Challenges of scaling soil carbon data over space and time

Sean M. Smukler

BCACARN Soil Organic Carbon Protocol Workshop

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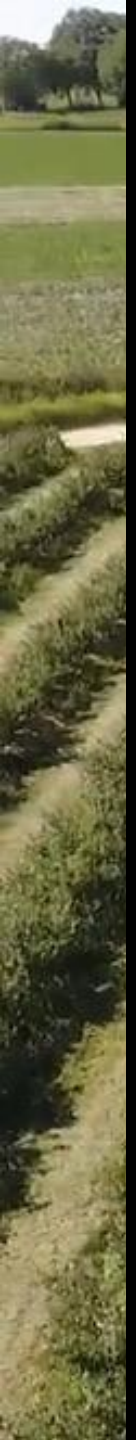
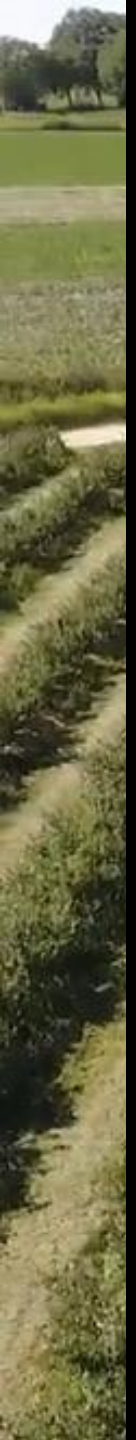
THE UNIVERSITY OF BRITISH COLUMBIA
Faculty of Land and Food Systems

UBC FARM
Centre for Sustainable Food Systems



The Next 15 Minutes

- The bigger picture
- Approaches for scaling from the plot to the landscape
  - Sampling design
  - Laboratory analysis
  - Hierarchy
- Ideas to consider



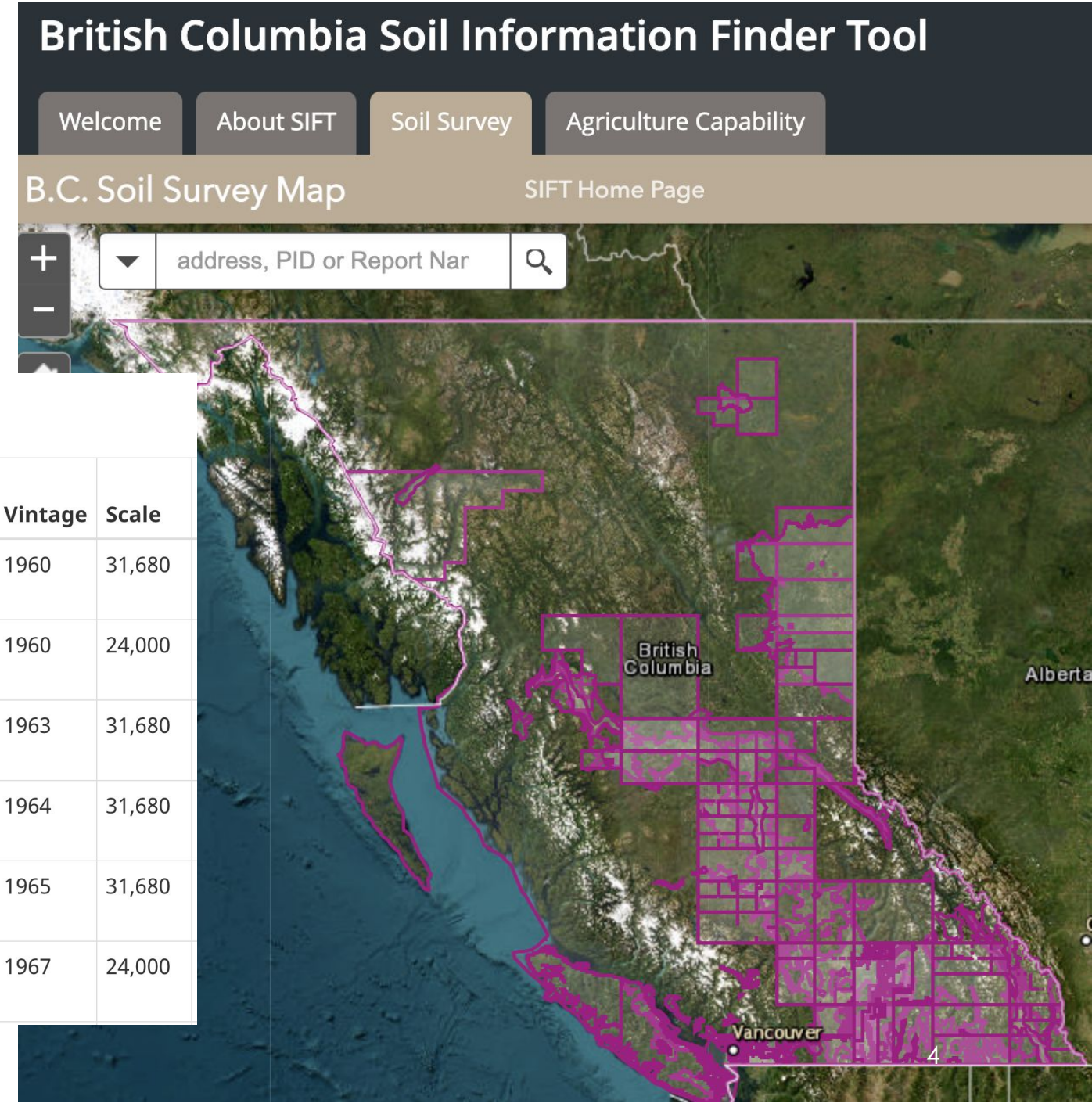
Key Questions to Answer Beyond the Plot?

- How do changes in SOC due to beneficial management practices compare with current practices?
- What is our baseline? What is the trajectory of this baseline?
- What is the maximum potential SOC capacity?
- Where do we prioritize interventions?
- How can we efficiently track impacts?

BC Soil Data

Detailed Soil Survey Reports

Report Number	Soil Survey Report	Vintage	Scale
bc101	Soil Survey of the North Okanagan Valley	1960	31,680
bc102	Soil Survey of Chilliwack Map Area	1960	24,000
bc103	Soil Survey of the Ashcroft-Savona Area Thompson River Valley	1963	31,680
bc104	Soil Survey of the Eagle River Valley	1964	31,680
bc105	Soil Survey of the Shuswap Lakes Area	1965	31,680
bc106	Soil Survey of Agassiz Area	1967	24,000



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Tracking changes in soil organic carbon across the heterogeneous agricultural landscape of the Lower Fraser Valley of British Columbia

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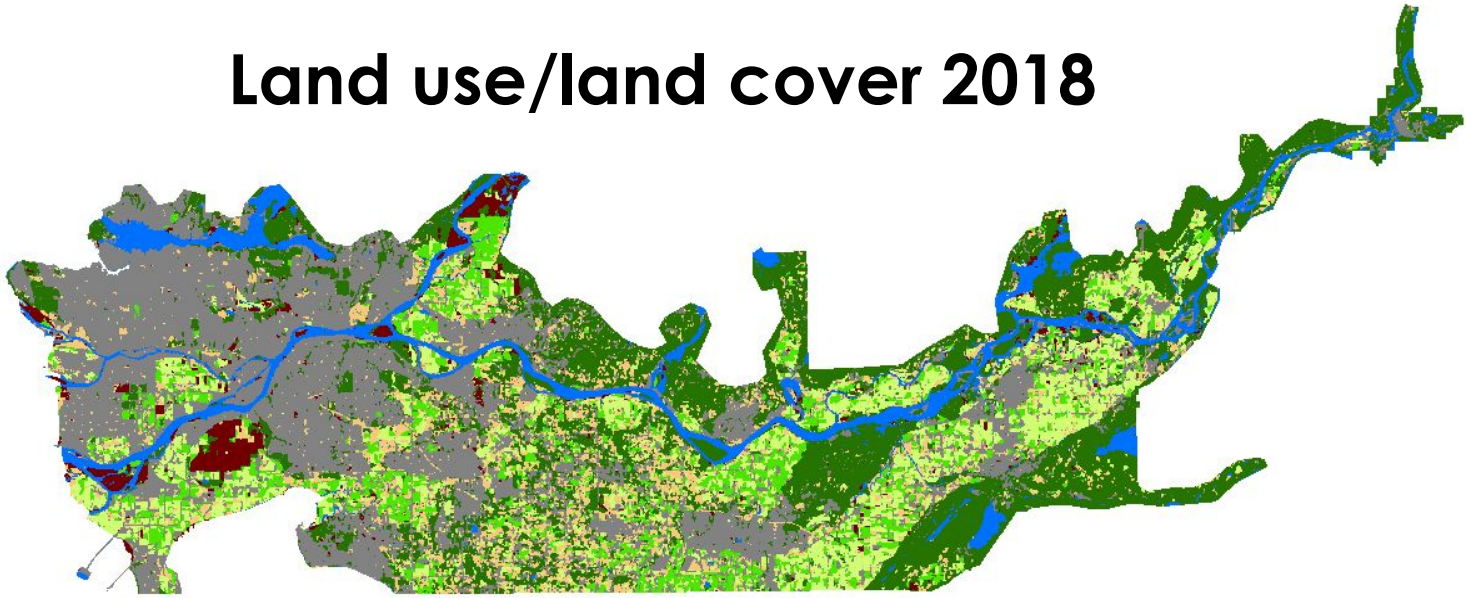
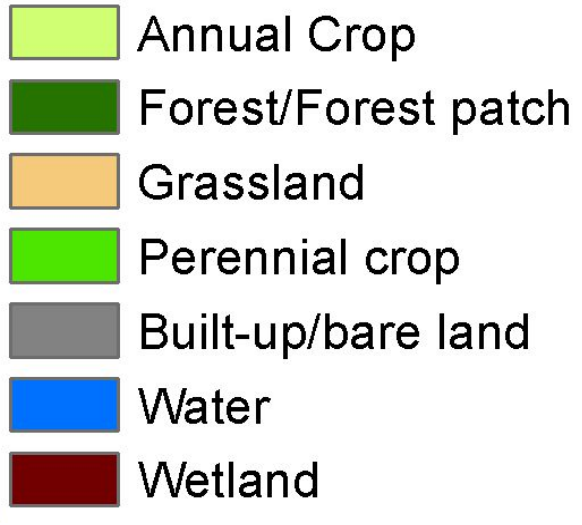
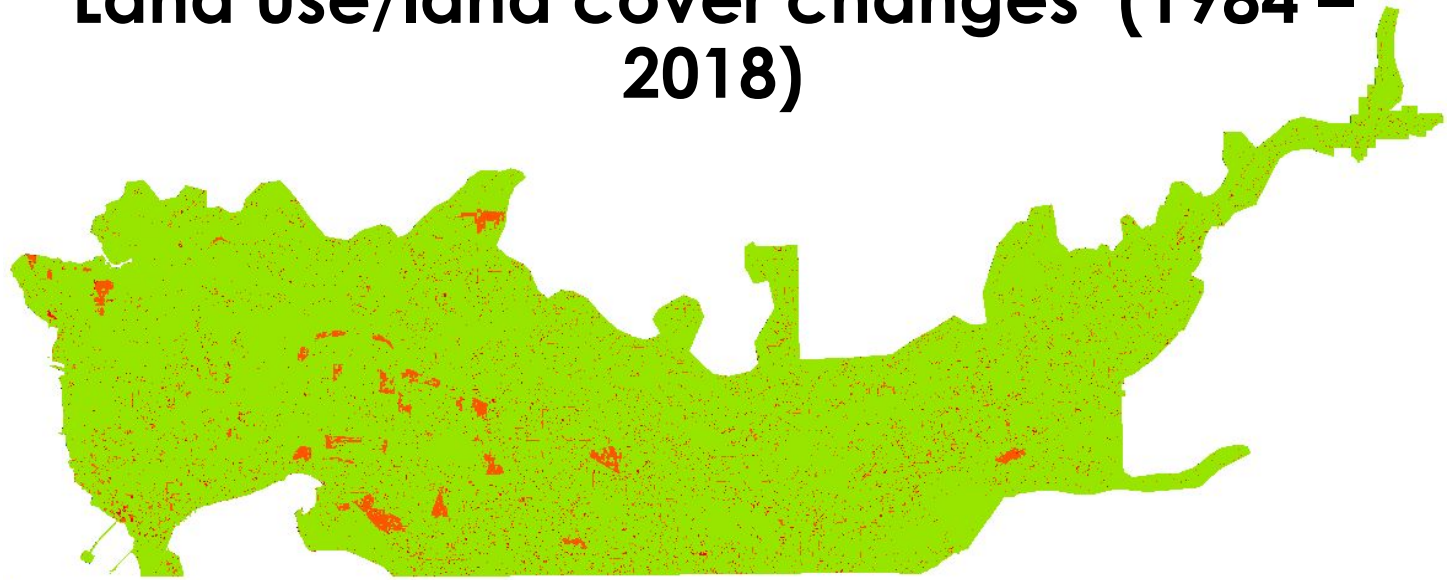
Siddartho Paul
PhD 2020

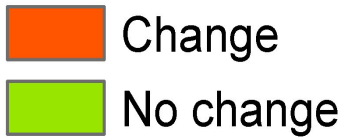
Land use/land cover 2018



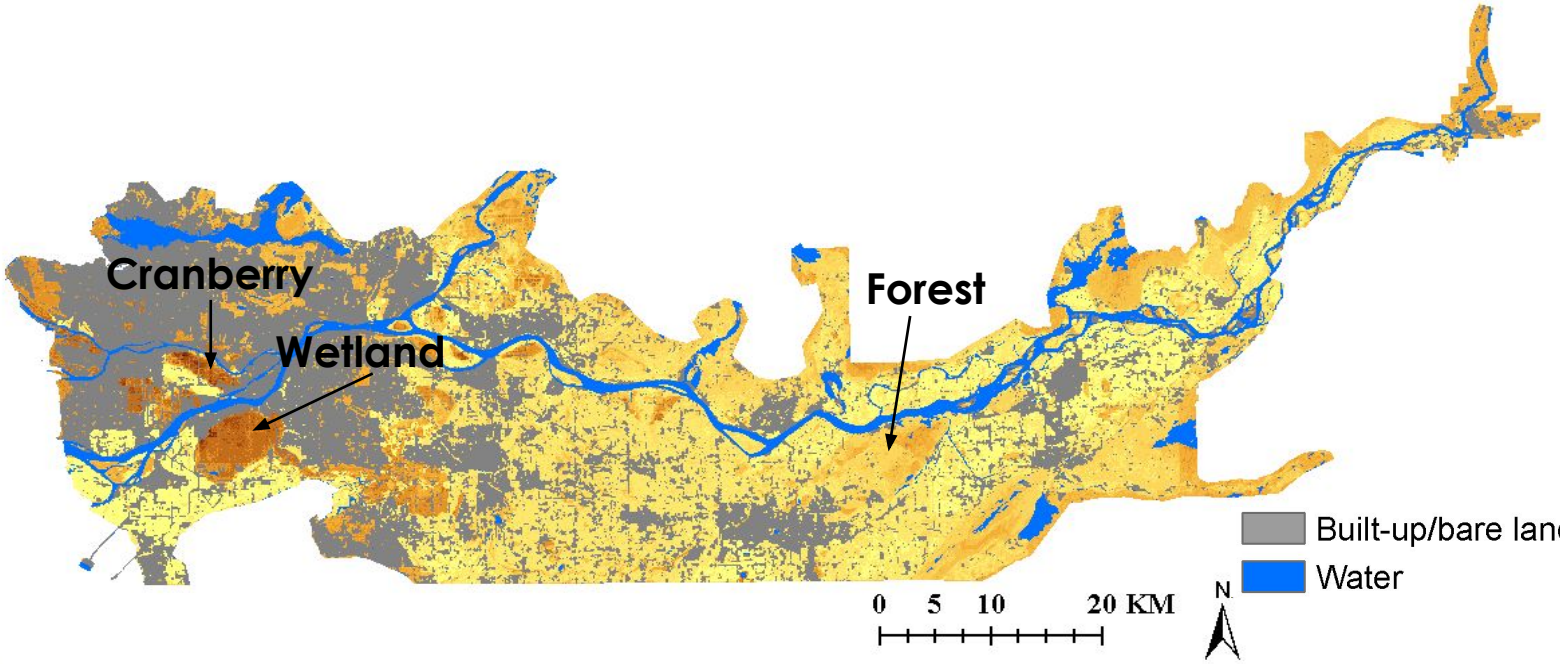


Land use/land cover changes (1984 – 2018)



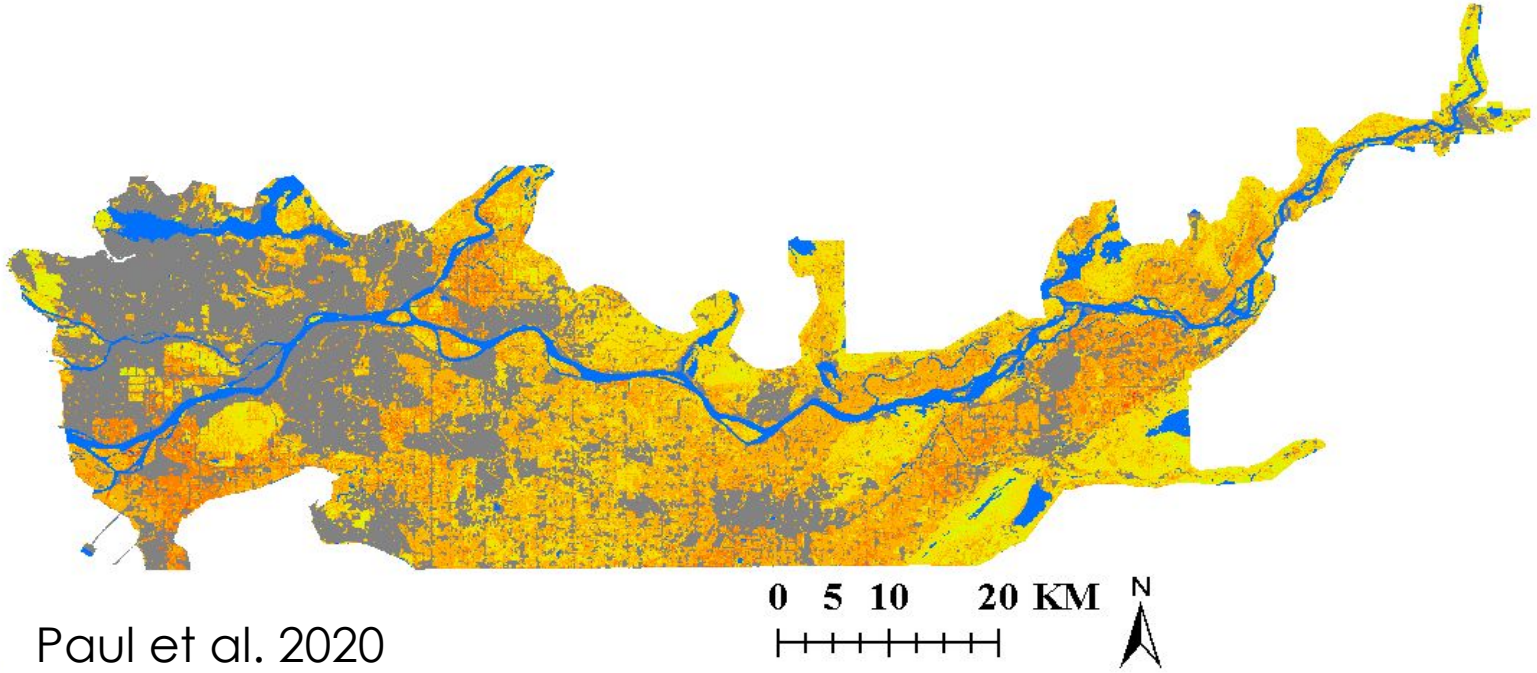


Paul et al. 2020



Soil organic carbon (g/kg)

- 10.62 - 46.71
- 46.71 - 82.81
- 82.81 - 118.90
- 118.90 - 154.97
- 154.97 - 191.09
- 191.09 - 227.18
- 227.18 - 263.28
- 263.28 - 299.37
- 299.37 - 335.47
- 335.47 - 371.56



Absolute change in SOC (g/kg)

- -126.45 - -97.31
- -97.31 - -68.15
- -68.15 - -39.02
- -39.02 - -9.87
- -9.87 - 19.26
- 19.26 - 48.41
- 48.41 - 77.55
- 77.55 - 106.69
- 106.69 - 135.84
- 135.84 - 164.98

Paul et al. 2020

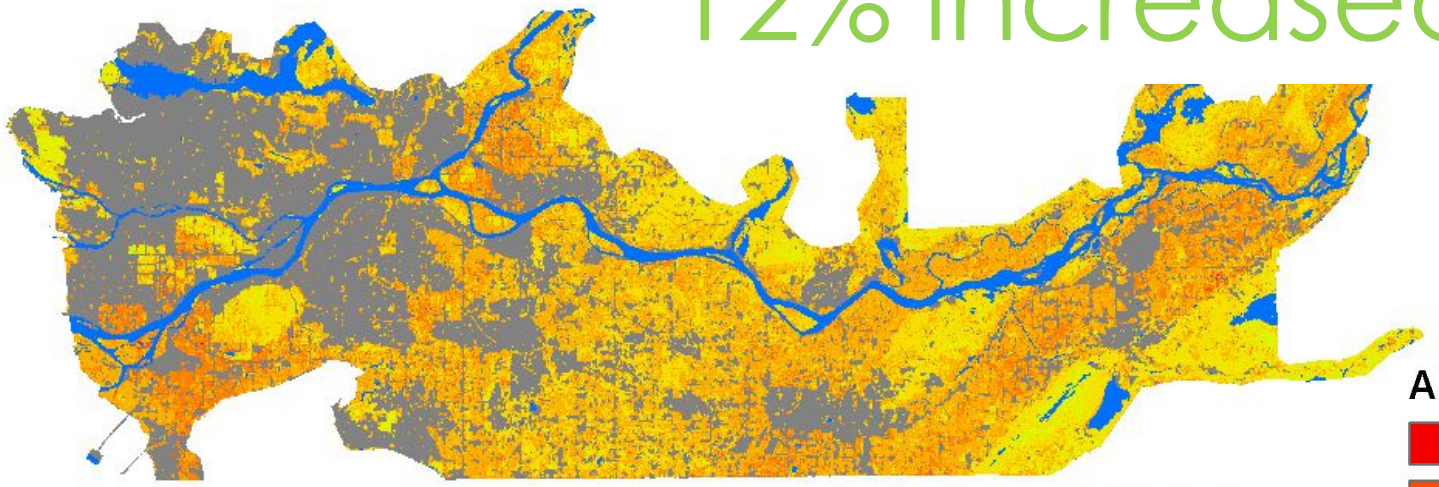
1984 to 2018

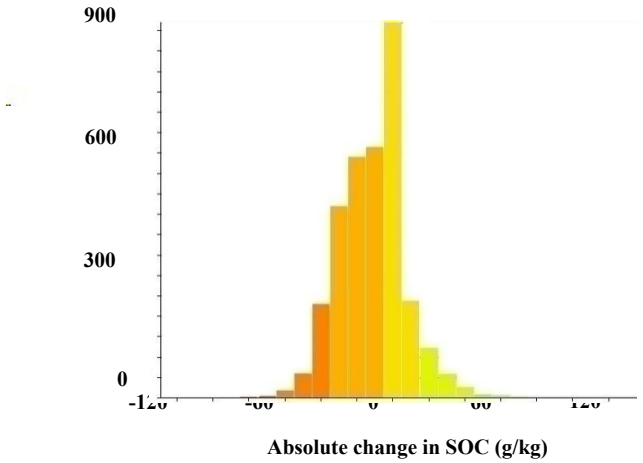
27% unchanged

61% declined

12% increased

5.8 Mt





0 5 10 20 KM

N

Built-up/bare land

Water

Absolute change in SOC (g/kg)

-126.45 - -97.31

-97.31 - -68.15

-68.15 - -39.02

-39.02 - -9.87

-9.87 - 19.26

19.26 - 48.41

48.41 - 77.55

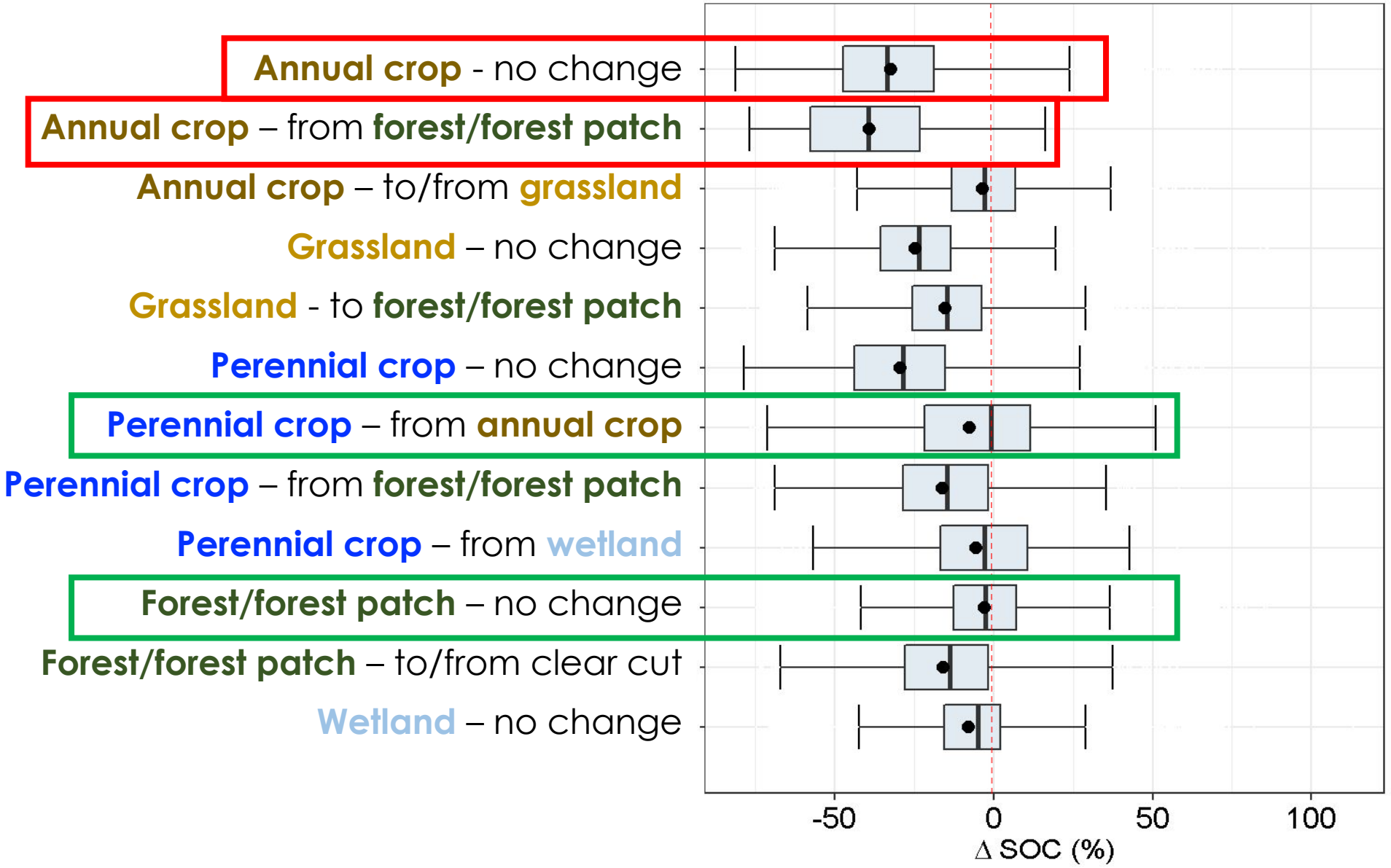
77.55 - 106.69

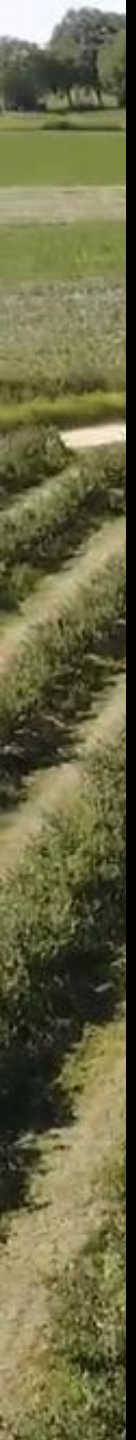
106.69 - 135.84

135.84 - 164.98

Paul et al. 2020

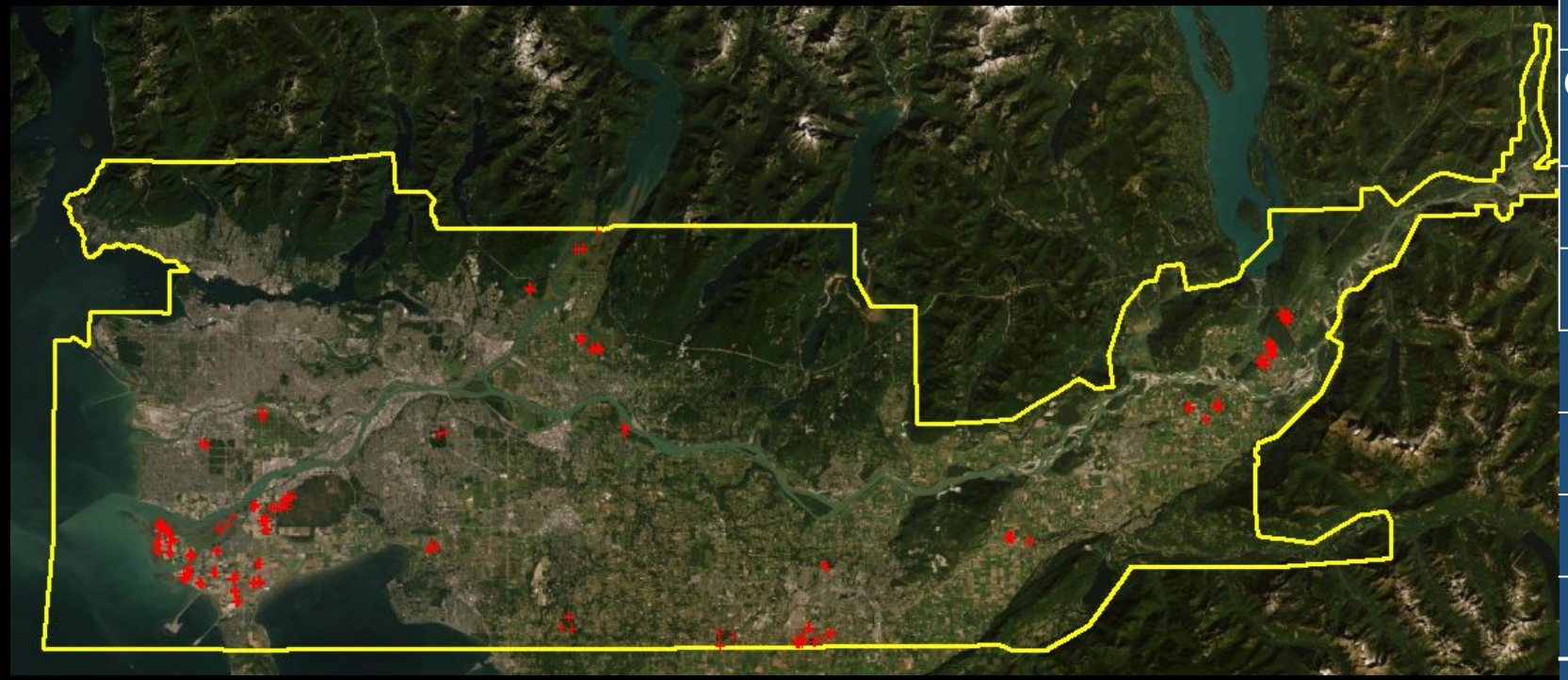
ΔSOC from 1984 to 2018





Scaling Methods

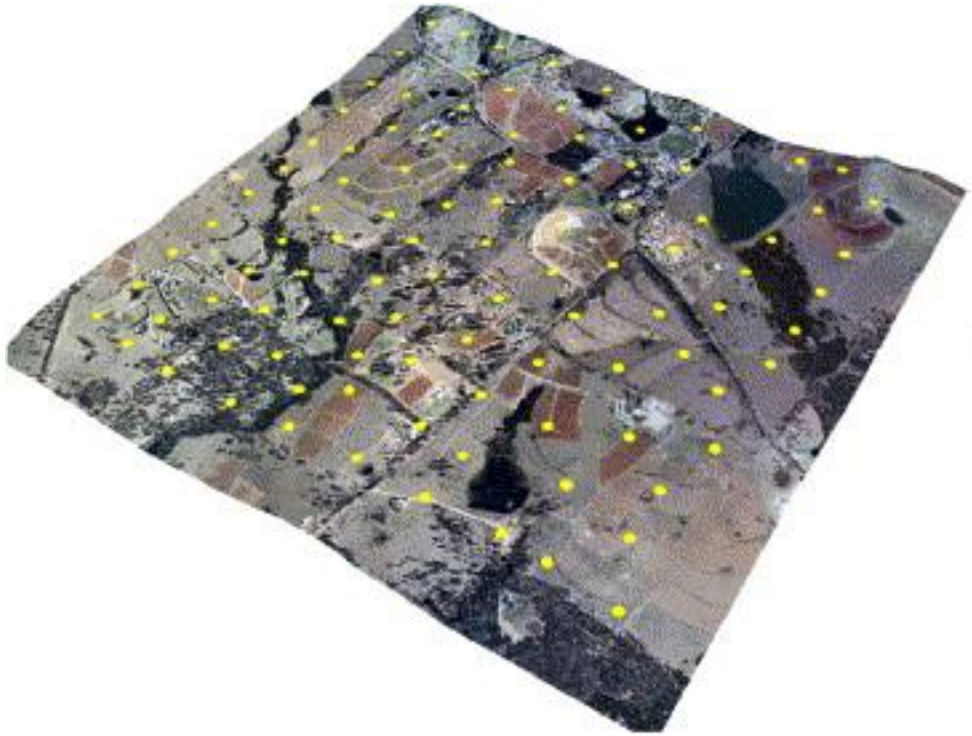
Sampling across lower Fraser Valley



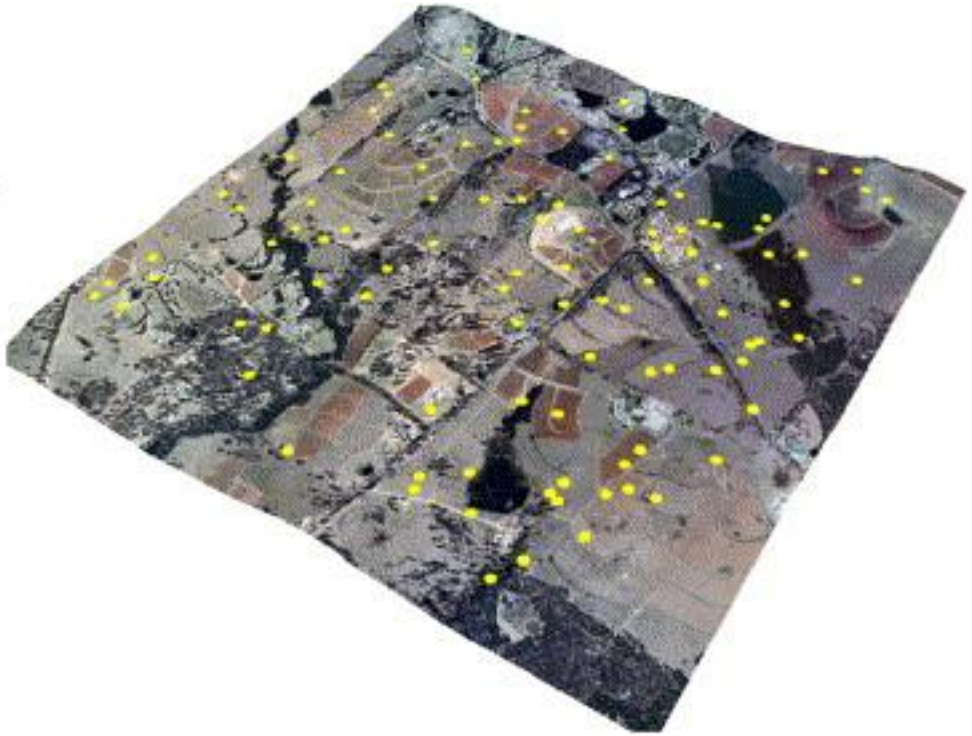
LULC TYPE	TOTAL PLOTS
Annual Crop	32
Grassland Setaside	44
Grassy Field Margin & Hedgerow	18
Riparian Buffer	14
Grassland	52
Perennial Crop	100
Winter Cover Crop	24
Forest/Forest Patch	15
Wetland	10
Total	**310**
Training	**70%**
Testing	**30%**

Conditioned Latin Hypercube (cLHS) Sampling

Equal spatial strata

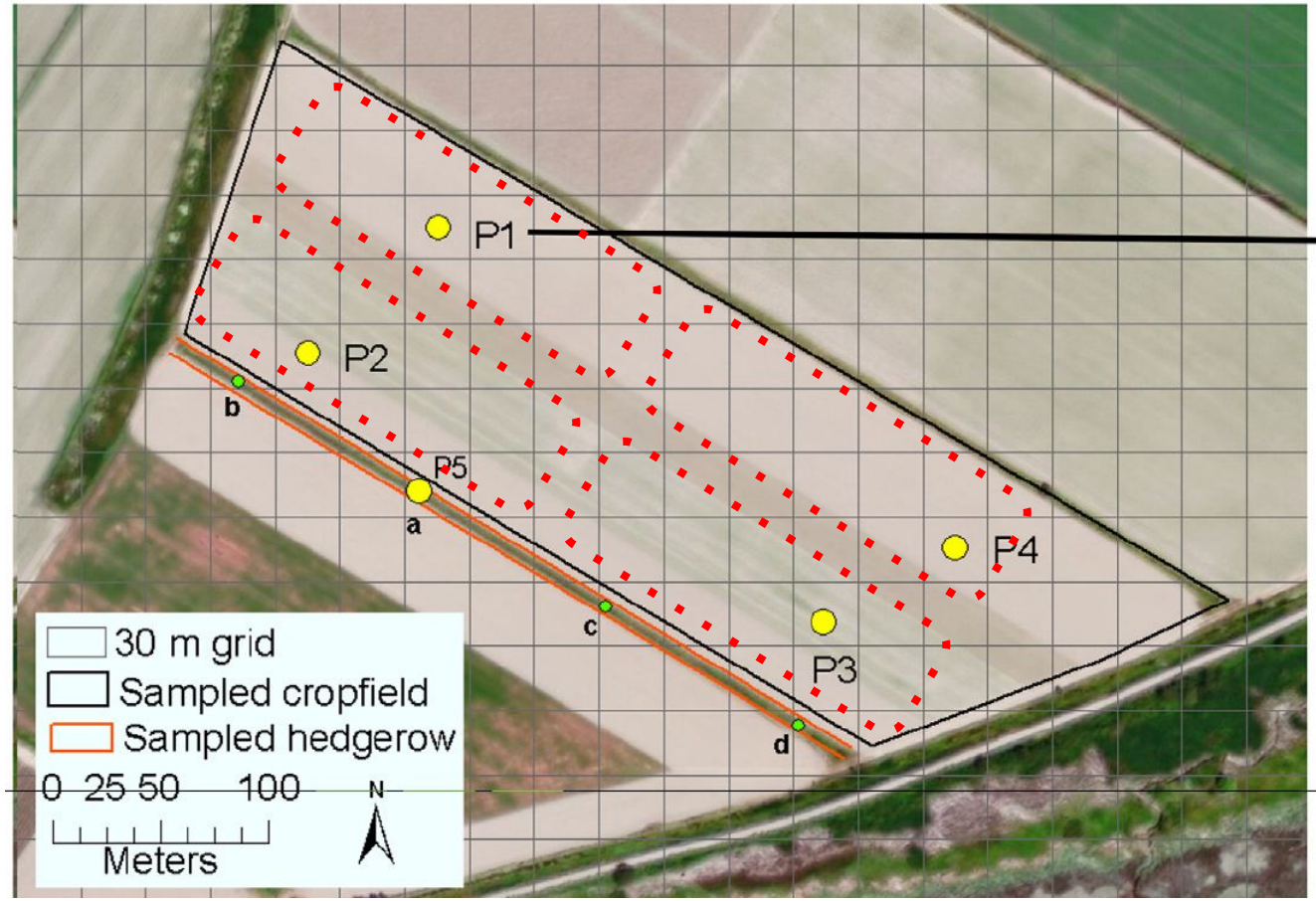


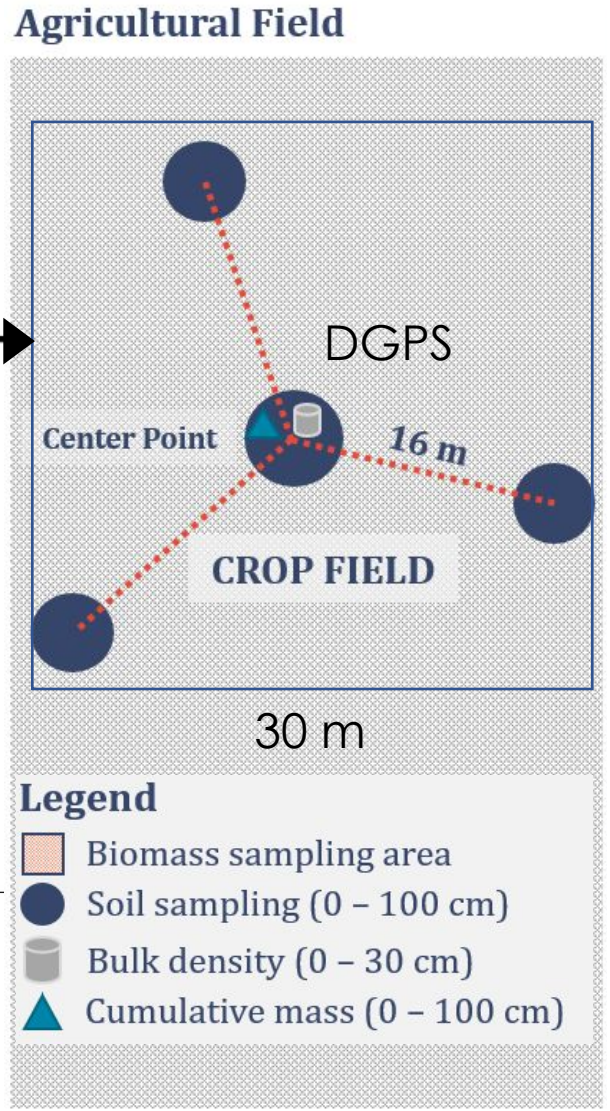
Sampling stratified by cLHS



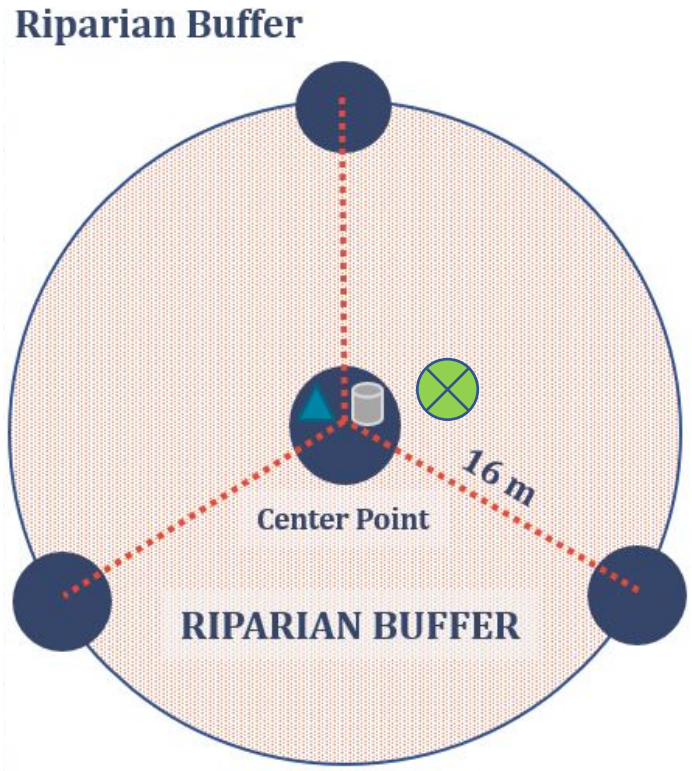
Minasny and McBratney 2006. A Conditioned Latin Hypercube Method for Sampling in the Presence of Ancillary Information. *Computers & Geosciences* 32, https://doi.org/10.1016/j.cageo.2005.12.009.

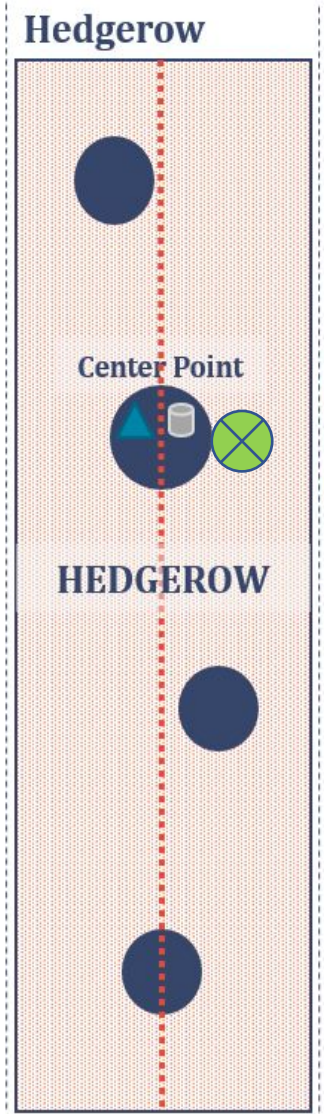
Sampling Design

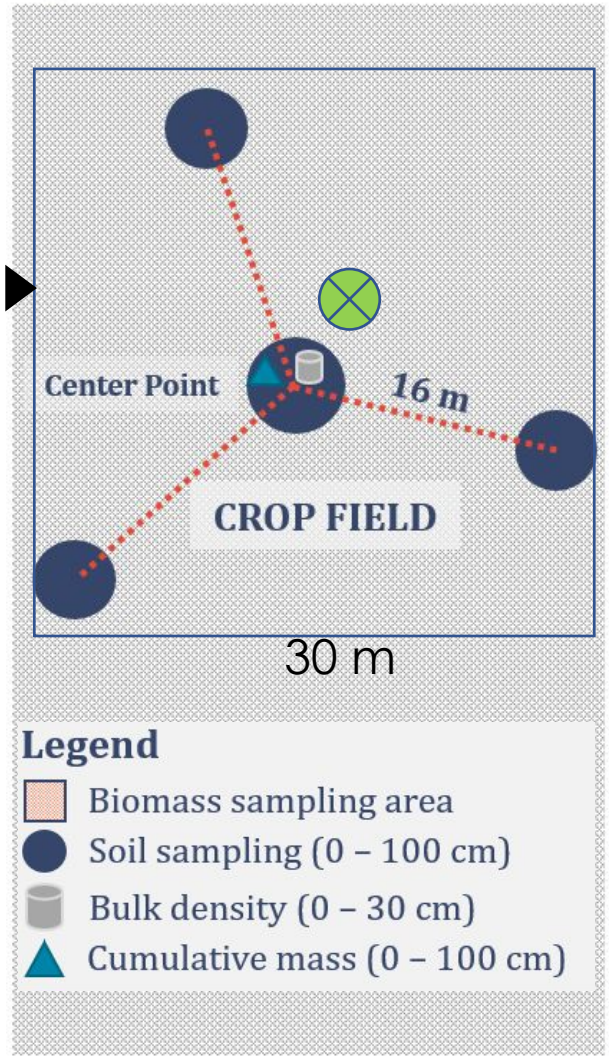




Sampling Design



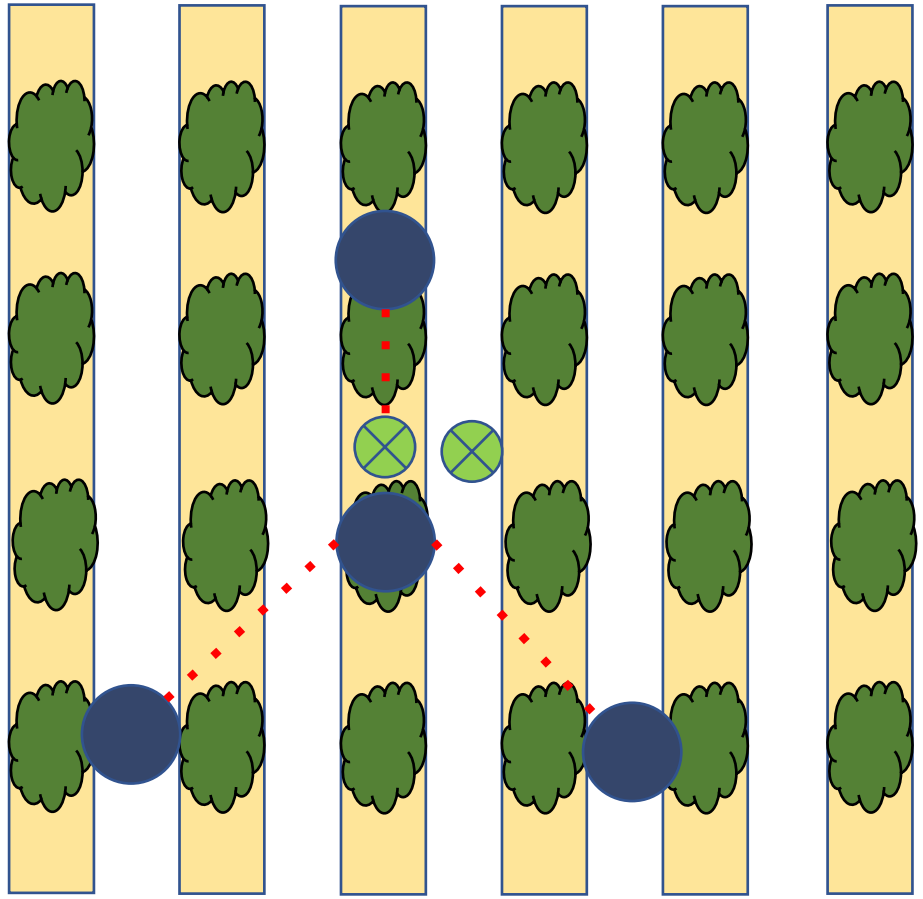




30 m

Sampling Design

Perennial row crops



Above- and Below-ground Carbon Sampling

SHRUB BIOMASS

Height

Width

Length

TREE BIOMASS

DBH

Height

BULK DENSITY

3.75-11.25 cm

18.75-26.25 cm

15 cm

30 cm

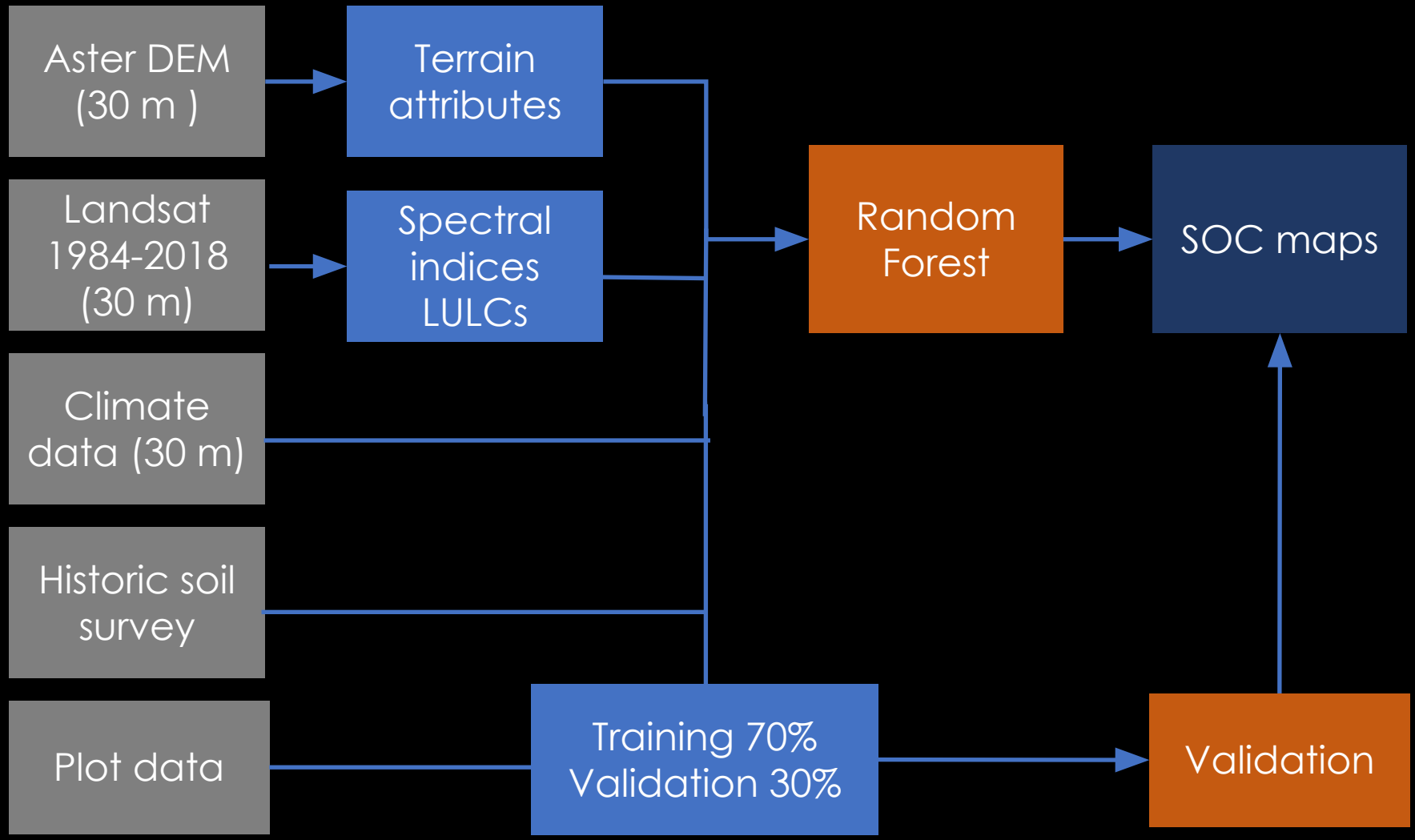
60 cm

100 cm

CUMULATIVE MASS

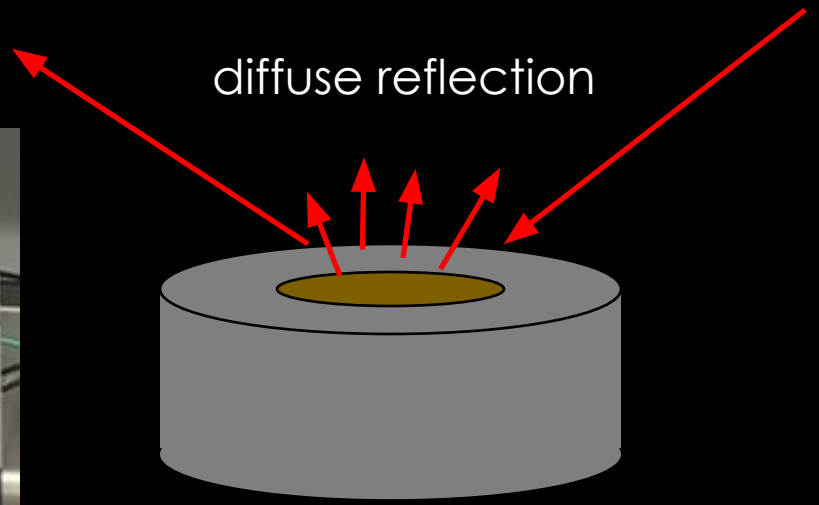
AUGUERED SAMPLES FOR LAB ANALYSIS

Soil Organic Carbon



Sampling Intensity and Costs

- Mid-infrared spectroscopy



frontiers in Environmental Science

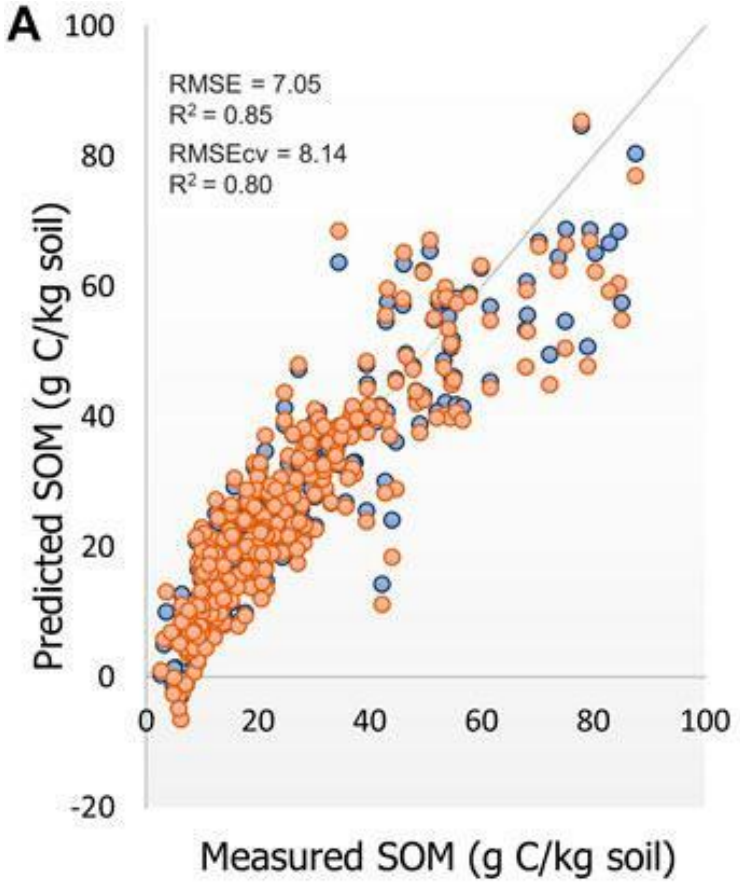
ORIGINAL RESEARCH
published: 17 May 2021
doi: 10.3389/fenvs.2021.634472

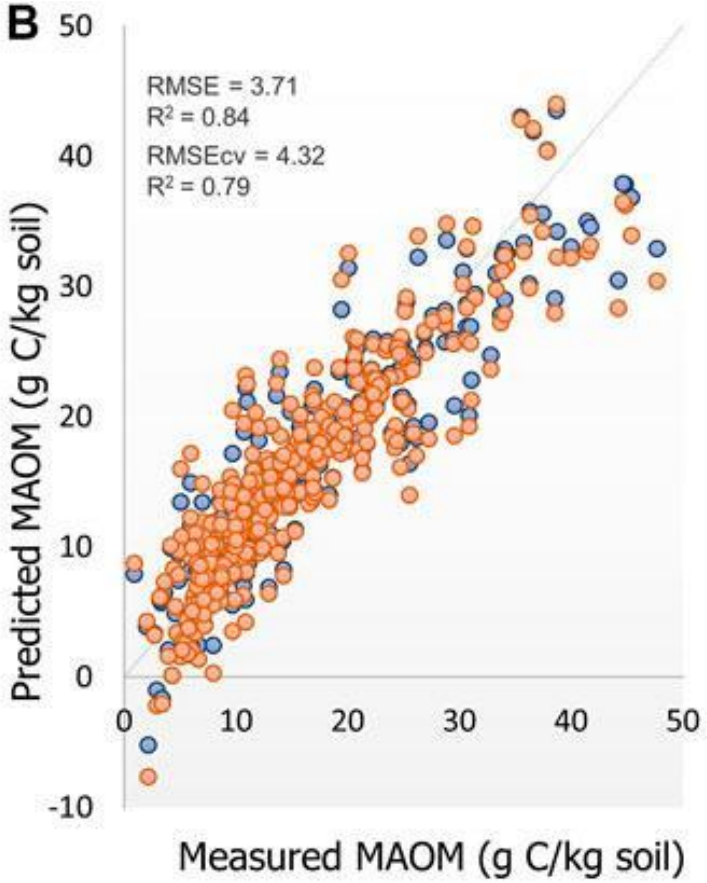
Check for updates

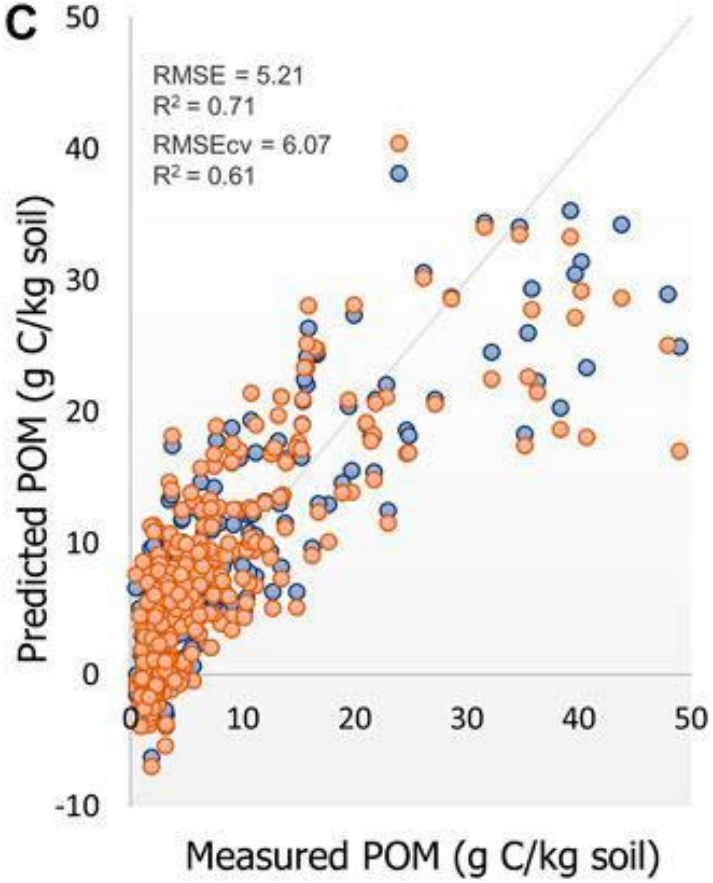
Using Diffuse Reflectance Spectroscopy as a High Throughput Method for Quantifying Soil C and N and Their Distribution in Particulate and Mineral-Associated Organic Matter Fractions

Paulina B. Ramírez[1], Francisco J. Calderón[2], Michelle Haddix[3], Emanuele Lugato[4] and M. Francesca Cotrufo[1,3]*

Measured Vs Predicted







Ramírez, et al 2021. https://www.frontiersin.org/articles/10.3389/fenvs.2021.634472.

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journal homepage: www.elsevier.com/locate/geoderma

Evaluating sampling efforts of standard laboratory analysis and mid-infrared spectroscopy for cost effective digital soil mapping at field scale

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Sampling Effort

- Cost of analysis
- Mid-infrared vs. standard laboratory analysis (SLA)

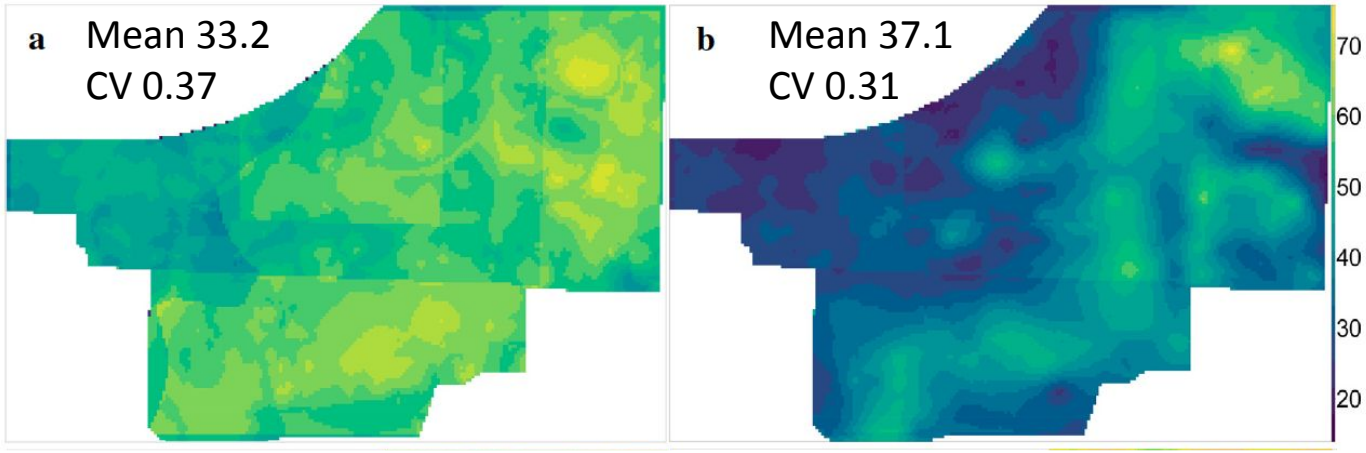
Field Mapping at 5 m Resolution

Kriging with external drift

Sand (%)

n=62

n=308



Standard laboratory analysis

MIR spectroscopy

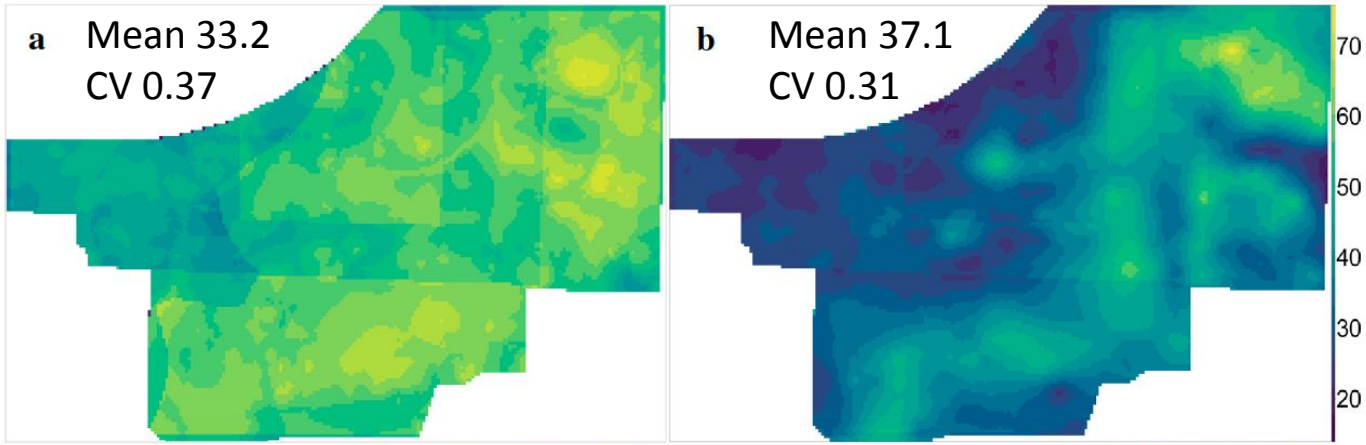
Field Mapping at 5 m Resolution

Kriging with external drift

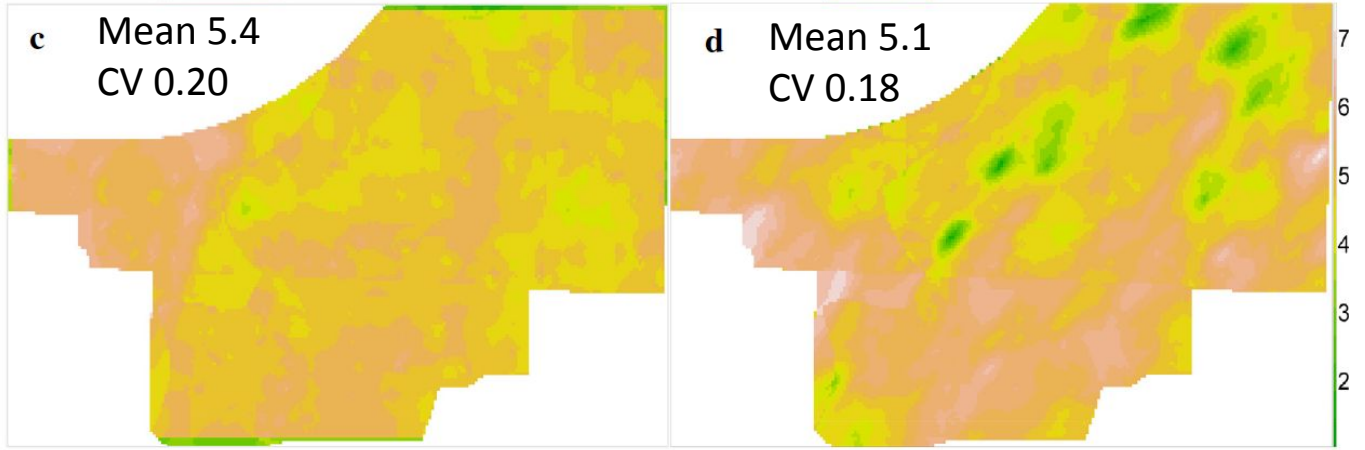
n=62

n=308

Sand (%)



SOM (%)

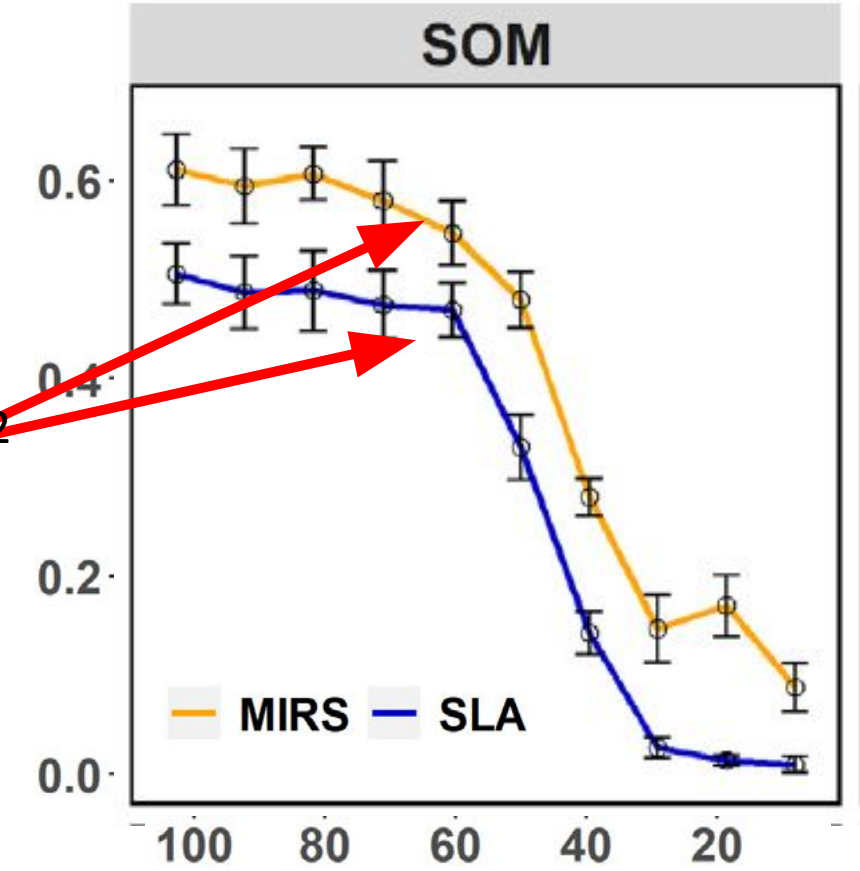


Standard laboratory analysis

MIR spectroscopy

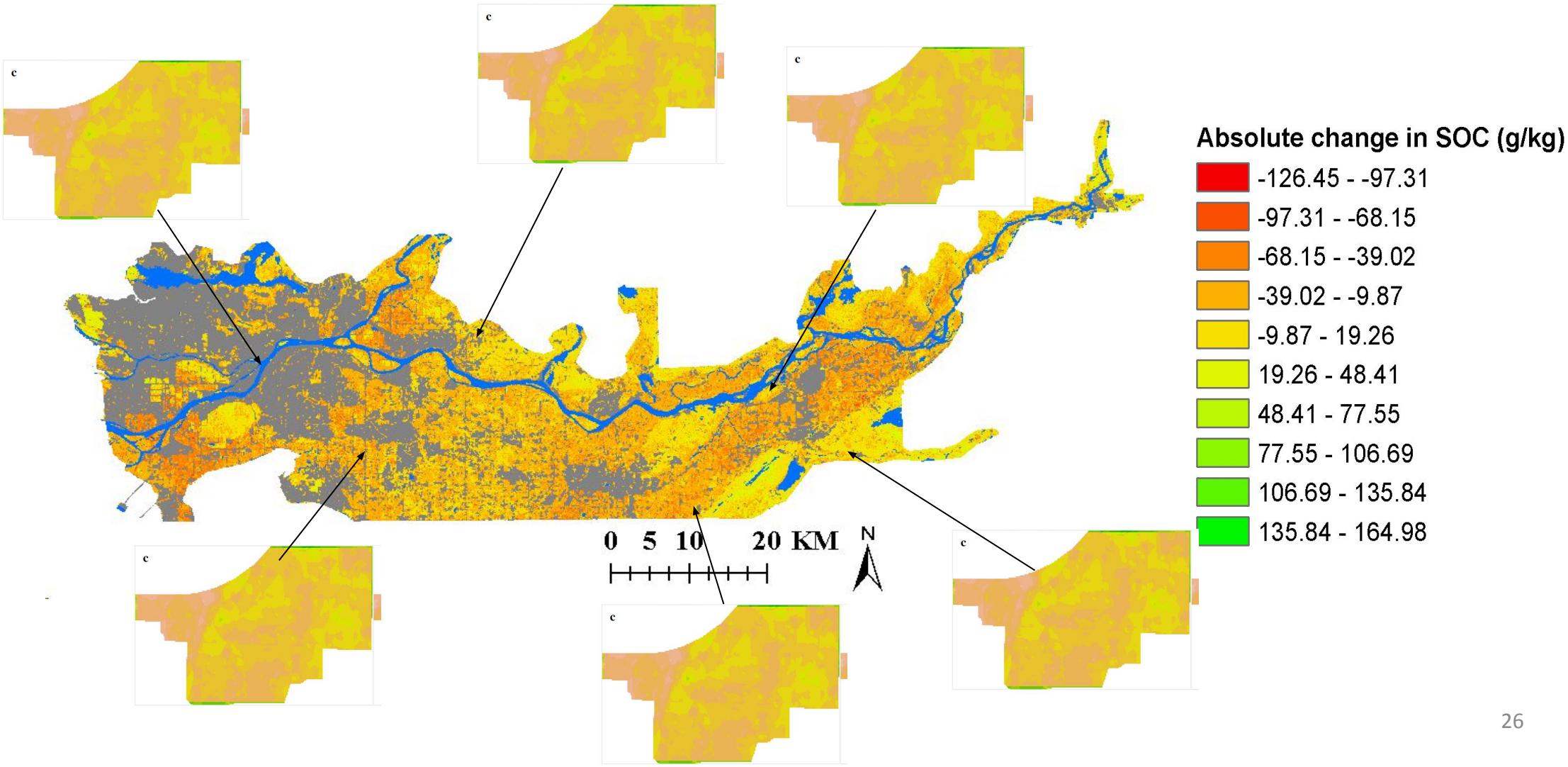
Sampling Effort

Sampling effort	Number of SLA samples	Number of SLA samples/ha	Number of MIRS samples	Number of MIRS samples/ha	Total cost (C$)
100%	62	1.15	308	5.70	2464
90%	56	1.04	277	5.13	2216
80%	50	0.93	246	4.56	1968
70%	43	0.80	216	4.00	1728
60%	37	0.69	185	3.43	1480
50%	31	0.57	154	2.85	1232
40%	25	0.46	123	2.28	984
30%	19	0.35	92	1.70	736
20%	12	0.22	62	1.15	496
10%	6	0.11	31	0.57	248



R^2

Hierarchical Sampling



Considerations

- Baseline sampling with landscape scaling in mind
- Sampling other land uses
- Field sampling tradeoffs in terms of costs and accuracy: what are the cost constraints?
- Strategies for integrating data in a hierarchy
- Long-term plans for analysis

Questions

The Sustainable Agricultural Landscapes (SAL) Lab
http://sal-lab.landfood.ubc.ca/