Tracking Social Outcomes From Environmental Protection Activities in Tāmaki Makaurau, Auckland 2022

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Cover image credit

Trees for Survival event at Dairy Flat, 2022. Photograph by Fiona Martin.

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Executive summary

This report presents findings on the Auckland public's engagement with a suite of environmental protection initiatives delivered by Auckland Council. It is based on a repeated survey of a large sample of Aucklanders (n = 2348) collected in 2022, with a baseline comparison to 2020. Across the 2022 period, several initiatives were implemented, enabled by increased investment in the environment from the Natural Environment Targeted Rate. The initiatives included diverse campaigns such as encouraging Aucklanders to plant native plants, control invasive weeds, and trap for pest animals, the use of kauri dieback cleaning stations, and responsible pet ownership.

This report focused on five outcomes: social capital, environmental activism, conservation at home, community-led conservation, and adherence to biosecurity practices. The results showed a notable increase in conservation at home, while other desired outcomes maintained a consistent, positive, status over the two-year period. Noting the timing of the survey period, COVID-19 public restrictions may have impacted some results. The COM-B framework was applied to interpret the findings and provide recommendations. Four intervention functions (training, enablement, restriction, and environmental restructuring) were identified as the most effective ways to focus future initiatives to enhance Aucklanders' engagement with pro-environmental behaviours.

Table of contents

List of tables

List of figures

Terms and abbreviations

Term/Abbreviation	Description
Biosecurity activities	Actions to reduce the spread and/or impact of pests or other exotic species. For example, using kauri dieback cleaning stations and cleaning gear used in freshwater before using at another site.
Capability physical	A source of behaviour in COM-B model, physical capacity to engage in the concerned activity such as skills.
Capability psychological	A source of behaviour in COM-B model, psychological capacity to engage in the concerned activity such as knowledge.
COM-B model	A model of behaviour change which explains that a behaviour (B) is performed when an individual has the capabilities (C), opportunity (O), and motivation (M).
Conservation	Protection and restoration of ecosystems, species and biodiversity.
EAS	Environmental Action Scale, measures public engagement on environmental issues.
Environmental protection activities	A wide range of pro-environmental behaviours and practices that are aimed at safeguarding the environment from degradation, pollution, and harm, which includes conservation.
Intervention functions	In the COM-B model, these are the categories of non-overlapping behaviour change functions. The real-life interventions may utilise multiple intervention functions at once.
LOC	Locus of Control is a measure of a belief of how much positive change for the environment can be brought about by an individual.
Motivation automatic	A source of behaviour in COM-B model, unconscious brain processes such as habits and emotions that energise and guide behaviour.
Motivation reflective	A source of behaviour in COM-B model, analytical decision-making that directs behaviour.
Natural Environment Portfolio	The suite of programmes and projects receiving funding from the NETR and contributing towards shared outcomes.
NEP	New Ecological Paradigm is a scale measuring endorsement of pro-environmental beliefs.
NETR	Natural Environment Targeted Rate.
NETR initiatives	Initiatives designed and delivered under the Natural Environment Portfolio.

Term/Abbreviation	Description
Opportunity physical	A source of behaviour in COM-B model, physical factors that lie outside the person that make the behaviour possible.
Opportunity social	A source of behaviour in COM-B model, social factors that support the behaviour.
Policy categories	Policy categories in the COM-B model are regulations, laws, and guidelines that enable intervention functions.
Pro-environmental behaviour	Actions and choices that contribute to the wellbeing and preservation of the natural environment.
SCS	Social Capital Scale is a measure of community social capital and its underlying factors.
Social capital	Social capital is the network of social connections that exist between people, and their shared values and norms of behaviour, which enable and encourage mutually advantageous social cooperation.
Social outcomes	Social outcomes in this report are the outcomes relating to Aucklanders engaging in environmental protection activities, e.g. conservation. This term was introduced to distinguish these outcomes from the direct biosecurity and biodiversity outcomes delivered by council staff, contractors, and conservation groups (e.g. the number of trees planted, the area of land under pest control).

1. Introduction

The Natural Environment Targeted Rate (NETR) was introduced by Auckland Council in July 2018 to fund conservation initiatives in accordance with the Auckland Plan 2050, the Auckland Council Indigenous Biodiversity Strategy 2012, and the Regional Pest Management Plan 2020-2030. Various programmes, delivering on biosecurity and biodiversity outcomes, were established and are referred to in this report as the Natural Environment Portfolio. Protection and restoration of the natural environment requires multi-agency, community and individual action. To realise the intended outcomes of this enhanced investment, it was essential to increase Aucklanders' involvement and, in some instances adherence to, environmental protection activities. Consequently, multiple programmes within the Natural Environment portfolio were designed with the aim of fostering greater participation and engagement among Auckland residents in these activities (see Appendix A).

While establishing a direct cause-and-effect relationship between the NETR programmes and shifts in population-wide pro-environmental behaviour may be too ambitious, monitoring Aucklanders' environmental protection activities could illuminate broader population trends. These trends could offer valuable insights for informed decision-making regarding future programmes and highlight specific areas within existing programmes that could benefit from additional focus.

The term 'social outcomes' was adopted to differentiate the outcomes of Aucklanders' environmental protection activities from the direct biosecurity and biodiversity outcomes delivered by council staff, contractors, and conservation groups (e.g., the number of trees planted or the area of land under pest control). For this report social outcomes pertain specifically to the results stemming from Aucklanders' engagement in environmental protection activities. These encompass a spectrum of behaviours, ranging from broad environmental activism to specific actions like planting native plants.

The first round of data collection took place in November 2020 (Ovenden & Roberts, 2021). This report details the methodology, analysis, and findings for a second round of data collected in 2022, compares it to the 2020 baseline survey, and makes recommendations for future design of NETR programme behavioural interventions. Relating the findings to a broader body of literature was beyond the scope of this report. The main body of the report presents the primary findings, while more detailed results can be found in the appendices.

1.1. Objectives

The objectives of the *Tracking Social Outcomes from Environmental Protection Activities in Tāmaki Makaurau, Auckland 2022* report are:

- Measure and analyse changes in Aucklanders' involvement in environmental protection activities over the past two years compared to the baseline measures taken in 2020.
- Identify the drivers of Aucklanders' engagement with environmental protection activities and relevant social outcomes.
- Provide design recommendations for NETR initiatives that involve behavioural components.

1.2. Understanding behaviour

The COM-B model and the Behaviour Change Wheel (Michie et al., 2011) was chosen to guide our understanding of the behaviours that we aim to foster in our initiatives. This framework was chosen because it has been widely applied across different areas and is supported by evidence (Crayton et al., 2020; Jatau et al., 2019; Khalilollahi et al., 2022) including having showed its effectiveness in encouraging pro-environmental behaviour (Allison et al., 2022). Another advantage is that this framework is focused on practical application and is supplemented by a methodology on how to develop effective interventions (Michie et al., 2011, 2013, 2016).

The main premise of the COM-B model is that behaviour (B) can be explained though the presence of capability (C), opportunity (O), and motivation (M). These three constructs are further split into six *sources* of behaviour – capability physical and psychological, opportunity physical and social, and motivation automatic and reflective. The Behaviour Change Wheel then matches the *sources* of behaviour with nine *intervention functions* (i.e. discrete behaviour change methods) and seven *policy categories* capturing the regulatory context that enables interventions (Figure 1). This matching is grounded in evidence and offers practical guidance (Michie et al., 2011).

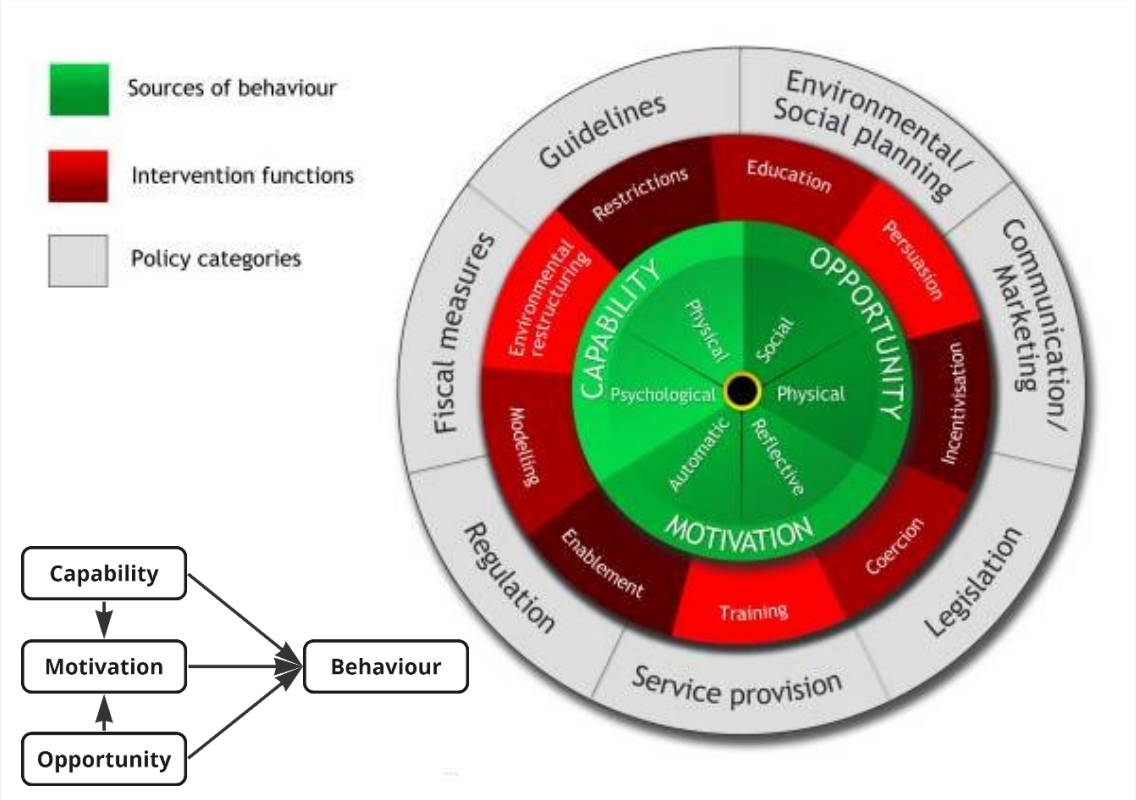


Figure 1. The COM-B model and the Behaviour Change Wheel

Practical application of the framework has some limitations. Although the model seemingly presents the sources of behaviour and other elements of the Behaviour Change Wheel within each level on an equal footing, evidence shows that different components have different weight in different contexts (Allison et al., 2022; Willmott et al., 2021).

Defining and measuring each element of the framework in application to specific practice is a challenge. In the absence of standardised measures, researchers must modify or develop new measures that might be not the best practice (Willmott et al., 2021).

An advantage of this framework is that the COM-B model and the Behaviour Change Wheel can highlight the gaps in practice. It can point out neglected areas such as continuously using only some intervention functions or mismatching the sources of behaviour with intervention functions. The framework can also bring attention to the lack of necessary conditions at the policy level (Michie et al., 2011).

To illustrate a practical application of the COM-B model, Natural Environment Portfolio initiatives have been mapped against the sources of behaviour that they are aiming to affect (Figure 2). As each activity is complex and can affect multiple sources of behaviour; the matching was done by the most obvious connection. For example, kauri dieback cleaning stations provide the public with the means and tools to clean their shoes and equipment to prevent the spread of the kauri dieback pathogen (physical opportunity). A more complex example is that the purpose of *Save Our Backyard Bird Song* campaign is to increase positive feelings and emotions among Aucklanders towards native species (automatic motivation) and encourage an assessment of their properties, e.g. presence of native plants, and self-assessment of how much they support biodiversity (reflective motivation).

Figure 2. Examples of Natural Environment Portfolio initiatives mapped to the COM-B framework

2. Methods

This section outlines the survey design, data collection method, and data analysis employed in this report. The 2022 survey largely followed the same methodology as the 2020 process, where possible, to maintain comparability.

2.1. Survey review

For the 2022 survey, the questions used to collect data in 2020 were reviewed by an internal expert panel of subject matter experts. The main change as a result of the review was the addition of the Social Capital Scale and the Environmental Action Scale. The 2022 survey questions are presented in Appendix B. Measures from the 2022 survey are described in Appendix C.

2.2. Data collection

We used the Auckland Council People's Panel to collect data. The same panel was used to collect data in 2020. The People's Panel is an online community of about 35,000 Aucklanders who have volunteered to give feedback on council's services, plans and policies by completing quick, online surveys sent to them by email. It is a cost-effective way to access Aucklanders, is the largest online local government panel in New Zealand and one of the most effective research and engagement tools at Auckland Council. However, it is noted that the profile of the panel is not representative of the Auckland population.

Data was collected via the Qualtrics survey platform (Qualtrics, 2020). The survey was open from Tuesday 22 November 2022, through to Sunday 04 December 2022. The data collection period was similar to that of the 2020 survey. An invitation to complete the survey was sent to 20,411 members of the Auckland Council People's Panel. Recruitment, data collection, and incentivisation was managed by the People's Panel team at Auckland Council[1]. There was an 11.5% response rate (n = 2351 completed responses).

Data collection aligned with the Auckland Council *Consultation and Research Survey Guidelines* and *Customer Privacy Policy*[2].

2.3. Sample size

The required sample size for 2022 survey was calculated using the standard formula for sample size calculation with a finite population correction factor. The Auckland adult population size in 2022 was estimated at around 1,200,000 (Stats NZ, 2022). The lowest

[1] For the sample selection, a randomly selected, broadly representative sample (based on Auckland's population) of 20,000 was drawn. After one reminder, it was found that younger respondents (aged under 35) were under-represented in survey results, so a second reminder was sent to this group. The People's Panel team also sent an invite and reminder to a small booster group of younger members who weren't included in the original invite (n = 411). This brought total panel members invited to 20,411. To incentivise participation, members were offered inclusion in a prize draw of five $100 e-gift vouchers. A median survey completion time was 12 minutes.

[2] www.aucklandcouncil.govt.nz/plans-projects-policies-reports-bylaws/our-policies/Documents/customer-privacy-policy.pdf

prevalence registered in the previous 2020 report was under 'participation in community conservation activities', at 7%. To detect statistical difference with a precision of 1.0%, a required sample size is n = 2496; for precision 1.1%, a required sample size is n = 2064. We aimed to achieve at least n = 2064 but not more than n = 2496.

2.4. Data analysis

The dataset was exported from Qualtrics into Excel and cleaned[3]. The scores of the scales with reversed scoring were converted. There were no missing data, but for some respondents, some demographics came from the People's Panel database instead of being collected as part of the survey (e.g. ethnicity, age if the year of birth was known). This was done to reduce the burden on the participants and avoid unnecessary data collection in alignment with internal procedures for the People's Panel.

We calculated descriptive statistics for all measures using the statistical software SPSS (IBM, 2021). Socio-demographic variables were used for descriptive purposes only. '*Not applicable'* choices were excluded from the 2022 analysis. We tested for differences between the 2020 and 2022 survey data using appropriate inferential statistics (e.g. non-parametric tests, mean differences, effect sizes) that are described fully in association with their application. For graphical presentation the answers were presented as proportional responses.

We decided against weighting the responses because our data did not meet the requirements for weighting, and weighting could have distorted the results instead of making them closer to the population values (Solon et al., 2015).

We tested all scales for internal consistency. Description of the methods and the results can be found in Appendix D.

We utilised generalised linear modelling (GLM) to understand the relationship between the input drivers, i.e. sources of behaviour, and each social outcome. Model distributions were selected based on Akaike's Information Criterion, with all models using a standard Gaussian distribution, other than the model for "Community-led conservation" which used a Gaussian distribution with a logarithmic link function. Models which still showed statistical violation even after transformations were interpreted using White's standard errors to provide a more robust interpretation of the results (Zeileis et al., 2020). To ensure reliable model performance measures 10-fold cross-validation was used to determine model performance, with both root mean square error (RMSE) and mean absolute error (MAE) calculated for each model along with R^2. Full outputs of the models can be found for corresponding social outcomes in Appendix G.

[3] Data cleaning is a procedure that includes fixing or removing incorrect, corrupted, incorrectly formatted, duplicate, or incomplete data.

3. Results and comparisons

The following section outlines the main findings and, where possible, compares them to the 2020 results. In cases where baseline data was absent but relevant research was accessible, we considered it a benchmark reference. Providing elaborate discussion and conducting detailed comparisons to wider research fell beyond the scope of this report.

3.1. Participants

We received 2351 completed responses to the survey. Three people indicated that they do not live in the Auckland region and were excluded from the analysis. The final sample was 2348 people.

3.1.1. Participant characteristics

Overall, the 2020 and 2022 samples were statistically comparable. Participant characteristics of the 2022 sample in comparison to the 2020 sample can be found in Table E1 (Appendix E). However, the 2022 sample was not representative of general Auckland population based on Census 2018 data (Stats NZ, 2020) (Table E2, Appendix E).

3.1.2. Garden and pet ownership

To understand the association between owning a garden or pets and pro-environmental behaviour, we asked if participants had a garden and also questioned them about pet ownership, including the type of pet they own. Most (92.2%) of respondents said that they had a garden[4]. Fifty-five per cent of respondents said they had at least one pet. The most commonly owned pets were cats (33.5%) and dogs (27.3%). See Appendix E for more information.

3.1.3. Outdoor activities

To understand the trends in outdoor activities that may relate to a biosecurity risk we asked people what activities they have engaged with, in the Auckland region, within three months prior to answering the survey. On average, in 2022, Aucklanders engaged with 1.5 activities within the specified time period. Almost a quarter (23.0%) engaged with three or more activities. The most popular activity in 2022 was visiting a beach (56.0%) closely followed by bush walking (54.7%) (Figure 3). Engagement with outdoor activities was similar to the 2020 findings (see Appendix E).

[4] Participants were asked *Do you have a garden or yard at home?* where garden was equated to having a physical space at home to perform pro-environmental behaviour.

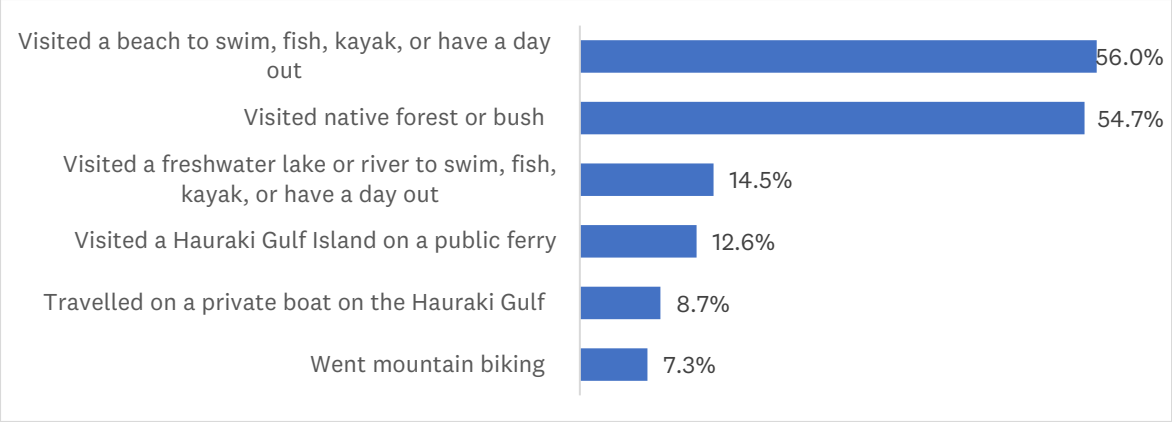


Figure 3. Engagement with outdoor activities in the past three months

3.2. Sources of behaviour

We used the COM-B model and the Behaviour Change Wheel to guide our understanding of pro-environmental behaviour. This section presents the primary findings related to the sources of behaviour:

- Psychological capability – Knowledge of biodiversity and biosecurity
- Physical capability – Practical skills
- Social opportunity – Social interaction
- Physical opportunity – Means to carry out pro-environmental behaviour
- Automatic motivation – Personal beliefs
- Reflective motivation – Personal responsibility

Detailed results are available in Appendix F.

3.2.1. Knowledge of biodiversity and biosecurity

We equated psychological capability to knowledge, in this case of biodiversity and biosecurity. Knowledge is considered important as the starting point for environmental action. In the 2022 survey, people were asked 22 questions. On average, they answered 73.4% correctly (Appendix F). In 2020 the rate of correct answers on knowledge questions was 74.1%. Statistically, this was an insignificant change. Thus, knowledge on biodiversity and biosecurity remained consistent since 2020.

3.2.2. Practical skills

We regarded physical capability as perceived practical skills and abilities to complete conservation activities such as planting native plants (Plant), weeding pest plants (Weed), and trapping pest animals (Trap). Participants rated they had slightly higher skills to plant native plants (41.2%) but lower skills to trap pest animals (26.0%) (Figure 4). The total score in 2022 on a scale of one to five was 2.98. In the 2020 survey, practical skills were measured using a different method; only two concepts, Weed and Trap, were assessed, and the wording of the questions varied. Where comparisons were possible, no changes have been observed since 2020 (Appendix F).

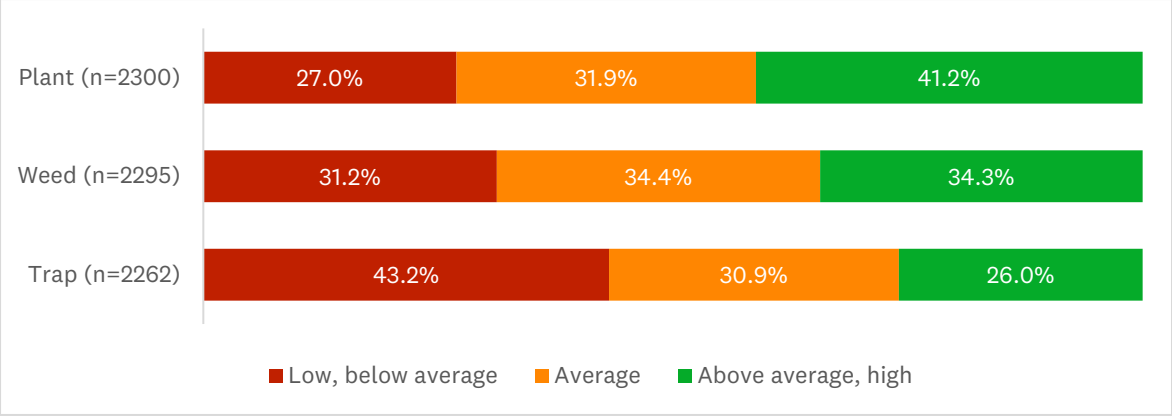


Figure 4. Perceived practical skills

3.2.3. Social interaction

We interpreted social opportunity as perceived social interaction. Social interaction was measured as the respondent's perceptions around three aspects:

- Join – whether the people who are important to the person would engage in activities with them.
- Connect – if there is an opportunity to build new relationships through doing pro-environmental behaviour.
- Support – if the person is supported doing pro-environmental behaviour by people who are important to the person.

Aucklanders said that overall social interaction was positive. However, despite whānau and friends being usually supportive of their conservation activities (69.6%), whānau and friends might be less keen to take part in the activities (40.1%) (Figure 5). The social interaction total score on a scale of one to five in 2022 was 3.57 (Appendix F); this parameter was not measured in 2020.

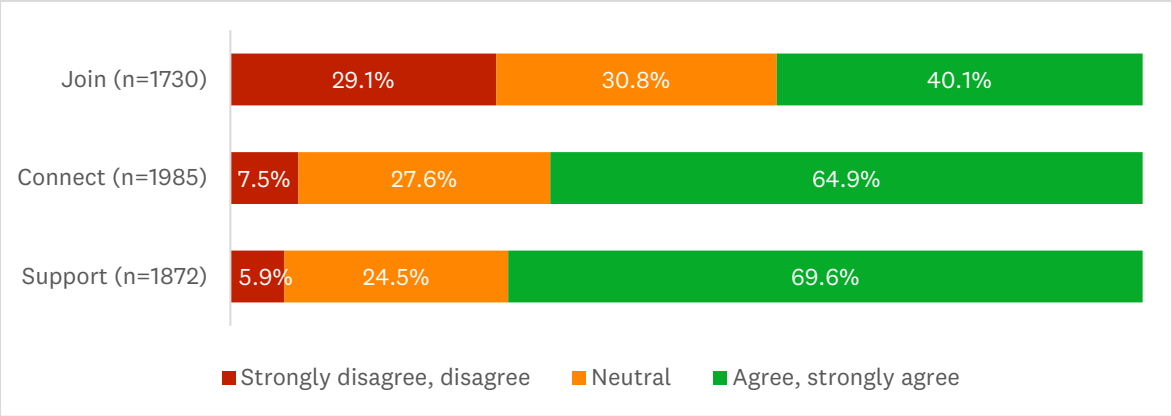


Figure 5. Perceived social interaction

3.2.4. Means to carry out conservation

Physical opportunity for this survey meant having the perceived *means* to carry out conservation such as space to plant native trees in a person's garden, availability of community events that Aucklanders could join, or resources (e.g. a car to travel to a

planting day). About half of the respondents agreed that there were means for them to plant (49.5%), weed (50.3%), and trap (45.0%), either at home or in the community (Figure 6). However, almost a third of the respondents disagreed or strongly disagreed (Plant 28.0%, Weed 29.3%, Trap 28.8%). The average score for means to carry out conservation, on a scale of one to five in 2022, was 3.55 (Appendix F). No comparison to 2020 was available as it was not measured.

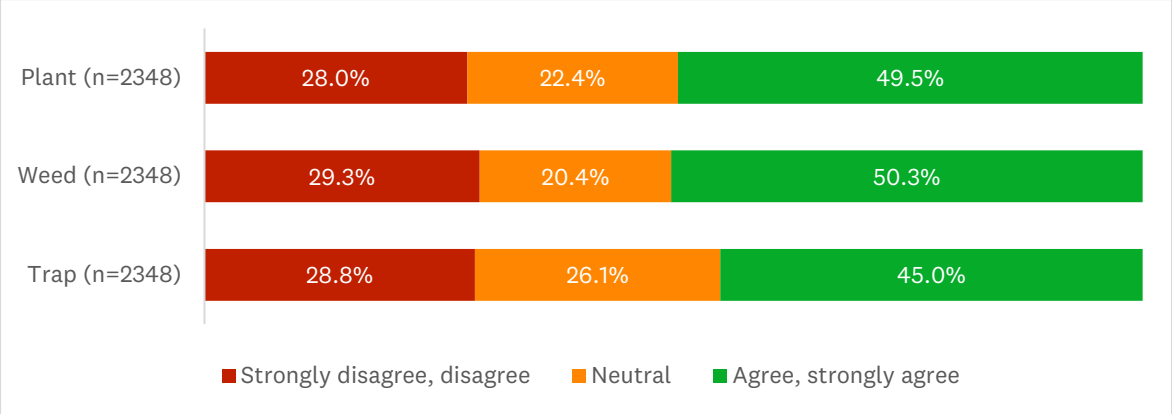
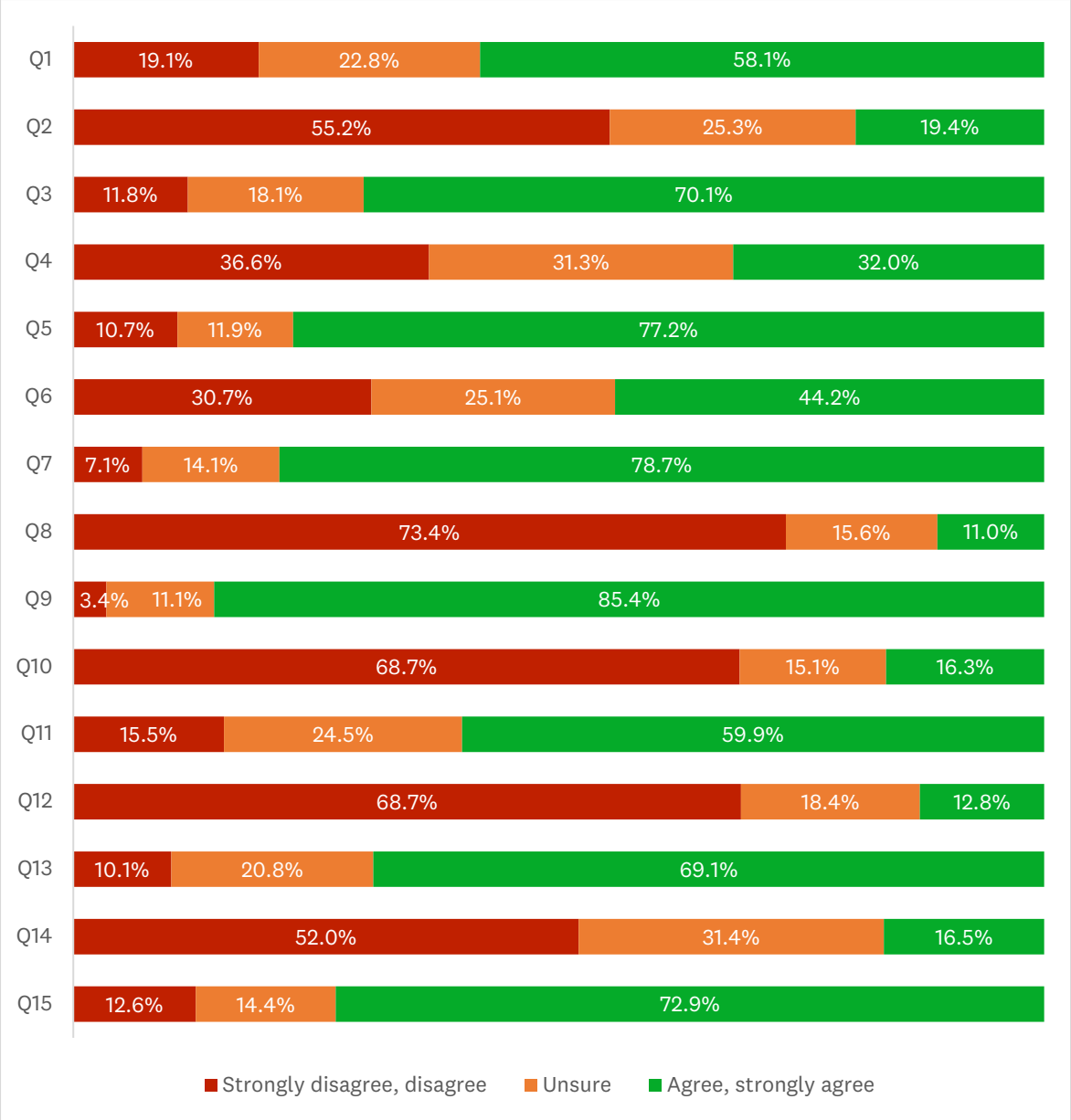


Figure 6. Perceptions of means to carry out conservation

3.2.5. Personal beliefs

In this report, we defined automatic motivation as general personal beliefs about the environment. We used the New Ecological Paradigm (NEP) scale to measure these beliefs, the same scale used in the 2020 survey. Figure 7 illustrates the responses to individual questions. The highest agreement was for question 9 *"Despite our special abilities, humans are still subject to the laws of nature"* at 85.4%. The highest disagreement was for question 8 *"The balance of nature is strong enough to cope with the impacts of modern industrial nations"* at 73.4%. The total 2022 NEP score on a scale of one to five was 3.79. In the 2020 it was 3.90. Statistical analysis showed that this difference was significant but with a small effect size (Appendix F). We concluded that the personal beliefs remained similar since 2020.

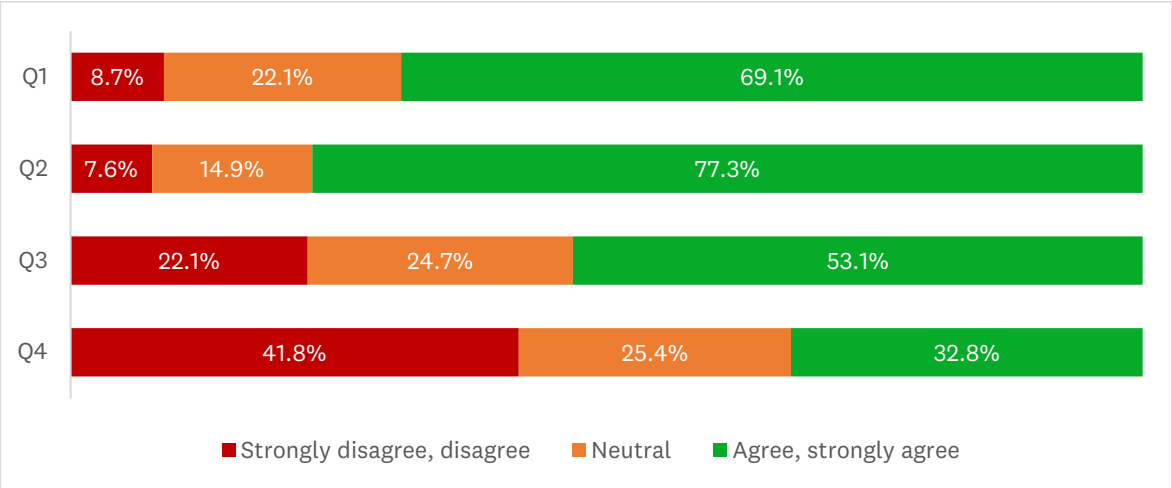


Legend
Q1. We are approaching the limit of the number of people the Earth can support.
Q2. Humans have the right to modify the natural environment to suit their needs.
Q3. When humans interfere with nature it often produces disastrous consequences.
Q4. Human ingenuity will ensure that we do not make the Earth unliveable.
Q5. Humans are seriously abusing the environment.
Q6. The Earth has plenty of natural resources if we just learn how to develop them.
Q7. Plants and animals have as much right as humans to exist.
Q8. The balance of nature is strong enough to cope with the impacts of modern industrial nations.
Q9. Despite our special abilities, humans are still subject to the laws of nature.
Q10. The so-called "ecological crisis" facing humankind has been greatly exaggerated.
Q11. The Earth is like a spaceship with very limited room and resources.
Q12. Humans were meant to rule over the rest of nature.
Q13. The balance of nature is very delicate and easily upset.
Q14. Humans will eventually learn enough about how nature works to be able to control it.
Q15. If things continue on their present course, we will soon experience a major ecological catastrophe.

Figure 7. Personal beliefs about the environment (NEP)

3.2.6. Personal responsibility

We interpreted reflective motivation in this survey as the Aucklanders' perceptions of personal responsibility and their role in protecting the environment. As in the 2020 survey, we used the Locus of Control (LOC) scale. Responses to individual questions of this scale are illustrated in Figure 8. The highest agreement was for question 2 *"It is important to reduce my impact on the environment"* at 77.3%. The highest disagreement was for question 4 *"My efforts to protect the environment are insignificant as long as others refuse to act"* at 41.8%. In 2022 the total average score on a scale of one to five was 3.67, in 2020 it was 3.70 (Appendix F). Statistically, there were no differences. Therefore, Aucklanders' perceptions around personal responsibility remained unchanged since 2020.



Legend
Q1. I have control over my own impact on the environment.
Q2. It is important to reduce my impact on the environment.
Q3. I am personally responsible for contributing to the environment's problems.
Q4. My efforts to protect the environment are insignificant as long as others refuse to act.

Figure 8. Perceptions of personal responsibility (LOC)

3.3. Social outcomes

This section outlines the key findings on five social outcomes measured in 2022:

- Social capital
- Environmental activism
- Conservation at home
- Community-led conservation
- Biosecurity

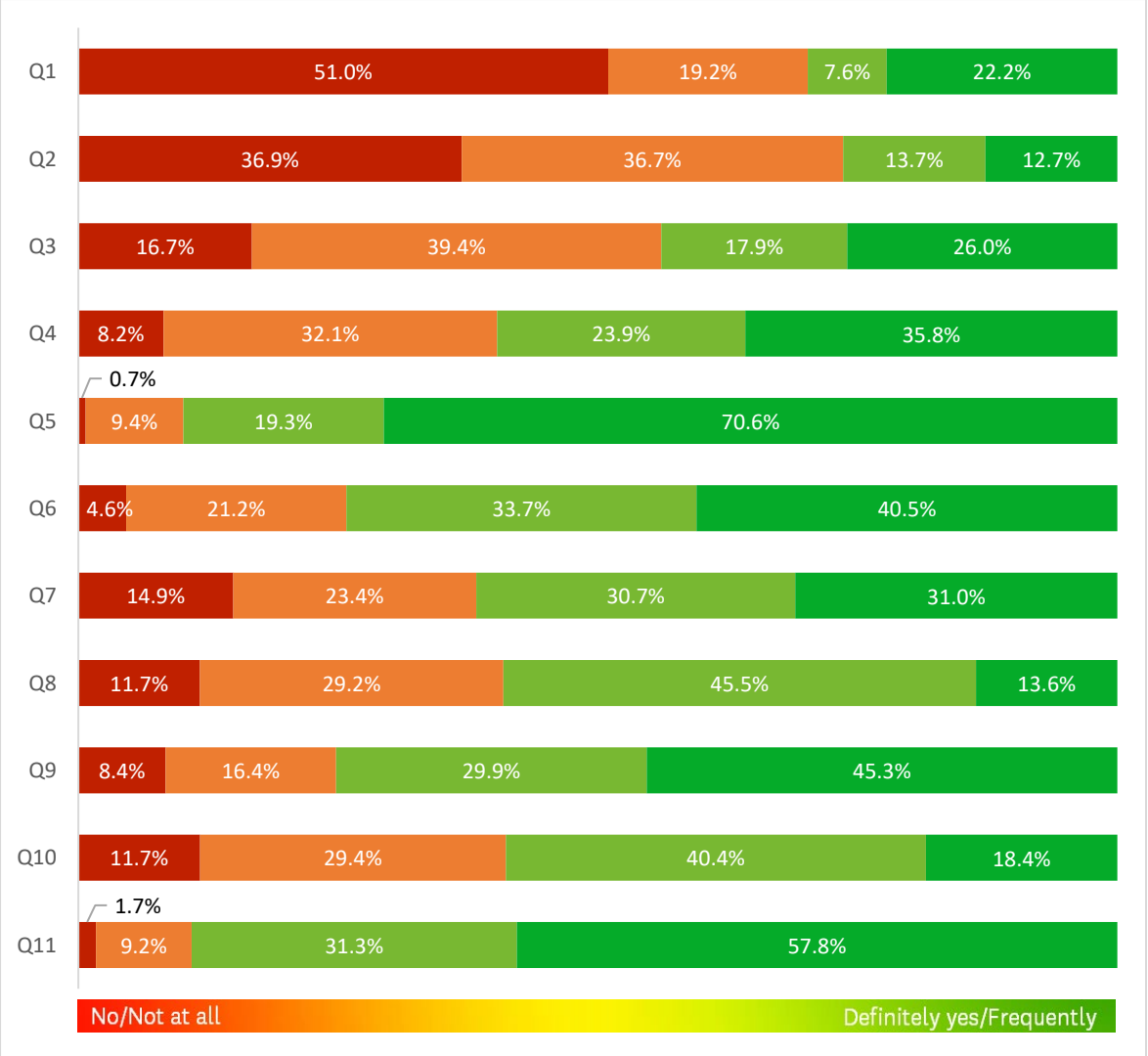
We also present a snapshot of statistical modelling on the association between the six sources of behaviour and each social outcome. Finally, we discuss the practical implications that these findings hold for NETR initiatives. Detailed results for each social outcome can be found in Appendix G.

3.3.1. Social capital

We chose to measure social capital based on Gerolemou et al. (2022) which showed that participation in conservation is associated with community building and community wellbeing. Social capital was not measured in 2020. However, the sample in Gerolemou et al. (2022) of 1207 Aucklanders was similar to our sample, and the data was collected around the time of our baseline survey in 2020. Therefore, we treated their findings as an alternative baseline.

The overall total score on social capital in 2022 was 2.80 on a scale of one to four (Appendix G). In 2020, Aucklanders scored 2.87. Statistical analysis showed that this difference was negligible. Therefore, we argue that the social capital of Aucklanders has remained unchanged since 2020. Figure 9 illustrates proportional answers to the individual questions of the Social Capital Scale (SCS) in 2022. The most common behaviour, frequently observed in 70.6% of respondents, was talking to family and friends outside of their household (question 5). In contrast, the least common behaviour, with 51.0% of respondents stating *'Not at all'*, was helping out a local group as a volunteer (question 1). Among the agreement statements, the highest proportion of *'Definitely yes'*, at 57.8%, was recorded for the statement suggesting that by helping others, a person helps themselves (question 11). Meanwhile, only 13.6% expressed certainty that most people can be trusted (question 8).

However, while the overall score remained consistent the same did not hold true for the individual factors of the scale (detailed in Appendix G, Figure G1). For example, connections with family and friends exhibited an increase, while the sense of trust and safety and the perceptions around social agency demonstrated a decrease.



Legend
Q1. How often do you help out a local group as a volunteer (e.g. church group, playgroup, sport club, food bank)?
Q2. How often have you attended a local community event in the past 6 months (e.g. church fete, cultural festival, school concert, craft exhibition)?
Q3. How often do you pick up other people's rubbish in a public place?
Q4. How often do you talk to your neighbours?
Q5. How often do you talk to your family or friends outside of your household?
Q6. If you disagreed with what everyone else agreed on, would you feel free to speak out?
Q7. Do you feel safe walking down your street after dark?
Q8. Do you agree that most people can be trusted?
Q9. Do you think that multiculturalism makes life in your area better?
Q10. Do you feel valued by society?
Q11. Do you agree that, by helping others, you help yourself in the long run?

Figure 9. Social capital (SCS)

Statistical model

We built a statistical model to see which of the sources of behaviour influenced social capital. Four sources of behaviour had statistically significant association with social capital: practical skills, social interaction, means to carry out conservation, and personal responsibility. The output table for the linear regression can be found in Appendix G.

Implications

Negligible change in the SCS score since 2020 indicates that the pandemic-related events of the past two years appear to have had no detectable negative influence on Aucklanders' social capital overall. However, the reduction in the sense of trust and safety and social agency was noted and will be considered in the design of future programme initiatives.

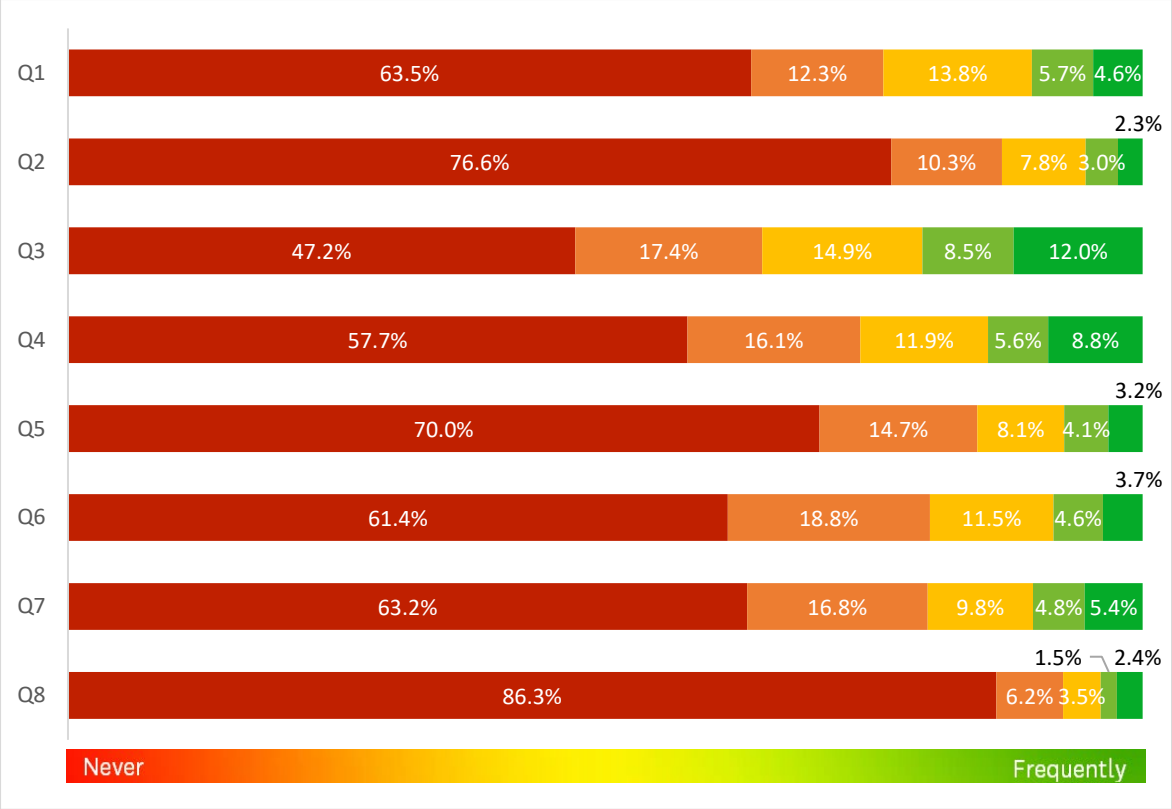
Based on our findings, initiatives targeting: 1) practical skills development (e.g. training on trapping), 2) social interaction (e.g. family-orientated conservation), 3) means to carry out conservation (e.g. provision of free pest animal traps, native seedlings), and 4) personal responsibility (e.g. self-assessment tools) are the most promising to increase social capital.

3.3.2. Environmental activism

To measure environmental activism, we equated it to general engagement with environmental issues and conservation. The Environmental Action Scale (EAS) was used to quantify environmental activism. This scale was developed purposefully for environmental research (Alisat & Riemer, 2015). The EAS was not measured in 2020. Figure 10 illustrates proportional answers to the individual questions that we asked to measure environmental activism. The item with the highest proportion of answers *'Frequently'* at 12.0%, was consciously making time to work on environmental issues (question 3). Conversely, the item with the greatest number of *'Never'* answers at 86.3%, pertained to organising community environmental events (question 8).

Although the sample in Alisat and Riemer (2015) was very different to our sample[5] in the absence of a baseline we decided to use their results as an indicative benchmark. The overall total score for environmental activism on a scale of zero to four in 2022 was 0.70. The indicative benchmark score was significantly higher at 1.29, though all differences related to public activities that were restricted across 2020-2022 (see detailed analysis in Appendix G). The additional analysis also revealed that questions linked to leadership, on average, received lower scores compared to those associated with participation.

[5] The sample in Alisat and Reimer (2015) was smaller, it included 299 people across five countries, including 18 known environmental activists. The data was collected prior 2015, meaning it was not affected by COVID-19 pandemic.



Legend:
Q1. Used traditional methods (e.g. letters to the editor, articles) to raise awareness about environmental issues.
Q2. Took part in a protest / rally about an environmental issue.
Q3. Consciously made time to be able to work on environmental issues (e.g. choosing environmental activities over other leisure activities; working in an environmental job; working part time to allow time for environmental pursuits).
Q4. Became involved with an environmental group (e.g. volunteer).
Q5. Attended training related to the environmental issues (e.g. workshop on trapping pests).
Q6. Participated in a community event which focused on environmental awareness (e.g. educational event, guided nature walk).
Q7. Participated in a community event which focused on conservation activities (e.g. planting trees, restoration of waterways).
Q8. Organised a community event which focused on the environment.

Figure 10. Environmental activism (EAS)

Statistical model

We built a statistical model to see which of the sources of behaviour influenced environmental activism. Three sources of behaviour had statistically significant association with environmental activism including: practical skills, social interaction, and personal beliefs. The output table for the linear regression can be found in Appendix G.

Implications

The EAS score seems to be relatively low in comparison to the indicative benchmark established in the Alisat and Reimer (2015) study. This may be attributed to the disparities in the samples, but it is also likely to be influenced by the COVID-19 pandemic. The present

findings could serve effectively as a baseline for future monitoring, enabling comparisons with subsequent data collected from the Auckland population.

Initiatives that potentially increase environmental activism could focus on: 1) practical skills (e.g. skill-focused practical training); 2) social interaction (e.g. opportunities to connect socially or engage people together with their whānau and friends); and 3) personal beliefs (e.g. emotional value-based campaigns such as celebrating conservation role models in the community). There is also an opportunity for further emphasis on fostering leadership within the community.

3.3.3. Conservation at home

We measured conservation at home by asking Aucklanders three questions about how often they plant native plants (Plant), weed pest plants (Weed), and trap pest animals (Trap) at their own home or property. Two thirds of respondents (62.4%) said that they frequently control pest plants and a third frequently plant native plants (36.1%) or control pest animals (33.7%) (Figure 11). There was a significant increase in the conservation at home score in 2022 compared to 2020, 3.11 vs 2.74 respectively on a scale of one to five (Appendix G). The biggest increase was for planting natives followed by trapping. We have also tested for an association between having a garden and conservation at home. People who said that they had a garden had significantly larger scores for conservation at home, suggesting that having physical space encourages more pro-environmental behaviour (for further details, see Appendix G).

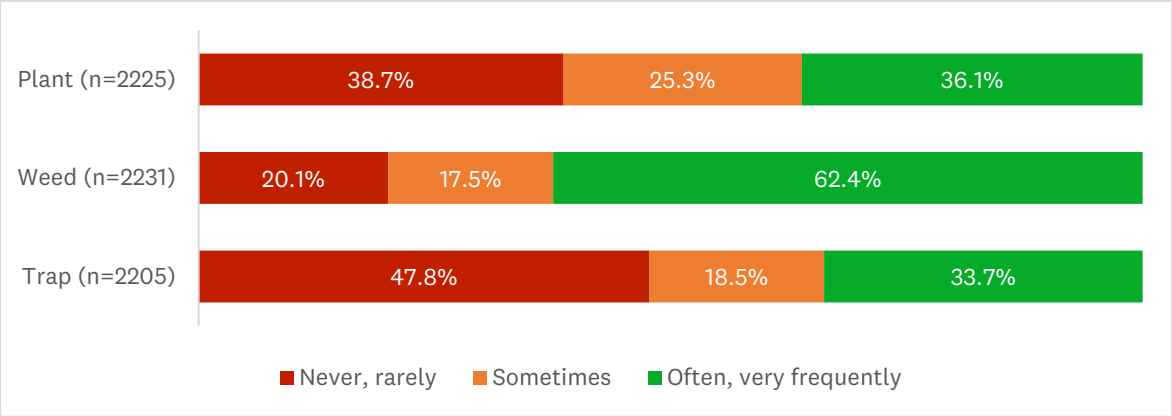


Figure 11. Conservation at home

Statistical model

We built a statistical model to see which of the sources of behaviour influenced conservation at home. Two sources of behaviour had statistically significant association with environmental activism including: practical skills and means to carry out conservation. The output table for the linear regression can be found in Appendix G.

Implications

The significant increase in conservation at home in the past two years could be attributed to external factors, primarily the pandemic. If so, there is a possibility that engagement

levels might regress to their pre-COVID-19 state, or potentially even decline further, as 'normal' life resumes.

Based on what we found, the most effective way to increase the rate of conservation at home is by increasing Aucklanders' practical skills, e.g. capability building around planting, weeding, and trapping. Another source of behaviour associated with conservation at home was having the means to carry out conservation, in this context interpreted as having the necessary space for planting, weeding pest plants, or trapping pest animals. Creating physical space for conservation work on private properties is outside the scope of NETR. However, it is possible to change attitudes towards physical spaces people already have. For example, people living in communal settings, like apartments or retirement villages with shared outside areas, could utilise these areas to do conservation. For people who rent, the focus can be put on activities that may not require owner permission (e.g. weeding or trapping instead of planting).

3.3.4. Community-led conservation

We measured community-led conservation by asking Aucklanders three questions about how often they plant native plants (Plant), weed pest plants (Weed), and trap pest animals (Trap) as part of a community-led effort. Figure 12 illustrates the answers to the individual questions proportionally. About 6% of Aucklanders frequently engaged with community-led conservation (Plant 5.6%, Weed 5.5%, Trap 6.4%). The total average score, on a scale of one to five, in 2020 was 1.50 vs 1.56 in 2020 (Appendix G). Our analysis showed that the difference was negligible, meaning that community-led conservation was maintained on the same level since 2020. Additionally, we tested the hypothesis that those who are engaged in conservation at home are more likely to engage with community conservation, and our analysis revealed that these behaviours are associated, but only weakly, with no notable difference between respondents with or without gardens (for further details, see Appendix G).

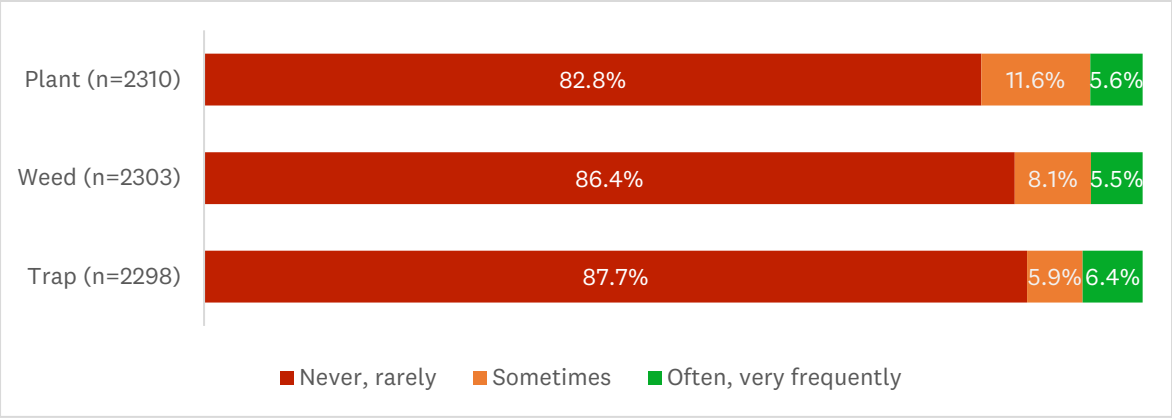


Figure 12. Community-led conservation

Statistical model

We built a statistical model to see which of the sources of behaviour influenced community-led conservation. Three sources of behaviour had statistically significant association

including: practical skills, social interaction, and means to carry out conservation. The output table for the linear regression can be found in Appendix G.

Implications

Increased engagement of Aucklanders with community-led conservation is an important benefit sought by the NETR. Given seemingly modest scores in both this scale and the EAS, more work is needed to better understand these scores. Establishing a practical and attainable target for how many Aucklanders are engaging in community conservation as well as the specific places (e.g. higher biodiversity value sites) where action is desirable is required. Nonetheless, the finding that community-led conservation remained stable in 2022 when compared to the results of the 2020 survey is encouraging.

The results regarding the relationship between community-led conservation and the sources of behaviour indicate that conservation groups possess a prime opportunity to enhance the involvement of Auckland residents in community conservation efforts. This is attributed to the ability of the community groups to 1) establish a supportive social atmosphere that fosters social interaction, 2) enhance the practical skills of their members, and 3) create opportunities by initiating conservation projects and providing means to carry out these projects. Given only a weak association between conservation at home and community-led conservation, prioritising the growth and functioning of the conservation groups stands out as the most effective strategy to increase public participation in community-led conservation.

3.3.5. Biosecurity

Engagement with biosecurity activities over the past two years was assessed across eight measures:

- Kauri – use of kauri dieback cleaning stations as part of kauri dieback mitigation.
- Freshwater – cleaning of freshwater equipment to prevent the spread of freshwater pests.
- Hauraki Gulf Islands (HGI) – checking gear/boat for pests to prevent their (re)introduction to the HGI.
- Plant – considering a pest status of a plant when buying it to prevent pest plant spread through private gardens.
- Cats – encouraging responsible cat ownership to reduce predation and disturbance of birds and other native animals by containing cats.
- Dogs – preventing disturbance of nesting birds by dogs by following dog rules at parks or at the beach.
- Desex – preventing increases in stray/feral pests by desexing cats and dogs.
- Escape – preventing pets becoming stray/feral pests by preventing them escaping into the wild.

Respondents could specify if certain biosecurity questions didn't apply to them. In such cases, these responses were excluded from the analysis for that specific biosecurity measure. If a respondent mentioned not owning a pet, all pet-related questions were automatically marked as *not applicable* in their responses.

The levels of compliance reported by survey participants were encouraging. Compliance ranged from 45.6% for cat containment to as high as 94.5% for pet desexing (Figure 13). Across all eight biosecurity measures a total mean score on a scale of one to five in 2022 was 4.00, which equates to participants reporting they comply with biosecurity measures 'often'. Four of these measures were comparable to the baseline 2020 survey (kauri, freshwater, HGI, and cats) and showed the total mean score on these biosecurity behaviours had not changed. Among individual behaviours, the only notable, but small reduction was for HGI question which could be explained by the programme changes (e.g. the formerly voluntary 'Pest Free Warrant' scheme is now required under the Auckland Regional Pest Management Plan 2020-2030) and possible pandemic related effects (e.g. less boat use due to restrictions). The data also showed an association between higher engagement in individual outdoor activities and corresponding biosecurity scores, especially notable for kauri and freshwater measures (for further details, see Appendix G).

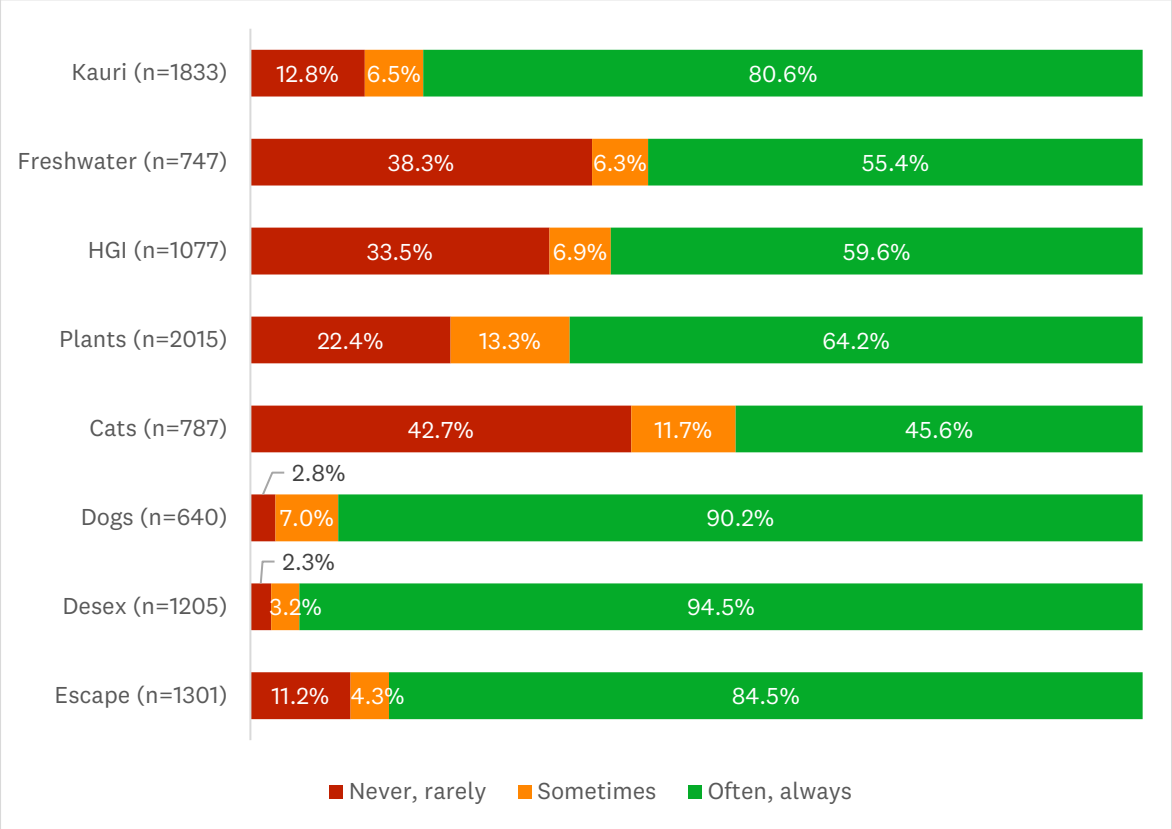


Figure 13. Biosecurity

Statistical model

We built a statistical model to see which of the sources of behaviour influenced biosecurity activities. All but one of the sources of behaviour had a statistically significant association with biosecurity activities. An exception was means to carry out conservation. The output table for linear regression can be found in Appendix G.

Implications

The survey revealed encouraging (45.6% - 94.5%) self-reported biosecurity compliance overall, similar to the 2020 results. This may show that Aucklanders are familiar with biosecurity measures and value them. Our findings also highlighted the effectiveness of targeted, location-specific interventions in the context of addressing kauri dieback. The more people engaged with a corresponding activity (e.g. bush walking in relation to kauri dieback) and were exposed to interventions, the more inclined they were to follow the biosecurity guidelines. These location-specific interventions could serve as a valuable model for achieving increased levels of biosecurity compliance.

Furthermore, statistical modelling has identified five sources of behaviour associated with biosecurity behaviour, with the exception of means to carry out conservation. However, we recognise that differences exist between various biosecurity behaviours, and measurement complexities need to be addressed. Further research is necessary to establish robust relationships and provide recommendations for enhancing adherence to each biosecurity practice.

3.4. Association between the sources of behaviour and social outcomes

The summary of the associations between the COM-B sources of behaviour and the desired outcomes (Table 1) showed that three sources of behaviour (physical capability, social opportunity, and physical opportunity) were associated with the greatest number of social outcomes and had a greater overall strength of association with the desired outcomes. At the same time, the scores of these three sources: physical capability (2.98), social opportunity (3.57), and physical opportunity (3.55) were the lowest out of the six sources of behaviour.

Table 1. Summary of association between the sources of behaviour and the outcomes

	Social capital	Environmental activism	Conservation at home	Community-led conservation	Biosecurity	Total score[6]
Psychological capability	-	-	-	-	*	1/1
Physical capability	*	**	****	*	**	5/10
Social opportunity	*	**	-	*	**	4/6
Physical opportunity	*	-	****	*	-	3/6
Automatic motivation	-	**	-	-	***	2/5
Reflective motivation	**	-	-	-	**	2/4

* The number of stars indicates the strength of association (coefficient β value <0.1 = *, 0.1 to 0.19 = **, 0.20 to 0.29 = ***, 0.30 and above = ****).
- Not statistically significant

[6] The score is presented as the number of outcomes that are statistically associated with this source over the sum of the 'stars' across the outcomes, where 'stars' indicate the strength of association.

4. Strengths and limitations

To our knowledge, this is the only survey of a large sample of Aucklanders that has focused on comprehensive measurement of pro-environmental behaviour, albeit self-reported, rather than perceptions and attitudes. Given a gap between attitudes and behaviour, measuring the latter has more practical value for planning of new initiatives and enhancing existing programmes. The repeated cross-sectional nature of this survey was an additional strength as it allowed us to track multiple variables over time.

This work also demonstrates the value of applying the COM-B model and the Behaviour Change Wheel to shape our understanding of pro-environmental behaviour. Although we could not claim the direct effect of NETR initiatives on social outcomes in Tāmaki Makaurau, this theoretical framework allows us to link sources of behaviour and the desirable outcomes and provides evidence-based matching of intervention functions.

A more representative sample of Aucklanders will be considered for future research. Although using the same sample in both the 2020 and 2022 surveys was useful for comparisons, we are concerned that this limits the use of the findings for initiatives which seek to connect with and influence all Aucklanders.

Using self-reported data is pragmatic and cost-effective, however, it must be acknowledged there are limitations of this approach. To mitigate this, we measured social outcomes in multiple ways, including a validated measure of general pro-environmental behaviour (the Environmental Action Scale), and used scales focusing on specific conservation behaviours (e.g. plant, weed, trap). Having a large sample also improved validity of responses by teasing out the trends.

5. Recommendations

Based on the findings described in Section 3.4 (Association between the sources of behaviour and social outcomes), focusing NETR programmes with behavioural components on developing practical skills (physical capability), strengthening and extending social interactions (social opportunity), and providing access to the means to carry out conservation (physical opportunity) could result in increased pro-environmental behaviour among Aucklanders. Initiatives focusing on increasing knowledge of biodiversity and biosecurity (psychological capability), changes in personal beliefs (automatic motivation), and promotion of personal responsibility (reflective motivation) could be scaled down or become a secondary objective, if choices must be made due to resource constraints.

To increase the effectiveness of future initiatives, their design could be better aligned with the chosen theoretical framework – the COM-B model and the Behaviour Change Wheel (see Section 1.2.), and the corresponding methodology (Michie et al., 2011, 2013, 2016). Under this methodology, the three sources of behaviour that we have identified as most associated with social outcomes, are linked with the following intervention functions[7]: training, enablement, restriction, and environmental restructuring (Table 2). Enhancing these four intervention functions in NETR programmes, alongside expert advice and other practical considerations such as budgets, is likely to positively impact the sources of behaviour and result in greater engagement of Aucklanders with environmental protection activities.

Table 2. Intervention functions in the COM-B framework

Intervention function	Definition	Example
Training	Enhancing hands-on capabilities.	Pest animal trapping workshops.
Enablement	Increasing means and/or reducing barriers to engaging with desired behaviour.	Provision of tools for conservation; development of leadership potential.
Restriction	Introduction of rules that reduce opportunity for unwanted or competing behaviour.	Ban on cat ownership in certain areas; rahui (restricted access) in the areas affected by kauri dieback.
Environmental restructuring	Changes to physical and social context to support desired behaviour.	Availability of kauri dieback cleaning facilities; a network of community conservation groups that support each other.

[7] Intervention functions in the COM-B model are the categories of non-overlapping behaviour change functions. The real-life interventions may utilise multiple intervention functions at once.

6. Conclusion

The social outcomes evaluated in 2022 mostly retained a favourable state, similar to the 2020 baseline, and other relevant benchmarks. The COVID-19 pandemic and associated public health restrictions may have affected many of our findings. There were less group activities available, due to restrictions on public gathering and recreational activities, and this may also have influenced the one outcome that did increase significantly, *Conservation at home*. However, considering the multitude of challenges posed by COVID-19 during the research period, which could have potentially led to a decline in social outcomes, our findings are encouraging. In addition, four intervention functions (training, enablement, restriction, environmental restructuring) were identified using the COM-B framework as the most effective ways to focus future initiatives to enhance Aucklanders' engagement with pro-environmental behaviours.

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Appendix A. NETR programme delivery 2020/2021 and 2021/2022 financial years

The Natural Environment Portfolio, at the time of the survey in November 2022, included eight programmes designed to deliver a range of biodiversity and biosecurity activities to meet agreed commitments. Initiatives in four of these programmes had a higher focus on NETR social outcomes[8]. The programmes were: Expanding Community Action, Mainland, Marine and Pathways, and Plant Pathogens.

The following briefly describes the initiatives relevant to social outcomes delivered under these programmes over the two financial years 2020/2021 and 2021/2022 (Environment and Climate Change Committee, 2021, 2022; Internal records).

Expanding Community Action | Te whakawhānui i ngā kaupapa mahi a te hapori – support to grow and amplify community-led conservation action to protect and restore the biodiversity of Tāmaki Makaurau.

- Funding support of over $1,755,000 for conservation groups across the two financial years. This included grants for 45 groups in FY21 and 69 groups in FY22 through the Regional Environment and Natural Heritage and Community Coordination and Facilitation Grants.
- Tools and resources for pest animal and pest plant control, restoration planting, monitoring and other equipment worth around $1.2 million was provided over the two years to over 250 community groups per annum for the two years.
- Four Pest Free Auckland media campaigns *Save Our Backyard Birdsong* with over 233,000 people in 2020/2021 and over 258,000 in 2021/2022 engaging with messaging shared in the campaigns in some way (e.g. like, share, comment).
- The *Trees for Survival* programme has expanded over these two years with 97 schools participating planting over 149,000 native plants with the support of around 6200 volunteers, restoring close to 15 hectares of riparian margins and wetlands.
- A variety of educational programmes including Te Aho Tū Roa and Enviroschools focused on growing conservation capability and knowledge across 77 schools, 15 kura, and 89 early childhood centres.
- Community-led protection and restoration of priority biodiversity areas on private land enabled 8.9 kilometres of fencing, 1.8 hectares of restoration planting, and 216 hectares of pest animal and weed control.
- Supporting the establishment of Tiaki Tāmaki Makaurau web portal to provide the community with easy access to 'how to' conservation guidance (funded through the Enabling Tools Programme).
- A programme run on local parks to connect more people with nature and support effective and co-ordinated community-powered conservation involving over 230 volunteer groups.

[8] Social outcomes in this report are the outcomes relevant to Aucklanders engaging in environmental protection activities, e.g. conservation. This term was introduced to distinguish these outcomes from the direct biosecurity and biodiversity outcomes delivered by council staff, contractors, and conservation groups (e.g. the number of trees planted, the area of land under pest control).

Mainland | Te tuawhenua – control pest plants and pest animals across Tāmaki Makaurau, especially in priority ecosystems.

- Pest plant buffer control area around Tāwharanui, Mahurangi East and Mahurangi West Regional Parks and Oakley Creek was established and is now managed by owners of neighbouring properties.
- 459 nurseries, markets, grocery stores, florist shops, pet stores and online trades have been inspected.
- A communications campaign, launched in July 2022 aims to ensure pet owners are doing their part to look after their pets and the environment, e.g. desexing and microchipping their pet cats, not releasing red-eared slider turtles into streams.
- Communications to people using Lakes Rototoa, Tomarata and other freshwater bodies across the region, to ensure they Check, Clean Dry their gear to prevent the spread of freshwater pests.
- Promotion and support of *Plant Pass* voluntary certification scheme for plant producers to recognise good biosecurity practice and provide assurance for plant buyers.

Marine and Pathways | Te moana me ngā ara kawe riha – pathway management, including surveillance, incursion response, education and engagement to protect Hauraki Gulf islands and marine ecosystems.

- Regionally, 1257 vessels were inspected as part of the Hull Surveillance Programme.
- Targeted surveillance at Leigh and Whangateau Harbours of 69 vessels found eight vessels with marine pests.
- Boat owner education on biofouling and hull cleaning, advice on in-water cleaning of infrastructure and marine pest identification.
- Dog inspections of 1433 vessels found 21 indications for pests, 58 risk goods and 8 prohibited biosecurity items.
- Introduction of *Pest Free Warrants* for transport operators that will become mandatory in 2024.
- The *Biosecurity Champions* programme at entry points to offshore islands and events such as the Hutchwilco NZ Boat Show, to raise awareness of risks and actions people can take.
- The *Hauraki Gulf Our Auckland story* campaign reached over 629,000 people with educational messages.

Plant Pathogens | Ngā iro kitakita ā-otaota – to prevent disease spread while allowing public access to natural reserves.

- In total, 144 kilometres of tracks had been upgraded to kauri-safe standard by the end of the 2021/2022 financial year. This represents 76% of the total planned NETR upgrade programme of 190 km of track network which began in 2019.
- The *Biosecurity Champions* programme at key regional and local park tracks, entry points to the Hauraki Gulf islands, and key events, to educate Aucklanders on kauri dieback and myrtle rust.
    - During 2020/2021 financial year, more than 30 full and part-time Biosecurity Champions worked across the Auckland region, engaging with the public and recording over 12,000 kauri dieback advocacy and engagement hours.

    - The following year, the programme was scaled back in response to COVID-19 restrictions and risk assessment. A more targeted programme operated at a smaller number of priority sites after Auckland returned to the orange traffic light setting.
- The annual kauri dieback disease track user survey for 2020/2021 financial year provided insights into the effectiveness of national and regional messaging. The survey was paused in 2021/2022 due to COVID-19 restrictions.
- Fourteen in-person training workshops were delivered to support volunteers undertaking pest animal and pest plant management off track and contractors working in high-risk industries and near kauri in 2020/2021. This transitioned to online workshop delivery in 2021/2022 with eight workshops delivering to 93 attendees across nine organisations.
- Engagement of *Pest Free Kaipatiki* to undertake kauri and myrtle protection advocacy and engagement in the Kaipatiki Local Board area. This includes supporting conservation groups with operating safely off track in kauri reserves in accordance with kauri dieback hygiene protocols and keeping residents updated around closures and upgrades of local reserves for kauri protection reasons.
- Funding of *Kauri Rescue*'s citizen science programme, assisting private landowners with managing kauri dieback on their properties, providing them with the support and materials needed to treat their trees and collect efficacy data, contributing to the wider pool of knowledge about kauri dieback treatment control.
- Collaboration with Motairehe marae and Department of Conservation on a *Myrtle Rust surveillance and monitoring programme* in Aotea.

Appendix B. Survey

Kia ora! Thanks for taking the time to give your feedback, first we have a few questions about you.

Q1 What type of home do you live in?

- Standalone house on a section
- Town house, unit or terrace house (house joined side by side)
- Flat
- Apartment
- Lifestyle block or farm homestead
- Retirement village or rest home
- Other
- Prefer not to say

Q2 Do you have a garden or yard at home?

- Yes
- No

Q3 What pets do you have at home?

- Cat(s)
- Dog(s)
- Rat(s)
- Other small mammals (e.g. guinea pig, ferret, mice), please specify _____
- Parrot(s)
- Other bird(s)
- Fish
- Lizard(s) or other reptiles
- Turtle(s)
- Frog(s) or other amphibians
- Other, please specify _____
- No pets

Q4 In the past 3 months, which of the following activities have you done in Auckland region?

- Visited native forest or bush
- Visited a freshwater lake or river to swim, fish, kayak, or have a day out
- Visited a beach to swim, fish, kayak, or have a day out
- Travelled on a private boat on the Hauraki Gulf
- Visited a Hauraki Gulf Island on a public ferry
- Went mountain biking
- None of the above

Q5 These few questions relate to your life in general.

	1 Not at all	2	3	4 Frequently
How often do you help out a local group as a volunteer (e.g. church group, playgroup, sport club, food bank)?	○	○	○	○
How often have you attended a local community event in the past 6 months (e.g. church fete, cultural festival, school concert, craft exhibition)?	○	○	○	○
How often do you pick up other people's rubbish in a public place?	○	○	○	○
How often do you talk to your neighbours?	○	○	○	○
How often do you talk to your family or friends outside of your household?	○	○	○	○

Q6 These few questions relate to your life in general.

	1 No/Not at all	2	3	4 Definitely yes
If you disagreed with what everyone else agreed on, would you feel free to speak out?	○	○	○	○
Do you feel safe walking down your street after dark?	○	○	○	○
Do you agree that most people can be trusted?	○	○	○	○
Do you think that multiculturalism makes life in your area better?	○	○	○	○
Do you feel valued by society?	○	○	○	○
Do you agree that, by helping others, you help yourself in the long run?	○	○	○	○

Q7 The following questions ask about your engagement with environmental issues and conservation activities. In the past 2 years, how often have you done the following?

	0 Never	1	2 Sometimes	3	4 Frequently
Used traditional methods (e.g., letters to the editor, articles) to raise awareness about environmental issues.	○	○	○	○	○
Took part in a protest/rally about an environmental issue.	○	○	○	○	○
Consciously made time to be able to work on environmental issues (e.g., choosing environmental activities over other leisure activities; working in an environmental job; working part time to allow time for environmental pursuits).	○	○	○	○	○
Became involved with an environmental group (e.g., volunteer).	○	○	○	○	○
Attended training related to the environmental issues (e.g., workshop on trapping pests).	○	○	○	○	○
Participated in a community event which focused on environmental awareness (e.g., educational event, guided nature walk).	○	○	○	○	○
Participated in a community event which focused on conservation activities (e.g., planting trees, restoration of waterways).	○	○	○	○	○
Organised a community event which focused on the environment.	○	○	○	○	○

Q8 Thinking about **home where you live**, how often have you done the following activities in the past 2 years?

	Never	Rarely	Sometimes	Often	Very frequently	Not applicable
Made an effort to plant native plants on the property.	○	○	○	○	○	○
Regularly controlled invasive pest plants on the property.	○	○	○	○	○	○
Regularly trapped or controlled pest animals on the property (e.g., rat traps, rat poison).	○	○	○	○	○	○

Q9 Thinking about **your community**, how often have you done the following activities in the past 2 years?

	Never	Rarely	Sometimes	Often	Very frequently	Not applicable
Took part in community events where we planted native plants.	○	○	○	○	○	○
Took part in community-led control of invasive pest plants.	○	○	○	○	○	○
Took part in community-led trapping or control of pest animals (e.g., rat traps, rat poison).	○	○	○	○	○	○

Q10 When engaging in different activities, how often did you do the following in the past 2 years?

	Never	Rarely	Sometimes	Often	Very frequently	Not applicable
When walking or biking in the bush, I cleaned my shoes, bike, and other gear of dirt at kauri dieback cleaning stations.	○	○	○	○	○	○
When visiting a freshwater lake or river I cleaned my boat, kayak, fishing equipment and other gear used in freshwater.	○	○	○	○	○	○
When traveling to a Hauraki Gulf island on a ferry or a private boat, I checked my gear and/or boat for pests.	○	○	○	○	○	○
When buying plants, I considered whether it could become a weed in the natural environment.	○	○	○	○	○	○

Display This Question:
If Q3 = Cat(s)
Or Q3 = Dog(s)
Or Q3 = Fish
Or Q3 = Rat(s)
Or Q3 = Other small mammals (e.g. guinea pig, ferret, mice), please specify
Or Q3 = Parrot(s)
Or Q3 = Other bird(s)
Or Q3 = Lizard(s) or other reptiles
Or Q3 = Turtle(s)
Or Q3 = Frog(s) or other amphibians
Or Q3 = Other, please specify

Q11 You have indicated that you have a pet. How often did you do the following in the past 2 years?

Display This Choice:
If Q3 = Cat(s)
Display This Choice:
If Q3 = Dog(s)
Display This Choice:
If Q3 = Cat(s)
Or Q3 = Dog(s)

	Never	Rarely	Sometimes	Very often	Always
Display This Choice: If Q3 = Cat(s) I contained my cat within my property (e.g., keep the cat inside at night, use a cat containment/fence).	○	○	○	○	○
Display This Choice: If Q3 = Dog(s) I followed all dog control rules at parks or at the beach.	○	○	○	○	○
Display This Choice: If Q3 = Cat(s) Or Q3 = Dog(s) I made sure my pets are desexed.	○	○	○	○	○
I ensured my pets could not escape into the wild or become lost.	○	○	○	○	○

Q12 Now we have some questions about the natural environment in general. Which of the following might indicate **high native biodiversity** to you?

- ○ Seeing native fish in streams and ponds
- ○ Lots of different native plants at my local park
- ○ Rubbish-free beaches and waterways
- ○ Natural outdoor spaces that I can enjoy
- ○ Different kinds of native birds in my backyard
- ○ A bright green mowed lawn
- ○ A healthy pine forest
- ○ None of the above
- ○ I don't know

Q13 Please tell us whether you think the following species are natives or invasive pests to the best of your knowledge:

	Native	Invasive pests	I don't know
Kowhai	○	○	○
Wild ginger	○	○	○
Moth plant	○	○	○
Nikau palm	○	○	○
Tūi	○	○	○
Possum	○	○	○
Long-tailed bat	○	○	○
Wallaby	○	○	○
Bellbird	○	○	○
Fanworm	○	○	○
Plague skink	○	○	○
Houttuynia	○	○	○
Kererū	○	○	○
Koi carp	○	○	○
Pukeko	○	○	○

Q14 How would you rate your practical skills to do the following activities?

	Low	Below average	Average	Above average	High	Not applicable
Skill to plant a native tree e.g. where and what to plant, hole size and depth, staking, mulching.	○	○	○	○	○	○
Skill to control invasive pest plants, e.g., identification, methods of control, disposal of pest plants.	○	○	○	○	○	○
Skill to control pest animals, e.g., setting traps, use of pest animal monitoring equipment.	○	○	○	○	○	○

Q15 Indicate how much you agree with the following statements:
Note, 'opportunity' may mean having space to plant native trees in your garden, or community events that you can join.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
There are opportunities for me to plant native plants either on my property or as part of a community activity.	○	○	○	○	○
There are opportunities for me to trap or control pest animals either on my property or as part of a community activity.	○	○	○	○	○
There are opportunities for me to control invasive pest plants either on my property or as part of a community activity.	○	○	○	○	○

Q16 Indicate how much you agree with the following statements.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Not applicable
My friends and whānau/family join me when I do conservation activities.	○	○	○	○	○	○
I can make new friends or connections through doing conservation activities.	○	○	○	○	○	○
My friends and whānau/family are supportive of me doing conservation activities.	○	○	○	○	○	○

Q17 How much do you agree or disagree with the following?

	1 Strongly disagree	2	3	4	5 Strongly agree
I have control over my own impact on the environment.	○	○	○	○	○
It is important to reduce my impact on the environment.	○	○	○	○	○
I am personally responsible for contributing to the environment's problems.	○	○	○	○	○
My efforts to protect the environment are insignificant as long as others refuse to act.	○	○	○	○	○

Q18 We are now going to ask about your views on nature. There are no right or wrong answers. Please be as honest and candid as you can. How much do you agree or disagree with the following?

	1 Strongly disagree	2	3 Unsure	4	5 Strongly agree
We are approaching the limit of the number of people the Earth can support.	○	○	○	○	○
Humans have the right to modify the natural environment to suit their needs.	○	○	○	○	○
When humans interfere with nature it often produces disastrous consequences.	○	○	○	○	○
Human ingenuity will ensure that we do not make the Earth unlivable.	○	○	○	○	○
Humans are seriously abusing the environment.	○	○	○	○	○
The Earth has plenty of natural resources if we just learn how to develop them.	○	○	○	○	○
Plants and animals have as much right as humans to exist.	○	○	○	○	○
The balance of nature is strong enough to cope with the impacts of modern industrial nations.	○	○	○	○	○
Despite our special abilities, humans are still subject to the laws of nature.	○	○	○	○	○
The so-called “ecological crisis” facing humankind has been greatly exaggerated.	○	○	○	○	○
The Earth is like a spaceship with very limited room and resources.	○	○	○	○	○
Humans were meant to rule over the rest of nature.	○	○	○	○	○
The balance of nature is very delicate and easily upset.	○	○	○	○	○
Humans will eventually learn enough about how nature works to be able to control it.	○	○	○	○	○
If things continue on their present course, we will soon experience a major ecological catastrophe.	○	○	○	○	○

Q19 Finally, we have some questions about you. This information helps us ensure we include the views of Aucklanders from all backgrounds on the People's Panel. It will also help us send you more relevant surveys, e.g., ones about your local area. All information is kept confidential[9].

Display This Question:

If Contact List FirstName Is Empty

Q20 What is your name? Please leave this question blank if you would prefer not to say.

- First name: _____
- Last name: _____

Q21 Which suburb / community do you live in? This list is in alphabetical order, please scroll until you find your suburb.

- [The list includes 410 suburbs]
- Other (please specify) _____
- I prefer not to say
- None, I don't live in the Auckland Region

[9] Demographics section is standard for People’s Panel surveys. Where possible, information was drawn from the panel database.

Display This Question:
If Gender Is Empty
Or Gender Contains I prefer not to say

Q22 Are you:

- Male
- Female
- Gender diverse
- I prefer not to say

Display This Question:
If Year of Birth Is Empty

Q23 Please select your year of birth:

▼ 2006 ... 1907

Display This Question:
If Ethnicity Is Empty
Or Ethnicity = I prefer not to say

Q24 Which ethnic group(s) do you belong to?

We want to hear from Aucklanders of all backgrounds. This information helps us understand if there are groups that we need to hear more from. Please select all that apply.

- ☐ NZ European / Pākehā
- ☐ Māori
- ☐ Other European
- ☐ Samoan
- ☐ Tongan
- ☐ Fijian
- ☐ Niuean
- ☐ Cook Islander
- ☐ Tokelauan
- ☐ Other Pacific peoples
- ☐ Southeast Asian
- ☐ Korean
- ☐ Chinese
- ☐ Indian
- ☐ Other Asian
- ☐ African
- ☐ Middle Eastern
- ☐ Latin American
- ☐ Other (please specify) _____
- ☐ I prefer not to say

Display This Question:
If Household Is Empty
Or Household = I prefer not to say
Or Household = I don't know

Q25 How would you best describe your household?

- Young single
- Young couple
- Group flatting
- Household with mainly pre-school kids
- Household with mainly school age kids
- Household with mainly older kids

- Household with kids of mixed ages
- Extended family household (three or more generations living together)
- Middle-aged single
- Middle-aged couple
- Older single
- Older couple
- Something else (please specify) _____
- I prefer not to say
- I don't know

Display This Question:

If ses://employmentstatus Is Empty

Q26 What best describes your employment status over the last three months?

- Working full-time
- Working part-time
- Unemployed and looking for work
- A homemaker or stay-at-home parent
- Student
- Retired
- Other

Q27 What is your highest education?

- No formal education
- Secondary school
- Certificate or diploma
- Bachelor's degree
- Postgrad degree
- I prefer not to say

Q28 Do you currently work for Auckland Council or any CCOs (council controlled organisations)?

- Yes
- No

Q29 Do you have any comments about the natural environment or this survey?[10]

End of survey

[10] This is a customary question for People's Panel surveys to provide engagement loop to the panellists. The feedback was recorded for internal practice improvement purposes but not included in this report as it was beyond the scope of this survey.

Appendix C. Measures

This appendix describes the measures taken in the 2022 survey.

1. Social Capital Scale

Engagement in conservation activities is associated with increased social capital[11]. A survey of Aucklanders (n = 1217) in August 2020 demonstrated that people who were members of conservation groups had higher social capital[12] scores than people who were not engaged with any community group (Gerolemou et al., 2022). We do not claim that activities funded by NETR will directly increase the social capital of Aucklanders. Yet, we do accept the evidence that there is an association between social capital and conservation and, therefore, we measured social capital as a social outcome.

The Social Capital Scale (SCS) measures the social capital of a community overall and orthogonal underlying factors of social capital (Onyx & Bullen, 2000). This original scale consists of 36 questions measuring eight factors. For this survey the scale was adapted to reduce burden on the participants and increase the completion rate of the survey. The scale used in this survey consists of 11 questions across seven factors scored on a 4-point Likert scale where 1 = no, not at all, 4 = definitely yes, frequently. Higher scores are associated with higher social capital.

2. Environmental Action Scale

Measuring general pro-environmental behaviour captures the influence of attitudes and beliefs and can vary from a specific environmental behaviour (e.g., planting trees) (Hadler et al., 2022). In this survey, we decided to use the Environmental Action Scale (Alisat & Riemer, 2015) to capture general environmental activism.

The Environmental Action Scale (EAS) measures public engagement in civic actions on environmental issues (Alisat & Riemer, 2015). The scale also measures two domains: participatory action and leadership action. The scale was adapted for this survey. The original scale had 18 questions; the adapted version consists of eight questions (five participatory and three leadership) measured on a 5-point Likert scale 0 to 4 where 0 = never, 2 = sometimes, 4 = frequently. Higher scores are associated with higher environmental action.

[11] Social capital is "the network of social connections that exist between people, and their shared values and norms of behaviour, which enable and encourage mutually advantageous social cooperation" (https://www.collinsdictionary.com/dictionary/english/social-capital).

[12] There was a statistically significant difference ($p < .001$) between mean social capital score 3.2 for members of conservation groups and the mean score 2.6 for participants that were not in any community group. Out of six types of community groups (conservation, cultural, sport, hobby, educational, religious), members of conservation groups had the highest social capital scores.

3. Environmental protection activities

Three scales were developed to measure specific environmental protection activities.

3.1. Conservation at home

Three questions were adapted from the 2020 survey around performing three conservation activities (plant, weed, trap) on a property under the person's control. The questions were measured on a 5-point Likert scale 1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = very frequently with a *not applicable* option. Higher scores are associated with higher engagement with environmental protection activities at home.

3.2. Community-led conservation

Three questions were adapted from the 2020 survey around performing three conservation activities (plant, weed, trap) as part of a community-led effort. The questions were measured on a 5-point Likert scale 1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = very frequently with a *not applicable* option. Higher scores are associated with higher engagement with environmental protection activities in the community.

3.3. Biosecurity

Eight questions, some adapted from the 2020 survey, and some developed for this round of data collection, measured adherence to council promoted biosecurity practices.

Four questions focused on high-risk biosecurity activities: 1) bush walking, 2) freshwater activities, 3) Hauraki Gulf travel, 4) introducing pest plants into the environment. The questions were measured on a 5-point Likert scale 1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = always, with each question having a *not applicable* option.

Another four questions were dependent on whether a person has indicated that they have a pet, all non-pet owners were automatically recorded as responding *not applicable*. Cat owners were asked about the frequency of containing their cats. Dog owners were asked about the frequency of following dog rules. Both cat and dog owners were asked about their pet desexing practice. All pet owners were asked about preventing their pets from becoming stray and/or feral. The questions were measured on a 5-point Likert scale 1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = always. There was no *not applicable* option because questions were triggered based on previous answers regarding pet ownership explicitly. Higher scores are associated with higher adherence.

4. Psychological capability

Psychological capability was equated to knowledge of biodiversity and biosecurity. It was measured using two sets of questions, one set focusing on understanding biodiversity (7 questions) and another set on biosecurity knowledge (15 questions). The answers were true/false type with a *Don't know* option. The questions were reused from the 2020 survey, though the scoring was modified. One point was awarded for each correct answer and then the overall percentage of correct answers was calculated. Higher scores are associated with higher knowledge.

5. Physical capability

Physical capability was regarded as practical skills and measured by three questions asking to rate person's practical skills to 1) plant native plants, 2) control invasive pest plants, 3) control animal pests. The questions were based on 2020 survey but modified. The answers were scored on a 5-point Likert scale where 1 = low, 2 = below average, 3 = average, 4 = above average, 5 = high with a *not applicable* option. Higher scores are associated with greater perceived skills.

6. Social opportunity

Social opportunity was interpreted as social interaction; this measure was developed specifically for this survey. Social opportunity was measured by three questions asking to rate person's perceptions around 1) whānau and friends' engagement, 2) an opportunity for the person to make new connections, 3) whānau and friends' support. The answers were scored on a 5-point Likert scale where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree with a *not applicable* option. Higher scores are associated higher perceived social opportunity.

7. Physical opportunity

Physical opportunity was defined as having means to carry out conservation; this measure was developed specifically for this survey. Physical opportunity was measured by three questions asking a person's perceptions about opportunities they have to 1) plant native plants, 2) control invasive pest plants, 3) control animal pests, on their property or in the community. The answers were scored on a 5-point Likert scale where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree. *Not applicable* option was not offered because we wanted the overall perception of physical opportunity in spite the level of ability or disability. Higher scores reflect greater perceived physical opportunity.

8. New Ecological Paradigm

The New Ecological Paradigm (NEP) scale is a measure of endorsement of pro-environmental beliefs (Dunlap et al., 2000), i.e. personal beliefs. This scale consists of 15 questions measured on a 5-point Likert scale from 1 = strongly disagree to 5 = strongly agree where odd numbered questions measure new environmental paradigm (NeP) while even numbered questions measure dominant social paradigm (DSP). Higher scores on NeP items and lower scores on DSP items are considered better. For the total NEP score, DSP item scores are reversed.

9. Locus Of Control

The Locus of Control (LOC) scale measures a belief of how much positive change for the environment can be brought about by an individual (McMullin et al., 2007), i.e. personal responsibility. The scale was modified and used in a large representative sample of Aucklanders (Macdonald et al., 2019) and then used in our 2020 baseline survey (Ovenden & Roberts, 2021). This modified LOC scale consists of four questions scored on a 5-point Likert scale from 1 = strongly disagree to 5 = strongly agree. Higher scores are associated with perception of personal responsibility.

10. Demographics and participant characteristics

We asked respondents their age, gender, ethnicity, household type, employment, education, their locality, the type of home they live in (e.g. standalone house, apartment), whether they have a garden, what pets they own, and what activities they took part in during the past three months (e.g. visited native forest or bush, travelled on a private boat on the Hauraki Gulf).

Appendix D. Internal consistency of measurement scales

We tested all scales for internal consistency using Cronbach's alpha (α) and Guttman's Lambda 6 (*G6*), using the psych package v.2.3.3 in R v.4.3.0 (Revelle & Condon, 2019). For a binary scale we used Kuder-Richardson Formula 20 approach. Most scales demonstrated acceptable (0.70 - 0.79) or good consistency (0.80 - 0.89) (Table D1).

The biosecurity scale comprised eight questions. Four questions related to performing biosecurity activities (e.g. cleaning shoes at kauri dieback stations) were presented to all participants, another four questions related to pets (e.g. following dog rules on a beach) that were presented only to pet owners. That is why this scale was split tested. Both parts showed poor internal consistency. The second part of the biosecurity scale also was less stable and less able to be generalised.

Table D1. Internal consistency of measurement scales

Scale	Raw α	Standardised α	*G6*
Physical capability	0.86	0.86	0.82
Social opportunity	0.75	0.75	0.69
Physical opportunity	0.87	0.87	0.83
New Ecological Paradigm	0.87	0.87	0.88
Locus of Control	0.56	0.58	0.55
Social Capital Scale	0.70	0.71	0.73
Environmental Action Scale	0.88	0.89	0.88
Conservation at home	0.75	0.76	0.68
Community-led conservation	0.81	0.82	0.76
Biosecurity Part 1 (activities)	0.58	0.58	0.51
Biosecurity Part 2 (pets)	0.63	0.70	0.67

Psychological capability was a binary scale (correct/incorrect answer). It was assessed using Kuder-Richardson Formula 20 approach and with the test score indicating a poor reliability (*KR-20* = 0.5477).

Based on internal consistency measures, findings related to psychological capability, Locus of Control, and biosecurity should be interpreted with caution.

Appendix E. Participant characteristics

This appendix provides a comprehensive overview of the respondents. It includes comparison between the 2022 sample to the 2020 baseline and census data from 2018. Additionally, it describes garden ownership, pet ownership, and the level of engagement with outdoor activities among the surveyed participants.

1. Comparison between 2020 and 2022 samples

Participants in the 2022 sample, overall, were comparable to 2020 sample. Table E1 presents characteristics of both samples. Although there were statistically significant differences[13] on all but one parameter (location) between the 2020 and 2022 samples, having statistically significant results on large samples is common and not always meaningful. Indeed, almost all effect sizes were very small[14]. An exception was the household type with a medium effect size ($V = 0.2889$). The 2022 sample reported more families without children but a smaller number of multi-family households (e.g. adult children living with parents, multi-generational household). However, the difference is likely to be due to the different categorisation between 2020 and 2022 surveys rather than an actual change in population. The household data was partially drawn from the panel database which included 14 categories and a free text option that could have caused differences in categorisation.

[13] Statistical significance was assessed by a chi-square (x^2) test, $p < .05$ indicates significance.
[14] Effect size in this occurrence was measured using Cramer's V where < 0.1 is a small effect, 0.3 is a medium effect, > 0.5 is a large effect.

Table E1. Participant characteristics

Demographics	2020 (n = 1813)		2022 (n = 2348)		Statistical significance
	n	%	n	%	
Age groups		n=1674			
15-24	57	3.4	68	2.9	x^2 = 28.278, p = .0001, V = 0.0839
25-34	222	13.3	291	12.4	
35-44	329	19.7	344	14.7	
45-54	336	20.1	452	19.3	
55-64	359	21.4	557	23.7	
65-74	264	15.8	443	18.9	
75+	107	6.4	193	8.2	
Gender		n=1720			
Female	908	52.8	1232	52.5	x^2 = 13.449, p = .0038, V = 0.0557
Male	764	44.4	1074	45.7	
Gender diverse	11	0.6	22	0.9	
Prefer not to say	37	2.2	20	0.9	
Ethnicity (multiple allowed)		n=1649			
NZ European/Pākehā	1159	70.0	1634	69.6	x^2 = 20.351, p = .0011, V = 0.071
Māori	175	11.0	254	10.8	
Pacific	101	6.0	121	5.2	
Asian	238	14.0	315	13.4	
MELAA[15]	31	2.0	58	2.5	
Other	191	11.0	344	14.7	
Prefer not to say[16]	-	-	47	2.0	
Education					
Post-graduate degree	NR	NR	696	29.6	-
Bachelor degree	NR	NR	767	32.7	
Certificate or diploma	NR	NR	530	22.6	
Secondary school	NR	NR	256	10.9	
No formal education	NR	NR	13	0.6	
Prefer not to say	NR	NR	86	3.7	
Employment					
Full-time	NR	NR	1208	51.4	-
Part-time	NR	NR	353	15.0	
Unemployed	NR	NR	47	2.0	
Retired	NR	NR	478	20.4	
Student	NR	NR	51	2.2	
Homemaker	NR	NR	101	4.3	
Other	NR	NR	110	4.7	
House type					
Standalone house on a section	NR	NR	1658	70.6	-
Town house, unit or terrace house	NR	NR	328	14.0	
Lifestyle block or farm homestead	NR	NR	103	4.4	

[15] Middle Eastern/Latin American/African

[16] For chi squared calculation Prefer not to say was grouped with Other.

Demographics	2020 (n = 1813)		2022 (n = 2348)		Statistical significance
	n	%	n	%	
Retirement village or rest home	NR	NR	30	1.3	
Apartment	NR	NR	142	6.0	
Flat	NR	NR	54	2.3	
Other	NR	NR	24	1.0	
Prefer not to say	NR	NR	9	0.4	
Household type		n=1804			
Family with kids	627	34.8	742	31.6	x^2 = 346.445, p < .0001, V = 0.2889
Family without kids	465	25.8	888	37.8	
Multi-family household	357	19.8	91	3.9	
Single person	207	11.5	374	15.9	
Non-family household (flatting)	101	5.6	94	4.0	
Other	21	1.2	97	4.1	
Prefer not to say	26	1.4	62	2.6	
Location		n=1688			
North	475	28.1	677	28.8	x^2 = 2.874, p = .7194, V = 0.0267
Central	541	32.0	746	31.8	
West	262	15.5	391	16.7	
East	139	8.2	168	7.2	
South	249	14.8	332	14.1	
Gulf	22	1.3	34	1.4	

NR – not reported.

Note, there was no missing data in 2022. In 2020, missing data was excluded from the analysis.

2. Comparison to Census 2018

The 2022 sample, same as the 2020 sample, was not representative of general Auckland population based on Census 2018 data (Stats NZ, 2020). This was due to the sample being drawn from Auckland Council's People's Panel. Most demographic parameters were significantly different (Table E2).

Table E2. Comparison to Census 2018

Demographics	Census 2018 (n = 1,571,718) %	2022 (n = 2348) %	
Median age (years)	35	55	*
Gender			
Female	50.5	52.5	
Male	49.4	45.7	*
Ethnicity (multiple allowed)			
NZ European/Pākehā	53.5	69.6	*
Māori	11.5	10.8	
Pacific	15.5	5.2	*
Asian	28.2	13.4	*
MELAA	2.3	2.5	
Other	1.1	14.7	*
Education			
Post-graduate degree	12.5	29.6	*
Bachelor degree	18.6	32.7	*
Certificate or diploma	16.7	22.6	*
Secondary school or below	52.2	15.1	*
Employment			
Full-time	51.9	51.4	
Part-time	13.7	15.0	
Unemployed	4.1	2.0	*
Not in the labour force	30.4	31.6	
Location			
North	24.5	28.8	*
Central	26.6	31.8	*
West	15.7	16.7	
East	9.0	7.2	*
South	23.6	14.1	*
Gulf	0.7	1.4	*

* Statistically significant difference, $p < .05$.

3. Garden ownership

We asked *Do you have a garden or yard at home?* By asking this question we wanted to gauge how many respondents have a physical space at home to perform environmental activities.

Overall, 92.2% (n = 2165) of respondents said that they have a garden. In 2020, 89.3% of respondents reported having a garden or backyard. There was a statistically significant difference between 2020 and 2022 but with a negligible effect size (x^2 = 10.422, p = .0012, φ = 0.0501)[17]. This means that the difference in garden ownership between 2020 and 2022 samples was negligible.

Figure E1 presents garden ownership by the house type in 2022. The largest proportion of people reporting having a garden, except lifestyle block dwellers with a 100% rate, was among people living in a standalone house on a section (98.6%). The largest proportion of people not having a garden was among those living in apartments (71.1%).

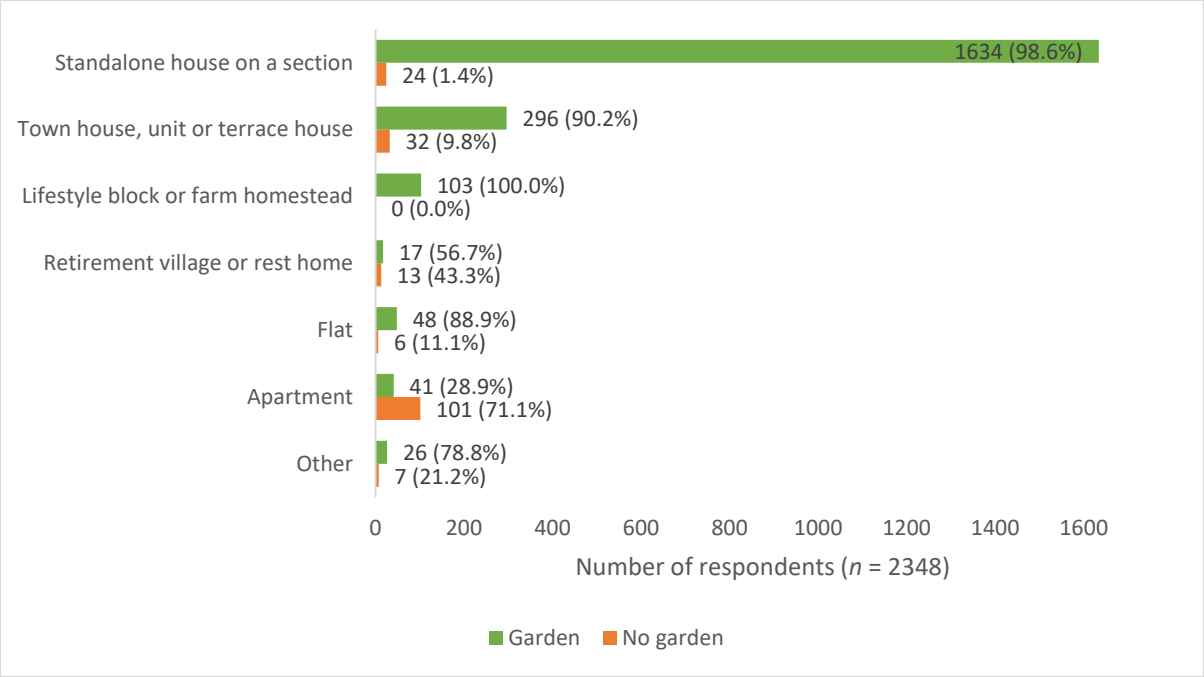

Figure E1. Garden ownership by an accommodation type

[17] Effect size was measured as Phi φ, where φ < 0.1 is a small effect, 0.3 is a medium effect, > 0.5 is a large effect.

4. Pet ownership

To understand the frequency of households with pets that may pose a biosecurity risk, we asked *What pets do you have at home?* There were 12 answer options.

Results for 2022 data collection are presented in Table E3. Pet categories in 2020 and 2022 were aligned only on cat and dog categories. Cats were the most reported pet across both timepoints at 33.4% in 2020 and 33.5% in 2022 (x^2 = 0.0056, p = .9402, φ = 0.0012), followed by dogs at 23.6% in 2020 and 27.3% in 2022 (x^2 = 7.0906, p = .0077, φ = 0.0413). The difference between 2020 and 2022 was negligible.

A small number of people reported owning rats (0.3%) or parrots (0.5%). *Other small mammals* mostly comprised of rabbits and guinea pigs, with only two people stating mice and no one confirming any mustelids as pets. Mustelids cannot be legally kept; therefore, it is possible that this result reflects hesitancy to report, and/or that these species are only present at very low frequencies within the population, below a level detectable in our sample. The *Other* category mostly consisted of farm animals like horses, sheep, and goats; some people reported insects (e.g. bees).

Table E3. Pet ownership in 2022

Pet (n=2348)	n	%	Pet	n	%
Cat(s)	787	33.5	Fish	126	5.4
Dog(s)	640	27.3	Lizard(s) or other reptiles	11	0.5
Rat(s)	6	0.3	Turtle(s)	11	0.5
Other small mammals (e.g. guinea pig, ferret, mice)	51	2.2	Frog(s) or other amphibians	12	0.5
Parrot(s)	11	0.5	Other	27	1.1
Other bird(s) (e.g. chickens)	91	3.9	No pets	1057	45.0

A large number of people (45.0%) reported having no pets. In 2020 6.6% of people reported that they had *'no pets or garden'*, this was due to the pet ownership question being merged with a garden ownership question (2020 question was worded *No pets or garden*). We believe 2022 data reflects realistic prevalence of pet ownership.

Overall, the representation of pets in our sample was somewhat similar to that reported for Aucklanders in the demographically representative Companion Animals in NZ survey in 2020. This survey reported cats in 35% of households, dogs 32%, fish 9%, birds 6%, rabbits 2.3%, other small mammals 1.5%, turtles, lizards and other reptiles 1.3% (Companion Animals New Zealand, 2020).

5. Engagement with activities

We wanted to know the prevalence of engagement with activities that may carry biosecurity risk. For that we asked, "*In the past three months, which of the following activities have you done in Auckland region?"* We maintained the same three-month duration as in the 2020 survey for comparability. Both 2020 and 2022 data were collected in November, so there were no seasonal differences. However, in 2020, just before the data collection, Auckland was heavily affected by COVID-19 restrictions. Starting from 12 August 2020 Auckland was under a lockdown at alert level three and remained at alert level two from 30 August 2020 till 07 October 2020. During this period there were limitations on public gatherings.

On average, in 2022 Aucklanders engaged with 1.5 activities in the past three months prior to answering the survey. Almost a quarter (23.0%) engaged with three or more activities. The most popular activity in 2022 was visiting a beach (56.0%) closely followed by bush walking (54.7%). Engagement with activities was similar to 2020 findings. All differences had a very small effect size (φ < 0.1) (Table E4).

In 2022, 27.3% of respondents reported doing none of the listed activities in the past three months vs 11% in 2020. This is because in 2020 the list of activities also included visiting a local park and playing golf. In 2022 we only asked about activities with biosecurity concerns. For that reason, we did not test statistical significance on the item 'None'.

The rate of engagement must be interpreted with caution. Engagement with outdoor activities is weather dependent and highly seasonal; prevalence is likely to change in the summer months.

Table E4. Engagement with activities

Activity	2020 (n=1809)		2022 (n=2348)		Statistical significance
	n	%	n	%	
Visited native forest or bush	1061	58.5	1284	54.7	x^2 = 5.997, p = .0143, φ = 0.0122
Visited a beach to swim, fish, kayak, or have a day out	-	-	1315	56.0	-
Visited a freshwater lake or river to swim, fish, kayak, or have a day out	285	15.7	340	14.5	x^2 = 1.152, p = .2831, φ = 0.0054
Visited a Hauraki Gulf Island on a public ferry	219	12.1	297	12.6	x^2 = 0.235, p = .6276, φ = 0.0024
Travelled on a private boat on the Hauraki Gulf	151	8.3	205	8.7	x^2 = 0.210, p = .6471, φ = 0.0023
Went mountain biking	200	11.0	172	7.3	x^2 = 17.231, p < .0001, φ = 0.0207
Visited local park	1489	82.1	-	-	-
Played golf at golf course	95	5.2	-	-	-
None	213	11.8	642	27.3	-

Appendix F. Sources of behaviour

This appendix offers the detailed results of the six sources of behaviour according to the COM-B framework. Where applicable, we include comparisons with measures collected during the 2020 survey.

1. Knowledge of biodiversity and biosecurity: Psychological capability

We equated psychological capability to knowledge of biodiversity and biosecurity. We used the same two sets of questions that were used in 2020 survey for comparability.

The first set – understanding biodiversity was assessed using seven questions where one point was awarded for every correct answer. Answers *Don't know* were considered incorrect. On average, in 2022 participants answered 4.6 (SD = 2.21) questions correctly out of seven. In 2020 (n = 1737), the mean score was 4.9 (SD = 2.20).

The second set – knowledge of biosecurity, i.e. differentiation between native and introduced fauna and flora, was assessed using 15 questions where one point was awarded for every correct answer. Answers *Don't know* and *None of the above* were considered incorrect. If these options were chosen, zero points were awarded for the whole set. On average, participants answered 11.5 (SD = 2.44) questions correctly out of 15. In 2020, only seven questions out of the fifteen were randomly presented to each participant. The mean score of correct answers in 2020 was 5.5 (SD = 1.36) out of seven.

To assess overall knowledge of biosecurity and biosecurity we calculated an overall rate of correct answers across both sets of questions. In 2022 the rate was 73.4% (SD = 16.8). In 2020 the corresponding rate was 74.1% (SD = 19.6). There was no statistically significant difference[18] between these two time-points ($t = 1.226$, $p = .2203$, $d = 0.0384$). The score of knowledge, however, should be interpreted cautiously because the instrument did not perform well on internal consistency (see Appendix D).

2. Practical skills: Physical capability

We regarded physical capability in COM-B model as practical skills and capabilities to complete pro-environmental behaviours. We asked respondents how they perceive their practical skills. Physical capability was measured in 2020 using a different set of questions therefore it was not fully comparable. Table F1 presents results by a question in 2022 data collection. The total score was 2.98, the middle of the range, an equivalent to *'average'.*

[18] Statistical significance was tested using two-tailed Student's *t*-test. Effect size was tested using Cohen's *d* (< 0.2 small, 0.5 medium, ≥ 0.8 large).

Table F1. Perceived practical skills

Activity	Question *How would you rate your practical skills to do the following activities? (Answers from 1 = Low to 5 = High)*	Mean (SD) (n=2310)
Plant	Skill to plant a native tree, e.g. where and what to plant, hole size and depth, staking, mulching.	3.22 (1.30)
Weed	Skill to control invasive pest plants, e.g. identification, methods of control, disposal of pest plants.	3.01 (1.21)
Trap	Skill to control pest animals, e.g. setting traps, use of pest animal monitoring equipment.	2.70 (1.27)
	Total	2.98 (1.12)

Physical capability was measured in 2020 using similar concepts (Weed and Trap) but differently worded questions. Skills to control pest plants (Weed) were measured by two questions: 1) ability to identify and 2) ability to control pest plants. The average score across these two questions was 2.96 (SD = 1.21). The difference from 2022 was not statistically significant and the effect size was negligible (t = 1.144, p = .2525, d = 0.0413).

Skills to control animal pests (Trap) in 2020 were also measured by asking people two questions: 1) ability to set a rat trap and 2) ability to use pest monitoring equipment. The average score across these two questions was 2.62 (SD = 1.38). The difference from 2022 was not statistically significant and the effect size was negligible (t = 1.690, p = .0912, d = 0.0603).

3. Social interaction: Social opportunity

We interpreted social opportunity in COM-B model as engagement in conservation activities with people who are important to the person, an opportunity to build new relationships, and support from people who are important to the person. We asked respondents to report their perceptions of social interaction with whānau and friends. Table F2 reports the results by a question in 2022 data collection. The overall score was 3.57, i.e. between *'neutral'* and *'agree'*. Social opportunity was not measured in 2020.

Table F2. Perceived social interaction

Area	Question *Indicate how much you agree with the following statements. (Answers from 1 = Strongly disagree to 5 = Strongly agree)*	Mean (SD) (n=2066)
Join	My friends and whānau/family join me when I do conservation activities.	3.09 (1.12)
Connect	I can make new friends or connections through doing conservation activities.	3.71 (0.92)
Support	My friends and whānau/family are supportive of me doing conservation activities.	3.84 (0.93)
	Total	3.57 (0.83)

4. Means to carry out conservation: Physical opportunity

Physical opportunity was regarded as an environmental determinant. To ensure understanding of the question, we have clarified: *Note, 'opportunity' may mean having space to plant native trees in your garden, or community events that you can join.* Responses across all three activities scored similar. The total score was 3.55, between *neutral* and *agree* (Table F3). Physical opportunity was not measured in 2020.

Table F3. Perceptions of means needed to carry out conservation

Activity	Question *Indicate how much you agree with the following statements. (Answers from 1 = Strongly disagree to 5 = Strongly agree)*	Mean (SD) (n=2348)
Plant	There are opportunities for me to plant native plants either on my property or as part of a community activity.	3.56 (1.13)
Weed	There are opportunities for me to trap or control pest animals either on my property or as part of a community activity.	3.65 (1.09)
Trap	There are opportunities for me to control invasive pest plants either on my property or as part of a community activity.	3.45 (1.14)
	Total	3.55 (1.00)

5. Personal beliefs: Automatic motivation

Automatic motivation in the COM-B model is concerned with emotions, impulses, and inhibitions and how they influence behaviour. Positive personal beliefs and emotions about the environment and people's role in protecting nature may elicit more environmental action. In this report, we defined automatic motivation as general personal beliefs about the environment. We used the New Ecological Paradigm (NEP) scale to measure automatic motivation, the same scale used in the 2020 survey.

The total 2022 NEP score was 3.79. In the 2020 sample the NEP score was 3.90. This is a statistically significant reduction but with a small effect size (t = 4.030, p = .0001, d = 0.164) making the difference negligible.

The sample that completed NEP in 2020 was smaller because the respondents were randomised to completing either NEP or Connectedness to Nature scale (not measured in 2022). Raw mean scores for each question of the NEP scale in comparison to 2020 sample are presented in Table F4.

Table F4. Personal believes about the environment (NEP)

Paradigm	Question *How much do you agree or disagree with the following? (Answers from 1 = Strongly disagree to 5 = Strongly agree)*	Raw mean (SD) 2020 (n=859)	Raw mean (SD) 2022 (n=2348)
NeP	We are approaching the limit of the number of people the Earth can support.	3.79 (1.19)	3.62 (1.33)
DSP	Humans have the right to modify the natural environment to suit their needs.	2.35 (1.11)	2.43 (1.19)

Paradigm	Question *How much do you agree or disagree with the following? (Answers from 1 = Strongly disagree to 5 = Strongly agree)*	Raw mean (SD) 2020 (n=859)	 2022 (n=2348)
NeP	When humans interfere with nature it often produces disastrous consequences.	3.98 (1.05)	3.92 (1.11)
DSP	Human ingenuity will ensure that we do not make the Earth unliveable.	2.75 (1.17)	2.91 (1.21)
NeP	Humans are seriously abusing the environment.	4.33 (0.99)	4.13 (1.14)
DSP	The Earth has plenty of natural resources if we just learn how to develop them.	2.93 (1.29)	3.19 (1.29)
NeP	Plants and animals have as much right as humans to exist.	4.24 (1.03)	4.24 (1.02)
DSP	The balance of nature is strong enough to cope with the impacts of modern industrial nations.	1.91 (1.08)	1.99 (1.12)
NeP	Despite our special abilities, humans are still subject to the laws of nature.	4.44 (0.85)	4.35 (0.86)
DSP	The so-called "ecological crisis" facing humankind has been greatly exaggerated.	1.92 (1.21)	2.08 (1.31)
NeP	The Earth is like a spaceship with very limited room and resources.	3.85 (1.19)	3.68 (1.17)
DSP	Humans were meant to rule over the rest of nature.	1.96 (1.22)	1.99 (1.21)
NeP	The balance of nature is very delicate and easily upset.	4.02 (0.97)	3.92 (1.05)
DSP	Humans will eventually learn enough about how nature works to be able to control it.	2.47 (1.14)	2.45 (1.11)
NeP	If things continue on their present course, we will soon experience a major ecological catastrophe.	4.06 (1.14)	4.01 (1.19)
	Mean total	3.90 (0.64)	3.79 (0.70)

NeP – new environmental paradigm
DSP – dominant social paradigm (reverse scored for total score)

The questions in the NEP scale were grouped into new environmental paradigm (NeP) or dominant social paradigm (DSP) (see Table F4). All NeP items scored above mid-point across both 2020 and 2022 surveys indicating an appreciation for the environment and its intrinsic value. The only DSP item (DSP reflects anthropocentrism) that scored above the mid-point in 2022 (3.19 points) was a belief that *the Earth has plenty of natural resources if we just learn how to develop them*. This item had the biggest change out of all items in the scale (mean difference 0.26) since 2020.

6. Personal responsibility: Reflective motivation

COM-B model defines reflective motivation as beliefs about capabilities and intentions that are based on evaluation and planning. The Locus of Control (LOC) scale has been used in previous 2020 survey to measure perceptions of a personal responsibility for the environment. The total LOC mean score in 2022 was 3.67 (SD = 0.77), in 2020 it was 3.70 (SD = 0.83). There was no statistically significant difference between 2020 and 2022 and the effect size was small (t = 1.189, p = .2347, d = 0.0375). Mean scores by individual items of the LOC scale are presented in Table F5.

Table F5. Perceptions of personal responsibility (LOC)

	Question	Raw mean (SD)	
	How much do you agree or disagree with the following? (Answers from 1 = Strongly disagree to 5 = Strongly agree)	**2020 (n=1725)**	**2022 (n=2348)**
	I have control over my own impact on the environment.	3.79 (1.16)	3.93 (1.01)
	It is important to reduce my impact on the environment.	4.07 (1.23)	4.15 (1.04)
	I am personally responsible for contributing to the environment's problems.	3.49 (1.29)	3.47 (1.28)
*	My efforts to protect the environment are insignificant as long as others refuse to act.	2.56 (1.27)	2.86 (1.34)
	Mean total	3.70 (0.83)	3.67 (0.77)

* This item is reversed scored for the total score

The question *My efforts to protect the environment are insignificant as long as others refuse to act* showed the biggest change since 2020 (mean difference 0.30). The lower the score of this item, the higher the sense of the importance of personal contribution. However, the score of this item has increased in 2022.

The internal consistency (see Appendix D) of the LOC scale measured by Cronbach's alpha across both 2020 and 2022 was poor (0.55 and 0.58 respectively) and similar to the findings in another survey (0.51) (Macdonald et al., 2019). LOC results should be taken cautiously for this reason.

Appendix G. Social outcomes

This appendix provides comprehensive insights into five social outcomes:

- Social capital
- Environmental activism
- Conservation at home
- Community-led conservation
- Biosecurity

We present the scores from Likert scale questions employed to evaluate each of these social outcomes. Where feasible, we offer comparisons with the 2020 survey results or an alternate benchmark. Additionally, we present an in-depth analysis of the statistical model that demonstrates the connections between each social outcome and the six sources of behaviour.

1. Social capital

We measured social capital because participation in environmental activity is associated with community building and community wellbeing (Gerolemou et al., 2022). Social capital was not measured in 2020 survey. However, due to the similarities in our baseline 2020 survey sample and sample in Gerolemou et al. (2022)[19] we used the latter as an alternative baseline. Social capital was assessed using a Social Capital Scale (SCS).

The overall mean score of the SCS in 2022 was 2.80 (SD = 0.48) (Table G1). This scale's measure was different from other scales used in this survey (range 1 to 4). Among individual questions, the highest score was 3.60 for family and friends' connections. The lowest scores were 2.01 and 2.02, both related to participation in the community.

Gerolemou et al. (2022) reported that mean score of social capital in 2020 was 2.87 (SD = 0.51). Although the difference between the results was statistically significant, the effect size was small ($t = 4.030$, $p < .001$, $d = 0.1413$)[18]. This small difference could be explained by the fact that sample in Gerolemou et al. (2022) had a greater proportion of people engaged with conservation than normal Auckland population. Therefore, we can argue that there was no meaningful change in SCS score among Aucklanders between 2020 and 2022.

[19] The sample in Gerolemou et al. (2022) was comprised of Aucklanders recruited via a market research company (n = 1207). This study, however, directly targeted members of conservation groups to achieve greater representation of active conservationists. Data was collected in August 2020.

Table G1. Social Capital (SCS)

Factor	Question *These few questions relate to your life in general. (Answers from 1 = No/Not at all to 4 = Definitely yes/ Frequently)*	Mean (SD) (n=2348)
Community engagement	How often do you help out a local group as a volunteer (e.g. church group, playgroup, sport club, food bank)?	2.01 (1.21)
Community engagement	How often have you attended a local community event in the past 6 months (e.g. church fete, cultural festival, school concert, craft exhibition)?	2.02 (1.01)
Social Agency	How often do you pick up other people's rubbish in a public place?	2.53 (1.05)
Neighbours	How often do you talk to your neighbours?	2.87 (1.00)
Family and friends	How often do you talk to your family or friends outside of your household?	3.60 (0.69)
Social Agency	If you disagreed with what everyone else agreed on, would you feel free to speak out?	3.10 (0.89)
Trust and safety	Do you feel safe walking down your street after dark?	2.78 (1.04)
Trust and safety	Do you agree that most people can be trusted?	2.61 (0.86)
Tolerance	Do you think that multiculturalism makes life in your area better?	3.12 (0.97)
Value of life	Do you feel valued by society?	2.66 (0.91)
Value of life	Do you agree that, by helping others, you help yourself in the long run?	3.45 (0.73)
	Total	2.80 (0.48)

Factors

The original SCS (36 questions) measured eight individual *factors* that contribute towards social capital. We have adapted the scale to fit the needs of this survey and because of this only seven factors remained (workplace relationships factor was dropped). Some factors in 2022 were measured by only one question (see Table G1 for each factor structure). Figure G1 displays the 2022 results (mean and standard deviation) categorised by factors. Despite the differences in measures, we believe it was useful to draw some comparisons between the 2022 survey and the alternative baseline from 2020 (Gerolemou et al., 2022).

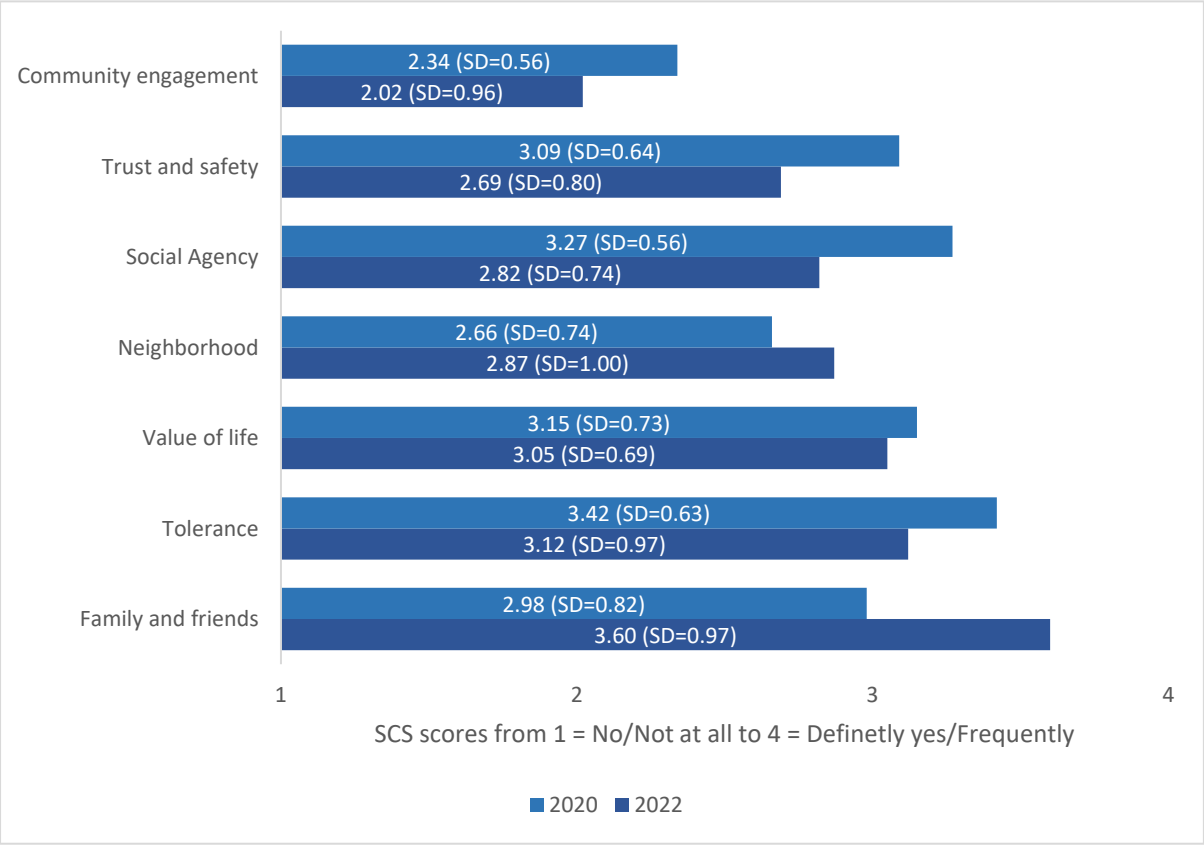

Figure G1. Factors of the social capital

Community engagement in the past three years was severely impacted by COVID-19 restrictions – government-mandated, socially expected, and by personal choice. Therefore, it was expected that community engagement was the lowest at 2.02 points. The next lowest score was for trust and safety at 2.69 points. Family and friends' connections, however, was the largest factor at 3.60 points.

The biggest change in the mean scores of individual factors from the 2020 study (Gerolemou et al., 2022) was an increase of family and friends' connections score (means difference 0.62). Neighbourhood connections also had an increase (mean difference 0.21). All other factors scores reduced, with the biggest reduction for social agency (mean difference 0.45) and trust and safety (mean difference 0.40). This change might be explained by the COVID-19 pandemic that made people reconnect with families, friends, and neighbours, but also introduced lots of societal anxiety, uncertainty, distrust, and even division over some issues (Badman et al., 2022; Officer et al., 2022).

Statistical model

The generalised linear model (GLM) built to predict SCS was able to explain about 19% of the variance in SCS scores ($R^2 = 0.19$)[20]. Four sources of behaviour had statistically significant association with the SCS (Table G2). These were reflective motivation ($\beta = 0.1285$, $p < .0001$), social opportunity ($\beta = 0.0694$, $p < .0001$), physical opportunity ($\beta = 0.0684$, $p < .0001$), and physical capability ($\beta = 0.0325$, $p < .0001$). This means that people

[20] R^2 value shows how much variance is explained by the model. In social science research R^2 values tend to be less than 0.5, values as low as 0.1 are acceptable.

who feel responsible for the state of the environment, have supportive whānau and friends, have an opportunity to do environmental behaviours (plant, weed, trap) either at home or in the community, and are skilful around conservation also score higher on social capital. However, the direction of the association is unclear. It might be that people with higher social capital engage more with planting, weeding, and trapping.

Table G2. Regression results for the SCS using COM-B model sources of behaviour as predictors

SCS	*β* coefficient	Std. Error	t-Statistic	Prob. *p*
Constant	1.747176	0.060887	28.695	< .0001
Psychological capability	0.005134	0.002736	1.876	.0607
Physical capability	0.032512	0.008689	3.742	.0002
Social opportunity	0.069358	0.007073	9.805	< .0001
Physical opportunity	0.068442	0.010434	6.559	< .0001
Automatic motivation	-0.016591	0.014333	-1.157	.2472
Reflective motivation	0.128503	0.012974	9.905	< .0001
R-squared	0.1940			
RMSE	0.4306223			
MAE	0.3425441			

2. Environmental activism

To measure general engagement with environmental issues and conservation activities in the past two years we used the Environmental Action Scale (EAS). A study that presented the development of this scale reported a total mean score of 1.29 (SD = 0.75) (Alisat & Riemer, 2015). The EAS result in our survey was significantly lower with a large effect size (t = 11.698, p < .000, d = 0.7459). However, the sample in Alisat and Riemer (2015) study and our survey were very different. This 2015 study had a smaller international sample (n = 299) from Bangladesh, Germany, India, Uganda, and the United States of America. The sample included 18 known environmental activists, which might have explained the higher EAS score. Furthermore, our data was collected in 2022, during the pandemic. The effect of public health measures is evident because the biggest difference between two studies was across items that related to in-person communication. For example, attended training in 2015 study scored 1.67 vs 0.56 in 2022, mean difference 1.11; participated in a community conservation activity in 2015 was 1.57 vs 0.72 in 2022, mean difference 0.85. Meanwhile items that were less dependent on in-person communication had similar scores. For example, consciously making time for conservation score in 2015 was 1.22 vs 1.21 in 2022, mean difference 0.01; using traditional methods to raise awareness in 2015 was 0.80 vs 0.76 in 2022, mean difference 0.04.

Among individual items, in 2022 the highest mean score was 1.21 (SD = 1.41) for conscious choice to make time for conservation activities. The lowest score was 0.27 (SD = 0.81) for organising an environmental community event (Table G3).

Table G3. Environmental activism (EAS)

Domain	Question *The following questions ask about your engagement with environmental issues and conservation in the past 2 years. (Answers from 0 = Never to 4 = Frequently)*	Mean (SD) (n=2348)
Leadership action	Used traditional methods (e.g. letters to the editor, articles) to raise awareness about environmental issues.	0.76 (1.17)
Leadership action	Took part in a protest / rally about an environmental issue.	0.44 (0.93)
Participatory action	Consciously made time to be able to work on environmental issues (e.g. choosing environmental activities over other leisure activities; working in an environmental job; working part time to allow time for environmental pursuits).	1.21 (1.41)
Participatory action	Became involved with an environmental group (e.g. volunteer).	0.92 (1.31)
Participatory action	Attended training related to the environmental issues (e.g. workshop on trapping pests).	0.56 (1.02)
Participatory action	Participated in a community event which focused on environmental awareness (e.g. educational event, guided nature walk).	0.70 (1.07)
Participatory action	Participated in a community event which focused on conservation activities (e.g. planting trees, restoration of waterways).	0.72 (1.15)
Leadership action	Organised a community event which focused on the environment.	0.27 (0.81)
	Total	0.70 (0.83)

Domains

The original scale grouped the items into two domains: leadership action and participatory action. We calculated the mean scores for these two domains in 2022 even though we reduced the number of questions determining each domain (see Table G3 for each domain structure). Participatory action mean score was 0.82 (SD = 1.00); leadership action was 0.49 (SD = 0.74). Alisat and Riemer (2015) did not report domain scores, so they could not be compared.

We tested internal consistency within the domains. Participatory action domain demonstrated good consistency (raw α = 0.89, standardised α = 0.90, G6 = 0.88) and Leadership action domain showed poor consistency (raw α = 0.63, standardised α = 0.63, G6 = 0.54)[21]. These results suggest that interpretations of leadership scores be viewed cautiously, though it should be noted that the overall consistency for EAS was still good (raw α = 0.88, standardised α = 0.89, G6 = 0.88), providing greater confidence in these overall results (see Appendix D).

[21] Cronbach's alpha (α) and Guttman's Lambda 6 (G6) were used to test internal consistency where 0.70 - 0.79 is acceptable and 0.80 - 0.89 is good consistency.

Statistical model

The GLM built to predict EAS was able to explain about 19% of the variance in EAS scores (R^2 = 0.19). The model's residuals did show violations in homoscedasticity so White's standard errors were used to provide a more robust inference of model behaviour. The model showed that three COM-B model sources of behaviour were associated with the EAS (Table G4). These were social opportunity (β = 0.1615, p < .0001), physical capability (β = 0.1687, p < .0001), and automatic motivation (β = 0.1290, p < .0001). Therefore, people with strong social support, a good set of practical skills for planting, weeding, and trapping, and who have a strong value-based belief system also had higher score on the EAS. Much like with social capital, the direction of the association remains uncertain.

Table G4. Regression results for the EAS using COM-B model sources of behaviour as predictors

EAS	β coefficient	Std. Error	z-Statistic	Prob. p
Constant	-0.962885	0.113988	-8.447	< .0001
Psychological capability	-0.000219	0.005042	-0.044	.9653
Physical capability	0.168729	0.016228	10.398	< .0001
Social opportunity	0.161509	0.010675	15.129	< .0001
Physical opportunity	0.009391	0.018572	0.5056	.6131
Automatic motivation	0.128982	0.024458	5.2737	< .0001
Reflective motivation	0.038008	0.021826	1.7414	.0816

R-squared	0.1934
RMSE	0.7504055
MAE	0.5665433

3. Conservation at home

We measured conservation undertaken by Aucklanders on personal properties, focusing on planting natives, invasive weed removal, and pest animal trapping. In 2022, controlling pest plants was an activity that was most endorsed by Aucklanders while trapping pest animals was the least endorsed one (Table G5). When compared to 2020, all three activities exhibited an increase in participation, with the most substantial rise observed in planting natives (mean difference 0.56) followed by trapping (mean difference 0.38). The overall mean score in 2022 was 3.11 (SD = 1.18) vs 2.74 (SD = 1.22) in 2020. The difference was statistically significant with a small to medium effect size (t = 9.440, p < .001, d = 0.300).

The increase in conservation at home in the past two years might be attributed to COVID-19 pandemic where social activities across Auckland region were restricted more than in other parts of the country, and many Aucklanders redirected their energy towards home-based activities. Nevertheless, it remains critical to exercise caution, as there is a possibility that engagement levels may revert to their pre-COVID-19 status as we transition back to pre-pandemic lifestyle. This phenomenon is known as behavioural reverse to old habits and is commonly observed as part of de-adaptation after a crisis (Broersma & Swart, 2022; Carden & Wood, 2018).

Table G5. Conservation at home

Activity	Question* *Thinking about home where you live, how often have you been doing the following activities in the past 2 years? (Answers from 1 = Never to 5 = Very frequently)*	Mean (SD) 2020 (n=1739)	Mean (SD) 2022 (n=2277)
Plant	Made an effort to plant native plants on the property.	2.35 (1.19)	2.91 (1.42)
Weed	Regularly controlled invasive pest plants on the property.	3.57 (1.47)	3.68 (1.37)
Trap	Regularly trapped or controlled pest animals on the property (e.g. rat traps, rat poison).	2.35 (1.52)	2.73 (1.53)
	Total	2.75 (1.22)	3.11 (1.18)

*The wording of the questions as in 2022 survey.

Statistical model

The GLM built to predict at home actions was able to explain about 36% of the variance in scores (R^2 = 0.36). The model's residuals did show violations in homoscedasticity, so White's standard errors were used to provide a more robust inference of model behaviour. The model (Table G6) demonstrated strong association between performing conservation at home and physical capability (β = 0.4669, p < .0000) and physical opportunity (β = 0.3355, p < .0000). This can be interpreted as increasing the skills around planting, weeding, and trapping may further increase conservation that Aucklanders do at home. The second influencing factor, physical opportunity, related to having a physical space to perform the activities. Physical opportunity measure, in this survey, lumped together 'opportunities at home or in the community', making interpretation more challenging. To help with interpretation we used the 'having a garden' variable for further analysis (see below).

Table G6. Regression results for conservation at home using COM-B model sources of behaviour as predictors

At home	β coefficient	Std. Error	z-Statistic	Prob. p
Constant	0.207918	0.142212	1.462	.1437
Psychological capability	0.009399	0.006804	1.3814	.1672
Physical capability	0.466898	0.022194	21.037	< .0001
Social opportunity	0.016159	0.017964	0.8995	.3684
Physical opportunity	0.335502	0.029722	11.288	< .0001
Automatic motivation	-0.024298	0.033261	-0.731	.4651
Reflective motivation	0.037038	0.031994	1.1577	.2470
R-squared	0.3595			
RMSE	1.029963			
MAE	0.803891			

Impact of having a garden

A Mann-Whitney U test was used to test whether there was a significant difference in Conservation at home scores between respondents with and without gardens (see Appendix E for more information on garden ownership), followed by a rank-biserial correlation (r_{rb}) to

assess effect size. It was found that there was a large significant increase in scores for respondents who did have gardens ($p < 0.001$; $r_{rb} = 0.70$) (Figure G2).

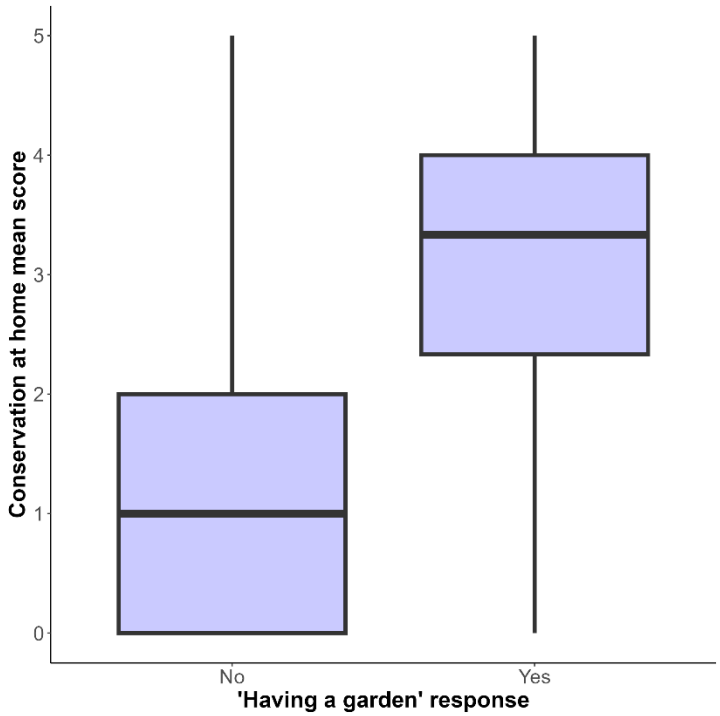

Figure G2. Relationship between conservation at home and having a garden

The interaction between biodiversity and gardening is an active research field (Diduck et al., 2020; Hanson et al., 2021; Santos et al., 2022; van Heezik et al., 2023). Supporting residents who have a home garden with practical skills to trap, weed and plant (or more broadly how to garden with biodiversity in mind) could grow their contribution to biodiversity protection (Mumaw & Mata, 2022; van Heezik et al., 2023).

4. Community-led conservation

We measured engagement with conservation that people could do as part of community-led effort, such as planting natives, controlling invasive weeds, and controlling pest animals. A marginal decrease in overall participation in community-led conservation was observed in 2022 when compared to 2020 (Table G7). The mean score for 2022 was 1.50 (SD = 0.83) vs 1.56 (SD = 0.93) in 2020. This decline held statistical significance, although the effect size was quite small ($t = 2.165$, $p = .030$, $d = 0.068$). While the engagement levels for planting and weeding remained relatively stable, there was a more pronounced decrease in trapping engagement, with a mean difference of 0.38. This reduction could potentially be attributed to the COVID-19 restrictions impacting social activities, or it might signify a genuine decline in trapping efforts.

Table G7. Community-led conservation

Activity	Question* *Thinking about your community, how often have you been doing the following activities in the past 2 years? (Answers from 1 = Never to 5 = Very frequently)*	Mean (SD) 2020 (n=1751)	Mean (SD) 2022 (n=2310)
Plant	Took part in community events where we planted native plants.	1.57 (0.94)	1.58 (0.98)
Weed	Took part in community-led control of invasive pest plants.	1.49 (1.06)	1.47 (0.95)
Trap	Took part in community-led trapping or control of pest animals (e.g. rat traps, rat poison).	1.62 (1.25)	1.44 (0.99)
	Total	1.56 (0.93)	1.50 (0.83)

*The wording of the questions as in 2022 survey.

Statistical model

The GLM built to predict in the community participation was able to explain about 20% of the variance in scores (R^2 = 0.20). The model's residuals did show violations in homoscedasticity, so White's standard errors were used to provide a more robust inference of model behaviour. The model (Table G8) showed that three sources of behaviour were associated with community-led conservation: physical capability (β = 0.0825, p < .0001), social opportunity (β = 0.0698, p < .0001), and physical opportunity (β = 0.0324, p = .0001). This finding can be interpreted that to engage people in community conservation they need practical conservation skills, strong social support, and conservation projects that they can join.

Table G8. Regression results for community-led conservation using COM-B model sources of behaviour as predictors

In the community	β coefficient	Std. Error	z-Statistic	Prob. p
Constant	0.300629	0.051084	5.885	< .0001
Psychological capability	0.000232	0.00237	0.0978	.9221
Physical capability	0.082469	0.007148	11.537	< .0001
Social opportunity	0.069808	0.005044	13.84	< .0001
Physical opportunity	0.032444	0.008519	3.8084	.0001
Automatic motivation	-0.00961	0.01127	-0.853	.3938
Reflective motivation	0.012395	0.009858	1.2574	.2086
R-squared	0.1977			
RMSE	0.7626792			
MAE	0.5621064			

Correlation between engaging with conservation at home and in the community

We wanted to test whether undertaking conservation activities at home is a steppingstone to engaging with conservation in the community. This could be explained as a "spillover effect" wherein the adaptation of one behaviour leads to the adaptation of another behaviour (Carrico, 2021). We tested whether Aucklanders who engage in conservation in their backyards also participate in community-led conservation. Our data was cross sectional, therefore not able to show causation, but could still potentially show an

association. However, although there was a positive correlation between conservation at home and in the community (Spearman's rho ρ = 0.3467), the correlation was weak. When this correlation was assessed independently for those with a garden and without a garden the correlations were similar (Spearman's rho ρ = 0.3538 and 0.2211 respectively). The strength of this relationship suggests that someone active in conservation at home may be satisfied with this as their primary contribution to conservation, and not seek involvement in a community-led conservation project. This finding is consistent with the literature on pro-environmental behaviour spillover (Carrico, 2021; Maki et al., 2019).

5. Biosecurity

We assessed people's involvement in biosecurity activities across eight key measures as outlined in Table G9 (for additional information on each area, refer to Section 3.3.5).

Respondents were able to indicate whether individual biosecurity activity questions were not relevant to them, and these responses were removed from the analysis for that biosecurity measure. If a respondent indicated that they did not own a pet, they were automatically marked as having responded *not applicable* to all pet related questions.

The total mean score for biosecurity activities in 2022 was 4.00 (SD = 1.08)[22]. In 2020, behaviour across only four areas was measured (kauri, freshwater, HGI, and cats). The mean score in 2022 of these four repeated items was 3.86 (SD = 1.35) compared to 2020 at 3.83 (SD = 1.40)[23] which is not a statistically significant difference with negligible effect size (t = 0.654, p = .513, d = 0.022). Therefore, overall biosecurity practices remained unchanged since 2020.

Table G9 provides a more comprehensive overview of each biosecurity measure, including statistical comparisons. These additional analyses were warranted due to the uniqueness of each individual biosecurity measure. For other outcomes, we compared the total score, as we were confident each measure related to the same concept (see internal consistency analysis in Appendix D). However, in the case of biosecurity measures, we recognised the added value in reporting them individually as well.

The only biosecurity measure, that demonstrated a meaningful, albeit small, reduction was HGI, checking for pests when travelling in the Hauraki Gulf (d = 0.2535). This could relate to the shift in our campaign focus whereby the *Check, Clean, Close* message was overshadowed by messages around regulatory changes. Social distancing restrictions due to COVID-19 had another effect on the activities and interventions that would have been normally delivered around checking for pests when travelling in Hauraki Gulf. For instance, *Biosecurity Champions* campaign was drastically reduced and major events such as Boat Shows were cancelled. Despite the reduction in checking for pests by Aucklanders, there were no increases in pest incursions on islands during this period which may indicate that an investment into *Pest Free Warranted* operators initiative was fruitful but also that the pandemic activity restrictions resulted in less recreational boating.

[22] For statistical purposes note, that mean 4.00 reported by SPSS in 2022 was based on n = 2280.
[23] For statistical purposes note, that mean 3.83 reported by SPSS in 2020 was based on n = 1575.

Table G9. Biosecurity

Area	Question*	2020		2022		Cohen's *d* [24]
		n[25]	Mean (SD)	n	Mean (SD)	
	When engaging in different activities, how often did you do the following in the past 2 years? (Answers from 1 = Never to 5 = Always)					
Kauri	When walking or biking in the bush, I cleaned my shoes, bike, and other gear of dirt at kauri dieback cleaning stations.	1742	4.12 (1.46)	1833	4.29 (1.30)	0.1230
Freshwater	When visiting a freshwater lake or river I cleaned my boat, kayak, fishing equipment and other gear used in freshwater.	234	3.20 (1.77)	747	3.29 (1.77)	0.0509
HGI	When traveling to a Hauraki Gulf island on a ferry or a private boat, I checked my gear and/or boat for pests.	300	3.89 (1.41)	1077	3.49 (1.73)	0.2535
Plants	When buying plants, I considered whether it could become a weed in the natural environment.	-	-	2015	3.75 (1.48)	-
	You have indicated that you have a pet. How often did you do the following in the past 2 years? (Answers from 1 = Never to 5 = Always)					
Cat	I contained my cat within my property (e.g. keep the cat inside at night, use a cat containment/ fence).	568	3.22 (1.47)	787	3.01 (1.69)	0.1326
Dog	I followed all dog control rules at parks or at the beach.	-	-	640	4.53 (0.84)	-
Desexed	I made sure my pets are desexed.	-	-	1205	4.82 (0.68)	-
Escape	I ensured my pets could not escape into the wild or become lost.	-	-	1301	4.40 (1.23)	-
	Total		3.83 (1.40)		4.00 (1.08)	

*The wording of the questions as in 2022 survey.

[24] Cohen's *d* effect size is < 0.2 small, 0.5 medium, ≥ 0.8 large.

[25] The number of respondents to individual questions varied due to *not applicable* answers being removed from the analysis.

Statistical model

The GLM built to predict biosecurity responses was able to explain about 13% of the variance in scores (R^2 = 0.13). The model's residuals did show violations in homoscedasticity, so White's standard errors were used to provide a more robust inference of model behaviour. The model (Table G10) showed that all COM-B model sources of behaviour, but for physical opportunity, were significantly associated with biosecurity environmental protection activities: Automatic motivation (β = 0.2130, p < .0001), physical capability (β = 0.1783, p < .0001), reflective motivation (β = 0.1488, p < .0001), social opportunity (β = 0.1101, p < .0001), and psychological capability (β = 0.0307, p = .0003).

Note, physical opportunity and physical capability measures were worded around plant, weed, trap activities (i.e. the conservation at home and in the community activities) and not those in the Biosecurity section of the survey. However, the goal of the model was not to produce the best model, but to ensure comparability in the findings between the different factors and to understand how the selected inputs impact the behaviour. Therefore, we maintained the integrity of the model.

Table G10. Regression results for Biosecurity environmental protection activities using COM-B model sources of behaviour as predictors

Biosecurity	β coefficient	Std. Error	z-Statistic	Prob. p
Constant	0.964458	0.178933	5.3901	< .0001
Psychological capability	0.030738	0.008457	3.6347	.0003
Physical capability	0.178348	0.026381	6.7604	< .0001
Social opportunity	0.110118	0.022436	4.9081	< .0001
Physical opportunity	0.057842	0.031155	1.8566	.0634
Automatic motivation	0.213028	0.038981	5.465	< .0001
Reflective motivation	0.148759	0.036882	4.0334	< .0001
R-squared	0.1344			
RMSE	1.174361			
MAE	0.8907601			

Association between engaging in outdoor activities and biosecurity

We tested whether engaging with a particular outdoor activity (see Appendix E, section 5 for details) in the past three months was associated with greater adherence to relevant biosecurity-compliant behaviour[26]. There was a medium-large positive association between more frequent adherence to cleaning procedures at kauri dieback stations and bushwalking (η^2 = .100) but a weak one for mountain biking (η^2 = .007). An association between doing freshwater activities and following freshwater biosecurity procedures was medium (η^2 = .085). Complying with biosecurity procedures when travelling to Hauraki Gulf islands had weak association with actual travel on a private boat (η^2 = .017) or a public ferry (η^2 = .019).

These results could indicate that targeted place-based interventions around kauri dieback and freshwater protection are achieving the intended outcomes. Apart from mountain

[26] Association was tested using two-way ANOVA Eta squared (η^2) where 0.01 is small effect, 0.06 medium effect, 0.14 large effect.

bikers, it appears the more people engage with these activities, and therefore get exposed to the interventions, the more they follow the biosecurity guidelines.

Response bias in biosecurity compliance

When analysing self-reported behaviours which relate to compliance there is a risk that answers may be affected by response bias whereby respondents provide inaccurate answers to present themselves in a favourable way. Over 90% of respondents said they *often* or *always* follow dog rules in parks and beaches. We are aware that the actual situation might be that people follow what *they think* the rules are, which may not be the same as the rules set by the council. This situation has been observed in the council's previous research (unpublished) on dog owners' behaviour at Te Henga (Bethells Beach). In this research dog owners were asked if they followed the dog rules at the beach, and the majority were sure that they did. However, when they were asked to state the rules, only some could recall the rules correctly. Kauri dieback research also reported a gap between self-reported on-track compliance and the observed behaviour (The Navigators, 2019).

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