Soil Health in NZ; a personal journey

Matthew Taylor

Whakataukī (Indigenous Māori proverb)

Te toto o te tangata he kai, te oranga o te tangata, he whenua, he oneone

"While food provides the blood in our veins, our health is drawn from the land and soils“

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Introduction

Soil health is not a recent development but stems from the work of the giants on who's shoulders we stand:

By 1911 Bernard Aston had published the first of a long list of studies on the chemistry of bush sickness

"While food provides the blood in our veins, our health is drawn from the land and soils", Indigenous Māori proverb

Roadmap

What is soil quality monitoring?

Soil Quality to Soil Health in NZ

- Beginnings
- Soil Quality research
- SoE monitoring
- Beyond soil quality monitoring

What could Soil Heath monitoring look like?

What is soil quality monitoring?

Measuring **how well soil does what we want it to do**

- The suitability of soil for its use.
  - No one property can describe soil quality
  - Targets and limits

Need to balance multiple and sometimes conflicting soil uses/services

- e.g. productivity and environmental protection
  - Tradeoffs

Soil quality is connected to biota (especially plants), air, groundwater and surface water quality

Compare: **Soil health is the condition of the soil and whether the soil has been degraded**, i.e. the multifunctional capacity of the soil system to deliver all its functions

Context: why we have soil quality monitoring in NZ

Need for evidence for State of the Environment National reporting

- Evaluating the effectiveness of planning and implementation
- Environmental protection

Need to provide early warning of emerging issues and contamination

Overseas (USA, Ireland).

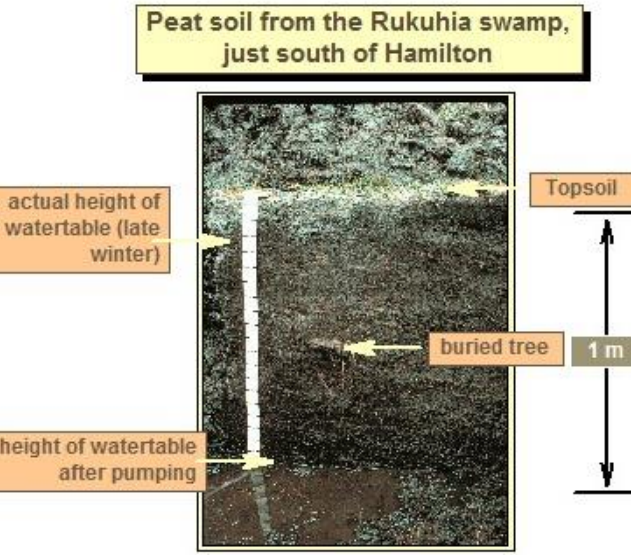
Providing for sustainable agronomic intensification and promotion of socio-economic well-being.

"sustainable intensification"

- ➢increases in outputs
- ➢finite inputs

Inherent and dynamic soil properties

- Inherent soil quality properties are not feasible for human change
- Give the suitability of a soil for a particular purpose



Dynamic factors
Note interactions between factors

- Compaction
- Excessive nutrients
- Loss of soil organic matter
- Soil acidity
- Stability/erosion
- Contamination
- Biological activity

My soil health journey: Start

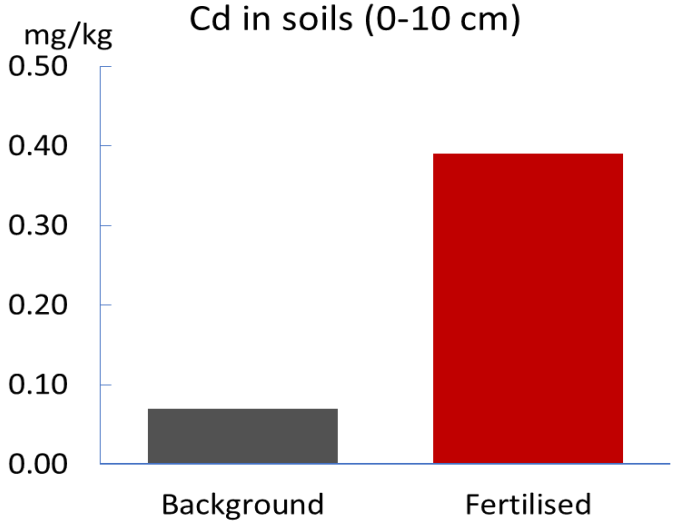
- 1st year science and health technology were combined
  - Applied focus
- Soil Bureau survey work

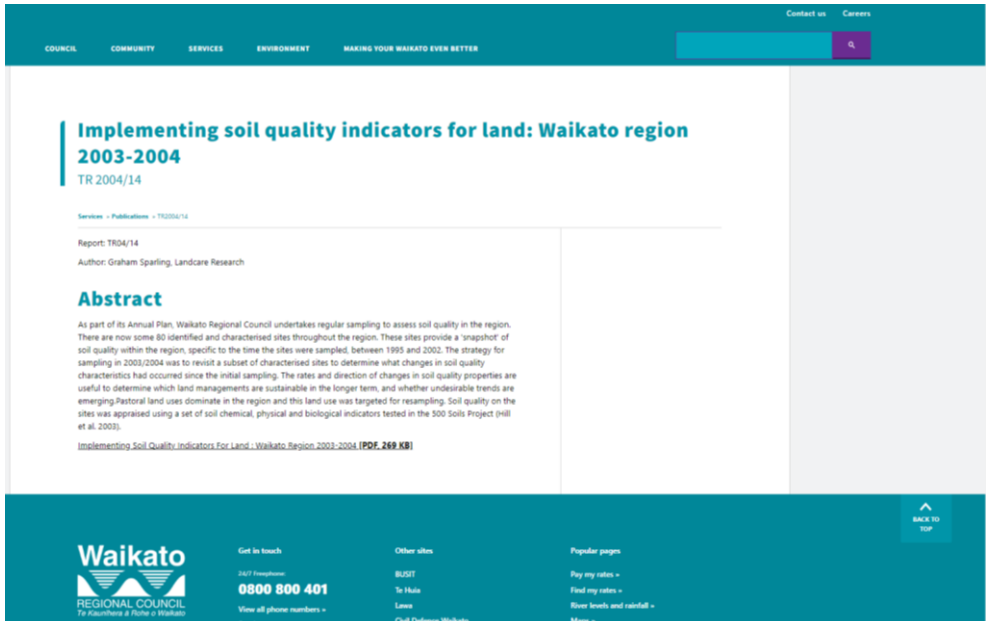
Soil Quality research – DSIR Soil Bureau/Manaaki Whenua Landcare Research

- Problem: There was a lack of nationally consistent or scientifically based soil quality monitoring data for New Zealand
- Initial conversations and development of the concept by Graham Sparling and Louis Schipper ~ 1994
- First field samples in 1995

Research and transition to RC phases

1. Sustainable Management Fund Research Projects
   a) 5001, Trialling Soil Quality Indicators for State of the Environment Monitoring (1997/98)
   b) 5089, Implementing Soil Quality Indicators for Land (1998-2001).
2. Concurrently, devolution of environmental management from central to regional government
   a) Required to report on the State of the Environment



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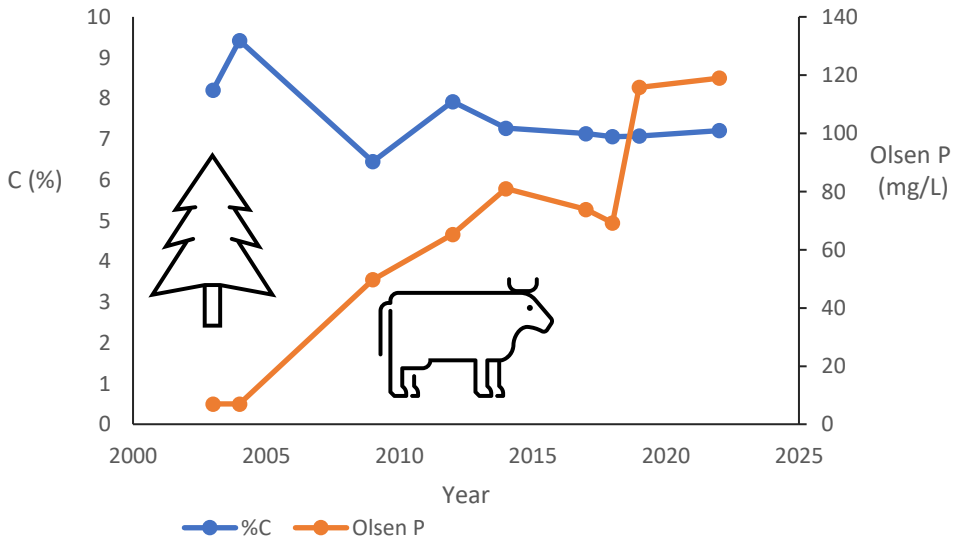
From research programme to monitoring programme

1. Regional Council's need to monitor
2. **The Land Monitoring Forum**
   a) National body of regional council soil and land scientists
   b) To coordinate and enable consistency across regions
      i. Initial manual
      ii. Reviews of target ranges
      iii. Contribute to the National Environmental Standard (soil quality)
      iv. Further development



How is soil quality currently assessed in NZ

- New NEMS – Consistent Methods, how we do it
- Seven soil characteristics are measured: total carbon, total nitrogen, mineralisable nitrogen, acidity, plant-available phosphorus, bulk density and macroporosity.
- As, Cd, Cr, Cu, Pb, Ni, Zn and total F are also specified in the NEMS
- Assessed under various land uses, e.g. native, forestry, cropping, horticulture, pasture.
  - Targets for each land use

Soil State of the Environment reporting

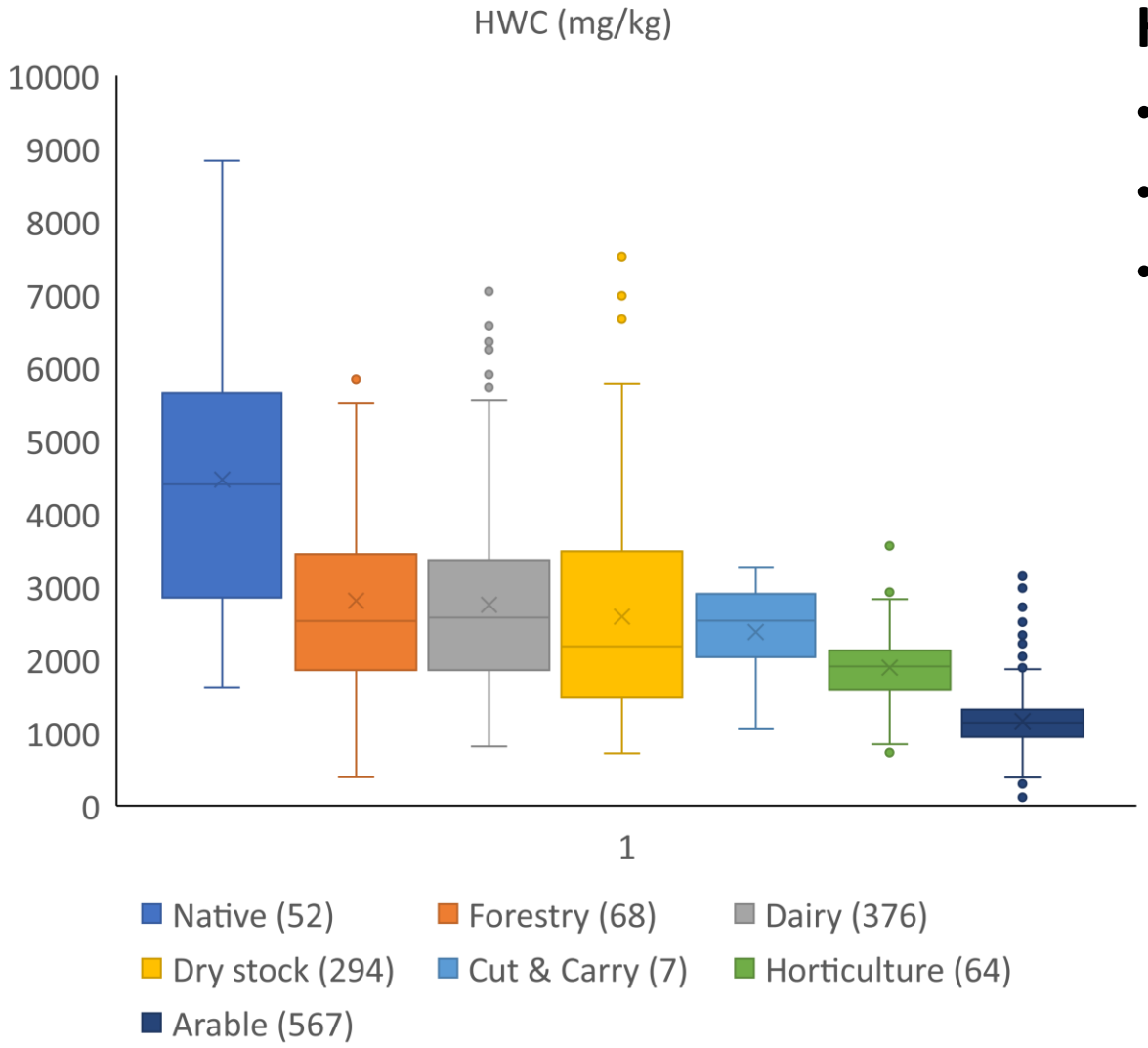
1. There is a balance between soil functions for productivity, environmental quality, plant and animal health, etc.
   a) Monitoring variables need to
      i. Be a measurable property.
      ii. Respond to change in a soil function, service or process.
      iii. Be stable enough for change to be associated with a specific soil function, service or process but responsive enough to show change within a manageable period.
      iv. Have definition of what is “good”.

2. Soils with good soil quality (or soil health) have strong resilience to external pressures.

3. No one property alone can describe a soil’s state.

4. Issue for a democracy, access to private property.

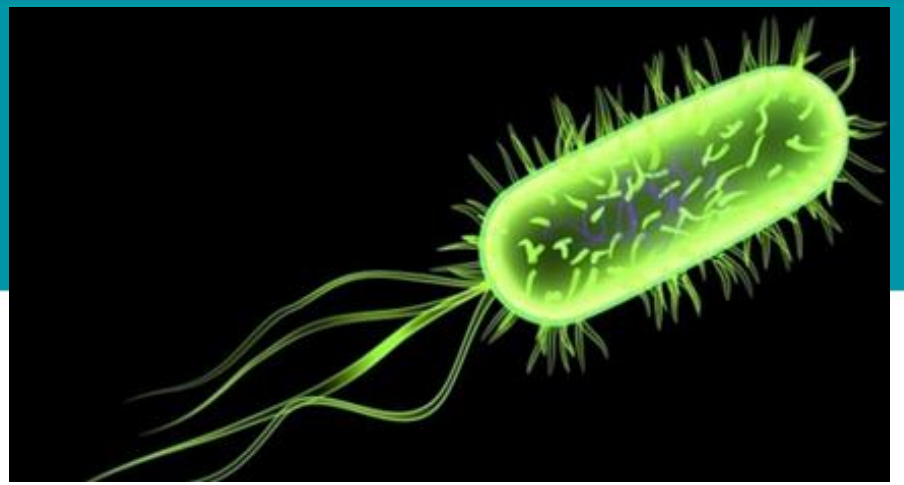
Beyond “soil quality monitoring”: Adding new variables

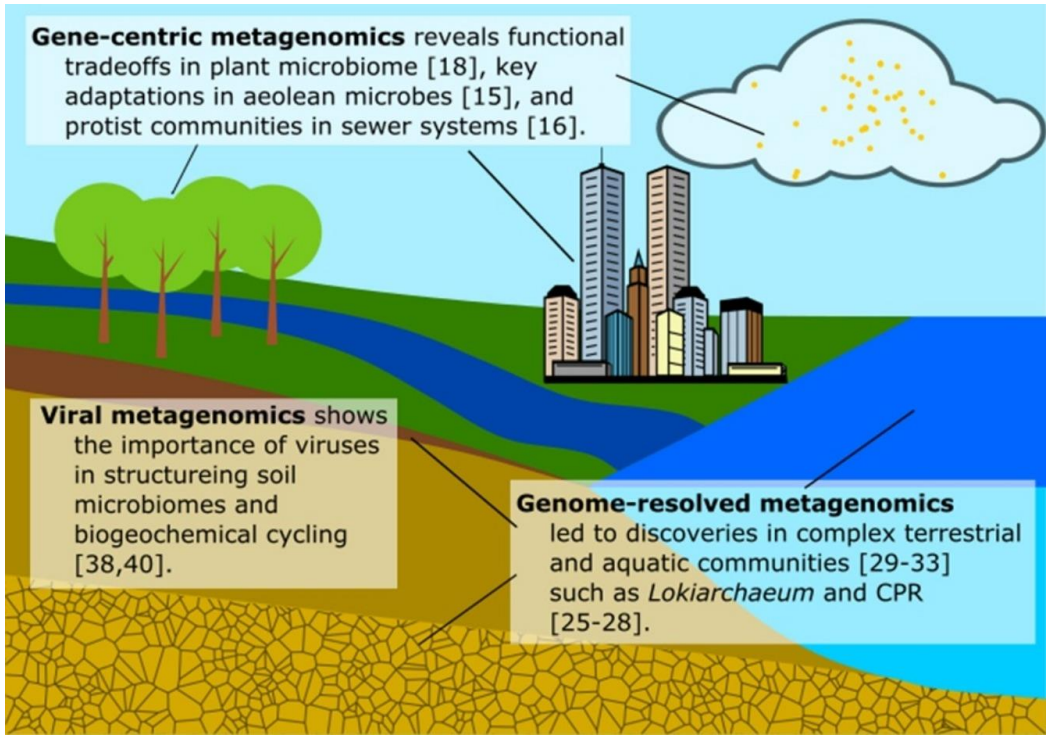


Hot water extractable C and N

- HWC is an integrated measure of soil biochemical quality.
- HWN as a measure of mineralisable N
- LMF have provisional targets

- eDNA
  - Microbial community and genomics assessment
  - Earthworms





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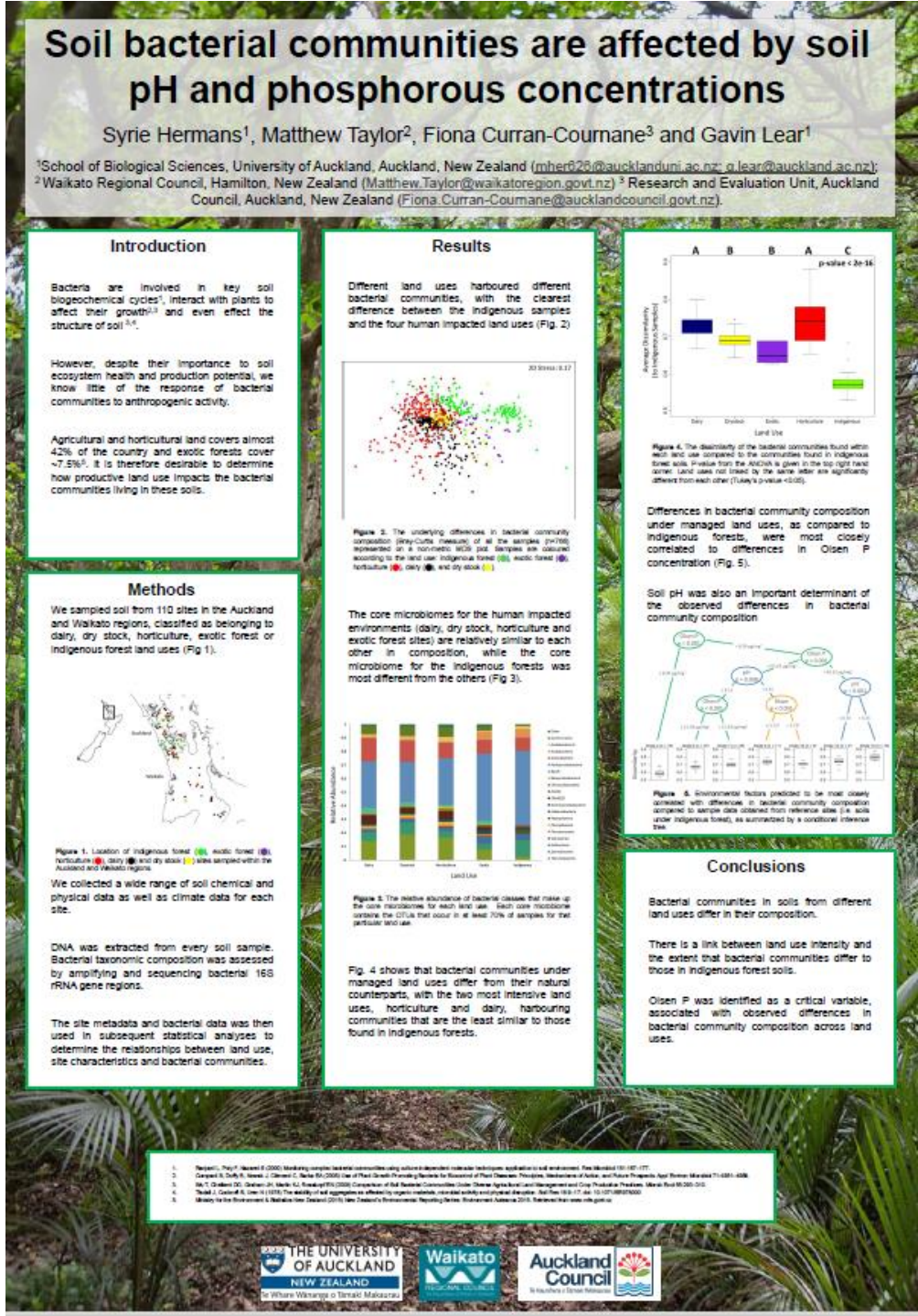


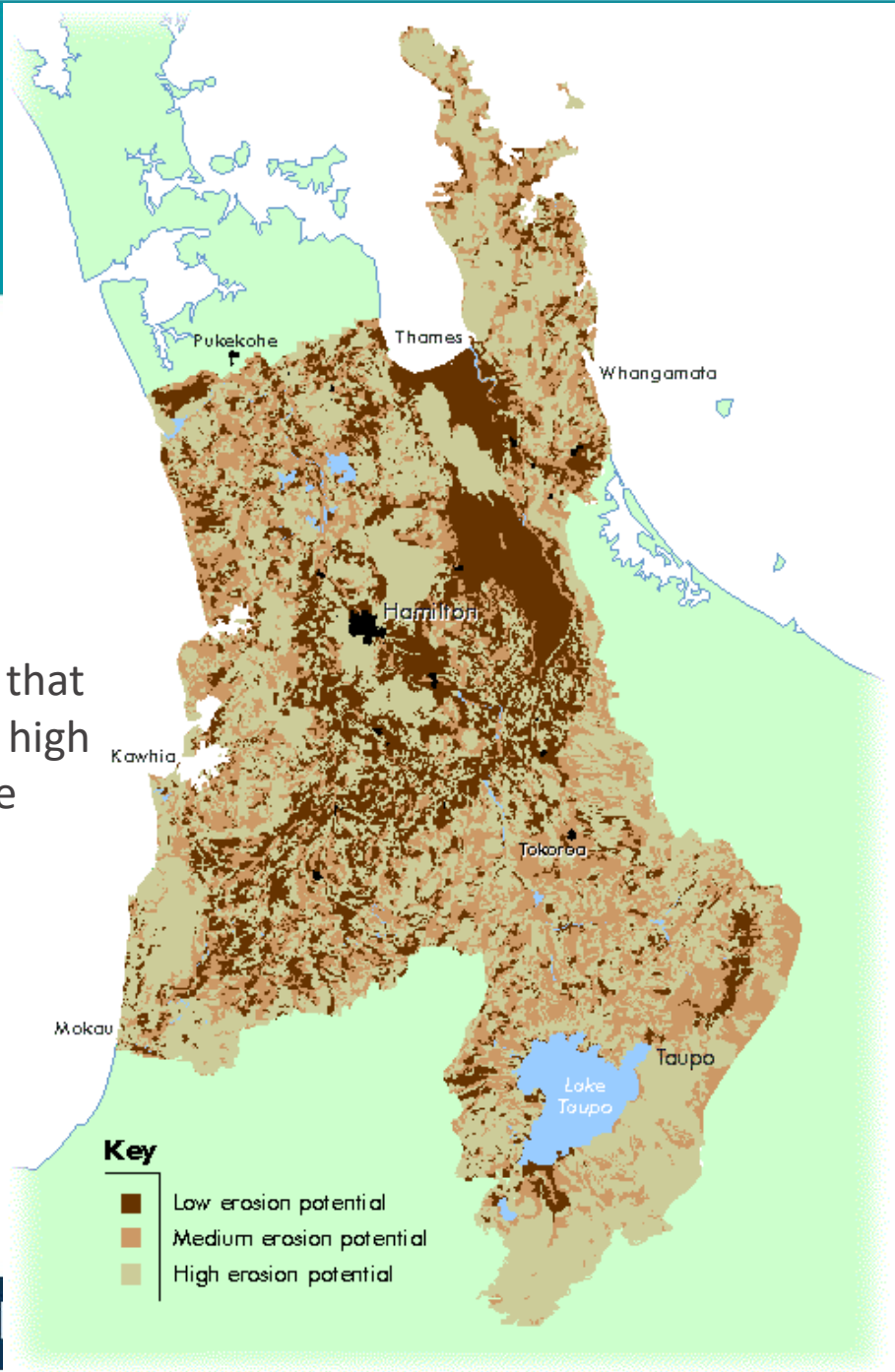
Beyond “soil quality monitoring”: Current research

- Pesticide Residue Research
  - Auckland University/Plant & Food Research
- Emerging Contaminants Research
  - Microplastics
  - Antimicrobial resistance
- Erionite (similar props to asbestos)

Beyond “soil quality monitoring”:Other monitoring

- Soil stability and erosion
  - Riparian survey

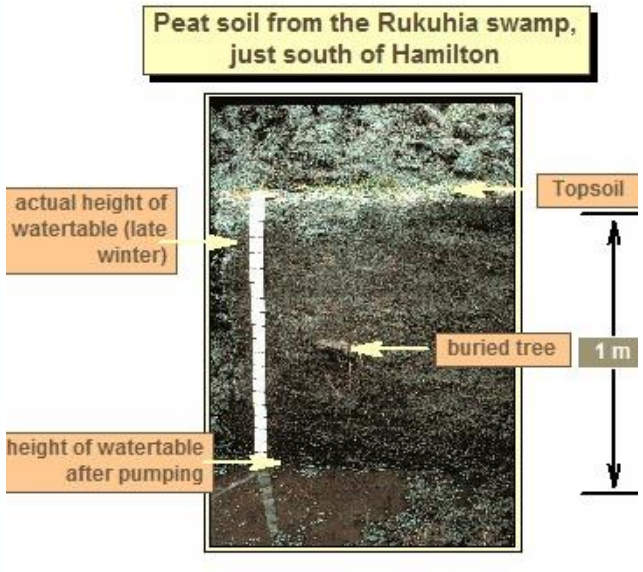
This map shows the areas that have a low, moderate and high potential for erosion in the Waikato region.



Land resource information derived from the New Zealand Land Resource Inventory (NZLRI) database maintained by Landcare Research NZ Limited. COPYRIGHT RESERVED.

Beyond “soil quality monitoring”:Other monitoring

- Carbon and Green House Gas
  - GHG regional inventory
  - Organic soils
    - Current extent
    - Quality
    - Waikato peatlands cover approximately 94,000 hectares and contain about 2,700 million cubic metres of peat.



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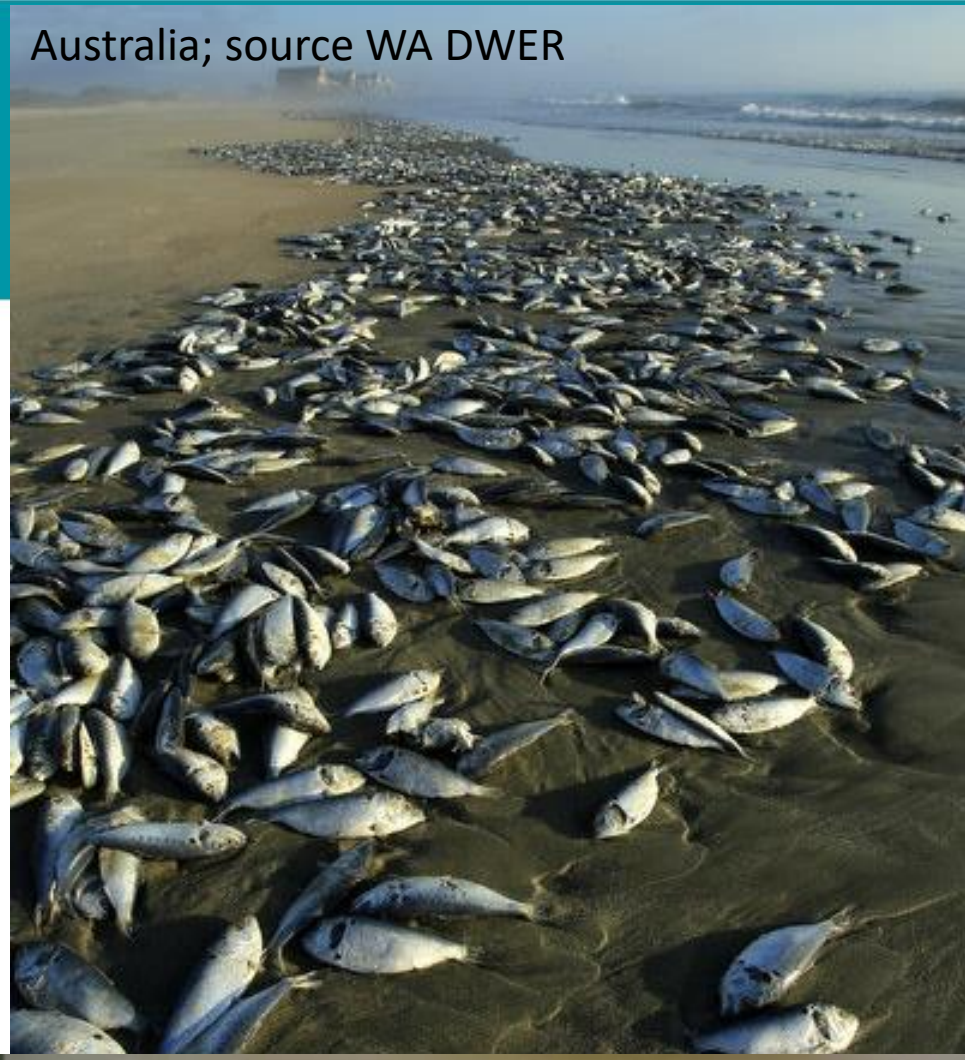
Beyond “soil quality monitoring”: ASS

- Soil acidity
  - Not topsoils
  - Acid sulphate soils
    - Marine sediments
    - Buried ~ 2 m down

Australian Acid sulphate soil (source WA DWER)



Australia; source WA DWER

Soil Health Research: Current

1. **Manaaki Whenua Landcare Research project 'Soil health and resilience: oneone ora, tangata ora',**
   a) To support the development of a longer-term and more comprehensive view of soil health and resilience; and to develop an integrated soil health framework that can be used by a wide range of end-users.
   b) The ongoing capacity of soil ecosystems to maintain the services they provide is fundamental to our well-being.

What will Soil Heath monitoring look like?

- A relative rating that depends on the suitability of the soil for its actual use only.
- Deviation from an ideal soil with ideal properties.

However, soil health depends on who the health is for!

Soil health from different points of view:

Specialised organisms

- Only grow in specialised environments
- Low level of biodiversity

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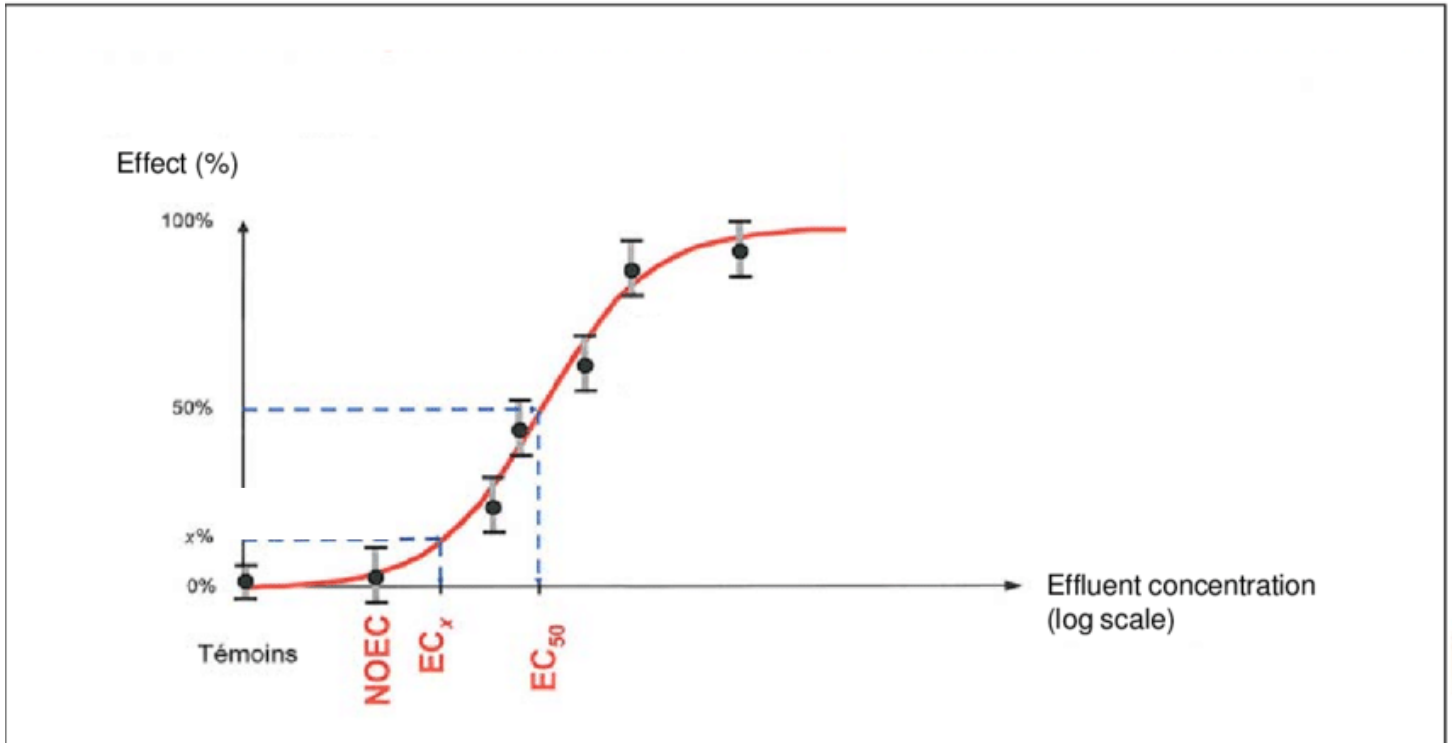
Soil health from different points of view:

General ecology

- Most soil and organisms can thrive
- Biodiversity

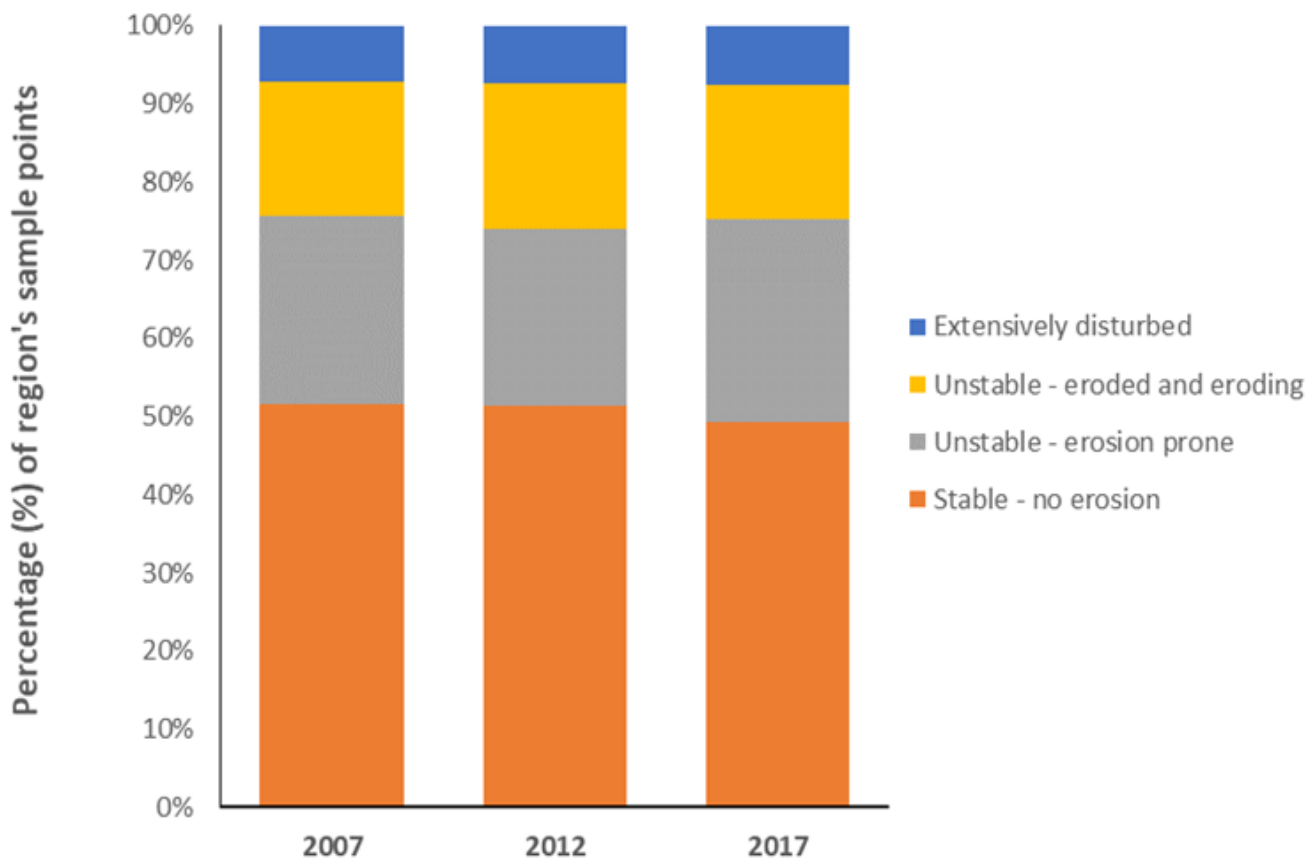


Soil health from different points of view:

Production
(and air health)

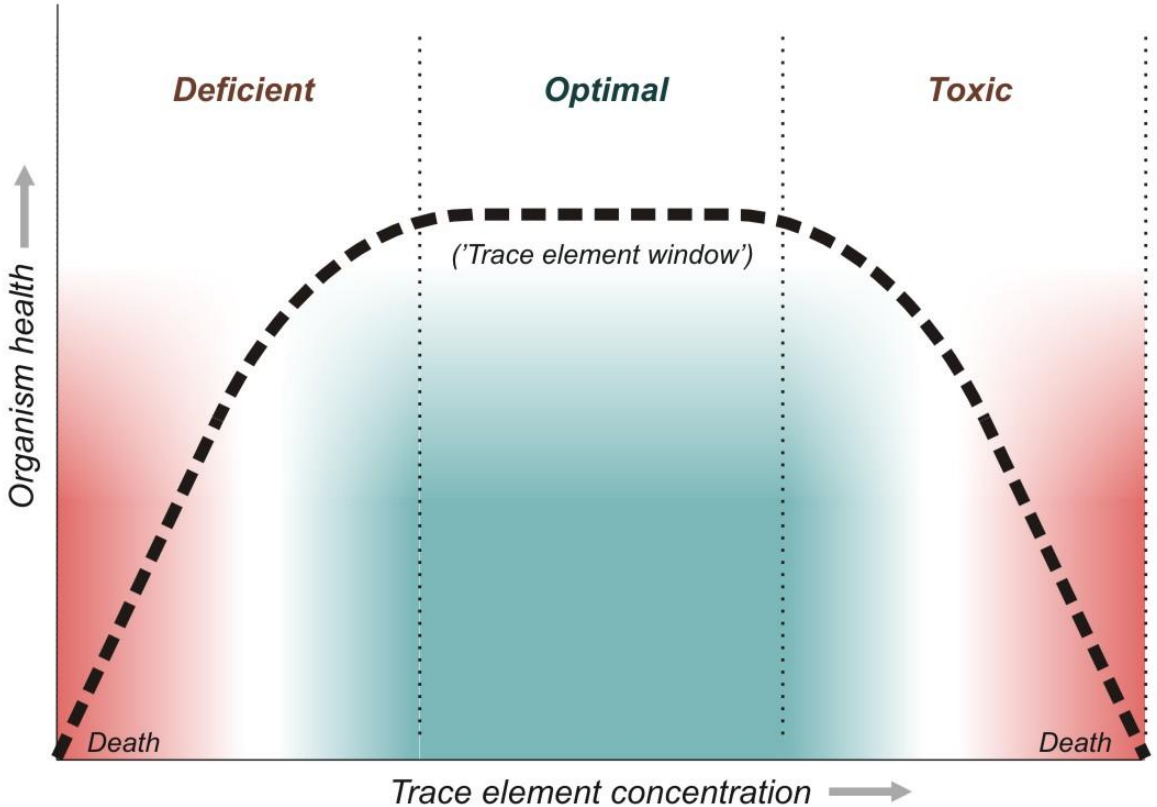
Soil health from different points of view:

Stability



Soil health from different points of view:

Nutrient management



Soil health from different points of view:

Water Quality
Contaminant treatment

Soil health from different points of view:

Structure

Soil health from different points of view:

SOM
GHG

Soil health from different points of view:

Contamination

- Loss of production
- Loss of biodiversity

Geothermal soil

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How to consider ash from active volcanoes?

Earthquake

Climate change

Growing bananas in New Zealand's South Island and 4 banana varieties to try

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Considerations for Soil Health monitoring

All is connected

a) Soil health impacts biology, water and air health
b) First nations and other native people have useful perspectives
    i. "Indigenous Māori perspectives of soil (oneone) and soil health incorporate the indivisible connection between the wider environment (taiao), ecosystems, and human health“ - Garth Harmsworth.
    ii. There is an ancestral lineage that links humans to all other organisms (down to microbes), through an intricate hierarchical web.
    iii. Long-term and multigenerational
    iv. All environmental domains are connected and related personalities

Soil Health monitoring: what we need

A balance between soil functions for productivity, environmental quality, and plant and animal health (including microorganisms)

- Multiple variables to allow assessment for different needs and veiwpoints
- Monitoring variables need to
    i. Be a measurable property
    ii. Respond to change in a soil function, service or process.
    iii. Be stable enough for change to be associated with a specific soil function, service or process but responsive enough to show change within a manageable period.

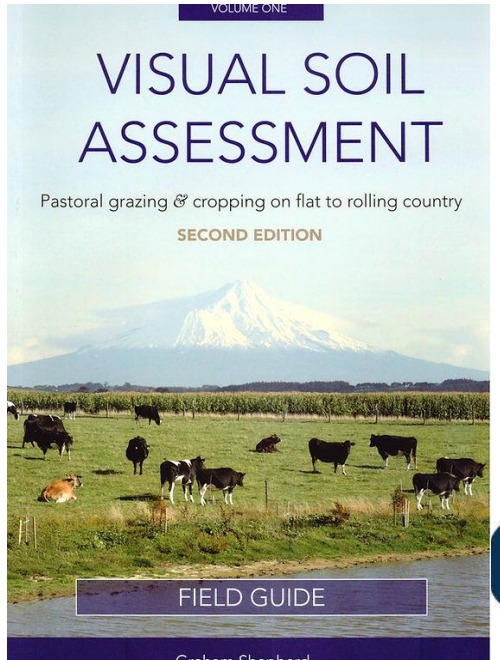
Physical indicators could include:
•soil bulk density
•macroporosity (which relate to compaction)
•soil aggregates which help to determine soil structure

Chemical indicators could include:
•pH,
•nutrients/fertility
•trace elements and pollutants

Organic matter and biological indicators could include:

- total organic carbon (C) and nitrogen (N),
- mineralizable nitrogen (as a surrogate for microbial biomass)
- measures of labile or soluble carbon and nitrogen (such as hot-water extractable C and N).
- abundance and diversity of microbes and other soil biota such as worms (difficult to measure, variable over time or difficult to interpret)
- soil food web interactions
- pests and undesirable biota

Visual Soil Assessment



How many soil scientists does it take to auger a hole?

Thanks