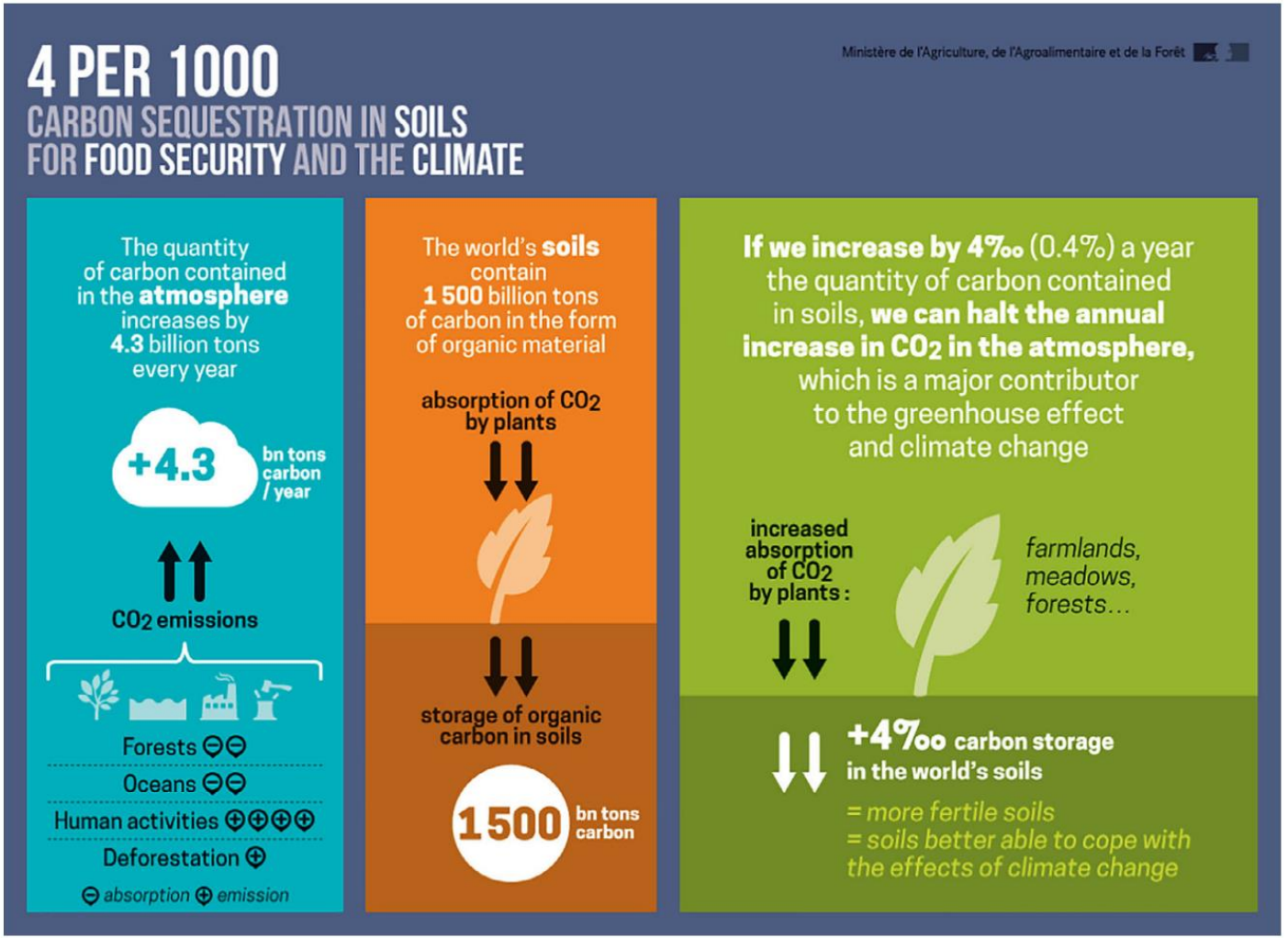
Manaaki Whenua
Landcare Research

MANAAKI WHENUA – LANDCARE RESEARCH

Soil carbon

Soil facts

- Top 1m of world's soil contains approx. 1,500 Pg C
- That's 1,500,000,000,000 t……..
- About 3 times that in the vegetation
- About twice that in the atmosphere
- How do we get more?
- Can we offset the 4.3 bn tons of annual emissions?

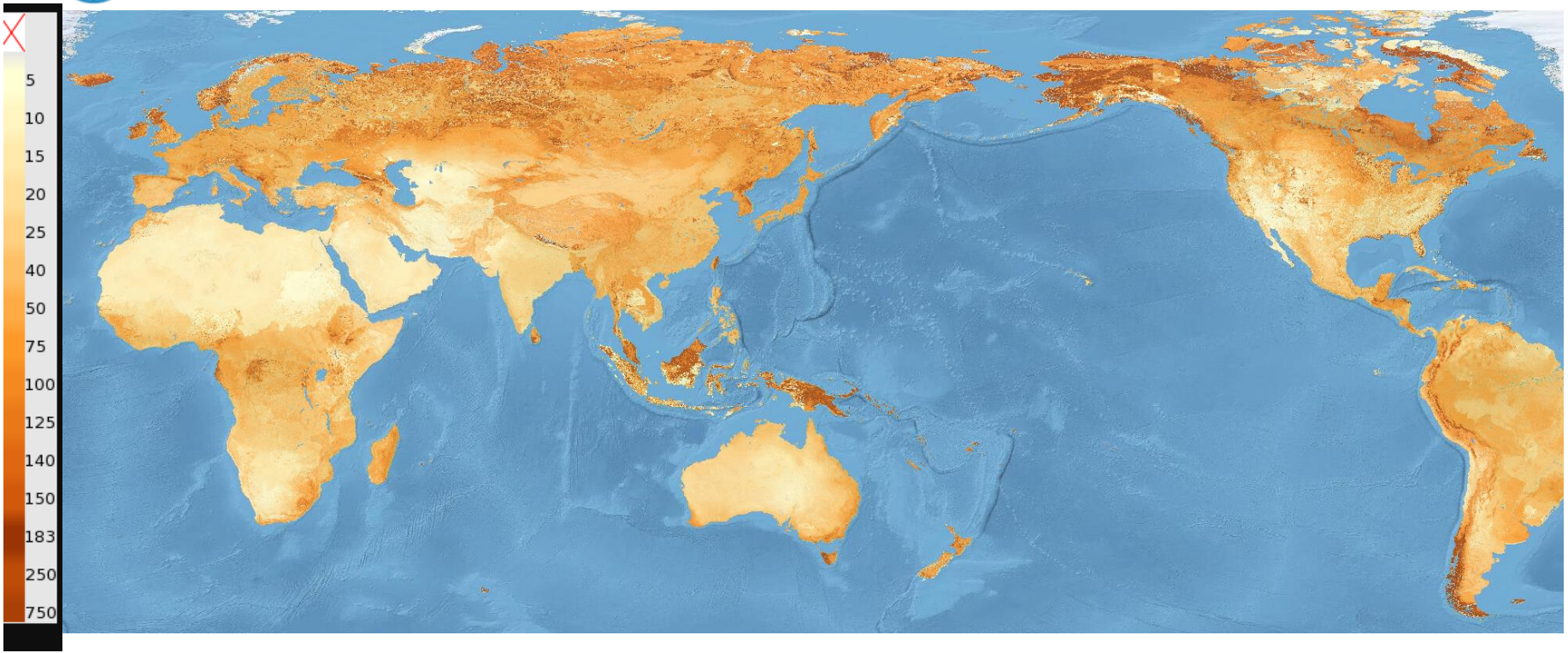


Dec 2015
COP 21

Global soil carbon

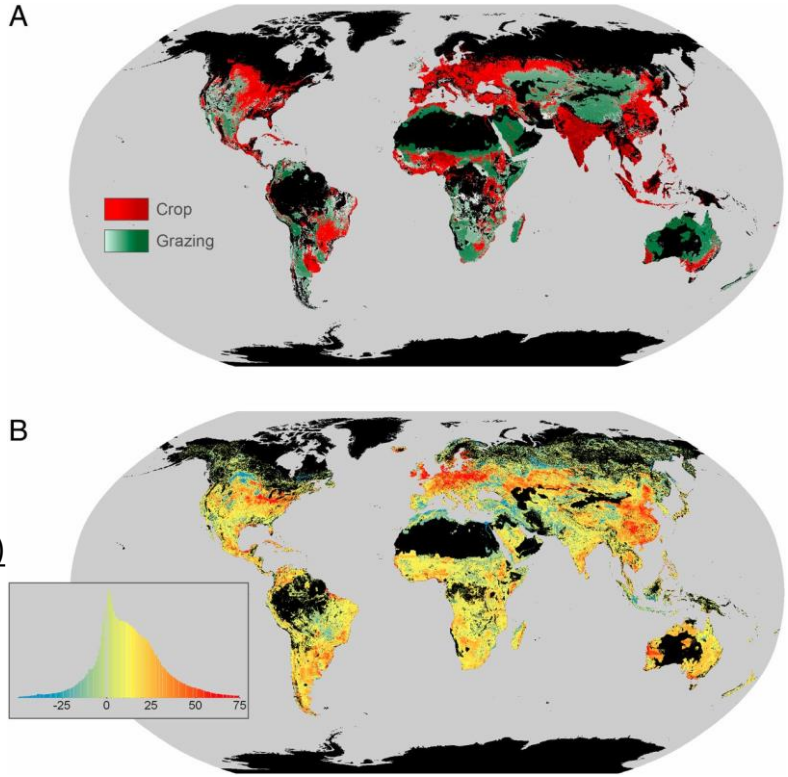
Food and Agriculture Organization of the United Nations

Global Soil Organic carbon Map (v1.5.0) 2019



How stocks have changed with time

Crop and grazing around the world

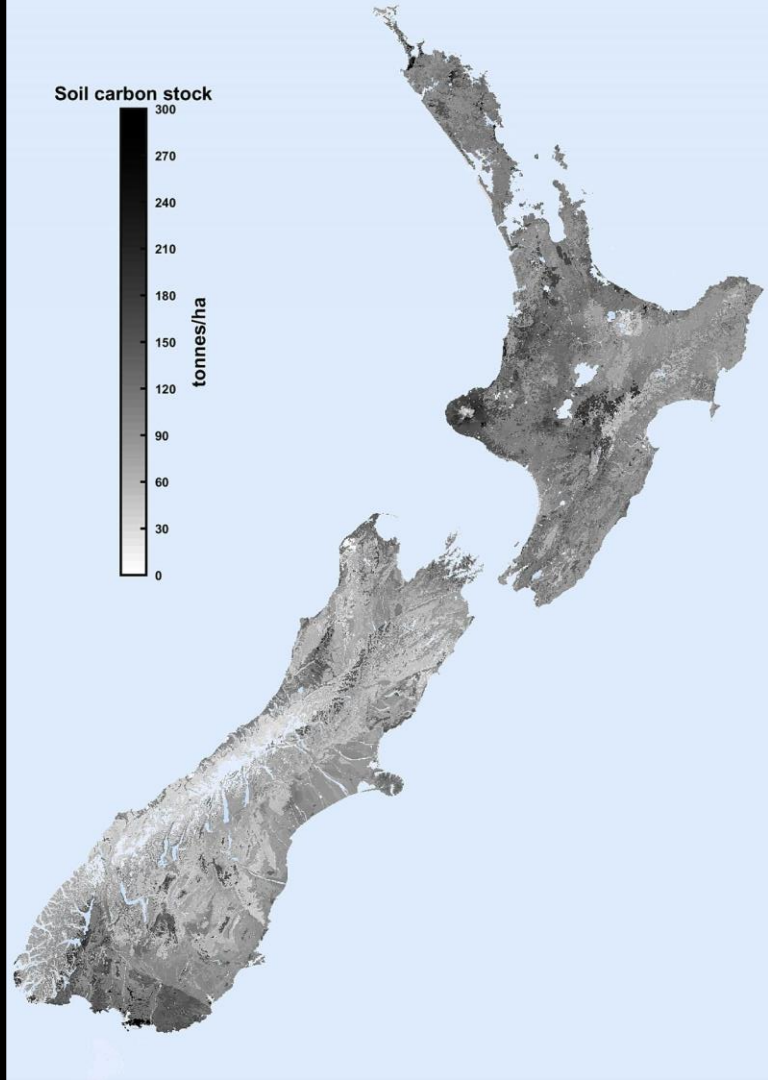


Soil carbon loss (t C ha^{-1})
Red: high
Yellow: intermediate
Blue: gains

"Soil carbon debt of 12,000 years of human land use" due to excessive cropping and over grazing.

Demonstrates substantial losses of soil C for large parts of the world (133bnt)

Sanderman et al. PNAS 2017;114:36:9575-9580



Average stocks to 30cm

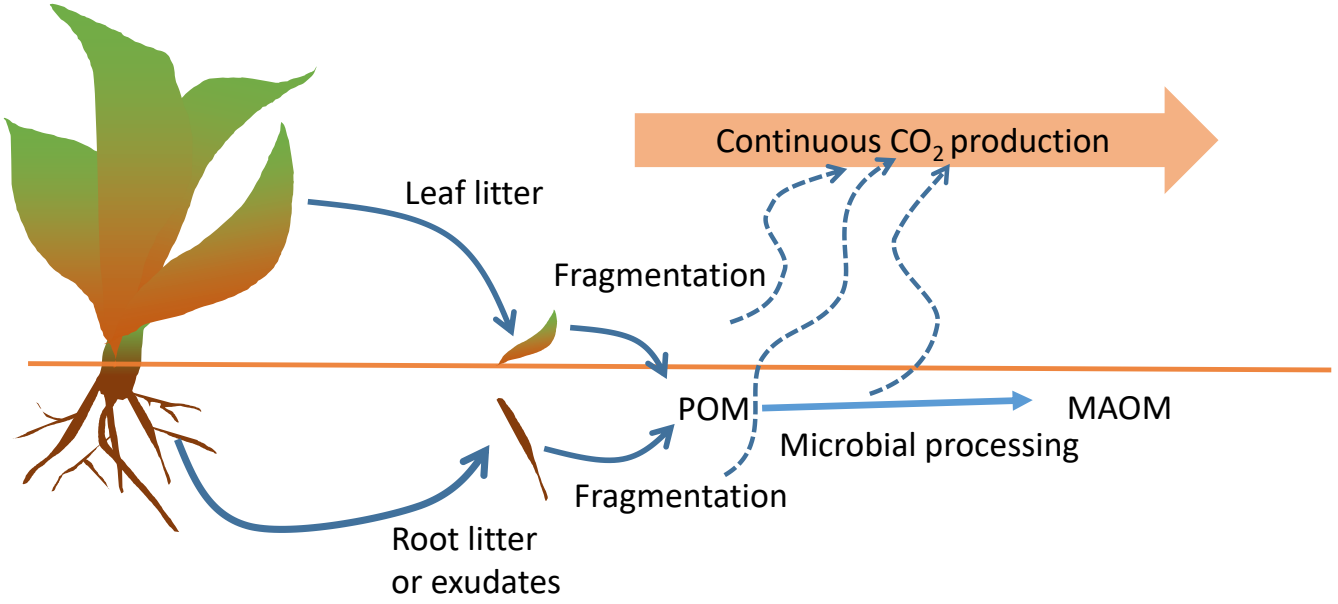
NZ	89 t C ha^{-1}
Australia	30 t C ha^{-1}
USA	45 t C ha^{-1}
Global	62 t C ha^{-1}

- NZ lost 3.3 t C ha^{-1} in last 26 years where land use change occurred
- First priority is to hang on to what we have!

Soil carbon balance

For soil carbon to increase need:

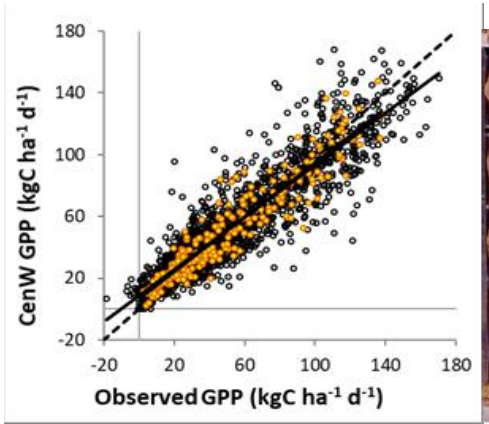
- Inputs through photosynthesis greater than losses due to plant and soil respiration
- Plant carbon transferred to soil (via roots and leaf litter)
- Carbon stabilised in soil (unavailable to microbes)



Assessing soil C stock changes

Three approaches:

- Measuring net CO_2 exchanges in the field
- Measuring soil carbon stocks against a baseline
- Modelling changes (IPCC Tier 1,2 or 3)



Food and Agriculture Organization of the United Nations

LEAP guidelines for assessment

Measuring and modelling soil carbon stocks and stock changes in livestock production systems

National soil C benchmarking & monitoring programme

About 100 sites in each of five broad land use classes:

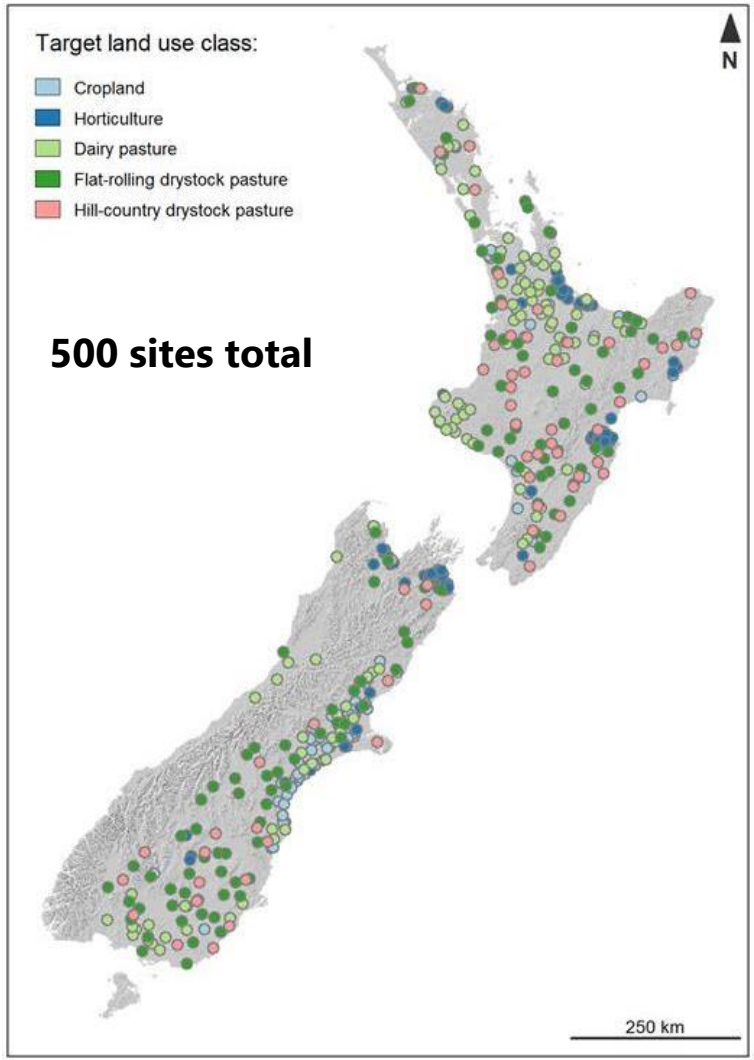
- Cropland
- Horticulture
- Dairy pasture
- Flat-rolling drystock
- Hill-country drystock

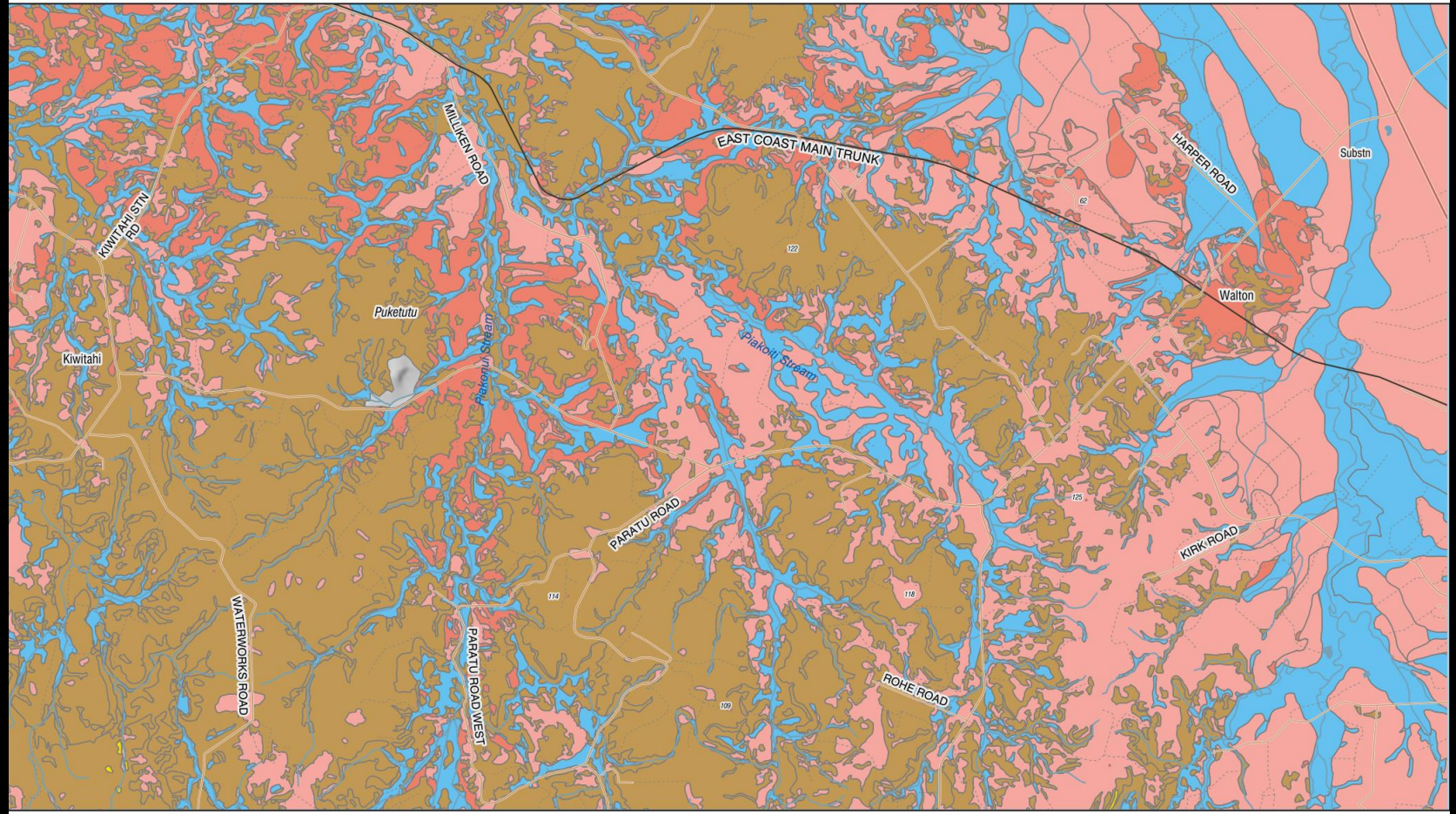
Sites randomly selected to avoid potential bias

Sampling to 0.6 m depth on a 4-year rolling schedule

- Benchmarking complete by 2023
- Three sampling points for all sites by 2031

Designed to be able to detect a change of 2 t/ha for each broad land use class, should such a change occur





S-MAPONLINE

Scale: 1:50,000

0 500 1000 1500 2000m

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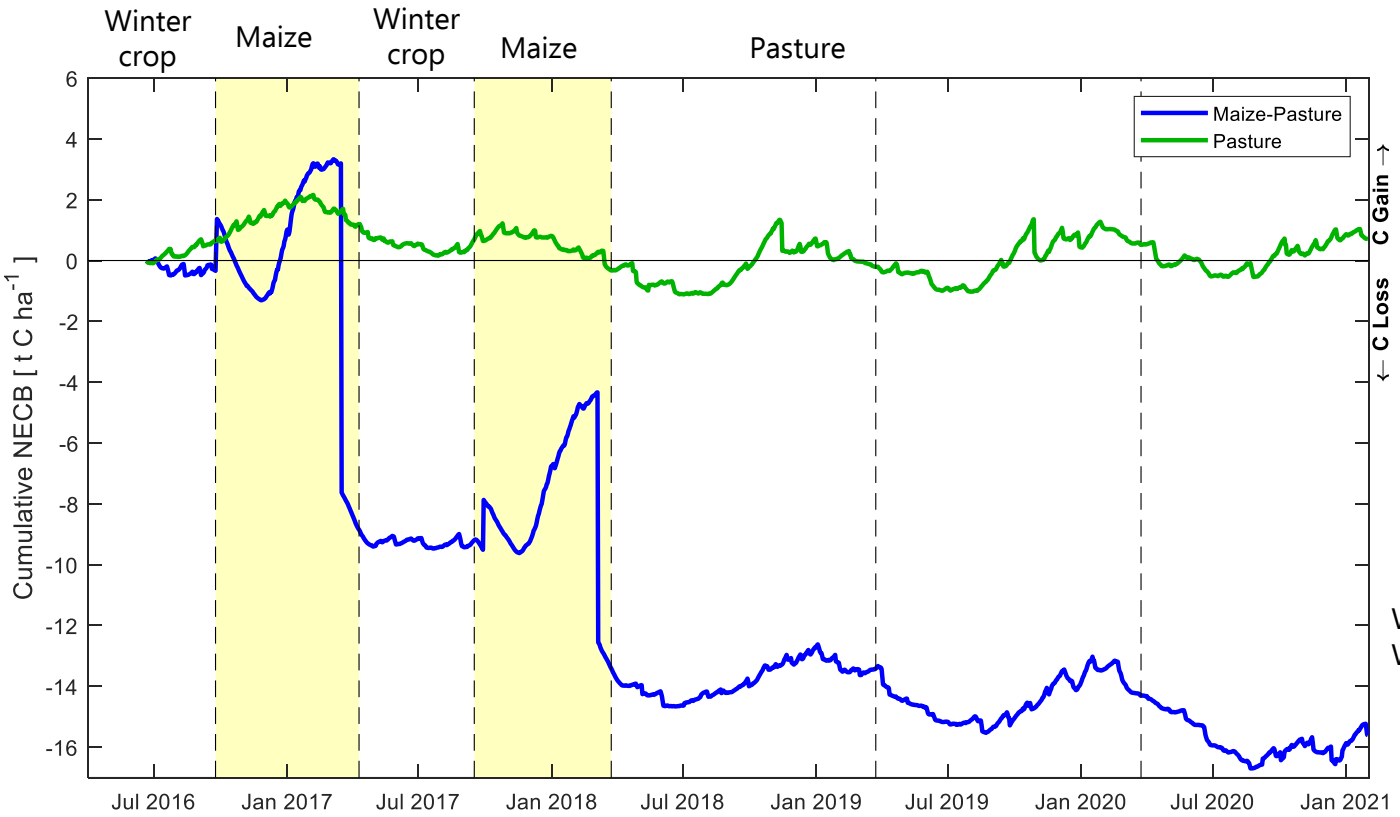
Grassland management and soil carbon in NZ

Management	Impact on soil C
Fertilisers	⇔ (P), ⬆ (N on infertile sites)
Irrigation	⇔ or ⬇ (flat sites)
Drought	⬇ (in short-term)
Manure / effluent	⬆ (likely small)
Supplementary feed (maize)	⬆ (on site) ⬇ (off site)
Sward renewal, tillage	⬇ (in short-term)
Mixed species	⇔ or ⬆ (more than 5 years)
Grazing intensity	⇔ or ⬆ (short, intense grazing)
Hill country grazing	⬆ (based on small sample size)

⇔ No change
⬆ Increase
⬇ Decrease

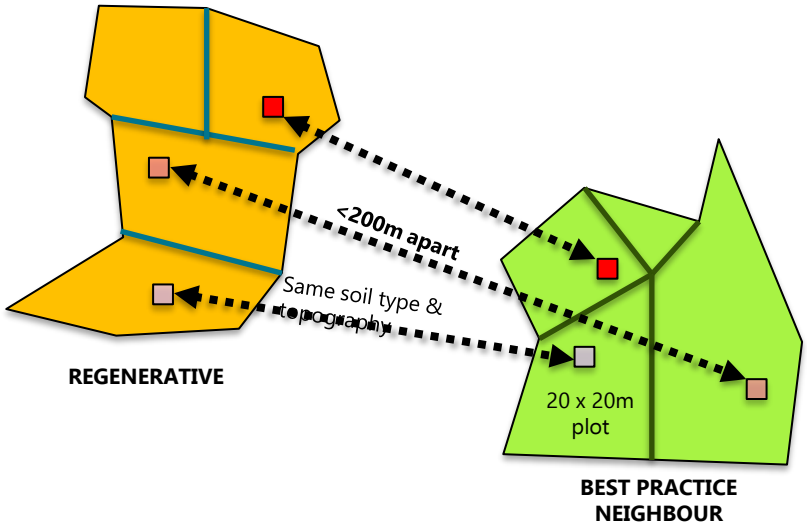
Schipper et al. 2007
Schipper et al. 2014
Rutledge et al. 2015
Whitehead et al. 2018
Mudge et al. 2021

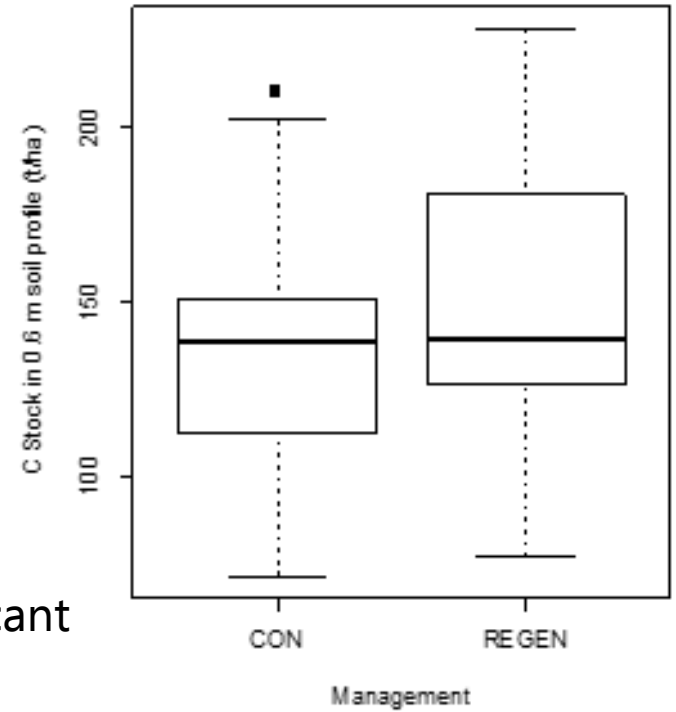
Maize silage cropping



Wall et al. Unpublished
Wall et al. 2020

Regenerative agriculture





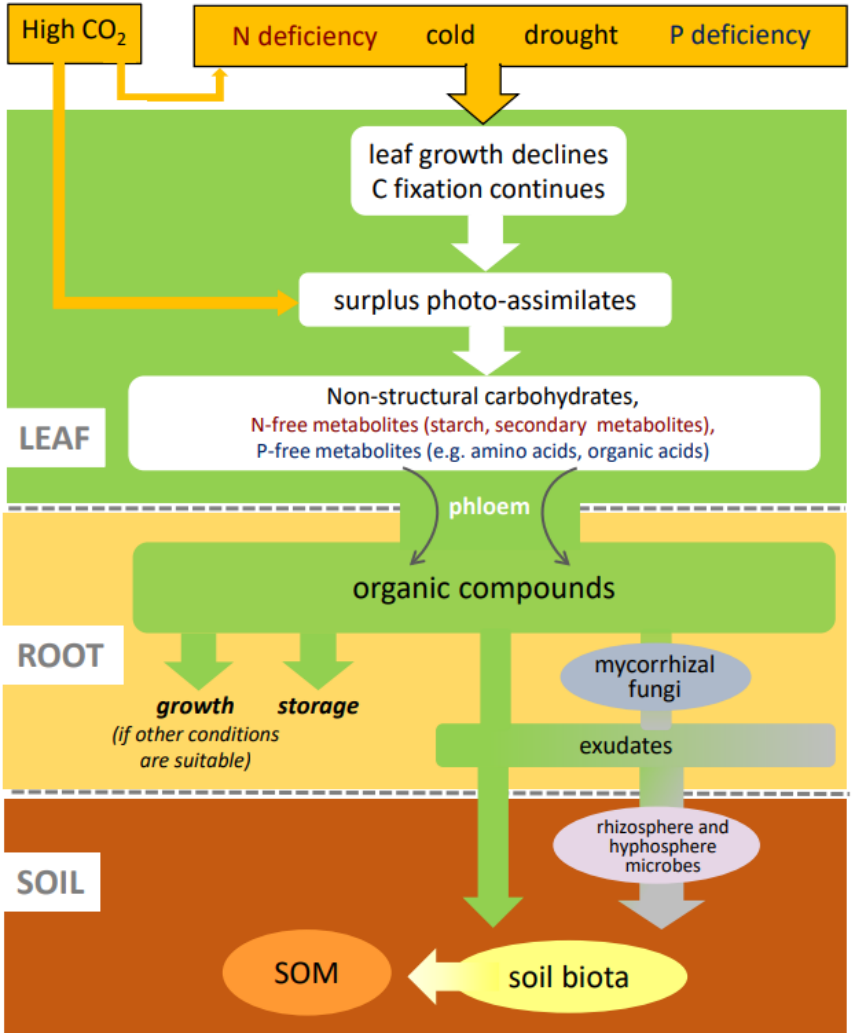
6 x paired farms (dairy, S&B): no significant difference in C stocks

Grelet et al. unpublished

Plant surplus carbon

- Plant growth limited before photosynthesis
- Remove limitation increases above ground growth
- Disposal of surplus carbon via roots
- Stimulates soil microbial respiration
- Some carbon stabilised

Sequester soil carbon, redesign systems for surplus carbon



Prescott et al. 2020

Conclusions

- Hang onto the soil carbon we have!
- Avoid unintended consequences (losses elsewhere, N_2O, water quality, etc)
- Gains possible, but magnitude site (soil) specific
- Modelling can show possible scenarios
- Measurements can confirm
- Regenerative systems a possible solution: need more evidence
- Need more evidence for magnitude of change with other management practices