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Indigenous peoples' attitudes and social acceptability of invasive species control in New Zealand

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ABSTRACT

Context. In Aotearoa New Zealand, a significant threat to biodiversity, conservation efforts and Indigenous cultural identity is the unwanted introduction of invasive pests, plants and pathogens. Currently methods to control invasive species in Aotearoa New Zealand, in particular mammalian pests (i.e. possums (*Trichosurus vulpecula*)) have had decreasing public support. This has likely come about for a number of reasons, including lack of social engagement and concerns over impacts combined with an increasing distrust of top-down initiatives. **Aims and methods.** We analysed opinions towards existing and emerging technologies to manage invasive species. Data were obtained from 1015 respondents who identified as Indigenous Māori from a national survey of 8199 respondents. Utilising psychological frameworks to investigate underlying beliefs of social acceptance, we analysed the responses using exploratory and latent class analysis methods to summarise the main perspectives. **Key results.** Our results revealed four distinct clusters of viewpoints amongwithin Māori respondents that were explained by known (objective) and subjective scientific knowledge around pest control methods, and Indigenous community wellbeing. We also observed a general neutrality in trust towards science, but more trust in scientists than science institutions. **Conclusions and implications.** Understanding the underlying values and viewpoints associated with pest control and including these in developing engagement plans will ensure a responsible process that empowers Māori. This way forward is key to sustain pathways of engagement and positive participation in decision-making.

Keywords: biodiversity, biosecurity, gene drive, Indigenous values, invasive species, technology uptake, toxins.

Introduction

Increasing pressure from pests and diseases, exacerbated by climate and other anthropogenic changes such as land clearance for agriculture, are adversely affecting global biodiversity. This has resulted in the development by many nations of strategic initiatives designed to provide for more sustainable management of our natural capital. Furthermore, it has been argued (Mills *et al.* 2011) that more comprehensive management approaches should incorporate intuitive and normative responses (e.g. human perspectives) and not just quantitative scientific accounts of disease and biological decline associated with pests and diseases.

One of Aotearoa New Zealand's most recent national plan for managing biodiversity and conservation is the Department of Conservation (2016) New Zealand Biodiversity Action Plan. Along with a conservation program known as Predator Free 2050 (PF2050), they form an integral part of a range of targets and initiatives designed to 'promote the sustainable use and protection of biodiversity through improved national guidance, information and industry background' (Baker *et al.* 2016). The PF2050 initiative is recognised as the world's largest mammal eradication program (Linklater and Steer 2018). Although foreshowing likely failure in achieving a predator free Aotearoa New Zealand by 2050 due to ecological and other uncertainties (e.g. social acceptance of large-scale eradication efforts), commentators such as Norton et al. (2016) have recognised that a 'sea change in public support, political will and financial instruments' will be essential to achieving the desired outcomes of PF2050. The adoption of this attitudinal change across society is difficult to measure. Seeking social license typically involves complex heterogeneous relationships where trust between those relationships is foundational (Edwards and Payn 2017). In the context of pest control technology, it has been suggested that social license, i.e. support for novel pest control technologies, is largely driven by an array of values, attitudes and beliefs held by the public (MacDonald et al. 2017, 2020). Furthermore, these values and beliefs are not homogenous across a population, but instead natural clusters of people emerge (Hine et al. 2014) that share common psychographics that influence their level of support for novel technology. Understanding and identifying the key variables involved that will ensure sustained and wider acceptance of invasive species control e.g. greater involvement of Indigenous communities, is the focus of a wider Aotearoa New Zealand study, of which some of the results will be discussed here (MacDonald et al. 2017, 2020).

Aotearoa New Zealand's bicultural setting began with the relatively recent arrival of Europeans in the late 18th century that caused substantial conflict and upheaval to Indigenous Māori, particularly after the 1840 signing of the Treaty of Waitangi (Whaanga and Wehi 2017). Land was subsequently confiscated and cleared for farming and settlement by Europeans, which resulted in reduced access to culturally significant resources for previous Indigenous owners and an increase in exotic flora and fauna for agriculture and 'acclimatisation' that would change Aotearoa New Zealand's biodiversity permanently. In addition, the European conservation ethic has dominated since the mid 19th century, shutting out Māori views and practices and further alienating them from their land (Star 2003).

As Māori are the second largest land owners after the New Zealand government (Māori Economic Taskforce 2011) it is critical that Indigenous views are reflected in relation to the management of pests and diseases, predators and the technologies used for the control of invasive mammal species control, including other invasive non-mammalian species (e.g. wasps (*Vespula vulgaris*)).

Utilising psychological frameworks to investigate underlying beliefs of social acceptance is not only vital for pest control technology and methods to be realised in Aotearoa New Zealand (Macdonald et al. 2017), but also provides a means to engage with different sociological segments based on these beliefs. Furthermore, Māori have a deep and spiritual connection to the land and the biota that inhabit it (Lambert et al. 2018; Black et al. 2019) and how these values manifests in opinion and eventual decision making towards genetic tools for pest control is unknown. This study is the first of its kind to provide a preliminary investigation of these issues as we explore potential drivers in Māori values, beliefs and attitudes and how these may influence opinions towards new and current technologies for pest control.

Methodology

Survey design

The current study was based on a New Zealand-wide sample (n = 8199 in total; self-identified Māori, n = 1015) (MacDonald et al. 2020). The survey was conducted online and drew from two panels – the Colmar Brunton© Panel and the SSI Panel. Interviewing targets were calculated using the most recent (2013) census and included ages within gender within sub-region, as well as ethnicity within sub-region. A Likert scale was used to calculate each of the survey variables. This scale is a psychometric scale commonly involved in research that employs questionnaires. It is the most widely used approach to scaling responses in survey research, such that the term is often used interchangeably with rating scale (Hensher et al. 2005). The survey adhered to ISO 20252:2012 certification and the project adhered to Research Association of New Zealand's Code of Practice; all responses were confidential. A full description of the survey questions for both Māori and non-Māori participants is given in MacDonald et al. (2020).

Explanatory variables

Briefly, to develop a segmentation model that explains attitudes towards novel pest control technology, theoretical and empirical insights were gathered from the literature on environment, new technology, science, invasive species and selected constructs that may influence the way people perceive novel technology and pest management. The attitudinal scales formed from the literature covered New Ecological Paradigm, which consisted of 15 questions e.g. *when humans interfere with nature it has disastrous consequences, on a scale from 1 (strongly disagree) to 7 (strongly agree)* (Dunlap et al. 2000); New Zealand Pest Management scale and attitudes towards current pest control methods, which was measured by nine questions e.g. *pest species are a significant conservation problem, on a scale from 1 (strongly disagree) to 7 (strongly agree)* (Aley 2016). Environmental behaviours and behaviours towards conservation of biodiversity were included as there is occasionally a gap between attitudes and behaviours, e.g. *participants rating six activities, composting organic waste on a scale of 1 (every week) to 7 (never)*. Scientific knowledge is based on the assumption that a well-informed, scientifically literate population is more accepting of science based policy. However, the link between knowledge and support in scientific issues or policy can be tenuous and dependent on the topic and can be easily influenced by other variables as seen with climate change (Zia and Todd 2010). Given the technologies proposed for pest management we wanted to explore the relationship between the different types of western-based science knowledge (science literacy, pest-specific knowledge, subjective knowledge) and the level of public support for the technologies. Trust, which is key to gaining public support of policy, was measured via trust in science and trust in organisations e.g. *today's scientists will sacrifice the well-being of others to advance their research, on a scale from 1 (strongly disagree) to 7 (strongly agree)* (Nadelson and Hardy 2015). The last two variables that were measured were 'values' that can inform attitudes and guide behaviour and this was examined using the personal-values questionnaire (PVQ); and socio-political views, which is how individuals perceive the social structure of society. Socio-political views have been effective in explaining attitudes towards the environment as well as novel technologies (Stanley and Wilson 2019).

Specific variables for Māori participants

In addition to the broader survey questions as described above, Māori participants were queried as to the degree to which selected variables influence their decisions regarding conservation management. These included: Whanau (family) wellbeing; Principles of the Treaty of Waitangi (New Zealand's founding document for partnership between the Indigenous Māori and the British Sovereignty); Māori Tikanga (protocols), such as manaakitanga [hosting of visitors and guests]; Iwi Tikanga (tribal protocols); and non-Māori specific variables including 'Broader wellbeing of my society' and financial considerations.

Measuring levels of support for pest control and importance of cultural factors in decision making

We used choice modelling to investigate opinion towards several attributes. Choice modelling is a widely accepted method in evaluating multiple respondent opinion towards several attributes (Hanley *et al.* 2001). Hensher *et al.* (2005) states that the behavioural rules linking utility and choice can be used to develop a formal model of choice, where sources of individual preferences (i.e. attributes) can be assessed against constraints on such preferences and the available set of alternatives to choose from. We express these using utility scores which are designed to predict the amount of (relative) utility a decision maker assigns to each of the alternatives, and are indicative as to which of the alternatives are most likely to be chosen. This approach is in concert with the Marley (1968) concept of establishing various connections *via* ranking probabilities between simple choice and ranking behaviour. In our study, these were: target species (i.e. wasps (*V. vulgaris* and *V. germanica*); rats (*Rattus norvegicus*); and stoats (*Mustela erminea*)), method (gene drive, trojan female, species specific toxin), outcome (death or infertility) and delivery method (aerial or ground).

Latent Class Analysis (LCA) (Long and Freese 2014) was used to identify membership of unobserved, or latent subgroups within the survey population based on individual responses from the multivariate data. In a LCA if two or more variables are highly correlated there is potential for it to be a consequence of a latent variable that is causing the relationship between the variables, in a manner such as described by McMurray *et al.* (2004). Undertaking cluster analysis assisted in the identification of groups having similar variables or patterns (Manly and Alberto 2016), using the values of the variables to provide a schematic for their grouping into similar classes. In order to determine that four classes was the optimal number of classes for this study, the Information Criteria indices (AIC, BIC) were reviewed. The class models are thus able to categorise individuals into clusters as indicated by their R-squared (correlation coefficient) values. Selecting individuals into clusters as indicated by the R-squared values is in accord with Veal (2005).

Statistical analyses of survey data

Statistical analyses were performed using XLSTAT (Microsoft Excel™). Exploratory data analysis was used as a first approach to analysing the datasets to identify and summarise the main trends. This allowed the topic to be explored as an intermediate step that informed subsequent analysis. Average scores from the Likert scales were calculated for each of variables listed in the Supplementary Table S1 available at the journal website. We justified the use of parametric statistics to describe the Likert data because of the relatively large sample size and normal distribution of the data.

Ethical approval for human participants

A representative sample of New Zealanders (including 1015 that identified as Indigenous Māori) was surveyed using the online Colmar Brunton Panel™ which adheres to ISO 20252:2012 certification and the project adhered to the Research Association of New Zealand's code of practice; all responses were confidential. Respondents received points for each survey they completed which are redeemed against goods or services. Participants consented to the survey and were only awarded points for completing the entire survey and responding to all questions; thus, there were no missing data.

Results

Latent class and cluster analyses reveal four distinct groups within the population

The results from the LCA and CA, using the behavioural variables listed below along with the Māori-only variables such as language and traditional knowledge improved the ability of the model to accurately predict cluster assignment (*R*-squared = 0.815) and allowed us to see that patterns of worldviews and behaviours group into four distinct clusters (Fig. 1, Table 1).

While not a focus of this survey, in general, Māori are more concerned by plant diseases (for example, kauri (*Agathis australis*) disease caused by *Phytophthora agathidicida* and myrtle rust (*Austropuccinia psidii*) affecting many of the native myrtle species belonging to the family Myrtaceae) compared to animal pests (which were the focus of this study). Animal pests prioritised from a conservation threat perspective were: stoats (*M. erminea*), rats (*Rattus* spp.), possums (*T. vulpecula*), cats (*Felis catus*) and wasps (*V. vulgaris* and *V. germanica*). Concern about deer was the lowest of all. In terms of 'Pest Specific Objective Knowledge', most respondents scored highly, although the distribution for all respondents is unevenly distributed. Most respondents scored moderately for 'Pest Subjective Knowledge'. Results in this study show that Māori perceive themselves as knowing more about pest control than is indicated by the objective measure. This was similarly found in other non-Māori respondents. The moderately high subjective knowledge, but the slightly lower objective knowledge, may result in a greater perceived risk of novel technologies.

Cluster 1 comprises 30% of the respondents and participants have the key characteristics of being much more likely to have Pest Specific Objective Science Knowledge and they are more likely to score highly for Objective Science Knowledge, Subjective Pest Control Knowledge and Pest Control Specific New Ecological Paradigm.

Cluster 2, similarly to cluster 1, comprises 30% of the respondents and has the identifying characteristics of people scoring highly for Pest Specific Objective Science Knowledge and to a lesser degree Objective Science Knowledge and Subjective Pest Control Knowledge than respondents in clusters 3 and 4, but not as high as in cluster 1.

Cluster 3 comprises a quarter of respondents and is very similar to cluster 2 except the respondents of cluster 3 are more likely to have lower Pest Specific Objective Science Knowledge than for clusters 1 and 2.

Cluster 4 contains 12% of the respondents and one key feature in this cluster is that respondents are more likely to score lowly for New Ecological Paradigm. In general individuals in this cluster have lower levels of scientific knowledge. Low scores are likely for Objective Science Knowledge, Pest Specific Objective Science Knowledge, Subjective Pest Control Knowledge and Pest Control Specific New Ecological Paradigm. Scores for General System Justification, Social Dominance from the PVQ and Trust in Organisations are typically higher scoring on the Likert scale.

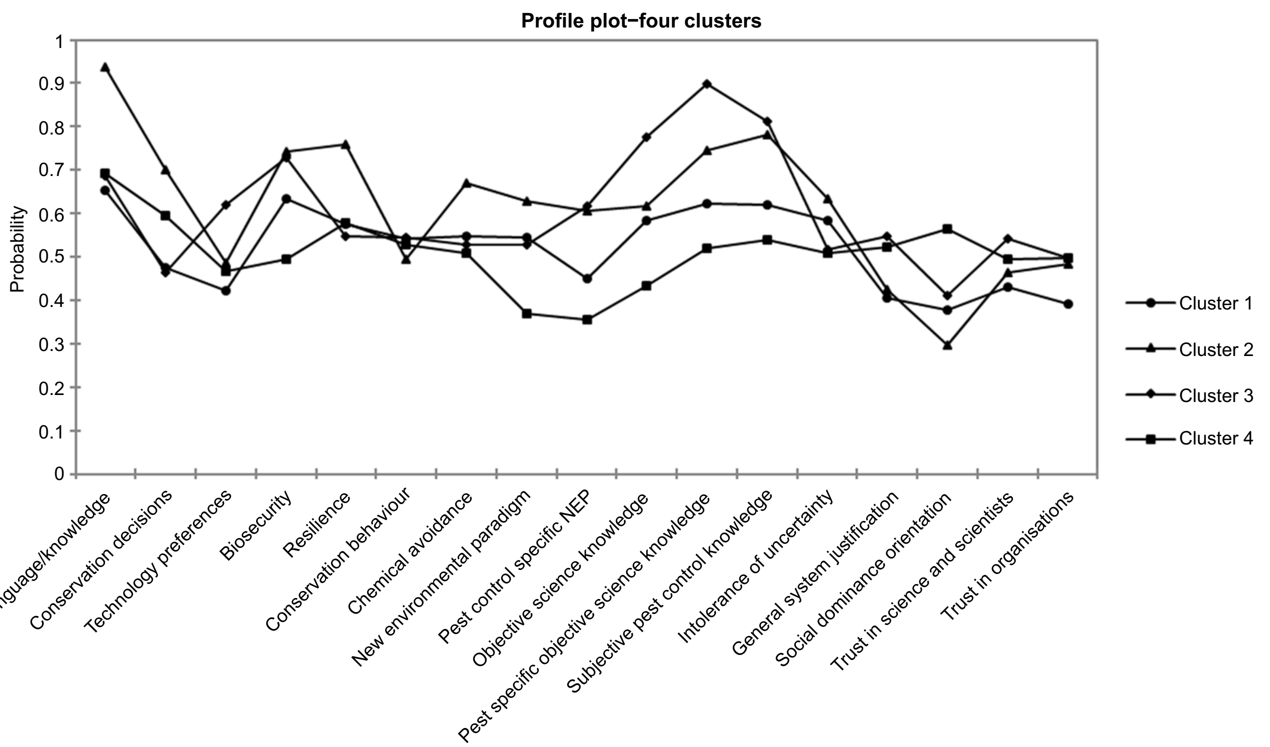

Fig. 1. Cluster analysis of Māori participants using the 12 behavioural questions and five Māori culture specific questions (*R*-squared = 0.815, *n* = 1015).

Table 1. Latent class analysis for Māori participants based on the Likert scale (scale of (1) very much like me to (6) not like me at all).

Profile (means)				
Variables	**Cluster 1**	**Cluster 2**	**Cluster 3**	**Cluster 4**
Conservation behaviour	4.54	4.43	4.48	4.44
New ecological paradigm	5.19	5.20	5.14	4.33
Chemical avoidance	4.63	4.34	4.37	4.02
Trust in science	3.77	3.99	3.83	3.97
Objective science knowledge	3.73	4.32	3.38	2.33
Pest specific objective science knowledge	3.00	4.00	1.66	1.63
Subjective pest control knowledge	4.05	4.23	3.75	3.18
Pest control specific new ecological paradigm	4.84	5.10	4.68	4.12
Intolerance of uncertainty	4.88	4.82	4.99	4.38
General system justification	3.59	3.82	3.53	3.98
Social dominance	2.91	2.90	2.82	3.97
Trust in organisations	3.69	3.87	3.71	3.94

Centred scores were used to calculate the mean. An explanation of each personal value follows in a narrative provided in the supporting information. Results for questions directed at Māori participants only are shown in Table 4.

Biosecurity and its importance to Māori

A majority of Māori respondents felt quite strongly about Biosecurity (mean = 5.24). In general respondents thought it was important to keep New Zealand free from new pests and diseases and that biosecurity was important to the New Zealand export industry (Table 2).

Māori cultural factors influence pest management views

The most important factors underpinning attitudes and decisions were extended family wellbeing and the broader wellbeing of society (mean 5.40 and 5.20 respectively; Table 3). Less important factors were Māori Tikanga (individual) protocols (generally defined), Iwi Tikanga (tribal) protocols and financial considerations; whilst the Treaty of Waitangi was the least important factor being considered by Māori participants (mean 4.55).

Table 2. Understanding of biosecurity and importance, $n = 1015$.

Variable	Mean (s.e.m.)
I am knowledgeable about biosecurity	4.03 (0.05)
Biosecurity is a government priority	5.37 (0.04)
It is important to keep New Zealand free from new pests and diseases	6.29 (0.03)
Biosecurity is a separate issue from conservation	4.32 (0.06)
Biosecurity is important to New Zealand's export industry	6.03 (0.04)
I have an important role in making sure pests and diseases do not get into New Zealand	5.02 (0.05)
I have an important role if pests and diseases do get into New Zealand	5.22 (0.05)
Biosecurity is important to me	5.65 (0.04)

Responses to pest control methods

Most respondents scored moderately for Pest Control Attitudes (Table 4). For this variable, Māori in general were least comfortable with poison delivery *via* aerial release (mean 2.25), with the most favourable method being hunting and the use of Trojan females, 4.13 and 4.20 respectively). However, the mean responses received for both gene drive and trojan female were explained by the significant number of do not know responses, rather than reflecting a lack of concern about the method used. The mean response for each of the questions relating to this variable are listed in Table 4.

Individual preferences and constraints towards target mammal pest species

Sources of individual preferences (i.e. attitudes towards conservation target pest mammal species (i.e. wasps, rats and stoats)) along with eradication delivery methods assessed against constraints on such preferences and the available set of alternatives is expressed by means of utility scores as summarised in Fig. 2. This data establishes various connections *via* ranking probabilities between simple choice and ranking behaviour. The scores predict the amount of (relative) utility each decision maker assigns to each of the alternatives, and are indicative as to which of the alternatives are most likely to be chosen. In this survey, participants assigned the highest probability to ground control methods (0.83) compared with the lowest probability of being selected which was aerial control (−0.83). Rats were the

Table 3. Factors influencing attitudes towards pest control, $n = 1015$.

Variable	Mean (s.e.m.)
Principles of The Treaty of Waitangi	4.55 (0.05)
Financial considerations	4.62 (0.05)
Iwi Tikanga (tribal) protocols	4.73 (0.06)
Māori Tikanga (individual) protocols	4.81 (0.06)
Broader wellbeing of my society	5.25 (0.05)
Extended family wellbeing	5.46 (0.05)

The Likert scale used to derive responses adopted a continuum of between 1 and 7, where 1 = no influence at all; 4 = moderate influence, and 7 = completely influences.

Table 4. Mean responses of pest control attitudes of Māori participants, $n = 1015$.

Control methods	Mean (s.e.m.)
Poison bait spread by aircraft	2.30 (0.04)
	2.10 (n = 974, 0.04)
Genetic editing most offspring male	3.00 (0.05)
	2.60 (n = 897, 0.04)
Selective breeding infertile males	3.20 (0.05)
	2.90 (n = 909, 0.04)
Poison bait laid by hand	3.30 (0.04)
	3.20 (n = 976, 0.04)
Toxin species – specific	3.40 (0.04)
	3.20 (n = 936, 0.04)
Gene drive	3.80 (0.06)
	2.70 (n = 673, 0.05)
Trapping	(0.03)
	3.90 (n = 979, 0.03)
Hunting	4.10 (0.03)
	4.10 (n = 987, 0.03)
Trojan female	4.20 (0.06)
	3.00 (n = 596, 0.05)

The Likert scale used to derive responses adopted a continuum of between 0 and 6 where 1 = 'should never be used under any circumstances'; 5 = 'I have no concerns at all about this method'; 6 = do not know. The row below the reported mean and s.e.m. for each method is for a reduced Likert scale of between 1 and 5 that removes the 'do not knows'.

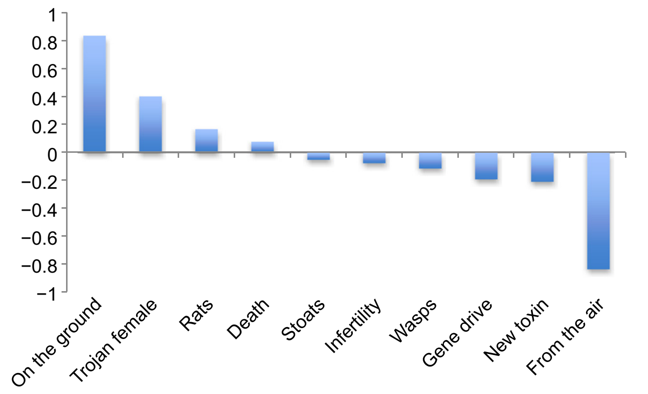

Fig. 2. Mean utility scores of preference towards target species e.g. rats (*R. norvegicus*), and methods of control e.g. ground methods such as trapping, $n = 1015$.

preferred pest species of targeted control (0.16), with wasps the least preferred (−0.11).

Discussion

This study was run in parallel with MacDonald *et al.* (2020), which reported on New Zealand publics' acceptance of gene drive approaches to pest management. This was in part a response to a declining support for the use of the vertebrate poison sodium fluroacetate, and alternatives have been sought that may be more acceptable as well as effective. This specific issue is a subset of a much wider discourse around the management of pests and pathogens in New Zealand. Moreover, the population in New Zealand is an interesting case to study as there are deeply entrenched environmental beliefs, strong conservation identity and an Indigenous population that relies on both the control of, and exploitation of, introduced mammals for cultural identity and community wellbeing (Robb *et al.* 2015; Russell *et al.* 2015; Bataille *et al.* 2020). Furthermore, the Indigenous Māori population has been asserting roles within associated science and policy networks, and in particular the inclusion of their traditional ecological understanding. Such knowledge can be seen as part of the resistance to colonisation that includes protest, treaty making, political and economic empowerment, legislation, cultural renaissance and regulatory influence (Lambert *et al.* 2018). In New Zealand, these achievements inform attempts by Māori to manage forest ecosystems and cultural keystone species. This movement is part of a more global trend towards community-led conservation, and one that places Indigenous communities at the centre (Palmer *et al.* 2020; Fabre *et al.* 2021). Moreover, recent research has demonstrated that employing good governance processes and managing social impacts may be more important than ecological effectiveness for maintaining local support for conservation (Bennett *et al.* 2021).

The parallel examination of the much larger (9000 vs 1000) non-Māori survey described in MacDonald *et al.* (2020) made two key findings, (1) that solely providing facts about emerging and currently used pest control methods had a counter-productive effect that polarised communities and societal views, (2) worldviews explained opinion towards emerging technologies and currently used methods of pest management, confirming that decision making is mostly based on underlying values and heuristics.

Our examination of the Māori survey data revealed four diverse and distinct clusters that are best defined by decreasing levels of western-based science knowledge and environmental attitudes as measured by the New Ecological Paradigm, and decreasing trust in organisations. The responses of each were not normally distributed, reflecting the polarised responses to pest control among the Māori participants and their underlying worldviews. Overall, the data shows that in the PVQ results Māori participants scored higher on the themes of Tradition, Power, Universalism and Self-Direction while scoring lower on measures of Conformity, Stimulation and Security than the general survey population as reported in MacDonald *et al.* (2020). The difference between the populations potentially reveals a greater desire for social equality and a more wholistic viewpoint of the environment to include people in conservation models. This worldview difference between Indigenous communities and western-based societies has been observed when conservation management strategies are developed (Díaz *et al.* 2018; Lambert *et al.* 2018; Bataille *et al.* 2020). On the whole the results in this study and MacDonald *et al.* (2020) suggest that both populations surveyed sit at the upper-middle range of New Ecological Paradigm scores, reflecting a predominantly eco-centric orientation (a commitment to the preservation of natural resources). Moreover, Māori expressed a greater sense of connection to the natural environment, and viewed human behaviour as contributing positively to ecosystem health and playing a key role for maintaining the balance of nature. However, one disadvantage with using the New Ecological Paradigm for Indigenous peoples is that it is based on traditional values and beliefs prevalent in Western societies that prioritise human welfare at the expense of nature, largely for economic gains. Māori traditional worldviews (for the proportion of Māori respondents that identify with these) may thus produce a different pattern of scoring for this variable, which may make the measure less meaningful or relevant. One way this could be tested is by comparing differences of Māori for subscales of anti-anthropocentrism and anti-exemptionalism (which denote fundamental beliefs about how humans are connected to the land/nature) and then comparing the relationship to other variables.

Trust in science

Trust in science, scientists and organisations are key in the pathway of the adoption of technology. Māori respondents predominantly scored moderately for 'Trust in Science'; this response was somewhat less 'trusting' than non-Māori participants (MacDonald *et al.* 2020). The reasons behind this finding could be many, but one potential explanation may lie in differences of foundational beliefs behind science. Studies have found greater religiosity, or more appropriately, spirituality as being more likely the case for Māori, which is negatively associated with trust in science and scientists (Turbott 1996; Nadelson and Hardy 2015). However, with Māori participants, there was greater trust for scientists than in all the other vocations. Local councillors, business leaders, government agencies and elected officials were relatively well trusted, followed by Māori Tribal leaders, news media journalists and least of all Mainstream Christianity based religious leaders. Another explanation of this lower level of trust compared with non-Māori participants might be from the point of view of science as a current authority figure as an institution/organisation rather than the scientists themselves. Lower levels of trust could perhaps be more reflective of a distrust or a dissatisfaction with the current authoritative order in society rather than anything to do with a distrust in the methods of science. However, when looking at the Trust in Organisations variable, Māori nevertheless had greatest trust in science than all other organisations (i.e. compared to elected officials, journalists, religious leaders, business leaders, government agencies, local councils and Māori Tribal leaders). This contradictory finding however could be explained by an underlying bimodal distribution for the Māori population subsample or the bidimensional nature of the measure used in the surveying (i.e. the two factors of trust in science and trust in scientists) that may differ.

Knowledge and uncertainty

Subjective and objective knowledge result in risks that can be both negative and beneficial to the individual (Zhang and Lui 2015) and the discrepancy between the two can lead to very different levels of perceived risks around new technology. For example, in the absence of objective science specific knowledge, subjective knowledge can increase some types of perceived risk of genetically modified food products (Klerck and Sweeney 2007). However, the presence of objective science knowledge has been associated with an increased willingness to buy genetically modified foods and reduced perceived risk in health. In our study we found that participants perceive themselves as knowing more about pest control than was indicated by the objective measure, with the results suggesting a bimodal distribution. This finding was similarly reflected in the general survey (MacDonald *et al.* 2020). This moderately high subjective knowledge and lower objective knowledge may result in a greater perceived risk of novel technologies. As this is the first kind of variable measured, adapted for pest management, there is no previous data to compare changes, or conclude relationships between objective and subjective pest specific knowledge.

Māori have a relatively high acceptance of uncertainty, or lower intolerance of uncertainty with majority of the population falling on the 'neither agree nor disagree' to 'somewhat agree' spectrum suggesting that, for the most part, they are reasonably accepting of uncertainty (though not with extreme high scores). However, it seems evident that Māori may be more avoidant of uncertainty. It could also suggest that Māori may be, to a slight extent, reasonably sceptical of new technologies potentially due to a greater perceived risk. There also could be a potential low-level interplay between the degree of trust that Māori have for scientific endeavours and accompanying technologies, mediating the relationship between uncertainty avoidance and perceptions of novel technologies. In other words, due to a lack of trust, uncertainty avoidance may be a coping mechanism in decision making. However, it needs to be recognised that this research is largely based on the concept of uncertainty avoidance and not intolerance to uncertainty, which are metrics used at two different levels. Thus, these interpretations should be viewed with a degree of caution.

Values and worldviews

Māori participants leaned towards a greater desire of societal change (within New Zealand specifically) compared to non-Māori participants (MacDonald *et al.* 2020). This is supported by the lower scores of security and conformity, both of which relate to the dimension of 'conservation' or the preserving of societal norms, and by the higher scores of 'System'. Very few respondents have very low or very high scores, indicative of lack of strong opinion either in agreement or disagreement with the propositions presented. Māori respondents scored moderately for General System Justification, which gives a measure for the tendency of a person(s) to defend the current status. This shows that, on the whole, Māori respondents had moderate rates of system justification (though there was notable variability on this metric), with most falling around the neutral to slightly disagreeing points on the spectrum, suggesting a slight trend towards challenging the status quo. Māori have a tendency for slightly lower scores of system justification indicating a slightly stronger desire for societal change, which, in conjunction with the lower Social Dominance Orientation scores, suggests that this change should be in the direction of greater equality between social groups. In our survey, most respondents scored moderately for Social Dominance Orientation, reflecting support for more egalitarian, rather than hierarchical, ways of living, and little support for dominance of some groups over others. Indications are that Māori place less value on enhancing some group status and power over others, consistent with their higher scores on universalisms (i.e. the value of equality for all people). Thus, it may be the case that Māori may be less politically or economically conservative in their views, and, conversely, may also be more open to equal inter-group relations. Some caution needs to be taken with these results as it is possible that this measure is reaching 'celling' effects (i.e. many extreme scores may be observed in the disagreeing to strongly disagreeing direction) that are skewing the overall results.

The aim of this study was to understand the drivers that shape Māori attitudes and social acceptability of invasive species control in New Zealand. The results provide the direction for progressing biosecurity and conservation methods to be more inclusive and focused towards achieving pest control and conservation goals. This also has implications for organisations and communities navigating diverse attitudes and aspirations for conservation and pest management. Indigenous peoples' decision making is based on values that differ from those of the non-Indigenous population. This distinction needs to be appropriately captured if people are to achieve greater social equality and conservation outcomes (Bennett *et al.* 2017).

Conclusions

Overall Māori feel very strongly about biosecurity and acknowledge its criticality in keeping New Zealand free from pests, diseases and predators, as well as its importance to the country's export industry. Our findings revealed a general neutrality in trust towards science, but more trust in scientists than science institutions. This is potentially due to differences of foundational beliefs behind science; the nature of current authoritative institutional order; and possibly, connections with religiosity and its associated negative impact towards development of trust in science and scientists. However, a greater level of trust is shown in science organisations as compared to religious institutions, governmental institutions and also Tribal leaders. These findings have been insightful to progress to further testing and validation of acceptability and cultural drivers of technology uptake to manage pests and diseases. The neutrality that tends towards a more positive outlook on science coupled with the high proportion of respondents who selected 'do not know', indicate there is potential for people to be persuaded with good engagement.

We also observed that Māori, as with the other non-Māori respondents in the wider survey, have a higher level of perceived knowledge compared to actual knowledge, although there are differences between objective and subjective knowledge bases for each group. Nonetheless there is a relatively high level of willingness to engage in conservation and eco-friendly behaviours and Māori are more willing than not to embrace new or novel technologies. The main influences for Māori decision making appears to be broader well-being of the society and whanau well-being, as well as traditional customs and values. These feature very significantly as factors affecting decision making with regards to environmental protection. Other considerations (e.g. financial factors, and Treaty of Waitangi principles) were less significant but appear to feature reasonably strongly in considerations. Our main goal of this study was to establish a baseline understanding of Māori opinions and values that underpin decision making regarding pest and disease management. Understanding the values and perceptions towards methods and technologies may help reduce conflict in future engagement and management decisions.

Glossary of Māori terms

Hapū = Sub-tribal group
Iwi = Larger, tribal group
Kaitiaki = Environmental guardian, trustee
Mātauranga = Modern term representing the corpus of intellectual knowledge or wisdom, both historic and contemporary, a term often associated with Māori
Tikanga = Appropriate cultural practices, protocols and customs
Tangata whenua = Local Indigenous Māori people
Te Ao Māori = Māori world-view
Whakapapa = A holistic ecosystem paradigm involving the interconnection and relationships between physical and metaphysical objects. In its simplest form this might refer, for example, to genealogy
Whānau = Extended family group

Supplementary material

Supplementary material is available online.

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Data availability. The raw data can be viewed upon request and this will be assessed in accordance with our human ethics agreement.

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