

Quantification and Valuation of Soil Ecosystem Services and Future Use in Resource Management



NEW ZEALAND
ASSOCIATION OF
RESOURCE
MANAGEMENT

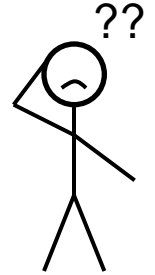


Layout

1. Soils, Value and Ecosystem Services
2. A Framework for Quantifying and Valuing Soil Services
3. Implementation of the Framework: Example and Results
4. Use of the Concepts in Resource Management

The Challenge of Valuing Soils

Differences in productive capacity \longrightarrow Land values
Carrying capacity? Versatility? Soil quality indicators?

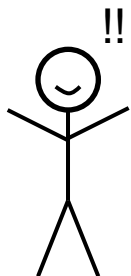


The **other roles** of soils play are not valued: **No holistic value!**

→ We need to value the **multi-functionality** of this scarce resource to include it in **decision making** to achieve land use **sustainability**.



Is the Answer in the Concept of Ecosystem Services?



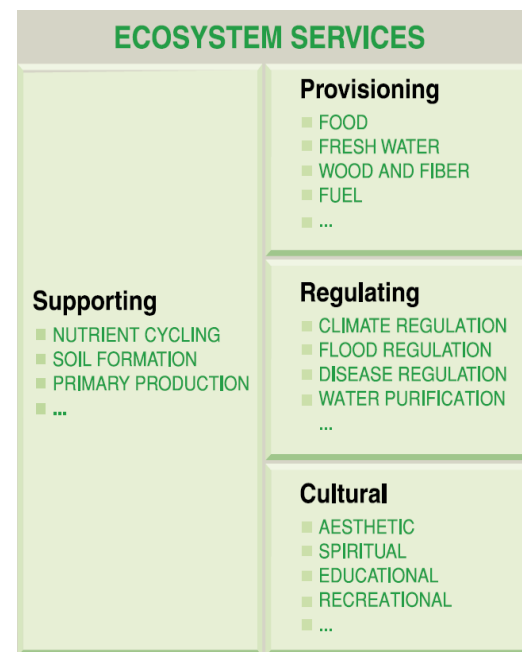
Millennium Ecosystem Assessment (2005):

- Introduced **ecosystem services** and the **different roles** of ecosystems
- Number of **limitations** and has been **heavily criticized**

Ecosystem services = “the benefits people obtain from ecosystems” (MEA, 2005)

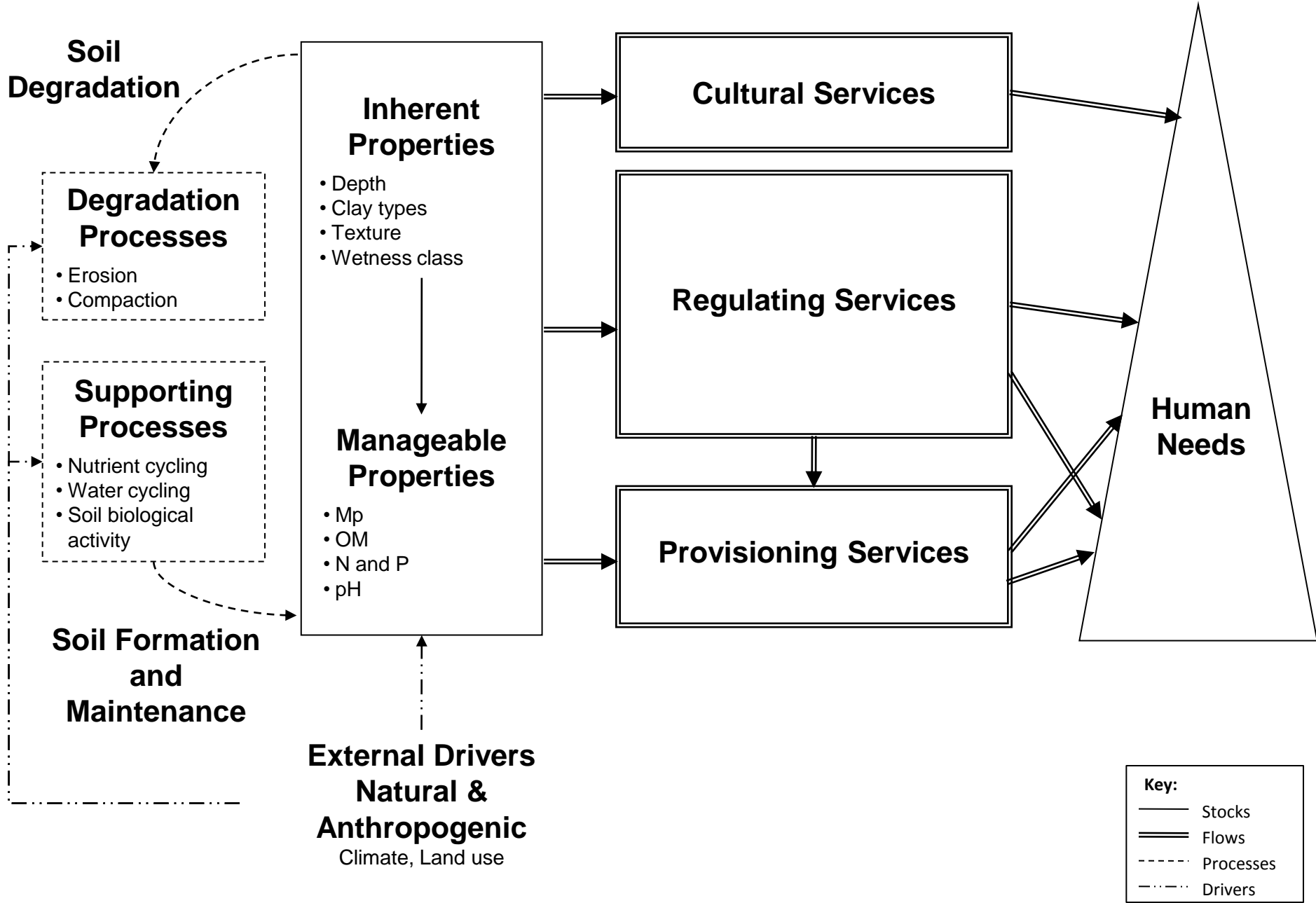
New framework to:

- Address the **limitations of the MEA** framework:
- Use **soil science knowledge** within ecosystem services frameworks to **inform land management**.



Soil Natural Capital

Soil Ecosystem Services



Soil Ecosystem Services

Soil Ecosystem services

→ “the beneficial **flows** arising from natural capital stocks and fulfilling human needs”

Provisioning Services:

- Provision of **food** (quantity and quality)
- Provision of **physical support** to human infrastructures and farms animals
- Provision of **raw materials**

Regulating Services:

- **Filtering** of nutrients (N and P) and contaminants
- **Flood** mitigation
- **Recycling** of wastes and detoxification
- **Carbon** storage and **regulation** of N₂O and CH₄ emissions
- **Biological control** of pests and diseases

Cultural Services:

- **Aesthetic** experience
- **Spiritual** enrichment (Earth sacredness)
- **Recreation**
- **Cultural uses**: bury the dead, building material, cook food (Maori hāngi) ...

Implementation of the Framework

Two different soil types:

- **Gley** soil, poorly drained: Te kowhai silt loam
- **Allophanic** soil, well drained: Horotiu silt loam

Horotiu silt loam



Soil properties (10 cm)	Horotiu silt loam	Te Kowhai silt loam
Bulk density	0.84	1.1
Total C (%)	5.5	2.5
P retention (%)	91	26
K sat (mm/day)	86	30
Field capacity (mm) (50 cm)	228	214
Wilting point (mm) (50 cm)	114	135

Te kowhai silt loam



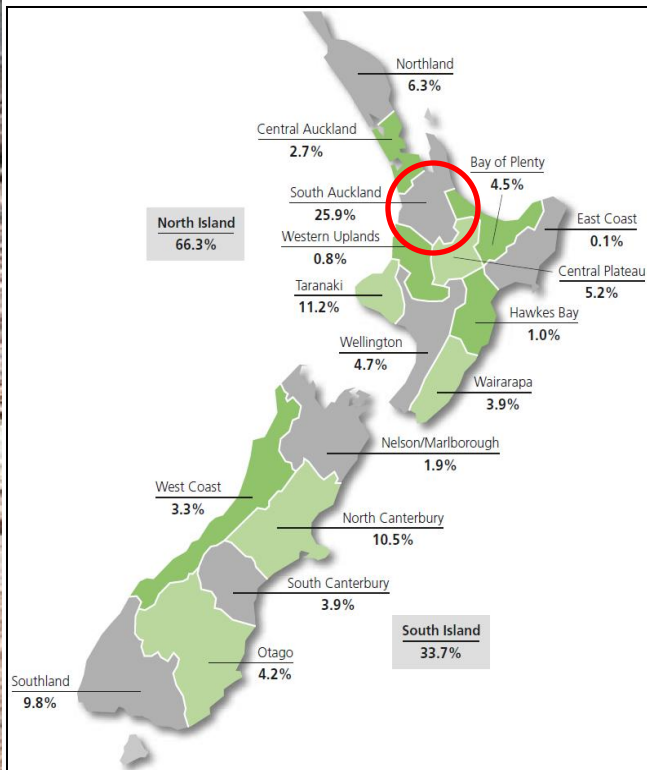
Case Study at the Farm Scale

A Waikato Dairy Farm: 110 ha, flat-rolling land

- 26% of NZ dairy cattle

Three stocking rates: 3, 4 and 5 cows/ha

Two different management of cattle treading: with and without a standoff pad.



Material and Methods

1 Quantification of the soils services :

- New definition of the services based on what soil does,
- Construction of proxies to measure each service,
- Modelling of the proxies daily for 35 years for each scenario.

SPASMO: Soil Plant Atmosphere Simulation Model
with additional functionality



OVERSEER[®] nutrient budget



2 Neo-classical economic valuation :

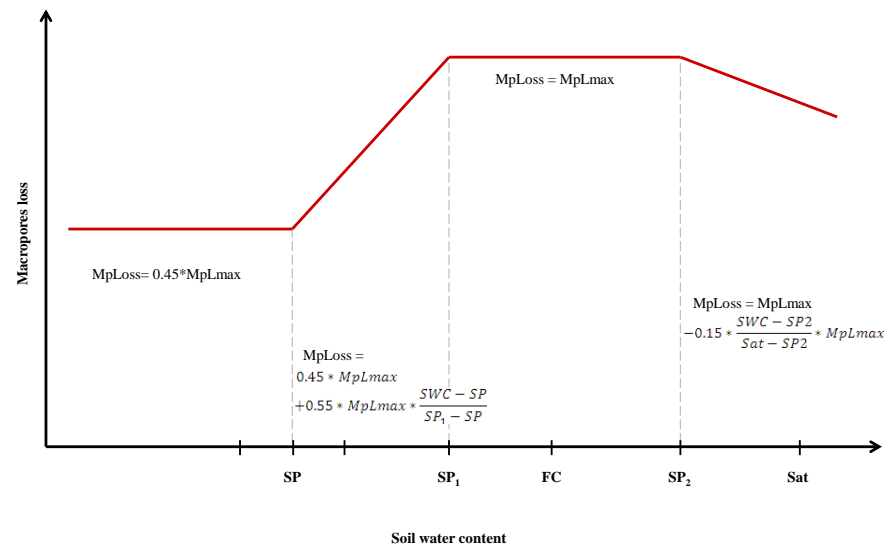
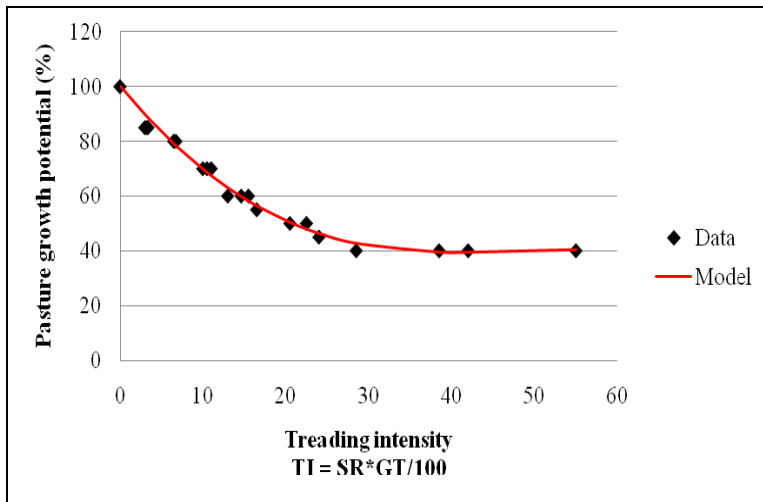
Economic value of each soil service in NZ\$/ha/yr.

Techniques used: Market prices, Replacement costs, Provision costs,
Defensive expenditures.

(Annualised construction costs, Annual maintenance costs, Market prices)

Functions added in SPASMO

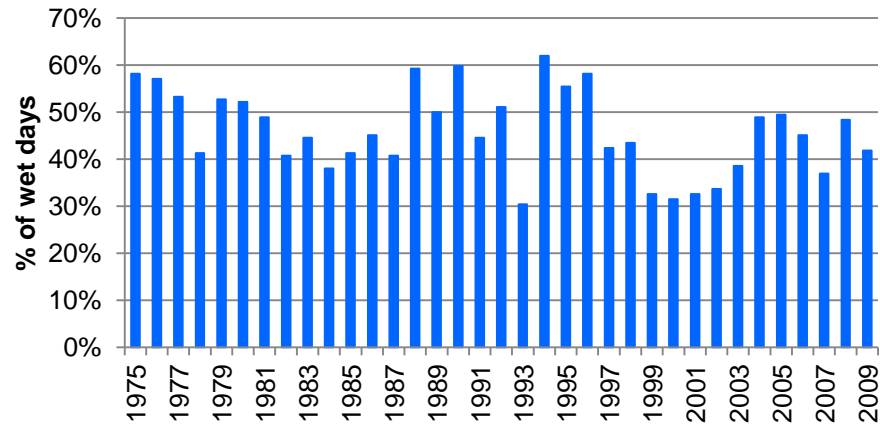
- Impact of a degradation process **cattle treading** on soil **Mp** and **pasture growth** including recovery,
- Macropores loss $f=(SWC)$
- Pasture utilisation $f=(SWC)$
- Cattle rotation: Use of a standoff pad $f=(SWC)$



Provision of Support to animals

1 Quantification:

- Model **SWC** with SPASMO.
- Calculate the number of days between May and October when $SWC > FC = \text{Wet Days}$
- Quantify the service for each year: $\text{Support} = 184 - \text{WD}$



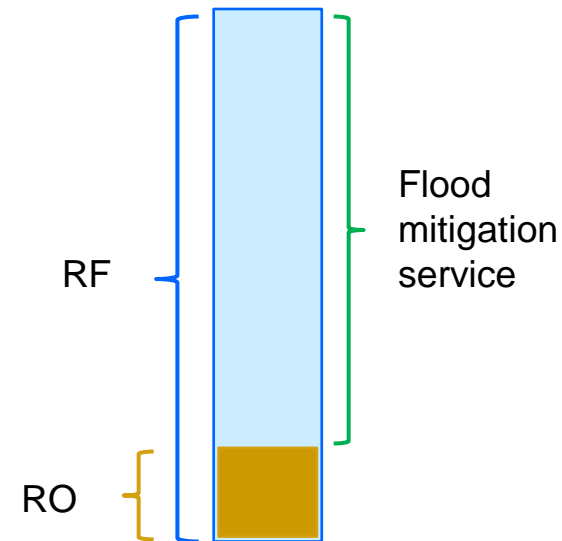
2 Valuation:

- Use the **provision cost** method.
 - Calculate size, construction and maintenance costs of a standoff pad (NZ\$/ha/yr)
 - Apply it to the number of days the cows have to be on the pad.
- Annualised construction costs + maintenance costs

Flood mitigation

1 Quantification:

- Model runoff and soil water content with SPASMO.
- Quantify the service for each day:
Rainfall (RF) - Runoff (RO)
→ Water stored by the soil (mm/ha/yr)



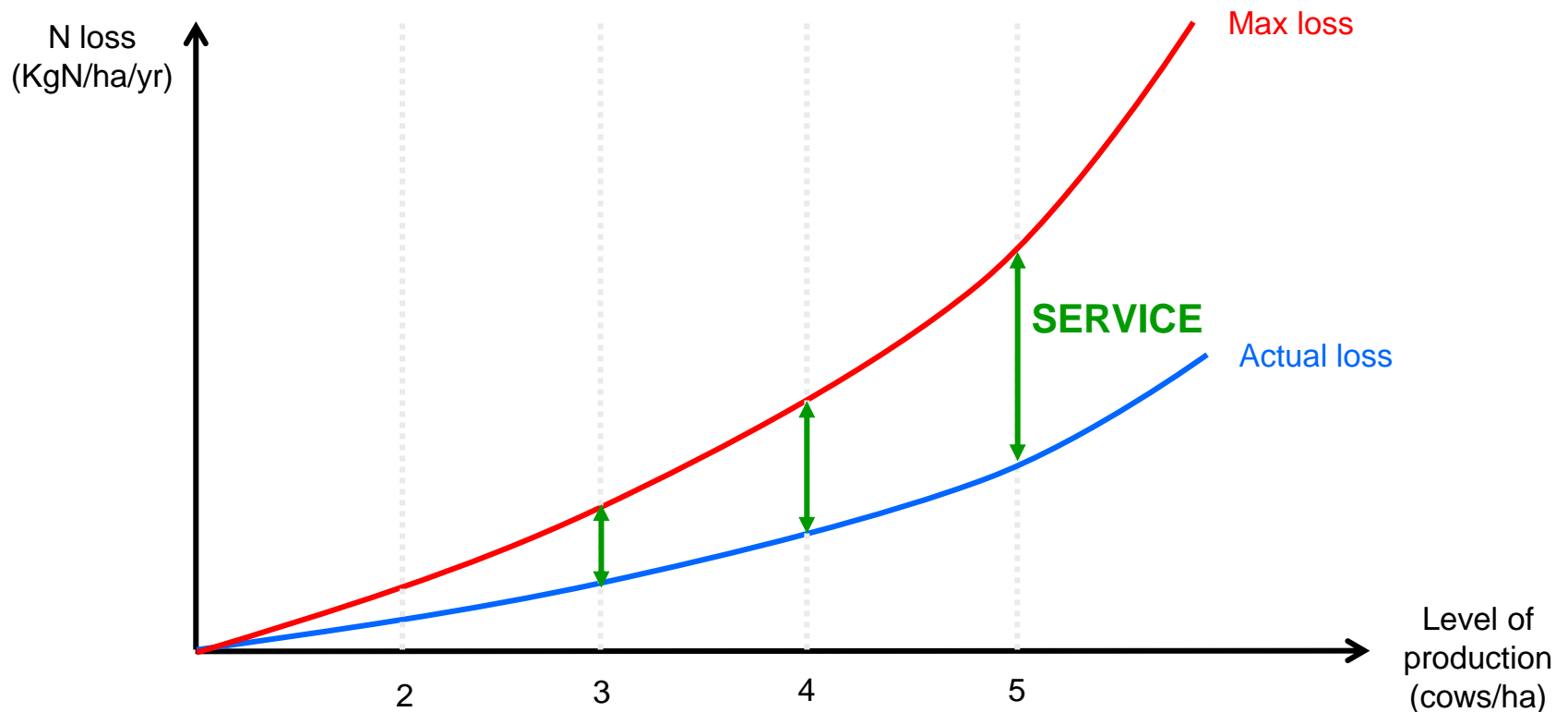
2 Valuation:

- Use the **provision cost** method.
 - Calculate the maximum amount **of water stored** by the soil for **7 consecutive days**
 - Calculate the **size and costs dams** needed to stored that water on farm.
- Value of flood mitigation (NZ\$/ha/yr)

The Filtering of N

1 Quantification:

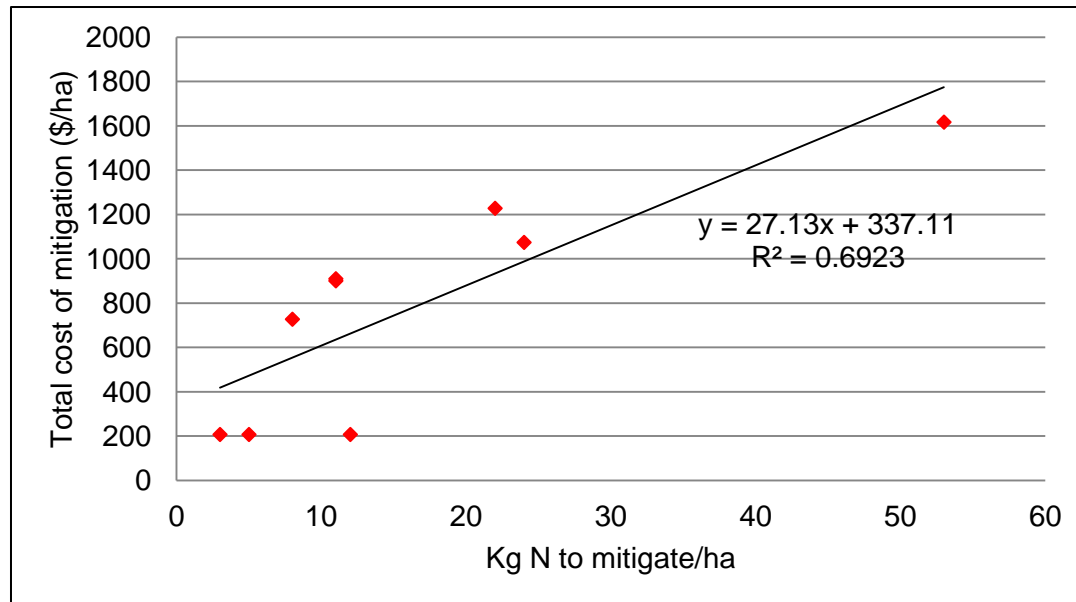
- Model Max and Actual **N losses** with SPASMO
- Quantify the service for each year: Max loss – Actual loss (kg N/ha/yr)
→ Defines the amount of N that is retained by the soil



The Filtering of N

2 Valuation:

- Use the **defensive expenditure method**.
 - Built a **mitigation function** with OVERSEER[®] using the costs and effectiveness of 3 mitigation techniques: standoff pad, low N supplements and nitrification inhibitors: \$/kgN to mitigate.
- What it will **cost to mitigate what the soil is currently retaining**.
- Apply it to the measure of the service → Value of the filtering of N



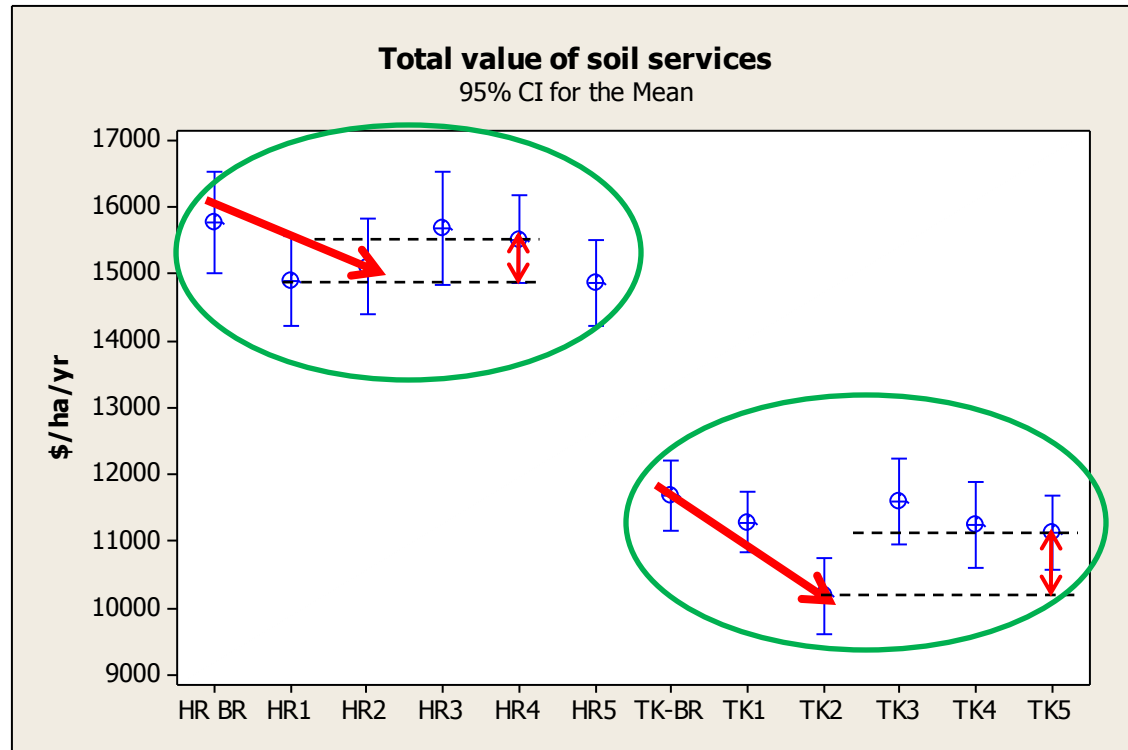
Horotiu silt loam, 3 cows/ha, no pad, 100 kg N/ha

Soil services		Average value of service (NZ\$/ha/yr)	
Provisioning	Provision of food Quantity	4,155	
	Provision of food Quality	38	
	Provision of support for human infrastructures	17	
	Provision of support for farm animals	112	
	Provision of raw materials	NC	
		4,322	27,4 %
Regulating	Flood mitigation	1,196	
	Filtering of N	554	
	Filtering of P	2,924	
	Filtering of contaminants	6,513	
	Recycling of wastes	78	
	Carbon flows	-36	
	N ₂ O regulation	15	
	CH ₄ oxidation	0.47	
	Regulation of pests and diseases populations	210	
		11,454	72,6 %
Total		15,777	100 %

→ Value of **regulating services** is much **greater** than value of the **provisioning services**

→ Value of the land, infrastructures and shares: NZ\$45,000 – 50,000/ha

12 scenarios: Impact of Management



→ Total value of soil services is **significantly different** between the 2 soil types.

→ Total value of soil services **decreased** when stocking rate **increased**.

→ Use of a standoff pad shows **different thresholds** for the maximisation of the provision of services for the 2 soils.

Link Policy Development directly to Natural Resources

- **Nutrient discharge allowances** for new dairy farms
- **De-couple policy** from existing land uses and activities,
- Link directly to land,
- Basis for “defining **property rights**” (limits /thresholds)



	LUC I	LUC II	LUC III	LUC IV	LUC V	LUC VI	LUC VII	LUC VIII
Year 1 (when rule comes into force) (kg of N/ ha/year)	32	29	22	16	13	10	6	2
Year 5 (kg of N/ ha/year)	27	25	21	16	13	10	6	2
Year 10 (kg of N/ ha/year)	26	22	19	14	13	10	6	2
Year 20 (kg of N/ ha/year)	25	21	18	13	12	10	6	2

Reproduction of Table 13.2 from Horizons **Regional Council's proposed One Plan** showing the proposed nutrient discharge allowances as a function of Land Use Capability Class.

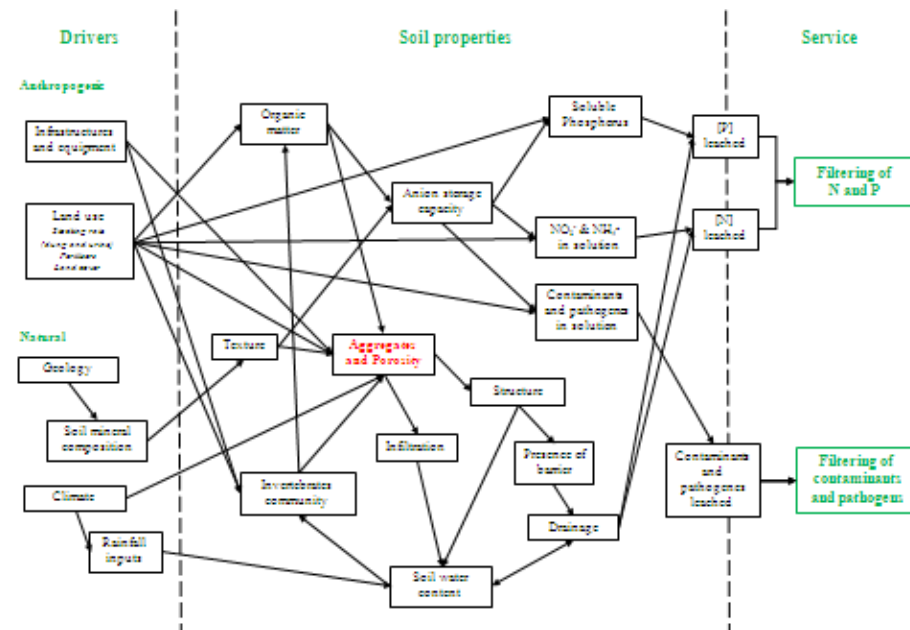
National State of Environment Report

- Enables **aggregation** of indicators (e.g. soil quality indicators)
- Quantification of the **net change** in Natural Capital stocks through change in ES
- Links to other **Environmental indicators**
(e.g. Erosion, land cover use, soil health, land to water)
- Explore the **relationship between indicators**
(e.g. Soil and water quality threshold-limits)



Soil quality Indicators

Macroporosity
Total N
Total C
Olsen P
pH
Min. N



Existing Policy Development and Evaluation

- **Extend** existing analysis & evaluation in sustainable land management
- Evaluate **soil conservation**: compare costs of implementation to benefits on the value of soil services
- Add the change in ES from soil erosion, to **downstream benefits** of limiting soil erosion.



Base for Future Resource Management

Exploring resource utilisation by land use and practices

- New insights into the current use of our natural resources
“Value of current land uses”
- Inform the debate on nature resource use into the future
“Land is a finite resource”

Guide future investments in Ecological Infrastructure

Land development towards “anthropogenic pedogenesis”





Thank You!



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