Manaaki Whenua
Landcare Research

Understanding connections between people and soil: how do people value soils?

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Understanding connections between people and soil: how do people value soils?

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Purpose

This document reports on investigations undertaken as part of the 'Soil health and resilience: oneone ora, tangata ora' project, to understand the connections between people and soil, and more specifically how people interact with, value, and use soil. The aim of this report is to capture and record the wealth of information generated as part of the investigation and, apart from Section 4.1, is not utilised in other project outputs.[1]

Funding

This research is part of an MBIE-funded project 'Soil health and resilience: oneone ora, tangata ora' (C09X1613) that began in late 2016 and aims to support the development of a longer-term and more comprehensive view of soil health and resilience in New Zealand.

Background

Soil is fundamental to human and societal well-being and globally an increasing demand is being placed on soil as a resource and for farmers to grow more food more sustainably. To sustainably manage soils, a more holistic well-being approach to soil policy is needed, one that goes beyond the instrumental values of soils that are currently the perspective of the predominant western-centric ecosystem services. Many indigenous cultures, including Te Ao Māori, take a more holistic approach to soils and soil health but generally soil health does not have a high profile in New Zealand, and little is known about how New Zealanders value soil. Intrinsic and relational soil values also provide important connections between people and soil and their well-being. Therefore, understanding the plurality of values is important for developing more sustainable land and soil policy and soil management practices.

Methods

We interviewed 25 people from a wide range of industries, government, and community organisations. This report summarises their perspectives. In the interviews we asked participants:

- What they valued about soil
- How they were connected to soil
- How they knew a soil was healthy
- What they thought were the benefits and threats to a healthy soil
- What strategies were available to protect soil (at different scales, e.g. local, regional, national and global)

[1] Note: Section 4.1 on soil values has been included in this report for completeness and is adapted from the Stronge et al. (in press) article submitted for publication in March 2022.

- Where they got their soil knowledge and information from
- What the broader societal values associated with soil(s) were.

We adapted the Nature Futures Framework (NFF) for soil and used this framework as a lens to thematically assess what values were being assigned to soil and soil health (Fig. 1).

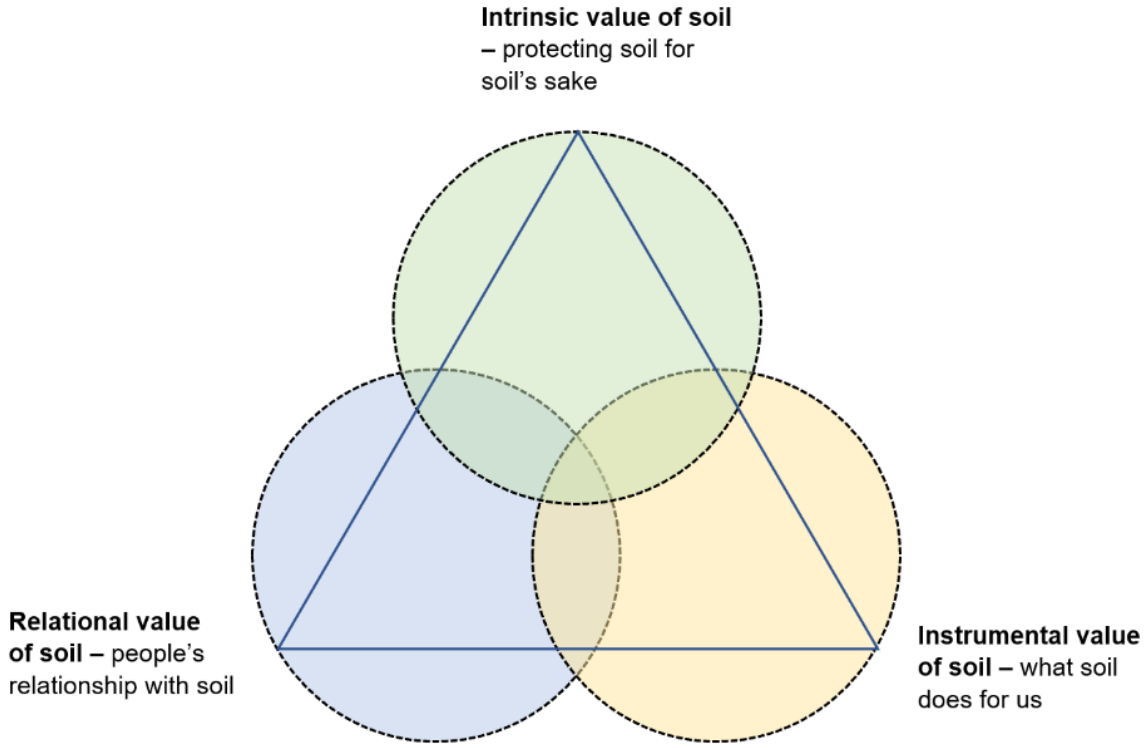

Figure 1: Nature Futures Framework for soil (adapted from PBL 2018).

Results

- The interviews showed that all three NFF value perspectives were important.
  - Intrinsic value – a living entity independent of people.
  - Instrumental value – a life-giving entity that provides many ecological services to people, and the environment.
  - Relational value – both personal and collective well-being. Connections were made from soil to land, place and people.
- Soil is intertwined with people's lives, livelihoods, and well-being, and participants felt a responsibility to care for soil. They made links between soil health and culture, their spirituality, and sense of place, and the importance of healthy soils for future generations.
- Our research highlights the range of values assigned to soils and soil health & well-being that are also central to Māori perspectives on soils.
- A range of tools/indicators for measuring soil health were identified by interviewees and varied depending on their sector, experience, knowledge, or occupation. Typically, the seven common soil indicators (pH, total carbon, total nitrogen, Olsen P,

anaerobically mineralisable N, bulk density, and macroporosity) were mentioned but the visual soil assessment (VSA) was mentioned most often. Digging a hole is an important first step when assessing soil health, enabling the structure, smell, friability, colour, microbial activity, worm abundance, and macroporosity to be determined.

- Social indicators of soil health were also identified (e.g. the uptake or composting or home gardening) and knowledge of the history and age of a soil, past land uses, and climatic conditions were also suggested as important for improving decision making for soil management.
- Intrinsic (e.g. ability to store carbon, soil's biological, physical, and chemical properties, terroir), instrumental (e.g. less need for fertilisers and sprays, highly productive) and relational benefits (e.g. a healthy river for swimming and fishing) of a healthy soil were identified. Biodiverse, resilient, and sustainable soils were identified as being important to ensure healthy soils for future generations.
- Threats and pressure to soils were grouped into four broad areas:
    a Climatic effects
    b Management practices
    c Land use policies relating to urbanisation and high-class soils
    d Forestry effects.
- Strategies to protect soil varied depending on the industry, interviewee's role and community connection. Four themes were identified:
    - Management practices
    - Education, advocacy, and communication
    - Legislation, policy and regulation
    - Culture and connection.
- A variety of sources are used to obtain soil information but the most important were sharing knowledge or having a conversation with others, information from consultants, soil experts or scientists, grey literature, peer-reviewed literature, on-line websites, education or training, and VSA monitoring and assessments.
- A disconnect between soil and society, and urban and rural communities has led to a lack of understanding about where food comes from. A greater awareness of soil and the benefits it provides to society will create a stronger appreciation for sustainably looking after soils. Soil policies need to take a more holistic view of soil and consider its intrinsic, instrumental and relational values.

Conclusions

Soil is a socio-ecological system that impacts people's individual and collective well-being but conversely, people also have a major impact on soil. Our research aimed to understand the plurality of soil values held across different industries, government, and community organisations in Aotearoa-New Zealand (A-NZ). We interviewed 25 participants to whom soil matters to understand how they are connected to and value soil. We used an adapted Nature's Future's Framework (NFF) to analyse how these participants' express their intrinsic, instrumental and relational soil values. We showed that our participants assign multiple, co-existing values to soil, intertwining their livelihood,

connection to place and people, intergenerational knowledge, cultural and spiritual values, and soil as a life-giving entity and provider of food and fibre.

While there are commonalities between Western-centric and Māori soil health values, they are based on different knowledge systems, with their own tools, actions, and approaches for sustainably managing soils.

In this research, there is a strong narrative that we live in a society where people, particularly urban people, are disconnected from soil. While New Zealand could do more to educate people about the importance of soil and the multiple threats that exist for soils (such as contaminated land, urbanisation, and loss of high-class soils), everyday practices where people can touch and interact with soil are needed to provide opportunities for understanding its value. Comprehensive soil health and well-being policies that take a more holistic view of soils and bring together diverse backgrounds and knowledge systems are urgently needed to ensure soils are sustainably managed for future generations. These soil policies also need to integrate the plurality of soil values and knowledge from both Te Ao Māori and western soil science.

More targeted extension and educational material and activities about soil would help people appreciate soil more and to understand the connection between food and soil, e.g. the concept of open-farms, community gardens, and garden-to-table initiatives. In addition, encouraging people to grow their own food and to compost their food waste would lead to better health and well-being outcomes. Participants suggested that we need to think more broadly about how soil benefits society, including its impact on nutrition, medicine, and recreational activities such as fishing and swimming. A-NZ would benefit from having a national soil advocate to raise awareness of the importance of A-NZ's soil and to provide leadership on protecting, restoring, and sustainably managing it.

1 Introduction

Soil is fundamental to human and societal well-being and globally increasing demand is being placed on soil as a resource and for farmers to grow more food with less intervention but at the same time sequestering carbon to mitigate climate change (Bennett et al. 2019). To sustainably manage soils, a more holistic approach to soil policy is needed, one that goes beyond the instrumental values of soils, which is currently the predominant western-centric soil science perspective. Instrumental values alone do not account for the range of values that people associate with soils and human well-being. Therefore, understanding the plurality of values is important for developing more sustainable land and soil policy and soil management practices.

A healthy soil means different things to different people, but those people who have a connection to soil on a daily basis do not underestimate its value to themselves, their family/whanau, and their local community:

> … I know for myself if I haven't had my hands in the soil for a few days I start to feel a bit stir crazy, maybe that's because I'm either trapped in the office or the house, but that is a big connecting factor for me. And particularly coming into farming 10 years ago… but being on the land, soil becomes quite addictive to participate with on a daily basis. And if we can get our children to start to experience that same level of connection where they have to be next to the soil and feel the soil more regularly than particularly urban children do now, then we're instilling in them the basis of their lifeline for the future. [SHV20b]

As part of the 'Soil health and resilience: oneone ora, tangata ora' project, we investigated the connections between people and soil, and more specifically how people interact with, value, and use soil. To do this, we interviewed people from a wide range of industries, government, and community organisations. This report summarises 25 perspectives from people involved with soil and for whom soil was important enough that they wanted to share their views. In these interviews we asked these people what they value about soil, how they know a soil is healthy, what the benefits and threats to a healthy soil are, what strategies are available to protect soil, and where they get their soil knowledge and information from – ultimately how are they connected to soil?

This report captures and records the wealth of information generated as part of this investigation, and, apart from Section 4.1, is not utilised in other project outputs.[2]

[2] Note: Section 4.1 on soil values has been included in this report for completeness but is taken from the Stronge et al. (in press) article submitted in March 2022 for publication.

2 Background

This social research is part of Research Aim 3 from the Soil Health and Resilience Oneone ora, tangata ora MBIE Endeavour project.[3]

In this research, we take a broader view of soil health than the dominant ecosystem services approach to soil health and soil health policy and focus on a well-being approach to soil health (see Stronge et al. 2020 for the background on this approach). Taking a well-being approach to soil health enabled us to focus on and to understand the many ways that stakeholders' well-being is linked to soils.

To date, the stakeholder engagement for the soil health and resilience project has focused primarily on production and policy groups, carrying out stakeholder and policy workshops and a survey. Here we expand on this engagement to look also at the values and priorities of other stakeholders in order to further develop our integrated soil health framework (see Stronge et al. (in press) for an outline of the framework).

Many indigenous cultures, including Te Ao Māori, take a holistic approach to soils and soil health, but generally soil health does not have a high profile in New Zealand, and little is known about how New Zealanders value soil. While the New Zealand Government has begun a process to protect versatile or high-class soils, there is a need for more research on the social and cultural values of soil to be undertaken so that these values can be incorporated into policy and decision making.

3 Methods

In this research, semi-structured interviews were used to understand how people value soil and soil health. As a research method, interviews can "yield rich insights into people's biographies, experiences, opinions, values, aspirations, attitudes and feelings" (May 2011, p. 131). We developed an interview schedule comprising eight open-ended questions which were piloted before conducting the interviews to ensure that a range of views could be expressed. These questions explored participants' connections to soil, benefits of and threats to a healthy soil, how soil is valued from social, cultural, environmental, and economic perspectives, indicators of soil health, soil information sources, strategies to protect soils, and the value of soil to New Zealanders and the wider society. A paper entitled 'Achieving soil health in Aotearoa New Zealand through a pluralistic value-based framework – Mauri ora ki te whenua, mauri ora ki te tangata' (Strong et al. in prep.) has been written and addresses the values associated with soil health and well-being. This report focuses on the findings from the remaining interview questions.

Purposeful sampling was used to recruit participants for the interviews (Patton 2015). We carried out 25 semi-structured interviews with participants chosen because they had a range of experiences with soil and collectively brought research, community, landowner,

[3] See https://www.landcareresearch.co.nz/discover-our-research/land/soil-and-ecosystem-health/soil-health-and-resilience/ for more information on the project.

leadership, environmental, farming, forestry and citizen knowledge (Palinkas et al. 2015). We then used snowball sampling to further recruit interviewees (Patton 2015). All interviewees gave consent for the interviews to be recorded. Participants were given the schedule of questions before each interview and interviews typically lasted between 45 and 90 minutes. The interviews were carried out virtually using either Microsoft Teams or Zoom video conferencing technology.

All interviews were transcribed using a professional transcription agency and transcripts were read for accuracy with the recording and if requested were returned to the interviewee for confirmation of an accurate account of the interview. Interview transcripts were analysed using qualitative data management software NVIVO 12.

We used an adapted Nature Futures Framework[4] (Fig. 1) (PBL 2018) as a lens to thematically assess what values were being assigned to soil and soil health. In this framework there are three broad categories: intrinsic values (the inherent value of soil – independent of people); instrumental values (the functions of soil for human's sake); and relational values (caring/stewardship or relationship with soil). Thematic analysis is a widely used, qualitative process or method for identifying, analysing, coding (organising), describing, and reporting themes from data (Fereday & Muir-Cochrane 2006; Nowell et al. 2017). We took a deductive approach to thematic analysis, using definitions for relational, instrumental, and intrinsic values from the adapted NFF framework.

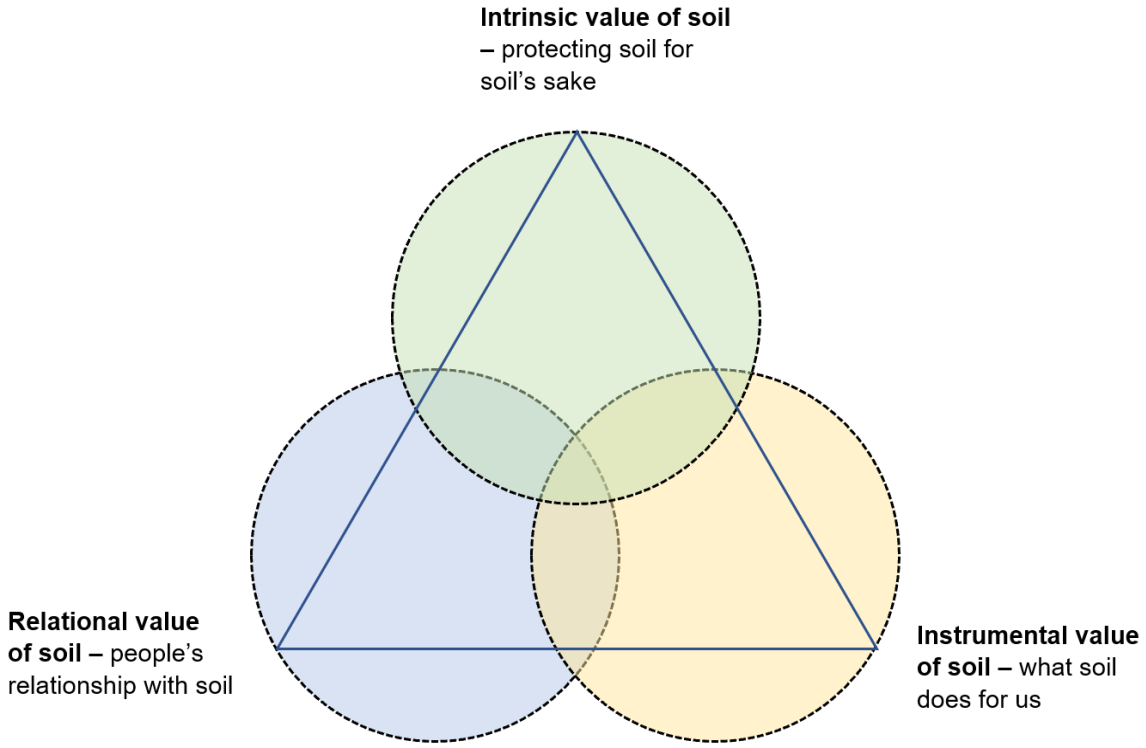

Figure 1. Nature Futures Framework for soil (adapted from PBL 2018).

[4] The NFF Framework provides a lens for understanding how people (both indigenous and non-indigenous) value nature. We have adapted and applied the framework to reflect how people value soils.

4 Results

This section provides insights from the interviews and focuses on understanding how the interviewees value soil, their connectedness to soil, how they know a soil is healthy, their perceived benefits and threats to soils, suggested strategies for protecting soil, their soil knowledge and information sources, and their views on the societal value of soil.

4.1 Soil Values

Interviews with stakeholders from the dairy, horticulture, livestock, forestry and viticulture industries, government organisations and community groups showed that all three value perspectives (instrumental, intrinsic, and relational) were important (Table 1). For some, soil had an intrinsic value, a living entity independent of people:

> The soil is that living and breathing layer at the surface of the earth….It's a combination of mineral and organic material, air and water, and it's a dynamic living system that has a very important role in our natural environment [SHV04]
>
> And it has life in it, so the soil includes what lives in it, the minerals and the air and the water and all the microbes and all that sort of stuff, so it's a bit of a community really isn't it? [SHV20b]

Others emphasised soils' instrumental value – a life-giving entity that provides many ecological services to people and the environment:

> I don't see any value in our topsoil for anything other than food value, whether it be grain or the running of stock and all that sort of thing. But that's the value of our soil is to sustain our population for food. Full stop. [SHV14]
>
> We get our – soil is where we get all our food from. And that's why soil is important, it feeds us. Without soil we would starve. [SHV21]
>
> [A] very significant percentage of the carbon storage is stored in the soil [SHV18]

People also viewed soil in the context of personal or collective well-being. These relational values covered a wide range of relationships between people and soil, and included connections to land, place and people. Soil is intertwined with people's lives, livelihoods, and well-being, so there is a responsibility to care for soil. Interviewees made links between soil health and culture and the importance of healthy soils for future generations:

> … if I care for the soil, the soil will care back for me...You're just connected to it more mentally, personally, spiritually sort of thing instead of it being a job. It's sort of a lifestyle, livelihood you could call it. Yep, you just have a real connection to it because you're brought up on it and it's not just only myself being brought up in it, my dad, grandfather, his grandfather, we go back seven generations, growing up on farms right back from being in India, yeah. [SHV22]

While a few interviewees focused on only one value perspective, most of the interviewees described an intermediate, multidimensional position where at least two or all three perspectives on soil coexist:

> I know I'm part of this land, because I know where my food comes from. I know its whakapapa… Just on a sustainable level, but also really maybe a spiritual connection to the land that you live on, because you know that it provides for you. [SHV23]

> It's everything, I guess. We're built on soil. It's what we're made of. Mankind's desire to break things down means that we tend to do that chemically, with a chemical mind, and that's a relatively easy process, but a large – soil really is a living product and to try to view that through a reductionist linear eye or mind certainly doesn't pay service to what – or in a way that we should. [SHV11]

Our research highlights the multidimensional nature of values assigned to soil and soil health by stakeholders with an interest in soil in Aotearoa New Zealand; an aspect largely neglected by the dominant Western-centric soil science paradigm. Importantly, the results also highlight that this multidimensionality is common to both Western-centric and Māori perspectives:

> It's hard to put a finger on, but for me soil is a giver of life. All life on earth relies on soil in one way, shape or form or at some point in time in the history or the future. …So, I feel a personal sense of responsibility around the impact that I have through my actions and so forth on it. Now whether we call that culture or whether we call that a sense of responsibility or whether we call it a sense of guardianship or kaitiakitanga or whatever, for me is immaterial. I think the principles are all the same whether we're Māori or otherwise. So, it's that deep connection; I come from the land I go back to the land. Fundamentally we're all made of soil in some way, shape or form, just a different cluster of elements. [SHV13]

This point is further demonstrated by the plurality of Māori soil health values outlined by Hutchings and Smith (2020). While there is a commonality, in that both Western-centric and Māori soil health values have a multidimensional aspect, each perspective is based on different knowledge systems. Each has its own understandings, tools, actions, and approaches for addressing soil health issues. However, despite this, there is a commonality in the goal of managing soils sustainably and in the case of Māori soil health values a particular reinforcement of balance and connection to achieve human well-being. Achieving the sustainable management of soil therefore requires bringing diverse backgrounds/knowledge systems together in a way that can address a common purpose or agreed goal.

Table 1. A summary by group of the assigned soil values (intrinsic (INT), instrumental (INS) and relational (REL)) to quotes from the interviewees

Groups	Number of interviewees	Example of interviewee quote
Agricultural Advisor	2	*So, I was heavily influenced probably from an agricultural perspective at an early age more around the productive capabilities of soil, and as I've grown older and had children and perhaps had more insight into what's happening globally, that connection to soil and awareness and understanding of its role in society and in earth's history and future has become a little more, I don't think esoteric is the word, but more profound perhaps. So, shifting it away from a soil as a tool from which we can derive food and income to soil is a resource that we need to protect and to manage, taonga [treasured possession] for want of a better description.* **[SHV13] INT, INS, REL**
Community gardens and urban farms	4	*Sometimes [we] are lucky enough to be a caretaker of this little bit of soil and what it can grow, what it can hold. I'm now learning a lot more about carbon sequestration and it's just amazing. Soil holds so many answers for us I believe.* **[SHV23] INS, REL**
Conservation	1	*Soil supports all things e.g. indigenous plants, veges, grow food I love - we work together as a team. I'm an absolutely unashamed foodie and I grow a large variety of vegetables at my place and building up my soils in my vegetable garden has been a really interesting project for the last 15 years. I'm quite proud of my soils. I'm a bit of a geek, when other fellow gardening friends come round, I'll actually show them my soils as well as my plants. And yeah, so that's been quite interesting for me. But also, I'm probably a botanical geek in general, so native New Zealand indigenous plants really, really interest me and obviously soil is a key component to their success and where they grow and how they grow and why.* **[SHV07] INS, INT, REL**
Dairy	2	*It [soil] grows our food, it grows our food for our family, we grow a lot of vegetables and fruit and so on around the house property. So, it's fulfilling in terms of not only what we consume, but the satisfaction of watching things grow out of a very productive soil.* **[SHV20a] INS, REL**
Forestry	1	*I guess it's almost a living creature, soil. I know it has organisms and that, but it's living in that it does a change and it grows, and it provides for life as well… We obviously are looking for soil to provide nutrition to our trees. So the chemical properties of soil. We look for infrastructure, for making roads and landings. So physical, also we don't want to reduce productivity through things like compaction and erosion. And then more and more we're actually looking at the biology, so how that's helping us tap into tree health and productivity… I'd have to say economic is the first one [value] that pops to my mind because it does allow for our livelihood. And then probably environmental jumps in second. Just we make a living from land, that means we care about the land, so we have to care about it, so that other generations can follow in our footsteps.* **[SHV25] INT, INS, REL**
Horticulture	4	*It's like a – you have an affinity with the region and the soil, the land. It's not until you start really – somebody asks you what – it's not until somebody asks you that you start thinking about it…When you move out from Puke, there's all those sorts of things to consider. But I don't know, but the soil is unique. If we were to buy a block of land… the soil type is right – it's the biggest the factor on making a purchasing decision on a farm – what's the soil type? Even within this region there's different soil types* **[SHV12] INS, INT, REL**

Groups	Number of interviewees	Example of interviewee quote
Livestock	5	*Everything stems from soil. If there's no soil health, we don't have animal health and if we don't have animal health we can't really bank on great human health.* **[SHV09] INS, REL** *The way that we farm is because of our view of the soil. We see it as a living entity and so we try and minimise the disruption, the disturbance and any detrimental practices.* **[SHV11] INT**
Researchers	5	*Uniqueness to me is… it's more about how soils are changing, you know… soils change throughout our landscapes and the soils in New Zealand are unique from the soils from Australia. Everywhere you go the soils different.* **[SHV06] INT** *From a Māori perspective it's where we come from. It's our whakapapa. It's our ancestry. So, there's no denying the importance of soil. On a scale of one to ten, one not important, ten very important, soil it's a ten.* **[SHV21] REL** *It [soil] grows plants which is also food as well as supporting the ecosystem. I think this comes back to sort of some of the functions and the ecosystem services in some respects as well. So, the ability to filter water and nutrient-loaded water and the opportunities that can offer if it's done right.* **[SHV24] INS, INT**
Viticulture	2	*Soil is literally the foundation of agricultural production and the foundation of civilisation. And yeah, people don't understand how intrinsically linked we are to soil.* **[SHV03] INS, INT, REL** *From a viticultural perspective, a specific example of how it [soil] matters to us is, if you could summarise it in one word, it's a French word and it's called 'terroir'. What terroir means, it encapsulates a whole range of things such as climate, both micro and meso-climate, and soil, and basically how that affects the type or styles of the wine. It's essentially a marker of the wine. So specific wines have specific terroir, and terroir is only available in that place. An example was Marlborough sauvignon blanc, the terroir you cannot replicate it anywhere else in the world.* **[SHV10] INS, INT**

4.2 Connectedness to soil

As highlighted in Section 4.1, soil provides intrinsic, instrumental and relational value to people. In this section we explore the relational values of peoples' connections to soil. While soil is important for producing food and fibre, soil also provides a connection between people and place. According to Sterling et al. (2020):

> Connectedness to place has a strong bearing on cultural identity, rootedness and belonging, sense of responsibility and stewardship, social engagement and natural resource management. Connectedness to place encompasses historical, physical, emotional, and spiritual bonds between people and their local environment. It is often informed and driven by knowledge of events and history, and experiences of survival and thriving in place. Connection to people includes relationships based on material (e.g., food, resources, land) or immaterial (e.g., trust, labour, knowledge, time, kinship, social alliances) circulation among individuals and within and across households and communities.

The interviewees expressed strong connections to soil through their soil knowledge, the land (as a resource for food and livelihood), a place of value (their turangawaewae), their people – whanau and local communities, and their culture and spirituality (wairua).

4.2.1 Soil knowledge

As expected, interviewees were very knowledgeable about soil, some dedicating their life to studying, learning, and helping others manage soil. Some of the topics discussed included soil types, the value of high-class soils, soil degradation, soil erosion, soil structure and contaminated soils. They understood the need to share their knowledge with their peers to build further understanding of its importance and how it functions in different ways. Interviewee SHV01 believes that most people do not know a lot about soil and do not want to get their hands dirty but, along with interviewee SHV06, suggests that digging holes in the soil is a good way to understand how soil changes over the landscape. Knowledge gained from university studies have influenced their interactions with soils:

> Well, my undergraduate and my postgraduate studies were in – focused on earth science and increasingly moved towards studying soil and for me soil underpins everything that we do and I guess I place quite a high importance on the value of soil in the sense that everything grows from it but often it's a bit unseen… But for me, it's the curiosity of what is the soil, why is it different in different places and what does that mean for the likes of growing plants. [SHV06]

> At a personal level I first really started looking into soils and understanding them at – well, I wouldn't say understanding them but becoming more aware of them – at university. I've always enjoyed geology and geography and earth sciences, and when I studied ag soils obviously is a beautiful blend of all of those and incorporates some biology and so forth as well. So it's something that I've always been quite fascinated by. [SHV13]

Ancestral knowledge built up over generations of working the land also informed interviewees enabling the landowners to understand and adapt to local weather conditions and the environment so a range of tools can be used to manage the soil.

> … we use some quite traditional farming methods mixed in with some cutting edge, state-of-the-art stuff. We, as a family, and myself personally, we believe in having a very full toolbox when it comes to cultivation and soil management, because no two days are the same. No two seasons are the same, and it's about doing the best thing given the weather conditions you're faced with. And the plough used in the correct times is still a valuable tool. It's been around since time immemorial, and when used properly it's still my very good tool…Yeah, and that comes from multiple generations of living in the same – and multiple weather patterns. [SHV15]

4.2.2 Connection to place and people

Soil is a giver of life and fundamental to a family/whanau's well-being. It strongly connects families to a place and ancestors both spiritually and culturally. These connections encourage families to take care of the soil for future generations. They depend on soil for their livelihood:

> I think it's a cultural thing for me, to be quite honest. I grew up with my grandfather, my uncles, and my dad, and I saw the way they managed soil back in the Cook Islands. To me, when I put my hand into the soil, it brings that kind of connection. Coming from a small island in the South Pacific, soil is an integral part of our community. If soil died, then that's one source of reliance gone. If soil dies, the entire community will also perish with it because you're only being dependent on one soil, on one resource. [SHV02]
>
> There's some amazing formations on the place and just it's I don't know whether it's the views or the colours or the topography, but it feels like – I suppose it's more spiritually than culturally isn't it? I feel very peaceful when I'm here. My happy place. Most of the time. [SHV09]
>
> I guess the soil is everything to us because without it we don't have a business, we don't have a life. We, as a family, have been involved in farming for many many many generations and … it's part of who we are. Our ancestors are buried here as well. Not on the farm, but close by. The soil is also… if we don't look after it, we're in trouble too. When we treat it rough, it kicks back. [SHV15]
>
> Well, it is the life source, really. If you don't look after your soil, you'll be in a bad way because you degrade it, you're going to come into poverty really because you can't grow your food, and you can't look after your family. Can't feed your family if your crops don't grow because you're not looking after your soil. It is the life source of farming, of all cultures really. A lot of cultures have gone out of existence because they haven't looked after their soil. I think stock farmers are actually soil farmers, they're farming the soil, you know, look after it so we keep going with it, and you're farming it, and pass it onto other generations. We have to, we look after it. [SHV17]

Soil is an integral part of different communities and cultures, providing links back to places and whanau:

> She [my grandmother] was an avid planter for all of those things, and women from around our village and other villages used to pick her flowers… My grandmother planted a whole lot of coconut trees because she said, "This may not be grown in your time, but your kids can drink from it." You know that kind of future looking thing. Yeah. Even my mother, she was an avid planter. In fact, my mother and father would often argue because she would like to get flowers, he'd say, "You can't eat them, so what's the use of growing those things? …So, my mother would always come back, but she'd always win. [SHV02]

> …living in Australia for a big chunk of my time is whenever I return to Australia, which I haven't lived there for a very long time, but for me it's seeing that red soil and so I have that emotional connection with how I perceive countries, I guess. Whereas, in New Zealand it's quite different in that we're very privileged here that everything is – not everything but more often than not things are green here, whereas so many of my early memories are all about drought and red soil and soil that supports a different type of life but it's a harsh life, whereas in New Zealand it's around it is quite bountiful. [SHV05]

> I'm looking to reconnect with that marae soon. There's family history there that I'm interested in and the soil there from that marae, from that area, there's a personal connection there as well, because that's where my great-grandfather lived and spent a lot of his time, so soon I'm looking to reconnect with that marae and my whakapapa. [SHV21]

Working directly with soil creates a very strong connection with soil and the motivation to care for it. But, while soil has instrumental value in providing a livelihood, it can also provide a spiritual connection:

> …if that's how you view land and the soil is part of that, you're always going to have a want to maintain it in the best way you can. You don't want to see it degrade or disappear or be damaged irreversibly and so I've seen that in our community programme as well where we're involved with the local hapū here. And the importance of that from a kind of spiritual sense and maintaining the soil is extremely high. [SHV06]

> Well I guess soil means a hell of a lot to me because I'm working with it all the time, 40 hours a week. I'm working in a place where soil is the basis of everything… I'm really intellectually interested in understanding it more and I sometimes have this amazing appreciation for it when I eat food from it, and I can really have the sense that I come from this mysterious dark substance just outside the door there. So I really love those feelings of connectedness… I was eating pumpkin soup and I just had this profound experience of wow, here I am eating this pumpkin soup, which was grown here last season, we'd stored it away for some months, and I'm hungry and this is going into my stomach and it's going to fuel me up and give me energy to work during the afternoon, and just this profound appreciation. It's almost like a spiritual experience where

> you're really keyed into that this food is from this place, this soil, and it's feeding me… But when you have these almost spiritual experiences of connecting to where my food comes from or where some of it comes from, it's just quite profound. [SHV19]
>
> I believe there is a spiritual connection to land, yeah. My grandfather said, "There's only two reason a man will go to war. That is for a woman, or for his land." That's his theory. But yeah, I mean, I think there is. I always feel a connection every time I touch the earth. When I'm in a garden, I feel a connection back to them, and probably because of I've got strong memories that I have of them. [SHV02]

However, thoughts about the spiritual connections to soil were sometimes difficult to talk about or express:

> …I love shifting animals and so when you lift that wire and that group of 40 or 50 cows, calves, heifers move through onto that fresh grass there's something almost palatable about the energy or their enjoyment. You really can sense it.
> **Q:** So it's almost like a spiritual kind of moment?
> **A:** Yeah, it is, and I guess when you start talking spiritual in all these sorts of things you're getting out on the limb, you're a fair way from the trunk.
> **Q:** Is that why you feel uncomfortable talking about it?
> **A:** I guess it is to a degree, yeah.
> **Q:** It's interesting isn't it, because Māori will talk about the spirituality of soil and the connections between them and the people and the sky and the earth and the land, and they have no problem talking about it at all.
> **A:** Yeah.
> **Q:** And yet –
> **A:** Yeah, your typical farmer struggles. But I think also because I do get a real sense of the dissatisfaction that many current farmers have, and I do wonder whether it is because of this. [SHV11]

4.3 How do you know a soil is healthy?

All interviewees were asked "how do you know a soil is healthy?" and "do you monitor it or use indicators to test it?" Some interviewees answered these questions by first clarifying what 'healthy' soil meant to them.

4.3.1 What is a 'healthy' soil?

Defining what 'healthy' means was important for some of the interviewees. Soil health means different things to different people, and according to the MWLR soil health and resilience website, 'Soil health requires a balance between soil functions for productivity,

environmental quality, and plant and animal health. Soil health can be assessed by indicators that measure physical, chemical and biological/organic soil properties'.[5]

According to interviewee SHV06, a 'healthy' soil is more than just soil 'quality' and can extend beyond physical, chemical, and biological measurements into cultural and social values. For example, in Hamilton, the Kukutāruhe community gardens have been established on a hectare of highly productive, high-class soil and a diverse group of cultures are now growing fruit and vegetables:

> …there's about 90 different individual lots, are made up of different cultures… there's a Chinese community use it… Spanish, Māori, Tongan, Samoan, a number of others as well. And so what's started to happen is that soil has been – is a 'conduit' the right word – but the catalyst for them to share ideas about how they use the soil and how they grow different things in the soil. And that's been – for those involved, it's been quite fascinating, apparently – and… a large Tongan area they have, they've had days on how to grow kumara… the soil has kind of ignited all these new interests from different parts of the community and we're starting to see it grow and grow very quickly. So that to me is having that soil available to foster that is a major kind of social value, isn't it? [SHV06]

Another interviewee described 'healthy' as an interesting term and subjective because it can mean different things to different people and in different environments or contexts. For a farmer it could mean very productive land, whereas in a dry land system, a healthy soil could support plants that can grow and thrive in stressful environments:

> …what I think of as a healthy soil in a dry land system, is soil that's a little bit stressed, to be honest, with plants that grow there, thrive in stressful environments. And when you alter those by putting in water and putting fertiliser to grow exotic grassland species, one person's idea of healthy soil might be that they've made it healthier, but for me, I see that as a problem, because they've altered it and now the plants and the insects that live there cannot live there anymore. So yeah, stressed soils in marginal spots and interesting geology, those soils have value as well I guess in their unaltered states. Healthy in their own funny little ways… [SHV07]

According to interviewee SHV24, soil 'health' refers to the biology of the soil and varies markedly between different soil types:

> I mean, some soils there are naturally less diverse in terms of their biological population…just simply because of their nature. But so long as they're healthy to the extent that is achievable with the natural state of that soil, then that's what a healthy soil is. [SHV24]

[5] https://www.landcareresearch.co.nz/discover-our-research/land/soil-and-ecosystem-health/soil-health-and-resilience/soil-health-and-resilience-research/soil-indicators/

4.3.2 Indicators and tools for monitoring or assessing soil health

When interviewees were asked how they know a soil is healthy, a range of tools/indicators were given, depending on their sector, experience, knowledge or occupation. These responses are summarised by group in Table 2.

In New Zealand, typically a group of seven soil indicators are measured when assessing the health of a soil. These include pH, total carbon, total nitrogen, Olsen P, anaerobically mineralisable N, bulk density, and macroporosity (Sparling & Schipper 2004). Combinations of all or some of these soil indicators were mentioned by the researchers that were interviewed.

Interviewees from the dairy, forestry, horticulture, livestock, & viticulture sectors, agricultural advisers, and researchers all talked about using visual soil assessments or VSA to measure soil health. Shepherd's *Visual Soil Assessment, Volume 1* (2000), provides a detailed VSA field guide for cropping and pastoral grazing and many of the visual properties or indicators outlined in this guide were also mentioned by the interviewees. Digging a hole was typically articulated as the first step when assessing soil health, enabling the structure, smell, friability, colour, microbial activity, worm abundance, and macroporosity to be determined. While the community garden and conservation sector interviewees did not specifically use the term VSA, their assessments also included assessing these soil properties too.

Other suggestions for determining soil health were made, such as a healthy soil system not blowing away, being able to support root and plant growth, the presence of weeds, e.g. broom and gorse indicate a poor soil, and having a structure to the soil so that it does not continually depend on fertilisers. Fertility testing, analysis of minerals like cadmium and other urban contaminants in the soil, and soil biology tests were also suggested as ways to monitor or assess the health of a soil. However, interviewee SHV05 commented, that there is no point in carrying out any soil tests if there is not a clear purpose as to how the information will be used or an understanding of what the information means so that changes can be implemented:

> …sometimes there's those educational barriers as well that people are doing it with good intent because somebody else has told them that they should be monitoring their water quality or monitoring their soil, but it doesn't necessarily mean that they know what to do with the information. So, it just does become a data collecting exercise but it's not necessarily the best way to collect the data or the best way to take the sample or that you're actually going to know what to do with the information in terms of needing to make change. If you got a result which indicated something wasn't good, how do you know it's not good? Where do you go for that source of information? [SHV05]

Interviewees also commented that it is important to know the history and age of a soil, its past land uses, and climatic conditions so that better decision making about what to grow and how to manage the soil can be made. In Southland, where historically flooding and drainage are problems, landowners are looking at how to slow down water on their land and for ways to ensure the soil is retained on their farms. According to SHV01, landscape

scale observations and road cuttings can also provide historical knowledge about soils, e.g. kauri eggcup podzols in Waipoua. In the forestry sector, different land preparation techniques can affect tree health and nutrition when valuable soil is removed, and only subsoil is left so tree growth, foliage sampling and tree nutrition are monitored (SHV25).

Social indicators of soil health were only mentioned by interviewees from the community garden sector. Interviewee SHV19 suggested that if people use the word 'soil' rather than 'dirt' that means that they were perhaps more appreciative of the role soil plays in their life. Letting children play and interact with soil may also allow children to connect with soil and reduce the barrier to interacting with soil as an adult. Signs of butterflies and snails in your garden indicate that your garden is healthy according to interviewee SHV02 and if they are absent there is cause for concern. A social indicator could also be the uptake of composting or home gardening because this requires interacting with soil.

4.4 Benefits of healthy soils

According to Jeffrey and Achurch (2017), 'Healthy, well-managed soils are fundamental to human existence' and not only will result in the production of healthy food and fibre but will provide clean air, water and a more regulated climate which can support and sustain communities. Our interviewee responses went beyond the instrumental values of soil and also included the intrinsic and relational values. However, sometimes the values were intertwined, especially when talking about benefits to future generations.

4.4.1 Intrinsic values of a healthy soil

Research on carbon that is stored in the soil and the carbon cycle associated with the ecosystem processes in the soil is being carried out. There is concern that with a warming environment the ability of the terrestrial ecosystem to absorb carbon will deteriorate as the temperature increases (SHV18).

A soil which has good structure, porosity and carbon content is healthy according to SHV08, and will help to mitigate flooding by absorbing and slowing down the movement of water into rivers, thereby reducing flood peaks and their associated damage. In contrasting conditions, a sheep farmer described their soil as:

> a rotten rock type of base, so a very granular type of black soil that is very good for growing matagouri scrub, beautiful free-draining productive soils. Very crumbly, very granular and dries out very quickly. So most people think that during the summer the hill will hang on in a drought – in a water deficit situation, it's actually the opposite, they brown off the quickest, and especially the soils that are exposed to the north and to the sun, they're very thin. [SHV16].

From a viticultural perspective, the soil determines the type or style of the wine and its "terroir". Terroir is specific to a place and the climate is also important. Marlborough Sauvignon Blanc was given as an example by SHV10:

> So that [soil] is hugely important to us as an industry, to what makes – well, it's basically the building block of our industry. Climate plays a part, but soil is the main determining factor. And that matters to us on a more specific point of view of how and where we plant vines, and how we manage them, on a variety-to-variety basis. [SHV10]

In the forestry industry, a healthy soil produces a healthier, more resilient and more productive forest (SHV25). A healthy soil will provide stability and correct root structure for a tree being planted and will help keep a tree upright in heavy winds or rain events. Keeping the soil on the property is key so that it does not move into waterways or neighbouring properties:

> We have some areas that we know we can work year-round and soil types. We have some that we know are only summer only work, you know, when it's dry. If the soil is wet, then we will stop operations. You know, if it's saturated, [the soil] loses stability. We try and minimise the disturbance so less tracking. If we are tracking, then we're trying to form them in a way that'll keep soil together. We might pull backtracks.[6] [SHV25]

[6] A back track: a track cut into the side of the hill and when the track is no longer necessary, the soil it returned, and the land is rehabilitated. [SHV25]

Table 2 A summary by group of the indicators and tools used to monitor and assess soil health, and corresponding relevant interviewee quotes (VSA is Visual Soil Assessment)

Group	Indicators/tools	Interviewee quotes when asked "how do you know a soil is healthy?"
Agricultural Advisors	VSA – structure, smell, friability, aggregation, alive, sustaining plant growth, in balance with its natural cycles. Fertility testing.	• *I'm not very good at describing but it's full of life. Yeah, it's that earthy thing … and I think scientifically it's some of the compounds that are being produced by microbes that are doing work and that's what you're smelling. It kind of smells good in a funny way.* [SHV08] • *It's enabling plant growth, it's enabling carbon capture, it's enabling respiration, it's enabling water infiltration. That's going to be a function of the soil's age and its origin and the minerals that make it up and the climate that it's in and so forth, but I guess a healthy soil is one that is functioning to its natural capacity.* [SHV13]
Community garden/ urban farm	Indicator weeds and lead tests in root vegetables and compost. Fertility tests. The colour, worms and microbial life. Social: Seeing lots of butterflies and snails in the garden. Uptake of composting or home gardening, using the word 'soil' instead of 'dirt' and not being afraid to get your hands dirty or play in soil.	• *I tell the kids, if you see pests in your garden, your garden is good and healthy. Because butterflies want to come and land on the vegetables that you're planting. That means you can eat it, you just need to wipe it clean, wash it, and eat it straight away. But if you don't see butterflies around your garden, it means something outside that's been added to your garden and it's no good.* [SHV02] • *Because we're certified [organic] that has driven our testing regime…We have tested lead soil levels and levels in our compost. But we have also measured fertility levels but we've never really had anyone analyse the results too much for us… That people use the word soil rather than dirt… It means people are a bit more appreciative of the role that soil plays in their life. Something about people not being afraid to get their hands dirty. I guess you can't say that in times of Covid, but in terms of that attitude where people don't want their kids to get dirty or whatever, don't want them to play in the soil or – seems to be a bit sad that people will hold onto those attitudes as adults where soil is something that should be kept well at arms' length and not to be interacted with which I feel like is a bit sad… The uptake of composting, maybe the uptake of home gardening is an indicator because once you start gardening, once you start trying to produce a yield then you're automatically usually will be led to thinking about soil, and I'd say the more organic you go in your growing style the more you're going to think about soil because I feel like the soil is much more fundamental to health when you're doing things organically.* [SHV19] • *…there's a soil map and it shows that we're part of I think it's what's called a low nutrient clay – sandy clay … So it's okay, it does drain… So our main focus is we do a lot of composting and putting the compost on the soil… so the weeds are generally different types of puha, all your different dandelion things…But a lot of my weeds are actually my self-sown vegetables. So, I weed out silver beet and perpetual spinach and New Zealand spinach if I'm not using them as a ground cover. And they either get fed to the chickens or to us.* [SHV23]
Conservation	Intact, biological soil community that predates humans. A vegetable garden that is black and full of good organic material and can retain moisture.	• *… fertilising and watering soil will make it healthy to some, but maybe the net biodiversity supported on top of that soil would drop from say 15, or 20 or 30 species, down to two when you do that. It's obviously just got to be nice and black and full of good organic material and retain moisture well. Although not too well. It rains a lot where I live, so for me I've put raised beds in and added a lot of organic material to make it less waterlogged in winter and drying*

Group	Indicators/tools	Interviewee quotes when asked "how do you know a soil is healthy?"
		and prone to cracking in summer. It's got the right fertility soil and structure and moisture retention. Good invertebrate life… if I've got lots of worms and things living in my soil, I know it's happy and healthy. [SHV07]
Dairy	Weeds. VSA – Dig up the soil and look at texture, aeration, and plants growing in it, the weather effects, and the history of the soil	• *Well, in a lot of ways our community is a farming community, and in some ways because we have field days and discussion groups through Dairy NZ and we discuss things like looking after the soil and not pugging it, and how much fertiliser to put on, that sort of thing. And also the state of it as evidenced by the weeds that came up from it as to the condition of it, that's quite a good indicator… we're taught through our industry training organisation to dig up the soil and look at it for texture and aeration and plants growing on it, …basically we read the state of the soil from the plants that are there, and what the weather's been doing. And when we dig a hole we think of how old the soil is…what's happened to it over time, and where it came from, and its current state of health judging by how much structure it's got and the unique colours or mottles that go through it, or water-logging smells, or anything like that…* [SHV20a]
Forestry	VSA. Look at tree growth, foliage sampling, prior land use, different colours and textures and monitoring tree nutrition.	• *So healthy trees, so they have the correct nutrition, that they're accessing that nutrition. So they're getting a good root structure in the soil. Visually you see it because you might see an area of a stand that's not performing well and then an adjacent area that is performing well. And you can see that the difference between the two areas might be that machines worked on that area. Or that was the old track that we pulled back, or last rotation that was at a track and that wasn't. We have seen at some land preparation techniques used to push soil. And so you would basically scalp all valuable topsoil and be left with subsoil in some areas. And we monitor – we not only do the visual, but we actually do foliage sampling throughout the rotation, looking at tree nutrition. And then in terms of the physical, it's visual. You see where the lands start to scar or where the topsoil's been moved or disturbed, and you start seeing subsoil at different colours and different textures.* [SHV25]
Horticulture	Annual soil testing, monitoring organic matter, silt run off, acidity and alkalinity (pH indicator), and fertility tests. Gorse and broom as indicators of poor soil. VSA – dig a square section & assess profile, organic matter and insects, worm holes. Cover crops, e.g. broccoli.	• *[The soil test] allows you to quantify what you're seeing with your eyes and then you can investigate. If you're using mapping software, well, then, you can target fertility issues. Like, you get a soil test in and it says that the paddock is pretty close to good, but you know that the bottom end is not doing any good, so you tow the machine around and you get that feel that the top end is perfect, and it's the bottom end. So, the lime application actually needs to go on the bottom acre and not the whole ten acres.* [SHV15] • *The best way I - the way I learnt in high school was we used to get a spade and then you chop out a square section and then we turn it over and we monitor the soil portfolio…the more organic matter and insects, when we turn over soil, we can tell if there's worm holes or if there's worms in there and other insects and bugs, then that's just a real basic way of finding out if the soil is healthy … for our business wise, we would use pH indicators to monitor the acidity and alkalineness in the soil and we would get our consultants to do that for us.* [SHV22] • *But adding compost every year and growing cover crops which get incorporated back into the soil you sort of try and maintain an organic level. If you've got organic matter in your soil, that promotes the bio – what do you call it? biodiversity in the soil. The health. You know when you've got healthy enzymes, the healthy bugs. And we've seen benefit of using compost and not growing so intensively… We did start growing broccoli a number of years ago,*

Group	Indicators/tools	Interviewee quotes when asked "how do you know a soil is healthy?"
		particularly broccoli because when you grow broccoli and you chop that back into the soil, it's like a biofumigant. And it's very good for your soil and your subsequent crops do benefit from the broccoli being grown in those soils. I know of some big growers who don't grow broccoli and they've leased their ground out to broccoli growers. Because they want to improve the soil health of their soil. [SHV12]
Livestock	VSA – Dig a hole and see what's in it, smell it, structure, good worm count and bacteria etc., well aerated soil with good density, supporting plant growth and not dependant on fertilisers. Tilling for drainage. Fertiliser soil tests every 2-3 years. Retain sediment and moisture.	• *So for me, a healthy soil is often one that's really well aerated but is stable enough that it's – it's got a density to it that it's not just going to blow away and that it can actually really support plant growth, but also it's in a system that doesn't have dependencies on always needing to add fertiliser to it.* [SHV05] • *That soil that we do manage well has a tremendous resilience and that soil, that ability to balance and produce in diversity, try to visually see where that is and the factors that play a part in that being healthy… and what factors were involved in them being degraded or not where we'd want them to be.*[SHV11] • *Just by eye, by looking at it, and I know how I treat it and the plants that grow on it. Southland historically has been around moisture and drainage, so I've spent a great deal of my farming career tilling, I put tilling in the drainage to get a healthy soil. So this has been the other really interesting point is that my father and myself, and probably my grandfather too who I never knew, spent most of their farming career getting rid of water from the farm as quickly as they can, and today the future's looking about slowing down water and retaining it on your farm, retain sediment, loss of soil.* [SHV16] • *I grow vegetables in the garden, and I like to see that, you know, got viable soil and good worm counts and, yeah, healthy growing plants… you have a dig underground, see what's in it. Have a smell of the soil and make sure it smells right, got the aerobic, air through it and stuff like that, a good crumb, good structure, yeah. So you got good worm life and bacteria and all that sort of thing. I've been in the regenerative farming group it's been encouraged to grow multiple different species and things like that. Not to disturb the soil, keep a living plant on the ground for most of the year if possible, all the time.* [SHV17]
Researchers	The 7 soil indicators, VSA – colour, structure and texture, worm abundance, healthy vegetation cover. Digging up soil with a spade and applying some pressure with your hand and see how it breaks apart. Soil testing by a lab. What's growing in the landscape. For a garden – high in organic matter. Monitor carbon and pH and see if it is changing over time, also	• *I don't do chemical tests. I'm visually checking it every time I dig a hole. You look at the soil where the roots are, what life is there, what the colours are. Depending on how dry it is, you assess – well colour and structure are two really important parts. And the process of digging the hole – it's hilarious. I go out with guys and they ask me if they can dig the hole. And you have to explain that the information you get from digging the hole yourself is important. How much pressure you need to put on, how the soil comes off the spade, how it breaks up when you are digging the hole. What you see while you're digging the hole, you know the little worms that tuck away nice and fast is really important.* [SHV01] • *If I was just looking at the ground as opposed to an exposed soil profile, then I'd be looking at the nature and the health thrift of the vegetation growing on the surface, whether there's any bare soil or whether there's a good healthy vegetative cover. But if I was looking at a soil and cross-section if you like, soil profile, then – or even digging a small hole to have a look at that, I'd be looking at physical characteristics: what's the structure like, is it totally compacted or has it got a clearly-developed structure with poor spaces for roots, air and water to move around in. What are the*

Group	Indicators/tools	Interviewee quotes when asked "how do you know a soil is healthy?"
	cadmium concentrations and other urban contaminants like copper and zinc.	*colours like, are they – are there signs of prolonged weakness or is there evidence of good aeration, signs of pans, or things restricting root growth or water movement. Yeah, those sorts of things. Yeah, well even the colour of the topsoil can tell you a lot about whether there's sort of – the likely levels of organic material in there. If it's a nice dark colour then it's likely to have a reasonable amount of organic material, carbon there, as opposed to very pale looking topsoils might suggest that it's lost a bit of its organic material there, which is a key attribute in a lot of ways for both physical and biological, chemical health of the soil.* [SHV04] • *Run it through your hands. There's a few basic tests that you can do. From a science point of view the first would be the visual soil assessment test, the VSA. So, that just means digging some up with a spade and applying some pressure with your hand, with your fingertips. If it breaks apart easily that's great. If it's quite firm, if it's hard, that's not so good. But typically for organic ash type soils, they do break apart, so they're friable. So that means if it's easy for the soil to break apart within your hand, that's also easy for say a plant root to penetrate through the soil into the – to go deeper. So the easier it is for a plant to establish itself, the easier it is for it to grow… Beyond that, there's a few more tests but they generally cost money. So like getting samples and sending it off to a lab. If you can look at the landscape and see what's growing. Are there lots of plants? Is the grass green? Are parts of the landscape green when others are brown?* [SHV21] • *It's understanding the functions of the soil. And the functions can be as a result of the physical and chemical state of the soil as well as the biological functions such as nutrient cycling…But in terms of the health of the soil, that's still fundamentally revolves around the biology and that is primarily in the natural state is about the nutrient cycling.* [SHV24]
Viticulture	VSA – digging a hole and breaking up the soil to assess for compaction, flocculation, macroporosity, soil structure, worm count etc. Mineral tests and soil biology tests, soil penetrometers, balanced soil nutrients, carbon status, water holding capacity, how soils are formed, positive and negative impacts on the soil.	• *Yeah, if you don't want to touch it or put it close to your face then it's probably a pretty good indicator that it's not very healthy.* [SHV03] • *Healthy soil, it comes to I think a range of factors… And a lot of that comes down to balance of nutrients, so we're not in excess or deficit… otherwise with excess or deficits, we are continually trying to fix problems which can negatively impact the overall health of the soil. We are looking pretty closely at carbon status, and at the minimum maintaining it… if not increasing it. We are looking at water holding capacity of soils, and tools or methods that we can use to maximise what we are doing there. I guess you break it down to physical properties as well, so we are looking at soil structure, how they are formed, what activities we are doing that are either negatively impacting or positively impacting the soil. An example of that is changing how we go about our day-to-day running a vineyard, to minimise… compaction, or minimising the number of runs we make over the soil in a season. We also look closely… at the microbial status of the soil as well, and trying to enhance that…And if you take soil out of the equation, no matter how good the day-to-day vine management is, if the overall health of the soil is going backwards, the quality of the wine will be going backwards.* [SHV10]

4.4.2 Instrumental values of a healthy soil

A healthy soil will grow a better product and require less inputs such as fertilisers. For a commercial crop grower, a healthy soil will increase the yield and quality of the crop, resulting in a longer shelf life for the consumer (SHV 22). Also, having a good healthy soil close to a large population is essential for growing fresh vegetables as there is less distance for the food to travel to the end user (SHV 14). From an ecosystem services perspective, a healthy soil will grow good pasture and horticultural crops and enable agricultural production (SHV04).

Healthy soil is needed for a good 'veggie garden' but can take years to develop (SHV07). Interviewee SHV22 described growing 'nice' plants and vegetables in their veggie garden as a sign of a healthy soil, but managing this organically can be challenging:

> The key one is if I've got a good veggie garden. Growing nice plants because I'm sure I've got some deficiencies because my veggies aren't growing as well as what I thought they might. And I'm trying to – I suppose you manage it organically. You know not use synthetic fertilisers and stuff and tend to use more organic composts and that sort of thing to get the nutrient levels right. But certainly haven't really achieved that yet. [SHV22]

For food production in a community garden, a healthy soil is essential – although a community garden project described by interviewee SHV18 is built on top of hugely disturbed soils:

> From a community and a personal point of view what we've found in our community project is that the soil's been hugely disturbed. In parts of the gully it's been basically used as a rubbish dump and so that the health of the soil – well, the soil has been abused essentially over many, many, many years, right from the point where the land was simply flattened, and all the soil was just pushed over the edge of the gully. But that was probably 60 years ago. Nonetheless it seems to be incredibly resilient. [SHV18]

In this community garden, 2–10 people work in the garden sharing ideas about what they are planting and learning from each other. The Tongan families grow 'amazing kumara' and the Chinese community grow vegetables with which other cultures are not familiar. The essence of this community garden was described as:

> …healthy plants, good food, clean water. I'm very intrigued by the fact that ground water passes through soil. Do you know what I mean? [SHV18]

4.4.3 Relational values of a healthy soil

Section 4.2 highlights the connections people have with soil and land including cultural and spiritual connections. A healthy soil also brings recreational benefits to people's well-being. For example, if soil is being washed into streams and rivers it can affect people's ability to swim and fish:

> Its [soils] ability to produce a crop. Its ability to capture, filter and store water. Its ability to sequester carbon. Its ability to perform nutrient cycling. But also the cultural and also social and recreational aspects that healthy soil provides us, that are linked to that provision of ecosystem services. [SHV03]

> Well, the key thing is healthy food, healthy ecosystems. It's kind of – to me, it's as simple as that. And that includes – when I think of healthy soil, I think of soil being in the right place, as well. So quality soil is not getting lost out to sea through erosion or ending up in our streams where they're pretty problematic there. So, yeah, healthy people, as well. If your streams are smashed, then it's no fun for anybody. Can't recreate in them, no fishing. Get the right soil in the right place, I guess. [SHV07]

4.4.4 Biodiverse, resilient and sustainable soils for future generations

Soil plays a significant role in supporting and protecting our biodiversity (Bennett et al. 2019) and influences both above and below ground productivity; contributing to decomposition, water & air quality, nutrient cycling & carbon storage, and hosts around 25% of the world's biodiversity (Collins et al. 2015; Bennett et al. 2019; Coker et al. 2019). While there is worldwide concern for protecting wildlife, soil biota does not have the same profile – soil species in general are not attractive or valued by the public (Decaëns et al. 2006). If soil and its biota are destroyed, cascading effects on ecosystem biodiversity and functioning will lead to impaired ecosystem services (Decaëns et al. 2006). A healthy soil with a rich biodiversity, on the other hand, will be more resilient and resistant to pests and diseases which will benefit future generations:

> A healthy soil is inherently biodiverse in terms of microbes, insects et cetera, and diversity seems to build resilience regardless of the context. Whether you can turn that into a productive function or not is a different question, I think, but diversity inherently seems to be connected with, well, increased diversity, increased resilience, and that applies to pest and disease pressure or it might apply to different temperatures or supporting different plant communities. [SHV08]

> Soil matters to us in the same way that water matters and air matters. It's an essential part of what we do. We really do, I think, have… an empathy and an appreciation for soil as an entity, as a living entity, if you like, and everything we try to do is to do as little damage as we can. To the contrary, to try to enrich that soil because we see that really is quite a compounding effect; the better we treat our soil, the richer and the stronger it gets and the better it is able to treat us in the future. We've got a large number of paddocks here and when you get things right, when your grazing and your management, if you like, probably more through good luck than good management, but when that aligns, it's phenomenal what actually happens – the grass has grown, the contentment of the animals and the resilience of that sward, which is a reflection of the soil, what's happening below the soil. [SHV11]

A farmer who talked about a 'regenerative mindset' not 'regenerative agriculture' describes this mindset as continual improvement to leave their land in a better state than when they took it over:

> It's a mindset of saying that what I have today I want to improve on, and I want to leave in a better state than what it was when I took it over. Now, how I'm going to do that is by applying a whole pile of practices that I've learned. Some of them would fit within the conventional agricultural definition and others might not, but it's about applying a whole suite of tools to a given set of resources, measuring where I am before I start and throughout that journey, and making tweaks to ensure that the indicators of performance that I've chosen for myself are improving rather than going backwards. [SHV13]

4.5 Threats to soils

Soil is a non-renewable and finite natural resource, prone to degradation, and susceptible to disequilibrium through climate change (Lal 2014) and as such is facing unprecedented threats (McBratney et al. 2017). Globally, six key challenges have been universally accepted as needing to be addressed to avoid risks to human, animal, plant, and microbial health: food security, water security, energy security, biodiversity, human health, and climate change (McBratney et al. 2017). Soil plays a vital role in each of these challenges (Field 2017). Soil is also important to A-NZ's environment, economy, and well-being (MPI 2015). However, according to Collins et al. (2014), human perspectives of soil are lacking, along with understanding, appreciation, and respect for soils. A guiding vison to 'recognise and manage explicitly our fragile, finite and precious soils to ensure productive and protective functions for all society' was proposed as part of the review (Collins et al. 2015, p. 12). Four key pressures were identified for New Zealand soil management: Intensification; Land-use change; Climate Change; and Legacy effects due to deforestation. Overall, the review stressed a need to better manage our soils in New Zealand with policies that move from a single-issue focus to a more holistic natural capital framework recognising the diversity and ecosystem services our soils provide.

Our interviews also reflect these pressures on soil with four broad areas identified by interviewees as being threatening to soils and soil health in A-NZ. These were climatic effects, management practices, land-use policies (including urbanisation and high-class soils), and forestry effects.

4.5.1 Climate Effects

Six of the interviewees highlighted climatic conditions as being a threat to soils and soil health, whether through flooding, drought, cyclones, and/or the effects of climate change. While some farmers are enjoying more rain and therefore 'greater grass growing capacity', others are finding the changing climatic conditions more difficult:

> You know, sitting here looking out at the brown hills now. We're mostly hill country farming. So we go brown quite quickly. So yeah, that's in my mind, you know, that's the biggest worry is lack of rain. The drought is – I'd like to have had a microscope in action by now so I could have informed you about

that, but I'm sure the microorganism activity must be quite a lot less and the ground's just dry and parched. [SHV09]

So what is really important to us is the moisture-holding capacity of the soil, so that if we have a good rain it sucks into the ground and doesn't dry out too quickly, and that plants can get the water from deep down is a big deal too. [SHV20]

Yes, rolling the soil, turning it to slop and from slop it goes to concrete and then you've got to rehabilitate it, basically. We had a block three, nearly 4 years ago. A sweet-corn crop taken off during a cyclone. It was a tough choice because the cyclone was flattening the corn. It was literally blowing flat to the ground, and they pushed on and harvested it, and all the soil wasn't happy for a couple of years in the places where the trucks and big machinery really made a mess. And some of that is about mitigating access... But you can't stop the harvest otherwise the crop is lost. You just have to hope by hell the damage is minimised to one sort of area, not too widespread and can be viably worked on to be improved. [SHV15]

Research into to how carbon is stored in soil and released under a warming climate is currently being explored by soil scientists as well as the carbon cycle associated with ecosystem processes in the soil (SHV18).

4.5.2 Management practices

According to interviewees, compaction, erosion, soil loss & disturbance (including sedimentation), overwintering of cows (& pugging), and contamination all threaten a healthy soil and must be carefully managed to reduce risk and possible prosecution (in the case of overwintering cows):

So, the key example is that one of the cattle and wintering. The vulnerabilities that Southland have around wintering livestock, especially on intensive fodder crops.
Q: There's been quite a bit in the media about that, hasn't there?
A: Yes, it's a huge issue down here. All the risks, especially around losing soil but you've got the added risk around prosecution now. It becomes quite stressful for a lot of farmers, very risky business. So, I just take that risk out of the way completely by not having cattle and other things - that we are growing less winter crops. This is the first year of my farming career that I've never grown a winter crop. [SHV16]

Changes to soil chemistry and erosion, and disturbance of soil can definitely be one of those threats, particularly in dry land communities where changes in soil fertility or the hydrology can severely and permanently alter those communities. [SHV07]

Another one would be contamination, say, by, from past land users – where say in the past some of the previous owner might have put on too much fertiliser or applied chemicals to the livestock or to the land thinking that they were doing a good thing. Whereas now we well know that, say for example,

> drenching your sheep in arsenic and then letting the sheep run over the soil and having arsenic in high concentration drip onto the land is, we know that's not a good thing now, but that was one thing that was done in the past. [SHV21]

Soil erosion is a particular threat to soils. High rainfall events can wash the topsoil off but also the way a field is ploughed can also lead to soil being lost:

> From land uses! I would say soil erosion. So, like high rainfall events which wash the topsoil off. And once that topsoil has gone, it's gone – generally gone forever. [SHV21]

> The way we plough the soil. I mean, you only need to go through to the Bombays and you see all these tractors going up and down fields. I don't know if they realise, I mean, they've been farming for years, right? But the wind picks up that soil, the topsoil, and it blows it away, and that's the most important part of the soil that should remain on the land, and not being blown away by the wind. I don't know if they realise that. [SHV02]

The threats or pressures are often linked, i.e. the way soil is managed is highly affected by the climatic conditions and the changes in land use. Intensification of stock or crops and weather events can together severely impact the land. For example, densification or intensive vegetable growing can be detrimental to the soil if there are pressures to harvest the produce in severe rain events:

> …intensive vegetables, one of the immediate threats to a healthy soil is having to harvest it in wet weather. That's a huge threat and quite often takes some careful juggling. And, unfortunately, with processed crops, if you calendar on the planting, sometimes you have to carry on harvesting to meet a supply contract, and it's never a good feeling or a comfortable equation, sometimes, because you can do a lot of damage with big heavy harvest equipment in the wet. [SHV15]

Pugging is a soil condition which occurs when soil pores fill with water creating a 'slurry' on the soil surface (Brown & Roper 2017). Pugging was highlighted by the interviewees as being a threat to soils and the understorey of forest floors, especially where there are intensive stocking rates of cattle:

> There are ungulates smashing up the understorey and severely pugging the forest floor – can really affect long-term forest health and regeneration and recruitment of forest species. [SHV07]

> Pugging. It's the treading of the cows, the heavy hooves in the wet, the wetter it is the worse it is, and the more cows the worse it is, too, and the longer they're in there the worse it is. The more often they go into the paddock the worse it is, so we don't generally put a whole lot of break fences up there. We give them the whole paddock once and that's it, we don't muck around with measuring little breaks and stuff because it means that you damage your paddocks more, and the damaging of the paddocks is more the limiting factor than whether or not you gave them the right amount of grass. [SHV20]

Intensification of stocking rates for dairy farms in Southland and Canterbury has also led to some farmers having difficulties in finding feed over the winter as consumer pressure for providing sustainable management practices and regulations take effect:

> So your average stocking rate for a Southland sheep and beef farm currently is nine. Five stock units to the hectare, where actually on a dairy platform it's 20 stock units to the hectare … more than a doubling of intensity, … then it's a huge amount of extra stock that's then in the province and they're very hard to find a home for in the winter. Regulation is constraining those places where you can winter dairy cows. It's very clear too, and I haven't even talked about markets, overseas markets, they are telling us loud and clear that they want their products to contain a lighter footprint on the land. We've got to be more sustainable with our products to maintain our position because we are New Zealanders in a position of privilege. So intensification of farming systems isn't going to create more value, it's actually going to create less value. There'll be more value in the future in higher sustainability, and we're seeing that with auditing programs and processes throughout New Zealand becoming very, very detailed. Very detailed through environmental and animal welfare. So, consumers at the end of the day, they dictate, they always have, and we can't afford to ignore that. [SHV16]

Management practices have changed over the years with vegetable growers now growing more cover crops to improve organic matter and letting the soil rest as part of their crop rotations. However, land availability is a threat to sustainably carrying out these management practices:

> Well, 70-odd years we've been pretty intensive. So, in the last 10 years, when we've bought new land we've looked – when we've purchased more land, it's not for growing more crops necessarily, but to de-intensify and grow more cover crops, so give the ground a rest. We're growing barley now in our rotation, which – barley we don't really make any money off it… it's a different crop type and all of the straw goes back into the soil when we harvest the barley. So, we're trying to improve the organic matter. Lift the organic matter in our soils... We have been for the last 10 or 15 years now, been – we're on a programme of applying compost to the soil… Just to improve the soil quality, the health of the soil ...Back in the day, father and them… after they harvest their potatoes, they just let it go to weed. And then they'd chop the weed in. That was their cover crop. Not a very good way of cropping, to be honest. But we're growing things like mustard, oats, barley and this year we've started doing a mixed cover crop with, I think, linseed, phacelia and radish. [SHV12]

Contamination is a key threat to soils when developments are occurring as it is sometimes easier for developers to dig up and dispose of soil in a landfill than it is to risk re-using it. Interviewee SHV24 suggested that the developers need to more carefully weigh up the risks associated with any contaminant level with the subsequent management options for the soil:

> One thing that happens way too frequently is that because of a slightly elevated contaminant load, then because of our current regulations, it's easier

> to just dig it up and dump it in the landfill, as opposed to actually using it. And that can actually be potentially more useful, valuable soil than what gets kind of imported onto site … but because it's just marginal, the risk associated with the subsequent costs and negative environmental impacts of that digging it up and dumping it, those negative impacts outweigh the risk associated with the initial slightly elevated contaminant status. [SHV24]

Management decisions for land affected by extreme weather events should be made with consideration as to what the future untended consequences might be, for example on the East Coast, harvesting trees planted to stop erosion are now having impact further down the catchment:

> I think we've learnt an awful lot, but every action comes with unintended consequences and I think the human race is really good at finding immediate technological solutions to the immediate problem in front of us without truly deeply understanding the broader implications of that, and there's so many examples of that; East Coast hill country was put into massive tracks of plantation and forestry as a result of Bola to a certain extent to stabilise those hillsides, and now we're having massive issues in trying to harvest those trees and the impact of slash on our beaches and so forth, that's been so publicised recently. [SHV13]

Weeds and the overuse of synthetic fertilisers, herbicides, and fungicides were outlined as threats to soil health during the interviews. Management practices differed, depending on the philosophy or farming practices of the farmer, e.g. whether organic, regenerative, biodynamic, etc., and the type of farming, e.g. beef & lamb, dairy, or for vegetables:

> Thistles, and the other thing is giant buttercups is a big threat. So we don't do boom spraying, but we do spot spraying to get rid of the weeds, and spread lime and fertiliser twice a season, and do a bit of seeding of clover. We have done some direct drilling of grass and clover but we only had one go at that, and it wasn't the whole farm… we're not really big on doing a lot of re-grassing. But the main thing is to actually keep the weeds out and that means weed spraying every time the cows come out of the paddock… weeds are a threat to your soil environment there. [SHV20a]

> Well, the practices that are prevalent in modern agriculture, like overuse of synthetic fertilisers, herbicides, fungicides – the negative effects of all those practices on – or continuous cultivation. The negative effect of those practices on soil health are pretty widespread, unfortunately. [SHV03]

Big infrastructure developments such as building new roads can lead to soil loss, compaction and erosion:

> …occasionally there's landslides. And once it's [soil] drifted down the slope you don't get it back up, basically. So that's just complete soil loss. [SHV03]

> We look for infrastructure, for making roads and landings. So physical, also we don't want to reduce productivity through things like compaction and erosion. [SHV25]

And sedimentation is a key farming issue in Southland:

> All our major catchments have estuaries at their exits…I've seen the sediment blooms out the Foveaux Strait after massive amounts of rain. [SHV16]

These issues are not just unique to A-NZ, many are also prevalent around the world:

> …and then soil erosion on a global context is obviously a huge issue, which is driven by a multitude of factors. [SHV03]

4.5.3 Land use policies – urbanisation and high-class soils

The interviews highlighted some key challenges for the development of land, urbanisation, and policy associated with the management of high-class soils. As global (and A-NZ's) populations increase and become more urbanised, high class, versatile lands with soil characteristics favourable for food and fibre are more likely to be encroached upon for housing (Curran-Cournane et al. 2016, 2018). Therefore, there is a need to protect these elite soils. However, in New Zealand the Resource Management Act (RMA) 1991 does not clearly articulate how highly productive land should be managed (MPI & MfE 2019). A proposed National policy statement (NPS) for Highly Productive Land (HPL) has been circulated for submissions and MPI & MfE are currently reviewing the proposal based on these submissions (MPI 2021). The purpose of the NPS is to provide clear and consistent policy that councils must follow when making decisions about land that is highly productive for primary production (MPI & MfE 2019). Two key pressures were identified from the submissions on the new policy: urban expansion and the accompanying loss of A-NZ's most versatile and productive land, and an increase in rural lifestyle developments close to urban areas (MPI & MfE 2020).

These pressures were also foremost in our interviewees' comments. A national policy for high-class land was well supported by the interviewees:

> I think it needs a national policy so that councils have to abide by it and not allowed to – or very strict rules on if they are to use high-class soils, they've got to consider alternatives… [SHV14]

4.5.3.1 Urbanisation and high-class soils

Traditionally, rural land has been handed down from one farmer to the next generation, but more recently with a pressure on housing, land near urban areas is now often at a premium meaning that valuable high-class soils are at risk of being used for housing developments and therefore the soil is locked up from producing food. Consequently, horticulturalists may end up cropping more intensively as they may not have enough land available to rest the soil between crop rotations:

> I'm just about come the last man standing, actually, because everybody's disappeared, they've sold their land and there's no younger ones coming on and that's the point. I am on the community board but I'll be trying to push things through, like instead of going onto more high-class soils and things, why don't we build up instead of out, and there's also areas of lesser grade

> hills and things that could be built on and that sort of thing. So that's possibly a line that I'll be looking at. But if you've got less and less people involved in the industry it's easier to manipulate an industry, I suppose you'd say. The general public, they drive along, they don't identify between a good soil and a bad soil. [SHV14]
>
> Urbanisation is a big threat to a lot of good soil. Land being wasted for better uses. Some people can spend a weekend mowing the grass. I see that as a huge detriment to the soil and the environment. [SHV15]
>
> …the urbanisation one is that sort of use of the highly productive soils to then be used to have houses on and which then pushes out the whole vegetable food growing area into soils that are potentially less productive. And so that's just really illogical. [SHV24]
>
> ... So when you do plant a crop, you are trying to get maximum yield. You don't get that if you just keep intensively growing crop after crop after crop and not resting the ground. So, a threat to soil health is land availability. If we haven't got enough land available, we're being forced to grow intensively crop after crop. And that land availability, or not having enough land available to crop on is a threat to soil health. [SHV12]

Re-zoning an area for development is complex and there are multiple perspectives that need consideration. As interviewee SHV06 described:

> …for example, a one-hectare subdivision may not go through because there's a small area of high-class soil on it. But at the same time, a rezoning outside a town or a city can suddenly soak up 70 hectares of pure high-class soil, just in one move. So I think, we have to think really carefully about that. I'm not against zoning and I think zoning could be improved and is a good tool, but it has to have the knowledge at the time when the rezoning gets done to – and also the weighting, because I think it's considered but there's a whole lot of other factors that can override the importance of the soil and I think we really need to look at that. [SHV06]

Internationally, countries such as Germany have a soil protection law even in their cities so you can, for example, only excavate the foundations of a house. This preserves the soil around the house. In A-NZ the opposite is carried out. According to one interviewee, developers are deliberately removing topsoil and vegetation and dumping them when constructing a house because of the possible risk and effects of soil contamination:

> I think part of it is that we predicate capital cost of construction over any long-term outcomes. So, if preserving soil meant it was more expensive to construct a house, it's not done. If you had to add compost and deep till after constructing a house to restore the landscape it would cost money, so it's not done. So, on these landscapes they don't plant. That's why you end up with lots of Pōhutukawa and palms… they're super tolerant, they don't need a big root ball, super drought tolerant. So, you have your same five plants being used in all sub-divisions and they're the toughest of the tough that can survive in the worst soil. [SHV01]

There was a case made for brownfield[7] soils to be used and not just discarded as landfill and for greenfield[8] developments to not be made on areas good for food production:

> I think within the urban areas there's a lot more potential for use of what they call brownfield soils. [SHV24]

> So it's very hard with – in the Waikato especially – Greenfield Development on really good food-growing land. And then even how we use our land. The Climate Commission has come out and suggested that we do need to change how we use our land in New Zealand for agriculture. [SHV23]

Another point made by an interviewee was that in urban areas the cumulative value of caring for soil from people owning a house and garden will provide space for nature:

> Urbanisation, like urban creep, that is an issue for soil health as well… if you own a house, you probably own some bit of soil surrounding it. And all those little bits added up are quite a significant area of land. And that's not really a conversation that's had, is how are we as homeowners, or property owners, how can we best manage our homes and gardens for providing space for nature. And within that, looking after the soil as best we can. [SHV03]

4.5.4 Forestry effects

There were concerns about growing significantly more pine trees because of the change in land use and the effect the trees could have on the soil systems. Interviewees talked about the soil being leeched and becoming very acidic when pine trees are grown and that there can be severe impacts on the environment when harvesting them in the future. They talked about planting the right tree in the right place:

> Grass is – apparently pasture and soils are supposed to be as valuable to the climate and the atmosphere as trees. It concerns me a little bit that they're pushing – the greens are pushing frantically to grow pine trees when you know what it does to the soil…… is it three generations of pine trees and they reckon you can't grow a thing on the soil? It's leeched – it's turned – it's very acidic. Makes acid soil… But yeah, just seems like a detrimental thing to do. …don't really think New Zealand's capable of saving the planet with the size of us. But planting pine trees is supposed to be the magic pill. That seems to be very tragic to be planting out all the farms down Manawatu and Wairarapa

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[7] **Brownfield soil:** disused or under-utilised industrial or commercial land and facilities that may be contaminated by low concentrations of hazardous waste or pollution and have the potential to be reused once cleaned up (remediated). Department of Internal Affairs Te Tari Taiwhenua. https://www.dia.govt.nz/diawebsite.nsf/wpg_URL/Resource-material-Building-Sustainable-Urban-Communities-Glossary?OpenDocument

[8] **Greenfield development**: built development (industrial, commercial, residential or mixed use) on a piece of previously undeveloped land (generally on the urban fringe), which had been either used for agriculture or was in its natural state. Department of Internal Affairs Te Tari Taiwhenua. https://www.dia.govt.nz/diawebsite.nsf/wpg_URL/Resource-material-Building-Sustainable-Urban-Communities-Glossary?OpenDocument

> apparently, they're getting planted out in pines. Fair enough hillsides, but I don't know about good grazing land. [SHV09]
>
> Not pine trees per se, but pine trees in the wrong place, particularly on steep, erodible hill country… A lot of the ones they're planting now it's just – the economics of harvesting wouldn't even be viable on today's cost of harvest, let alone what it's going to be in 30 years' time, they're just going to plant and leave…they're going to get to 25 years old and they're just going to slide down the hill and take all the soil with it. That's mad. [SHV08]
>
> …some of those sites were only ever planted for stability and trees. And then you happen to have a storm when the soils are vulnerable between rotations. [SHV25]

Another interviewee described a tension between private landowners and a push to protect native remnant forests or plant riparian vegetation, i.e. in their experience there is a sector of farmers that do not want to be told what to do on their land even if it will provide biodiversity benefits and improve native ecosystems:

> I get to work with a lot of older people and that's often their insight is in the early days it was rip, shit and bust and especially up until the early '80s when the government was actively subsidising the development of land and the clearance of indigenous forest and drainage of wetlands. And then that all changed pretty dramatically and slowly the social licence to clear native ecosystems is being removed and there's been tighter and tighter regulation around that. It doesn't always mean there's appetite at the local government level to actually enforce that regulation, but in theory there is more regulation. And you're right, people are definitely thinking, oh gosh, a bit of forest, or a bit of riparian vegetation is actually a good thing. So they're putting it back. But I guess what upsets me a bit is that there's still quite a few people out there who are in this day and age, in the 21st century – 20 years into the 21st century – people have still got that attitude of, 'It's my land and I'll do what I want'. And, 'Who has the right to tell me?' so that's a real fundamental challenge to anything to do with biodiversity, soil, fresh water. Anything to do with the systems that extend beyond the footprint of that land, is that tension with private land and that attitude of entitlement. It's a real sticky human problem. [SHV07]

4.6 Strategies to protect soil

While soil in many cultures, including Te Ao Māori, is given status or mana, the term soil is often used by the public to describe undesirable actions, e.g. 'soiled', 'dirt bag', 'befouled', 'contaminated', and therefore has a poor public image. Brevik et al. (2017) suggest that one way to build positive connections between soil and the public is to use the connection between soil and favourite foods for example, to build on the concept of 'terroir', which was initially used to connect soil with the production of wine but is now also used with other food products such as cheese, coffee, olive oil, etc.

The question 'what strategies/tools do we have to protect our soils?' generated much discussion with interviewees on a wide range of themes. These themes include management practices; education, communication and advocacy; legislation, policy and regulations; and culture and connections to soil. Generally, a broad range of tools applied at different scales and with different community sectors are needed to build knowledge of how to protect soils now and in the future:

> … if we can actually get the information out there and people have the knowledge to make the right decisions as opposed to regulation. But my experience at regional council is that you need a mixture of all of those things and so you need regulation, you need good policy at national, regional, local scale and levels and I think you need to start at different – at the early age, so the education, warming people into the situation, getting them familiar enough to make it kind of knowledge, just general knowledge about soil and you can do that best with kids. They'll be the ones that are growing up and they'll go through the system, and it'll take generations. [SHV06]

4.6.1 Management practices

This section highlights some the issues different industry sectors are facing and the strategies that could improve management practices and protect soils as suggested by interviewees. For example, when growing taro, wetting the soil before ploughing or after rain will help to stop soil blowing away when it is ploughed, and this principle is a good strategy for keeping soil on the land when cultivating on a large scale:

> I'm just saying things that I've observed on my own experience, and I know that when we dig up taro back home, if it's a dry grown, you get the water from the stream and just throw it on the thing and then start ploughing – ploughing by hand, not with a machine. [SHV02]

4.6.1.1 Viticulture and horticulture

There are many practices that people carry out that don't benefit the soil, such as over-mown grass, the liberal use of glyphosate, and the use of CCA (Copper-chromium arsenic) posts in the horticulture and viticulture industries. CCA posts have been shown to release heavy metals into the soil and environment over time. Many vineyards in the Marlborough region are due for replacement and so this was seen as a good opportunity for other options such as untreated hardwood, plastic or steel posts to be used instead. A safe work method statement (SWMS) was also suggested to ensure compliance and alternative posts to be used in all new vineyard developments or redevelopments:

> …let's say with the example of CCA posts, that having them in the soil is – you're constantly releasing heavy metals into the soil and into the environment. And the easy solution to the problem is to get rid of them, but we don't… And how we over-mow grass, and just all these things that people don't realise has a negative effect on the soil's ability to perform its functions for us and the rest of the planet. [SHV03]

4.6.1.2 Livestock farming and dairy

Farm Environment Plans (FEPs) are becoming more common and provide a mechanism for setting out actions to address farm management issues. Implementation of the new National Policy Statement for Freshwater (NPS-FW) will for example have an impact on how farmers manage their land. The FEP can help to address these impacts in a sustainable way.

Winter grazing of livestock is a problem in Southland and can cause issues for livestock health and welfare. Some farmers are moving away from winter grazing and using all-grass farming systems instead or planting a mixture of forage crops such as corn, broad beans, sunflowers, kale and radish with swedes. Other practical advice included direct drilling rather than cultivating the soil and grazing sheep vertically rather than horizontally on steep slopes to reduce soil erosion in winter:

> Basically, you put your animals on and feed them a portion every day and shift the electric fence and they eat single last nubbin of food before they're allowed onto the next bit. Often if it's growing really badly, having to push their faced down into a mix of mud and animal shit and stuff just to eat the last bit of that swede out of the soil. It's pretty horrible at times. And yeah, so some people – a very small number – are talking of going away from winter grazing entirely and just using an all-grass farming system. Or removing the cultivation aspect of it and doing things like direct drilling, which definitely has merit from an erosion reduction point of view, but it also does I think have some other possible problems with heavy reliance on herbicides to do that. [SHV07]

> Not so much turning it over but, yeah, direct drilling. Minimal tillage, yeah, keeping the soil covered, keeping it growing multispecies grasses and things.
>
> [SHV17]

Regenerative farming techniques were often mentioned by interviewees, and while not discussed here they are seen as prompting farmers to experiment and learn more about their soils and systems:

> I think it would be really great to have a bit more of a clear idea of what regen agriculture means in New Zealand, but I am really excited that when I sit around the table and hear my regen ag farmers talking about what they're up to, they're in a really positive headspace. They're experimenting again, they're interested in what they're doing, they're learning more about their soils, more about the system. It's not just animal, fertiliser, rye grass, and round you go, rinse and repeat. [SHV07]

Regenerative agriculture practices were also seen as a solution for retaining water in the soil as climate changes effects become more influential:

> Infiltration, techniques around – I think this is where regenerative agriculture has a nice fit in there around retaining water in our soil, instead of running

through the profile to drain over the top to waterways. So the key to that will be farming techniques. [SHV16]

Biodynamics is another movement that has some rituals and ways of farming that can and are being adopted by farmers:

> …with your biodynamic movement, I think a lot of that is – I mean, rituals and cultural in a sense. All the religiously-type groups have certain things that they do, and it's just sort of what they've always done, and some of it has good science potential and others it's just habit. It's picking out the good stuff. Yeah, well, we started this year with vegetables, inter-planting flowers and stuff to try and encourage the butterflies to piss off. Just little things like that the biodynamic guys have always done. The interplanting and the trying to keep the soil covered rather than trying to keep it aridly sprayed and the weeds down. [SHV15]

4.6.1.3 Community Gardens

Getting involved with community composting systems rather than having large wholesale food collection services could be a strategy for more people to connect with soil and to grow their own food, according to interviewee SHV19:

> There's food waste being created everywhere so we feel like there should be composting everywhere. Then you're composting for a reason, it's because you want to grow food… But I think local composting would be an amazing one as opposed to what the [Auckland] Council's rolling out, which is the – they're going to collect food waste but then they're going to take it off to this digester I think they're calling it, some huge facility out on the outskirts of Auckland, I guess. And it's kind of anonymous and it's not really helping people to see the value of food waste to turn into compost is to feed the soil to feed ourselves. So, the cycle is not really being promoted, the key part of that cycle being the soil. [SHV19]

4.6.1.4 Succession or next generation farming

Interviewee SHV07 noted a change in how the next generation of farmers are operating their farming systems – being more flexible and open to new regulations:

> I think they are much more aware of what the markets look at and what the consumers are interested in… So, yeah, there is definitely a younger group of farmers out there who are more aware of the world beyond the farm. They've definitely had the benefit of tertiary education and they are perhaps – they've grown up in an area of greater regulation as well. So they're not as frightened of it or as stressed out by it as maybe some of the older generation are who just don't – some of them just don't want to know… I think for a long time farmers have not had that much oversight or regulation. And so now that it's finally happening through arguably their increasing loss of social licence to farm the way they've farmed, that some people are finding that quite stressful.

> And younger farmers are just rolling with it, which is really encouraging. [SHV07]

However, a threat for future food production systems is the assumption that the next generations will want to farm and grow food and that there will be land available to do so. Interviewee SHV12 was optimistic that where there's a demand for food somebody will want to grow it for economic reasons. However, smaller families that don't have succession may want to sell their land or may be taken over by larger corporations. This could be problematic if the land is sold for housing developments and possibly creating tensions between neighbours and families if this happens. A solution suggested by interviewee SHV12 was to shift the conversation from owning land to being caretakers of the land i.e., placing a value on the land for food production:

> …he's [my uncle's] got no succession, so he decided to retire. And he wants to sell his land for housing. And he saw me… saying that no, we need to save the land for growing vegetables for future generations. They didn't like it. They still had the mentality that they own the land, they should be able to do what they want with it. And I had to explain to him, I said, "Look, you'll be dead in 20 years and that land right there," we were actually leasing the land off him, I said, "That land's growing crops as good as what you were growing them 20 years ago." Because for a while there they said, "Oh, that land's getting too old." And I said, "No, it's not. Look at that crop." Look at the crop today. Even the last crop, we only just harvested last week. Amazing crop… on there. And that's because that land has got resilience and tenacity to carry on cropping, growing crops year after year and still produce good quality crops. But it has – yeah, there's been a lot of tension between us. But I think they understand. Who can argue with me when I start telling them that we're only caretakers and that land is growing very good crops and it should remain growing crops for the next generation? Who can argue with that? [SHV12]

> **A:** And a lot of that is other families that have given up farming.
> **Q:** Yeah. What reasons would they be giving it up?
> **A:** Age and no next generation. So, we did lease a lot of former market gardens, Chinese market gardens and stuff, and the next generation are now selling them off because they want to do something else with the asset.
> **Q:** So, who is going to grow our food, then?
> **A:** It's actually quite a worry. I think it's something, that is – I mean, that was – probably why I agreed to do this interview because I think in 10 years' time New Zealanders, our fresh food will not come from New Zealand, because it will be cheaper to get it from elsewhere, from places that don't value things like we do. [SHV15]

Succession planning and recruitment opportunities will be important if younger people are to be involved in food production:

> So I'm going out, giving a talk about how great horticulture is and how much we have to value the soil, and then someone turns around and says, 'Hey, I want to work in the industry and value soil', but then as an industry, we don't

> really have great career progression for the younger generations, then it sort of all falls out, we've got to have great structure for it. [SHV22]

4.6.1.5 Tools and tests

Section 5.3 outlines indicators and tools for monitoring and assessing soil but interviewee SHV13 found that the key to a healthy soil is developing innovative tools and measuring and monitoring what you are doing:

> …providing the tools that enable them to do that, (a) to measure where they are currently and (b) some tools to try out, and (c) some tools to measure whether or not that worked and to monitor progress over time. If we can get a really comprehensive and knowledgeable set of tools around that then I think we're going a long way to achieving some of that aspiration. Then you apply over the top of that economic levers like the ability to store carbon and therefore generate income from that, the valuing in a monetary sense of ecosystem services whether that's around carbon sequestration, nitrogen, phosphorous, biodiversity, all of these are credits that are starting to be traded globally. So those are all just incentivises for doing a better job, but I still maintain that most people want to do a better job, they just need guidance as to how to. [SHV13]

Interviewee SHV09 commented that with a spade and a refractometer you can tell a lot about what your soil is doing.

4.6.2 Education, advocacy and communication

Educating the public, children, farmers, horticulturalists, landowners, and students about soil systems is viewed as an important strategy for protecting soils, and one that should be approached in many ways such as through schools, agricultural curriculum that teaches students the fundamentals of soil, and policies such as the proposed National Policy Statement for Highly Productive Land (NPS-HPL), which can focus and advocate for the protection of highly productive land for primary production:

> When we talk to youths, or just engage with schools and just engage from family and farmers, there's always something, there has to be something missing, and I think that the missing thing could be the cultural component. The emotion that we all belong somewhere, right? We all have people, and we all have a piece of land that we call our own. I took that, and with my experience with gardening; I took that and turned it into a program for youth. I allow them to get their hands dirty, to do the hands-on work, to get their hands dirty, and watch them thrive. Not only are you teaching them to grow stuff, and hopefully for the future as well, turn their gardens in their own home, but you can also teach them about empathy. You look after a plant and you watch it grow, and you see the fruits of it and then you can share those fruits with people you love. [SHV02]
>
> I've found it interesting with some of the agricultural graduates that I've engaged with, and it makes me feel old, but I think about what I was taught at

> university 20 odd years ago around the fundamentals of soil and I'm a little bit shocked that that doesn't even seem to be in the curriculum. [SHV05]
>
> I think we have to build it from a number of fronts, we can't just take one approach and say, 'Here we go', that's why having the NPS, national policy statement, is a good addition but it shouldn't be what we focus on and I think every – regional councils to me play a large role in this and working with Landcare in conjunction with regional councils and those connections are really important because having the connections where you can get the information, robust science and information through to the implementation in the community is really how it happens in that respect. [SHV06]
>
> …it's probably educating the public. And that comes from people actually understanding the impact that soil quality and health has on, not just what farmers do, but how that actually impacts them on a daily basis. [SHV10]

Extension and educational material are available to help increase farming and gardening knowledge and to encourage more holistic thinking but what is not known is how the knowledge is being applied, how to connect the many different programmes, and therefore prevent silos forming. Australia has a National Soil Advocate to raise awareness of the important role soils play and to provide leadership on 'protecting, restoring and maintaining the health of the Australian agricultural landscape, to enhance productivity, guarantee a food secure nation and sustainable farming communities'.[9] Aotearoa-New Zealand does not have an advocate or champion for soil as Australia does, but an independent person with respect and authority on soil would be of benefit to enhance the protection of New Zealand soils according to interviewee SHV05.

Learning about how soil impacts us in our daily lives could inspire people to appreciate soil more, especially young children and using different narratives to find the right soil connection is the key:

> I think most people would be inspired and fascinated by modern understandings of how amazing soils are. You call it soil it sounds boring, but you actually dive into some of these amazing things and – you could go to a primary school and you teach kids about how plant[s] will share resources and nutrients and water with each other to help each other out… but I think ultimately everybody, or most people connect to it because ultimately it's this source of your food and health and well-being, and you're just better connected to things that people care about and it's not hard to do. If they care about food – nutrition – that's a no-brainer. If they like diving and fishing, then they're interested in sediments and erosion loss… If they're dependent on medicine for the rest of their lives that are derived from compounds synthesised from soil microbes. There's so many different ways you can connect. [SHV08]
>
> For me again it comes down to value. We're really good at protecting stuff we really value… and so for me again it's about if people are aware of our impact

[9] See https://www.pmc.gov.au/domestic-policy/national-soils-advocate

> and the implications of our impact on soils and what damaging soils will do to us and to those that we care about, both people and ecosystems, then we're going to be in a better position to incentivise change. [SHV13]

Making good decisions about soil also relies on good education and resources, and sometimes looking back and reviewing what works and what needs to change:

> Well, I'm a firm believer in just good education and good resources available to the people at the coal face so that they make good decisions based on good information. So, you pick up these papers and you've got one scientist saying you should be doing this and the next scientist saying you should be doing that… Let's go backwards and review what's been done and what needs to change and what doesn't need to change. There are some farming practices that need [to be] stopped. There are problems. There's no question about that. [SHV15]

Communicating ideas about soil and creating awareness can be achieved through social media, community gardens and growing food at school:

> …creating awareness through pockets of gardens in the community, and reintroduction back into schools. If you create awareness that creates protection. Same strategy as what we use for seatbelts. [SHV02]

The media can also present examples where best practice farming is not evident and possibly help change unsustainable practices:

> Yeah, there was some activism and some very shocking photographs that came out in August 2019, showing some really appalling worst case scenario practices with winter grazing in Southland. It was quite polarising I think for the Southland community. A lot of farmers just got very defensive and sort of didn't want to engage and didn't want to acknowledge that these things happen. They just sort of said, 'Oh no, that's just the worse, worst case scenario. That's very rare.' I think they're probably right to one extent, where one of the photographs showed a calf being born into those conditions. And that is quite rare in my view. But seeing cows walking around up to their hocks in mud is not as rare as farmers might want to imply, I think. [SHV07]

An alternative perspective suggests that there are many tools to protect soils and that 'we need to stop hitting people with big sticks and actually have a more open discussion about the future of our soils much the same as we are about our health at the moment…' (SHV15):

> I'm not 100 per cent sure, to be honest. I mean, it's a conversation that needs to start – people talk about farm open days and stuff, but I don't think that's the answer. That's about just putting cotton wool and making everything fluffy, and that's – I think it's just that public debate about what we actually want. Election time, I think politicians talk about expensive fresh vegetables, but they've got no idea why fresh vegetables are expensive. It's not greedy farmers at all. It's just what they cost. I don't think our industry is particularly good at

> showing the world or showing the public just what it actually costs to grow a lettuce. [SHV15]

Networking and talking to people at seminars and conferences are ways to engage with scientists and provide opportunities to ask questions but ultimately many farmers go with their 'gut instinct' when making decisions about farm operations:

> Well, you always go with your own gut instinct, which one you feel fits your operation better, but you look around them, you talk to people. 'Have you tried this and what was your experience?' And that comes again from conferences and seminars and stuff. Networking with people and asking them the questions. This scientist will say, 'On so-and-so's farm we tried this', so you actually ring the guy and he'll say, 'Oh, no, no, no', or 'Greatest idea since sliced bread'. And then you dig a bit deeper and take a punt. Sometimes it is just gut instinct because you feel it seems a good way to do it. That's with what you want to do. [SHV15]

4.6.3 Legislation, policy and regulations

A perspective was shared by interviewee SHV03 that there is very little regulation of agricultural, viticultural, and horticultural practices at both the national and international scale. There is the perception by some landowners that the government is 'meddling with private industry' and that people are 'very quick to jump to assumptions around government regulation' and chorusing 'oh, the nanny state!' or we are 'verging on communism'. This reaction was explained as follows:

> … in the new liberal, capitalist world that we live in, the government interfering is seen as a massive negative, because it stops economic growth, or it could potentially stop economic growth. But actually, if the government steps in to regulate to protect the resource, then ultimately the resource is going to be able to provide better … which is going to sustain the economy [SHV03]

Section 22 (Open Space Covenants) of the QEII National Trust Act 1976 was described as a piece of legislation that can provide protection for soil:

> Well, it's not specifically designed for this, but I do think the QEII National Trust Act 1976 is pretty good. We do think about, well in our Act we talk about open space values, which is a really wonderful grab bag miscellaneous of pretty much anything you want…I think it's Section 22 and it's in the interpretation at the start. But anyway, it can be landscape values, it can be biodiversity values, cultural values, archaeological, et cetera. So, I think that soils could fall into that, and not by design, perhaps more by accident. [SHV07]

In Southland, for example, there are a few covenants where their key values are for protecting the soils and the land immediately adjacent and keeping them in their natural context:

> … these little postage stamp spots sometimes, they're quite small – in the middle of vastly intensified land use that's had all its soils changed, cultivation

> and obviously addition of fertiliser and removal of the indigenous plant cover and the indigenous insects to a large extent. These little protected areas are a wonderful kind of bit of time travel to see what the soils might have been like – maybe not going back to the moa and when we had all the fauna and everything here but certainly going back before the farming changed that soil dramatically. Yeah, so that I think is quite a good little tool. [SHV07}

Interviewees SHV06 and SHV12 are hopeful that the NPS-HPL will give regional councils guidance on where land can be developed and where protection is needed for the production of food:

> … that's where the national policy statement would probably be good because it's actually placed the onus on the Regional Council, the district council to come up with better rules. It's just that I'm not sure that every region's got the same level of knowledge and the same number of people to work on it and provide things that make sense without too much political intervention because Regional Councils are governed by politicians. [SHV05]
>
> Apart from that, what more can you do? You've got to have some legislation in place that protects the land from developers. [SHV12]

There was a call for soil policies that will protect soils against future urban development:

> The only strategy I see has got to come from the government… They've got to come up with a soils policy and tell us what we should be protecting and what we shouldn't be… Someone once said to me, 'There's nothing on that paddock' but they didn't realise you've got to rest your paddocks and things like that. They'd rather see a house there. [SHV14]
>
> I'd say the main strategy would be policies protecting say against rural development – converting some of our more versatile soils into housing development. [SHV21]

In the forestry industry there are National Standards and company standards that determined what operations are allowed on particular soil types:

> I think there's things at local government around land use limitations which I guess are partly to think about the soil. I guess I'm thinking some areas are zoned for urban development, some are rural. We, forestry, we have things like the National Environmental Standards, which is based on land use capability, which includes soil type and that's to try and avoid things that can be damaging to the environment and the soil and socially, but allow free use in areas where there is less risk of that. [SHV25]

If a soil is vulnerable, then they will only work those areas when the soil is dry to minimise impact. Consideration also needs to be made by operational managers about the day-to-day planning of a forestry operation to ensure that soils are not being disturbed unnecessarily:

> And so we have rules around that when, you know, tracking must stop if wheels are getting up to the hub, or slash raking must stop if it's disturbing the soil. [SHV25]

4.6.4 Culture and connection – our relationship with soil

Culture and connection are key components of how to improve people's relationships with soils. Interviewees articulated this in different ways, e.g. a disconnection due to urbanisation, our domination over soil, interconnections between people and soil, and making soil more visible:

> People haven't made the connection [to soil] because… they're so far removed from the land. [SHV06].

For one dairy farming family, having a strong, regenerative culture and strong values are considered essential and is 'intermeshed' with a sustainable, regenerative soil, i.e. they are taking a more holistic approach to soil and people which is consistent with Te Ao Māori worldviews. They believe that by taking an equitable approach towards people working in the farm system and using regenerative soil practices, pressures on the land will be reduced and more sustainable:

> I think that's one thing that Walter Jehne[10] talks about in terms of regenerating the soil, and the soil being a sponge and reabsorbing what it needs to keep the cycle going. And that cycle is as much around the cycle of water and nutrients as it is around human relations and people and knowledge and longevity, and that whole then creates that preventative model that has the ability for long term survival. The basics of it really are if you want to regenerate soil you've got to regenerate your culture, and so culture and soil are closely intermeshed, and that's sort of the Māori version anyway of it so that gives validity to the Māori thinking. [SHV20b]

Interviewee SHV11 described our relationship with soil as being patriarchal or one of domination over soil and that we need to be more nurturing or matriarchal and to view soil as a living being that needs empathy and respect:

> Yeah, currently we're very patriarchal, we dominate the soil, we get it to where it needs to be or where we feel it needs to be, whereas I think it should probably be more of a nurturing and allowing expression and allowing to flourish. [SHV11]

Respecting soil (as part of a terrestrial ecosystem) is also an important value to SHV18 and for this participant, soil is seen as fundamental to all life. However, they felt that soil is invisible to most people and, as an ecosystem in itself, needs to be acknowledged:

[10] Jehne W 2020. Regenerate Australia – The Concept. Future Directions International. https://www.futuredirections.org.au/wp-content/uploads/2020/06/Associate-Paper-Walter-Jenhe-FINAL.pdf

> Well, my view about terrestrial ecosystems, which includes soil, is that … currently the services they provide are invisible to the large majority of people. Although if you ask someone, you asked a gardener, what do you think about soil, they would tell you. But I think it's about protecting ecosystems and the soil is an incredibly important part – is an ecosystem in itself. So, I think it's part of a wider view that these ecosystems are not just aesthetic, they're actually fundamental to our existence and we must start by acknowledging that and then if you acknowledge that then you will behave in a way that is more respectful of the services that they provide…But soil should be up front because that's where you grow the food. [SHV18]

4.7 Soil knowledge and information sources

The 2013 Survey of Rural Decision Makers of New Zealand farmers, foresters and growers found that other farmers, scientists, and veterinarians were the three most trusted sources of information for farmers (Small et al. 2016). When interviewees were asked where they got their soil knowledge and information from in this study, we found that they used a variety of sources (Fig. 1). Thirteen of the twenty-five participants obtain information by having conversations and sharing their knowledge with other people, farmers, consultants, soil expert and scientists. Grey literature such as books and reports, peer reviewed literature and on-line websites are the next most frequently used sources of information for the interviewees. Education and training provided experience and expertise along with the national soil databases, conferences, seminars, field trips and field days. Crown Research Institutes (CRIs) and universities provided both expert knowledge as researchers and educational training:

> I probably have a group of scientists that I've built relationships with over the last few years. And it probably helps that I've got a bit of a background in soil science myself… But typically, it'd be Landcare or Ag Research in terms of the people that I work with the most… Lincoln Uni… But for me it's about forming those partnerships so you can have that discussion as well rather than just reliant on an individual expert. [Beef & sheep farmer]

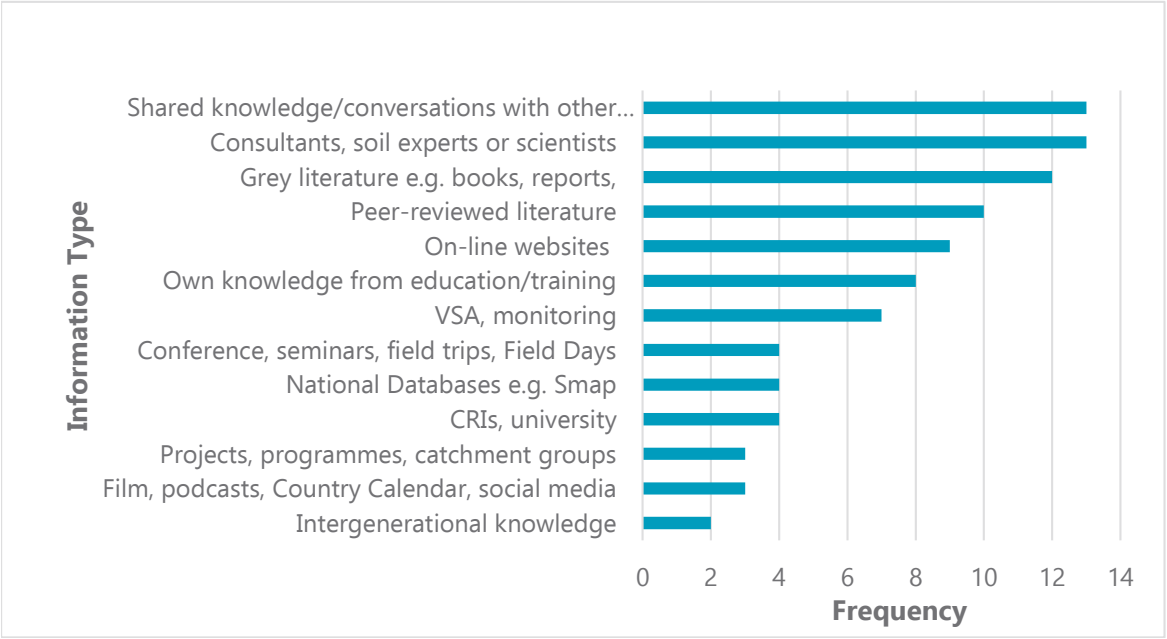

Figure 2. A summary of where the twenty-five interviewees obtain their soil knowledge and information from.

Table 3 shows where interviewees from the nine different sectors obtained their soil knowledge and information from. Interviewees from each sector read grey literature. i.e. reports and non-scientific papers for soil information but the majority of interviewees also use on-line websites and peer reviewed literature. Sharing knowledge and having conversations with other people, peers, farmers was important to most of the sectors. They also rely on consultants, soil experts and scientists for new and up-to-date knowledge:

> Movies, films, podcasts, audio books. Yeah. Talking with people, peers… for me that's a really good way of learning. I find the information that I acquire from conversations probably sticks a lot better than what I read from a peer review journal, for instance. Yeah. Facebook. Soil-related pages on Facebook. [Viticulturalist]
>
> I guess if you're asking where I learnt about soils, I did soil science at Lincoln with horticultural science, and I worked a little bit with soils … the Conservation Department, and that was all about mapping the relationship between soils and landform and vegetation, it was a brilliant scheme which went through all those sorts of things. [Dairy farmer]
>
> There's a huge amount on the internet. Yeah, Google's a pretty amazing tool. I don't use it as much as I could. Yeah, there's a – friends and acquaintances. Like your fert rep, they're very passionate about all that sort of thing. He sends a lot of links to me. [Beef and lamb farmer]

Table 3. A summary by sector of where interviewees obtain information about soil from

Information type	Agricultural Advisors	Community garden	Conservation	Dairy	Forestry	Horticulture	Livestock	Researchers	Viticulture
Grey literature e.g. books, reports etc.	✓	✓	✓	✓	✓	✓	✓	✓	✓
On-line websites		✓	✓		✓	✓	✓	✓	✓
Shared knowledge/conversations with other people/farmers, collaboration	✓	✓	✓			✓	✓	✓	✓
Peer-reviewed literature	✓		✓			✓	✓	✓	✓
Consultants, soil experts or scientists	✓	✓	✓			✓	✓	✓	
VSA, monitoring, dig a hole		✓		✓			✓	✓	✓
Own knowledge from education/training	✓			✓			✓	✓	
Projects, programmes, catchment groups			✓			✓		✓	
CRIs, universities	✓						✓	✓	
Conference, seminars, field trips, Field Days						✓	✓	✓	
Film, media, Country Calendar							✓		✓
Intergenerational knowledge		✓						✓	
National Databases e.g. Smap					✓			✓	
Social media						✓			

4.8 Societal values of soil

A final question in the interview invited participants to think more broadly about soil and to consider its value to society. A variety of topics were discussed ranging from the disconnect between soil and society, urban and rural communities – especially urban people and where food comes from, how internationally, New Zealand's soil are young and therefore generally still well-functioning but that we need to care more for our soils and ensure that the management of them is sustainable for future generations.

> I think having a society that's disconnected from soil, disconnected from a fundamental source of where our sustenance comes from, how we get to live, to be alive, then that's just not right, you're not going to be able to – it leads to all sorts of adverse outcomes. [SHV19]
>
> …retaining certain amounts of small areas of high-class soil in the city in urban spaces and in urban developments where people can locally produce… People have run out of space. [SHV06]
>
> I think there's a lot of disconnect between the urban and rural. There used to be a lot of city folk used to have uncles and family on farms, but a lot of it's gone now. Most folks want to be a part of bringing the urban folk back in so that we can all live and work and appreciate what each other does. Yeah. I think there's been a bit of government, you know, putting all these regulations on us and been a bit of urban, rural, divide really. I just want to be a part, to bring them back into the circle, that we're all in this together. [SHV17]
>
> I think if the public were more aware of the value of soils that would go a long way towards changing how we look at soils. And I think if a lot of people – if they understood the value of soil in terms of the services that it provides as in, the main one for me would be providing food, then I think if every family had their own garden to grow their own food, that would go a long way to alleviate the pressure on our food production systems. So I think in general a greater awareness of the value of soil within the general public. [SHV21]

Internationally, developing countries were thought to have a stronger appreciation for sustainably looking after their soils because they are more reliant on them. However, politics can greatly affect some countries and how they deal with a long history of contaminated soils:

> Yeah, I think in poorer countries where they're going to be a little bit more reliant on sustaining themselves, the more reliant you are on sustaining yourself the more you're going to think about soil. But if you don't have any – if food is something you just swap for money, then I can't see how you're really going to appreciate soil [SHV19]
>
> I think it's something that's – well, it's definitely a huge issue, especially in over-developing places like some parts of China and India, and even in the central South America and that. Possibly up in the United States. They're actually tracking surprisingly in a positive direction except for the glyphosate issue. Europe will always be Europe. That's a political quagmire and it always

> has been. And the soil has always been right in the middle of it. You've still got parts of Belgium that are horribly toxic from the First World War. [SHV15]

There was some hope that new soil policy by the EU and the FAO emphasis on the importance of soil would create more awareness of its role in society:

> I think there are glimmers of things changing. Like I know that the EU is just currently doing up their new soil policy and that's out for consultation now. And you've got FAO and other organisations trying to emphasise the importance of soil. So I think there are some international movements that are working towards trying to generate awareness and greater appreciation of the importance of soil. But yeah, I think it's that classic of, I think a lot of people just view it as dirt. [SHV25]

Finally, being connected to the land and soil is a requirement for interviewee SHV23's future lifestyle choice:

> … when I think about the future where I want to live or what I want to do – and knowing that age will affect that and your abilities, but yes, I want to be able to have access to land and soil. I want to be able to have greenery around me. I want to be able to walk on some – the ground, the grass or whatever easily. [SHV23]

5 Conclusions

Soil is a socio-ecological system that impacts people's individual and collective well-being; conversely, people also have a major impact on soil. Our research aimed to understand the plurality of soil values held across different industries, government, and community organisations in A-NZ. We interviewed 25 participants to whom soil matters to understand how they are connected to and value soil. We used an adapted Nature's Future's Framework (NFF) to analyse how these participants' express their intrinsic, instrumental and relational soil values. We showed that our participants assign multiple, co-existing values to soil, intertwining their livelihood, connection to place and people, intergenerational knowledge, cultural and spiritual values, and soil as a life-giving entity and provider of food and fibre.

While there are commonalities between Western-centric and Māori soil health values, they are based on different knowledge systems with their own tools, actions and approaches for sustainably managing soils.

In this research, there is a strong narrative that we live in a society where people are disconnected from soil, particularly urban people. While New Zealand could do more to educate people about the importance of soil and the multiple threats that exist for soils (such as contaminated land, urbanisation, and loss of high-class soils), everyday practices where people can touch and interact with soil are needed to provide opportunities for understanding its value. Comprehensive soil health and well-being policies that take a more holistic view of soils and bring together diverse backgrounds and knowledge

systems are urgently needed to ensure that soils are sustainably managed for future generations. These soil policies also need to integrate the plurality of soil values and knowledge from both Te Ao Māori and western soil science.

More targeted extension and educational material and activities about soil would help people to appreciate soil more and to understand the connection between food and soil, e.g. the concept of open-farms, community gardens and garden-to-table initiatives. In addition, encouraging people to grow their own food and to compost their food waste would lead to better health and well-being outcomes. Participants suggested that we need to think more broadly about how soil benefits society including its impact on nutrition, medicine and recreational activities such as fishing and swimming. A-NZ would benefit from having a national soil advocate to raise awareness of the importance of A-NZ's soil and to provide leadership on protecting, restoring, and sustainably managing it.

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