māori values and mātauranga Māori would fit into their processes, and their organisations' lack of commitment and rigour in partnering with Māori. One noted that discussions didn't happen in an "*early-on or structured way*" and that they weren't "*organised or well thought through*" (C6). Several referred to "*trying*" but couldn't give any successful examples. In terms of organisational processes, one decision maker said "*I would say that our current*

mechanisms don't allow for that easily" (C10), while another said that "*there's often not really access to that information in a timeframe that's achievable*" (L5). In relation to decisions made at a national level by central government agencies, one commented that "*one of the challenges we have with fully factoring mātauranga Māori into decision making is that it's localised, place based*" (C10). A couple of participants also commented that there was a lack of "*capacity and capability*" in their local iwi and hapū.

The difficulty in, and tendency to see barriers to, considering Māori knowledge and values in decision making was linked to a lack of successful examples of partnering with local iwi and hapū or using mātauranga Māori in decisions. However, a small number of participants from central and local government spoke positively about the contribution of their local iwi and hapū, as well as mātauranga Māori, to their decision making. These participants spoke with both confidence and enthusiasm when they spoke about the partnerships that they had developed. They were able to give specific and detailed examples. One mentioned a "*wealth of knowledge and understanding*" (L3).

This group included one of the participants who raised the lack of capacity as an issue. However they did not view this lack of capacity as something that prevented them from partnering with the local iwi or hapū. Rather, they said:
"*now that is now part of our … [process] that we will talk to mana whenua very early to look at their views and what they feel about that and that might be everything from just, from their perspective it might be they're happy for us to go away and do what we want or they want to be partnering and part of the solution*" (L7).

Trust is central to participants' views on risk assessment quality and usefulness
Trust, or a lack of trust, emerged as central to the way that the decision makers in this study thought about risk assessment. While rarely mentioned specifically, all the participants made comments that related back to the importance of trust in one way or another. I found two major sub-themes regarding trust. The first related to trust or lack of trust in the risk assessment[17] itself. The second related to trust or lack of trust in the individuals providing the risk assessment. These sub-themes overlapped and both of them had a direct impact on the way participants thought about the risk assessments they received. The participants views on the quality and usefulness of risk assessments affected the way that they took risk assessments into account in their decisions.

Trust or a lack of trust in risk assessments and underpinning information
I found considerable overlap between those participants who expressed trust in risk assessments and those who expressed a lack of trust. It wasn't the case that some participants tended to trust risk assessments and others didn't. It therefore seemed more likely that trust related to either the risk assessments themselves or to something related to the risk assessments.

The reasons participants gave for trusting, or not trusting, risk assessments mainly related to the information sources used. Participants expressed a need to see where the information in a risk assessment had come from. For example, one central government decision maker said "*I like to see references. And I like to know… what is the info that they have used to come up with the work?*" (C6).

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[17] We interpreted "risk assessment" broadly as advice related to biosecurity risk. In some cases, participants also refered to other types of advice, such as legal advice, but with the same themes of trust or lack of trust.

Participants differed in exactly which sources of information they considered reliable or unreliable, but they usually emphasised scientific literature as something that they trusted.

- *"it's where is the information from and is it credible. So it would have to be sound research that's been peer reviewed and preferably published or if it's not published and it's in a pre-published state, then it would have to be research that had a sound methodology that's been undertaken by a reputable service provider." (I1)*
- *"I think the assumptions can change depending on the source of the information. So some of them that we'd consider really reliable, whereas others you take with a grain of salt." (I3)*

A number of participants expressed doubt about the validity of using information about a pest or pathogen's behaviour and impacts overseas to predict their behaviour and impacts in New Zealand. In some cases, this extended to doubts about predicting the behaviour and impacts in one part of New Zeland based on another part of New Zeland.

- *"unfortunately when they're new, you don't really know because they're new to the area. You don't know how they're going to fit in with the ecosystem and affect it… you are utilising biological information and potential impacts from other countries sometimes or other regions… when you don't really know how something is going to behave in New Zealand, it's difficult to assess the risk." (L4)*

Trust or a lack of trust in advisers doing risk assessments

Trust, or lack of trust, in people providing advice emerged as an important sub-theme relating to the value of risk assessment to participants. It was mentioned by more participants, more frequently and with greater emphasis than trust or lack of trust in the advice itself. As with trust in the advice, trust related to specific advisers or circumstances, rather than some participants being trusting and others not trusting. The importance of trusting the people giving advice is summed up by a central government decision maker who said *"for me it's also really important who's telling me that information". (C6)*

Participants talked about a range of different people providing advice, including advisory staff within an organisation, acknowledged experts in particular fields and people affected by decisions who were providing input into a decision process. There was no clear pattern in the degree to which advisers were trusted and what role they had. The exception was a degree of mistrust expressed by some central government participants towards some people in industry groups, due to perceptions of bias.

Clear differences emerged in the reasons participants gave for trusting advisers, and the reasons they gave for not trusting advisers. The main reason that participants expressed for trusting advisers was their knowledge and experience. A lack of experience was also a reason that advisers might not be trusted, but it seemed less important than other factors.

- *"we've got a lot of people in our industry that have worked overseas and have experienced a lot of the pests and diseases that we don't yet have here." (I3)*
- *"you can't take away that history and experience" (L1)*
- *"I suppose that ascribing more or less credibility… or more effort that I will have to put… to assessing some information based particularly [on] the experience that people people have,*

*have they seen cases like that before or is something that we will have to start from scratch."
(C6)*

A less common reason that participants expressed for trusting advisers was the processes that the advisers followed, as illustrated in the following quote: "*If they get it wrong, so be it. At least they are… we can go and say "… followed the due process". It's very clear and transparent how they did their work (C5a).* In one case, a participant expressed a strong preference for written advice, commenting "*I take that into account very strongly because once they've given me their advice in writing, they're actually putting their reputation on the line (C8).* However another participant noted the opposite – that advisers were reluctant to commit themselves in writing, noting that:

- *"I might have a verbal conversation… And I say what would be really helpful to me is if you could sort of summarise this and give me your view. So I tend to get a lot of words… written advice seems to be quite general.*" (C2)

The most commonly stated reasons for a lack of trust were a perception that the advisers lacked context and perspective about an issue, and a perception that the advisers were biased in some way. The perception about lack of context and perspective was indicated by participants in different ways, for example, using words like "*purist*" and "*siloed*".

- *"they are siloed because they just think about their little bit in the world and so all they're going to do is give you advice on their little bit in the world"* (C8)

One way that participants expressed their perception about a lack of context was by suggesting that advisers provided advice from a scientific perspective only, summed up by one central government decision maker as:

- *"a lot of risk assessors see themselves as scientists so risk assessment feels like a scientific exercise instead of a contribution to solving a real problem"* (C3)

Perceptions that people providing advice were biased were often indicated directly, by terms such as "*biased*" or "*slanted*". Participants perceived biases as coming from people with a particular perspective on an issue, such as representing an industry's interests or having a "personal agenda". They also referred to advisers having a different attitude to, or appetite for, risk, such as being "*risk averse*".

- *"I was looking for advice that would be able to tell me that this was not a… problem. And what I heard, I was really clear in my mind, was hope… what I knew to be a sort of a bias… that wasn't based on any evidence."* (C1)
- *"So if I go and see one scientist, they can be incredibly risk adverse. And if I go and see another scientist, they can say, well, everything that Joe said was right, but really, it's not likely to happen, they're talking about a 1000 year event or something like that. And I'm saying, well, that doesn't really help to me."* (C2)

It wasn't always clear how the participants formed the perception that advisers lacked context or were biased, and whether those perceptions were formed from the advice or the advisers themselves. The following quotes, as well as those in the previous paragraph, give examples that may indicate how participants reached their conclusions.

- *"where the advice is contradictory… I feel really exposed"* (C2)
- *"It's like this model output. I think you have to look at these things and kind of use gut instinct to some extent and I think one of the things you have to assume is that no model*

> *is perfect and no assessment framework is going to be perfect either and if something smells a bit funny then it just could be."* (I4)

- *"The thing I find challenging is it's still a bit of a black box... I don't understand why. I just have to accept that these people know how to do the job and they're doing it properly."* (C3)

Discussion

The main intention with this research is to guide the future development of risk assessment and decision making frameworks for use in biosecurity in New Zealand. However the results of the research show that developing a good framework is only part of the challenge.

Why are frameworks not used often?

The lack of structured frameworks used in biosecurity decision making presents both an opportunity and a challenge for researchers. On the one hand, the use of a good decision process is widely considered to be important for good decision making[18] . Therefore, developing a better framework for biosecurity decisions or risk assessment could lead to better decisions. On the other hand, there are frameworks already available, both specific frameworks for biosecurity and generic frameworks, as described in the accompanying report. Although these frameworks could be used, mostly they are not. The finding that structured frameworks, even if available, aren't widely used for biosecurity decision making is consistent with what is reported from other fields (Addison et al. 2013, Yates et al. 2003). So there is no guarantee that a newly-developed framework would be used either.

Addison et al. (2013) considered the use of models to inform decision making in conservation, a field closely linked to biosecurity. They noted there were numerous examples of models helping conservation decisions, but that many decisions were made using what they referred to as *"unstructured subjective judgments"* such as intuition and personal experience. To better understand the reasons, they reviewed scientific and grey literature for evidence of the attitudes of those who participated in environmental decision making. They identified nine main objections:

1. We don't need models for decision-making, we have experts
2. Developing and using models in decision-making is too resource intensive
3. Models do not represent my conceptual understanding of the decision context
4. Models focus on environmental considerations of the decision context, but fail to capture the social, economic and political factors which influence conservation management options
5. Models are either too complicated or too simple
6. There are insufficient data to do quantitative modelling
7. Inadequate data quantity/quality leads to inaccurate model predictions
8. I don't understand the way scientists communicate
9. Model outputs are too uncertain for decision-making

These objections fit well with many of the comments made by participants in this study in terms of their decisions processes and use of risk assessments. For example, the importance that participants placed on trusted advisers is consistent with objection 1 above. Some participants indicated that they didn't have time to use frameworks – as one participant said *"Ideally, all projects and all*

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[18] See the accompanying report on risk assessment and decision making frameworks (Newfield 2021) for supporting evidence.

decision making should go through a process, but we're all busy people under the pump, and sometimes for those quicker things you just make a decision based on experience" (L1). Addison et al. (2013) included time under objection 2. Comments from some participants indicating that they thought some advisers lacked context or a big picture view are consistent with objection 4. A lack of data was mentioned by many decision makers, as an example, one industry decision maker noted "*sometimes the information we can get, it doesn't go into any of those systems nicely so we just have to do our best*" (I3). A couple of participants raised difficulties in understanding risk assessments, similar to objection 8, as illustrated by the following quote: "*often the language used in risk assessment is risk assessment language, it's not audience language*" (I7).

Also in the field of conservation, Knight et al. (2008) found that two-thirds of conservation assessments published in peer-reviewed scientific literature did not lead to management action. They described this as an example of "knowing-doing gap". They found that only a quarter of the conservation assessments published identified implementation as one of their objectives, and that there was a strong correlation between assessments published with implementation as an objective, and those that were implemented. If the researchers hadn't intended their work to result in any management action, it probably wouldn't be. Roux et al. (2006) described a similar disjunct in natural resource management in South Africa. In their case, they highlighted that the concept of "knowledge transfer", implying a one-directional flow, was a major barrier, and that "co-production" of knowledge through collaborative learning was a better model to use.

The examples from conservation fit with my own experience as an adviser and manager of advisers in the biosecurity system. When researchers developed tools or models without involving those with practical experience, the tools or models usually weren't used. From the other side, if we did risk assessments without working alongside those who needed to use the results, our risk assessments often appeared to be ignored.

How are decision processes perceived?

The different ways that participants viewed decision making processes – as collaborative, adaptive and intuitive – also pose challenges and opportunities for researchers. In particular, if a framework doesn't fit with how decision makers think about decisions, it's much less likely to be used. However, these ways of viewing decisions may also help in evaluating potential frameworks for their suitability in biosecurity decision making.

The two frameworks already in use and developed specifically for biosecurity decision making provide useful examples. The Biosecurity Decisions Framework[19], from the New Zealand Ministry for Primary Industries (MPI)[20] describes decision making as a cyclical or adaptive process, consistent with how a number of participants described the process. However, while consultation with stakeholders is mentioned, collaboration is not strongly emphasised in the framework. The other framework is part of the Marlborough District Council's biosecurity strategy. It was developed in 2017 to help council staff make decisions on whether to intervene in pest management activities. Like the Biosecurity Decisions Framework, it emphasises consultation over collaboration. It is a nine-step, linear process, so is not specifically an adaptive process. However, the framework was

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[19] The Biosecurity Decisions Framework is discussed further in the accompanying report on risk assessment and decision making frameworks (Newfield 2021).
[20] At the time MPI was known as MAF, or the Ministry of Agriculture and Forestry

described by a staff member from Marlborough District Council[21] as scalable, and could therefore be run again if new information became available.

- *it's kind of a nine step decision framework… we run through this almost on a daily, weekly… depending on the scale of whatever is happening, we will do these steps sometimes in a course of an hour in discussions or sometimes, if we needed to, over the course of months or years as we analyse how we may intervene.*

The Biosecurity Decisions Framework is not the only framework that fits with decision making as an adaptive process. The framework in the Food and Agriculture Organisation Biosecurity Toolkit (2007), and the Invasive Species Adaptive Management Framework for South African National Parks[22] (Foxcroft and McGeogh 2011) both describe the process as circular and allow for new information to prompt a changed decision.

Collaboration may be more difficult to incorporate, because few frameworks highlight this. While most have some aspect of dialogue, such as consultation or risk communication, this is not the same as collaboration. The participants that we spoke to valued the input of peers and people that they regarded as experts, something quite different from formal consultation or risk communication. However, the "Dialogue Decision Process" model (see Tani and Parnell 2013), described in the accompanying report, is based on collaboration. The decision making process is described as a series of interactions between a "decision board" and a "project team". By describing the process in terms of interactions between two groups, the Dialogue Decision Model allows for collaboration with peers and experts.

Intuition may be the hardest aspect to incorporate into future decision making frameworks, and it is even debatable whether it should be. The intuition of experts, in particular expert decision makers, can be very good, but often it is not (Kahneman and Klein 2009). The literature of heuristics and biases is filled with examples of the way that human intuition misleads us (e.g. Tversky and Kahneman 1974), and those who are "expert" in a field, including scientists, are not immune (Wilson et al. 2020). As well as drawing us to factually incorrect conclusions, such as under- or over-estimating the distance to a particular landmark (Tversky and Kahneman 1974), these biases can have real impacts on questions such as "who do we regard as experts?". For example, Thomas et al. (2019) found that women were less likely to publish invited commentaries in medical journals, when compared with male colleagues who had similar levels of seniority and publication history. Invited commentaries are, as their name suggests, written by authors who are invited by the journal editors, so perceptions about who is regarded as "expert" are important.

However, to disregard intuition would be to ignore the reality of decision making. The participants in this study knew that they were using their own intuition, and they generally considered that to be a good thing. There is also evidence from the field of Naturalistic Decision Making that indicates real value in the intuition of experienced decision makers (e.g. Klein 2008). Simon (1987) described the intuition and judgement of experienced managers as "*analyses frozen into habit and into the capacity for rapid response through recognition*". In a field such as biosecurity, where timely decision making is important[23], it is not surprising that the participants valued this kind of rapid process.

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[21] This staff member is quoted with permission to identify the organisation, as it wasn't possible to use the quote without identifying the organisation that they work for.
[22] Both described in the accompanying report on risk assessment frameworks
[23] The importance of timely decisions in biosecurity was raised by a number of participants.

Whether or not intuition is a good thing in biosecurity decision making may depend on what that intuition is based on. Kahneman and Klein (2009) provide some insight by distinguishing "skilled" intuition from "heuristic-based" intuition, which is prone to systematic bias. Skilled intuition is based on the recognition of a familiar pattern. It develops with time and the right environment, in particular, an environment which provides sufficient predictability for people to learn. If the environment isn't sufficiently predictable, people can still develop intuition, and confidence in that intuition, but their intuition won't be reliable.

The examples of intuition quoted by <u>Kahneman and Klein (2009)</u> were quite specific, for example chess masters selecting their next move or neonatal intensive care nurses intuitively recognising infection in infants. The biosecurity decisions that the participants in this study talked about were varied, and it was far from clear whether participants could reasonably know whether a decision that they had made was a good one. A number of participants talked about the difficulty they had in knowing that they were successful, either because results might not show for a long time or because the results were difficult to measure. These points suggest some useful areas for future research, such as defining what a good biosecurity decision is, from the perspective of the diverse participants in the biosecurity system, and better measuring the success of biosecurity decisions.

My own experience working with decision makers in the biosecurity system also points to some areas where further research may help. My experience of decision makers in the biosecurity system is that they do use intuition, and that this can result in decisions that are confusing and even illogical to an outsider[24]. However, when I worked closely with decision makers, in a collaborative way, I found that there were usually quite clear and compelling reasons that they made the decisions that they did. Together, we were able to articulate the criteria that they were using for their decisions, and that the decisions became more understandable as a result.

Why are values assessed inconsistently?

Decision makers in the biosecurity system are required by legislation to consider impacts on a wide range of values and factors. In the Biosecurity Act (1993), the values and factors are described in different ways in different parts of the Act. For example, when considering the importation of risk goods, the values are summarised as "human health, the New Zealand environment, and the New Zealand economy[25]". While this list appears shorter than the list of "cultural, economic, environmental, social" values commonly described by participants, the definition of "environment" includes social and cultural values[26]. Other factors that must be considered include the likelihood of risk goods carrying organisms, New Zealand's international obligations, the effect of control measures on the level of risk, and practical and economic implications of control measures.

Different types of biosecurity decision have subtly different requirements. Decisions about biosecurity responses relate to the definition of Unwanted Organism, which refers to impacts on

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[24] Occasional comments from participants referring to decisions made in other parts of the biosecurity system suggest that decision making is sometimes not even comprehensible to other "insiders" working in slightly different areas of the biosecurity system.

[25] Section 23(4)biii

[26] Section 2(1) **environment** includes— (a) ecosystems and their constituent parts, including people and their communities; and (b) all natural and physical resources; and (c) amenity values; and (d) the aesthetic, cultural, economic, and social conditions that affect or are affected by any matter referred to in paragraphs (a) to (c)

"natural and physical resources or human health[27]". In this case, the definition of "natural and physical resources" is broad, including all types of organisms and ecosystems, as well as landscapes and structures[28]. Pest management, that is, managing established species of plant, animal or microbe under statutory plans, has slightly different values again. The focus of pest management is on managing organisms that affect "economic wellbeing, the environment, human health, enjoyment of the natural environment, and the relationship between Māori, their culture, and their traditions and their ancestral lands, waters, sites, wāhi tapu, and taonga"[29].

However the legislative landscape in which biosecurity decisions are made is much more complex than just the Biosecurity Act, with participants mentioning 11 other pieces of primary legislation. Each piece of legislation has differences in emphasis for the values that must be considered. For example, the Hazardous Substances and New Organisms Act specifies that decision makers "*shall take into account the principles of the Treaty of Waitangi (Te Tiriti o Waitangi)*"[30], quite different from the wording in the Biosecurity Act[31]. The Conservation Act is different again, expressly stating that "*this Act shall so be interpreted and administered as to give effect to the principles of the Treaty of Waitangi*"[32].

The diverse pieces of legislation and policy that participants considered may be one reason why they didn't consider values in a consistent way. It simply wouldn't be legal to make decisions about controlling pests on public conservation land in the same way as decisions on the importation of risk goods.

Addressing legal and policy differences is outside the scope of this project. However, any future research to support risk assessment and decision making also needs to sit within this legal and policy landscape. For example, if a framework is being applied to international trade and addresses uncertainty, that framework needs to consider the SPS Agreement, which is specific about when and how precaution should be applied in international trade. The SPS Agreement states that sanitary or phytosanitary measures affecting trade can only be applied "to the extent necessary[33]" and are not maintained "without sufficient scientific evidence"[34]. Where the scientific evidence is uncertain and precaution is applied, additional evidence shall be sought and the measures reviewed "within a reasonable period of time[35]". Such rules create real challenges in the often uncertain situations faced in biosecurity.

However, legal and policy differences don't explain the full picture of why values are considered in different ways by different decision makers. For example, local government decision makers differed in how much they talked about taking environmental, social and cultural values into account, despite operating under the same legislation and policy. Although some of these differences could relate to

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[27] Section 2(1)
[28] Section 2(1) **natural and physical resources** means— (a) organisms of all kinds; and (b) the air, water, and soil in or on which any organism lives or may live; and (c) landscape and land form; and (d) geological features; and (e) structures of all kinds; and (f) systems of interacting living organisms and their environment
[29] Section 54(a)
[30] Section 8
[31] An additional complication is that the Biosecurity Act is currently under review. One of the areas being considered during the review is how te ao Māori is reflected in biosecurity regulation (MPI 2020).
[32] Section 4
[33] Article 2.2
[34] Article 2.2
[35] Article 5.7

different councils having different goals, some comments indicated that there could be other reasons for the differences, such as a difficulty in knowing how to take the values into account. For example, one participant said that "*we are definitely looking at biodiversity, cultural and economic. The social values are something that we certainly wouldn't not look at but they're much harder to describe*" (L7).

One of the most obvious potential reasons for participants struggling with social and cultural impacts may be the more limited research in this area, compared to other impacts. In the published literature, much social research on invasive species focused on the conflicts or potential conflicts created by the social benefits of invasive species (e.g. Novoa et al. 2018, Estevez et al. 2014, Marshall et al. 2011) and by social impacts of controlling invasive species (e.g. Glen and Hoshino 2020, Roberts et al. 2018, Crowley et al. 2017a). I found very few publications documenting the social impacts of invasive species or pests[36]. Notable exceptions were for wilding conifers (Gawith et al. 2020), kauri dieback (*Phytophthora agathidicida*) and myrtle rust (*Austropuccinia psidii*, Lambert et al. 2018), and brown marmorated stink bug (*Halyomorpha halys*, Haye et al. 2015).

Existing frameworks are also limited in the degree to which they address social and cultural values. For example, while the Biosecurity Decisions Framework (MPI 2008) states that social and cultural impacts should be considered, it doesn't give any further detail about how these should be considered. The FAO Biosecurity Toolkit (FAO 2007) also gives limited guidance, mentioning factors such as "recreation, lifestyle and cultural values" and discussing the example of social impacts for bovine spongiform encephalopathy in Canada (BSE, also known as "mad cow disease"). The framework for the World Organisation for Animal Health notes that "environment" can include tourism and social amenity (OIE 2010) while the International Plant Protection Convention Framework mentions "social effects (such as employment, tourism)", but neither has further guidance.

As well as more obvious barriers like the lack of documentation of social and cultural impact, or lack of guidance in frameworks, there may also be less obvious barriers. The problem of experts and decision makers seeing themselves as "objective", and those who disagree with them as "irrational" is well-recognised in the field of risk assessment (for example, see Sandman 1993). As an example of how pervasive this problem is, the International Standard for Risk Management (ISO 31000) defines "risk perception" as a "*stakeholder's view on a risk*", with the accompanying note that "*Risk perception reflects the stakeholder's needs, issues, knowledge, belief and values.*"

These kinds of attitudes did not appear prevalent among participants. They didn't use words like "irrational", or dismiss anyone's view of a risk as a "perception". In addition, many participants described decision making as a collaborative process, indicating that they sought and considered inputs from others into the process. However, it was clear that some people and information sources were trusted, and some were not. Some people were perceived as "biased". If decision makers don't trust those who have information relevant to certain values, then it's likely that their information won't get a fair hearing.

When questioned about whether their decisions had used mātauranga Māori as an input, most participants made statements indicating that they were willing to do so. However, the fact that so

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[36] Searching Google Scholar using the search terms **social impact** (and "**social impact**") or **cultural impact** with either **invasive species** or **pest**.

few said that they actually had done so suggests that there are particular barriers in this area. In some cases the barriers may be personal. For example, some responses sounded like justification, such as when participants stated that they were "trying" and then proceeded to identify the reasons why they found it difficult. While few were openly negative, one participant, who had previously sought the input of local iwi when making some decisions, commented, "*they are yet another factor around zero risk*". On the other hand, some barriers appeared more institutional. The lack of clarity provided by the Biosecurity Act, for example, is unlikely to encourage individuals or organisations to change their approach. A lack of access to the appropriate people within an organisation's timeframe is another institutional barrier.

Why are some advisers trusted and others not?

The main intention with this research is to guide the future development of risk assessment and decision making frameworks for use in biosecurity in New Zealand. However the results of the research show that developing a good framework is only part of the challenge. The participants in this study were concerned with the trustworthiness of the advisers and experts producing risk assessments, as well as the actual risk assessments. In fact, the trustworthiness of advisers may be more important than the assessments. Therefore trust must be considered when developing and implementing any framework.

The risk communication literature offers some insights that may help with understanding how trust works in the context of risk assessors and decision makers. Although the risk communication literature usually puts risk assessors and decision makers on the same side, across from the wider public (e.g. Peters et al. 1997, Sandman 1993, Kasperson et al. 1992), in our work I have observed similar dynamics between risk assessors on the one hand and decision makers on the other.

Peters et al. (1997) found that perceptions of trust and credibility in risk communication related to three factors:
* knowledge and expertise
* concern and care
* openness and honesty

Participants in this study clearly expressed that knowledge and expertise was something that they considered important in advisers. On the other hand, neither concern and care nor openness and honesty were directly mentioned.

A number of statements made by participants suggested that they were thinking about the motivation of advisers. For example, one central government decision maker referred to the importance of involving the right people with the "*right expertise and motivation*" (C9). The motivation of advisers may relate to concern and care, for example if a decision maker believes that an adviser is motivated by a concern for biosecurity. This factor fits with 'commitment' as described by Kasperson et al. (1992), who recognised that commitment to a goal such as protecting public health was one dimension of trust related to the location of hazardous waste facilities.

An example where advisers' motivation was perceived in a negative way as a lack of concern is shown by the statement that "*a lot of risk assessors see themselves as scientists so risk assessment feels like a scientific exercise instead of a contribution to solving a real problem*" *(C3)*. By suggesting that risk assessors are not concerned with solving real problems this decision maker implies that they are not concerned with biosecurity.

Statements about bias in advisers may also relate to concern and care. When participants talked about bias in advisers, they often related to the adviser representing a particular viewpoint, whether this was a personal 'risk appetite[37]' or related to an organisation that they were representing. For example, one central government decision maker said "*I kind of think okay, well, are they likely to be thinking about the broader public interest? (C1)".* On the other hand, only one decision maker offered the perspective that they themselves may be biased or lack perspective.

- *I think objectivity is something that you would like to be in everything but the reality is it's not in everything because everyone is reading information from a particular perspective, some are better than others and I'm not one of those. (I7)*

Motivation and bias may also relate to openness and honesty, for example if a decision maker believes that an adviser is concealing their motives. However, we found no evidence that participants were concerned with the openness or honesty of advisers. Statements relating to openness and honesty, or lack of it, were almost entirely absent. Either openness and honesty is not something participants considered to be important in their advisers, or it is so widely accepted that they didn't consider it necessary to discuss it. We consider the second reason more likely – in our experience there are no perceptions that advisers are not honest when doing risk assessments, and any lack of trust relates to other dimensions. While there are no statements from participants that talk directly about how they perceived the honesty of advisers, the following quote gives some indication of their reasoning.

- *I always assume that it's possible that the information I've got is incomplete or incorrect. But I also assume it's the result of best efforts of good people. (C3)*

The degree of scepticism that a number of participants expressed about using information from other countries surprised me. Invasiveness elsewhere is recognised as one of the more reliable factors in predicting invasive species (see for example Grosholz 2018, Seebens et al. 2018, Kulhanek et al. 2011, Williamson 1999). The geographical distribution of species is a fundamental part of many predictive models (Elith and Leathwick 2009). While there are pitfalls in using overseas information, and in developing and using models based on this information (Lake et al. 2020), they remain an important tool to inform risk assessment.

This is not to say that participants dismissed evidence from overseas completely. However, the uncertainty they expressed suggested that this is an area where future research may be useful. Research could consider when and how overseas information is useful, as well as when and how it is not.

Conclusions and future research

The National Science Challenge programme *He Tangata, He Taiao, He Ōhanga*, aims to incorporate information from a holistic set of values into a new biosecurity risk assessment framework, to help inform better biosecurity decisions. This study is the first stage in that programme and describes the current state of decision making based on risk assessment in the biosecurity system. This study aims

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[37] This term was used by some participants in discussion of risk assessment. The International Standards Organisation defines risk appetite as the "*amount and type of risk that an organization is willing to pursue or retain*". In this context, the term 'risk tolerance' may be more appropriate. Risk tolerance is defined as an "*organization's or stakeholder's readiness to bear the risk after risk treatment in order to achieve its objectives*".

to identify gaps in current knowledge and tools, and to help identify the research needed to achieve the programme goals.

The results of this study suggest that there are significant gaps in terms of frameworks and tools that support the consideration of a holistic set of values. In general, the decision makers interviewed for this study were considering a broad range of values, but they were not doing so in a consistent way. A number of them recognised the lack of tools as one of the barriers they faced. They particularly noted a lack of frameworks and tools for considering social and cultural values, but also sometimes struggled with environmental and economic values.

Another gap appeared to be in the area of decision making frameworks more generally. The majority of decision makers in this study did not talk about using formal frameworks or describe their decision process in a structured way. A number of participants were concerned that their organisations weren't using frameworks. However, this didn't necessarily mean that no frameworks were available. Two frameworks developed for biosecurity decisions were in use, and other frameworks developed for biosecurity and other fields are available (see accompanying report for more information on decision making and risk assessment frameworks). Risk assessment frameworks are also available, again some were used but only in specific areas. No frameworks or tools were used across multiple organisations or types of decision.

The limited and inconsistent use of formal frameworks and tools for risk assessment and decision making raises an important question – why are frameworks and tools not being used? Clearly, there are frameworks available, even though they don't adequately address a holistic value set. Are the existing tools too limited in focus to be used more widely than they are at present? Are decision makers waiting for the ideal tool, and not using any while they wait? Or are there other barriers?

The decision makers in this study identified a number of barriers to using frameworks or tools, and these were similar to objections raised to the use of models in conservation. A lack of time, a lack of suitable data and a tendency to prefer advice directly from trusted advisers rather than formal tools were all barriers to implementing frameworks and tools. Frameworks and tools are also unlikely to be used unless those who are intended to use them play a real role in their development.

Many of the decision makers interviewed for this study described their decision process as collaborative. They welcomed the input of the "right people" and those who are able to earn their trust are listened to. On the one hand, this shows that they are open to participatory decision processes. On the other, it creates challenges for those who are "outsiders". Part of the challenge may be to develop frameworks that create opportunities for a more diverse group of participants to build trust with decision makers.

Decisions in biosecurity are often made with limited information and under time constraints. As a result, a number of decision makers in this study highlighted the need to respond to new information and change decisions. Any framework or tool for biosecurity decision making needs to allow for an adaptive process – decision making is not linear.

The reliance that many decision makers placed on intuition raises the question of whether they are relying on skilled intuition or heuristic-based intuition. The development of skilled intuition relies on reliable feedback on the quality of decisions, and the extent to which decision makers in the biosecurity system get this feedback is unclear.

Overall, this study does support the need to incorporate information from a holistic set of values into a new biosecurity risk assessment framework in order to help inform better biosecurity decisions. This conclusion is supported by the accompanying report on risk assessment and decision making frameworks (Newfield 2021), which shows that existing frameworks do not address a holistic set of values in any detailed way.

However, this study also suggests that a new framework may not be used. Most decision makers are not currently using formal frameworks, even though many are available, indicating that there may be some barriers to adoption. From this study, two possible barriers emerged. The first is that existing frameworks may not work with the way that decision makers see their decisions. The second is that decision makers may not trust the existing risk assessment frameworks, or those who have developed them.

In order to overcome the first barrier, any new framework will need to take into account the adaptive nature of biosecurity decision making – that decisions need to be made with imperfect information and revised as new information comes in. It may also be useful if the framework supports a collaborative process.

In order to overcome the second barrier, how a framework is developed may be as important as the content of the framework. Any new framework needs to be developed in a way that builds trust between those developing the framework and those using the framework. Some of this may depend on the knowledge and experience of those developing the framework. It may also relate to the way that decision makers perceive the motivations of those developing the framework.

Areas for future research
- Better documenting social and/ or cultural impacts
  - Although decision makers are expected to account for social and cultural impacts in their decisions, there appears to be relatively little research documenting these impacts for existing pests or invasive species.

- Developing frameworks and tools for assessing impacts
  - There was a lack of frameworks and tools for considering social and cultural values, and in some circumstances environmental and economic values.

- Identifying what makes a good decision in biosecurity
  - Decision makers need feedback on the quality of their decisions, and defining success from a diverse range of biosecurity system participants would improve that feedback

- Better understanding intuition in biosecurity decision making
  - "Intuition" may relate to unstated criteria and reasoning in decision making; documenting this reasoning may improve the transparency of decisions

- Identifying barriers to using frameworks and tools

- This study has identified some of the barriers to using frameworks and tools, but, given the number of unused or little-used frameworks and tools, the problem warrants further attention.

- Developing participatory processes for biosecurity decision making
    - The decision makers in this study welcomed collaboration in their decision making. Creating better opportunities and mechanisms for wider participation would improve the diversity of inputs into the process

- Better understanding when and how to use overseas information in decision making
    - A number of decision makers were uncertain about the extent to which they could rely on information from other countries and other areas to make decisions for their areas.

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Appendices

Appendix 1: Questions used for interviews

What is your role is in the organisation?

What sorts of decisions do you make that require risk assessment input?

What legislation or policy shapes what you consider in making your decisions?

Can you run through your decision-making process for me from start to end – the steps, who is involved and where does risk assessment fit in?

What influence or decision role do you have on the scope, objectives, and timeframe for risk assessments and when? (followup question: How has that worked for you?)

What factors do you consider when making your decision? What values are considered in reaching a decision ?

What other information sources other than risk assessment do you use in coming to your decision? (followup questions: Who do you get that from? What form is it provided to you in?)

How do you make judgements or prioritise these factors?

Are you aware of any decisions that you have made or that others have made that uses mātauranga Māori as an input? (followup question: If so, then can you describe how that process was undertaken – the steps, who was involved and how this information was used).

What risk assessment framework, decision process or guidance do you or those that provide advice to you use? Is it possible to obtain a copy?

Are there any assumptions that you make about the information that is provided to you to use?

What works well and what doesn't work so well in your use of risk assessment in decision-making – what are the challenges?

What are the implications of getting it wrong? What are the benefits of making a good decision?

What do you see as the key things that could be improved to help you make better decisions?

What do you see as the key things that could be improved to provide you with better risk assessments?

What type of uncertainties do you usually face in your decision making? How do you take these uncertainties into account?

When do you know that you have enough information to make a decision? What triggers do you use to decide more is required?

Under what conditions do you escalate decision-making to others above you?

Are you able to measure the success of your decisions? If so, then do you, and how?

Can you give me an example of what you consider to be a good decision that used risk assessment as an input and perhaps one that was not as good. (followup question: What were the factors that led to a successful decision or otherwise in your view?)