Soil Carbon, Life Cycle Assessment, and The New Zealand Apple

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Take home message:

- ∞ Measuring soil carbon stocks requires an assessment of spatial variability, which greatly affects sampling intensity and frequency.
- ∞ In apple orchards, sampling depth needs to be a minimum of 50 cm, in order to account for at least 80% of the soil carbon stock to 1 metre.
- ∞ To be economically viable, sampling should be carried with an interval of several years to reliably (statistically) detect a change in the soil carbon stock.

Introduction

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Soils of the world retain three times more carbon than the atmosphere, and therefore can impact climate change mitigation [1]. Moreover, soil carbon plays a major role in the soil water, nutrients and biodiversity cycles, and is positively correlated with soil "health" and crop productivity [2, 3]. Therefore monitoring changes in soil carbon stocks is essential for the sustainability of our food production systems and strengthening food security. Finally, considering a 1% increase per year, **accounting for soil carbon stock change could compensate for up to 70% of the "cradle to orchard gate" carbon footprint of New Zealand apples consumed in Europe** [4]. The objective of this study is therefore to investigate soil carbon stock spatial variability at the tree and orchard block scales, to determine minimum sampling intensity and frequency for carbon monitoring and footprinting.

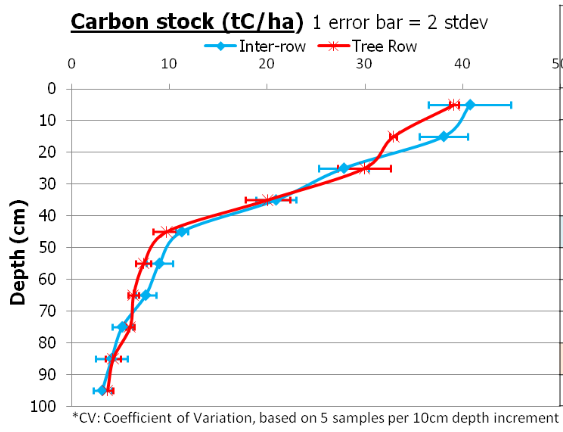
Experiment 1 : Soil profile

<u>Objective</u>: Measure variability at tree scale

- Two treatments:
  - Tree Row (between trees)
  - Inter- row (centre of grass alley)
- 5 sampling locations/treatment
- 2 variables per 10 cm depth increment
  - Bulk density
  - Total carbon content (LECO analyser)
- 10 depth increments from 0 to 1 m

➢<u>Total:</u> **100 samples**
5 samples per "treatment x depth increment"

<u>Fig 1</u>: Carbon stocks as a function of depth (*Graph*). Coefficients of variation per depth increment (*Tables*).



Depth (cm)	CV* Inter-Row	CV* Tree Row
0-10	10%	1%
10-20	7%	1%
20-30	9%	9%
30-40	10%	11%
40-50	5%	14%
50-60	15%	10%
60-70	14%	9%
70-80	21%	8%
80-90	40%	19%
90-100	30%	16%

*CV: Coefficient of Variation, based on 5 samples per 10cm depth increment

- ➢**Soil carbon stocks decrease rapidly with depth.**
- ➢**Coefficients of variation increase with increasing depth.**

<u>Table</u>: Cumulative carbon stock as a function of depth.

Depth increments (cm)	Cumulative carbon stock* Inter-Row	Cumulative carbon stock* Tree Row
0-10	24%	25%
10-20	47%	45%
20-30	64%	64%
30-40	76%	77%
40-50	83%	83%
50-60	88%	87%
60-70	93%	91%
70-80	96%	95%
80-90	98%	98%
90-100	100%	100%

* As % of top meter

➢**Some 80% of the 1m soil carbon stock is present in the top 50 cm.**

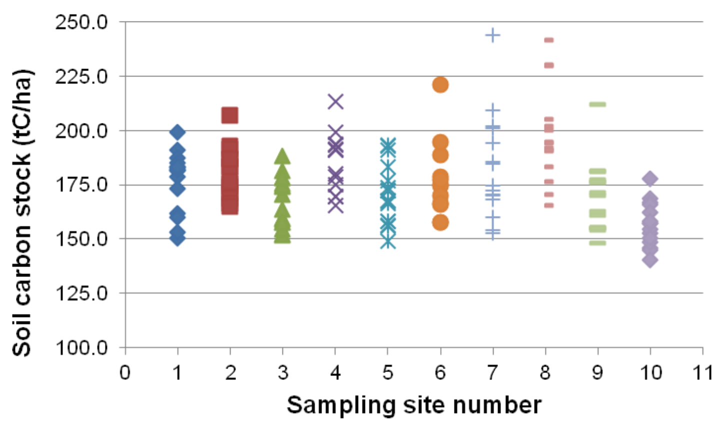
Experiment 2 : Orchard block

<u>Objective</u>: measure variability at "orchard block"* scale
(*One variety, one rootstock, one soil type down to 1 metre)

- ➢10 sampling sites (on a 0.3ha orchard block)
- ➢16 one metre soil cores/site, cut in half
  - Top half
  - Bottom half
- ➢1 bulk density profile / site
  - 10 depth increment from 0 to 1 m

➢<u>Total:</u> **320 samples**

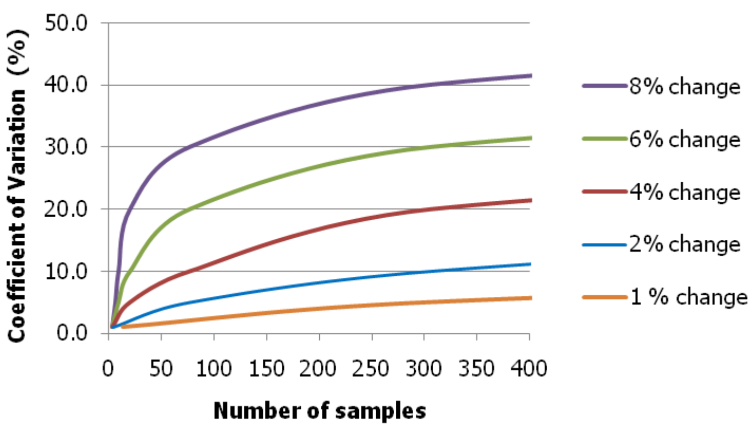
<u>Fig 2</u>: Soil carbon stock for each 1 metre deep soil cores
(one colour = one sampling site = 16 soil cores (data points)



➢**Coefficients of variation range from 6.5% to 13.1% between 1 m soil cores for each of the 10 sites.**

Implications

<u>Graph</u>: Number of samples required for various coefficient of variation, to detect a 1% to 8% change in the soil carbon stock.



(10% statistical significance level, statistical power = 0.8)

Monitoring soil carbon stocks for carbon footprinting purposes involves intensive sampling in order to meet essential statistical requirements. This may not be economically viable.

➢**Sampling should be carried with an interval of several years, allowing for a bigger change to take place, therefore fewer samples would be needed to observe it.**

<u>References</u>

[1]] Lal, R. (2004). Soil carbon sequestration impacts on global climate change and food security. Science 304, 1623–1627
[2]] Lal, R. (2008). Carbon sequestration. Philosophical Transactions of the Royal Society 363:815–830
[3] Lal, R. (2010). Beyond Copenhagen: mitigating climate change and achieving food security through soil carbon sequestration. Food sec. 2:169-177
[4] Périé et al. (2012). Including Soil and Biogenic Carbon in the Carbon Footprint. Example: The New Zealand Apple Life Cycle. Poster. LCA Food 2012 conference, Saint Malo, France.

Results on this poster are preliminary results. Please contact the authors for updates before citation.

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