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A systematic literature review of attitudes to pest control methods in New Zealand

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Project

This systematic literature review on attitudes to pest control methods in New Zealand has been funded as part of New Zealand's Biological Heritage National Science Challenge (NZBHNSC) Programme 2: Reducing risks and threats. The review meets milestones 1.1 and 2.1 in the contestable-funded Challenge Project 2.6: Exploring New Zealand's social licence towards novel pest control technologies.

Objectives

The aim of this report is to systematically document and analyse the literature on attitudes towards pest control in New Zealand. The review uses a rigorous, repeatable, and updateable systematic review methodology to determine what we currently know about the public perceptions of pest control. The review uses a population-intervention-comparator-outcome context (PICOC) framework to assess the current range of pest control approaches, the pest species targeted, the ways in which the public have been characterised, and how public attitudes have been reported over time.

Methods

A comprehensive, systematic literature review with a specifically defined protocol is used to scope, search, source, critically appraise, synthesise, and analyse academic and grey literature. The purpose of the review is to reduce reviewer bias and to increase transparency. Inclusion and exclusion criteria, and key terms and qualifiers, were used to determine which articles were included in the review. The excluded articles and why they were excluded are tabled in Appendix B.

Findings and synthesis

The literature search of title and abstract resulted in the initial identification of 91 articles using the key terms and qualifiers. After applying the inclusion/exclusion criteria, 28 articles were identified for further synthesis and analysis. These articles were synthesised according to themes relating to pest species and control methods; scale, localities and organisations; and how the attitudes to pest control had been reported by the authors.

A wide range of pest species and pest control methods have been targeted when carrying out surveys of public attitudes to pest control over the last 26 years. Specific studies of public attitudes to possums, rabbits, and stoats have also been conducted using pest control methods such as aerial 1080, biological control, and biotechnology. While rats, wasps, feral cats and hedgehogs are significant pests in New Zealand; very little social research has been carried out on these species.

Eighteen different pest management tools were identified from the articles included in this literature review. Existing or commonly used pest control methods such as shooting, trapping and poisons were generally preferred by the public over novel or new technologies. However, of these lethal control methods, poisons are the least preferred method. Rationales for preferring existing methods over new technologies include uncertainty or perceived risks associated with not knowing future impacts.

Nineteen of the included articles carried out their research at the national scale using surveys or focus groups, with eight at the regional scale, and only one study carried out locally. Interviews, focus groups, and surveys were commonly used to elicit data, and two studies also held huis. The Department of Conservation (DOC) was identified as being a key organisation responsible for managing or controlling introduced pests by the majority of respondents from wildlife surveys.

The findings have shown that there is not one public but multiple publics with a wide range of attitudes to existing novel pest control technologies.

The majority of articles consider linked social, ecological and health considerations as major drivers of risk. Economic, cultural, and political perceptions of risk relating to pest management are not widely considered in attitudinal research. Trust and community participation are also used to frame research in several cases.

Discussion and conclusions

This systematic literature review shows that while there are a range of perceived risks and different levels of acceptability depending on the pest species being targeted and the control method being used, there is a need to broaden attitude research further to investigate a wider range of pests and control tools. Criteria that have become synonymous with attitudinal research on invasive pests and their control in New Zealand include: humaneness; safety for humans and non-target species; specificity to the target species; effective control of the target species; cost efficiency; generation of additional benefits; tested or well researched and proven control; and no visible death (Wilkinson & Fitzgerald 2014). However, these criteria need to be supported with good communication, trustworthy science, rigorous and robust decision-making processes, and inclusive consultation with local communities.

To secure social license for further scientific advances in novel methods of invasive pest control, social research must be integrated spatially at the local, regional and national scales and within a broader context of social acceptability and change. Social complexities exist for the ethics and philosophy of new or novel technologies, and the public attitude research is yet to be elevated to this level. For new biotechnologies to be socially acceptable, ‘social licence to operate’ needs early and continuous engagement of the science community with society at all levels and in all areas (Gluckman 2016).

This systematic literature review has enabled the relevant articles on public attitudes to New Zealand pest controls methods to be identified, analysed and synthesised. Fear of the unknown is unproductive and will not lead to new advancements to control New Zealand’s

major pests. Ultimately, New Zealand society will decide which pest control technologies are acceptable or not.

Recommendations

Novel technologies for pest control are being developed in New Zealand but without public acceptance they may be met with strong opposition by the public. Next steps could include:

- Research on the social acceptance of novel technologies for the control of a wider group of pests including both vertebrates and invertebrates e.g. wasps, rats, feral cats and hedgehogs.
- Attitudinal research on invasive pests at different spatial scales, particularly at the local scale but also exploring the concepts and politics of 'a sense of place'.
- Ethical and philosophical research on the social complexities of novel technologies.

There is a gap in the literature on public attitudes to invasive plants or weeds and their control which should be investigated from a societal perspective.

The majority of research in this review has focused on the attitudes of adults to pest control methods but there is a need to understand the attitudes of young adults as well – especially with the PFNZ long-term goal of eliminating eight introduced mammalian predators throughout New Zealand by 2050 (Russell et al. 2015).

Key words

Attitudes to pest control; New Zealand; novel technologies; biotechnology; aerial 1080, biological control; invasive species; systematic literature review; social licence.

1 Introduction

New Zealand's ecosystems and economy are under increasing pressure from terrestrial and aquatic pests, weeds and diseases (Goldson et al. 2015). They threaten land, fresh water and marine systems through competition, predation, disease, and by altering landscapes, habitats and biophysical processes (Ministry for the Environment & Department of Conservation, 2017). In addition, these threats will increase significantly over the next twenty years due to increased international travel, tourism and trade, changing global distributions of pests, a changing climate, and other accumulating environmental pressures (Ministry for the Environment & Department of Conservation, 2017).

While the public generally accepts the need to control vertebrate pests in New Zealand (Fitzgerald, Fitzgerald, & Wilkinson, 2005; Fitzgerald, Wilkinson, & Saunders, 2000), concerns about the continued use of non-selective poisons for managing invasive wildlife and animal welfare issues have highlighted the need for alternative novel pest control methodologies (Duckworth et al. 2006). However, public acceptance of new or novel technologies to control pest species in New Zealand varies widely and often these technologies are perceived as being risky (Fitzgerald et al. 2000). The ability to implement these new technologies is dependent on the attitudes of the public to them.

2 Background

This systematic literature review provides an empirical and theoretical context for further research on the social acceptability of novel technologies for pest control in New Zealand. The review focuses on attitudes to pest control methods identified in the New Zealand literature, and informs Research Aim 2 of New Zealand's Biological Heritage National Science Challenge (NZBHNSC): Reducing risks and threat. It uses reproducible, methodological strategies to select, critically appraise, synthesise, and analyse the data. This process reduces reviewer bias and increases transparency to help inform future research directions and to identify gaps in the literature (Berrang-Ford et al. 2015).

A review protocol outlining the scope of the review, the research strategy, the appraisal and inclusion/exclusion criteria, synthesis or data extraction methodology and analysis, critical reflection, and timeframe is used to ensure transparency and reproducibility. The systematic review protocol has three main functions:

- To protect against bias by clearly describing the methods to be used before carrying out the literature review hence making it reproducible in the future
- To provide guidance on conducting the review according to the prescribed methodology
- To make a statement of intent with regards to the topic being reviewed (Khan, ter Rief, Glanville, Sowden, & Kleijnen, 2001).

Focused research questions and explicit search strategies are used in this review along with stated inclusion and exclusion criteria to eliminate selection bias.

3 Objectives

The overall aim of the review is to provide a reproducible synthesis of the literature on attitudes to pest control methods in New Zealand using a systematic literature review process.

3.1 Research Questions

There is one over-arching research question in this systematic review that is supported with three additional queries, broken into a series of more focused questions:

What research has been conducted on public attitudes to pest control in New Zealand?

a) What pest control approaches were researched?
   - What pest species were targeted?

b) What attitudes to pest control were reported?
   - How were the attitudes categorised?
   - What arguments were presented?

c) How has the public of pest control been characterised in the past?
   - What scale was used – local, regional, national?
   - What localities were researched?
   - What organisations were involved?

4 Methods

4.1 The scope of the review

Different frameworks can be used to assist with defining the scope of systematic reviews. A PICOC (Population**,** Intervention/Exposure, Comparison, Outcome, Context) framework provides the parameters for this systematic literature review (Bilotta et al. 2014; (Booth, Sutton, & Papaioannou, 2016). The parameters of the review are listed below:

Population: All New Zealand pest control stakeholders including Maori and the New Zealand general public;
Intervention: Pest control approaches used in New Zealand;
Comparison: Social impact of using different pest control methodologies in New Zealand;
Outcomes: Social acceptance (social license to operate) of different pest control approaches; and
Context: The primary focus is in New Zealand.

4.2 The search strategy

Table 1 shows the five stages of the review (Booth et al., 2016). An initial scoping search of the literature on Web of Science informed the key search terms and enabled the development of a search strategy. A comprehensive, systematic search of the academic and grey literature, and reference citations from this literature, was then carried out with detailed documentation of each step.

Table 1 Five stages for carrying out a systematic review of literature (adapted from Booth et al. 2016)

Stage	Description	Strategy
1	Initial scoping search of the literature	Familiarise yourself with the topic and volume of literature on select databases
		Identify key search terms
2	Conduct search	Search databases using identified search terms
		Search grey literature
		Document any modifications
3	Bibliography search	Search the reference lists and bibliographies of all relevant retrieved papers for additional studies and influential authors
		Identify any key citations and use this study to source new material and repeat this process (snowballing) for additional searches
4	Verification	Contact experts to verify all relevant papers have been retrieved
5	Documentation	Record details of sources searched, search strategies used and number of references found for each method of searching

4.2.1 Literature sources

Peer reviewed articles were extracted from Web of Science (WOS) core collection, Scopus, New Zealand Science, and Academic Search Complete (EBSCO). Grey literature was sourced by searching databases from the Department of Conservation (DOC), Parliamentary Commissioner for the Environment (PCE), Auckland Council websites (technical reports), and the Landcare Research Digital Library. Relevant New Zealand university theses were identified using an open access database nzresearch.org.nz.

Database tools such as thesaurus searching, free-text searching, Boolean operators and applying limits to extracted publications assisted with refining the database searches.

4.2.2 Inclusion and Exclusion Criteria

This systematic literature review was tasked with finding studies that contained:

1. Pest control attitude studies
2. A pest control management method(s) including novel or new technologies
3. A vertebrate or invertebrate pest or weed
4. Research carried out in New Zealand

Table 2 outlines the eight criteria that were used to include or exclude a publication, article or report identified in the literature search.

Table 2 Inclusion and Exclusion Criteria

	Inclusion Criteria	Exclusion Criteria
1	Written in English	Written in other languages
2	Peer reviewed literature indexed in Scopus, Web of Science or CABI	Peer reviewed literature not indexed in these databases
3	Grey (non-peer reviewed) literature identified	Grey (non-peer reviewed) literature not easily accessible.
4	Explicit focus on attitudinal studies to pest control methods in New Zealand including new or novel technologies	No focus on the attitudes of stakeholders to pest control i.e. focus is on the pests animal or plant not attitudes about controlling it
5	Studies identified using key terms and phrases outlined below.	Studies that don't use the key terms and phrases outlined below may be discarded if not relevant to the research questions
6	Located in New Zealand	No New Zealand focus
7	Methodology outlined	No explicit methodology
8	Full article available in the timeframe*	Full report not available in the timeframe*

* Initially, the first seven criteria were identified but, given time constraints for the completion of the review, an eighth criteria "Full article available in the time frame" was added.

4.2.3 Key Terms and Phrases

The following key terms were identified following an initial scoping search on Web of Science and using Fraser (2006), a 'pearl growing' document, i.e. a highly relevant document that identifies key terms and articles (Booth et al. 2016).

- **Attitude studies**: attitudes, views, perceptions, public attitudes, Maori beliefs, iwi beliefs, environmental attitudes, and public opinion
- **Location:** New Zealand
- **Pest control methods:** control**,** pest control, trap(ping), toxins, poison(s), 1080, chemical control, biological control, integrated pest management, biotechnology, genetic manipulation, gene editing, selective breeding, sterility, irradiation, gene drives, Trojan female technique
- **Pest species:** invasive animals**,** introduced mammals**,** possum, wasp, mustelid, stoat, weasel, ferret, rats, mice, feral/wild cats, feral/wild goats, invasive plants, and weeds

Table 3 shows the key terms and qualifiers that were used in the database search strategy. These terms were modified depending on the characteristics of the specific database and the amount of relevant literature located. An excel spreadsheet was used to document the

search strategy and to keep a record of the date of the search, the limits of the search, the terms used, and the numbers of retrieved and included articles. See Appendix A for examples of peer reviewed database and grey literature searches.

Table 3 Key terms and qualifiers used in the database scoping search strategy

Key Terms	Attitud* or view* or percept*
	AND
	"New Zealand"
	AND
Qualifiers	Pest control method or pest species (see key terms and phrases)

4.3 Appraisal and synthesis of the extracted data

The title and abstract (or executive summary) of each document was assessed according to the inclusion/exclusion criteria. Appendix B lists the excluded studies and why they were excluded. Citations in documents that closely fitted the inclusion criteria were also searched for any further articles or relevant documents that should be included in the review. Key themes from the research questions were extracted for the included literature. The methodologies of the included studies were not critically appraised for robustness according to CASP (Critical Appraisal Skills Programme) because there was insufficient time to complete this detailed process and there is debate around whether a quality assessment of qualitative research should be carried out (Booth et al. 2016). Articles that contained a single viewpoint (or opinion) and no explicit methodology were excluded (exclusion criteria 7).

The synthesis stage of the review is where key themes and patterns start to emerge from the data extracted. A pragmatic approach to the synthesis or data extraction process was taken due to the time constraint. A data extraction summary table was used to record and extract data from the studies. Studies included in this review were then analysed in more depth enabling links to be identified between the research questions and the data from these studies. The table also provided an audit trail for the extraction and synthesis process.

4.4 Analysis

Themes from the research questions were used to extract and code the data from the included studies for analysis. A 'thematic synthesis' typically uses a comparable type of analysis to bring together and integrate the findings of multiple qualitative studies within systematic reviews (Booth et al. 2016, p. 149). The data were summarised and filtered using excel spread sheets and organised into related areas. Conceptual maps were used to organise data and to enable 'outsider' and missing studies or gaps in the literature to be identified. This analysis utilised three strategies:

1. Search for patterns and themes identified using the coded data.
2. Identify differences between studies and isolated subgroups of studies, e.g. pest species researched, pest control methods used, demographics, framing and arguments used.
3. Pursue a line of argument – use an iterative process where studies are compared.

5 Findings

5.1 Search results

Database searches were carried out from 28 March to 7 April 2017. Ten databases were searched (Table 4) and after reviewing citations in articles closely fitting the key terms and qualifiers (Table 3), a total of 2028 articles were retrieved. An analysis of the title and abstract of those retrieved articles using the exclusion criteria outlined in Table 2 resulted in 91 articles being accepted for further review.

Table 4 A summary of the databases used in the systematic literature review; the articles retrieved and accepted after reviewing the title and abstract of the database searches.
'Already accepted' refers to articles that occur more than once in the database searches therefore are duplicates and already included

	Database	Articles retrieved	New Articles Accepted	Already Accepted	Articles rejected
1	Web of Science Core (WOS)	549	25	25	499
2	UoA Theses	45	2	0	43
3	nzresearch.org	110	12	9	89
4	ND Ltd Global ETD Search	266	3	0	263
5	NZ Science	478	23	20	435
6	EBSCO	48	2	4	42
7	Landcare Research (LR) Digital Library – LR Science Series	37	2	5	30
8	SCOPUS	289	8	29	252
9	Auckland Council technical reports	0	0	0	0
10	DOC Science for Conservation	192	0	3	189
11	From citations	14	14	0	0
	Total	**2028**	**91**	**95**	**1842**

5.2 Applying the exclusion criteria

The next step was to obtain, where possible, the full text of the 91 accepted articles. The inclusion/exclusion criteria were again applied resulting in 28 articles being identified for synthesis. A summary of the reasons for excluding 63 papers is shown in Table 5 and a list of the excluded papers is tabled in Appendix B. Thirty of the articles were excluded because the research did not focus on the attitudes of the stakeholders or the focus of the research was not about pest control methods. Unfortunately, because of the tight deadline for this review, eight articles were unable to be reviewed because of difficulty accessing them. Nine papers that were rejected were about public attitudes but not about pest control methods. In ten cases, the methodology was either not obvious or was from a single stakeholder perspective. The remaining six papers were rejected because the research had been published in another article already included; was a confidential client report, or a literature review.

Table 5 A summary of the reasons for excluding papers from the final synthesis

Exclusion Reasons	No. Articles
Not key terms or qualifiers	30
Unable to locate article in time frame	8
Methodology not determined (includes single perspective)	10
Attitude study but not qualifiers	9
Duplicate or data reported elsewhere	2
Literature reviews	2
Confidential client report	2
Total	**63**

6 Synthesis

The 28 articles that met the inclusion criteria are synthesised according to themes from the research questions outlined in Section 3.1. Table 6 lists these articles and provides a summary of the type of literature (peer reviewed or grey literature); the sources from which they were identified; research methods used, scale, localities, and research organisations carrying out the research. Some articles were identified in multiple database searches. Only three articles were identified on weeds or invasive plants in this review but they were all excluded because they didn't meet the key terms and qualifiers (see Appendix B excluded articles nos. 6, 38 and 59).

Date parameters were not specified in the searches but Sheppard and Urquhart (1991) was the earliest article identified that met the inclusion criteria. During the 1990s, seven articles were identified and this increased to eleven articles from the 2000s. Ten relevant articles have been authored since 2010.

Attitudinal research in the 1990s primarily focused on rabbits and possums and how acceptable trapping, shooting, poisons, and biological control were as pest control methods.

Table 6 Articles included in the systematic literature review and a summary of the type of literature, source, research methods used, scale, localities and researchers' organisations.
Abbreviations: **Literature type**: G Grey literature, P Peer reviewed, T Thesis; **Source**: DOC Department of Conservation, LRSS Landcare Research Science Series, NZS New Zealand Science, WOS Web of Science, UoA University of Auckland; **Scale**: L Local, N National, R Regional; **Researchers**: AER Agriculture & Economics Research Unit, FAS Fitzgerald Applied sociology, HFRINZ Horticulture and Food Research Institute of New Zealand, IBAC Independent Biotechnology Advisory Council, NZIPFR New Zealand Institute for Plant & Food Research Ltd LR Landcare Research, SPCA Society for the prevention of cruelty to animals, SU Stanford University, UoO University of Otago, UNITEC Institute of Technology

	Included Study	Title	Lit. Type	Source	Research Method(s)	Scale	Localities	Researchers
1	Bidwell (2012)	Talking about 1080:risk, trust and protecting our place	T	NZRO, EBSCO	Interviews	R	West Coast	UoO
2	Bidwell & Thompson (2015)	Place invaders: Identity, place attachment and possum control in the South Island West Coast of New Zealand	P	WOS	Interviews	R	West Coast	UoO
3	Farnworth et al. (2014)	Understanding attitudes toward the control of non-native wild and feral mammals	P	WOS, SCOPUS	Survey	R	Auckland	UNITEC/SPCA
4	Farnworth et al. (2011)	What's in a Name? Perceptions of Stray and Feral Cat Welfare and Control in Aotearoa, New Zealand.	P	SCOPUS	Survey	R	Auckland & Kaitaia	UNITEC/SPCA
5	Fitzgerald et al. (1994)	Doing good, doing harm: public perceptions and issues in the biological control of possums and rabbits	G	Fraser (2006)	Focus groups & survey	N	New Zealand	FAS & LR
6	Fitzgerald et al. (1996a)	Public attitudes to the biological control of rabbits in New Zealand	G	Fraser (2006)	Focus groups & survey	N	New Zealand	FAS & LR
7	Fitzgerald et al. (1996b)	Public perceptions and issues in the present and future management of possums	G	Fraser (2006)	Focus groups & survey	N	New Zealand	FAS & LR
8	Fitzgerald et al. (2000)	Public perceptions and issues in possum control	P	Fraser (2006)	Focus groups & survey	N	New Zealand	LR
9	Fitzgerald et al. (2002)	Social acceptability of stoats and stoat control methods: focus group findings	G	NZS, SCOPUS, DOC	Focus groups	R	Northland, Auckland, East Coast	FAS
10	Fitzgerald et al. (2005)	Social acceptability of stoats and stoat control methods: Findings of a survey of the NZ public	G	NZS, SCOPUS, DOC	Survey	N	New Zealand	FAS

	Included Study	Title	Lit. Type	Source	Research Method(s)	Scale	Localities	Researchers
11	Fraser, W. (2001)	Introduced Wildlife in New Zealand: A survey of general public views	G	Fraser (2006)	Survey	N	New Zealand	LR
12	Gamble et al. (2010)	Interviews with NZ community stakeholders regarding acceptability of current or potential pest eradication technologies	p	WOS, EBSCO, SCOPUS	Focus groups & interviews	N	Auckland, Waitakere, Timaru	NZIPFR & AgResearch
13	Green & Rohan (2012)	Opposition to aerial 1080 poisoning for control of invasive mammals in New Zealand: risk perceptions and agency responses	P	WOS, EBSCO, SCOPUS	ERMA submission analysis	N	New Zealand	DOC
14	Horn & Kilvington (2002)	Maori and 1080	G	NZS	Interviews & hui	N	New Zealand	LR
15	Kannemeyer (2013)	Public attitudes to pest control and aerial 1080 use in the Coromandel	T	UoA	Interviews & survey	R	Thames-Coromandel	UoA
16	MacKay et al. (2000)	Public views on the biotechnology question	G	Fraser (2006)	Meetings & focus groups	N	New Zealand	IBAC
17	McEntree (2007)	Participation and communication approaches that influence public and media response to scientific risk: A comparative study of two biosecurity events in New Zealand.	P	NZRO	Interviews	L	East and west Auckland	UoA
18	Niemiec et al. (2017)	Landowners' Perspectives on coordinated, landscape-level invasive species control: The role of social and ecological context	P	WOS	Interviews & survey	R	Hawke's Bay	SU & LR
19	Richardson-Harman et al. (1998)	Consumer perceptions of fruit production technologies	P	WOS	Survey	R	Kerikeri & Auckland	HFRINZ
20	Russell (2014)	A comparison of attitudes towards introduced wildlife in New Zealand in 1994 and 2012	P	WOS	Survey	N	New Zealand	UoA

	Included Study	Title	Lit. Type	Source	Research Method(s)	Scale	Localities	Researchers
21	Sheppard & Urquhart (1991)	Attitudes to pests and pest control methods: Results from a sample survey of the NZ population in February 1991	G	NZRO	Survey	N	New Zealand	AER
22	Tipa (2008)	Damned if we do, damned if we don't	G	EBSCO	ERMA submission	R	Ngai Tahu	Ngai Tahu
23	Wilkinson & Fitzgerald (1997)	Public perceptions of biological control of rabbits in NZ: some ethical and practical issues	P	NZS, SCOPUS	Focus groups & survey	N	New Zealand	FAS & LR
24	Wilkinson & Fitzgerald (1998)	Public attitudes to rabbit calicivirus disease in NZ	G	LRSS	Focus groups & survey	N	New Zealand	FAS & LR
25	Wilkinson & Fitzgerald (2006)	Public attitudes toward possum fertility control and genetic engineering in NZ	G	LRSS	Survey	N	New Zealand	LR & FAS
26	Wilkinson & Fitzgerald (2014)	Social acceptability of the Trojan Female Technique for biological control of pests	G	Google scholar	Focus groups	N	Christchurch, Wellington, Geraldine, Northland & Lincoln	LR & FAS
27	Wilkinson et al. (2000)	Public and interest group perceptions of possum fertility controls: a summary of the focus groups	G	NZS	Focus groups & hui	N	New Zealand	LR
28	Wilson & Cannon (2004)	Community consultation processes for aerial 1080 applications	G	NZS, SCOPUS	Case studies & interviews	N	Coromandel, Tongariro, Taranaki, Golden Bay, West Coast, Stewart Island	DOC

Media attention and public debate on the Rabbit Calicivirus Disease (RCD) to control rabbits led to public attitude research by Wilkinson and Fitzgerald in 1996. From 1997 to 2014 attitude studies on pests and their control are dominated by these two authors who between them have co-authored eleven of the included articles (Fitzgerald et al. 1994, 1996a, 1996b, 2000, 2002, 2005; Wilkinson & Fitzgerald 1997, 1998, 2006, 2014; Wilkinson et al. 2000). Their research has primarily focused on attitudes to a single pest species using focus groups to ascertain attitudes to a control method and surveys to sample the representativeness of the attitudes.

Since 2000, pest control research on public attitudes has been dominated by the acceptability of using 1080 or insecticides aerially and finding alternative approaches that are perceived to be less risky.

6.1 Public attitude research on pest control in New Zealand

Introduced vertebrate and invertebrate pests are causing substantial damage to New Zealand's native biota, agriculture, and horticulture and forestry industries (Russell et al. 2015; Wilkinson & Fitzgerald 2014). Possums (*Trichosurus vulpecula*), for example, eat an estimated 7.67 million tons of vegetation annually and also carry bovine tuberculosis, which can cause stock losses and threaten New Zealand's dairy, beef and deer industries (Russell et al. 2015). In addition, despite New Zealand having an excellent biosecurity system, its borders are under constant threat from well-known exotic pests due to globalisation and free trade (Goldson et al. 2015).

The New Zealand public is becoming more aware of the problems pests pose to them and New Zealand's native environment due to campaigns such as Predator-Free New Zealand and DOC s "Battle for our Birds". New Zealanders want to have their say as to how pest species are controlled, what methods are used, and whether or not some pests are pests at all (Wilkinson et al. 2000), e.g. deer can be viewed as both a pest and a resource.

Over the past 26 years, New Zealand's biosecurity industry has focused on developing and refining technologies for introduced invasive species management and understanding the biology of target pest species (Russell 2014). However, there has been relatively less work focused on public attitudes to pests and their management. This systematic review gives an overview of the New Zealand attitudinal studies that have been carried out over the last 26 years to control vertebrate and invertebrate pest species. Public attitudes to freshwater and marine pests; and pathogenic microorganisms were not identified in this review because they were outside the scope of this review.

6.2 Attitudes to pest management tools

A range of pest management tools were identified from the articles included in this literature review. Figure 2 shows the relationships between these articles and the dominant pest control methods researched. Niemiec et al. (2017) is not represented in Figure 1 because the pest control methods were not specified in this article. Some studies such as

Farnworth et al. (2011, 2014) incorporate a range of pest control methods in their surveys which span across manual, biological control and biotechnology methods.

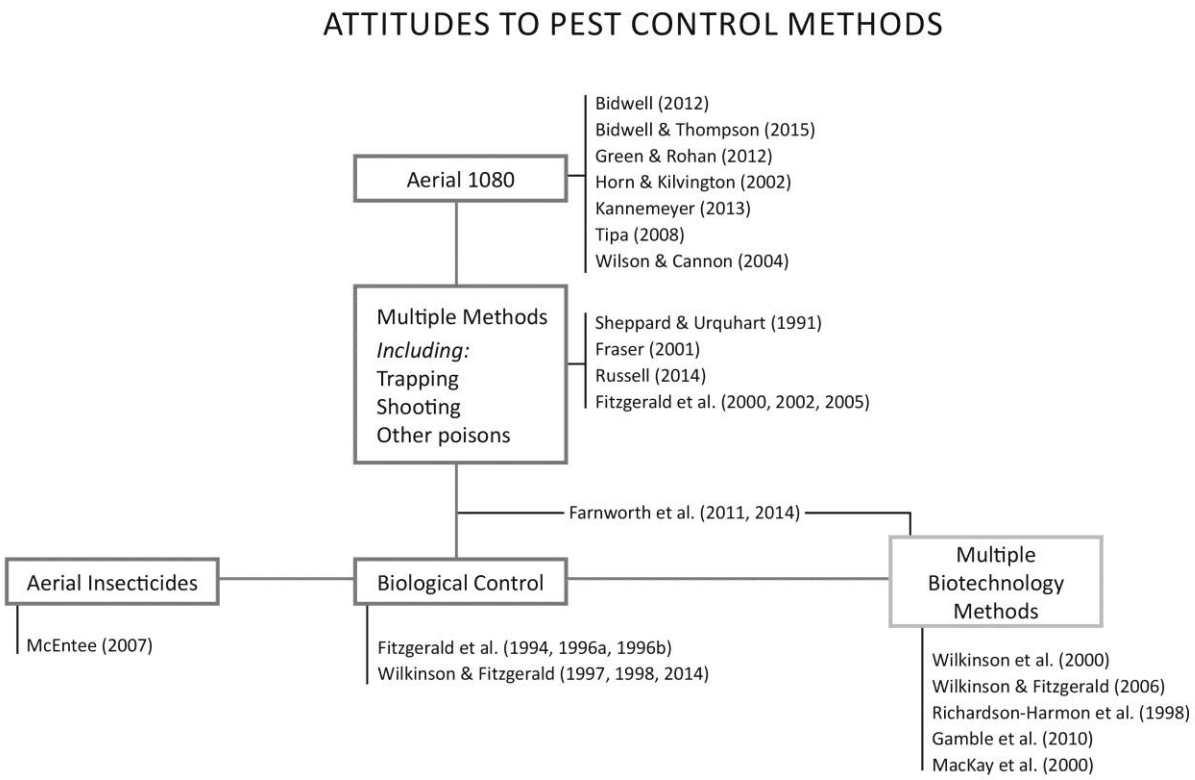

Figure 1 Pest control management approaches researched in the included articles on public attitudes to pest control. Articles are broadly grouped according to the dominant pest control method researched. The links indicate connections to other pest control methods also researched in the article e.g. Wilkinson et al. (1997) focused their research on the acceptability of biological control methods but also researched shooting, trapping, other poisons, aerial 1080, and biotechnology methods.

6.2.1 Aerial 1080

Half the studies analysed in this review either specifically research attitudes to aerial 1080 or include aerial 1080 as a pest control method option. This reflects a negative response to the use of poisons in general and controversy around distributing 1080 baits aerially.

Support for the use of aerial 1080 has varied markedly since it was first introduced in 1954; primarily to control possums (Kannemeyer 2013). Sheppard and Urquhart (1991) found that 44–45% of respondents thought 1080 was suitable for controlling possums and rabbits, whereas (Fitzgerald et al. 1996b) found that ground baiting of 1080 was 10% more acceptable (37%) than aerial applications (27%) (Fraser 2006). UMR omnibus surveys carried out in 2001 (Green & Rohan 2012) and repeated in 2007 found a rise from 32% to 43% respectively in public opposition to the use of 1080. Similarly, in the Russell 2012 survey, 40% of respondents believed 1080 should not be allowed to be used; approximately 9% more than the Fraser 1994 survey (Russell 2014). Fraser (2006) attributes this variation in

public concern about aerial 1080 to the different phrasings of the questions and media coverage effects.

Research by Kannemeyer (2013) supports this reasoning and compares different 1080 application methods and scenarios. In a 2012 survey of Coromandel people, 78% of respondents supported the use of 1080 if it was used in a bait station compared with 51% if 1080 was broadcast aerially – a change of 17%. However, the level of support increased to 70% if aerial 1080 was only used to control possums, rats, and stoats in remote or inaccessible areas **and** was the only cost-effective treatment to protect New Zealand's native species. This research demonstrated the importance in understanding attitudes to applying the toxin as well as the toxin itself. In addition, Kannemeyer (2013) found that Coromandel respondents opposed to the use of aerial 1080 were most concerned about the possibility of 1080 residues in their waterways (controllability) and the perception that it was indiscriminate and would kill native and non-target species (specificity). These community concerns are consistent with Māori concerns about the use of 1080 (Tipa 2008). Respondents' reasons for the continued use of aerial 1080 accrued to the benefits of targeting multiple pests at once, economic benefits to farmers to control bovine tuberculosis, its cost effectiveness in remote areas, and the belief that there was no better alternative (Kannemeyer 2013). This research also showed a significant difference between those respondents who had watched the Graf brothers' DVD "Poisoning Paradise" and their support for or against aerial 1080.

Other attitudinal studies on aerial 1080 have explored the social, economic, and environmental perceptions of risk about 1080 use (Green & Rohan 2012), community consultation processes regarding aerial 1080 (Wilson & Cannon 2004), and Maori cultural concerns (Green & Rohan 2012; Horn & Kilvington 2002; Tipa 2008).

Horn and Kilvington (2002) used a range of qualitative methods to study how the aerial 1080 consultation processes affected the way Māori communities dealt with the use of 1080 in their local areas. They concluded that Māori hold a similar range of views to non-Māori on the use of toxins in their local environments, i.e. there is no single Māori view. Some iwi or hapū felt the use of 1080 was justified in their tribal areas; other iwi saw 1080 as a threat to some aspect of their lives. Their concerns agree with those identified in Kannemeyer (2013), i.e. the perceived effect of 1080 on water supplies and human health, threats to native birds, and the danger to dogs when poison is used. Māori have spiritual connections to the land and so applying poisons to the environment can be abhorrent to them. Environmental groups too have an ethic of caring for the earth (Horn & Kilvington 2002). Māori generally consider all the arguments for and against an approach to pest-control before accepting it. Central to this decision-making is the level of trust in the information sources and the way the consultation processes proceed to enable iwi to learn about the issues (Horn & Kilvington 2002).

An example of a specific iwi's response to using aerial 1080 is outlined in Tipa (2008) and confirms findings from the Horn and Kilvington (2002) research. Tipa (2008) found support from Ngai Tahu for the continued use of 1080 to control invasive rodents, mustelids, and marsupial pests, but this support came with the restrictions that there was more community and iwi involvement in pest control operations and that locally, the most appropriate method, not the most efficient or cost-effective method was used. Their vision was to

ensure that biodiversity values in their native forests were enhanced. This vision was to be achieved by building trust with the agencies carrying out the pest control and by using best-practice methodologies; good communication processes and effective monitoring.

6.2.2 Manual methods – trapping, other poisons and shooting

Other lethal pest control methods besides aerial 1080 which dominate research are kill trapping, other poisons (e.g. brodifacoum, pindone), and shooting (10, 10, and 8 articles respectively). Survey research on attitudes to pest control methods generally show a preference for manual methods of pest control over poisons (Fitzgerald et al. 1996a). In addition, women in particular are less accepting of the use of poisons to control pests (Green & Rohan, 2012; Russell, 2014; Wilkinson & Fitzgerald, 1997, 1998). Shooting and trapping were more acceptable than poisons because they were perceived to be humane, safe and to create employment (Fitzgerald et al. 1996a, 2000). However, following focus group discussion, Fitzgerald et al. (1996a) found that uncertainties and costs associated with manpower options and biological control for controlling rabbits resulted in a reluctant acceptance of the need to use aerial 1080.

6.2.3 Multiple Methods

There are seven articles that explore attitudes to a range of pest control methods (Sheppard & Urquhart 1991; Fraser 2001; Fitzgerald et al. 2002, 2005; Farnworth et al. 2011, 2014; Russell 2014). All these articles use surveys to elicit information about attitudes apart from Fitzgerald et al. (2002), which used focus groups to investigate current stoat-control methods such as trapping, poisons, and biological control with a genetically engineered biocontrol to reduce stoat fertility. Participants' preferred control method for stoats was trapping but the traps needed to be humane. Overall, there was a preference for improving currently used methods than embracing new methods. New technologies which introduced new organisms were seen by all groups as perpetuating the problematic cycle of needing to find other non-native organisms if the new organism became invasive itself.

Surveys have traditionally been used to elicit attitudes about the classic lethal pest control methods of poisons, kill traps and shooting. Farnworth et al. (2014), however, also researched non-lethal methods such as live capture trapping, repellents, and using a predator exclusion fence. This survey differs from other surveys because the focus is on animal welfare and included horses, cats, dogs, and deer along with the prevalent rats, stoats, possums, and rabbits. Three views were analysed: conservationists, protectionists and the general public. The protectionist groups were dominated by females and preferred non-lethal control methods for all the pests except for rats and stoats where trapping was preferred. Overall, conservationists and the general public preferred lethal methods but the general public preferred 'trap neuter release' for feral cats and dogs.

6.2.4 Biological control

Seventeen of the articles in this review use the term biological control to define a pest control approach in their research. Many of the earlier articles refer to the traditional

biological control approach where a pest species is controlled through the introduction of a natural enemy (Sheppard & Urquhart 1991; Goldson et al. 2015) by introducing a predator (stoats to control rabbits), a virus (rabbit calicivirus disease, RCD), parasites (wasp parasitoids) or using biopesticides such as *Bacillus thuringiensis.* However, advances in genetic technology have led to novel biological control approaches being developed which consequently have broadened the boundaries of what constitutes biological control. The Trojan Female Technique (TFT) is one such example, where naturally occurring mutations are used to disrupt the fertility of a pest population and could be used for both vertebrate and invertebrate pest control in the future (Wilkinson & Fitzgerald 2014).

While weed biocontrol has been hugely successful and RCD initially had an impact on rabbits, in practice, researchers have had difficulty developing effective biological control agents for vertebrates (Wilkinson & Fitzgerald 2014). Introducing a new biological control agent for pest control can also bring new controversies and challenges (Fitzgerald et al. 1996a, PCE 2000).

Five articles in this review specifically research public attitudes to the biological control of rabbits and/or possums (Fitzgerald et al. 1994, 1996a, b; Wilkinson & Fitzgerald 1997, 1998); however, all the research was carried out more than seventeen years ago. A more recent comparison of public attitudes using wildlife surveys carried out in 1994 and 2012 concluded that preferences for the use of biological control remained low and had not changed since the 1994 survey carried out by Fraser (2001) (Russell 2014). Overall findings from the articles in the review show that the acceptability of biological control was related to practical, ethical, and equity issues that related to perceptions of risk and included: controllability of the technology, host specificity of the control organism and the vector, potential risks for mutation and transfer to humans; as well as the credibility of experts (Wilkinson & Fitzgerald, 1997).

More recently, Wilkinson & Fitzgerald (2014) used focus groups to understand the range of attitudes about pests for current and potential forms of pest control such as TFT. The focus groups were differentiated by belonging to the general public (rural, urban males and urban females), Maori, community-based conservation interests, community-based animal welfare interests; scientists and biosecurity specialists, and pest managers. The psychometric perspectives of 'dread' and the 'unknown' were identified as risk perceptions in this TFT study and compared to other studies they found that focus groups were generally favourable towards TFT in principle. Other issues raised included the need for further research to include the ecological effects of removing predators from an ecosystem (predator release effect), and the potential irreversibility and uncontrollability of TFT organisms once released.

In general, public attitudes to biological control were characterised by high levels of uncertainty, unpredictability and unintended consequences; frequently due to limited knowledge and understanding of how the technology works (Wilkinson & Fitzgerald 2014). Overall, biological control methods are generally perceived to be more acceptable and humane than poisoning but less acceptable than manual methods.

6.2.5 Biotechnology

Mackay et al. (2000) found confusion and difficulty over defining biotechnology (see the glossary for biotechnology definitions) as the term is often used interchangeably with genetic engineering, genetic modification, or synthetic biology (PCE 2000). A flow chart showing novel technologies within the fields of biodiversity conservation and symbiology is attached in Appendix C (Cook 2017). This chart provides a context for gene editing and gene drives which are new genetic technologies that use the Clustered Regularly Interspersed Short Palindromic Repeats (CRISPR) system to locate and change specific genes in cells and organisms. Potentially, this gene editing system could be applied to control invasive species such as wasps in the future. However, none of the articles in this review have researched attitudes to this specific technology.

Five articles in the review focused on understanding public attitudes to biotechnology as their pest control method. Public views in the IBAC 2000 report ranged from embracing biotechnology to wanting a complete ban on biotechnology in New Zealand (Mackay et al. 2000). The public engaged in this research could see the benefits of using biotechnology for medical applications but otherwise they were extremely cautious of its use and outlined provisos for moral and ethical leadership and a tight legal and regulatory framework for it to operate in. There was a strong view from participants in the IBAC 2000 research that genetic modification did not have a place in New Zealand agriculture. There was concern that New Zealand's "green image" would be tarnished.

In two of the studies, focus groups and a telephone survey (Wilkinson et al. 2000; Wilkinson & Fitzgerald 2006) were carried out to understand attitudes of fertility-based biological control for possums which had the potential to involve the use of genetic engineering. People's attitudes to the possum problem strongly influenced their view on the development of fertility controls. They found that the New Zealand public at that time wanted new methods to replace the current possum control methods (leg-hold trapping and 1080 poisoning) and considered fertility control a highly acceptable approach. Fertility control was viewed as being superior because it was perceived to be specific, humane and effective. However, this acceptance was tempered by the type of genetically engineered (GE) organism or product used to deliver the possum fertility control. A fertility control that didn't involve the use of GE would have received a greater level of public support (Wilkinson & Fitzgerald 2006). Women were found to be less in favour of GE-based control than men and results showed that the use of a GE control could lead to strong opposition (Wilkinson & Fitzgerald 2006).

Gamble et al. (2010) interviewed community stakeholders regarding the acceptability of three pest eradication technologies (aerial spraying of a biopesticide or pheromone and the sterile insect technique) to control insect biosecurity incursions. Acceptance of the technologies proposed to eradicate insect biosecurity risks was found to depend on the risk benefit trade-offs. Controllability over the use of aerial sprays caused concern to some participants.

Richardson-Harmon et al. (1998) surveyed consumers on the risks and benefits of fruit production technologies which included genetic engineering, chemical fertilisers, chemical pesticides, irradiation and organic farming. They found that the benefits of genetic

engineering in fruit production were perceived to outweigh the risks to both consumers and the environment but pesticides and irradiation in fruit production were considered to be too risky.

In summary, since 2000 there has been a considerable amount of research conducted on public attitudes to biotechnology (Gamble & Kassardjian 2008) however there is limited attitudinal research specifically related to vertebrate and invertebrate pest control.

6.3 Attitudes to New Zealand pest species

A wide range of pest species have been targeted in surveys researching public attitudes to pest control over the last 26 years. Figure 2 shows the pest species targeted in the included articles in the systematic review. Tipa (2008) and Mackay et al. (2000) are not represented in Figure 2 because the pest species were not specified in these articles.

Sheppard and Urquhart (1991), the oldest paper identified, carried out a survey of 1000 adults and highlighted rabbits, possums and wasps as being considered serious pests. This survey also explored the acceptance of methods for controlling these pests and found that the introduction of natural enemies or diseases was not an acceptable way to control pests in New Zealand. Despite wasps being identified as a problem by a third of the respondents in Sheppard and Urquhart (1991), no specific attitudinal study on wasps was identified in this review.

While some studies focused only on one pest, such as possums (Fitzgerald et al. 2000; Wilkinson et al. 2000; Wilson & Cannon 2004; Wilkinson & Fitzgerald 2006), rabbits (Fitzgerald et al. 1996a; Wilkinson & Fitzgerald 1997, 1998) or stoats (Fitzgerald et al. 2002, 2005); other attitudinal studies assessed multiple pests (Fraser 2001; Russell 2014; Farnworth et al. 2014; Niemiec et al. 2017). All research involving multiple pests in this review utilised surveys to determine public attitudes except for two studies, Kannemeyer (2013) and Niemiec et al. (2017) which used a mixed methods approach combining qualitative interviews with a survey.

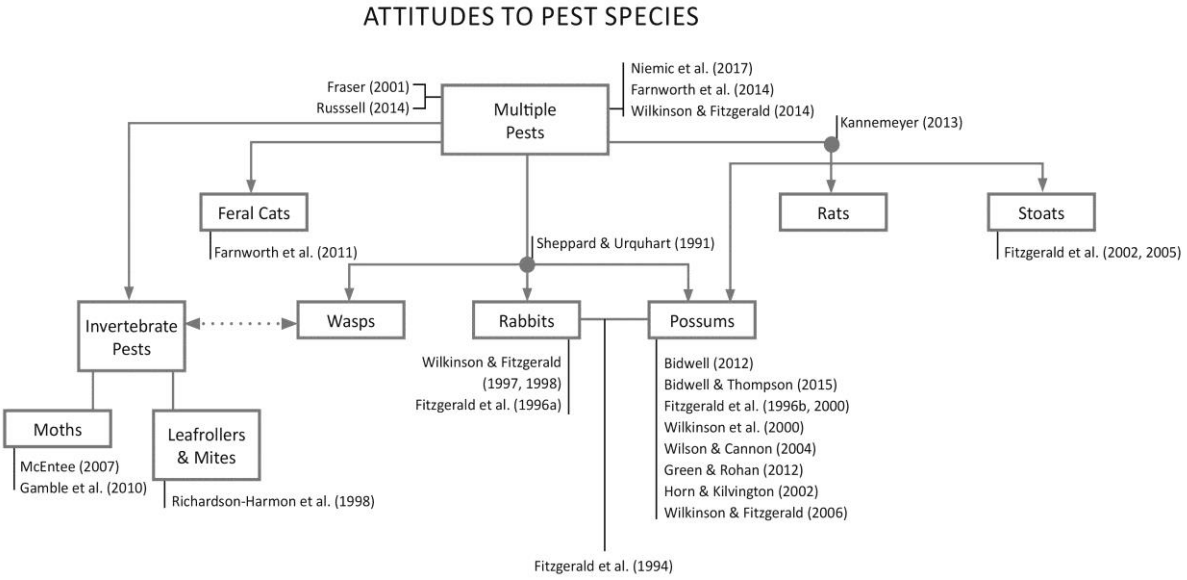

Figure 2 Pest species identified in the included articles on public attitudes to pest control.
Articles are grouped according to the target pest researched. Arrows indicate connections to pests e.g. Sheppherd & Urquhart (1991) targeted wasps, rabbits and possums whereas Fraser (2001) and Russell (2014) surveyed multiple pests. Farnworth et al (2011) focused their research on feral cats.

6.3.1 Rabbits

Rabbits (*Oryctolagus cuniculus*) have been an ongoing, major vertebrate pest in New Zealand since the 1880s; reaching plague proportions on pastoral lands and serious affecting the viability of farming in some areas (Wilkinson & Fitzgerald 1997). An attitudinal survey by Sheppard and Urquhart (1991) found that people living in rural areas considered rabbits more of a problem than people living in towns and cities. Shooting and commercial harvesting were seen as preferable to gassing, 1080, predators and diseases at that time. While 90% of the respondents had heard of myxomatosis as a means for controlling rabbits, they also considered the disease "a slow painful death to rabbits". Wilkinson & Fitzgerald (1997) similarly found that the introduction of the myxoma virus resulted in a public ethical debate about its effects on rabbits.

In 1994, Rabbit Calicivirus Disease (RCD) was identified and seen as a possible biological control agent for rabbits. A national study of New Zealanders' perceptions of rabbits and possums and their attitudes to various control methods (particularly biological control) was carried out in 1994 by Fitzgerald et al. (1994, 1996a). This research was followed by specific rabbit studies in 1996 on biological control (Wilkinson & Fitzgerald 1997). In July 1997, the Deputy Director General of Agriculture decided not to officially release RCD in New Zealand. However in August, 1997 RCD was released unofficially (Wilkinson & Fitzgerald 1998). Findings from focus groups and a telephone survey carried out before the RCD release explored the public's attitudes to the control of rabbits and RCD. Not controlling rabbits was considered the most risky option for the environment and the economy at that time. Manual methods were considered to present the lowest risks with shooting being seen as

less risky than trapping. Poisoning was considered the riskiest control method of all the technologies available at that time; especially for females. Biological control was rated between manual methods and poisoning methods in terms of acceptability and riskiness. Despite a large, publicly funded Rabbit and Land Management Programme, and public debate over the outbreak of RCD in Australia at that time, public attitudes about the rabbit problem and how to deal with them had changed little according to Wilkinson & Fitzgerald (1998).

Fraser (2001) also carried out a survey of New Zealand wildlife in 1994 which was repeated in 2012 by Russell (2014). Results from the 2012 survey showed that rabbits were still considered a pest by most respondents and need to be controlled (Russell 2014). This shift to "control" not "extermination" in the 2012 survey is thought to be related to the high-profile, unofficial introduction of the RCD in 1997 which significantly reduced rabbit numbers (Russell 2014). The use of poisons to control rabbits was still seen as less favourable by respondents than trapping in the 2012 survey.

6.3.2 Possums

The Australian brushtail possum (*Trichosurus vulpecula*) has been established in New Zealand for over 150 years (Kannemeyer, 2013). While valued for its fur, possums are also widely recognised as a pest due to their impacts on the dairy industry, native forests and predating nests of native birds (Clout & Ericksen 2000). Five articles in the review specifically target possums by researching its present and future management (Fitzgerald et al. 1996b); biology and impact (Fitzgerald et al. 2000); and fertility control options using focus groups (Wilkinson et al. 2000) and a survey (Wilkinson & Fitzgerald 2006). The fifth article (Fitzgerald et al. 1994) investigates public perceptions in the biological control of both possums and rabbits. A further five articles carried out surveys which included public attitudes to possums (Farnworth et al. 2014; Fraser, 2006; Niemiec et al. 2017; Russell, 2014; Sheppard & Urquhart, 1991), while another six articles researched the impacts of possums by considering public attitudes to aerial 1080 from different perspectives (Bidwell, 2012; Bidwell & Thompson, 2015; Green & Rohan, 2012; Horn & Kilvington, 2002; Kannemeyer, 2013; Wilson & Cannon, 2004).

A key report on attitudes to possums is the study commissioned by the Parliamentary Commissioner for the Environment (PCE) in 2000 entitled "Caught in the Headlights". This report investigated New Zealanders' attitudes to possum control options (PCE 2000). The PCE report is significant because it assessed how people would perceive fertility control and genetic engineering as possible new pest control methods for possums (Wilkinson et al. 2000). Findings from this study showed that although possums were viewed as a threat to New Zealand's biodiversity, they were not seen as the only threat (PCE 2000). While there was some interest in the new technologies, there was also strong support to utilise the current control methods more extensively and more effectively.

In a comparative survey of attitudes to wildlife in New Zealand in 1994 and 2012, sixty-six per cent of respondents, regardless of gender, were concerned about possums and 92% of respondents in the 2012 survey considered seeing possums as the least preferable animal when rating wildlife (Russell 2014). In the 2012 survey, 66% of respondents were more

concerned about possum impacts on both the agricultural industry and conservation values than in the 1994 survey. As with rabbits, the use of poisons to control possums had lost favour in the 2012 survey in preference for trapping (Russell 2014).

6.3.3 Stoats

In May 1999, stoats (*Mustela erminea*) were considered a significant threat to New Zealand biodiversity so the New Zealand Government created a special 5-year fund for stoat control research (Fitzgerald et al. 2002). Two key attitudinal studies on stoats resulted from this research: Fitzgerald et al. (2002) - a qualitative study using seven focus groups and Fitzgerald et al. (2005) - a quantitative study using a telephone survey. No other attitudinal studies specifically on stoats were identified. Stoats belong to the mustelid family along with ferrets (*Mustela furo*) and weasels (*Mustela nivalis vulgaris*) but the latter two pests, unlike the stoat, are often categorised as mustelids in studies and not specifically targeted for attitudinal research.

In 2001, focus group discussions conducted by Fitzgerald et al. (2002) revealed that very few participants in the three general public groups (urban men, urban women and rural mixed) had any direct personal experience of stoats, compared with the four interest groups (scientists, pest control and conservation, animal welfare, and Maori). Overall, stoats were viewed negatively and were seen as “ruthless killers”, especially for their predation on native species such as kiwi. Trapping was preferred over poisons for controlling stoats but both were seen as having problems. Negative responses by participants to proposed new technologies to kill stoats or reduce their fertility were due to their lack of knowledge of the potential risks and effects on non-target species. Participants in this research showed a clear preference for researchers to improve current pest management techniques rather than implement new techniques to kill or reduce stoat fertility. An outcome of these focus group discussions was a request for the public to be involved or at least consulted about decisions on the introduction of new stoat control methods.

A representative survey of the general public in 2002 to assess attitudes to current stoat control methods, and possible biological control methods found widespread support for controlling stoats and improving stoat control methods (Fitzgerald et al. 2005). There was a preference shown for kill trapping over poisons and a strong message that the public did not support the use of diseases that could affect other animals. There was also clear opposition to the use of a virulent strain of the canine distemper virus and the public was less supportive of the use of genetic engineering of organisms to develop or deliver fertility control. The study concluded that improving trapping methods for stoats would be the most socially acceptable option.

6.3.4 Wasps

Social wasps (*Vespula germanica* and *V. vulgaris*) are the most damaging widespread invertebrate pests in New Zealand and pose a significant risk to human health (Lester et al. 2013). Wasps were topical in the 1990s and were considered an emerging pest species (Russell 2014) but no specific attitudinal studies on wasps were identified in the database searches for this review. However, they have been studied alongside vertebrate pests in a

number of surveys (Sheppard & Urquhart 1991; Fraser 2001; Russell 2014), and in a recent focus group study by Wilkinson and Fitzgerald (2014) in which all eight focus groups identified wasps as one of the main pests in New Zealand along with possums, stoats, and rats.

The survey carried out by Sheppard and Urquhart (1991) also identified wasps as a "very serious" or "serious" pest and almost a third of the respondents indicated that they had a wasp problem regardless of whether they lived in a town, city or rural environment. Almost half the respondents also thought that not enough was being done to control wasps at that time. Diseases and petrol were thought to be either "very suitable" or "suitable" wasp control methods by a high proportion of respondents. Insecticides were only favoured by 45% of respondents. Interestingly, of those opposed to the use of diseases to control pests, 40% were in favour of using diseases to control wasps.

Wasps were identified as pests and perceived negatively in the Fraser 1994 survey (Fraser 2001). Even though wasps are nationally classified as pests and many people encounter them, Russell (2014) found that there is less concern about them as a perceived pest. Russell (2014) concluded that pest management spending should include wasps. No specific research on public attitudes to wasps and how they could be controlled has been carried out since the 1991 Sheppard and Urquhart survey. However, scientists are researching ways to control pest populations by controlling fertility, and the Trojan Female Technique (TFT) may be applicable for managing pests like wasps (Gemmell et al. 2013). Conducting social research alongside the development of the TFT would be beneficial to understanding public acceptance of this technique.

6.3.5 Feral cats

Feral cats (*Felis canis*) are known predators of New Zealand's native biota (Farnworth et al. 2011) but are notably excluded from the predator-free New Zealand (PFNZ) concept because there is debate over the appropriate way to distinguish between feral, stray and companion cats and their appropriate management (Russell et al. 2015).

Farnworth et al. (2011) is the only attitudinal studies identified in this review that specifically focuses on stray and feral cats. The general public from the city (Auckland) and semi-urban (Kaitaia) localities were surveyed in this study to understand their perceptions of feral and stray cats and the acceptability of cat control methods. Control of feral or stray cats can be divided into lethal (poisoning, trapping or hunting) and non-lethal (trap neuter release (TNR), contraception, and trap neuter re-home (TNRh) methods (Farnworth et al. 2011). Lethal control was perceived to be more acceptable for feral cats than for strays. There were differences in perceptions towards acceptability of control methods between cat owners and non-owners, with the former being more concerned about conservation and welfare issues.

Feral cats have been included in wildlife surveys carried out by Fraser (2001), Russell (2014) and Farnworth et al. (2014), as well as in a study of landowners' perspectives on invasive species control by Niemiec et al. (2017). There appears to be widespread public support (Russell 2014) and landowner support (Niemiec et al. 2017) for the control of feral cats.

6.3.6 Invertebrates

Three studies were identified in this review that focused on invertebrate pests and incursions apart from wasps (Richardson-Harman et al. 1998; Gamble et al. 2010; McEntee 2007). Each of these studies used a different methodology to ascertain public views on invertebrates and insights into their control. Richardson-Harman et al. (1998) used a survey to understand the range of responses from communities throughout New Zealand on the perceived risk and benefits of plant gene technology (to produce healthy, bigger fruits; to improve flavour of fruit and to reduce the need for pesticides) compared to other fruit production methods such as selective breeding, organic farming, irradiation, use of fertilisers and pesticides to control leafrollers and mites. They found that gene technology terminology was important when determining attitudes toward fruit production methods, e.g. the transgenic term was not well known. The most positive attitudes held were for fruit production techniques that had high benefits, low risks, and were well known to both scientists and the public e.g. organic farming. Pesticides and irradiation were considered the least acceptable control treatments for horticultural produce because the risks were perceived to be greater than the benefits for the majority of respondents. All the genetic engineering applications tested were perceived to have lower risks and higher benefits than irradiation and perceived similarly to the application of fertilisers.

McEntee (2007) used semi-structured interviews and content analysis of metropolitan and community newspaper articles to provide insights into the way invertebrate incursion control programmes were communicated to the public by biosecurity agencies. The study compared the community and media responses to the aerial spraying of biological insecticides to control the white spotted tussock moth (WSTM) (*Orgyia thyellina*) (Programme 1: WSTM) and the painted apple moth (PAM) (*Teia anartoides*) (Programme 2: PAM). The WSTM programme promoted participatory science and a team approach with strong leadership, whereas the PAM programme favoured public education over engagement and marginalised a strong and loud opposition to the programme. Differences in organisational culture between the two programmes were cited as the reason for the different outcomes, i.e. strong criticism of the PAM programme in the media compared with the WSTM programme.

The third invertebrate article also used a mixed method approach to understanding community responses to three pest eradication technologies proposed for use in New Zealand (Gamble et al. 2010). Two biosecurity incursions – the painted apple moth (PAM) *T. anartoides* and the Asian gypsy moth (AGM) *Lymantria dispar* – were used as examples to understand public attitudes to (1) aerial spraying of a biopesticide, (2) aerial spraying of pheromones, and (3) the sterile insect technique (SIT). Interviews and thematic analysis were used to understand the prevailing attitudes. Overall, the use of aerial sprays was of concern to the public because of the inability to control exposure to them and the potential health fears. In contrast, SIT was seen as posing fewer concerns but participants were unfamiliar with this control method. Acceptance of the various technologies proposed for the eradication of insect incursions depended on the trade-off between the real and perceived costs to the community and the environment compared with the cost incurred to the community if the pest was allowed to exist. Another outcome of this research was the perception that biosecurity agencies in New Zealand were slightly removed and inaccessible.

In addition, the importance of trust in authorities was identified as an important attribute when implementing new technologies.

6.3.7 Other vertebrate pests

Surveys of the general public by Fraser (2001), Farnworth et al. (2014), and Russell (2014) have examined attitudes to combinations of the following vertebrate pests: rodents, deer (*Cervus* spp.), feral goats (*Capra hircus*), feral pigs (*Sus scrofa*), wallabies, thar, chamois (*Rupicapra rupicapra*), and feral horses (*Equus caballus,* Kaimanawa herds).

All three species of rats (Ship rat *Rattus rattus*; Norwegian rat *Rattus norvegicus*; Kiore *Rattus exulans*) and mice (*Mus musculus*) are listed as part of the mammalian predator-free New Zealand programme (Russell et al. 2015) but no specific attitudinal study on their control or management was located as part of this review.

Large introduced animals that are hunted, such as deer, thar, and chamois, are now classified as game animals under the Game Animal Council Act 2013 (Russell 2014) and are viewed as either a resource, or, to a lesser extent, as a resource with negative impacts (pest) that add to the outdoor experience. Deer, especially, are a low priority for control management, and attitudes towards them had not changed when compared with the Fraser 1994 survey. Attitudes to feral pigs and goats in New Zealand are in a state of flux (Russell 2014), with both species still being considered both a pest and a resource. In the 2012 Russell survey, attitudes to feral pigs and goats had shifted closer to those held for deer.

Two species of wallaby have been eradicated since Fraser's 1994 survey but they were still considered pests by respondents in the Russell 2012 survey (Russell 2014). Attitudes to wild horses are specific to the Kaimanawa Ranges and were included in the Fraser 1994 and Russell 2012 surveys. Fraser (2001) found that survey respondents preferred a compromise where wild horses were retained in the region but their numbers were reduced to protect threatened native flora. The wording in the Russell 2012 survey reflected this outcome and the wild horse management question was changed from "eradication" to "control". More respondents thought that wild horses were a pest than a resource in the Russell 2012 survey (Russell 2014).

In contrast to the general public surveys of introduced wildlife, Niemiec et al. (2017) carried out a mixed method study using interviews and a survey to provide benchmark data on landowners' perspectives on management practices for the control of possums, stoats, ferrets, and feral cats in the Hawke's Bay region. This study is part of the Cape to City (C2C) programme and will track changes in landowner perceptions as the C2C programme evolves. While respondents in this study viewed stoats, ferrets, and feral cats as significant pests, especially compared with native birds and other animals, only half the respondents were conducting pest control on their land other than possum control. Besides possums, rats and mice were commonly the most controlled predators by landowners. Respondents recognised a need for a coordinated approach to pest control for biodiversity values to be improved and diseases such as toxoplasmosis to be reduced.

Hedgehogs are not mentioned in any of the included attitudinal articles in this review but are listed by Goldson et al. (2015) alongside rats, mice, mustelids, hares, rabbits, possums, wild pigs, and feral cats as posing serious threats to New Zealand's native fauna.

6.4 Reporting of attitudes to pest control

In a review of current and future challenges of New Zealand pest management, Goldson et al. (2015) outlined a number of public concerns for existing and new pest management methodologies regarding the use of pesticides and animal welfare issues. As well as a list of core capabilities such as taxonomy, pest impacts, and development of novel control tools, the need for social science research is highlighted. Russell et al. (2015) suggest that the economic and social challenges are just as great as the biological challenges in removing multiple introduced species from New Zealand in the Predator Free New Zealand (PFNZ) project. This section highlights how the attitude literature for this review has been framed and gives an overview of the key arguments.

6.4.1 How were the attitudes categorised or framed?

'Social licence to operate' (SLO) is a concept that refers to ongoing local community and stakeholder approval or social acceptance of the activities of a corporation (Edwards & Trafford 2016). This concept is built on a foundation of social responsibility and is gaining traction in New Zealand (Edwards & Trafford 2016). SLO is relevant to this review because for a pest control operation to be sustainable, the local community and associated stakeholder groups need to be engaged. In addition, social attitudes are known drivers in the implementation of science and technology (Russell 2014)

There are multiple ways to frame attitudinal research about invasive pests and their management. The majority of articles in this review are framed around the drivers of risk perception from a social, ecological, and health perspective. Economic, cultural and political perceptions of risk relating to pest management are usually not the main focus of attitudinal research. Trust and community participation are other frames identified in this review.

Risk perceptions and communication about aerial 1080 are framed from a cultural or Māori perspective in Horn and Kilvington (2002) and Tipa (2008). Māori focus groups also provide a cultural perspective in some articles (Fitzgerald et al. 2000; Wilkinson & Fitzgerald 2014). Horn and Kilvington (2002) also use perceived control and the consultation process as frames for their research, building on principles of social support and trust to gain mutual respect between communities and pest control agencies.

Wilson and Cannon (2004) also investigate community consultation processes for a pest control method. Their research is framed in the context of key factors influencing community consultation processes and the types of processes or methods used to engage with the community. This research is published by the Department of Conservation and uses six case studies to evaluate the consultation and information-sharing processes in aerial 1080 operations.

Economic framing perspectives with regard to pest control include the categorisation of a pest as a resource (Russell 2014) and the impact of a pest on agricultural (Niemiec et al. 2017) or horticultural values (Richardson-Harman et al. 1998). Balancing the commercial and recreational benefits of an introduced species with their negative ecological impacts can be difficult and is often determined by whether it is perceived to be a pest or a resource (Russell 2014).

Two articles (Bidwell 2012; Bidwell & Thompson 2015) differ in their research approach and are framed in the context of warfare and invasion in the West Coast community, leading to themes of 'other' invading our place and 'outsider' discourses. Differing individual constructions of place influenced the way they perceived control and protection of their place. Trust is also another important framing in these two articles and a number of other articles in this review. Trust in biosecurity agencies is perceived to play an important role in determining how well the public will accept pest control technologies in Gamble et al. (2010), who frame their research from the perspective of a community stakeholder and the role of authorities. Niemiec et al. (2017) consider landowners' perspectives at a landscape level and frame their research in a socio-economic and ecological context, which is important for the future management of invasive species in the Cape to City project.

McEntee (2007) uses participation and communication approaches to understanding public and media responses to two biosecurity events. This research encompasses approaches outlined above and highlights the need for biosecurity agencies to step beyond the operational focus of their statutory responsibilities and to build consensus based on participation, trust and understanding.

Animal welfare concerns provide framing for three articles: Farnworth et al. (2011, 2014), and Wilkinson and Fitzgerald (1997). Conservationists and protectionists' attitudes are compared with the general public when assessing the impact of major pests (feral cats, rats, possums, and stoats) and lethal and non-lethal pest control methods (Farnworth et al. 2014). This research highlights the importance of placing opinions, especially extreme ones, within the context of the full range of views on the issue. As well as the animal welfare and animal rights framing, Wilkinson and Fitzgerald (1997) also frame their research from the environmentalists' viewpoint, issues about the acceptability of biological controls, and public information for decision-making. The importance of engaging with the public and key interest groups when communicating new pest control technologies is highlighted to reduce the risk of further polarising the decision-making process.

In their most recent article, Wilkinson and Fitzgerald (2014) frame their research in the context of 'pestiness' and use this context to identify attitudes to the acceptability of current and future pest control methods using the Trojan Female Technique. The focus group questions were divided into biological, ecological, field deployment, policy, and continuation of the research. As with other studies, frames also included trust in science, decision-making, and 'knock-on' effects.

Analysing the framing of these articles has identified a range of viewpoints. The ethical view, where perceptions of risk are identified, dominates most of the attitude research on pest control but this analysis has also shown that the local community, public, conservation, and

science views exist as well. Some concluding threads that run throughout the included articles are categorised below:

Local community

- Trusting authorities early in the consultation period is important (Gamble et al. 2010; Tipa 2008)
- There is no one set of tools or one strategy that will fit every community consultation process (Wilson & Cannon 2004)
- Interactions with iwi are part of an ongoing process (Horn & Kilvington 2002)
- Acceptance of new technology is a trade-off between the real and perceived costs to the community and the environment compared to the costs of doing nothing (Gamble 2010)

The Public

- There is no one public view (Russell 2014) and the community may not speak with one voice (Bidwell & Thompson 2015)
- 'Pestiness' is not universally agreed on (Wilkinson & Fitzgerald 2014)
- Strongly held environmental attitudes are resistant to change (Wilkinson & Fitzgerald 1998; Russell 2014)
- Dealing with pests is not just a technical issue – it is a public issue (Wilkinson et al. 2000)
- There is no connection between new technological knowledge and acceptability by the public (Richardson-Harman et al. 1998)
- Conflicting attitudes are only weakly linked to environmental knowledge (Russell 2014)

Ethics including animal welfare

- Poisons are the least acceptable form of pest control method, especially for women (Wilkinson & Fitzgerald 1997, 1998; Green & Rohan 2012; Russell 2014)
- Men are more accepting of lethal pest control methods than women (Wilkinson & Fitzgerald 1998, 2006; Fitzgerald et al. 2005; Green & Rohan 2012; Russell 2014)
- The public are concerned about the unknown and long-term risks of new technologies (Gamble et al. 2010)
- There is a preference for modifying an existing pest control method over developing a new technology (Fitzgerald et al. 2002, 2005)

Conservation

- Iconic and endangered species such as kiwis need protecting (Fitzgerald et al. 2002, 2005; Tipa 2008; Kannemeyer 2013)
- Concern about upsetting the local 'ecological balance' leads to increases in other pests (Niemiec et al. 2017)
- Environmental attitudes are slow to change and only weakly linked to environmental knowledge (Russell 2014)

Science

- Scientific perspectives dominate because of legislative protection (McEntee 2007)
- It is possible to reach agreement about how to proceed even when people do not like the idea of a pest control method such as aerial 1080 (Horn & Kilvington 2002)
- Clarifying terminology is important (Wilson & Cannon 2004) and communication must be specific when new organisms and biotechnology methods are proposed (Wilkinson & Fitzgerald 1997)

6.4.2 What arguments were presented?

The main arguments on attitudes to pest control management presented in this literature review relate to perceptions of risk and the acceptance of existing pest control methods or the development of new technologies. This section reviews the arguments presented by social researchers over the last 26 years, beginning with the survey by Sheppard and Urquhart (1991).

In 1991, social research conducted by Sheppard and Urquhart (1991) focused on how people perceived a range of pests and their attitudes to different pest control methods. Poisons, shooting, and traps were common control methods for the main pests – rabbits and possums – while wasps were killed with insecticides and petrol. This survey introduces a common thread seen throughout the articles reviewed, i.e. people do not like using poisons, and scientist like to investigate new technologies or ways to control pests. At the time of this survey, the myxoma virus and its vector, the European rabbit flea, were being researched to control rabbits but concerns over the specificity of the flea and the perception by the public that the disease caused rabbits a slow painful death meant this biological control method was not approved. Arguments of specificity and humaneness of a control method are prevalent at this time. Differing attitudes from different demographics are also highlighted, i.e. rural versus urban and the difference between men and women's attitudes. However, the continued use of natural enemies and diseases to control pests was deemed acceptable because, in the context of other forms of control, it was seen as no better or worse than those already being used at that time.

Biological control

In the 1990s, research on the biological control of rabbits and possums increased (Fitzgerald et al. 1996a) and a number of studies on the perceived risks of biological control were carried out (Fitzgerald et al. 1994, 1996a, b; Wilkinson & Fitzgerald 1997, 1998). Attitudes on the acceptability of a range of different control methods were researched along with specific attitudinal research on the rabbit calicivirus disease as a biological control. Arguments arising from this period of research include rabbits and possums being viewed as both pests and an economic resource. Awareness of the concept of "biological control of pests" was not a strong determinant of the acceptability of biological control. Humaneness and specificity of the control method are important to the public and manual technologies such as shooting and trapping are most acceptable (Wilkinson & Fitzgerald 1997). However, scepticism about the information being provided on new technologies is highlighted by Wilkinson and Fitzgerald (1997) and they argue that more public information is needed so that the public can understand the impacts and risks associated with the control methods being used. In addition, they argue that participatory decision-making would help to reduce concerns when a new technology is being proposed (Fitzgerald 1996a). Fear of "unintended consequences" was commonly raised as a concern by participants in the recent study by Wilkinson & Ferguson (2014) in relation to biological controls. Participants in this research argued that once organisms were released there is the possibility that the organism would be uncontrollable and may have unforeseen effects.

Biotechnology

By the end of the 1990s, biotechnology as a term is being used to describe a wide range of techniques and the complexity of the topic leads to attitudinal studies focusing on the public's attitudes to biotechnical techniques for invasive pest management. Richardson-Harman et al. (1998) investigate biotechnology in relation to food production and argue that there is no connection between knowledge of a new technology and its acceptability in practice. The terminology used by scientists is highlighted as an important consideration when carrying out biotechnology research (Mackay et al. 2000). 'Fear of the unknown' and the 'inability to contain a product if it was released' were identified in a number of attitudinal studies involving biotechnology. A lack of trust in the companies developing the technology was also considered (Mackay et al. 2000). A threat to New Zealand's "green image" was also cited as an argument for not pursuing genetic engineering in New Zealand (Mackay et al. 2000).

Uncertainty also drives the perception of risk literature on attitudes to new technologies and existing methods. Many of the articles researching attitudes to biological control or novel biotechnology methods have found that the public are conservative when it comes to embracing new technology. There is an unknown quantity or unpredictability about new methods that leads to a preference for modifying existing pest control methods rather than introducing new ones (Wilkinson & Fitzgerald 2000, 2014).

Aerial 1080

Running parallel to arguments about attitudes to biotechnology were public attitudes to possums and the aerial 1080 debate. Poisons, especially 1080, are viewed by pest control agencies as a cost-effective pest management tool that can be used at a landscape scale and kill multiple pests including possums, rats and stoats (Kannemeyer 2013). A number of articles from 2000 focus on attitudes to aerial 1080 (Horn & Kilvington 2002; Wilson & Cannon 2004; Bidwell 2012; Green & Rohan 2012; Kannemeyer 2013; Bidwell & Thompson 2015).

Trust in science and science institutions are identified by social researchers in relation to the aerial 1080 issue and are a common thread throughout many articles in this literature (Gamble et al. 2010; Bidwell 2012; Green & Rohan 2012; Kannemeyer 2013; Wilkinson & Fitzgerald 2014). Reasons for distrust often relate to personal experiences from the past, but distrust is also argued to be due to perceived levels of incompetence, secrecy over transparency, not applying the precautionary principle, exploitation and perceptions of not making commitments for the public good (Bidwell 2012). Wilkinson et al. (2000) argue that the most useful way to maintain public trust is to be open and honest when making decisions about novel technologies, while Bidwell (2012) argues the value of consulting with individuals and the local communities, including Maori.

Other arguments driving the aerial 1080 debate and the development of new technologies are place attachment, uncertainty, controllability and equity. Place attachment or a deep attachment to the natural environment is an argument used by a number of researchers in this review (Bidwell 2012; Kannemeyer 2013; Bidwell & Thompson 2015). Linked to this concept is that of controllability, in which communities or individuals may see a lack of political and economic control in the decision-making processes for pest management, i.e. they perceive themselves to have little influence over the decisions that are made in 'their place'. While place attachment to the natural environment is especially important for Māori, non-Māori also have a strong attachment and want to protect New Zealand's unique environment (Bidwell 2012).

Benefits to native species

Attitude research from the 1990s focused on the economic benefits to New Zealand's agricultural industry through the control of rabbits and possums, but benefits to New Zealand's native species were also becoming apparent in conservation areas where pest control was being carried out. Since 2000, attitude research arguments have included benefits to environmental and conservation values and the perceived threats to endangered species such as the iconic kiwi (Fitzgerald & Wilkinson 2002). During this time, community groups became more involved with pest control, resulting in attitudinal research on community consultation processes (Wilson & Cannon 2004). Arguments from this research highlighted the need to understand that every conservation area was different and every community was unique and needed its own set of tools or strategies to control pests (Wilson & Cannon 2004).

Controllability

Equity as a social concern is highlighted in Niemiec (2017) at the landscape scale, and relates to landowners being concerned that if all landowners do not participate in controlling their pests such control is a waste of time. The concept of collective awareness to achieve widespread control was seen as a challenge, and urban landowners were also expected to fulfil their pest control obligations if the C2C project was to succeed. Perceived control is also important because people feel safer when they have direct control over a situation in which they have an interest (Horn & Kilvington 2002). In a community, this may mean that they have some influence over the outcome of a pest control treatment, e.g. buffer zones around a water way (Kannemeyer 2013).

6.5 Scale, research method, and locality

An analysis of the 28 included articles showed research in 18 articles was carried out at a national scale, nine at a regional scale, and one at a local scale. The article that carried out research at the local scale (East and West Auckland) used interviews to provide insight into the way in which two biosecurity incursion programmes, to eradicate two invasive moth species, influenced communication and participatory strategies with the public and media (McEntee 2007).

Three articles carried out surveys in the Northland/Auckland region. The first two studies determined attitudes to non-native wild and feral animals (Farnworth et al. 2014) and feral cats (Farnworth et al. 2011), while the third article investigated consumer perceptions of fruit production techniques (Richardson-Harman et al. 1998). Interviews were utilised by Bidwell (2012) and Bidwell & Thompson (2015) to understand attitudes to aerial 1080 on the West Coast of the South Island; and aerial 1080 attitudes were also researched using both interviews and a survey in the Thames-Coromandel District (Kannemeyer 2013). Mixed method research was also conducted to determine landowner perspectives on invasive species in the Hawke's Bay Region (Niemiec et al. 2017). Tipa (2008) outlined the Ngai Tahu perspective on submissions to the Environmental Risk Management Authority (ERMA) on aerial 1080. In addition, Green and Rohan (2012) also reviewed submissions from the ERMA review of aerial 1080 but at the national scale.

All the articles by Fitzgerald and Wilkinson, apart from Fitzgerald et al. (2002), were carried out on a national scale using either surveys (Fitzgerald et al. 2005; Wilkinson & Fitzgerald 2006), focus groups (Wilkinson et al. 2000; Fitzgerald et al. 2002; Wilkinson & Fitzgerald 2014) or a combination of both (Fitzgerald et al. 1994, 1996a, b, 2000; Wilkinson & Fitzgerald 1997, 1998) to determine attitudes towards possums, rabbits, and stoats in particular, using various pest control methods. Surveys of the New Zealand public regarding introduced wildlife were generally carried out at the national scale (Sheppard & Urquhart 1991; Fraser 2001; Russell 2014) apart from those cited above. Wilson and Cannon (2004) used interviews at six locations around New Zealand (including iwi and hapū) and six nationwide focus groups to provide an overview of the Department of Conservation (DOC) information-sharing processes with communities about the use of aerial 1080 to control possums. A mixed methodology approach was also used nationwide by Mackay et al. (2000) to determine public views on the biotechnology question.

Huis were held by researchers in two articles - Wilkinson et al. (2000) organised a hui with South Island iwi to gain their perspective of possum fertility control methods and Horn & Kilvington's (2002) researched Māori attitudes to aerial 1080 communication and partnership processes; however, the location of the hui was not identified.

6.6 Organisations, researchers and populations sampled

New Zealand universities involved in attitude research specifically on invasive pests and their control are the University of Auckland (McEntee 2007; Kannemeyer 2013; Russell 2014), University of Otago (Bidwell, 2012; Bidwell & Thompson 2015), Lincoln University (Sheppard & Urquhart 1991), and Unitec (Farnworth et al. 2011, 2014). Research by Wilkinson (Landcare Research and Department of Environment and Primary Industries, Victoria, Australia) and Fitzgerald (Fitzgerald Applied Sociology) account for the majority of the articles included in this review.

Attitudes to pest control agencies responsible for the control of introduced pests were investigated in three articles (Fraser 2001; Kannemeyer 2013; Russell 2014). The Department of Conservation (DOC) was identified by the majority of respondents in all these surveys as being a key organisation responsible for managing or controlling introduced pests. Respondents in the Fraser 1994 survey identified MAF (now Ministry of Primary Industries MPI) as the next key organisation, whereas as in Kannemeyer (2013), respondents selected the Waikato Regional Council as the next most important organisation, followed by the Ministry for the Environment, the New Zealand Royal Forest and Bird Society, and MPI. The Animal Health Board (now TB Free New Zealand) was not identified in any of these surveys as being a key pest control organisation despite being strongly committed to eradicating bovine tuberculosis from possums and carrying out significantly more aerial 1080 operations than the DOC (Russell 2014). This finding may be highly contingent on an organisation's visibility in the media and their mandate to carry out pest management on private or public land (Russell 2014).

The populations sampled in this review range from landowners from the Hawke's Bay region to a broad cross-section of the New Zealand public from both rural and urban demographic regions, such as: animal welfare groups, conservationists, local communities with an interest in pest control, iwi or hapu, farmers, scientists, biosecurity specialists, policy advisers, DOC staff, media, and school students.

Only one article in this review engages with the younger generation or adolescents. Richardson-Harman et al. (1998) investigated attitudes to new gene technologies for fruit production and the perceived risks associated with them by secondary school children from Kerikeri High School and Mt Roskill Grammar School in Auckland. When compared with the adolescents, adults rated the use of pesticides as a more well-known and risky method whereas they rated irradiation as less well known and more risky than the younger respondents. Otherwise respondents from all the groups sampled held similar attitudes towards the techniques tested. Adolescents and young adults form a sector of the population whose attitudes are difficult to sample. They appear to be absent from most focus groups or their response to surveys is limited. Attitudinal surveys on pest control tend

to be dominated by respondents from the older age brackets i.e. over 50 years old (Kannemeyer 2013).

A number of studies found differences in the attitudes of men and women towards pest control methods. Women and younger people (under 40 years old) in particular appear to be less accepting of poisons, especially 1080 (Sheppard & Urquhart 1991; Fitzgerald et al. 1996a, 2000).

7 Discussion

To date, the limited attitudinal research specifically on New Zealand invasive pests and their control has concentrated on the vertebrate mammals – rabbits, possums, and stoats. Attitudes to other major pests such as rats, mice, feral cats, hedgehogs, and wasps, which are known to threaten New Zealand's native biodiversity, have sometimes been included in general wildlife surveys but have not been extensively researched.

A gap exists in the literature on public attitudes to invasive plants or weeds and their control as none of the articles identified in the database searches met the criteria necessary for inclusion in this review.

The pest control methods that have driven attitude research in New Zealand are aerial 1080, biological controls and biotechnologies. A recent PCE report, "Taonga of an island nation: Saving New Zealand's birds", highlights innovations in trapping, poisons and genetic science which may have the potential to suppress and/or potentially eradicate mammal predators on a wide scale in New Zealand (PCE 2107). Species specific toxins, the TFT, and gene drive are examples of such biotechnologies and according to PCE (2017) are fast-evolving fields of genetic science. However, if New Zealand's native species are to be protected and the goal of becoming predator free by 2050 is to be achieved, attitude research must accompany any new or novel pest control approach.

In this review, research showed that the public has difficulty accepting new technologies because of the perceived unforeseen risks. For example, concern about the unintended consequences of introducing TFT as a novel non-lethal approach to control pest populations was highlighted in Wilkinson and Fitzgerald (2014). The public also needs a guarantee that the method will be humane, safe, and specific to the target species. Attitudes to poisons have remained static over time but women, in particular, are still less accepting of using poisons than men to control pests. Aerially broadcasting 1080 pellets to control possums, rats, and stoats continues to polarise the public and has led to numerous attitudinal studies being identified in this review. The PCE still advocates using aerial 1080, especially in beech forests when there is a mast event, because of its cost-effectiveness in controlling possums, rats and stoats over large areas of rugged and difficult to access terrain (PCE 2017). Pest control at a landscape scale is important for ensuring New Zealand's native species can thrive.

The research in this review shows that there are a range of perceived risks and different levels of social acceptability depending on the pest species targeted and the control method used. Wilkinson et al. (2014) identified a list of criteria necessary for accepting an existing or

current pest control technique and these criteria have become synonymous with attitudinal research on invasive pests and their control in New Zealand:

- Humaneness
- Safety for humans and non-target species
- Specific to the target species
- Effective at controlling the target species
- Cost efficient
- Generating additional benefits
- Tested or well-researched and proven
- Does not involve visible death

However, these criteria need to be supported with good communication, trustworthy science, rigorous and robust decision-making processes, and inclusive consultation with local communities (Wilkinson & Ferguson 2002, 2014). It would also be prudent for researchers to include media responses to scientific risk when investigating public attitudes to pest control.

Overall, this review has shown there is a need to broaden attitude research not only to investigate a wider range of pests and control tools, but also to explore the concept and politics of 'a sense of place'. Bidwell & Thompson (2015) suggest that where there are divergent interests and values, finding areas of common ground to encourage respect and trust between those opposing views may be the way forward, along with including a wider group of public attitudes within the management structure. With new approaches to pest management in New Zealand being developed and ongoing incremental improvements in conventional control, acceptance by the public of any new or novel technologies is paramount (Duckworth et al. 2006). A study by Lee et al. (2005) on public attitudes toward emerging technologies found that people's emotional reactions to nanotechnology was partly influenced by their experiences with and attitudes to previous scientific controversies, which highlights the need to sustain effective public communication and involvement regarding decision-making of new technologies.

For scientific advances to continue to be made to control invasive pests, social research needs not only to be integrated at the local, regional or national scale but also to be broadened to understand the implications of pest control management at the societal level. Social complexities exist about the ethics and philosophy of new or novel technologies, and research into public attitude has yet to be elevated to this level. Finally, for new biotechnologies to be socially acceptable, 'social licence to operate' needs early and continuous engagement of the science community with society at all levels and in all areas (Gluckman 2016).

8 Conclusions

There are multiple ways to frame attitudinal research about invasive pests and their management. In this review, the majority of articles focus on the drivers of risk perception from a social, ecological, and health perspective. Trust and community participation are other frames identified in this review; however, economic, cultural, and political perceptions of risk relating to pest management are usually not the main focus of attitudinal research.

This systematic literature review has enabled the relevant articles on public attitudes to New Zealand pest controls methods to be identified, analysed and synthesised. The findings have shown that there is not one public but multiple publics with a wide range of attitudes to existing, new or novel pest control technologies. Social research needs to be carried out alongside the development of any new approaches to pest management. In addition, research on novel technologies should also be broadened to the societal scale and include ethical and philosophical dialogues. Fear of the unknown is unproductive and will not lead to new advancements to control major pests such as possum, rabbits, stoats, rats and wasps. Ultimately, New Zealand society will decide which pest control technologies are acceptable or not.

9 Recommendations

Novel technologies for pest control are being developed in New Zealand but without public acceptance they may be met with strong opposition by the public. Recommendation three from PCE (2017) suggests developing a programme of staged engagement with the general public on the potential uses of genetic techniques to control predators. Next steps could include:

- Research on the social acceptance of novel technologies for control of a wider group of pests both vertebrate and invertebrate e.g. wasps, rats, mice, feral cats and hedgehogs.
- Attitudinal research on invasive pests at different spatial scales, particularly at the local scale but also exploring the concepts and politics of ‘a sense of place’.
- Ethical and philosophical research on the social complexities of novel technologies.

There is a gap in the literature on public attitudes to invasive plants or weeds and their control which should be investigated from a societal perspective.

The majority of research in this review has focused on the attitudes of adults to pest control methods but there is a need to understand the attitudes of young adults as well – especially with the PFNZ long-term goal of eliminating eight introduced mammalian predators throughout New Zealand by 2050 (Russell et al. 2015).

10 Limitations of the review

This review aimed to be comprehensive but some older grey literature was not able to be accessed in the time frame available. An adjustment was made of the inclusion and

exclusion criteria as the review proceeded as there were a number of papers from the 1990s that were single viewpoints rather than scientific studies that utilised qualitative and/or quantitative methodologies to determine public attitudes. A quality assessment of the methodologies used in the included studies was not conducted due to the limited time available for the review.

The outcome of the review is still subject to 'reviewer effects', even though a systematic review process was used throughout. While I sought to conduct an objective review, my own prejudices and the fact that I authored one of the articles may have affected the analysis.

10.1 Review of the Review

Landcare Research and Department of Conservation researchers reviewed this systematic review as part of the approval process and publishing of this report.

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Appendix A Examples of database searches

1. Web of Science (WOS) Core Collection Search

WOS is a multidisciplinary index to the journal and conference proceedings literature of the sciences, social sciences, arts and humanities; providing references and cited references from more than 230 disciplines.
All of the WOS searches used the following advanced search parameters: English, 1900–2017, all document types, and not Chemical indexes

Database	Date	Search terms		No. papers retrieved	No. papers included	Retrieved & Already included	No. Papers excluded
		Key terms	Qualifiers				
WOS 1	27-Mar-17	(Attitud* OR View* or Percept*) AND "New Zealand"	AND "Pest Control"	12	7	0	5
WOS 2	28-Mar-17	(Attitud* OR View* or Percept*) AND "New Zealand"	AND ("toxi* or poison* or 1080 or "chemical control")	58	2	2	54
WOS 3	28-Mar-17	(Attitud* OR View* or Percept*) AND "New Zealand"	AND ("biolog* control" OR "integrated pest management")	29	6	1	22
WOS 4	28-Mar-17	(Attitud* OR View* or Percept*) AND "New Zealand"	AND (("invas* mammal* OR animal") OR pest* OR predator*))	101	9	11	81
WOS 5 & 6	28-Mar-17	(Attitud* OR View* or Percept*) AND "New Zealand"	AND (("Introduc* mammal* OR animal*") OR possum* Or rat* OR Stoat) + Refined to ecology, biodiversity conservation, environmental sciences, geography physical and evolutionary biology	57	0	0	57
WOS 7	28-Mar-17	(Attitud* OR View* or Percept*) AND "New Zealand"	AND ("invas* plant*" OR "invas* weed*")	4	0	0	4
WOS 8	28-Mar-17	(Attitud* OR View* or Percept*) AND "New Zealand"	AND (("novel or new or innovat* tech*") AND ("biodivers* conservat*"))	16	0	1	15
WOS 9	28-Mar-17	(Attitud* OR View* or Percept*) AND "New Zealand"	AND (("novel or new or innovat* tech*") AND ("biodivers* conserv*"))	109	0	0	109
WOS 10	28-Mar-17	(Attitud* OR View* or Percept*) AND "New Zealand"	AND ((*gene* OR trojan* OR *tech*) AND biodivers* AND conserv*)	16	0	1	15

WOS 11	28-Mar-17	(Attitud* OR View* or Percept*) AND "New Zealand"	AND ((*gene* OR trojan* OR *tech*) AND biodivers* OR conserv*)	109	1	4	104
WOS 12	28-Mar-17	(Attitud* OR View* or Percept*) AND "New Zealand"	AND ((Maori* OR Iwi*) AND (invasiv* OR "pest* Control*")	4	0	1	3
WOS 13	28-Mar-17	(Attitud* OR View* or Percept*) AND "New Zealand"	AND ((wasp* OR rat* or possum* or mustelid* or cat*) AND (invasiv* OR "pest* Control*")	34	0	4	30
			Total	**549**	**25**	**25**	**499**

2. New Zealand Science

Index records of New Zealand science publications provided by Crown Research Institutes and The Royal Society of New Zealand

Database	**Date**	**Search terms**		**No. papers retrieved**	**No. papers included**	**Retrieved & Already included**	**No. Papers excluded**
		Key terms	**Qualifiers**				
NZ SCI 1	5-Apr-17	(Attitud* OR View* or Percept*) AND "New Zealand"	AND "Pest* control")	28	13	3	12
NZ SCI 2	5-Apr-17	(Attitud* OR View* or Percept*) AND "New Zealand"	AND (tech* or gene*)) AND conservat*	70	3	1	66
NZ SCI 3	5-Apr-17	(Attitud* OR View* or Percept*) AND "New Zealand"	AND Maori AND pest*)	3	0	2	1
NZ SCI 4*	5-Apr-17	(Attitud* OR View* or Percept*) AND "New Zealand"	((possum* OR wasp* OR stoat* OR rat*) AND 1080)	269	2	1	266
NZ SCI 5*	6-Apr-17	(Attitud* OR View* or Percept*) AND "New Zealand"	AND "biolog* control"	18	4	6	8
NZ SCI 6*	6-Apr-17	(Attitud* OR View* or Percept*) AND "New Zealand"	AND ((tech* OR gene*) AND control)	91	1	7	83
			Total	**479**	**23**	**20**	**436**

* from 1950

3. SCOPUS

Scopus is the largest abstract and citation database of peer-reviewed literature; covers Sciences, Engineering, Medicine, Social Sciences and some Arts. Contains 49 million records; 78% with abstracts. Over 5.3 million conference papers are included

Database	Date	Search terms		No. papers retrieved	No. papers included	Retrieved & Already included	No. Papers excluded
		Limiting or exclusion terms	Key terms and Qualifiers				
Scopus 1	6-Apr-17	Advanced search - Limited to NZ. Excluded Earth and Planetary Science and Medicine	(Attitude OR view* OR Perception) AND Zealand AND "pest control"	21	0	7	14
Scopus 2	7-Apr-17	Advanced search - Limited to NZ. Excluded Earth and Planetary Science	(Attitude OR view* OR Perception) AND Zealand AND (Maori AND "pest control")	0	0	0	0
Scopus 3	7-Apr-17	Advanced search - Limited to NZ. Excluded Earth and Planetary Science	(Attitude OR view* OR Perception) AND Zealand AND 1080	6	0	2	4
Scopus 4	7-Apr-17	Advanced search - Limited to NZ, social science, agricultural and biological science and environmental science	(Attitude OR view* OR Perception) AND Zealand AND (biotech* or gene*)	208	5	4	199
Scopus 5	7-Apr-17	Advanced search - Limited to NZ, social science, agricultural and biological science, environmental science, veterinary, biochemical genetics and molecular biology.	(Attitude OR view* OR Perception) AND Zealand AND ((possum OR Wasp OR Rat OR Stoat Or Cat) AND control)	15	2	6	7
Scopus 6	7-Apr-17	Advanced search - Limited to NZ; Excluded Earth and Planetary Science; immunology; and microbiology	(Attitude OR view* OR Perception) AND Zealand AND "biological control"	22	0	4	18
Scopus 7	7-Apr-17	Advanced search - Limited to NZ; Excluded Earth and Planetary Science; Medicine, and chemical engineering	(Attitude OR view* OR Perception) AND Zealand AND ("invasiv* plant" OR pest)	17	1	6	10
			Total	**289**	**8**	**29**	**252**

Appendix B Excluded articles

A list of all the articles that were excluded from the literature search and the reason for their exclusion

	Author(s) and Year	Title	Exclusion Reason
1	Aerni (2009)	What is sustainable agriculture? Empirical evidence of diverging views in Switzerland and New Zealand	Not key terms or qualifiers: About sustainable agriculture
2	Alspach (1993)	Pest problems: the view of the Animal Health Board	Methodology not determined: Single stakeholder perspective
3	Atkinson (1988)	Some attitudes to controlling or eradicating unwanted plants and animals	Unable to locate in the time frame
4	Beck et al. (1992)	IPM for greenhouse crops in NZ: grower acceptance	Unable to locate full publication in timeframe
5	Cameron et al. (1993)	Analysis of importations for biological control of insect pests and weeds in NZ	Not key terms or qualifiers: Changing practices to biological control
6	Clayton (2003)	Weeds, People and Contested Places.	Not key terms or qualifiers: Historical account of the way weeds have become introduced into NZ
7	Clout and Sarre (1997)	Model marsupial or menace? A review of research on brushtail possums in Australia and New Zealand	Not key terms or qualifiers: Review of possum literature but doesn't include the social impact
8	Coleman 1993	The integration of management of vertebrate pests in NZ	Not key terms or qualifiers
9	Corner (2002)	Two studies on the control of wildlife-derived tuberculosis: farmer views and model validation	Not key terms or qualifiers: Farmers attitudes to eradicating tuberculosis in cattle
10	Couchman and Fink-Jensen (1990)	Public attitudes to genetic engineering in New Zealand	Unable to locate in the time frame
11	Cowie (2006)	Utilising the human dimensions of wildlife management approach to initiate an understanding of the ways in which New Zealanders value wildlife in Aotearoa, New Zealand	Not key terms or qualifiers: Research is about wildlife values
12	Coyle and Fairweather (2005)	Challenging a place myth: New Zealand's clean green image meets the biotechnology revolution.	Not key terms or qualifiers: Article about 'clean green image' of NZ and biotechnology
13	Craig et al. (2000)	Conservation Issues in New Zealand	Not key terms or qualifiers: An overview of conservation issues in NZ in 2000
14	Daugherty and Towns (1991)	The cat's breakfast	Not key terms or qualifiers

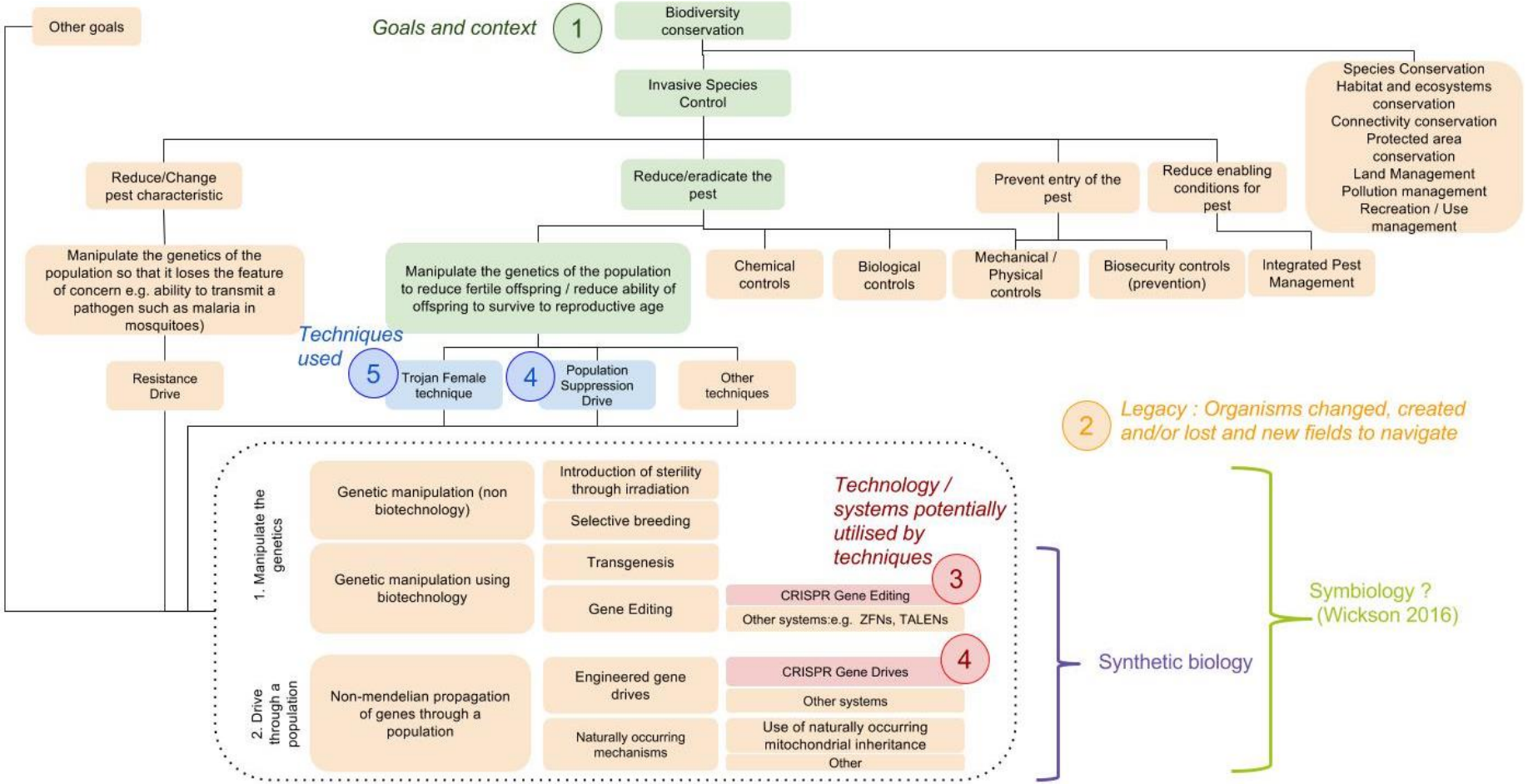
	Author(s) and Year	Title	Exclusion Reason
15	Douglas et al. (1998)	Weeds - noxious plants or valuable crops - a need for flexible regulation and attitudes	Not key terms or qualifiers: Regulatory
16	DSIR Plant Protection (1992)	IPM grower survey	Not key terms or qualifiers: An Orchardist communication
17	Duckworth et al. 2006	Pest control: does the answer lie in new biotechnologies	Not key terms or qualifiers
18	Fraser (2006)	Public attitudes to pest control: A literature review	A literature review but key studies added to this review list
19	Fraser (1995)	Public attitudes to introduced wildlife and wildlife management in NZ	Duplicate report presented in Landcare Research Science Series No. 23 Report 2001
20	Gamble (2001)	Genetic engineering: The New Zealand public's point of view	Not key terms or qualifiers: On genetic engineering of plants and plant based products
21	Gamble (2002)	Public perception of genetic engineering	Unable to locate paper at the website and other papers from Gamble reviewed
22	Gamble (2009)	Guardians of our future: New Zealand mothers and sustainable biotechnology.	Not key terms or qualifiers: Focus is on sustainable biotechnology in relation to mothers and their children
23	Gamble and Kassardjian (2008)	The use of selected community groups to elect and understand the values underlying attitudes towards biotechnology	Not key terms or qualifiers: Focus is not on biotechnology for pest control but interesting research which explores the social, cultural and spiritual dimensions of biotechnology
24	Gamble et al. (2000)	Genetic engineering: the public's point of view: report to stakeholders.	A client report - confidential
25	Goldson et al. (1998)	What is a safe biological control agent	Not key terms or qualifiers: Mitigating the risk of introducing biological control agents
26	Gunn (1994)	Animals and society: how simple are the issues	A client report - confidential
27	Guthrie (1993)	Pest problems - the view of the NZ-conservation -authority	Not key terms or qualifiers: Single stakeholder perspective. Overview of pests
28	Hall et al. (2016)	Community attitudes and practices of urban residents regarding predation by pet cats on wildlife: an international comparison	Not key terms or qualifiers: Domestic cat interactions with wildlife in Australia, NZ, the UK, the USA, China and Japan

	Author(s) and Year	Title	Exclusion Reason
29	Harrod et al. (2016)	Use and perception of collars for companion cats in New Zealand	Not key terms or qualifiers: Domestic cats not feral cats
30	Holt (1993)	Pest problems: the view of the NZ Forest Owners' Association	Not key terms or qualifiers: Single stakeholder perspective
31	Houston (1993)	Pest problems - the view of tu NZ Federated Farmers	Not key terms or qualifiers: Single stakeholder perspective
32	Hughes (1993)	Pest problems - the view of the NZ forest owners association	Not key terms or qualifiers: Single stakeholder perspective
33	Hughes (1997)	Registration of biological pesticides: a regulator's viewpoint	Not key terms or qualifiers
34	Hunt and Rosin (2007)	The active kiwifruit orchard: orchard/orchardist interaction	Not key terms or qualifiers
35	James (2001)	Understanding the conservation expectations of Aucklanders	Not key terms or qualifiers: Focus is on DOC and broad conservation values in Auckland
36	Jay (2004)	Symbolic order and material agency: A cultural ecology of native forest remnants on Waikato dairy farms	Not key terms or qualifiers: Explores dairy farmers agricultural production values and land management practices
37	Jay and Morad (2006)	The socioeconomic dimensions of biosecurity: the New Zealand experience	Not key terms or qualifiers: History of culture and politics around biosecurity and introduction of the Biosecurity Act (1993) in NZ
38	Lyttle (2014)	The relationship between public understanding of science and support for environmental restoration	Not key terms or qualifiers: Focus is on environmental restoration and the public
39	Macer (1997)	Public perception of biotechnology in New Zealand and the International Community: Eurobarometer 46.1. Tsukuba Science City, Japan, Eubios ethics Institute	Unable to locate in the time frame
40	Marsh (2004)	An investigation into the determinants of innovation in the NZ biotechnology sector	Not key terms or qualifiers: Economic framework for analysing determinants of innovation in the NZ biotechnology sector
41	Martin (1990)	Pesticide use: a scientific view	Not key terms or qualifiers: Single stakeholder perspective
42	McEntree (2006)	Science communication in an age of risk: a case study of two biosecurity incursions	Unable to source a copy of the thesis; Results published in McEntree (2007) paper
43	Munn (1995)	Sustaining Pest control: a Maori view	Unable to access the proceedings online
44	Ogilvie (2010)	There’s a rumble in the jungle: 1080 poisoning our forests or a necessary tool?	Unable to locate in the time available

	Author(s) and Year	Title	Exclusion Reason
45	Ogilvie et al. (2010)	Vertebrate pesticide risk assessment by indigenous communities in New Zealand	Not key terms or qualifiers: Outlines steps taken to allow Maori to assess 1080 risk
46	Penman (1994)	Pesticides in plants: perceptions, education and reality	Not key terms or qualifiers: Raises some interesting points about the acceptance of new technology such as biotechnology
47	Piddock (2014)	Non market value of biodiversity on agricultural land by rural landowners: a case study	Not key terms or qualifiers: Research on improving biodiversity on farms
48	Potts (2009)	Kiwis against possums: A critical analysis of anti-possum rhetoric in Aotearoa NZ	Methodology not determined: Single stakeholder perspective
49	Prime (1993)	Pest problems: the view of Nga Whenua Rāhui	Methodology not determined: Single stakeholder perspective
50	Roberts (2009)	Consultation concerning novel biotechnologies: who speaks for Māori?	Not key terms or qualifiers: Focus on ethical issues concerning consultation with Maori on biotechnology issues (individual versus collective rights)
51	Salmon (1993)	Pest problems: the view of an environmentalist	Methodology not determined: Single stakeholder perspective Talks about the need for a new integrated vision for NZ and importance of 1080.
52	Kerr and Cullen (1995)	Public preferences and efficient allocation of a possum-control budget.	Not key terms or qualifiers: Possum control budgets and the willingness of people to pay for possum control
53	Shaw et al. (2014)	Historical trends in frog populations in NZ based on public perceptions	Not key terms or qualifiers: Survey of public perceptions to frog populations in NZ
54	Shields et al. (2016)	Potential ecosystem service delivery by endemic plants in NZ vineyards: successes and prospects	Not key terms or qualifiers: Focused on increasing ecosystem services
55	Sivak (2006)	Culture and science: A critical assessment of public consultation about biotechnology in New Zealand	Not key terms or qualifiers: Assesses the public consultation process around biotechnology and the pest control methodologies or attitudes to them
56	Steve (1999)	Perceptions and reality in pest control on kiwifruit in New Zealand	Methodology not determined
57	Waage (1997)	Biological control in the green oasis	Not key terms or qualifiers:

	Author(s) and Year	Title	Exclusion Reason
58	Warner (2012)	Fighting pathophobia: how to construct constructive public engagement with biocontrol for nature without augmenting public fears	Not key terms or qualifiers: Focus is on the US although a comparison with NZ is made.
59	Watts (2000)	Ethical pesticide policy: beyond risk assessment	Not key terms or qualifiers: Developing pesticide policy
60	Williams (1993)	Effects of public perceptions and global market strategy on the development of biological-control technology in NZ	A review by the author of 4 aspects of vertebrate pest management and potential barriers that might inhibit the use of biological control. Uses Sheppard & Urquhart (1991) results.
61	Williams (1993)	Effects of public perceptions and global market strategy on the development of biological control technology in New Zealand	Duplicate of Williams (1993)
62	Wilson-Salt (1996)	An analysis of consumer beliefs and attitudes towards agrichemical use and agrichemical residues on fresh fruits and vegetables	Not key terms or qualifiers: Focus is on consumer attitudes to agrichemical use and residues on fruit and vegetables
63	Wreford (2000)	Genetic engineering and organic agriculture: perceptions of organic exporters, producers, and consumers	Not key terms or qualifiers: Specifically about organic production

Appendix C Summary of key biotechnology themes: A context for gene editing and gene drives



This figure provides a context for gene editing and gene drives within the fields of biodiversity conservation and symbiology.
This representation also attempts to distinguish between: technologies; techniques that develop specific ways to deploy technologies; the goals and/or intended impact; and the legacy and/or new fields that develop to manage the outcomes of the technology. This context/breakdown is provided as (i) many of the ethical issues and effects of gene editing and gene drives also apply to other technologies/techniques/goals/outcomes and should be discussed within this context, (ii) the context is used to categorise the literature provided in this bibliography, (indicated by numbering), and (iii) it supports opening up the discussion around a need for a new language and frame of reference.

Glossary

Biological Control	using biological means such as parasites, viruses or predators to control a pest
Biotechnology	studying or manipulating one or more of the basic components of living things: tissues, cells, proteins, genes or DNA. It can include identification and characterisation of genes, genetic engineering, growing cells in a culture, or utilising cell components other than genes.
Genetic engineering	the process by which genes are added to or deleted from an organism to change the inherited characteristics of the organism
GMO	a genetically modified organism that has been modified by genetic engineering
Socially acceptable	Acceptance of a pest control technology in society
Stakeholder	A person, group or institution with interests in a policy, programme or project relating to an issue or problem
Transgenic	a plant or animal that has had genes transferred to it from another species