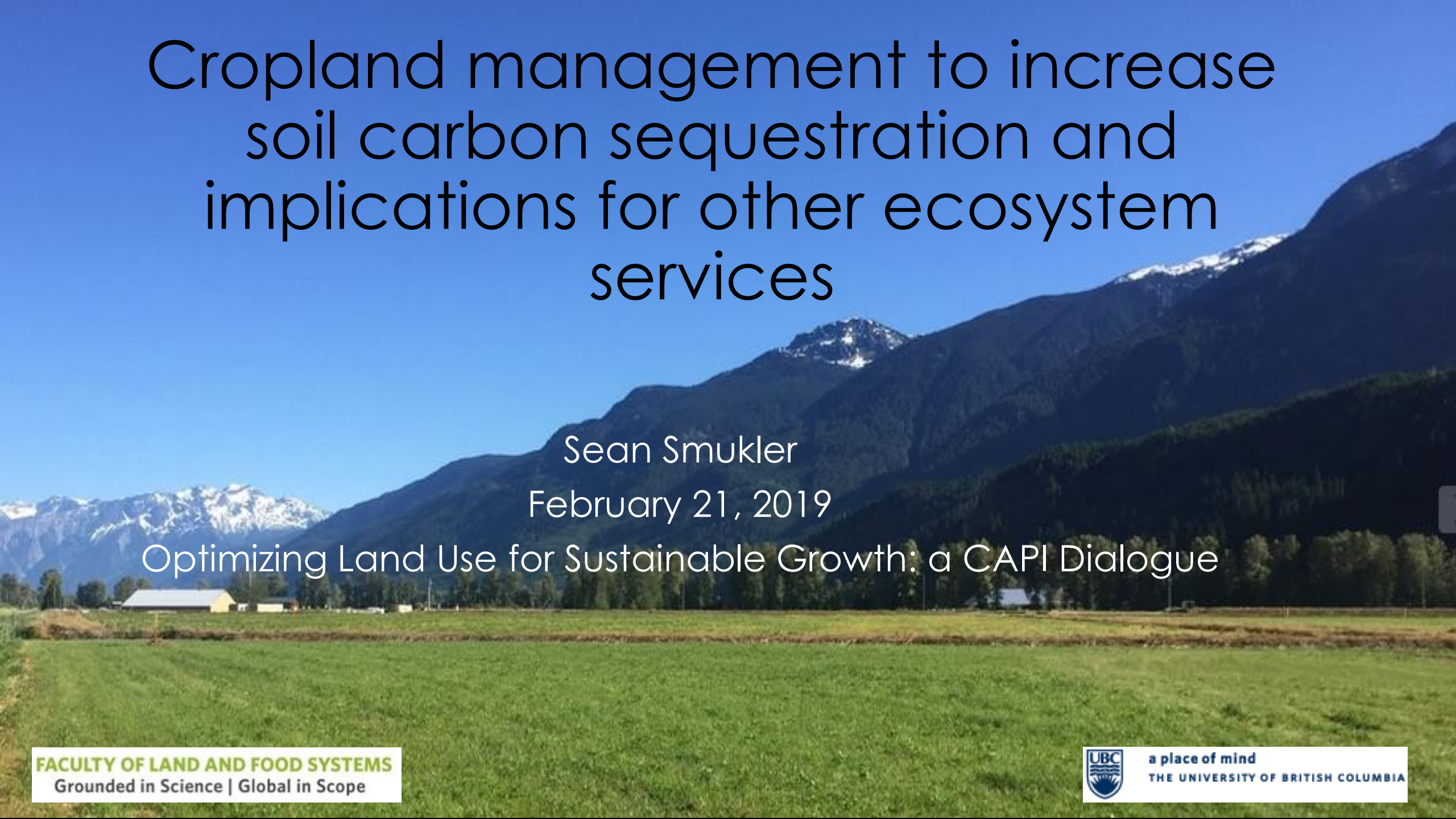
Cropland management to increase soil carbon sequestration and implications for other ecosystem services

Sean Smukler

February 21, 2019

Optimizing Land Use for Sustainable Growth: a CAPI Dialogue



FACULTY OF LAND AND FOOD SYSTEMS
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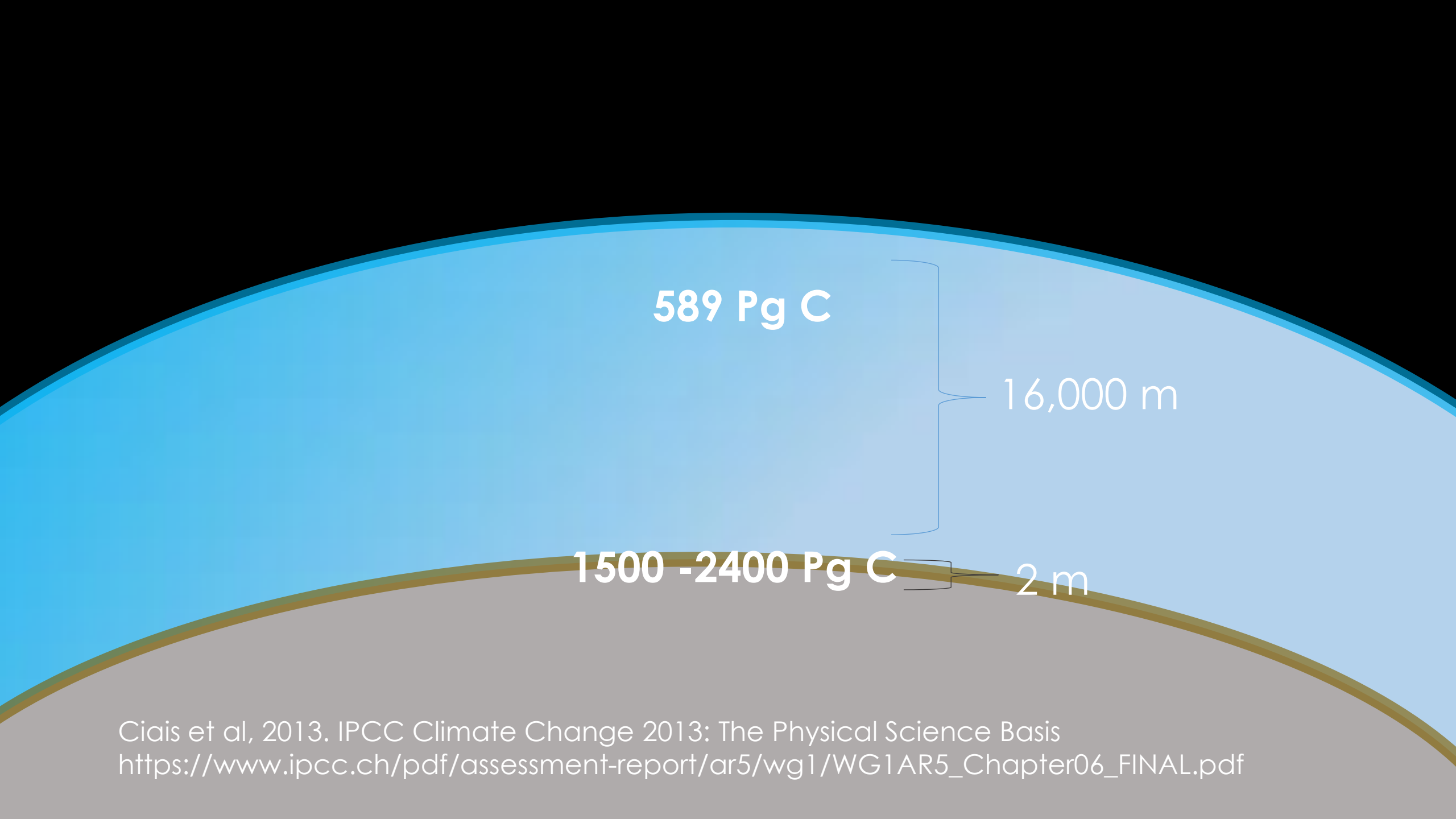
a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA



Ciais et al, 2013. IPCC Climate Change 2013: The Physical Science Basis
https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter06_FINAL.pdf

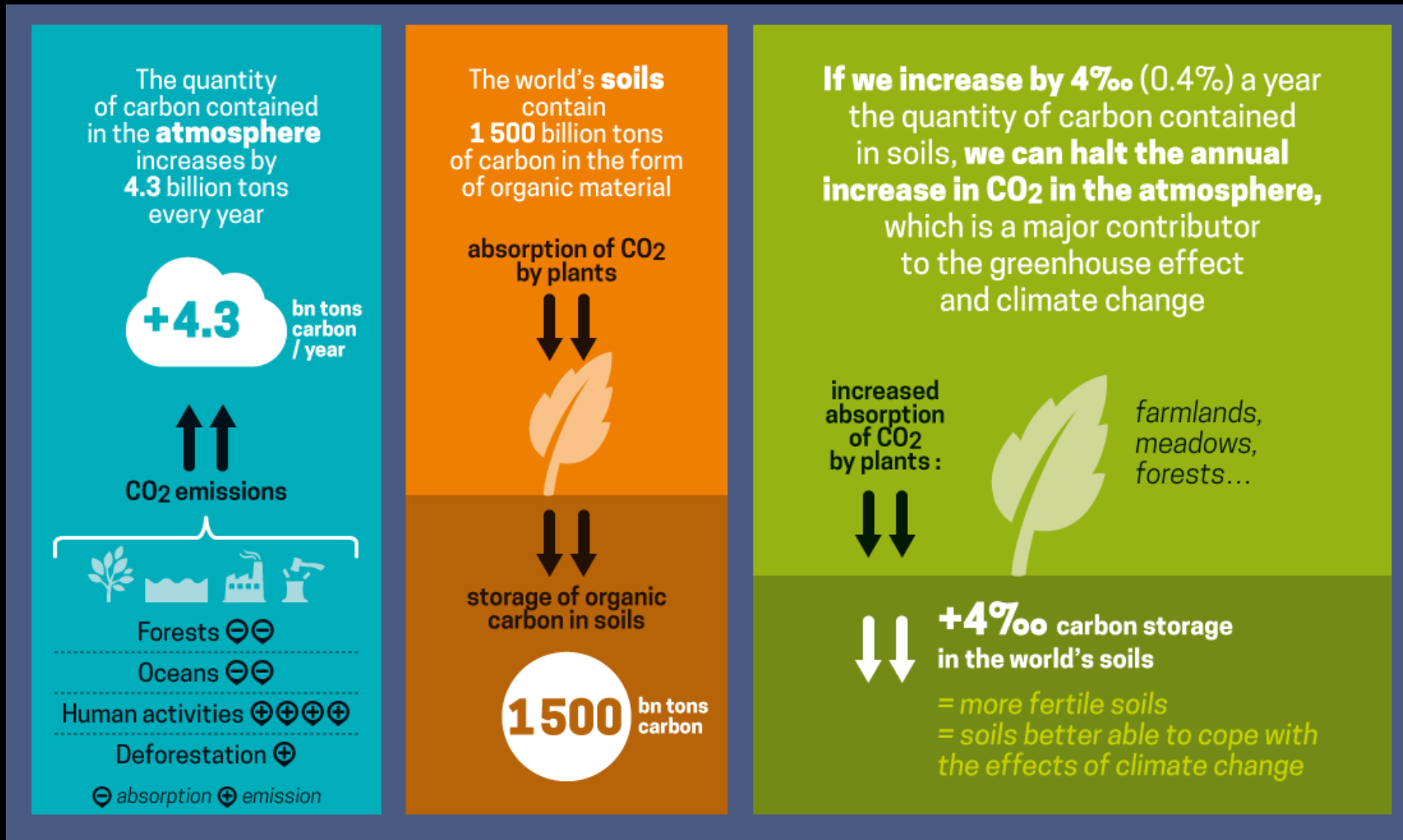
The Next 30 Minutes

1. **Opportunities** for increasing cropland soil carbon (SOC) sequestration
2. **Challenges** for adoption of SOC beneficial practices
3. Managing **risks and trade-offs** with other ecosystem services
4. Examples of **solution** strategies and recommendations

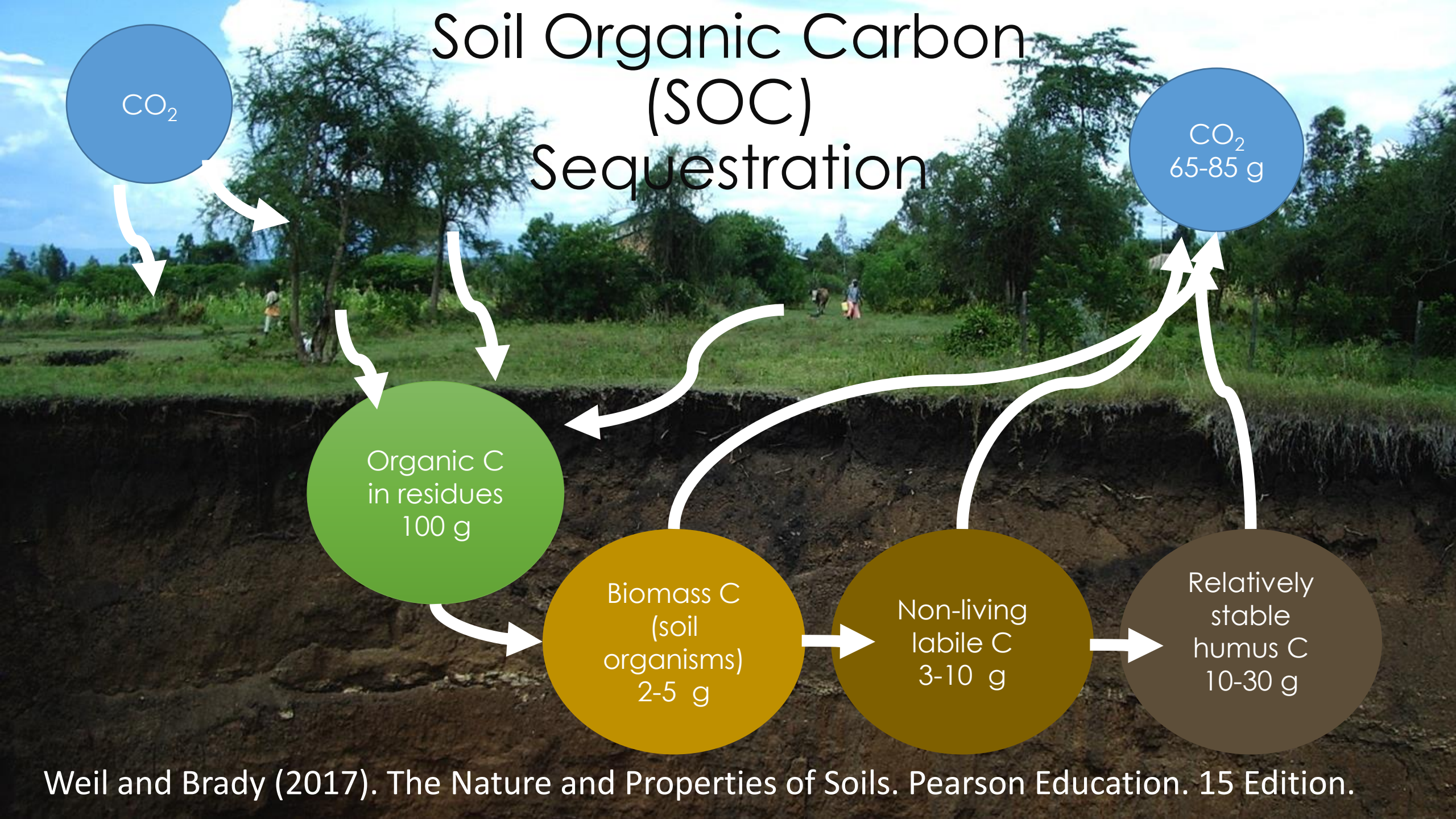
Opportunities for increasing cropland soil carbon sequestration

4 per mille Soils for Food Security and Climate

Launched at the COP21 in December 2015

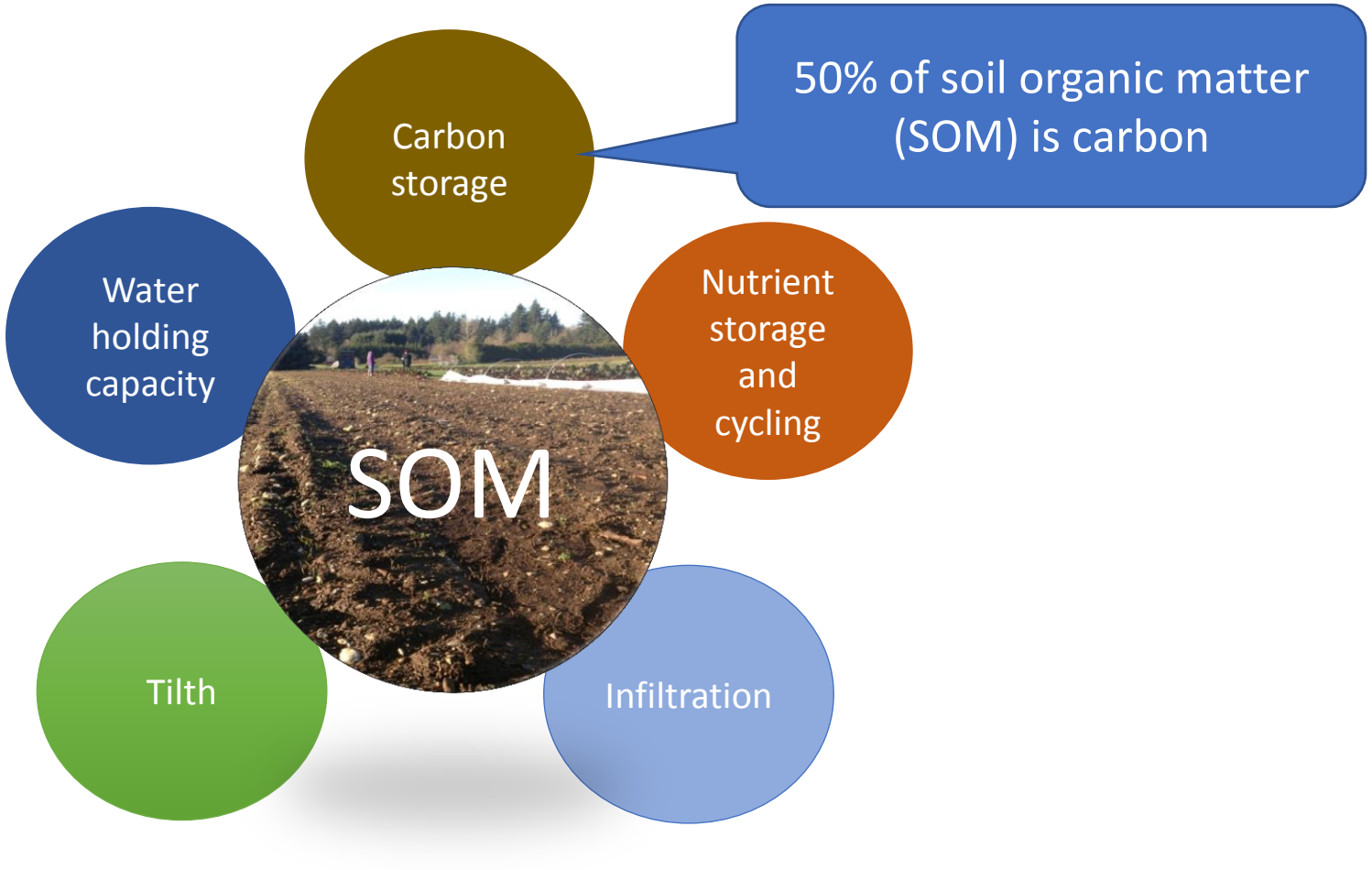


Soil Organic Carbon (SOC) Sequestration

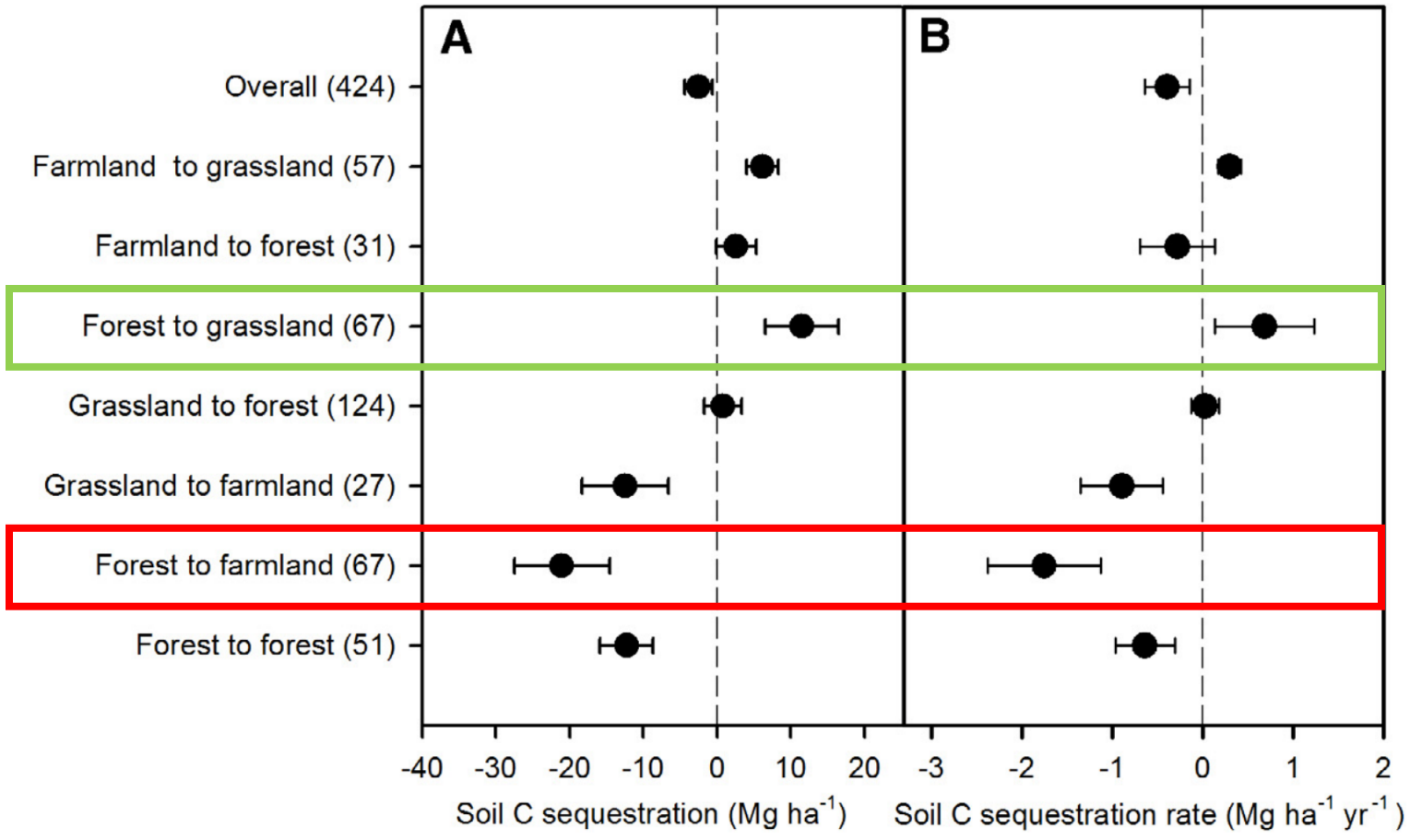


Weil and Brady (2017). The Nature and Properties of Soils. Pearson Education. 15 Edition.

Examples of the Benefits of SOC



SOC and Land Use Change



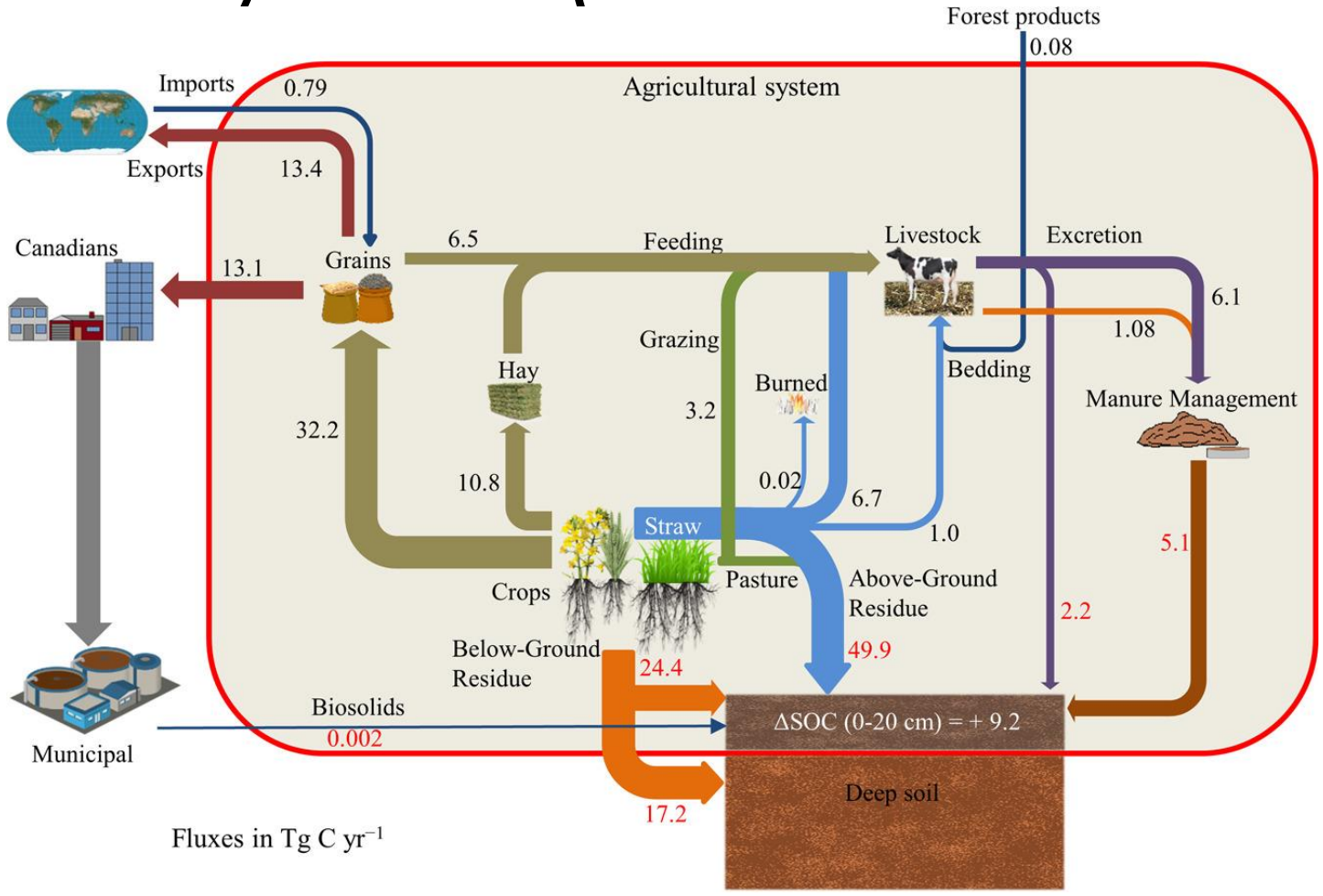
Deng et. al 2016 Global patterns of the effects of land-use changes on soil carbon stocks. Global Ecology and Conservation Volume 5,

Increase Organic Inputs

Improve Nutrient Management
Biosolids applications
Compost applications

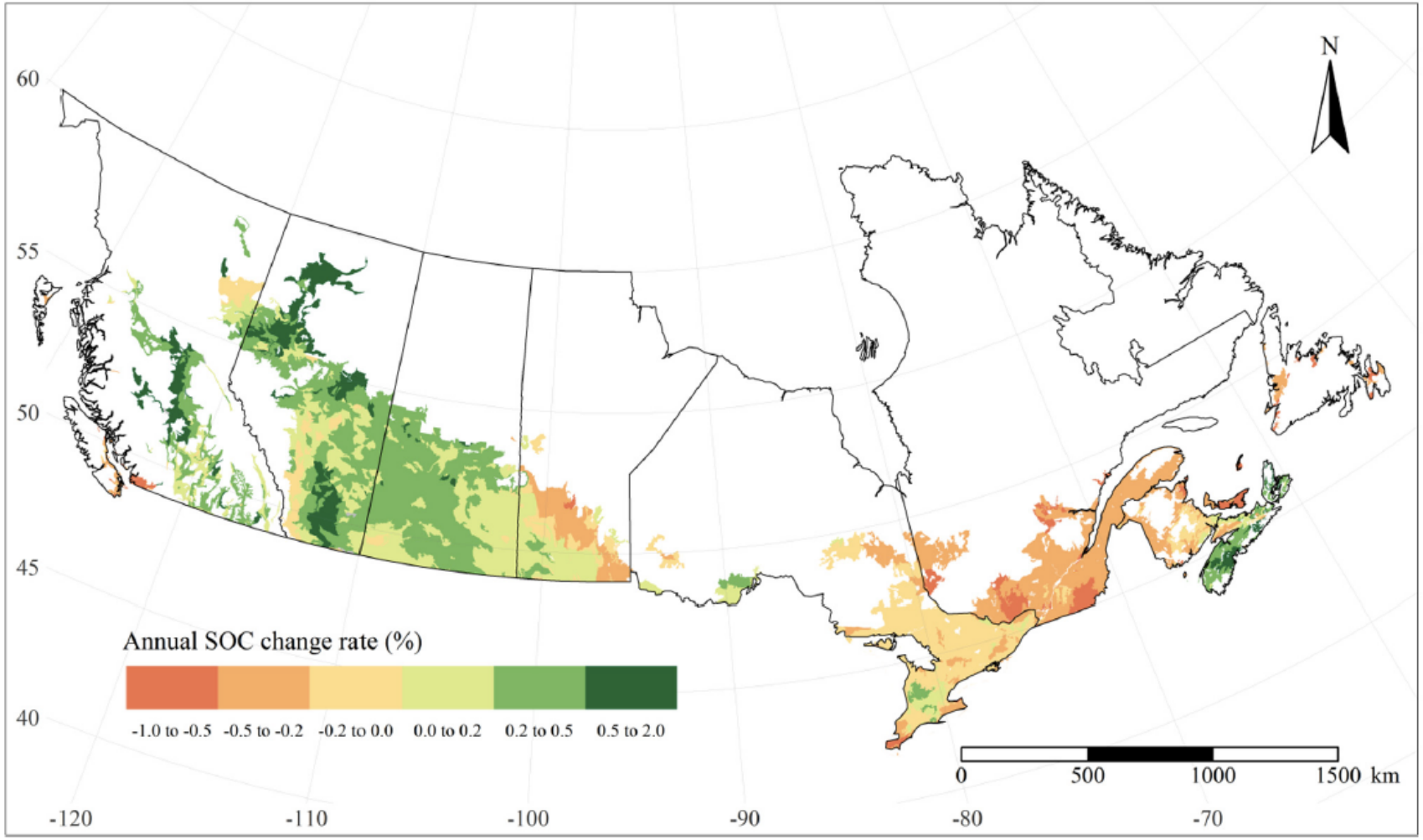
Increase Crop Yield and Root Inputs

Modelled Carbon fluxes in Canadian agroecosystem (2005–2015 average)



Fan, J., B. G. McConkey, B. C. Liang, D. A. Angers, H. H. Janzen, R. Kröbel, D. D. Cerkowniak, and W. N. Smith. 2019. Increasing crop yields and root input make Canadian farmland a large carbon sink. Geoderma 336:49–58.

Modelled Annual rate of change of SOCs (%) from 1971 to 2015 in 0–20 cm



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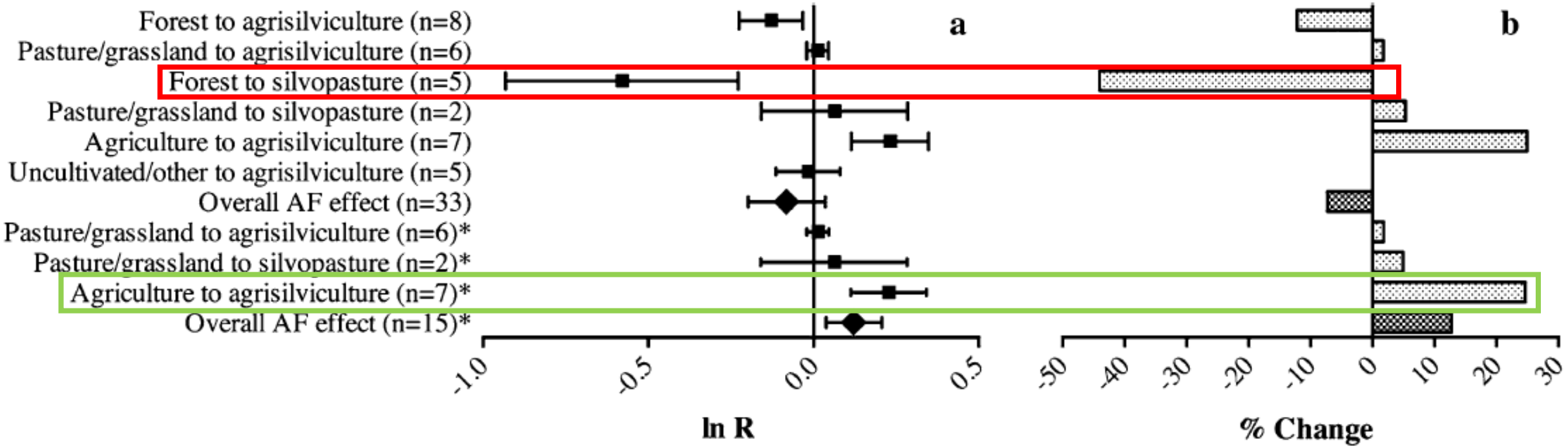
Reduced soil disturbance

Cover crops
Reduced tillage
Strip crops


Increase Diversity
Crop rotations
Incorporate Grassland Set-Asides
(GLSA) into crop rotations


Plant trees in and around crop fields -
agroforestry

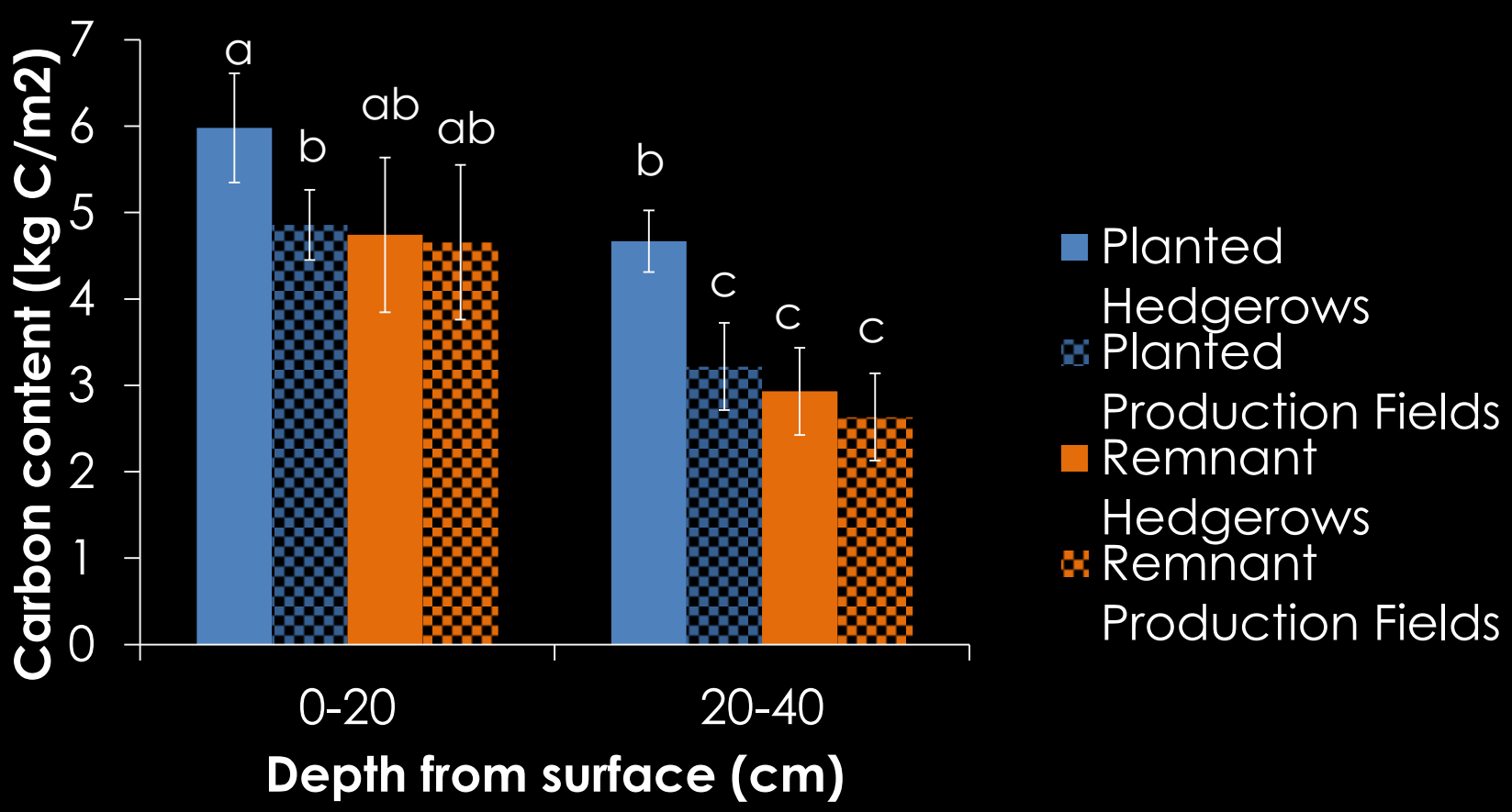
Agroforestry Meta-Analysis of SOC

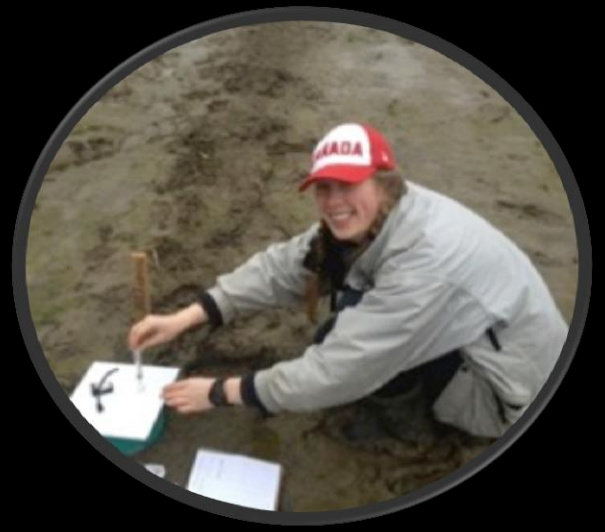


De Stefano, A., and M. G. Jacobson. 2018. Soil carbon sequestration in agroforestry systems: a meta-analysis. Agroforestry Systems 92:285–299.

Plant hedgerows

Hedgerows and SOC

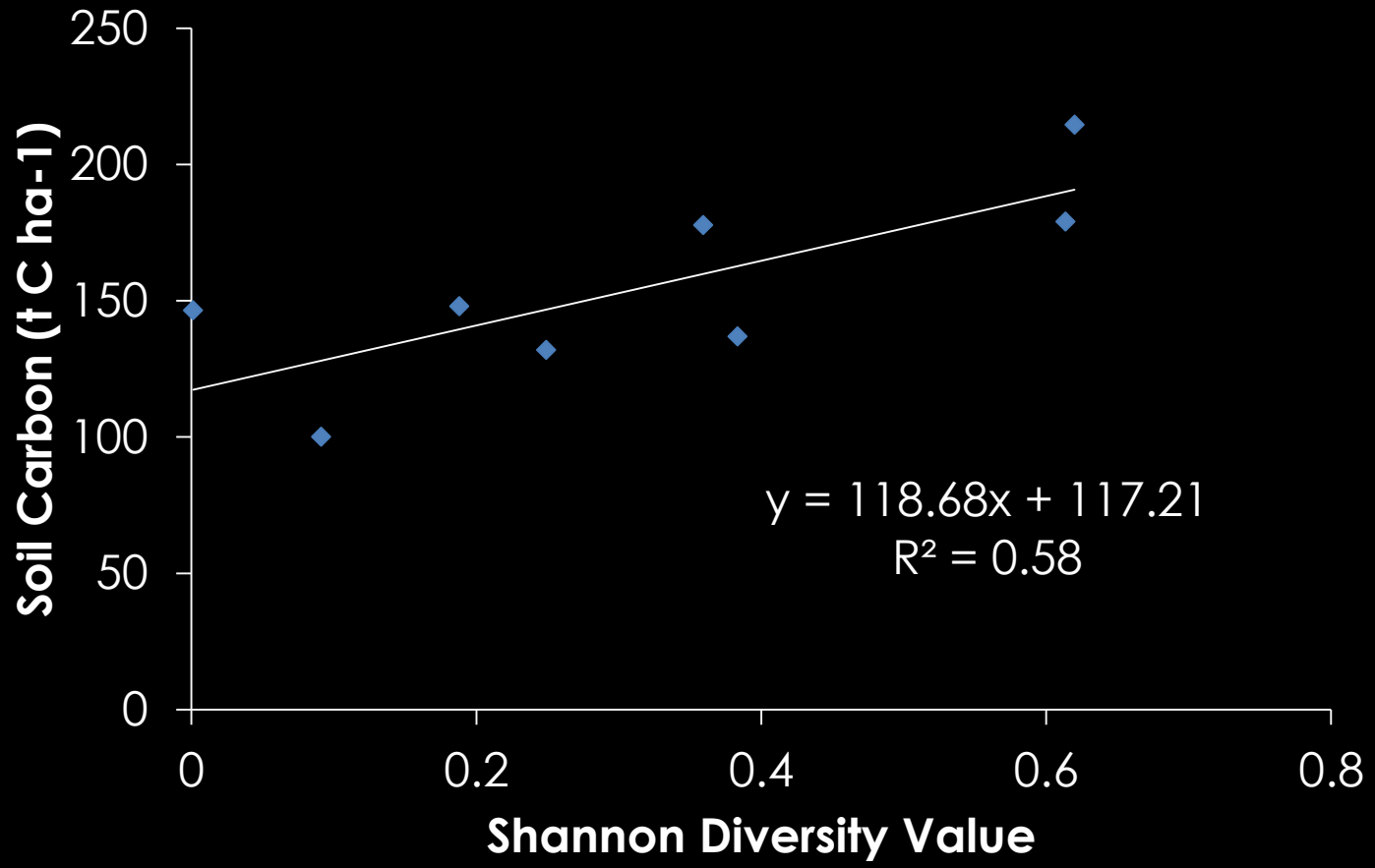




Bryanna Thiel
MSc, 2014

Thiel, B., S. M. Smukler, et al. 2015. Using hedgerow biodiversity to enhance the carbon storage of farmland in the Fraser River delta of British Columbia. Journal of Soil and Water Conservation 70:247–256.

Hedgerow Biodiversity and Carbon Storage



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Getting Carbon into the Soil

tCO_2-eq/ha/yr

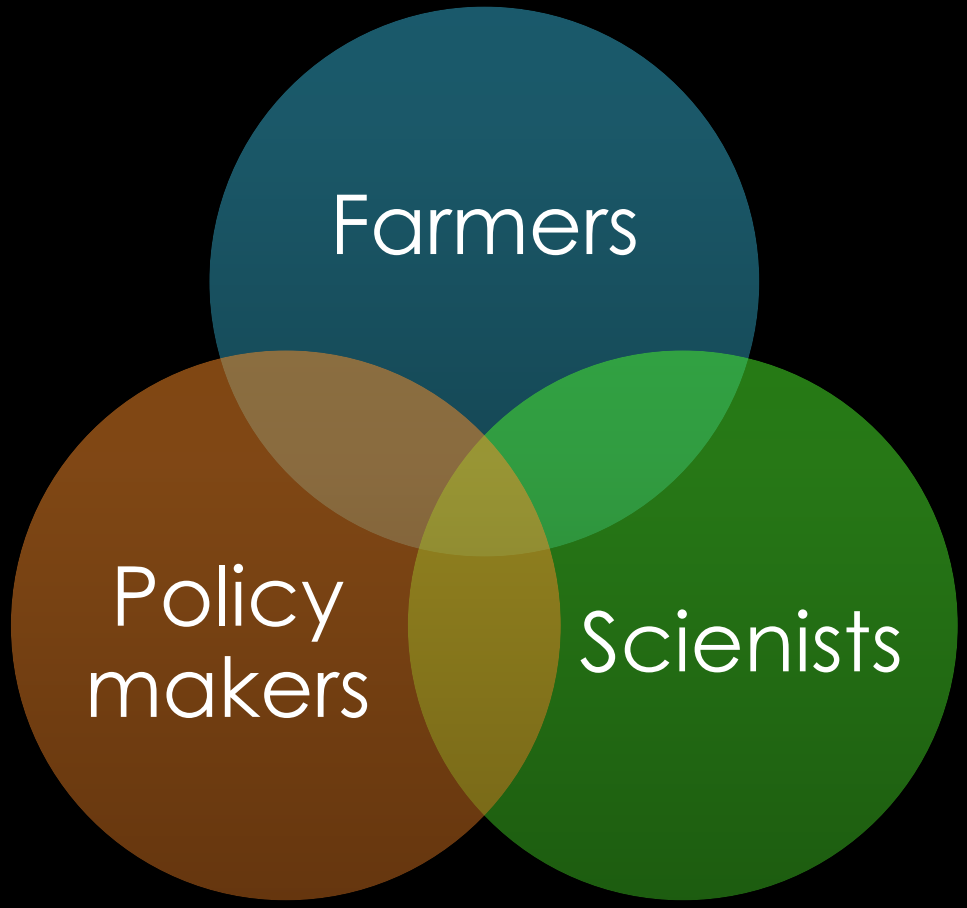
Uncertainty is high

Climate Zone	Practice	Ave.	Low	High
Cool moist	Nutrient management	0.55	0.01	1.10
	Tillage and residue management	0.51	0.00	1.03
	Set-aside and LUC	3.04	1.17	4.91
Warm moist	Agro-forestry	0.70	-0.40	1.80
	Restoration of degraded soils	3.45	-0.37	7.26

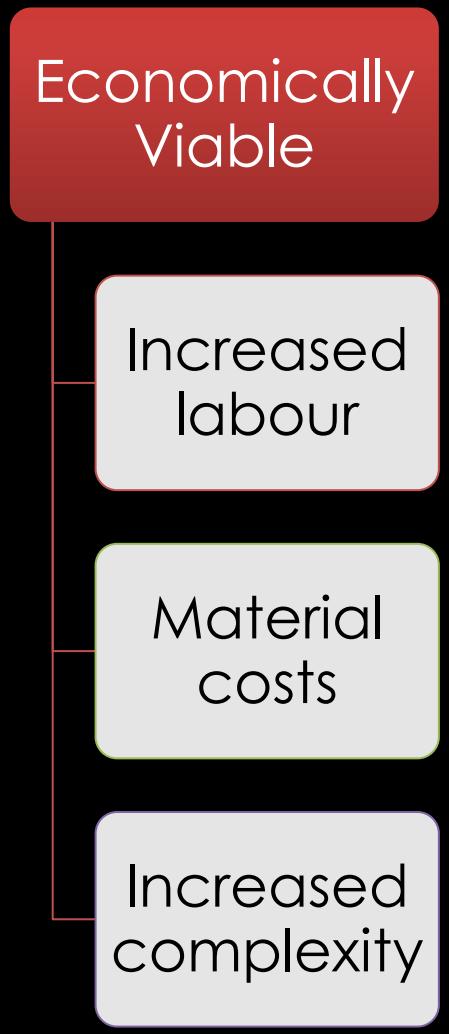
Smith et al 2007 Agriculture. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the IPCC

Challenges for adoption of SOC beneficial practices

Shared Challenge



Farmer Challenges



Scientific Challenges

Guidance for beneficial management practices

Monitoring, reporting, and verification

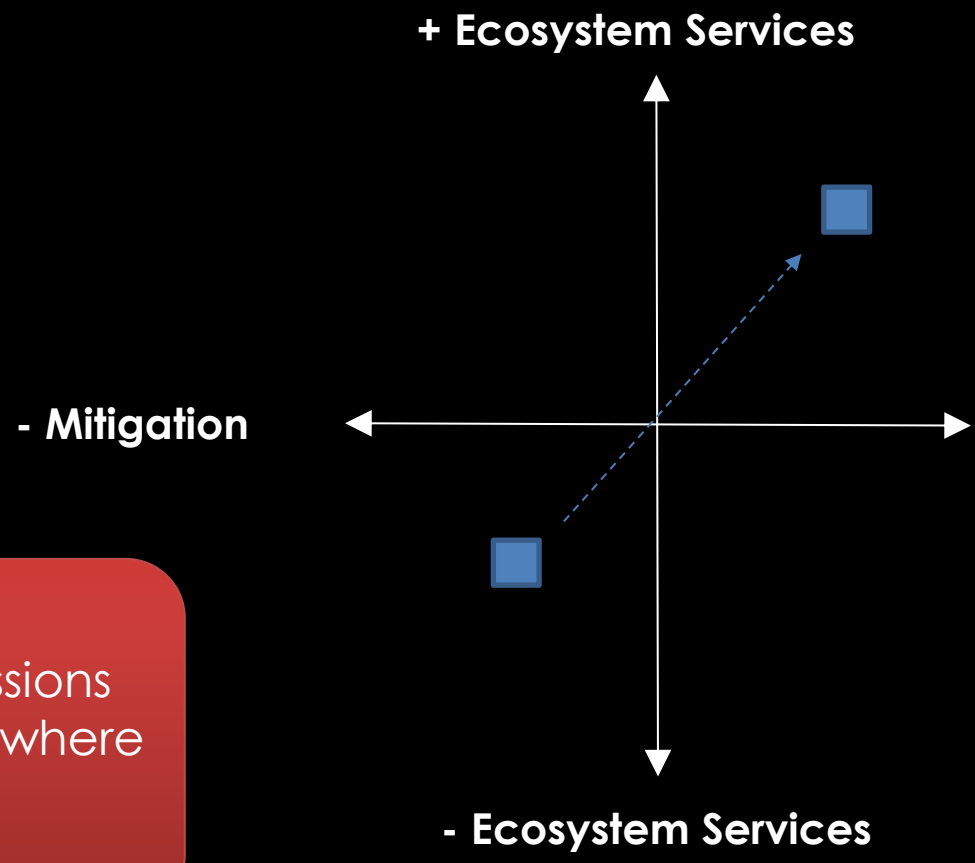
Policy Challenges

Farmer Incentives

Must be carefully designed

Managing **risks and trade-offs** with other ecosystem services

Tradeoffs Between SOC Sequestration and other Ecosystem Services



Increased habitat and biodiversity

Increased N_2O emissions
Land conversion elsewhere (leakage)

Loss of nutrients and/or pesticides to aquatic ecosystems

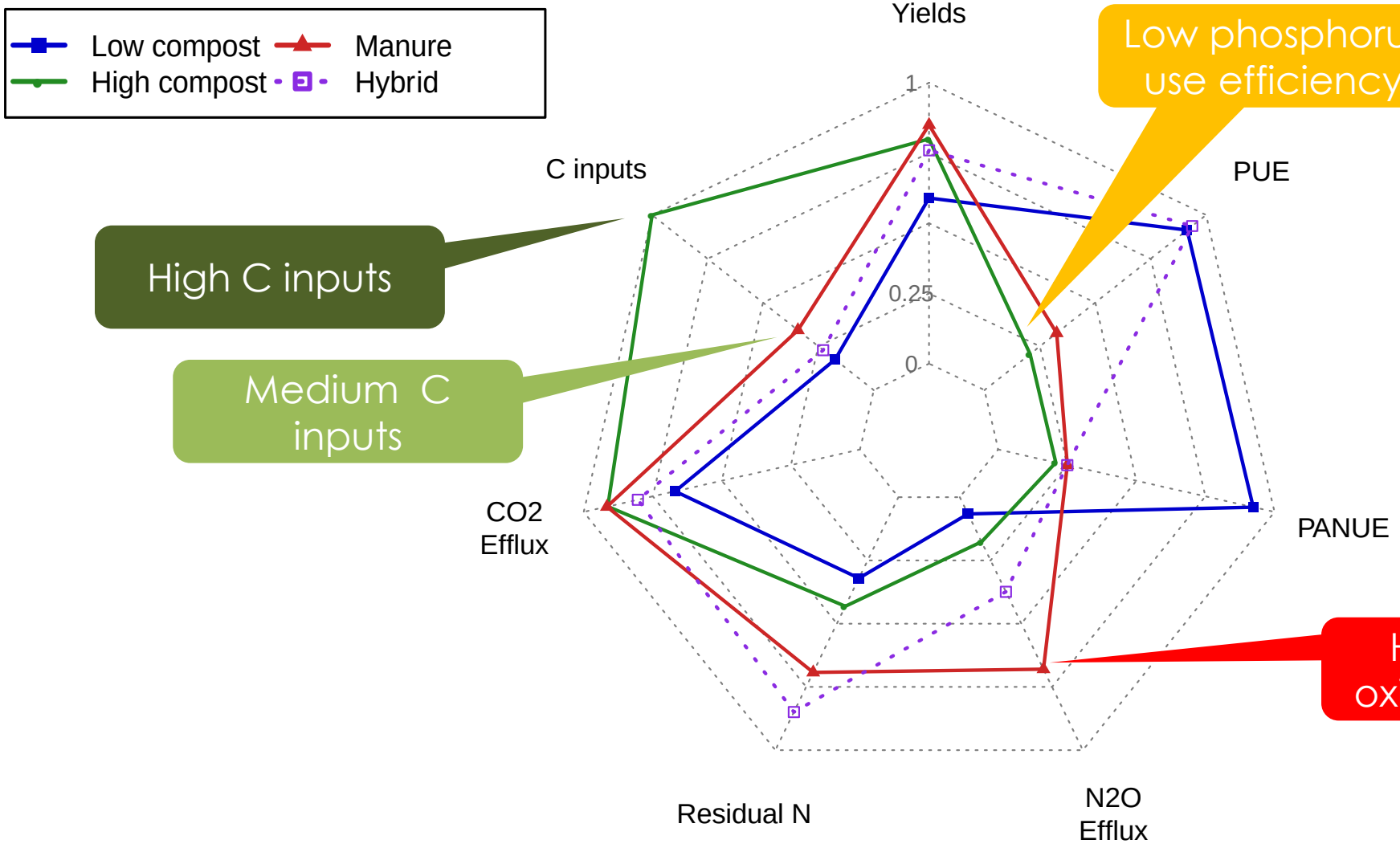
Potential Field Scale Trade-offs

- **Four treatments**
  - **Low Compost:** municipal compost matching P removal
  - **High Compost:** municipal compost matching crop N demand
  - **Manure:** poultry manure matching crop N demand
  - **Hybrid:** control + blood meal to match crop N demand

Maltais-Landry, G. and Smukler, S. In prep.

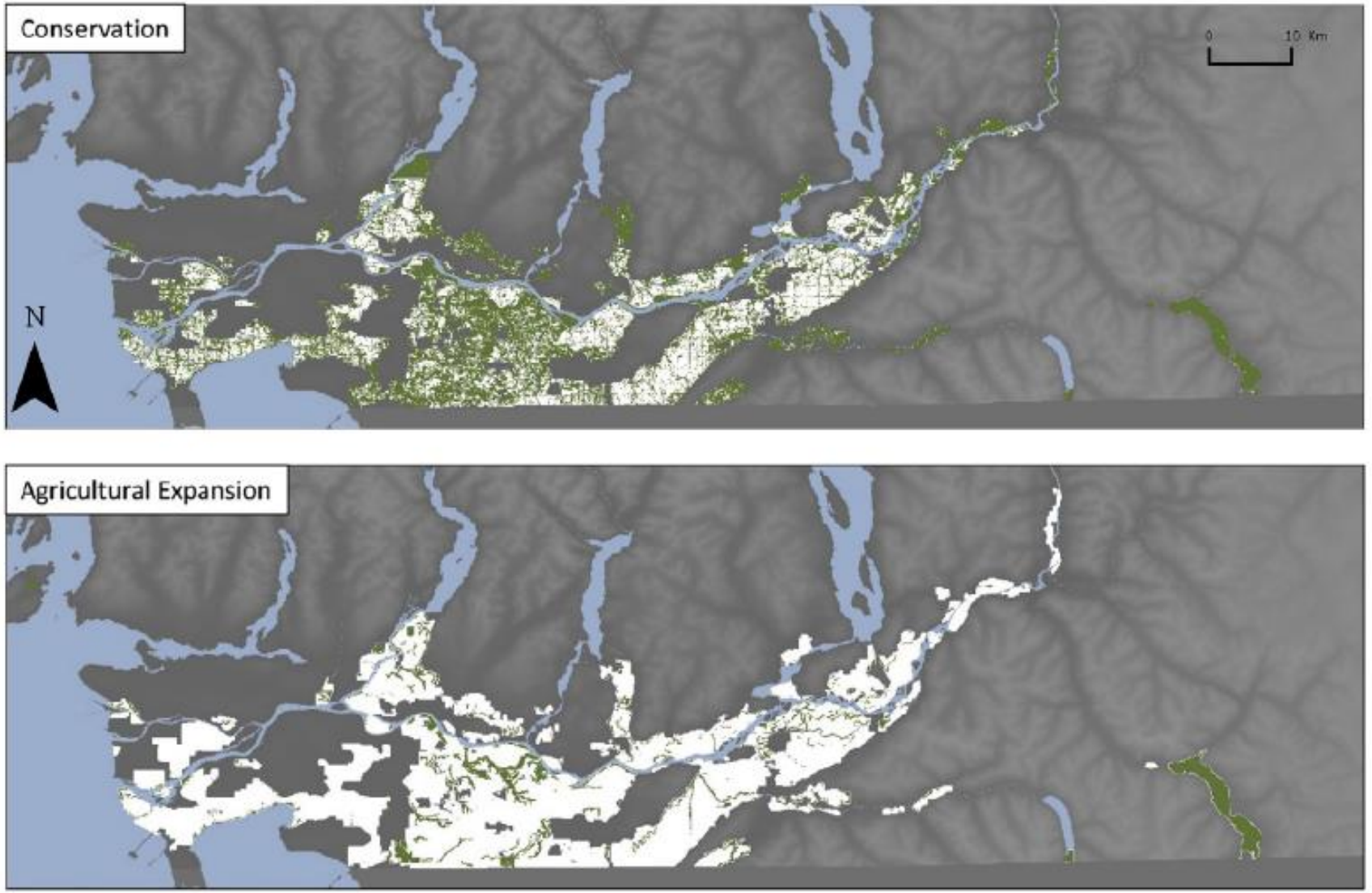
Gabriel Maltais-Landry, PhD

Potential Field Scale Trade-offs



Maltais-Landry, G. and Smukler, S. *In prep*

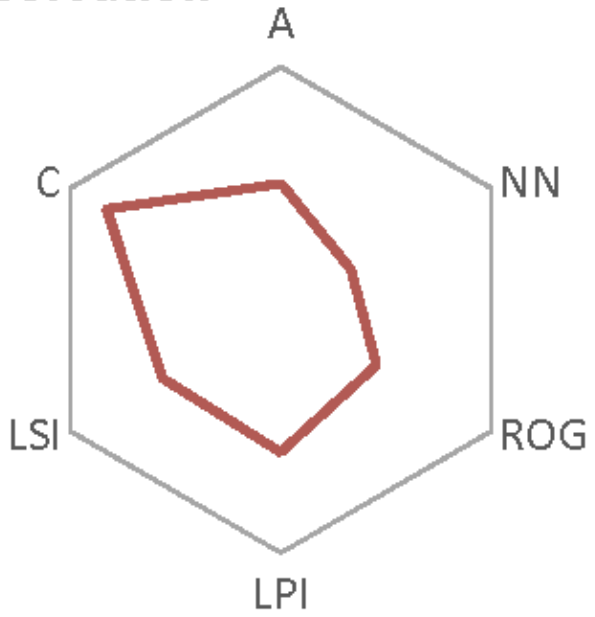
Potential Landscape Scale Trade-offs



Rallings, A. M., S. M. Smukler, S. E. Gergel, and K. Mullinix. 2019. Towards multifunctional land use in an agricultural landscape: A trade-off and synergy analysis in the Lower Fraser Valley, Canada. Landscape and Urban Planning 184:88–100.

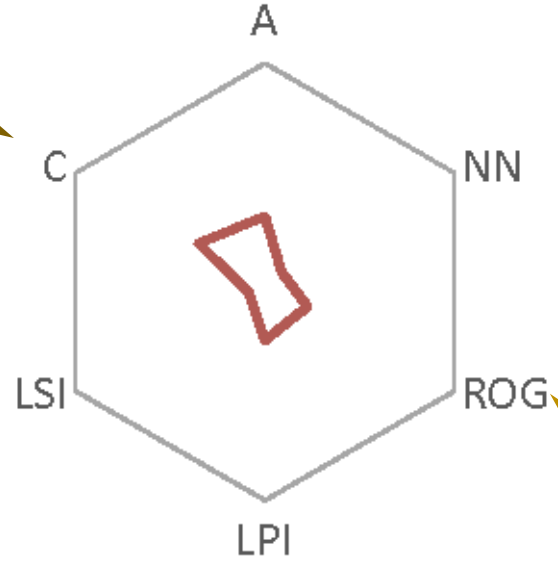
Carbon vs. Habitat

Conservation



Above ground carbon stocks reduced by 80.0%

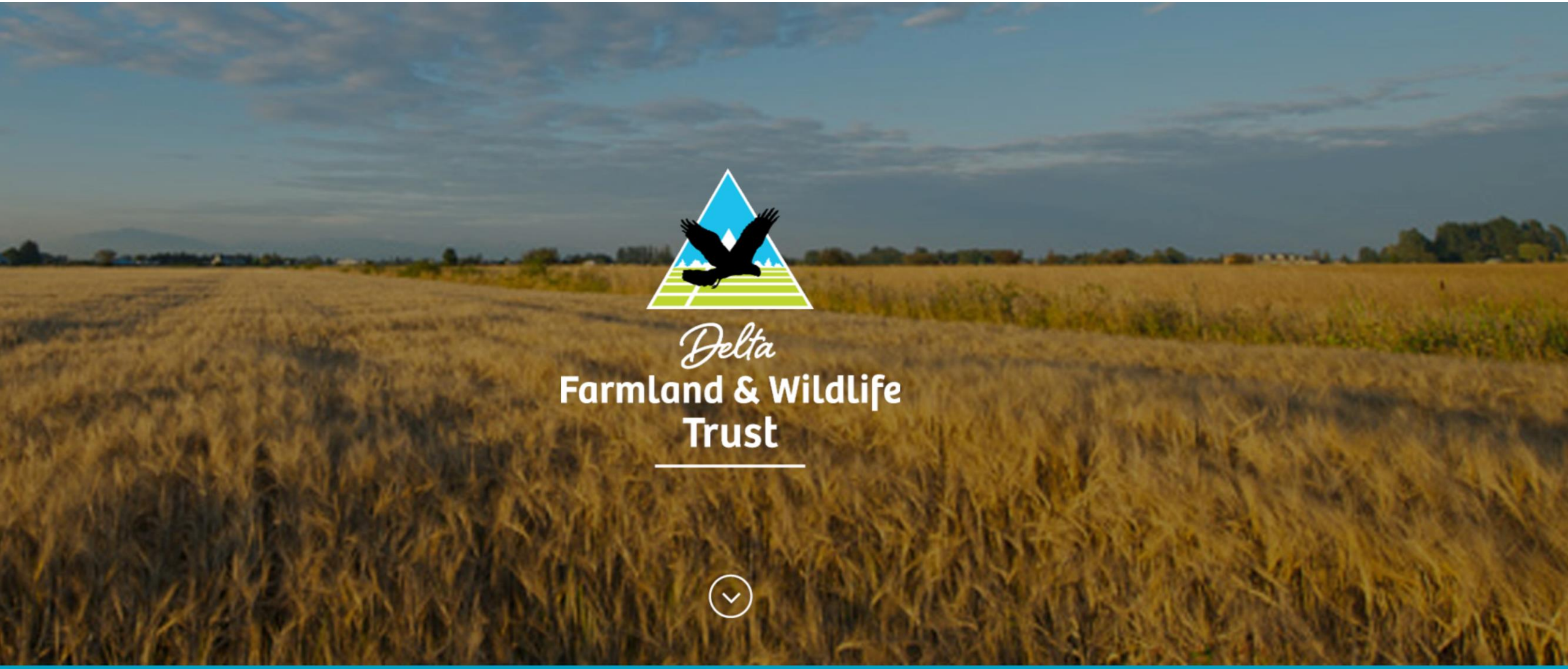
Agricultural Expansion



Habitat connectivity decreased by 51.8%,

Rallings, A. M., S. M. Smukler, S. E. Gergel, and K. Mullinix. 2019. Towards multifunctional land use in an landscape: A trade-off and synergy analysis in the Lower Fraser Valley, Canada. Landscape and Urban 184:88–100.

Examples of **solution** strategies and recommendations



Supporting local farms that feed families and the birds!

- Since 2002, close to 13 million tonnes of CO2e have been voluntarily removed
- Offsets are estimated to have generated about $170 million for farmers and aggregators.

$15 million to fund Incentives Program and Demonstration Projects

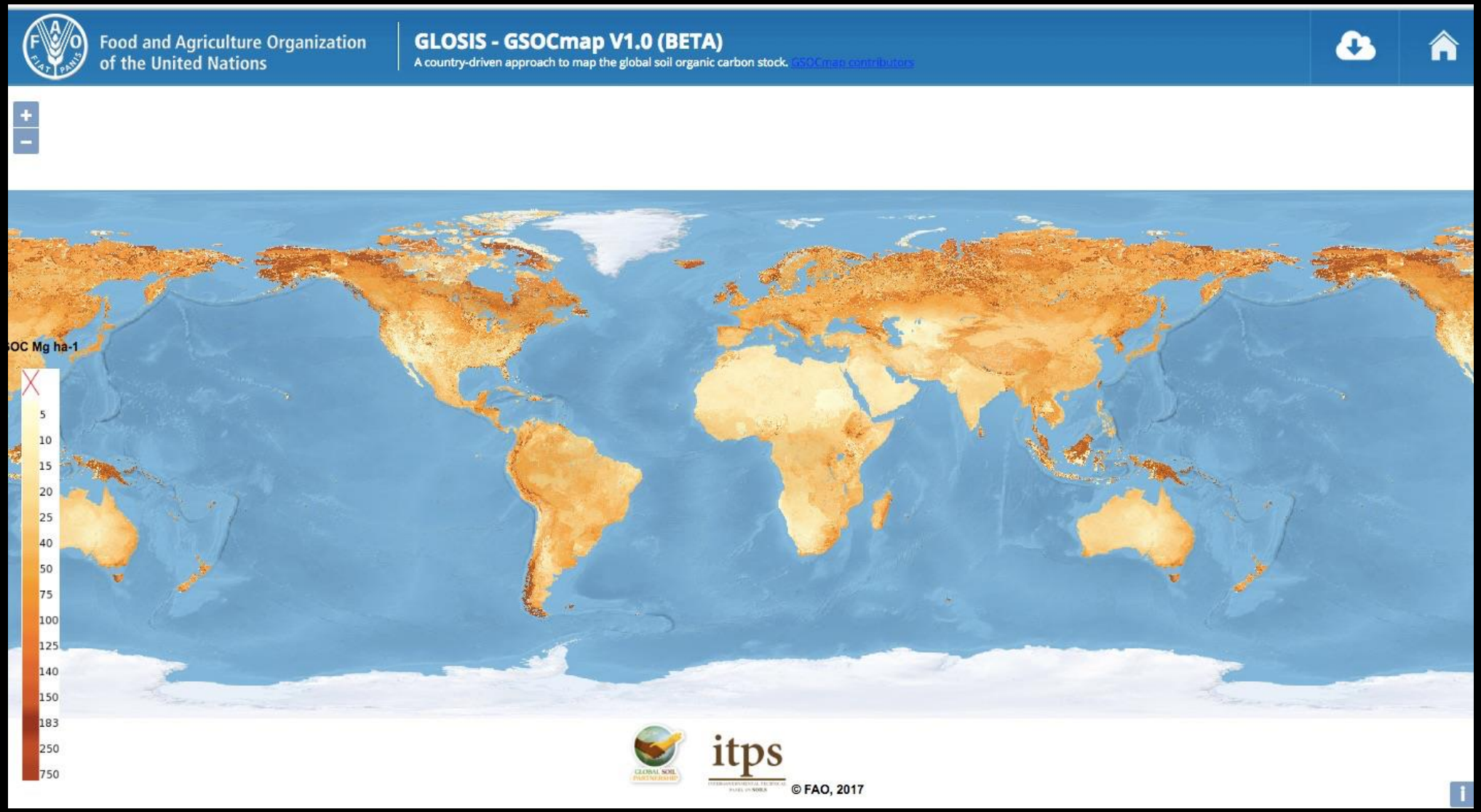
Healthy Soils Initiative Objectives

(1) providing financial incentives to California growers and ranchers for agricultural management practices that sequester carbon, reduce atmospheric GHGs and improve soil health,

(2) funding on-farm demonstration projects that conduct research and/or showcase conservation management practices that mitigate GHG emissions and improve soil health, and

(3) creating a platform promoting widespread adoption of conservation management practices throughout the state.

1. Develop a baseline



Sidd Paul

Soil Organic Carbon (%)
High : 4.50
Low : 1.50
Railway Lines
Road Network
0 1 2 4
Kilometers
N

http://sal-lab.landfood.ubc.ca/people/siddhartho-paul/

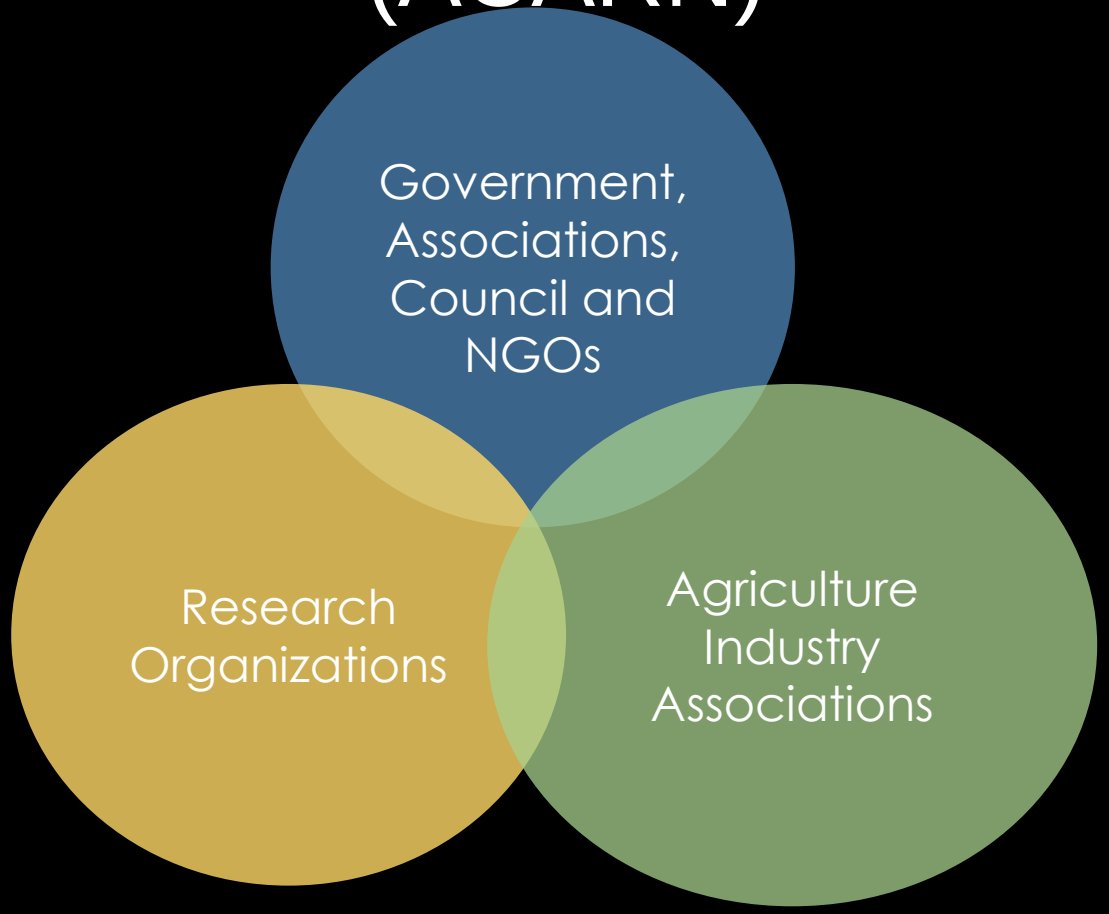
2. Analyze options, identify and prioritize management solutions

- Quantify impacts of management options
- Develop cost effective analysis
- Reduce uncertainty
- Assess potential tradeoffs
- Model future benefits

3. Coordinate and collaborate

- Optimize the use of resources
- Find synergies
- Build knowledge strategically

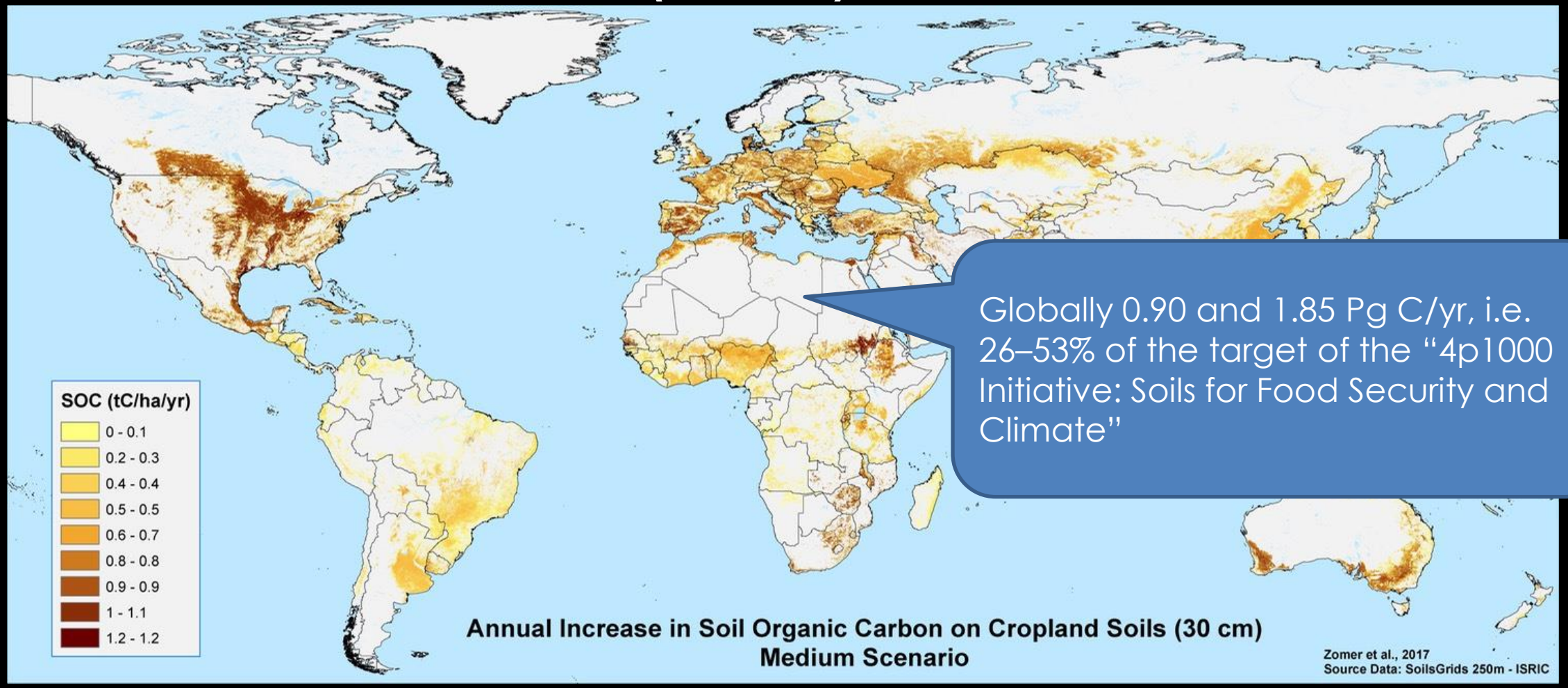
BC Agricultural Climate Change Adaptation Research Network (ACARN)



4. Establish policy

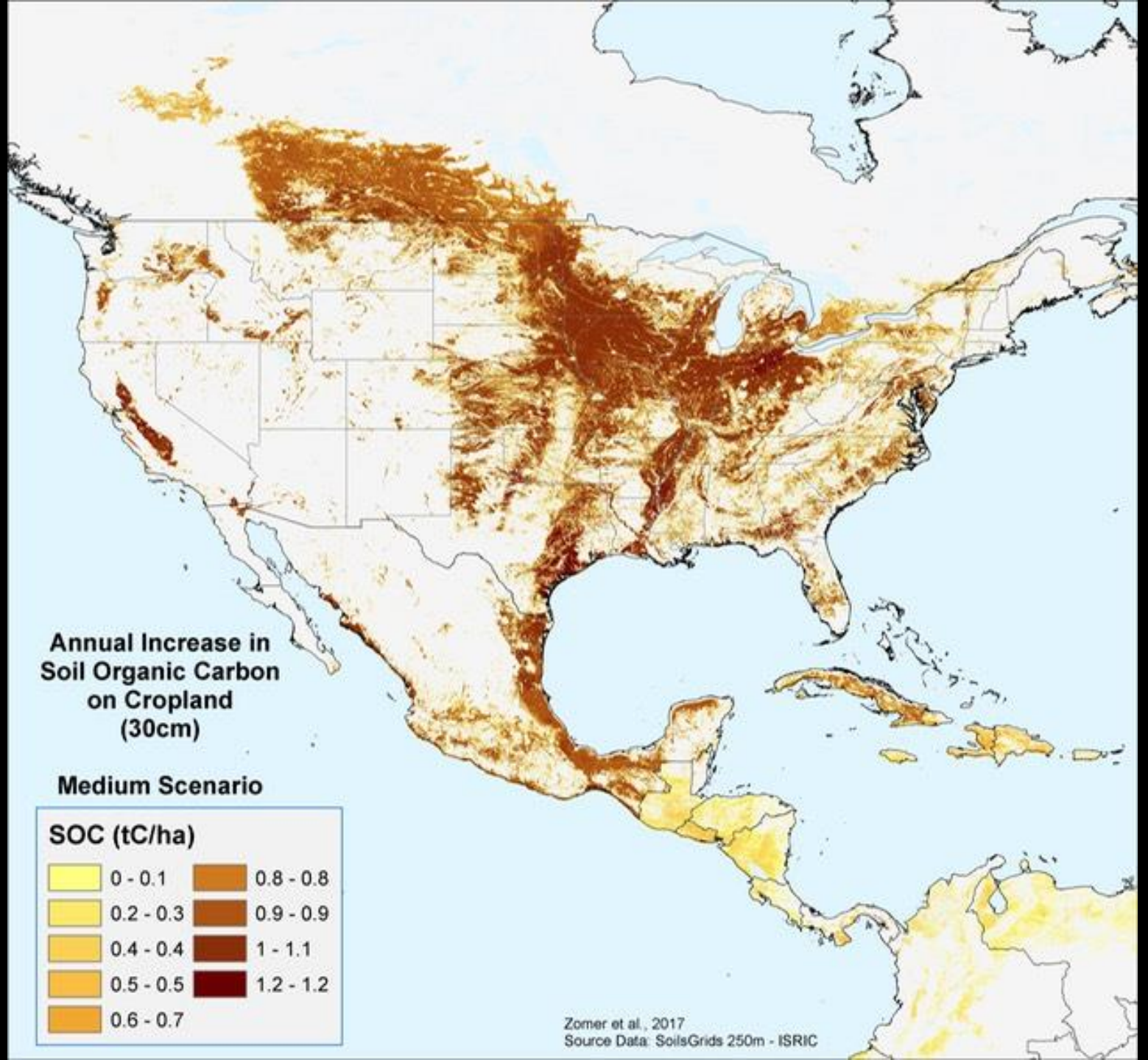
- Resources have to be committed
- Extension services need investment and deployment
- Need to provide incentives for farmers to adopt different practices

Projected Annual increase in soil organic carbon (SOC) 0-30 cm



Globally 0.90 and 1.85 Pg C/yr, i.e. 26–53% of the target of the "4p1000 Initiative: Soils for Food Security and Climate"

Zomer, R. J., D. A. Bossio, R. Sommer, and L. V. Verchot. 2017. Global Sequestration Potential of Increased Organic Carbon in Cropland Soils. Scientific Reports 7:15554.


Annual Increase in Soil Organic Carbon on Cropland (30cm)
Medium Scenario
SOC (tC/ha)
0 - 0.1
0.2 - 0.3
0.4 - 0.4
0.5 - 0.5
0.6 - 0.7
0.8 - 0.8
0.9 - 0.9
1 - 1.1
1.2 - 1.2
Zomer et al., 2017
Source Data: SoilsGrids 250m - ISRIC

Questions

To find out more about our research:

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

Centre for Sustainable Food Systems at the UBC Farm http://ubcfarm.ubc.ca/