The Human Factors of Kauri Protection

Review and synthesis of social science research

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1. Executive Summary

Given that humans have the most influence over kauri dieback (KDB) spread or mitigation thereof, the National Kauri Dieback Programme (KDP) has applied social science and behaviour change methodologies to try to mitigate its spread by influencing human behaviour. The purpose of the current report is to review the extant social science research on KDB, identify key insights and social science knowledge gaps, and provide recommendations for future research and investments.

Review Findings

Drawing from across twenty-seven reviewed documents, and six interviews with KDB social science researchers, overall findings suggest that:

- There has been a general increase in awareness and valuing of kauri (62.3%), an increase in knowledge of KDB (36%), and the willingness to engage in Kauri protective behaviours (46% at cleaning stations; 19.1% of other behaviours). There is also an overall trend showing that cleaning station design significantly increases behavioural compliance.

- Though less clear, research findings suggest that people have personal, social, and ecological reasons for why they value kauri and its protection; with some evidence suggesting these values may differ across audiences. Interestingly, recent results also suggest that there are mixed feelings regarding the effectiveness and longevity of the current approach to KDB management, with an initial increase in the 'perceived seriousness between 2012 and 2016 (19%) followed by a decline in 2019 by 3%.

- Findings also show that different groups may differ in their view of KDB and its seriousness depending on their level of identification to a particular activity (e.g., hunters tend to view KD protective behaviours as more unachievable and ineffective and tend to be more closed off to information about KDB. They also seem to have some concern about KDB and whether KDB management has considered the impact there might be on hunting rights and access). Finally, there is some research which suggests that there is a growing KDB culture where there is higher peer to peer influencing of behaviours.

Recommendations

Based on a social science review of the findings and through the application of best practice social science principles, this report presents the following recommendations for future research and investment:

Methodological**.** Given the complexity of the KDB problem, as well as the myriad of social science fields and methods, a behavioural- and social-psychology perspective was applied in this review which seeks to understand and predict specific behavioural patterns at both the individual and group level. Based on this approach, it is recommended that:

- More attention be given into following social science best practice guidelines and the selection of methods that are appropriate for bespoke research questions (which may require participatory research).

- E.g., the research question “why do people value kauri?’ could be first explored through open ended interviews, the findings from which could then be used to select a suite of reliable and valid metrics, such as ‘level of agreement that kauri are a national icon,’ ‘are ecologically significant’ and ‘warrant protection.’[1]

- Future quantitative research invests in theoretically justified and robust metrics and analytical methods, which can be used across studies and over time.
  - E.g., Some studies categorised the participants by asking them activity’ by what behaviours they performed during their ‘last visit’ whereas in other cases it was measured by how frequently one has engaged in that behaviour in the past 12 months, The difference in measurement makes comparison more challenging and so future studies would benefit from clear metric definition and consistent measurement methods.

- The consideration and inclusion of a fuller suite of measurement options that can offer greater precision and depth to specific research areas.
  - E.g., given the gap between ‘self-reported’ and ‘observed’ behaviours; (a finding consistent with the reviewed KDB studies and wider literature), more observational data-collection methods would be beneficial such as capturing ‘staying on track’ behaviours through surveillance cameras or by research assistant surveying in addition to more common ‘self-reported’ survey or interview/focus group methods.

- The application of qualitative approaches that offer problem exploration and solution identification from a grass-roots level.
  - E.g., a participatory research process could be used to ask local communities more openly what they think key issues are with kauri protection and what areas would warrant further research, whether it be social research or otherwise.

Operational. Though the specific focus of any short-term research will depend on the strategic direction that the KDP takes, it is recommended that the following knowledge gaps be given more urgent attention:

- Examination of a broader range of Kauri protective behaviours, such as staying on track behaviours and off-track behaviours (such as hunting/trapping/farming); with a specific focus on methodologies that can capture greater in situ nuance.

- Identification of specific audiences within the KDB space and the underlying values, beliefs and attitudes that drive behaviour and what would enable long-term buy in into a common vision.

- Improve our understanding of the full KDB overall culture. This could be approached by exploring the full behavioural journey from at home cleaning behaviours, to on-track\on kauri lands, right through to home return. Included in this evaluation should

[1] This should be interpreted as an ‘example’ operationalisation only as each research question would require a consideration of what ‘valuing kauri’ would be defined as followed by a selection of appropriate, valid, and reliable metrics that satisfy the definition.

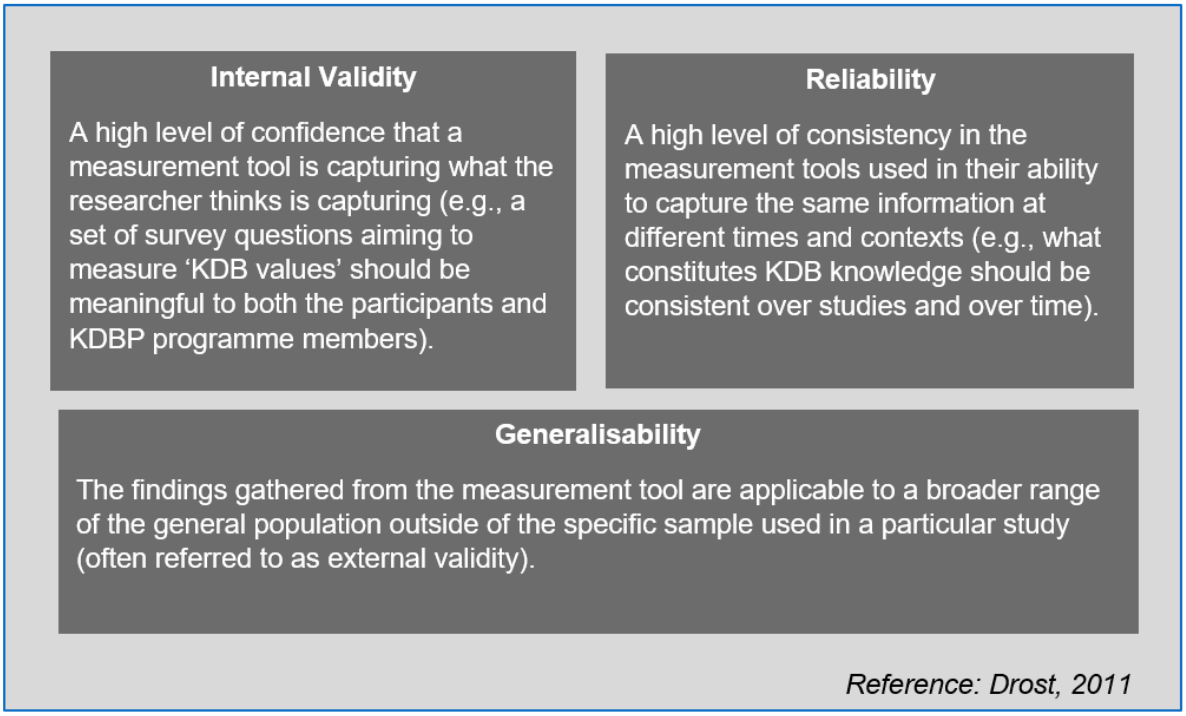
be channels of KDB information and the wider KDB culture. Additionally, a series of social impact assessments could be applied for specific communities of interest or where the impact of KD protection is most severe (for the kauri and local people).

Strategic. From across the documented research, as well as in conversation with all six social science researchers, the following overall strategic recommendations emerged:

- A need for greater integration of social sciences across the full spectrum of KDB research right from the planning stages, through to research design, data-collection, analysis, piloting, implementation, and evaluation.

- Strive towards integrating social science best practice benchmarks of validity, reliability and generalisability across social research conducted as part of the KDBP (see Figure 1 for more detail).

Figure 1. A summary of the three key research benchmarks.



- Move towards a more transdisciplinary, co-design social research approach that ensures buy in from across KDBP partners (and beyond) to allow for more knowledge sharing as well as greater cohesion, collaboration, and trust among those engaged in KDB social science research. This shift would align closely with the National Programme Strategic Plan for Behaviour Change, the Science Plan and the National (Kauri Dieback) Pest Management Plan).

2. Background

Kauri (*agathis australis)* are iconic New Zealand trees that have social, cultural, and environmental significance (Bradshaw et al., 2020). They are treasured as a national taonga by tangata whenua and New Zealanders alike and are valued for their central role in New Zealand ecological systems (Dickie & Black, 2016). As such, the emergence and on-going threat of the kauri dieback disease (KDB) is of great concern given its potential to spread and permanently damage kauri forests and surrounding ecosystems. As a response to this threat, the national kauri dieback programme (KDBP) was launched with aims to identify ways to prevent, mitigate and manage the immediate spread of KDB while also seeking long-term solutions.

Though much is left to be understood about KDB, there is sufficient evidence to confirm that the primary fungal agent of the disease (*Phytophthora agathidicida*) is predominately spread by soil movement, rendering human locomotion one of the key vectors of KDB transmission (Bradshaw et al., 2020; Dickie & Black, 2016; Heggie-Gracie & Robertson, 2015). Consequently, the KDBP is increasingly looking towards the social sciences to further our understanding of the risks caused by human behaviour to kauri.

The objective of the current report was to review and evaluate the social science research to date relating to KDB. To this end, the report includes:

- A high-level summary of existing social science published research and grey literature (international and NZ specific), highlighting what aspects have been examined and insights gathered.

- A social science research knowledge-gap analysis identifying the limitations of the research to date as well as what remains unclear or under-explored.

- Supplementary Appendix A, which provides more detail on the reviewed social research and literature. It should be noted however that this summary should be seen as a directory rather than an exhaustive account of all insights that could be gleaned from individual pieces of research.

- A set of recommendations for potential lines of investment for future research and/or operational implementation that could increase compliance of identified Kauri protective behaviours as well as overall engagement with the KDB issues, including a schematic representation of how research could be prioritised. Relevant social science principles will be used to direct the programme towards best practice theoretical and methodological approaches.

- An integration of report findings within the strategic framework of the KDBP more broadly. This includes an assessment of how the report findings relate to the Kauri Dieback Science Plan (KDB Science Plan), the National Programme Strategic Plan for Behaviour Change[2] (KDB Strategic Plan) and the National (Kauri Dieback) Pest

[2] Developed by the Kauri Dieback Programme Behaviour Change Workstream.

Management Plan (NPMP).

- Supplementary Appendix B, which provides a prioritisation schematic for structuring the recommended research steps forward. It is important to highlight that this schematic is reflective of overall ‘research’ priorities, and as such, greater integration with wider KDBP strategic planning and operationalisation is advised.

- An A3 representation of overall research conclusions which will exemplify the key findings as well as an outline of a possible research designs for future studies.

3. Report Outline

Since KDBP's establishment in 2009, there has been increasing demand for evidence-based social science perspectives that may elucidate the influence of forest users and wider communities in KDB prevention, mitigation and management. Beginning with the Kauri Dieback Protection group in 2010, a series of studies have been conducted by KDBP and independent research consultancies. This report synthesizes the findings of the social science research concerning KDB, drawing from both academic manuscripts and grey literature. To sum, this report presents:

- A review of key social research questions concerning KDB as well as to the methods and metrics used for in their investigation.
- A summary of the extant research findings including key insights and areas of progress as well as remaining research gaps and limitations.
- A high-level analysis of the documented and available KDB social science research to date; highlighting key social science research knowledge-gaps.
- Recommendations for future social science research relating to KDB as well as guidance on methods by which this could be achieved.

Supplementary to the report is Appendix A which provides a descriptive summary of all included social science research that was reviewed. Specifics provided in the summary include research sources, key research objectives, methods and measurements, and key relevant insights.

Defining this Social Science Review

Like the natural sciences, the 'social sciences' include several distinct fields of inquiry including (but not limited to) psychology, anthropology, sociology, human factors and communications; each with their own specific disciplines, philosophical viewpoints and methodologies. In the process of this review, a number of different fields were identified including social psychology, behavioural science, social research, anthropology, sociology, ergonomics, human factors, urban design, communications, marketing and consultation. While they are complimentary, it was considered important to outline the specific social scientific lens applied for this report to inform the reader on its advantages and limitations.

A behavioural- and social-psychology perspective which seeks to understand and predict specific behavioural patterns at both the individual and group level was applied in the review (Breakwell, et al, 2006).

The selected approach focuses on operationalising key influencing variables to measure behaviour and identify changes in such behaviour with a high level of precision and clarity over time. To achieve this, it is preferable that the measurement constructs used are transparent and consistent, increasing the likelihood that the results found will be valid, reliable across time and generalisable to broader populations. Figure 2. A summary of the three key research benchmarks. presents a summary of these three key research benchmarks. This research approach is particularly useful in the context of KDB given that one of the key aims of the KDBP is to identify and change specific behavioural patterns over time, meaning the research calls for a high level of precision and comparability.

A noteworthy limitation to any rigorous research approach lies in that, to attain the higher level of confidence and precision of research findings, a greater amount of time and resources are required, often narrowing down the research focus to a smaller set of variables and contexts. This it can make the synthesis of research findings more difficult to achieve given the lower level of comparably of studies. To overcome this limitation, this review gathered insights by synthesising findings according to available evidence and the reviewers expertise, balancing the level of confidence we can have in a given study's findings with its limitations, As a result, the report offers a graduated review where some insights hold greater weight as compared to others, which could benefit from further examination.

While linkages have been made between the findings and their operational implementation, including engagement and communication efforts, a detailed examination of these areas necessitates bespoke expertise and, as such, is beyond the scope of this report.

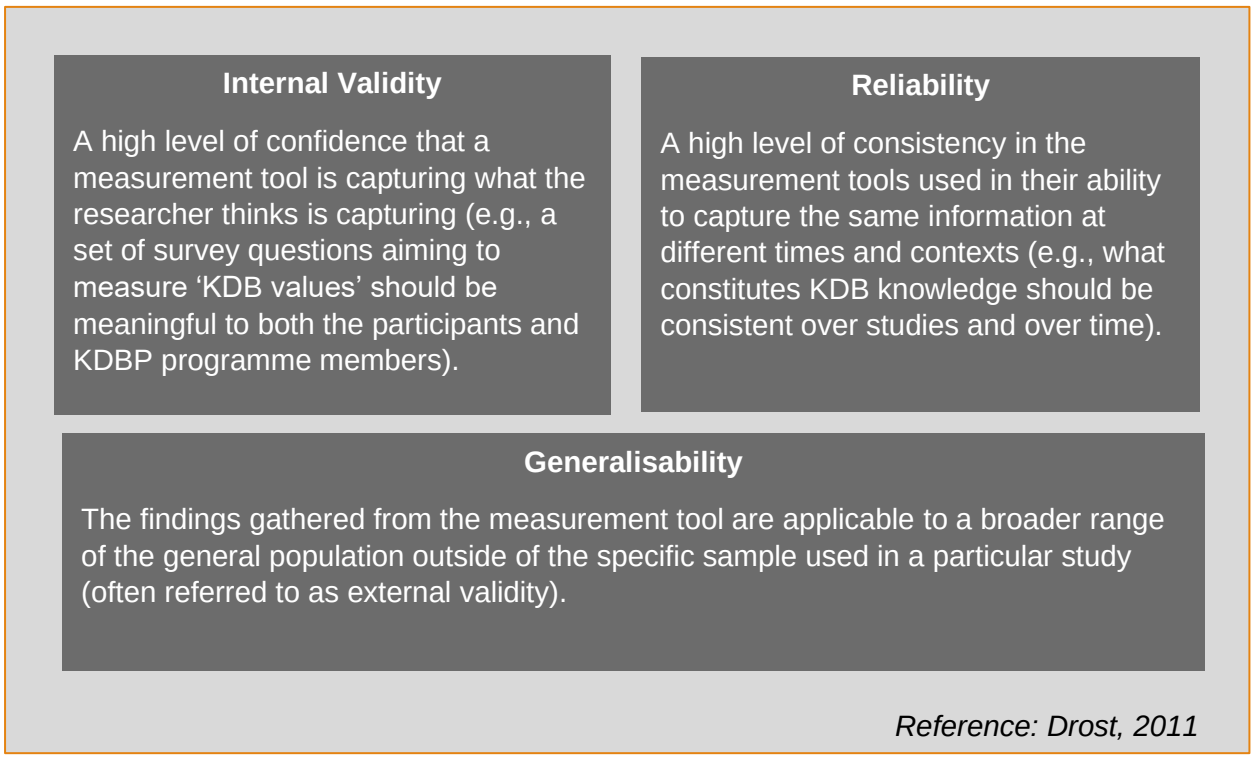
Availability of Research

Given the independent nature of this report, the corpus of the works reviewed consists of predominately completed and published projects, and as such, some aspects of the analyses and recommendations provided are being addressed by work currently in progress. A more up-to-date collation of works may identify overlap between recommended future research projects outlined in this report and investigations already underway within the KDBP such as research underway by the Ngā Rākau Taketake; National Science Challenge.

Other Scientific Perspectives

While the focus of this report is on social science research on KDB from a western science perspective, it is acknowledged that this is just one of many other scientific paradigms, including mātaranga māori, which warrant equal weight, specialist attention and expertise. As the reviewer of this report did not hold such expertise, no analysis of Māori focussed research has been included.

Figure 2. A summary of the three key research benchmarks.



4. Methods

Research Documents Sourcing

A total of 27 social research documents relating specifically to KDB were reviewed, including NZ specific reports (n = 26) as well as international (n = 1) and local academic articles (n = 1). These were predominately sourced via online public access either through the KDB website or through public academic databases such as open source and google-scholar. Broadly speaking, the review focused on the 'human factors' aspect of KDB research. As such, key word searches included 'social' 'human' 'kauri dieback' and 'behavioural.' Documents with limited access were acquired through contact with key social science contacts in the KDBP (who also had access to broader academic literature).

Where appropriate, additional supplementary materials were examined such as survey materials, research proposals, reports drafts, newsletters, posters, working documents and excel sheets[3]. Three relevant strategic KDB documents were also included to inform the future development of social research planning including the KDB Science Plan, KDB Strategic Plan and the NPMP (see the reference section for more information).

As the primary focus of this report was to review the 'overall knowledge' about KDB social research, each research document was assessed for its:

1. Relevance to understanding the human factors aspect of kauri protection
2. Methodological approach and rigour
3. Key findings and overall insights
4. Research strengths and limitations

Methodological Approach

In light of the applied social psychological and behavioural science approach, the selected social research best practice guidelines were used to inform the subsequent summary and synthesis of the research.

- Measurement Definitions. In social science research, particularly when employing quantitative methodologies, it is important that the researcher is confident to a reasonable degree that what they are measuring is capturing the same variable each time, across time and contexts. While it is often not practical to use fully tested psychometric tools, it is difficult to make direct comparisons of trends without a reasonable level of consistency in the variable concept (construct validity) and the reliability of the metric to capture the same concept consistently across time and contexts (reliability) (Drost, 2011).

  For example, 'knowledge of KDB' in some instances was measured through the self-reported perception of one's own knowledge (e.g., I feel I know a fair amount about KDB issues)[4] whereas in other instances, it was measured through people's ability to identify key vectors (e.g., human spread/pig spread). Such inconsistencies make it difficult to compare KD knowledge across studies and over time as this compromise

[3] For confidentiality reasons, supplementary materials are not included in the reference section.
[4] This is referred to as 'subjective knowledge' which has been found to have different relationships with other psychological and behavioural metrics as compared to 'objective knowledge'.

our ability to determine whether what the concept really 'is' and therefore what was actually measured in each instance.

- Data Collection Procedures. Another important step to increasing confidence in social scientific findings is consistency in the methods of data collection. Of specific relevance to the KDB social science literature is sampling (e.g., sample size, random selection or strategic selection), equipment (e.g., which cleaning stations were used and their relative similarity; presence/absence of cameras), investigator influence (e.g., an unidentified researcher; a conservation or KDB ambassador[5]), observational consistency (e.g., what was considered 'thorough' cleaning behaviour) and experimental design (e.g., was behaviour tested pre and post cleaning station or only post; seasonal effects of weather).

- Analytic Procedures. Given some level of confidence in consistent measurement and data-collection, a third step is ensuring that the analytic process of the data is consistent. For example, it was noted that across KDB social science studies, metrics were often 'grouped' to capture wider insights such as summating 'strongly agree' 'agree' and 'somewhat agree' responses to combined scores of 'agreement'. Another key example is what is considered 'full' 'partial' and 'non-compliance' of certain cleaning station behaviours. While it is acceptable that such analyses be performed, these should be noted so that cross-study comparisons can be made. Additionally, when comparing across groups it is good practice to assess for statistical significance which relies on aforementioned methodological conditions of consistent and valid measurement and data collection steps.

  Similarly, qualitative analytic techniques come with their own validity checks. When conducting thematic analyses, coding schemes and inter-coder consistency become important validity and reliability checks, often termed 'trustworthiness' and 'credibility' in the qualitative methodological literature (Willig, 2008). Moreover, given the varied array of qualitative research approaches, it is important that any methodology or analytic process used is well-described to give the reader an idea of how information was gathered and interpreted. A useful example of this is the Navigator's (2019) work who applied the COM-B model for structuring their qualitative data-collection and analysis. To further bolster our understanding and confidence in the findings, it would have been beneficial to have their thematic analytic process described (i.e., how themes were identified and described; if there was more than one coder etc).

- Measurement Tools. It is commonly accepted in the social science space that, though useful, there are limitations with measurement techniques, particularly self-report metrics which are the predominant approach in social research. Aside from everyday limitations to memory and recall, research shows that people are prone to 'self-enhancement' or 'self-serving biases' whereby they may exaggerate their responses to present a more positive self-image (Paulhus et al., 2003). In light of these limitations, there is often a gap between 'self-reported' and 'observed' behaviours; a finding consistent with the reviewed KDB studies and wider literature.

[5] In the context of KDB, an ambassador is defined as an appointed individual whose job is to both inform the public about correct KD protective behaviours as well as promote the KDBP on the whole.

In alignment with these guidelines as well as the balanced approach to this review, any conclusions drawn about patterns of findings were weighted according to the level of rigour of the research methodologies, and as such emphasis and caveats provided where appropriate.

Given the independent nature of this report, the corpus of the works reviewed is not exhaustive as it consists of completed, published projects (both academic and grey literature). As such, some aspects of the analyses and recommendations provided may be addressed in the future by work currently in progress. A more up-to-date collation of works may identify overlap between recommended future research projects outlined in this report and investigations already underway within the KDBP such as research underway by the Ngā Rākau Taketake, National Science Challenge. Where applicable, the review offers recommendations for research areas and design approaches that would offer useful insights if conducted on an on-going basis.

Researcher Interviews

Six KDB researchers were consulted with a background in social science to provide further insight into the research to date and identify potential ways forward.

Consultation with social researchers consisted of six one-on-one semi-structured online video interviews. Interviewees were selected by key KDBP personnel who had organisational knowledge of the social science research within the programme. Snowballing techniques were also used to identify further interviewees to account for any researchers who were not available.

Each interviewee was provided with a brief outline of the research objectives and how their responses would be used. With granted permissions, all discussions were video-recorded and discarded within three weeks of the interview. To maintain the participants' confidentiality, interview responses were integrated into the wider report discussion[6].

[6] Please note that this was a consultation exercise aimed to offer expert advice to guide and elaborate the review process but is not representative of a full qualitative research approach.

5. Review: KDB Social Science Research

The social science research on KDB to date has had three main areas of focus:

1. Behavioural - looking at specific KDB protection behaviours.
2. Psychological - looking at levels of awareness, knowledge and perception of KDB as well as motives for specific perceptions and behaviours (i.e., values and barriers).
3. Social/cultural - looking at the role of social norms and exploring KDP's social licence to operate. Some focus has also been put towards understanding group-level similarities and differences across these domains.

The following section outlines the key variables and findings across the studies in reviewed materials as well as the methods and measurement tools used. It is acknowledged however that the review revealed considerable methodological and measurement differences across studies which presented a few analytic limitations.

Behaviour

Since 2010, it appears that most of the KDB social research has focussed on identifying and instilling Kauri protective behaviours for forest track users. There has been a particular focus on identifying which on-track cleaning or 'hygiene' behaviours forest visitors performed at KDB cleaning stations which, for the most part, asked forest users to scrub their footwear and spray with disinfectant on entering and exiting Kauri forests (Aley & Macdonald, 2018; Auckland Council, 2013; Beauchamp et al., 2016; Benson & Dixit, 2010; Binnie, 2013b; Colmar Brunton, 2016, 2019; Heggie-Gracie & Robertson, 2015; Joanne Aley, 2019; Ough-Dealy & MacDonald, 2017, 2016; Ovenden, 2020; Premium Research, 2012; Wegner, 2014a; Wood & Ryan, 2020).

The other main protective behaviour of research focus has been on'staying on track' (Aley & Macdonald, 2018; Auckland Council, 2013; Beauchamp et al., 2016; Benson & Dixit, 2010; Binnie, 2013a; Colmar Brunton, 2016, 2019; Heggie-Gracie & Robertson, 2015; Ough-Dealy & Macdonald, 2017; Ough-Dealy & MacDonald, 2016; Premium Research, 2012; The Navigators, 2019; Wegner, 2014b).' A few studies have explored more specific behaviours such as at home cleaning, dog-walking, tree felling, tree fencing and hunting (e.g., staying up slope/carrying in situ cleaning gear; (Auckland Council, 2013; Colmar Brunton, 2016; Colmar Brunton, 2016; Council, 2018; Dixit & Benson, 2010; Heggie-Gracie & Robertson, 2015; Wood & Ryan, 2020).[7]

The measurement of these behaviours was predominately conducted using self-report survey questionnaires (either online or in-person; (n = 11) or through qualitative interviews and/or focus groups (n = 6). Some studies adopted observational methods collected either via camera footage (n = 2) or in-person observers (n = 4).

Compliance Rates at Cleaning Stations.

With cleaning stations varying considerably (from brush and spray bottle, barrel and grate set ups to fully equipped Mark II station), as well as variation in what is considered

[7] Important to note that hunting, dog walking, fencing, felling and at home cleaning was predominately measured by means of asking people for the 'main purpose' of their visit to a kauri forest, rather than it being a measurement of how they engage in 'kauri protective behaviours' while engaging in these activities.

'compliance' (e.g., from full compliance in correct order to performing 'any one of the recommended behaviours)' alongside differences between 'self-reported' and 'observed behaviours,' comparing direct percentages of cleaning station behaviour compliance over time is unadvisable. However, looking across the studies there is evidence to suggest that compliance rates have increased more generally, indicative of an increased willingness to engage in Kauri protective behaviours on the whole (see Appendix A for specific percentages of compliance within the specific context of each study).

An examination of specific study findings reveals possible influencing variables that may be contributing to greater compliance rates.

- *Cleaning station design.* Three key studies provide overall evidence that the incorporation of social science and ergonomic principles has resulted in significant increases in cleaning station behavioural compliance. The most notable example comes from Ough-Dealy & MacDonald, (2016) where the researchers tested compliance rates pre- and post-instillation of the Mark II cleaning station, which incorporated improvement advice from engineers, designers and background research on signage such as the use of gates, chevrons, and a yellow and black biohazard colour scheme (see MacDonald, 2015; Ough-Dealy & MacDonald, 2016, 2017). Comparing pre- and post-new-station installations, findings showed a 46% increase in compliance rates from 51% to 97% in one of the four tracks tested at a Mark II cleaning station. This is particularly noteworthy when compared to compliance rates of the previous station designs at barrel and grate (74%), spray bottle and brush (33%) and sign only (0%).

  A follow up study was conducted by Ough-Dealy & MacDonald in (2017) which found an additional increase in compliance to (98%) with further improvements to station design.

  The third relevant study was conducted by Aley (2019) who tested various experimental treatments on the most recent Mark II KDB cleaning station. Three of the treatments were alternations to cleaning station design including: 1) the 'watching eye effect' simulating a sense of surveillance, 'biosecurity' colouring and icons (activating an existing biosecurity schema) and the inclusion of a 'pledge-board' (creating a sense of public commitment). Her results showed some increase in compliance where there was greater overall compliance in the biosecurity treatment and pledge-board. It also highlighted however the importance of testing theoretically plausible options as exemplified by the increase in *non-compliance* in relation to the watching eye treatment.

  These mixed findings highlight the need for further verification, which would benefit from theoretical backing and in situ testing. One example of this could be to explore whether the reduction in compliance for the watching eye effect can be explained by the possibility that people prefer clear instructions where the cause and effect are obviously linked. Indeed, international research into the watching eye effect did have a positive impact on behaviour in an illegal setting, the rationale for this finding being that this effect works when there is a threat of real consequences (Ayal, 2019). As such, the reduction in compliance in the context of KDB due to the watching eye may have been due to a confusion as to what an 'incorrect' behaviour would result in and may have just been viewed as being overtly manipulative.

Based on the above studies, it is evident that cleaning station design appears to have a significant impact on behavioural compliance. In saying that, it is important to note that design features are only effective insofar that other practicalities are taken care of. Several studies found that people often reported not engaging in Kauri protective behaviours due to aspects such as lack of equipment and poorly maintained cleaning stations (Benson & Dixit, 2010; Colmar Brunton, 2016, 2019; Smith, 2017; Wegner, 2014a). This emphasises the importance of a wholistic, programme approach to selecting, supporting, and maintaining Kauri protective cleaning stations.

- *Signage.* Across the research**,** signage has been reported as one of the main sources of information about KDB – both with regards to general knowledge about the disease as well as the specific behaviours requested of the public (Auckland Council, 2013; Benson & Dixit, 2010; Colmar Brunton, 2016, 2019; Wegner, 2014a). Conversely, it was highlighted that one of the main reported barriers to not engaging in Kauri protective behaviours was a lack of clear information, much of which was often identified on the signage itself (Benson & Dixit, 2010; Colmar Brunton, 2016, 2019; Smith, 2017; Wegner, 2014a).

  MacDonald's signage review (2015) provided a robust starting point for investigation of how to improve signage in the KDB context, emphasising the importance of incorporating social scientific theoretical basis to signage design and in situ testing. Her review offered the following signage recommendations based on hazard communication theory:

    - Yellow and black colouring
    - Good pictorials
    - Appropriate reading level
    - Kauri dieback signage could be improved by adding a signal word (e.g., DANGER)
    - Clearly stating cause and effect of the hazard and the compliant behaviour
    - Removal of all capitalisations

  Ough-Dealy and MacDonald, (2016) incorporated some of these suggestions into their station design, including the use of yellow and black colouring, appropriate reading level, adding the signal word of 'DANGER' and clearly stating cause and effect of the hazard of compliant behaviour. While it is not possible to discern to what extent the signage contributed to the increase in compliance rates in their study specifically, it is indicative that the incorporation of hazard communication elements may be effective for influencing behavioural changes.

  In addition to research-based signage design, MacDonald, (2015) also emphasised the importance of in situ testing to identify effectiveness and ineffectiveness of possible treatments. Demonstrating this, Aley, (2019) found that a design of a normative messaging treatment did not correspond with significant increases in cleaning station compliance behaviours.

  To date, there have been several studies exploring specific design aspects and messaging (e.g., Aley et al., 2018; Dealy, 2021; Wood & Ryan, 2020). However, apart from these studies, none of the designs have been explicitly tested in situ for corresponding compliance behaviours. As such, it is recommended that signage be

piloted and that any significant findings be implemented into the overall design of kauri signage consistently across different regions/land tenures; a step that was emphasised by three of the interviewees.

Additionally, there is research to suggest that there is a clear link between the adoption of behaviour and the perceived beneficial outcomes of that behaviour (Abroms & Maibach, 2008). Signage could therefore offer re-assurance that the practice of cleaning is having the desired impact in terms of reducing KDB.

Performance of Other Kauri Protective Behaviours

Performance of other Kauri protective behaviours[8] appears to be occurring at notably lower rates as compared to cleaning station behaviours. Specially, measurement of 'staying on track' behaviours fall between 8% (Premium Research, 2012), 7% (Binnie, 2013), 54% (Auckland Council, 2013), 46 % [9] (Heggie-Gracie & Robertson, 2015), 66% (Colmar Brunton, 2016) and 73% (Colmar Brunton, 2019), cleaning equipment 23% (Premium Research, 2012), 5% (Auckland Council, 2013), 20.5% (Heggie-Gracie & Robertson, 2015), 9% (Colmar Brunton, 2016) to 55% (Colmar Brunton, 2019) and dog walking protective behaviours, such as keeping them on leashes 8% (Heggie-Gracie & Robertson, 2015) and 12% (Colmar Brunton, 2016; overall changes are presented in Table 1).

Table 1. Percentage Change of Behaviour Over Time

Behaviour	**2012**	**2013**	**2015**	**2016**	**2019**	**Percentage Change**
Staying on Track	8 %	7 % / 54 %	46.8 %	66 %	73 %	39.1%
Cleaning Equipment	23 % / 5 %	-	20.5 %	9 %	55 %	14.2 %
Dog walking behaviours	-	-	8 %	12 %	-	4 %

**Note:* Percentages were calculated by averaging across the earliest studies and most recent study results*
***Note:* Due to methodological differences across studies, as well as 'before' and 'after' dates, the presented percentages should be seen as indicative of the 'general trend' only, and further examination, including the testing for statistical significance, would be advisable for more reliable, clear results.

As demonstrated in the table, there have been some increases in self-reported Kauri protective behaviours with an overall average 'increase' in other kauri protective behaviour engagement of 19.1%. To gain further clarity, it is recommended that future research examine these behaviours with more depth through more observational data (e.g., surveillance or researcher capturing of people going off track in some areas) as well as consistently used self-report metrics across studies.

It also seems that the programme's investment in the cleaning stations has meant that this is cleaning station use is the most instilled behaviour, which may explain the lower rates of

8 Other behaviours refer to any behaviours that are considered 'protective' against KDB that are not performed at KDB specific cleaning stations (e.g., keeping on track/keeping dogs on leads/ cleaning equipment at home).
9 This is an approximate percentage taken from a graph in Heggie-Grace & Robertson's' 2015 paper.

other protective behaviours. To date, no research has explored other Kauri protective behaviours through observation or tracking methods, so it is not possible to discern the accuracy of the self-report measures to date.

Summary: behavioural findings

- General willingness to engage in KDB protective behaviours has increased over time.
- Cleaning station co-design and field testing has yielded greatest increases in behavioural compliance.
- Signage designed according to hazard communication theory appears to have contributed to greater compliance rates. Wider piloting and consistent application across regions/land tenures is recommended.
- As compared to cleaning-station behaviours, other KDB protective behaviours have seen less increase in compliance over time. This may be due to the proportionally higher investment in cleaning station research as well as less robust and consistent measurement of these behaviours. More in-depth exploration of 'other KD protective behaviours' is recommended.

Psychological

Several psychological variables were measured to identify ways of influencing levels of compliance and overall engagement with KDB. The key variables captured were:

- **Awareness of KDB** (Auckland Council, 2013; Benson & Dixit, 2010; Binnie, 2013b; Colmar Brunton, 2016; Colmar Brunton, 2016, 2019; Council, 2018; Heggie-Gracie & Robertson, 2015; Ovenden, 2020; Premium Research, 2012; Wegner, 2014a).
- **Knowledge of KDB** including recognition of key vectors (Benson & Dixit, 2010; Colmar Brunton, 2016, 2019; Ovenden, 2020; Wegner, 2014a) and being able to identify a diseased tree (Benson & Dixit, 2010; Colmar Brunton, 2016, 2019).
- **Perception of kauri** and **level of importance** of its protection (Benson & Dixit, 2010; Colmar Brunton, 2019; Smith, 2017; Wegner, 2014a).
- **Psychological motivations** and **barriers** for performing desired behaviours (Auckland Council, 2013; Benson & Dixit, 2010; Colmar Brunton, 2016, 2019; Heggie-Gracie & Robertson, 2015; Ough-Dealy & Macdonald, 2017; Ough-Dealy & MacDonald, 2016, 2017; Smith, 2017; The Navigators, 2019; Wegner, 2014b); and
- **Social identities** such as **demographics**, **forest user activities** and **place/location differences** (Benson & Dixit, 2010; Colmar Brunton, 2016, 2019; Heggie-Gracie & Robertson, 2015; Ovenden, 2020; Smith, 2017; The Navigators, 2019; Wegner, 2014a).

All the psychometric variables were captured using explicit self-report measures. Measurement techniques were mostly quantitative and qualitative questioning in surveys (n =13), followed by a few interviews and/or focus groups (n= 4) and forums (n= 2).

Awareness and knowledge of KDB

Awareness appears to *have been the* most popular area of interest across the reviewed research, followed closely by knowledge of KDB. Though it was not explicitly defined, it appears that 'awareness' in this context refers to a participants' unprompted recognition of KDB as an issue (in a 'yes' or 'no' dichotomous fashion). Knowledge, on the other hand, appears to be capturing a participant's understanding of the nature of the disease, how its spread and what key behaviours have been recommended to mitigate its spread. In some instances, this has included the self-reported ability to identify diseased trees. Looked at

another way, ‘knowledge’ could be seen as capturing the ‘degree of awareness’ people have about KDB, with greater knowledge showing a greater involvement in the issue (whether they are supportive or oppositional to the scientific information itself). This possible interpretation is based on a reflection on how ‘awareness’ and ‘knowledge’ has been captured in a way that could be two ends of the same spectrum. This however is speculative and would benefit from explicit examination in future studies.

Across the research, it has been shown that awareness of KDB has significantly increased over time from 21% in 2010 to 83.3% in 2019. As seen in Appendix A however, the percent of awareness increase has not been linear; a pattern which could be indicative of actual changes or due to different measurement techniques across studies.

Similarly, a review of the research suggests that there has been an increase in knowledge of KDB, represented by higher scores of peoples’ ability to identify key KDB behaviours (4% in 2010 to 74.6% in 2020); identification of humans as a key KDB vector (69.1% in 2014 to 93.4% in 2019), and self-reported ability to identify diseased trees (7% in 2010 to 20% in 2019). However, again, there is considerable variation over time and across studies as demonstrated in Appendix A – where the same methodological caveats apply.

It is recommended that a distinction be made between people’s ‘agreement’ with scientific statements about the KDB disease and a ‘lack of awareness’ of it. This is a subtle but important difference as, in some cases, participants are reported as being ‘unaware’ or ‘unknowledgeable’ regarding KDB, yet the measure itself asks the degree to which they ‘agree’ that something is the case (say, that human’s and pigs are a main vector or spread). In other words, there may be instances where participants are aware of the scientific position on a particular issue but may disagree with its conclusion. This point is raised as research has shown that some groups have mistrust in the management of KDB (government and scientific authorities) and that will be misinterpreted if ‘agreement’ with official positions is synonymised with ‘knowledge’ or ‘awareness.’

Psychological motives and barriers towards KDBP

Aside from understanding how aware people are of KDB and their current willingness to engage in Kauri protective behaviours, examining the ‘why’ behind these patterns has been raised as an important area of inquiry to better understand how to increase rates of compliance. A common approach has been exploring the level of importance people place on kauri and their protection from KDB.

On the whole, it appears that there has been relatively high value placed on kauri and its protection, with the Benson and Dixit, (2010) study showing levels of perceived importance at 71% - increasing to 90% in Colmar Bruton’s (2016) report. However, Colmar Bruton’s (2019) study found that levels of importance have declined in recent years, with importance coming out at 68% for individuals and 59% for their local communities; a finding which suggests that there may be a growing sense of disenchantment with the KDBP. Such an interpretation is further supported by research from the Navigators (2019) which found that their participants expressed a ‘lack of hope’ (from both those who were compliant and non-compliant with Kauri protective behaviours) that their actions would have any lasting impact on the KDB problem.

Across both quantitative and qualitative findings, it appears that the main self-reported reason for seeing KDB as important has been because its seen as iconic species with historical value followed by the desire to preserve its cultural and environmental significance (Benson & Dixit, 2010; Colmar Brunton, 2016, 2019; Council, 2018; Wegner, 2014a).

The main psychological barriers to engaging in cleaning behaviours has varied from study to study, but a common thread – and perhaps most dominant belief – is the doubt or futility of the behaviour itself (Benson & Dixit, 2010; Heggie-Gracie & Robertson, 2015; E. MacDonald et al., 2016; Wegner, 2014a), expressed by a lack of belief in its effectiveness or achievability (Colmar Brunton, 2019; Wegner, 2014a)[10], or not agreeing with the prospect that humans are a key vector (Benson & Dixit, 2010; Colmar Brunton, 2016; The Navigators, 2019).[11]

A more overarching barrier to compliance and endorsement of the KDBP seems to be a perception that KDB is not a priority in the context of more pressing environmental and conservation issues; (Colmar Brunton, 2019). It also appears that people may be feeling a sense of futility due to the lack of perceived social cohesiveness, expressing doubt that others will undertake appropriate behaviours (Benson & Dixit, 2010; Heggie-Gracie & Robertson, 2015; Wegner, 2014a) and a lack of commitment to kauri protection by KDB management authorities (Colmar Brunton, 2019; The Navigators, 2019).[12] This is related to but distinct from practical barriers mentioned earlier, overlapping with the variations in levels of KDB knowledge.

Groups-level differences social identities

Alongside positive attitudes and values, international research suggests that people's 'social identities' can have a significant impact on their willingness to engage in pro-environmental behaviours. Broadly speaking, social identities denote the 'roles' individuals identify with and the 'groups' they participate in (Fielding & Hornsey, 2016; Gatersleben et al., 2014).

In the context of the KDB social science research, the most common approach to exploring the influence of social identity on KDB behaviour has been through comparing people's behaviour and perceptions across 'prescribed' social identities such as demographics (gender, age, ethnicity, location etc) or activity user groups (walkers, trampers, hunters, farmers). Some focus has been put towards understanding different 'user' groups, or 'personas' with the objective of examining how different groups differ in their perceptions and behaviours towards KDB and KDBP, often with the intention of aligning communications and messaging with group needs and mindsets.

Before proceeding onto group level findings however, a few best practice aspects are mentioned to help provide clarity to the interpretations.

- *Demographics.* Demographic information such as age, gender, income, education, and location is frequently collected in most social science research primarily to describe the nature of the sample, and therefore, the ability for findings to be generalised across wider populations (Hughes et al., 2016). In other instances, demographic information is collected to assess differences in behavioural or psychological patterns across groups such as perceptions or behaviour between men

[10] This includes a sense that they can personally influence the outcomes of KDB – often termed as self-efficacy.

[11] As mentioned in the Awareness and Knowledge section, it is difficult to discern whether people 'disagree' that humans are a vector or do not 'know' that they are given the way that the knowledge metrics were construed.

[12] Given that the research spans both quantitative studies with a variety of metrics as well as qualitative studies with non-statistical findings, the findings regarding motivations and barriers are a summarized to represent a high-level view. Appendix A provides specific details for individual patterns should that be of interest.

and women, or in different locations. These are useful as a means of catering to specific groups and audiences, particularly when it comes to behaviour change initiatives or communications campaigns in a broad sense.

In saying this however, due to the 'categorial' nature of demographic groupings, they are limited in explaining the 'why' behind behaviour (Hughes et al., 2016). As such, it is often beneficial to also explore how groups of people differ according to underlying attitudes, perceptions or beliefs; a methodology termed 'psychographics' (Hardcastle & Hagger, 2016). A useful example of this is MacDonald's et al (2020) work which segmented their research sample into four 'perspectives' according to underlying values. This method better predicted the participants' opinions towards conservation issues than did their demographic profile.

- *Group membership.* Much like demographic variables, the collection and interpretation of group-level variables such as a person's belonging to a particular club or engaging in a particular activity depend on following data-collection methods that are clear and consistent. Once again, a theoretical underpinning would allow for clear interpretation (though theoretical predictions are usually more relevant to quantitative rather than qualitative research where more emphasis is placed on describing a particular social group rather than generalising or predicting behaviour across a general population, Willig, 2008).

- *Group level comparisons***.** In following social science best practices for quantitative research, it is important that whenever there 'group-level' comparisons are made, the sample collection procedures are consistent and the group membership is distinct; that the sample is of a sufficient size and, if those conditions are met, that comparisons reach statistical significance such that interpretations can be made with clarity and confidence.

Likely due to understandable research and funding constraints as well as difficulties in programme coordination, these best practices principles have seldom been satisfied in the research corpus to date – caveats which are often acknowledged by the authors of the studies themselves. In most cases, the 'activity-group' samples are of small and differing sizes, making any significance testing uncertain and our interpretation of the findings tentative (e.g., Colmar Brunton, 2016). Moreover, the differences in metrics across studies make comparison tenuous, for example, in some instances, participants were asked which activities they had done in the past 12 months, whereas in other cases they were offered multiple-choice answers or asked their 'main activity' in general. It is also unclear what the criteria were for activity selection. Finally, with any quantitative group-level difference testing, theoretical justification and clear hypotheses are important for meaningful and clear interpretations of findings. Aside from Wegner's 2014 and Colmar Brunton's 2019 research, none of the other studies provide explanation for their group categorisation (for both demographics or activities), limiting the findings to mostly descriptive interpretations. Indeed, explanations for the 'why' behind observed patterns of behaviour were often speculative, unclear or absent[13].

[13] It is also acknowledged by the author that this is based on the information provided in reports and supplementary materials, which often did not explicitly include a description of metrics and sampling selection procedures.

As such, the below group-level findings will be mostly drawn from Wegner's (2014) and Colmar Brunton's (2019) reports which met the criteria of sufficient sample sizes, theoretically justified sampling selection and tested for group-level statistically significant differences. These will be supplemented by tentative findings from the remaining literature but should be seen as 'possible overall trends' that highlight potential important areas for future research. The Navigators (2019) qualitative report is also given special mention as a 'within-group' exploration that, though cannot be generalised, provides valuable insights of specific community groups.

Group level differences

- Older cohorts appear to be more aware of KDB than younger cohorts (Auckland Council, 2013; Benson & Dixit, 2010; Council, 2018; Heggie-Gracie & Robertson, 2015; Premium Research, 2012; Wegner, 2014a),
- Younger cohorts appear to be less knowledgeable of KDB and more likely to walk off tracks than older cohorts (Wegner, 2014a).
- Young men appear to be less likely to see themselves as playing an important role in the protection of kauri and more likely to feel that not enough is being done (Colmar Brunton, 2019).
- Hunters and landowners/farmers appear to be more aware of KDB as compared to the broader population (Benson & Dixit, 2010; Colmar Brunton, 2016).
- Hunters tend to view required behaviours as less plausible or achievable (Benson & Dixit, 2010). On the one hand, this may be due to the practical challenges of performing some of the KDB behaviours in a hunting context (e.g., it is challenging to stay off roots when tracking a pray or to stay clean while moving from kauri to non-kauri areas, especially when you don't have access to water). On the other hand, the expressed resistance to Kauri protective behaviours could be influenced by the fact that the more people perceived KDB controls as threatening[14] to their identity (e.g., as a hunter), the more likely they were to see the controls as ineffective or impractical and were less likely to intend to use cleaning stations or believe that kauri need protection (Wegner, 2014). Hunters were also more likely to doubt management efforts as shown by lack of trust (Wegner, 2014).
- Aucklanders tended to be more aware than those in other locations (Auckland Council, 2013; Benson & Dixit, 2010; Heggie-Gracie & Robertson, 2015; Wegner, 2014a), however, when statistically tested, location-based differences were not found to be a significant predictor of awareness or compliance (Heggie-Gracie & Robertson, 2015; Wegner, 2014a).
- Dog owners appeared to be less compliant with KDB behaviours as compared to the general population (Wegner, 2014a),
- Runners appeared to be more likely to report intending to use a KDB cleaning station and stay on track as compared to the general population (Wegner, 2014a). In conversation with one of the experts however, there is experience of the opposite finding where runners were less likely to comply as has been noted by track ambassadors.
- Urban landowners appear to have greater awareness and knowledge of KDB (Colmar Brunton, 2016).
- Locals appear to have greater knowledge but also more resistance towards perceived effectiveness of controls and intended compliance (Wegner, 2014). This trend was also highlighted by two of the interviewed experts as being particularly

[14] 'Threat' in the context of Wegner's (2014) refers to the degree a particular KDB protective behaviour is associated with a person's identification with a particular activity that would be difficult to engage in while conforming KDB protective behaviours.

noteworthy, especially given the common assumption that it is intentional tourists that are more likely to be non-compliant.

Wenger (2014).

Of specific mention is Wegner's (2014) research which examined the relationship between 'activity' and 'place' identities and their influence on KDB knowledge, attitudes, behaviour, and sense of perceived 'threat' by KDB management.

Contrary to expectations, activity identity (i.e., whether someone engaged in a particular behaviour or not, such as hunting, cycling or walking), though related to greater knowledge of KDB and control efforts, was not related to attitudes and compliance behaviours. Strength of identification with activities also failed to yield significance. This is consistent with Heggie-Gracie and Robertson, (2015) research finding no differences in awareness or compliance via forest activity.

Place identity (i.e., a person's identification with a particular location or place) had a positive relationship with perceiving KDB as a threat, where greater identification with their particular location was related to greater intention to use cleaning stations and staying on track alongside seeing the protective behaviours as effective and practical. These were however weak correlations, possibly due to small sample sizes and large number of confounding variables.

The Navigators (2019)

The Navigator's (2019) offer a qualitative insight into off-track user groups where they conducted 24 (n = 19 male; n = 5 female) semi-structured face to face interviews with hunters (n = 8), farm decision-makers (n = 8) and community trappers (n = 8) with the intention of gaining a realistic view of the probability that certain groups would engage in protective behaviours[15].

The majority of their research was looking across the groups to explore similarities in motivations and barriers (see appendix A for a summary of those findings). However, group-level willingness to engage in Kauri protective behaviours was also explored (see The Navigators report, pg. 38 - 42). Their results further supported the observed quantitative data suggesting that those who engage in hunting behaviour tend to be more closed off, and reject KDB information and requested behavioural changes more so than the general population. It also further corresponded with the finding that landowners/farmers are more knowledgeable of KDB and control efforts and show a willingness to learn and engage with KDB. The trapper's group appeared as the most willing to engage, but also, with the least knowledge of KDB (as compared to the other two groups); a pattern which has not been explicitly examined by quantitative data.

[15] Efforts were made to include Māori participants into each user group. However, as mentioned on the onset of this report, given the in-depth community-based knowledge required to explore cultural-specific findings and ways of knowing, findings regarding differences between Māori and other ethno-cultural groups are not included in this report.

Summary: psychological findings

- Awareness and knowledge of KDB appear to have increased over time.
- Perceived importance of kauri and its protection has increased since 2010 but has also slightly declined in more recent studies.
- Perceived psychological barriers to performing KDB protective behaviours may be due to doubt in cleaning behaviour effectiveness and achievability as well as doubt in others' commitment (authorities and public) to addressing the problem.
- Identification and involvement with a physical location appeared to be associated with greater KDB knowledge and willingness to learn, alongside greater questioning.
- No statistically significant differences were found in KDB perceptions or behaviours

Social/cultural

Almost half of the reviewed studies (n = 12), to varying degrees, explored social and cultural influences on levels of compliance and engagement. Specifically, there has been an exploration into the effects of social norming, community communication and acceptance, and perceptions of KDB management overall (Colmar Brunton, 2016; Colmar Brunton, 2016, 2019; Council, 2018; Heggie-Gracie & Robertson, 2015; Joanne Aley, 2019; E. MacDonald, 2015; Ough-Dealy & Macdonald, 2017; The Navigators, 2019; Wegner, 2014a).

In most instances, these social aspects were explored by capturing the perceived social acceptability of KDB behaviours and speculating about its influence on actual behaviour. Aley (2019) took a further step to test a particular social norming treatment on cleaning-stations usage[16] (discussed in further detail below).

Social norms

It has been acknowledged that people's perceptions and behaviours do not occur in a vacuum but are heavily influenced by social contexts and expectations which, in turn, go on to create what can be loosely referred to as the development of 'social norms, (Reynolds et al., 2015).

Though few studies have explicitly measured the influence of social norming in the KDB context (except for Aley, 2019), inferences can be drawn from a number of works regarding the importance of social perceptions. Looking across studies, it seems that one's perception of the social expectation and/or acceptability of KDB behaviours can be seen as both a motivator and as a barrier, depending on how one perceives the wider KDB culture.

- *Social norms as motivators*. Many participants reported engaging in Kauri protective behaviours because they felt it was the 'right thing to do' or that important others in their lives would expect them to do so (Colmar Brunton, 2016; Heggie-Gracie & Robertson, 2015; Wegner, 2014a) which can be seen as 'moral' statements dependant on social perceptions of 'right and wrong;' or what is acceptable and

[16] From a communications point of view, engagement (and predominant methods of engagement) with the KDBP programme has been examined, such as key sources of KDB information (see FY 18/19 Summer Campaign, 2019 for a good example; Thompson, 2019). Though this research differs from the social research method, and so is beyond the scope of this analysis, it is nevertheless greatly informed by and relevant to the social sciences and should be explored in future research.

unacceptable (Farrow et al., 2017). Such findings a mirrored by Wegner's (2014) research which found that the intention to use cleaning stations was strongly associated with the attitude that cleaning is important or 'the right thing to do' and the belief that loved ones would approve. Similarly, Heggie-Gracie and Robertson (2015) found that feel an expectation to comply from their friends and whānau and that it is the right thing to do.

Though this has not been explicitly focused on and tested, there may be some overlap between the degree to which people feel they have a moral obligation to protect kauri and their willingness to share KDB information and encourage kauri protective behaviours in others. A cursory view of the advocacy statistics suggests that about one third of participants feel a strong sense of social commitment to addressing KDB through their self-reported willingness to 'advocate' by sharing KDB information to others. Specific rates of Advocacy range from 17-25% (Colmar Brunton, 2019; Heggie-Gracie & Robertson, 2015) to 32% (Colmar Brunton, 2016; Ovenden, 2020). Colmar Brunton found no significant differences in advocacy across demographic profiles.

Aley's (2019) work sheds further light onto the impact of social norming. In her study, one of the treatments involved an explicit attempt to create a sense of 'social expectation or acceptance' to use a cleaning station with the sign that read - '90% of people are brushing their shoes.' This treatment however did not have a significant impact on actual compliance behaviour. As already mentioned, the pledge/commitment wall had a significant, positive impact on compliance behaviour (which can be seen as another form of social norming). Combined, these findings highlight both the potential of social influence as well as the importance of testing any conceptual design or theoretical frameworks for their efficacy in this specific context. One such step forward would be to explore whether the failure of the normative messaging in this instance was because of lack of credibility of the text or because it was perceived as being overtly manipulative. It could be that the sign text reading '90% of people clean their shoes' may be contradicted by people's experience of witnessing a lack of compliance, and therefore feeling like they are being deceived.

- *Lack of social norms as a barrier.* A few studies showed that one of the most common barriers to action is feeling like others would not do their part, assumedly creating a sense of futility (Benson & Dixit, 2010; Colmar Brunton, 2016; Heggie-Gracie & Robertson, 2015; Wegner, 2014a). Ough-Dealy and MacDonald (2016/2017) found that one of the perceived barriers to using the cleaning stations was people feeling that others may avoid using the cleaning stations altogether. This can be seen as another concern about the 'culture' around KDB and protective behaviours. The 70% of people who did not report advocating for KDBP suggests that the majority of participants across the studies still hold some reservations about the general culture of kauri protective behaviours, which may be contributing to the growing sense of futility. A way to further explore this explanation could be through the application of Equity Theory, which main premise is that people's social behaviour is motivated by its perceived 'fairness', where the higher an individual's perception of fairness, the more motivated they would be to engage in that behaviour (Al-zawahreh, 2012).

Social licence to operate

Broadly speaking, a social licence to operate (SLO) describes a community's overall positive sentiment or approval towards a particular action being undertaken by a governing entity or authority (such as research or intervention campaign). The process of establishing an SLO positions communities with as much authority as managing bodies in the decision-making process (Boutilier, 2014; Edwards et al., 2019).

While SLO has not been measured explicitly in any of the KDB social science research to date, tentative inferences can me made. Overall, there is evidence to suggest that a large proportion of people value kauri and support its management as shown by the positive motivations to engage in protective behaviours. Across several studies, participants expressed the desire for greater investment into the programme and protecting the kauri (Colmar Brunton, 2019; The Navigators, 2019; Wegner, 2014a) particularly those who seem to have more involvement or investment in kauri trees such as landowners who perhaps have greater connection to the land (The Navigators, 2019). In saying that, it is still not clear to what extent the public and specific groups are supportive of KDBP, with participants often expressing doubt in the government protection of kauri and the environment.

Ambassadors

Another social aspect that has been examined has been the influence of track ambassadors. Aley (2019) and Ovenden (2020) research suggests that their presence could have a positive influence of on compliance behaviours. Specific mention has been given to the Auckland Council's Kauri Ambassador programme, recently renamed to Biosecurity Champions, which has had ambassadors present at kauri-lands for the past ten years. Anecdotally, three of the interviewees expressed that this programme has had a positive impact on KDB perceptions and compliance. Apart from Aley's (2019) work however, the interviewees were not aware of any social science research that has explicitly tested the impact of ambassadors on KDB behaviour change efforts. It would be beneficial to ascertain the longevity of any impact ambassadors have had on social behaviour (i.e., whether impact only occurred with their physical presence or whether any notable changes persisted even in the absence of ambassador's post interaction). This is particularly important given that the presence of ambassadors is a resource-intensive option that may not be feasible in all locations.

Summary: social/cultural findings

- The impact of social norms and the wider KDB culture has been acknowledged as being important for establishing long-term kauri protective behaviours.
- Though yet to be fully examined, there is some evidence to suggest that the perceived culture of KDB impacts people's motivation to perform kauri protective behaviours, where the more they feel 'others' engage, the more willing they are to engage.
- There appear to be mixed views regarding whether KDBP has SLO, with no research explicitly and pointedly exploring this research question.
- Suggestive evidence that ambassadors may be having a positive impact on willingness to engage in kauri protective behaviours, though not yet explicitly tested.

6. Overall Conclusion

Drawing from across twenty-seven reviewed documents, and six interviews with KDB social science researchers, overall findings suggest that:

- There has been a general increase in awareness and valuing of kauri (62.3%), an increase in knowledge of KDB (36%), and the willingness to engage in Kauri protective behaviours (46% at cleaning stations; 19.1% of other behaviours). There is also an overall trend showing that cleaning station design significantly increases behavioural compliance.

- Though less clear, research findings suggest that people have personal, social, and ecological reasons for why they value kauri and its protection; with some evidence suggesting these values may differ across audiences. Interestingly, recent results also suggest that there are mixed feelings regarding the effectiveness and longevity of the current approach to KDB management, with an initial increase in the 'perceived seriousness between 2012 and 2016 (19%) followed by a decline in 2019 by 3%.

- Findings also show that different groups may differ in their view of KDB and its seriousness depending on their level of identification to a particular activity (e.g., hunters tend to view KD protective behaviours as more unachievable and ineffective and tend to be more closed off to information about KDB. They also seem to have some concern about KDB and whether KDB management has considered the impact there might be on hunting rights and access). Finally, there is some research which suggests that there is a growing KDB culture where there is higher peer to peer influencing of behaviours.

7. Discussion: Overall Trends and Insights

The Perceived Value of Kauri and KDB Management Efforts

Of those included in study samples, it seems that New Zealander place considerable value kauri and support the KDP in its effort to manage the disease. This is reflected in part by a growing awareness and knowledge of KDB and, to some extent, increases in compliance of key behaviours (predominately at cleaning stations).

In saying this, the research has also revealed a decline in the perceived seriousness of KDB and a growing sense of questioning of kauri protective behaviours and control efforts. On the one hand, this finding can be interpreted as an emerging sense disenchantment with KDBP, the reasons for which could be growing doubt in the efficacy of the management controls or 'fatigue' in the face of other, more pressing environmental issues.

On the other hand, however, it could be that, with greater awareness and knowledge about the KDB issue, people are engaging in more nuanced, critical thinking as they face the same questions that experts in the field face. It is possible that with greater involvement, the rationale behind behaviours, and therefore the scientific backing to its development, comes into question; which would mean that these individuals would be both more invested and willing to address KDB and, simultaneously be more critical of current controls. Such an interpretation is supported by the finding that those who spent more time in the forest tended to have greater KDB knowledge but also were more likely to question the effectiveness of cleaning behaviours (Wegner, 2014). Indeed, there was a relationship found between increased knowledge and greater questioning. This interpretation would also explain the desire for more information about KDB and KDP as well as well-designed and maintained cleaning stations (Wegner, 2014).

The Weak Relationship between Awareness and Compliance

On the onset of the social science KDB research, there appeared to be an assumption that increasing awareness would result in desired levels of Kauri protective behavioural compliance. This is reflected by research reports from 2010 to 2015 which predominately focused on awareness and self-reported compliance (though the relationship between variables were not statistically examined in most cases). However, both across and within studies, findings have shown that an increase in awareness and education has not corresponded with an increase in the intention to engage in Kauri protective behaviours (Wegner, 2014).

Four of the six interviewees raised this as a significant misperception that is not specific to the KDBP but is reflective of a common trend found in the wider environmental psychology literature, particularly when it comes to pro-environmental behaviours (Kollmuss & Agyeman, 2002). A similar pattern has been noted regarding an assumption that more positive attitudes towards KDBP would correspond with greater compliance, an assumption that is challenged by the studies reviewed and supported by international research (Antimova et al., 2012).

To test out the theory whether more specific attitudes are better predictors of specific behaviours, more attention was placed towards understanding specific behaviours. Ough Dealy and MacDonald's 2016 and 2017 employed the Theory of Planned Behaviour to see how specific beliefs, motivations and barriers affected specific behaviours (such as using cleaning stations). Their findings showed an increase compliance rates by more than 25%; adding weight to the need to target specific behaviours with nuanced understanding about

the social, psychological and physical influences on that behaviour. However, we do not know the longevity of this behavioural change, especially in the face of any sense of questioning or doubt in the efficacy of the behaviours themselves.

A Discrepancy between Self-Report and Observed Behaviour

Consistent with much literature on conservation or environmental behaviours (Oliphant et al., 2020), self-reported behavioural compliance often did not match observed behaviours in situ. As mentioned in the methods section, the reason for this is likely due to cognitive biases that can influence self-report measures, particularly when it comes to a socially desirable behaviour such as kauri protection.

In saying this, the work done by Auckland Council (Ovenden, 2020) showed relatively high correspondence between self-reported and observed behaviours, comparing survey data with surveillance camera monitoring. While promising, some caution was advised by our one of our interviewees who explained that our understanding of the robustness of this data is limited, given that the camera footage was reportedly blurry, and black and white, often making it hard to tell exactly which behaviours were being performed. Additionally, the very presence of the camera (alongside the signage which informed the track-visitors that they were being recorded) may have influenced the behaviour itself, lending to a smaller gap between self-reported and actual behaviour. Our clarity of these findings is further compromised by the fact that the survey data was collected by ambassadors who were there in both a research and promotional capacity, and therefore may have influenced the behaviour during the survey period. Given Aley's (2019) findings which showed that the presence of ambassadors made a significant difference to cleaning station compliance, we cannot tell which aspects of Ovenden's (2020)study contributed to the close relationship between self-reported and actual compliance. Finally, as there is currently no standard cleaning station design implemented across kauri tracks, we cannot be certain what 'compliance' entails in this specific instance as its level of difficulty may differ to other stations.

Focused Behaviour Change Research

At a very high level, the research to date has shown that areas which have had specific research focus, with a social science lens, have been associated with the greatest level of positive change. Exemplifying this, the focus on a specific behaviour (i.e., cleaning station behavioural compliance) has seen the greatest level of increase across the studies. This trend is supported by wider environmental and conservation psychology literature which has shown that specific behaviours need to be addressed with specific attitude and belief interventions and likewise that a focus on general attitudes often does not lead to behavioural changes (Heimlich & Ardoin, 2008).

Moreover, these findings provide further support for the effectiveness of cleaning station co-design between engineers, designers and social scientists (who in turn engage community members). The value of this process is evidenced by the large difference in compliance rates across cleaning station designs, shown in Ough-Dealy and MacDonald's 2016 and 2017 work on the development of the Mark II station. Though many aspects still require further examination (such as the track popularity; seasonal effects on behaviour, longevity of behavioural change), nevertheless a percentage increase of 25% was seen across tracks – providing considerable support for the social scientific co-design process.

Finally, the emphasis placed on informing people of the correct cleaning behaviours via effective signage appears to have yielded in greater knowledge of this behaviour, with more people mentioning the need to 'scrub, spray and clean' as compared to other recommended

kauri protective behaviours. Likewise, behaviours that have not received as much specific research attention (such as staying on track) have seen less improvement over time and in some instances, have even gone in the opposite direction as is the case with dog walkers and hunters.

8. Moving Forward: Limitations, Knowledge Gaps and Future Research

Significant progress has been made with regards to our knowledge about public values, perceptions and behaviours relating to KDB. We've also gained valuable insights about ways in which to influence the public towards more kauri protective behaviours through both the design of equipment and operational efforts but also in terms of communication and engagement approaches to include and educate more people about the issue.

Notwithstanding such progress, there are always areas that would benefit from further exploration and improvement. The following section draws from across the research to highlight key social science research knowledge gaps and offers suggested areas that could benefit from more attention in the future. The section will be split into two parts: 1) overarching methodological gaps and 2) topic-specific gaps. Section one will be used to inform section two.

Methodological Gaps

A few key methodological issues have been noted across the studies which future research would benefit from addressing.

- Definitions. Aside from Wegner (2014)'s report, there were no operational definitions provided of key concepts. As discussed earlier in the report, this compromises the researcher's ability to compare findings across studies.
- Theory. In most studies, the link between research design, methodological choices and theorical basis was not clear, making the findings difficult to interpret. In other words, understanding 'why' certain patterns emerged in the results was rarely explained through wider social science literature. Indeed, Wegner (2014) was the only report to provide explicit hypotheses and therefore offer more nuanced explanation for subsequent findings.[17] One of the interviewees stressed the importance of integrating a theoretical basis to the research both for interpretation of the results but also for the ability to publish, replicate and share findings with the wider social science community. This level of research rigour however may not be necessary in situations where the findings are short-term or very localised (e.g., Auckland region specific behavioural approaches). As such, the main emphasis here is to determine the 'scope' of the research (i.e., is its purpose to be evaluated long-term or to address an immediate issue) and cater the research methodology accordingly.
- Measurement. The measurement of key variables often varied, and sufficient detail was often not provided to ascertain to what degree findings could be compared across studies, particularly when reported in percentages or proportions of the general population. No reliability or validity statistics are provided for any of the psychometric variables.
- Grouping variables**.** Linked with the theoretical and measurement issues, the grouping analyses, while useful, have been largely descriptive in meaning and as

[17] This does not apply to qualitative research which does not aim to predict but to explore a social environment in more of an open fashion. The findings from which however should also be interpreted accordingly and not generalized to wider populations.

such, it is difficult to know *why* one group differs in its perception and behaviour to another group. This is particularly problematic given the overlapping nature of the groups. This was mentioned across four of the interviews as being a particularly problematic knowledge gap given the emphasis that is given to targeting messaging according to assumed group differences.

- Analytic procedures. Overall scores on key concepts (e.g., compliance/agreement) were often calculated differently such that comparison across studies is difficult (e.g., partial compliance vs full compliance vs any compliance). Continuous Likert scales were often summated into dichotomous answers putting people either 'agreement' or 'disagreement.'
- Equipment. Due to differences in cleaning station design, it is difficult to assess what aspects of the cleaning stations was related to greater or lesser compliance. This was corroborated by four of the interviewees, who raised the a lack of consistency in cleaning stations and signage at various kauri Infected areas as a confounding issue. Aside from Ough-Dealy & MacDonlad's (2016/2017) work and Aley (2019), no information was provided about the 'types' of cleaning stations that the questions were referring to. The same lack of information applies for signage. This knowledge gap was further raised by one of the interviewees regarding the lack of design elements for non-foot-traffic station users, such as those using wheelchairs, prams, bicycles etc.
- Sampling. A few sampling differences were present across studies including – size, selection methods (panel, random, sourced) and location specificity. This is particularly relevant given the potential differences in user groups.
- Statistical significance/evaluation. The majority of studies did not test for statistical significance, either for within study group-differences or across study (and therefore time) differences. The testing of statistical significance is important with regards to the evaluation of initiatives aiming to assess its effectiveness so as to identify areas for improvement.
- Short term vs long-term effects**.** Almost none of studies have examined or discussed the difference between short-term and long-term behaviour change effects. MacDonald (2017) explains this in the context of signage where people reach 'habituation' (i,e., the original effects of a particular treatment or design may fade over time). The importance of this is exemplified by the apparent decrease in perceived importance of KDB protection in the last ten years of research. Due to measurement issues however, we are unable to identify which aspects may be contributing to this decline. Adding to this discussion, all six interviewees raised the necessity to consider long-term behavioural solutions, partially due to the long gestation period of KDB but also due to the wider need for biosecurity awareness and appropriate behaviours more broadly.

Topic-Specific Gaps

Assuming the aforementioned measurement issues are addressed, the following specific areas would benefit from research attention.

Behavioural variables

- *Cleaning station behaviour.* It is still unknown which cleaning stations, and which design aspects, are contributing to greater levels of compliance, especially full compliance at a high frequency rate in the current sequence of behaviours (Ough-Dealy & MacDonald, 2017).

- *Other kauri protective behaviours.* No research to date has measured 'observed' levels of other kauri protective behaviours such as staying on track and cleaning equipment at home as well as more specific behaviours such as avoiding track closures and off-track behaviours such as farming or hunting. This was raised by five of the six interviewees as a significant knowledge gap given that, although forest track users occur at high frequency, other behaviours may be more impactful with regard to the spread of soil and proximity to kauri.
- *Signage.* There is a considerable lack of documentation of the specific signage used at specific sites and across studies, and also how the signage corresponds with the various cleanings station designs. Moreover, very little in situ testing has occurred on how signage corresponds to observed behavioural changes. As such, it is still unclear how signage design relates to compliance across contexts, groups and with specific cleaning station designs.
- *Seasonality.* It was noted that in majority of the studies, testing of cleaning station behaviour was conducted during summer months; (an interviewee clarified that this is predominately to ensure sufficiently high sampling numbers). Nevertheless, it is unknown how behaviours would change in wetter, and therefore muddier, conditions which could significantly impact the level of risk during certain periods of the year.

Psychological variables

- *Explicit vs implicit motivation.* Much like there is a gap between self-reported an observed behaviour, so too there is often discrepancy between self-reported reasons or 'explicit' motivations for engaging in behaviour and the underlying more unconscious motives. Colmar Brunton (2019) discussed this in the proposal of their report. However, no specific analyses were made regarding which 'implicit' or unconscious motivations were influencing more conscious intentions and actual behaviour. Further exploration of this would be useful for understanding aspects such as the growing sense of futility (which may or may not be related to self-reported reasons) or could explain the diffusion of responsibility – the tendency for people to not perceive themselves as the source of risk as compared to others, despite information of otherwise, such as the potential difference between locals and non-locals.
- *Values and beliefs.* In line with the above, research has shown that more fundamental values and beliefs are better predictors of attitudes and behaviour than explicit, self-reported attitudes. To date, no research has explored the psychographics behind KDB related perceptions and behaviours – variables which are essential for the development of distinct 'personas' that can be understood and engaged with in a meaningful way through targeted communication. Three of the interviewees raised this as a considerable gap in our knowledge, emphasising the importance of not viewing 'activity groups' (e.g., hunters, walkers, cyclists) as homogenous groups but rather as clusters of people with differing motivations and barriers to both forest visitation as well as willingness to engage in kauri protective behaviours.
- *Off-track users.* Except for the Navigator's (2019) research, little research has been conducted on off-track users regarding kauri protective behaviours and the motives (explicit and implicit) for complying or non-complying. There is no measurement of rates of behavioural compliance currently, self-reported or observed.
- *Track closures.* Little of the research has been conducted on rates of compliance with track closure kauri protective behaviours and the motivations for compliance and non-compliance.

- *KDB in a wider environmental context.* As mentioned, findings suggest that KDB may be declining as a priority issue in people's minds, with less perceived seriousness and growing sense of futility. However, the reasons for this trend are not clear. One explanation could be a habituation to extant behaviour change techniques, another could be the emergence of larger, more pressing matters (environmental or others). Futility could be arising due to a perceived lack of connection between their behaviour and the consequences or their behaviour (i.e., people cannot see any improvement to the physical environment). Finally, it may be reflective of greater overall engagement leading to more critical view of the programme and science. With the current level of nuance in measurement however, it is not possible to discern which explanation holds most weight.

Socio-Cultural Variables

- *Social norming*. Though commonly asked how they feel and perceive others' kauri protective behaviours, no research to date has explored how these factors impact their own motivations and behaviour. Aley (2019) began this process, exemplifying the importance of testing theoretically plausible approaches to creating social norming in the KDB space. In further discussion with one of the interviewees, it was mentioned that there is a need to conduct broader research and test various *types* of social norms, which may or may not apply to the KDB context.
- *Social licence to operate*. Some inferences can be made regarding SLO, but no research has directly explored how a particular community perceives and feels about the current KDB control efforts overall. The importance of this was stressed by two of the interviewees which mentioned that research on the ground was at times met with some resistance, revealing on-going tensions between community members and the control authorities of KDBP (a pattern not easily visible in the extant studies).
- *Ambassadors.* Aside from Aley (2019), no research has been conducted to statistically examine the influence of ambassadors on both in situ compliance as well as on overall public perceptions of KDB management and related authorities, which, in turn, may influence long-term behaviour (even in the absence of ambassadors). The lack of ambassador research was raised as an important gap by three of the six interviewees given their prevalence not only in the KDB space but across a wider gambit of biosecurity programmes across the country.

9. Recommendation: Research and Investment

Reflecting on the review of insights and knowledge gaps, the following section offers next steps for potential future lines of investment.

Efforts have been made to align the recommendations of this report with other key KDB strategic documents, such as the KDB Science Plan (KDB Strategic Science Advisory Group, 2019), the KDB Strategic Plan (Ashcroft et al., 2019) and the NPMP (New Zealand Government, 2021). The section is categorised into Operational and Strategic research recommendations, covering both immediate needs with extant knowledge as well as future focussed needs for long-term management. The last section will address recommendations for possible synergies with KDB communications.

Appendix B offers a synthesis of the following recommendations and presents a prioritisation schematic which suggests a possible research-plan going forward.

Operational Recommendations

- Further examination of key behaviours. While significant headway has been made in identifying and understanding key kauri protective behaviours, the following steps are recommended to gather more robust behavioural insights.

    - *Observational studies.* Given the discrepancy between self-reported and observed behaviours, a greater number of studies should examine correspondence between these two measurement methods. Two methods that could be employed to this end would be a) hidden cameras with standardised coding methods (e.g., the model by Ovenden, 2020), or b) observations made by surveyors, ensuring that these research individuals are not ambassadors or associated with the promotion of KDBP. It is important that any observations made have a clear coding process, with consistent definitions of what is considered ‘acceptable’ levels of compliance.

      Of particular importance is the measurement of observed other (not cleaning station) kauri protective compliance behaviours (such as staying on track) and off-track behaviours (such as hunting/trapping) as there is currently no observational data in this space.

    - *Experimental studies.* It is also recommended that where possible, behaviour change treatments are piloted in experimental settings prior to implementation in real-world settings where there are numerous confounding variables that cannot be controlled. One particularly pertinent area warranting pilot testing is KDB signage, and the framing of messages according to social science principles. Noting, Colmar Brunton’s ‘Scrub, Check, Spray’ (2021) research may be useful in this context which can be built upon and tested in situ incorporating the findings gained after the studies completion.

    - *Journey mapping.* Across all six interviews, it was mentioned that there is a need to explore the full journey of kauri protective behaviours, beginning from at home cleaning behaviours right through to entering a track, the track journey and at home cleaning behaviours. This sort of journey mapping could

also enhance our understanding of the social aspects relating to KDB behaviours such as where people sourcing of information about KDB and their patterns of advocacy. This is consistent with Community Based Social Marketing approach where it may be possible to identify specific barriers to behaviour change that only become evident when considering the end-to-end journey.

Given appropriate resourcing, it may also be beneficial to trial novel behaviour change implementation using a 'repeated measures' longitudinal design whereby the same individuals are asked about their KDB perceptions and behaviours across time; thereby allowing researchers to better predict, with greater precision, the factors that contribute to most influence to behavioural outcomes.

- *Transdisciplinary communication and research.* In line with the KDB Science Plan, it is recommended that, where possible, links be made between social science findings and the on-the-ground physical spread of KDB. This would not only offer a way of motivating (and maintaining motivation) with the public but also would perhaps inform the different scientific disciplines to develop better ways of mitigating the spread and gaining further insight of the disease.

- Identification of key audiences**.** Across the reviewed research, interviews and wider KDB strategic documentation (KDB Science Plan; KDB Strategic Plan; NPMP; pg 51), a common thread has been the need to identify key KDB audiences. This would enable the KDBP to better meet the needs of effected communities and target communication in a way that is relevant and impactful as their engagement and identification with certain activities may impact their views and willingness to contribute to kauri protection.

  One of the first areas to begin would be the exploration of the emergent group-level trends with more depth to understand these differences more fully, and at the same time, glean deeper insights into more general patterns of motivation and behaviour. A pertinent area to begin would be an in-depth exploration of locals given findings which suggest they are less compliant and yet supportive of the KDBP. In other words, there are some less 'overt' psychological processes at play that are leading people to justify their non-compliant behaviour despite seeing the validity in the KDB issue and the need for kauri protective behaviour. Other group-specific differences that warrant further exploration is the difference in behaviours between age cohorts, different activity groups (e.g., walkers, runners, dog walkers) and high-risk users (e.g., hunters/trappers). The need for group-level nuance was highlighted in the NPMP which acknowledges that "*community is not uniform in its views (there are many voices in a community) - just as there are many publics and not one public* (New Zealand Government, 2021)". Such group-based research could be conducted using existing methods with more specific metrics and clearer activity-group definitions.

  Given the limitations of a demographic or activity-based approach to persona building, an additional step is recommended to further our understanding of the 'why' behind group differences. One particularly useful method for achieving this is through the development of KDB profiles by applying the theoretical framework of

'psychographics' whereby audiences are grouped by their underlying 'psychological profiles.' One benefit of this approach is that it enables researchers to identify the underlying core beliefs, values and attitudes that are not only related to key variables of interest (such as environmental or conservation issues) but can help *explain* the motivations behind them. This further insight would enable researchers to better cater behaviour change initiatives as well as communication experts to frame information in a way that address core issues that are often not plainly visible with more explicit approaches.

MacDonald et al (2020) offers a useful example of the usefulness of psychographics by showing that neither technical knowledge nor positive attitudes towards a particular issue (e.g., conservation) predicted pro-conservation behaviour as well as more fundamental values. Given the close overlap in conservation views, one way forward could be the application of MacDonald et al's four psychographic profiles to the context of KDB and behaviour, assessing which core values are associated with support for kauri and its protection as well as engagement in protective behaviours.

Alternatively, a bespoke segmentation model could be created that caters for the specific needs of the KDBP by incorporating existing profiles (e.g., activity-based groupings) and exploring the underlying values and beliefs associated with both those activities and perceptions of KDB, which could be done both qualitatively and quantitatively, (depending on the specificity and scale of the research question). For example, while we know that most of the studies have shown that the public appears to value kauri for its environmental, social and cultural reasons – we do not know the relationship between these values and the activities and behaviours that people engage in. It could be the case that those who choose to engage in hunting/trapping behaviours have more fundamental values that not only predict their engagement in these activities but also their views of KDB, such as a value for freedom, nature, independence and transparency. Another example could be that many who engage in kauri protective behaviours do so because they value social cohesion, obedience and trust in authorities – and therefore act out of a sense of social obligation and responsibility rather than conservation values. It is important to note that these suggested patterns are speculative and necessitate examination.

A psychographic approach to KDB profiling would enable researchers to discern with greater precision what values and beliefs are related to 'self-reported' behaviour as compared to actual behaviour, and further nuances therein (such as those who perform behaviours 'every time' as opposed to 'some of the time).'

The identification and understanding of different KDB related profiles would also enable co-development of KDB research and solutions as well as on-going communication efforts that address more core issues and needs. This may be particularly useful in the context of higher-risk groups (such as hunters/ trappers/ farmers) which have a more complex array of needs and investments when it comes to kauri and recommended protective behaviours.

- Explore wider KDP perspectives. It appears that the majority of the social science research on KDB has been focused on specific behaviours and achieving a certain understanding in the minds of the public (i.e., that kauri are valuable, and their protection should be a priority). However, it was mentioned by two of interviewed experts that KDB is a 'complex' and 'systematic' problem that has social, cultural and environmental implications that could be connected to broader issues in New Zealand (such as conservation, climate change and national identity).

Though some inferences have been made, no research to date however has explicitly explored how New Zealand's view kauri, KDB and its protection on a broader level and in context of its relationship to broader issues in New Zealand. A better understanding of the current image of KDBP would enable partners to leverage off positive motivation while also addressing doubts, concerns or disagreements that may be contributing to the apparent decline in perceived seriousness of KDB in recent years. Of particular importance is the need to explore the degree to which people are resistant to kauri protective behaviours due to personal barriers (e.g., cleaning station design and maintenance; ability to perform the behaviour, the perceived effectiveness of the behaviour) or social barriers (e.g., perceived lack of commitment from other forest users as well as the overall management authorities). Ways in which such research could be approached include:

- *Content Analysis.* Across social science disciplines (such as psychology, sociology and media studies), content analyses are used as to assess overall public 'impressions' of a particular topic on both individual and collective levels (Neuendorf, 2011). This could be achieved through an analysis of media discussions on KDB and KDBP, evaluating the general language used and sentiments expressed in KDB related news articles, comments, and blogs. At a more granular level, focus groups and interviews could be conducted to explore how people feel about KDBP overall, rather than the studies to date which have had a more specific focus on cleaning behaviours.

- *Choice Modelling.* Given the decline in perceived seriousness of KDB (especially in the context of wider New Zealand issues)**,** another useful approach could be the use of choice-modelling. Borrowing from micro-economics, this statistical method examines how people perceive the importance of a particular issue when pitted against other important issues. MacDonald et al., (2020) employed this method to assess how appealing a novel pest control technology was in context of other technological options. The advantage of this method is that it shows the process of prioritisation and how people's values relate to the choices and behaviours that they ultimately choose to engage in. In the context of KDB, insight could be gained on where KDB sits in the grander scheme of environmental and social issues and which motivations are more likely to result in actual behaviour.

Strategic Research Recommendations

- Integration of social scientists into the KDBP. To create a transdisciplinary programme environment, as outlined in the KDB Science Plan, and in following the principle of Tatari (KDB National Programme), it is recommended that social science subject matter experts (SMEs) be included into the KDBP at the strategic level. The importance of a more integrated social science lens across the entire KDBP (and connected partners such as the National Science Challenge) was highlighted by three of the interviewees as essential for gathering meaningful insights that would allow for greater precision, relevance and longevity of research findings. A key first step towards this goal would be to include social scientists and other relevant experts at the research design phase to ensure that the right research questions are posed at

the onset of any research programme. Such an approach would be in accord with a key assumption in the NPMP which states: "*Social science research will need to be integrated into all aspects of the KDP to inform decision-making to ensure it is based on sound, robust and rigorous social science evidence* (pg. 51)."

- Embedding of social science methodologies. Alongside continued support from experts, it would be useful to establish a social science research toolkit and standard operating procedures that could be referred to by a wide range of programme members. At a high level, the two key steps would be 1) the conduction of literature reviews to ensure that any approach was informed by previous research and 2) the selection of appropriate and reliable metrics, which would allow for comparison across studies and long-term evaluation.

- A co-design research approach. In accordance with the KDB Science Plan, and the recommendations of one of the key experts in participatory research, it is recommended that the overarching research process be conducted in consultation with and response to specific effected communities as well as the wider public. This would not only ensure more robust, relevant and long-term solutions but would also be a way to assess whether a given initiative has the social licence to operate through the establishment of relationships and the building of trust with effective communities and the public more broadly. To achieve this, three key levels of engagement are recommended.

    - *Participatory research.* As mentioned by one of the interviewees, a 'participatory' research approach is recommended, where community members are involved in the formulation of the research questions and the identification of possible solutions (e.g., protective behaviours). As such, methodologies, such as the deliberative consultation processes or citizen science could be considered where community engagement occurs throughout the research process, and then further moving into solution development. The NPMP makes an explicit address for the need to engage in more participatory approaches for meaningful stakeholder engagement and the collaborative development of a shared vision ((New Zealand Government, 2021; pg 51). Synergies may be possible between KDBP and the work currently underway by Dr Marie McEntee and Dr Natasha Tassell-Matamua who are leading the 'Mobilising Action' Project under the Ngā Rākau Taketake National Science Challenge remit which is aiming to explore many similar themes.

    - *Community testing and monitoring.* To ensure that any implementations are both effective and relevant, it is recommended that operationalisations of key insights (e.g., cleaning station treatments, signage design, wider communication approaches) be piloted (and perhaps on multiple occasions) with key communities and operational staff before more permanent, long-term rollouts. Experimental or semi-experimental research designs may be useful here, whereby the behaviour or psychometrics in question are compared across time (e.g., pre- or post-new cleaning station/signage treatments) or across groups. Additionally, as suggested by two of the interviewees, qualitative approaches could be employed, such as deliberative consultation meetings, whereby participants discuss their responses suggested

behaviours and equipment (e.g., cleaning stations) allowing for an iterative refinement process towards a final solution. Colmar Brunton (In press) are currently conducting similar research in their exploration of “Scrub, Check, Spray’ messaging whereby they are requesting that participants to record their responses to instructions and then voice aloud their likely behavioural responses. Aley’s (2020) presents a useful example of the benefits of a qualitative, deliberative process whereby something as nuanced as a single word (e.g., soil vs dirt) could have a significant impact on people’s interpretation of signage and resultant levels of compliance.

- *Evaluation of community impact.* The impact of any final programme initiative on potentially affected communities is worth consideration where it is possible to explore and address wider community needs that may not be immediately visible within the research. Such a step was mentioned by an interviewee who had noted that some hunters’ resistance to kauri protective behaviours was related to their reliance on hunting to provide food for their families or due to the fact that a path closure meant that their children no longer had a safe route to school;’ a connection that could easily be missed in more structured survey settings. Social Impact Assessments (SIAs) are a particularly useful tool in this context, which explore the impact that a programme or project may have on the economic, social and cultural well-being of effected communities (see Russell et al., 2017 for a useful example). Moreover, the results of a SIA could also offer further insight into KDB SLO in given communities, which, according to the NPMP may be particularly useful in the coming future given the likelihood of novel technologies being needed to address the KDB issue (New Zealand Government, 2021; pg 53).

- Long-Term Research Programmes. As mentioned in both the KDB Science Plan, The KDB Strategic Plan and the NPMP; while immediate operational research and solutions are necessary, there is a growing need to establish long-term management of KDB and wider forest health. This was raised across all six interviews as an essential strategic shift for the sustainability of kauri protective behaviours towards an establishment of long-term biosecurity behaviours more broadly. This is further supported by the NPMP which highlights the challenge of maintaining consistent behavioural compliance and engagement given the long-term latency of the disease (New Zealand Government, 2021; pg 51). It is recommended that greater focus is placed on longer-term engagement and behaviour change research, such that changes in compliance behaviours can be compared to environmental changes, such as the spread of KDB.

  While there are a multitude of longitudinal social science methodologies, in the context of KDB, it is recommended that focus be placed on both tracking changes in specific behaviours over time (e.g., cleaning station usage) as well as the broader perceptions and sentiments towards KDB and its management. Given that the research on KDB and its impact on wider forest health is still unclear, there may changes to what behaviours are asked of the public and, as such, more integrated, long-term social solutions may be required that allow for flexibility and adaption and less on short-term behavioural treatments. With a broad perspective, it may also be more suitable for integration with wider KDB social initiatives such as the Biosecurity

Direction Statement put forth for 2025 (MPI, 2016).

- Strive toward best social science practices**.** It is recommended that the following key best social science practices be given more focus to produce more relevant, reliable and robust findings. Better comparisons across groups and studies could not only raise the profile of said research (potentially attracting the attention of international communities) but could also increase the return on investment of social science research as decision makers are able to use the evidence to better align programme efforts and resources.

    - *Measurement.* It is recommended that key concepts be discussed, defined and consistently measured (such as awareness, KDB knowledge, motivation and compliance), and that their use is recorded in future studies (alongside reliability metrics). In qualitative studies, it may be more appropriate for definitions of concepts to emerge from discussion, in which case, it would be beneficial to have that process recorded and explained for clarity of understanding and interpretation.

    - *Theoretical justification.* It is recommended that theoretical justification be provided for the use of specific variables alongside the provision of hypotheses (where relevant). This would greatly enhance our ability to meaningfully interpret and operationalise research findings.

    - *Statistical significance.* Given that one of the key aims of the KDB social science research is to examine 'shifts' (in awareness, in knowledge, in compliance, in attitudes), statistical tests would greatly enhance our ability to assess the robustness and reliability of any noted differences across groups and over time studies.

    - *Standardisation.* Where possible, it is recommended that there is standardisation of behaviour change materials such as cleaning station design, signage and any other relevant factors (such as survey administrations/ambassadors). This would not only greatly enhance the validity and reliability of any research findings but may also enhance the perceived cohesiveness of the KDBP by the public more generally.

    - *Evaluation.* It was raised across all the interviews that there was seldom evaluation of implemented campaigns or treatments in situ, which in turn inhibits the programme's ability to ascertain which aspects are contributing to or detracting from compliance levels and overall engagement. In addition to research metrics, evaluation may also include some form of return on investment in economic terms, enabling programme partners to allocate and acquire future funding. Given its importance, it is recommended that a final step of "evaluation' be added as a final step to the research process described in the KDB National Programme.

Communication Recommendations

While it is beyond the scope of this report to offer an expert approach to KDB communications, a few areas have been identified that would greatly benefit from and toward social science research.

Firstly, the identification and understanding of different KDB personas, and underlying values, beliefs and attitudes would be directly useful for the framing of overarching communication messaging, making sure that the same issue is examined from multiple viewpoints. Such integration between social science and the communications departments of KDBP have already yielded beneficial results, whereby it has enabled for more empathic and precise approach to communicating with hunters, farmers and trappers based on the work done by the Navigators in 2019. Three of the interviewees raised the importance of the application of persona-based findings to the communication space, where they felt that it would enable for more precise, relevant and meaningful messaging and creatives.

Secondly, insights regarding current perceptions of KDBP on a more global level may enable communication experts to identify areas where there is perhaps misunderstanding, a lack of information, or inconsistency in messaging. By looking at perceptions of KDBP on a cultural level, it may provide insight into the KDB 'brand;' how it is currently being viewed and ways in which it could be improved - an area that was considered largely unexplored by three of the interviewees who had experience in marketing and communications.

Thirdly, a fuller understanding of the full kauri protection behavioural journey may offer insights into touchpoints for communication that otherwise may have been overlooked; both areas that people may be receiving information that we are currently unaware of as well as gaps in communication. This is particularly important given that a majority of study participants reported learning about KDB on entry of tracks, revealing a greater need for communication outside the context of kauri forests themselves.

Finally, greater transdisciplinary work across KDBP research areas may allow for more up-to-date and relevant science communication whereby public questions can be addressed with timely disclosure, clarity and accuracy – features that have been found to convey a sense of 'transparency.' Considering a possible sense of fatigue and doubt in KDBP, increasing the perceived transparency of the programme may be beneficial, with research showing that transparency can enhance perceived trustworthiness of management programmes (Schnackenberg et al., 2020).

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Appendix A: Summary of Reviewed KDB Social Science Research

Reference	Objectives	Methods	Key Findings
Kauri Dieback Formative Research Report & Summary Presentation (Synovate, May 2010).	• To better understand attitudes and perceptions of higher-risk users of affected or at-risk kauri forests.	• Online Survey (N = 1,000) • Interviews (N = 5) with forest club groups. • Focus groups (N = 5) with hunters, walkers, landowners, dog walkers, contractors	***Quantitative:*** • 21% - KDB Awareness • 29% of forest users rate the disease as less than important. • 7% self- KDB Tree Identification (self-report) • Possible group differences in awareness and perceived importance • 82% not aware of correct kauri protective behaviours, 14% unsure. ***Qualitative:*** • Kauri valued for cultural, ecological, economic, and historical reasons. • Some feel because others don't do it, there is no point. • Little scientific knowledge of disease and how its spread. • There is doubt about the role humans play in its spread. • Information sourced form clubs/groups, websites, officials, signage and word of mouth.
Kauri Dieback National Survey (Department of Conservation, 2012)	• Measure awareness of KDB and reported kauri protective behaviours.	• Survey (Online and Telephone; N = 3,885).	• 42% awareness of KDB/ 58% unawareness of KDB • 18% self-reported engagement in at least some kauri protective behaviour. Of these, 91% reported performing shoe cleaning behaviour. • 23% cleaned equipment, 8% stayed on tracks, 4% read signage.
National Survey of New Zealanders – Kauri Dieback, (Department of Conservation, 2013)	• Measure awareness of KDB and reported kauri behaviours.	• Telephone Survey (N = 2,293) • Comparing with only telephone interviews from 2012 survey.	• 59% Awareness of KDB • 47% reported engaging in some KDB behaviours (note: as this report compared with a sub-sample of the 2012 report, making the previous percentage of reported kauri behaviours 45% – meaning that there was a lack of significant change of 2%. • 89% reported cleaning shoes, followed by 27% cleaning equipment, 7% staying on track, 1% reading signage.

People's Panel Kauri Dieback Survey (Auckland Council, 2013)	• Understand how much Aucklanders know about KDB, how they think it should be managed and how information should be communicated	• Survey (n = 2,983 from the Auckland 'People's Panel)' • (n = 94 public responses)	• 82% awareness of KDB • 57% heard of KDB via tv/newspaper/radio; 53% from signage • 63% awareness of track closures • 55% report always 'using cleaning stations' on entry (50% on exit) • 5% reporting cleaning equipment

Factors Influencing Public Responses to Kauri Dieback Control Measures (Wegner, 2014)	• Identify factors & motivations influence forest user compliance
	• Inform messaging strategies.
		• Intercept surveys in 7 Kauri Forests (n=747)
		• Interviews during surveys (n=9)
			• 75.7% awareness of KDB
			• 88.9% self-reported compliance of cleaning stations
			• 16.6% self-reported walking off track on last visit
			• 69.1% identified at least one correct vector of KDB
			• Lower awareness did not correspond to lower compliance
			• 52% felt, to some extent, that others would use cleaning station every time
			• Reported motivations for compliance more positive (n = 220) than negative (n = 116)
			• Most participants expressed a desire to protect kauri (n = 135). Positive feelings towards Kauri relate to protecting New Zealand's natural heritage.
			• Negative feelings towards KDBP related to:
			  ○ A lack of information
			  ○ Difficulties with cleaning stations
			  ○ Feeling restricted
			  ○ Encumbered with effort
			  ○ Feelings of doubt and uncertainty regarding the behaviours and overall programme.
			• Main reported reasons for non-compliance - doubt surrounding the effectiveness of cleaning and likelihood of others not complying
			• Control efforts mostly associated with the Department of Conservation and the Ministry of Primary Industries.

			• Activity identity (e.g., being a runner/hunter) had no influence on KDB knowledge, perceived threat by KDB management, attitudes, values or behaviour. • Place identity (i.e., identifying with a particular location) did have a slight influence on perceived seriousness of KDB, intention to use cleaning stations and a perception that the requisite behaviours were practical and effective.
Evaluation of Kauri Dieback Signage (Macdonald, Nov 2015)	• Recommendations for suggested changes to KDB signage based on theory to increase cleaning station compliance.	• Desktop Review of relevant literature and extant KDBP Signage.	• The review offered the following signage recommendations based on hazard communication theory: o Yellow and black colouring o Good pictorials o Appropriate reading level o Kauri dieback signage could be improved by adding a signal word (e.g., DANGER) o Clearly stating cause and effect of the hazard and the compliant behaviour o Removal of all capitalisations
Kauri Dieback Awareness and Compliance Report (Heggie-Grace & Robertson, 2015)	• Gather information about why people choose to use KDB cleaning stations	• Intercept surveys at stations (n = 689) across 9 regional areas in Auckland. • Surveillance cameras over a period of approx. 1 month in Jan-Feb (N = 3,621. Footage was assessed on use of trigene spray only, brush only, or both spray and scrub as well as no use of the cleaning station.	• 78% awareness of KDB • 89% recognised the importance of scrubbing and spraying • 29% recognised importance of staying on track • 90% agreed that using the cleaning stations was the ‘right thing to do’ • 69% self-reported compliance of using stations. • 54% actual observed compliance • 39% believe others are compliant • 79% of track visitors see an expectation to comply coming from • their friends and whānau • 66% of track visitors perceived the cleaning stations as effective • There was very little variation in awareness between locations • Lowest levels of awareness among young track visitors • 61.% in-park signage main source of knowledge about KDB followed by word of mouth (27 %)

Kauri Dieback Survey Report (Colmar Brunton, Feb 2016).	• Measure awareness, perceptions, and self-reported behaviours. • Compare with 2011 research. • Understand barriers to kauri protective behaviours. • Inform future engagement.	• Online Survey (N = 1,200) with forest user groups with weighted samples by region. • Two day online qualitative forum with 34 forest users, farmers, landowners and non-compliant users.	***Quantitative:*** • 66.7% - KDBP awareness (74% for landowners) • 25% - KDB tree Identification (self-report) • 75% think its a serious problem - 90% think its important. • 82% can name one correct kauri protective behaviour. Of these, 72% aware of foot/equipment cleaning behaviours, 33% staying on track behaviours. • Mostly likely to name incorrect behaviours are non-forest users. Dog walkers reported having least amount of KDB knowledge (6%). • 40% - use disinfectant incorrectly (to clean dirt) • 37% - cannot recall the main message on signage. • 32% - have spoken about KDB to others (advocacy) ***Qualitative:*** • KDB considered serious and important to manage because of the trees' uniqueness, magnificence, and historical significance to NZ – but is not a high priority in the context of other environmental threats. • Main reason for not advocating is not trusting the science, being unsure of behaviours and not enough information in general.
Kauri Dieback Prototype Cleaning Station Research Report (Ough-Dealy & MacDonland, May 2016)	Increase compliance behaviour by 25% from baseline (pre-prototype installation).	• Installation of Mark II Cleaning station • Intercept surveys and behavioural Observations (full, partial or noncompliance) Pre- and post-installation. • Pre n = 215 Post n = 357	• Compliance increased from 51% (pre-installation) to 97% (post-installation) • 74% compliance at barrel and grate station • 33% at brush and spray stations • 0% at signage only stations • 98% self-reported cleaning behaviours at all stations • Prior to installation, people's perceived barriers to using the station were: a need for better design of cleaning stations; location and make more prominent (18%), concern about the chemicals in the disinfectant (8%) and doubt of the overall impact of cleaning shoes (3%) • Perceived barriers dropped to less than 2% post-installation.
Kauri Dieback Prototype Cleaning Station Cleaning Trial (Beauchamp,	Test the effectiveness of the current prototype KDB cleaning station to assist	• Behaviour observation of: length of time taken to use cleaning station	• Observers noted that it took over 1 minute for users to use the station and even when used, mud remained on user boots.

Ough Dealy & Williams, Aug 2016)	development of the Mark II station.	prototype and degree of cleanliness. • Four treatments were observed: Muddy station, clean station, sticky mud on boots, smooth mud on boots.	• Residual spray from 'brushing' resulted in confirmation (particle spread) within a 3-metre radius of the station. • The bushes alone took 10 minutes to clean, which did not include the rest of the station.
Risk posed by different vector types for the spread of Kauri Dieback (Smith, 2017)	Assess the level of risk posed by different activity and industry types with particular regard to the extent to which they might distribute soil.	• Background research vector groups a • compiled list of contacts • Interview (N =) • Risk analysis	• Overall risk analysis showed no clear need to focus on any one vector group as they all present a moderate risk score. • Recreational users were seen as having a higher perception risk score - generally are not as likely as others to view KDB as a cause for concern (as compared to industry, tourism, infrastructure and education & learning groups). • 54% of recreational users not interested in more information about KDB. • 50% felt that more information specific to their industry should be made available. • 67% were poor amongst the local guiding industries
Kauri Dieback Recreation Project Tane Mahuta Type 2 Cleaning Station Research Report (Ough Dealy & MacDonald, June 2017)	Resolve issues with Mark II station (as identified by experts) without reducing user compliance. Determine whether elements could be utilised in other cleaning stations (e.g., barrel and grate)	• Intercept surveys and behavioural Observations (full, partial or noncompliance) • N = 55	• Post-modifications, compliance was at 98% on entry and 90% on leaving which was consistent with self-reported behaviour. • Perceived benefits to using the Mark II cleaning station were: it would reduce the spread of the disease, help the forest stay healthy (64%), it was easy to understand and to use (46%), it was important (21%), it cleaned their shoes (15%), it was compulsory (13%), increased awareness of the issue (5%) and it looked better (5%) • Perceived barriers included, the flooring was slippery (11%), people avoiding the cleaning stations (9%), not being sure why they should clean their footwear – needed more information on dieback (9%), difficult to clean kids' shoes, prams and bicycle and wheelchair tyres (4%), maintenance (4%) . • Most people mentioned wanting more information about the issue

Kauri dieback signage icons: public testing (Aley, 2018)	Test Icons developed MPI and in use by programme partners, and icons used by DOC.	• Intercept question where public were shown one icon at a time printed on an A4 sheet, with a maximum of two icons only. • The exact words of the response were recorded.	• Icons were understood for messages about brushing and spraying your shoes. A new 'stay on track' icon (included images to not touch trees), was more successful rather than the more widely used original 'stay on track' icon. (specific percentage differences not possible) • A department of conservation 'inspect' icon failed to achieve any level of correct understanding. The two newly designed 'inspect' icons were more successful in portraying the message to check your shoes, but still fail to invoke the message to check specifically for soil (specific percentage differences not possible)
Mark II Prototype Cleaning Station – compliance research report (Aley & MacDonald, Oct 2018)	Test levels of compliance with revised Mark II cleaning station, incorporating findings from social science and operational research.	• Observational survey of track users entering and existing cleaning stations (full compliance, partial compliance and non-compliance). • Mark II (N = 1705) • Barrel and Grate (N = 128)	• 90% of track users did something to clean their footwear at the cleaning station. • 3% to 64% performed full compliance behaviours (i.e., brush, inspect, disinfect). • 72% to 95% performed partial compliance behaviours (including those performing full compliance). • Variation occurred across locations, though no statistical significance was tested so differences are not reported in discussion.
Keep Kauri Standing research Full Results (Auckland Council, Aug 2018)	Evaluate the effectiveness communications May 2018 campaign specific to awareness and sentiment of track closures and Understanding of KDB.	• Online Survey (N = 1,005) between July and August. • External panel was used to collate participants from 2 regional park areas.	• 72% awareness of KDB • 61% awareness of track closures. Of those, 82% it was for prevention of KDB and 92% of those who know the issue is 'very severe' or 'severe' are supportive of the closures. • Young people (18-34) were the most likely to visit regional parks but had lower awareness, understanding, and support for the closures. • Those in support of the closures felt a strong connection to kauri and/or feel it is our duty to protect the environment.
Kauri Dieback Programme research. Phase 1 – Research	Measure: • Awareness and knowledge KDB	• Online Survey (N = 2,054) of forest users and non-users across 4	• 83% awareness of KD • 68% identify people as key vector, 34% identify pigs as key vector – 32% identify both key vectors, 26% falsely identify wind as a vector

Update Survey (Colmar Brunton, Feb 2019)	• perceived seriousness of KDB • Protective behaviours • Motivation and barriers to behaviours • Perceptions and sentiments of track closures, CANs and rāhui • which groups should be prioritised • Personas (note; these are not reported due to method concerns – see accompanying report for more detail)	Upper North Island Regions (weighted by demographics) • Specific user groups include: hunters (3%), contractors (1%), recreational users (82%), community groups (7%), locals (15%) and landowners (8%)	• 20% reported that they could identify a diseased tree; 68% expressed that they had a 'little bit' of knowledge of how KD is spread and how to prevent it. (Landowners had higher knowledge at 78%) • 41% reported scrub on exit and entry; 37% scrub and spray on exit and entry. • 73% reported staying on tracks in public forests. • 71% saw information about KDB through news/programmes and 58% through print media/news. • 25% encouraged others to follow kauri protective behaviours. • 68% see KDB as serious for NZ and 59% for local community. Reasons include – New Zealanders have a responsibility to protect environment from biosecurity threat (77%), kauri trees seen as iconic (70%); kauri seen as supporting ecosystem (58%). • Motivated by desire to protect for ecological (90%) and social (90%) reasons. • Main reasons for lack of perceived seriousness kauri are just one of many threatened animals and plants in NZ (53%) and that there are more important threats (27%) • 53% believe preventative behaviours would be effective; 43% are unsure or disagree. • 62% expressed that more and/or clearer information would be effective in encouraging uptake of key behaviours; correspondingly, 54% believe enforcement would assist, alongside the provision of equipment and resources (48%) • 49% don't believe they have an important role to play in the protection of kauri • 49% had some doubt in the current KDB management efforts. • 37% expressed some doubt in government to protect environment. • Main barriers to not always using cleaning stations was inadequate station equipment (30%); lack of clear instructions (28%) and concerns about chemicals (22%)
Kauri Dieback Forest User Research:	Understand the attitudes and drivers of	• Face to face semi-structured	Across the 3 risk groups, two distinct mindsets emerged – those 'open to change' and those 'closed to change.'

Phase 2 – Report (Navigators, May 2019)	behaviour for 3 at-risk groups of off-track forest users (Hunters, Farmers and Trappers).	interviews (N = 24) • Regions in Northland, Auckland and the Waikato	**Closed to change tended to:** • Disagree with scientific explanations for KDB spread • Doubt premise for preventative behaviours • Have low levels of trust in government • Hunters appeared to be most closed, followed by farmers. • Hunters felt targeted by DOC and MPI **Open to change tended to:** • Agree with scientific explanations for KDB spread. • More accepting premise for preventative behaviours (and report engaging in them) – though with some reservations. • Trappers (community or conservation) tended to be more open to change, with a commitment to conservation. • Poor relationships between farmers and hunters, and between hunters and government agencies – barrier to communication, knowledge sharing and co-development of solutions. • Desire to engage in a conversation that gives the users a 'reason to believe.'
Kauri Dieback Track User Study (Auckland council, Ovenden, 2020)	Monitor the success of initiatives aiming to raise awareness of KDB and enable correct use of the cleaning stations	• Intercept Surveys across 9 location in the Auckland region (N = 299) • Surveillance cameras monitored actual compliance. Signs were in place to alert visitors to the presence of cameras.	• 83.3% awareness of KDB; with greater awareness for locals as compared to international visitors. • 93.4% report humans as key vector of spreading KDB. • 74.6% report 'scrub then spray' behaviours. • 54.6% report 'staying on track' behaviours. • 94.3% self-reportedly 'usually' used cleaning stations. • 94.2% of observed footage showed some performance of cleaning behaviours. • 74.5% performed correct order of behaviours. • 29.4% heard of Controlled Area Notices (CANS); 36.% not aware of consequences of non-compliance with CAN. 54.8% not aware of rāhui.
Behaviour change	Increase compliance of track	• 5 x behavioural treatments at 15 locations	• Normative messaging treatment - no significant effect. • Watching eye treatment - Strong evidence that people changed their behavior toward more non-compliance.

research: DOC hygiene stations Kauri Dieback Recreation Project (Aley, 2020)	users at DOC hygiene stations	• Treatments included: normative messaging, biosecurity schema activation, watching eye effect, pledge wall and ambassador. • Behaviours observed for full, partial, less than partial and non-compliance.	• Biosecurity schema activation treatment - evidence that people changed their behaviour toward more partial compliance. • Pledge/Commitment wall treatment - strong evidence that people changed their behaviour toward more correct compliance and less non-compliance. • Ambassador treatment - strong evidence that people changed their behaviour more correct compliance and less noncompliance
Exploring Clean (Wood & Ryan, 2020)	Understand how public interprets the meaning and intent behind the word 'clean' in the context of hygiene behaviours for at risk KD forests.	• Two week asynchronous online qualitative discussion. • Respondents engaged between 2 – 3 hrs each. • Sample N = 32, undertaking at least one of following activities: hunting, running, tramping, walking, camping, dog walking, community activity or working during visits.	• The word soil does not seem to be associated with what people see and find in the soles of their shoes. • Dirt was considered bad. Soil was considered good. Therefore, dirt-free, seen as a more effective message than soil-free. • Clean in everyday life perceived to mean spotless, tidy and as close to new as possible. • 'Arrive clean, Leave clean' was seen the clearest phrase for a sign. It is directional so people know both what to do and what is expected of them. • People are divided as to whether boots must be 'spotless' to be clean for the forest, or just 'clean enough'. • Participants divided on 'save' or 'protect Kauri'. Some liked the implied urgency of ;save'; others preferred the guardianship implied by 'protect'. • Overall, key finding is a single word can impact perceptions of both what is being asked and of the overall 'sentiment' towards KDB.

Appendix B: Recommendations Prioritisation Schematic

Based on a research design perspective, the below criteria were created to prioritise the report recommendations. Higher scores indicate greater priority with the lowest score being 5 (low priority) and highest score being 15 (high priority). Note that this prioritisation process is from a social research perspective and requires integration with broader KDBP strategic objectives.

Table 2. Criteria for Assessing Relative Priority of Future Research

Criteria	Definition	Rating
Scope	The time and resources required to successfully undertake the research to a high degree of rigour.	1 (Long-term timeframe/high cost).
		2 (Medium timeframe/medium cost)
		3 (Short-term timeframe/low cost)
Current Knowledge	The amount and/or level of confidence of the evidence currently available in a particular area.	1 (Little evidence/Low confidence)
		2 (Some evidence/moderate confidence)
		3 (Sufficient evidence/high confidence)
Depth of Knowledge	How generalisable the research findings would be beyond the specific context	1 (Very context specific/low generalisability)
		2 (More broadly applicable/medium generalisability)
		3 (Broadly applicable/high generalisability)
Immediate Relevance	The need for evidence in order to inform immediate decision-making	1 (low relevance/long-term benefit)
		2 (medium relevance/medium term benefit)
		3 (high relevance/immediate benefit)
Strategic Alignment	Alignment with existing strategic initiatives and direction as outlined in the KDB Strategic Plan, KDB Science plan and NPMP	1 (not currently mentioned in KDBP social science strategy)
		2 (some overlap with KDBP social science strategic direction)
		3 (high overlap with KDBP social science strategic direction)

Research Area	Variables	Recommended Research Design	Priority Score
Further Examination of specific behaviours and possible influences	• Staying on Track • Cleaning at home • Effect of Ambassadors • Effects of Social Norming	• Build on and refine existing surveys from Colmar Bruton studies to include clear and consistent questions about specific behaviours (i.e., staying on track/cleaning at home). • Conduct observational data collection where possible using surveillance cameras or research assistants in numerous locations. • Compare locations statistically for those 'with' and without ambassadors/social norming treatments.	Scope = 3 Current Knowledge = 2 Immediate Relevance = 3 Depth of knowledge = 2 Strategic Incorporation = 2 **Overall score: 13**
Identification and understanding of key audiences	• Local vs non-locals • Older vs younger cohorts • High-Risk groups	• Conduct literature review looking at 1) similar overseas examples and 2) possible theories that could explain the current findings such as the diffusion of responsibility and identity threat. Develop hypothesis based on background research. • Develop surveys and/or interviews (depending on specificity of context) to test the hypotheses. • If successful, develop communication 'prototypes' based on the findings and assess changes in willingness to engage in kauri protective behaviours. • If successful, share findings with communication team and develop materials specific for the identified cohorts.	Scope = 2 Current Knowledge = 1 Immediate Relevance = 3 Depth of knowledge = 2 Strategic Incorporation = 2 **Overall score: 10**
Exploring Wider KD motivation and Perspectives	• Nation-wide KD Psychographics • Assess Regional Social Impact of KDP	**Psychographics** • Conduct comprehensive literature review on 1) Ppeople's perceptions of conservation/environmental issues, 2) existing research on behaviour change in similar fields, 3) underlying psychological and social influences that have shown promise in published research. • Identify key variables and develop/collate robust, reliable, and valid metrics such as fundamental values, worldviews as well as likelihood of performing kauri protective behaviours and support for KDBP. • Perform a segmentation statistical model and interpret according to theory. **SIA** • Identify key KDB impacted locations and conduct individual social impact assessments through a process of place-background research and interviews.	Scope = 1 Current Knowledge = 1 Immediate Relevance = 1 Depth of knowledge = 3 Strategic Alignment = 2 **Overall score: = 8**