



Agriculture et
Agroalimentaire Canada

Agriculture and
Agri-Food Canada



**Current status of maritime soils: specific
focus on PEI soils.
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2019 Island Agrology Workshop, August 18-20th

Canada

Outline

- ❖ **SOM as an indicator of soil quality**
- ❖ **Factors affecting C storage**
- ❖ **Role of annual mineralization in affecting C storage**
- ❖ **Contribution of different types of residue to C storage**
- ❖ **30 yr change of C storage western- versus eastern Canada**
- ❖ **Long-term trend of SOM in PEI**



SOM, indicator of soil quality

- ❖ **Enhances soil resiliency against degradation**
- ❖ **Reduces soil compaction, enhances aggregation, water infiltration, and soil aeration**
- ❖ **Increases ability of a soil to supply nutrients**
- ❖ **Food source for the soil living organisms**
- ❖ **Mitigates climate change, stores CO₂ from the atmosphere**

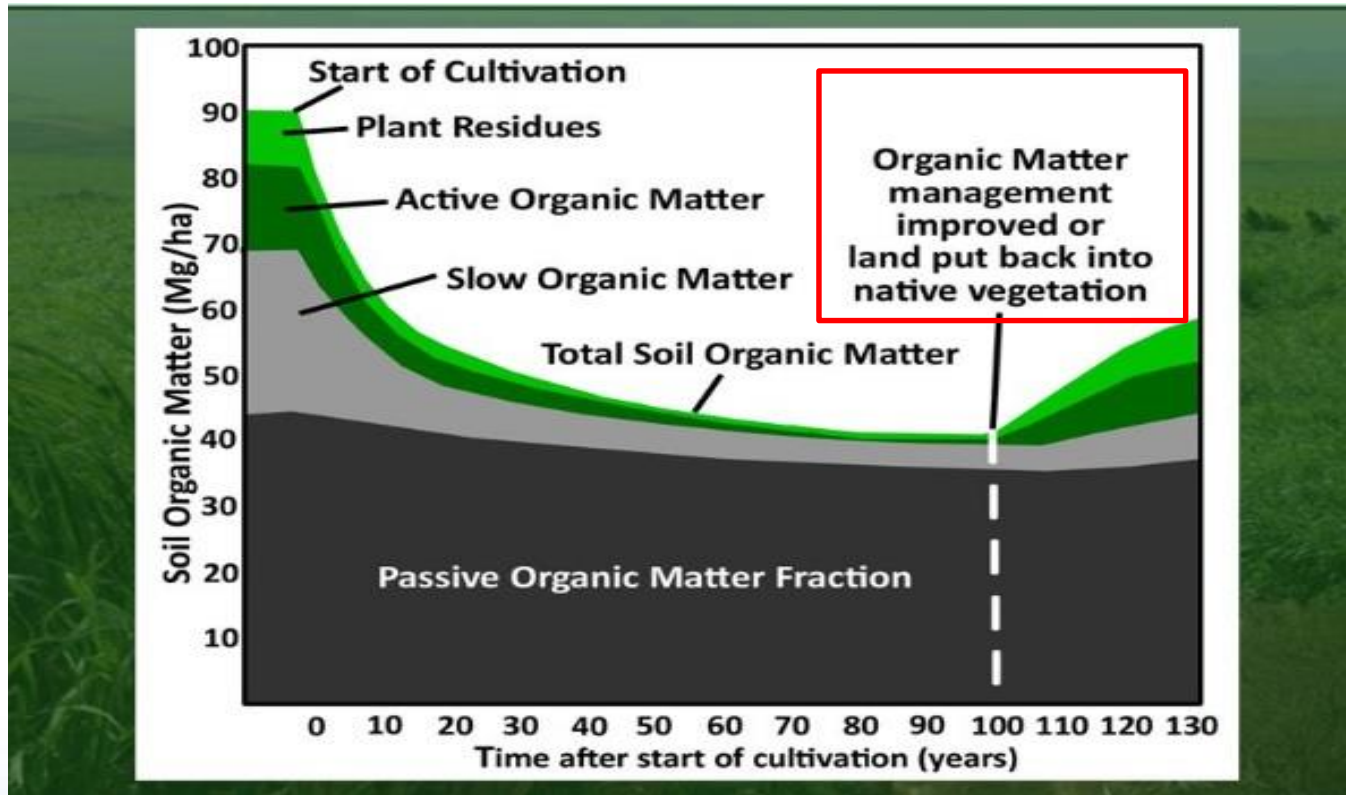


Factors affecting C storage

- ❖ C storage is affected by balance of:
 - Soil C **inputs** (plant and animal residues) and
 - Soil C **losses** (decomposition, erosion, uptake through plant and animal production)
- ❖ **Soil type**
- ❖ **Soil management practices**
- ❖ **Climate**



SOM, mixture of organic compounds



After 40 yr of cultivation, the active SOM has lost 90% of its mass. Much of the loss comes at the expenses of active SOM (Brady and Weil, 2002). The higher the active C (labile C)= the more biologically active is the soil (greater potential of nutrient turnover).

Annual mineralization rate of SOM (K_2)

Soil texture	Mineralization coefficient (% per year)
Sandy	2.5
Sandy loam	2.0
Sandy clay, loam, clayey sandy	1.2-1.5
Clayey	1

Adapted from Soltner, 1996

Yearly SOM decrease due to annual mineralization

Example of a sandy loam soil with:

3% SOM

Plow depth: 20 cm (8 inches)

Bulk density : 1.4 tonne/m³

SOM reserve: 84 tonnes/ha

Annual losses due to mineralization

(mineralization rate of 2%)= 1.7 tonnes/year/ha)



Proportion of crop residues and organic amendments to stable carbon
(dry matter basis)

Crop residue	Coefficient of humication (K_1)	Organic amendments	Coefficient of humification (K_1)
Alfalfa (1st year)	0.20	Well decomposed manure	0.50
Prairie (establishment year)	0.15	Partially decomposed manure	0.40
Winter cereal		Manure with straw	0.25
Above ground	0.15	Dry straw	0.15
Below ground	0.15		
Grain corn		Sludge for waste treatment	0.20
Above ground	0.12		
Below ground	0.15		
Spring cereal			
Above ground	0.15	Adapted from Soltner, 1996	

Estimate C storage trends based on:

Mineralization coefficient (K_1)

Humification coefficient (K_2)



Free software



Humus balance simulation: free software

The screenshot displays the 'Bilan Humique' software interface. At the top, it identifies the user as 'Marc F. Clément' and the year as '2009'. The main section, 'Cultures et Sols', is set for 'Basses terres du St-Laurent' climate. A field with number '001' is defined as 'Pomme de terre' (potato) on '08- Sable' (sandy) soil. The field area is 1.0 ha with a yield of 40,000 kg/ha and 8,000 kg/ha of dry matter. The soil is set to 'Faible' (low) for organic matter influencing factors. The simulation results show a 'K₂' of 2.50% and a 'Prévision de M.O. sur 100 ans' (organic matter prediction) of 3.0%.

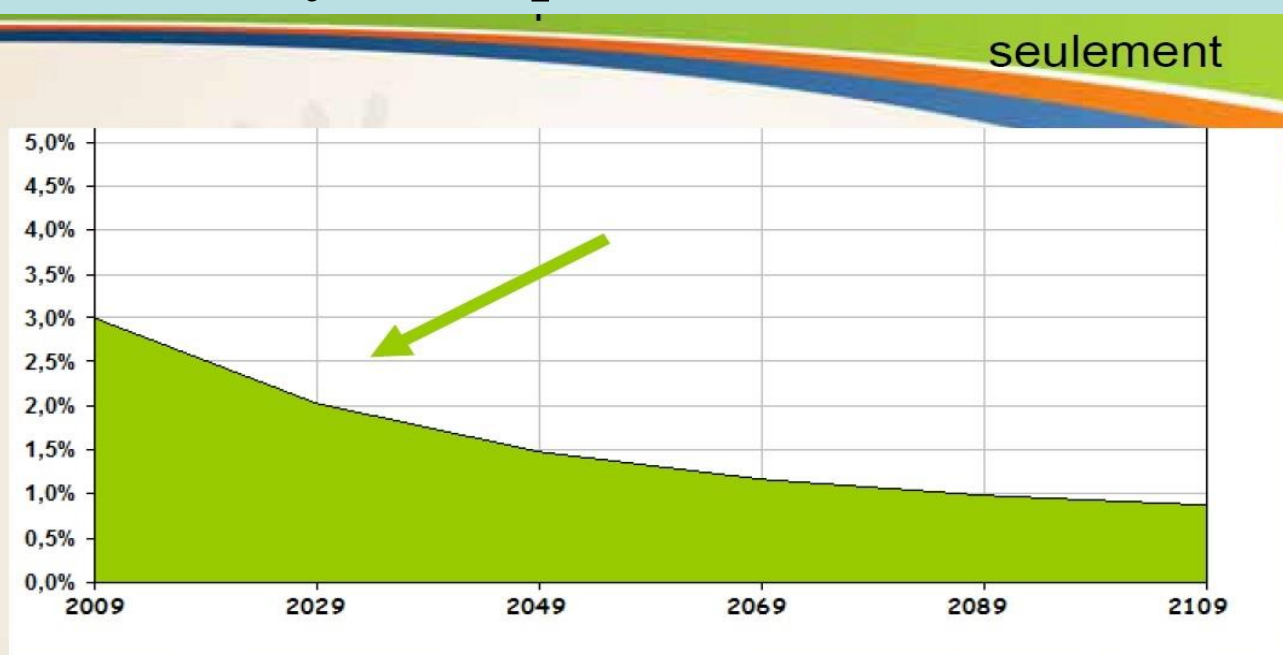
Parameter	Value
Year	2009
NIM	123456789
Agronome	Marc F. Clément
Climate Zone	Basses terres du St-Laurent
Field Number	001
Culture	Pomme de terre
Superficie	1.0 ha
Rendement	40 000 kg/ha
Base M. Sèche	8 000 kg/ha
% Matière Sèche	20%
Sol	08- Sable
Autres facteurs influençant le K ₂	Faible
Façon Culturelle	2 Sarclages
K ₂	2.50%
Pourcentage de matière organique	3.0%

Annual mineralization rate= 2.5% on a sandy soil, with a rotation potato-oat (straw stays in field) with no organic amendments added.

<http://www.mapaq.gouv.qc.ca/fr/Productions/Agroenvironnement/fertilisants/Pages/Bilanhumique.aspx>

Humus balance simulation in a Quebec soil: rotation: potato-oat (straw stays)

For a sandy soil of pH 6.0 to 6.5




Agriculture, Pêcheries
et Alimentation
Québec

SOM expected to go from 3 to 2% in 20 years.

https://www.craaq.qc.ca/UserFiles/file/Evenements/COLLSOL11/Clement_PPT.pdf

Soil organic matter indicator: eastern Canada versus western Canada



The screenshot shows the Agriculture and Agri-Food Canada website. The header includes the text "Agriculture and Agri-Food Canada" and the "Canada" logo. A search bar is visible in the top right. The navigation menu includes "Programs and Services", "Industry, Markets and Trade", "Science and Innovation", and "Help". The breadcrumb trail reads: "Home → Science and innovation → Agricultural practices → Soil and land → Soil Organic Matter Indicator".

Soil and land

- Soil management
- Soil nutrients
- Soil and water
- Land management through grazing
- Riparian areas

Soil Organic Matter Indicator

The Soil Organic Matter Indicator combines two separate indicator models - the Soil Organic Carbon Change Indicator and the Relative Soil Organic Carbon Indicator – to assess how organic carbon levels in Canadian agricultural soils are changing over time. The indicator gives a useful picture of soil health and an estimate of how much carbon dioxide has been removed from the atmosphere by plants and stored, or sequestered, as soil organic carbon in agricultural soils. This indicator has tracked soil organic matter associated with Canadian agricultural activities from 1981 to 2011.

i What are Agri-Environmental Indicators?

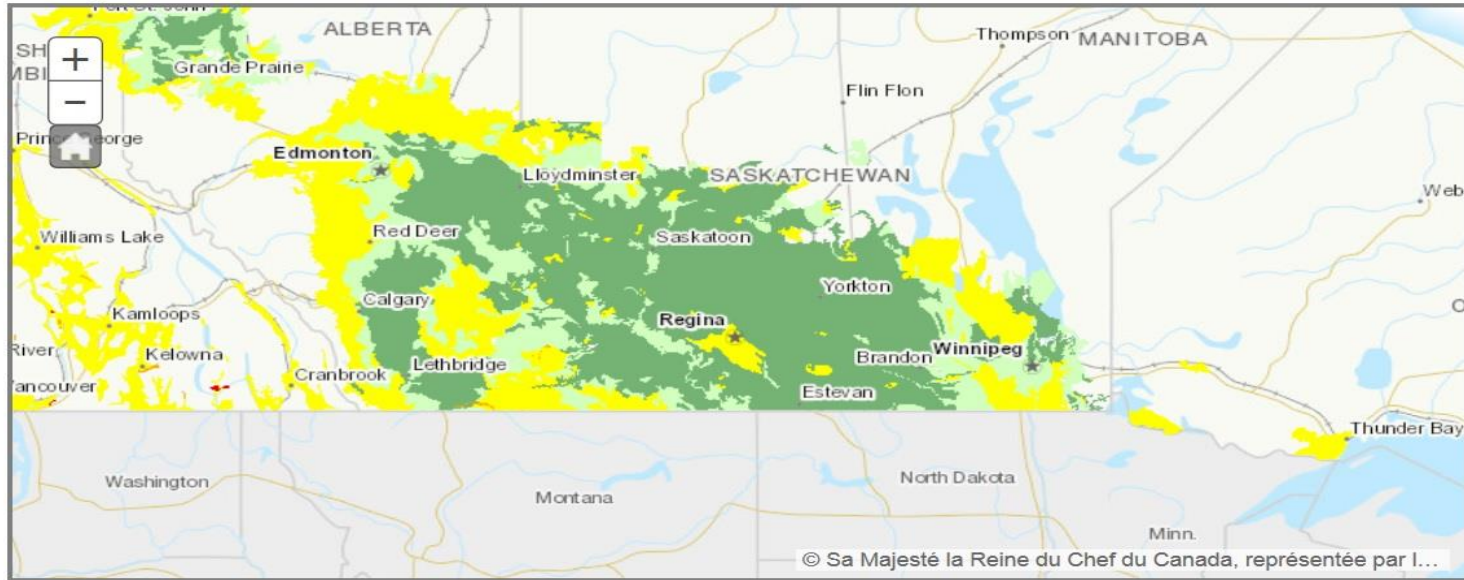
Agri-Environmental Indicators (AEIs) are measures of key environmental conditions, risks, and changes resulting from agriculture and of the management practices that producers use to mitigate these risks. They help explain:

From 1981 to 2011

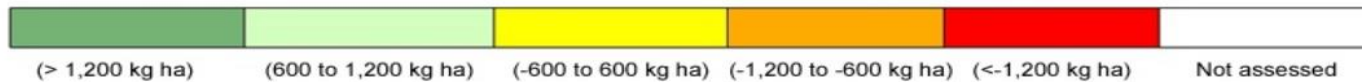
<http://www.agr.gc.ca/eng/science-and-innovation/agricultural-practices/soil-and-land/soil-organic-matter-indicator/?id=1462905651688>

Cumulative soil organic carbon changes (kg/ha) in Western Canada

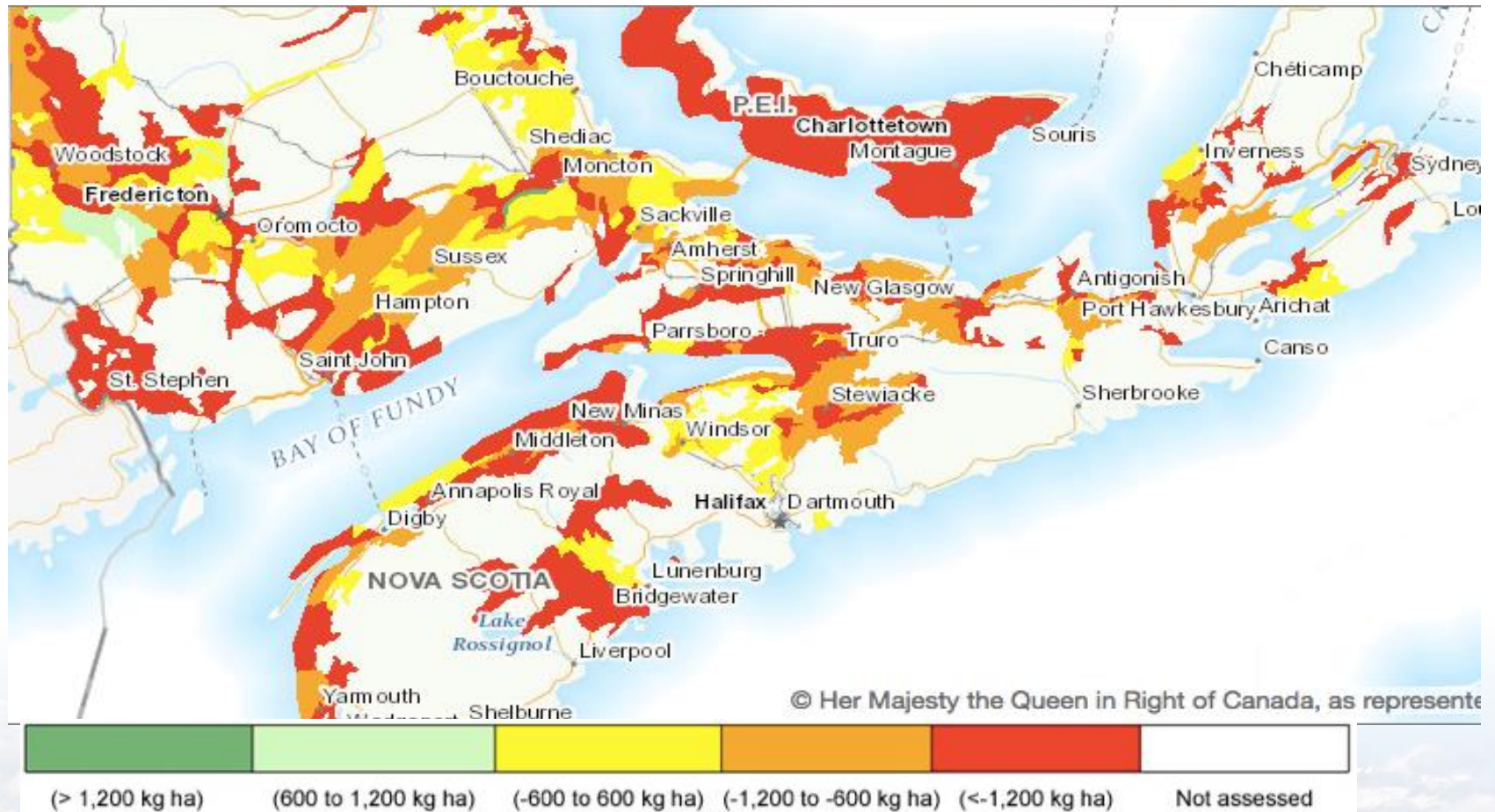
Figure 4: Cumulative Soil Organic Carbon change (in kilograms per hectare) from 1981 to 2011 due to changes in tillage and summerfallow



Legend:

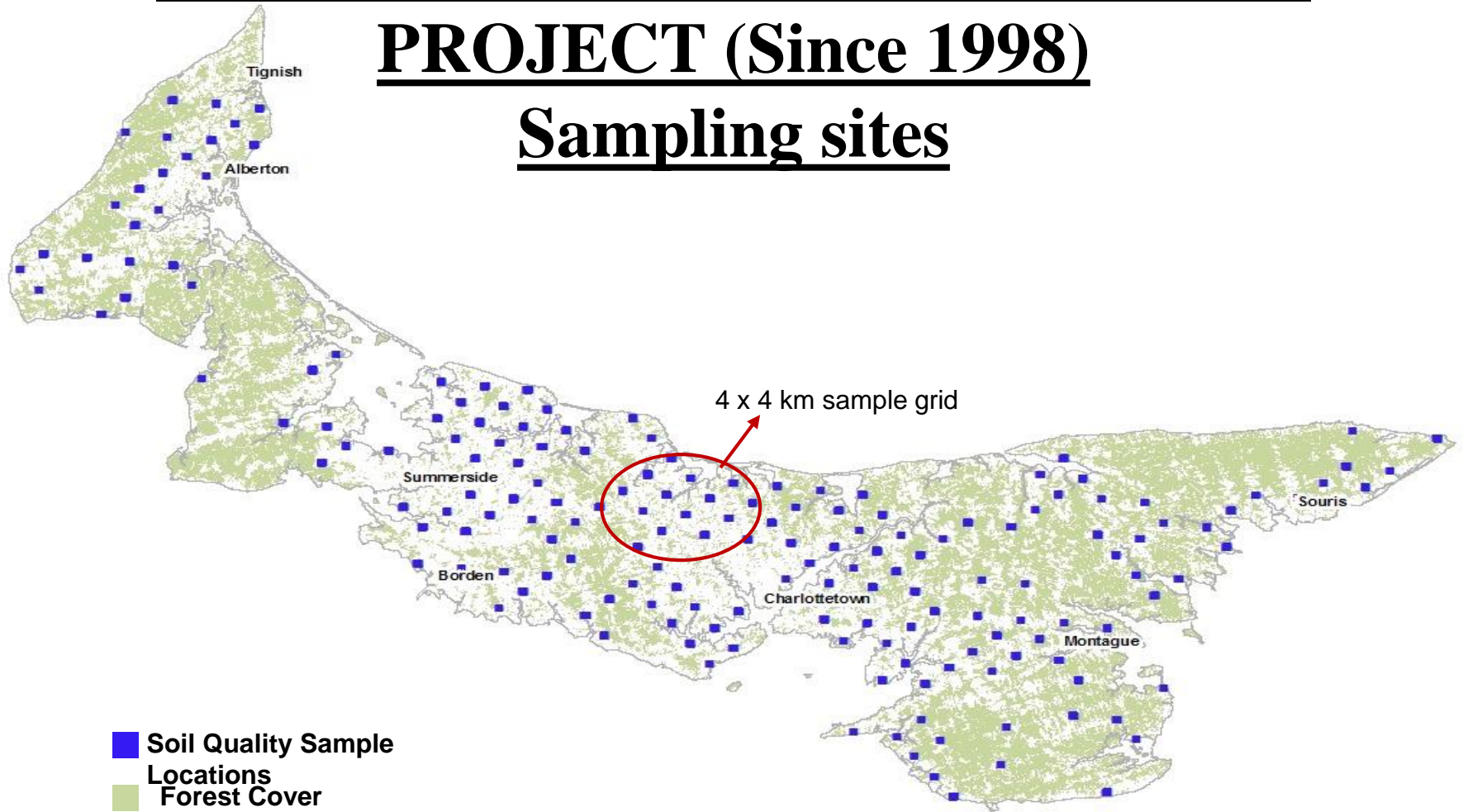


Cumulative soil organic carbon changes (kg/ha) in eastern Canada



PEI SOIL QUALITY MONITORING PROJECT (Since 1998)

Sampling sites



**A composite soil sample is taken at each sampling point by mixing 5 subsamples.
Return to the same site every three years.**

PEI SOILS

- Podzolic soils rich in Al and Fe contents
- Sandy loam, well drained and fertiles
- Low in organic matter
- Prone to erosion



A dynamic agricultural industry changes

Increased

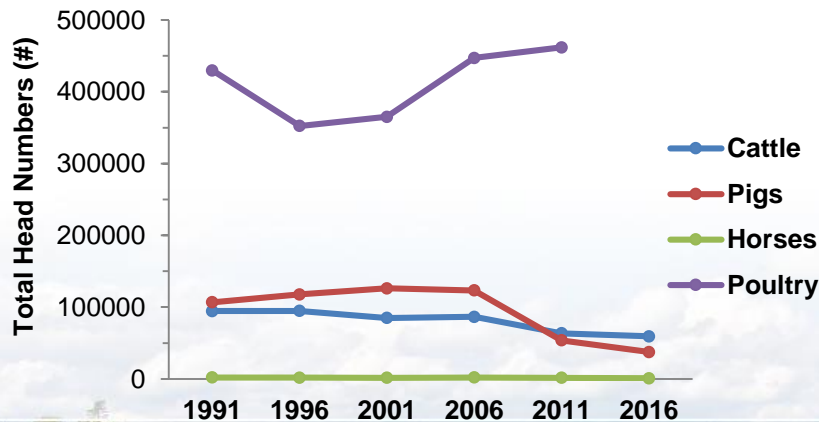
- ❖ New cleared land previously under forest (western PEI)
- ❖ Soybean acreage

Decreased

- ❖ Potato acreage
- ❖ Number of livestock
- ❖ Manure input
- ❖ Forage/hay acreage

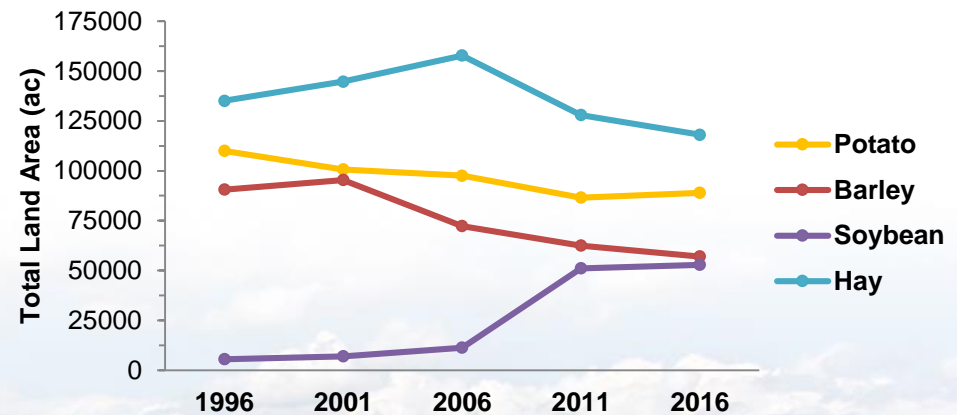
Crop rotation has changed due to wireworm pressure. Inclusion of new crops: **mustard, buckwheat, soghum sudan grass**

Total Livestock Numbers (1991-2016)



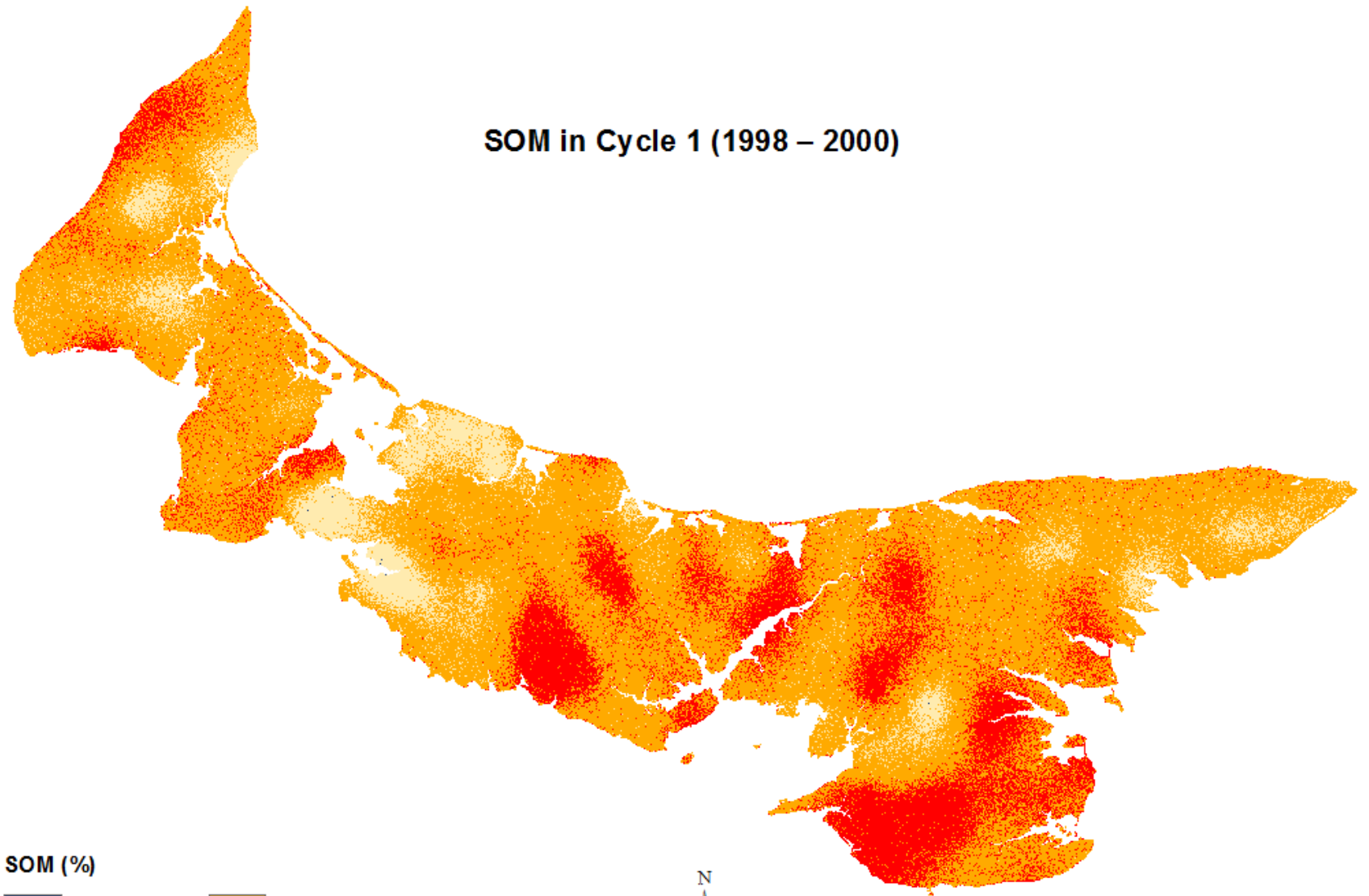
2016, Statistics Canada

Total Crop Acreage (1996-2016)

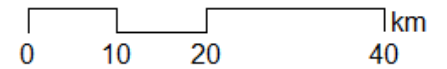
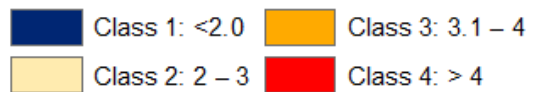


2016, Statistics Canada

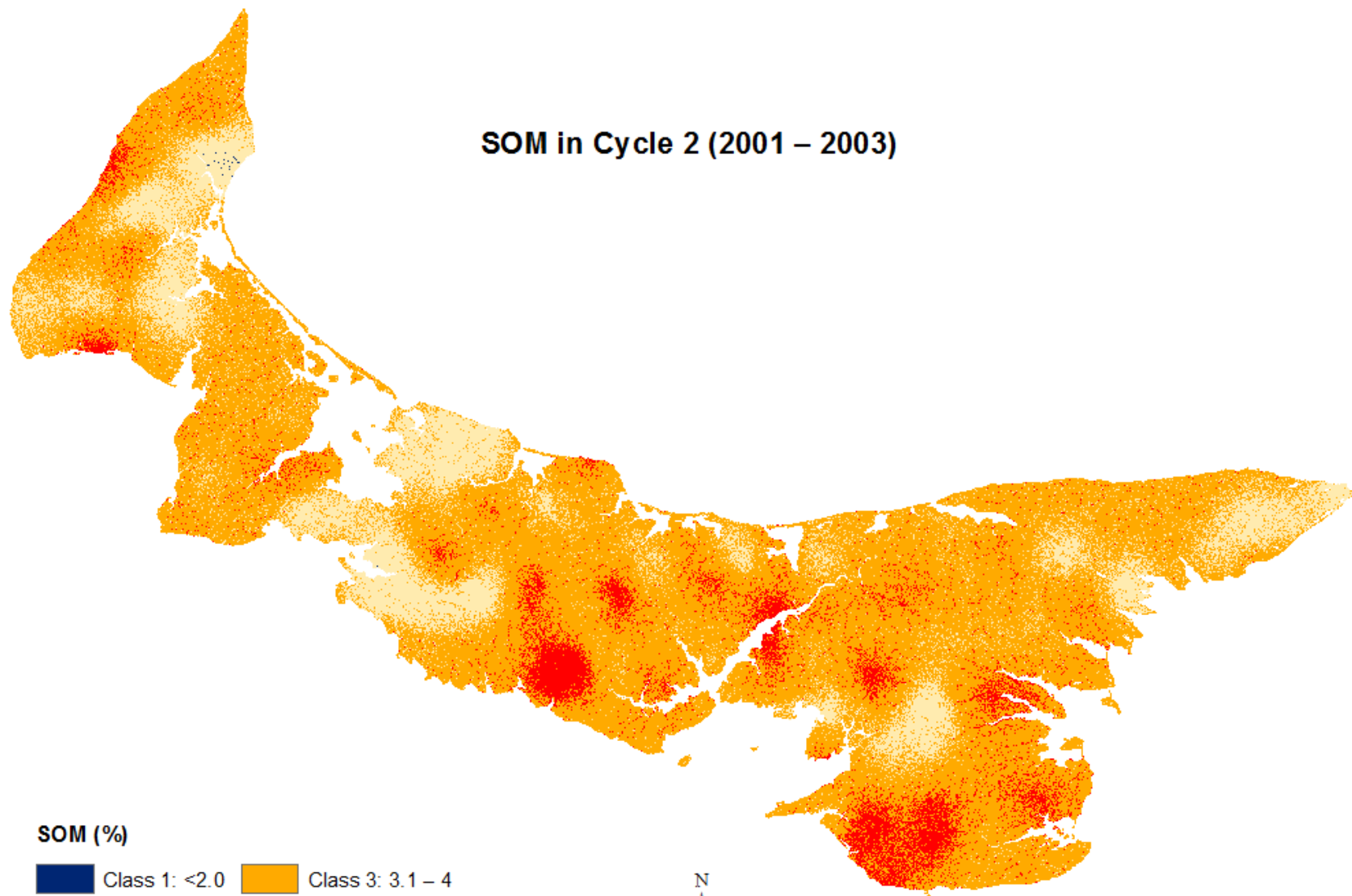
SOM in Cycle 1 (1998 – 2000)



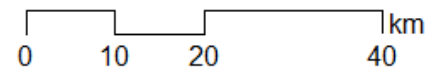
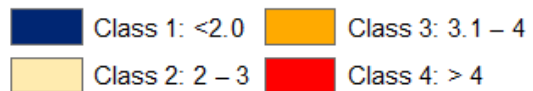
SOM (%)



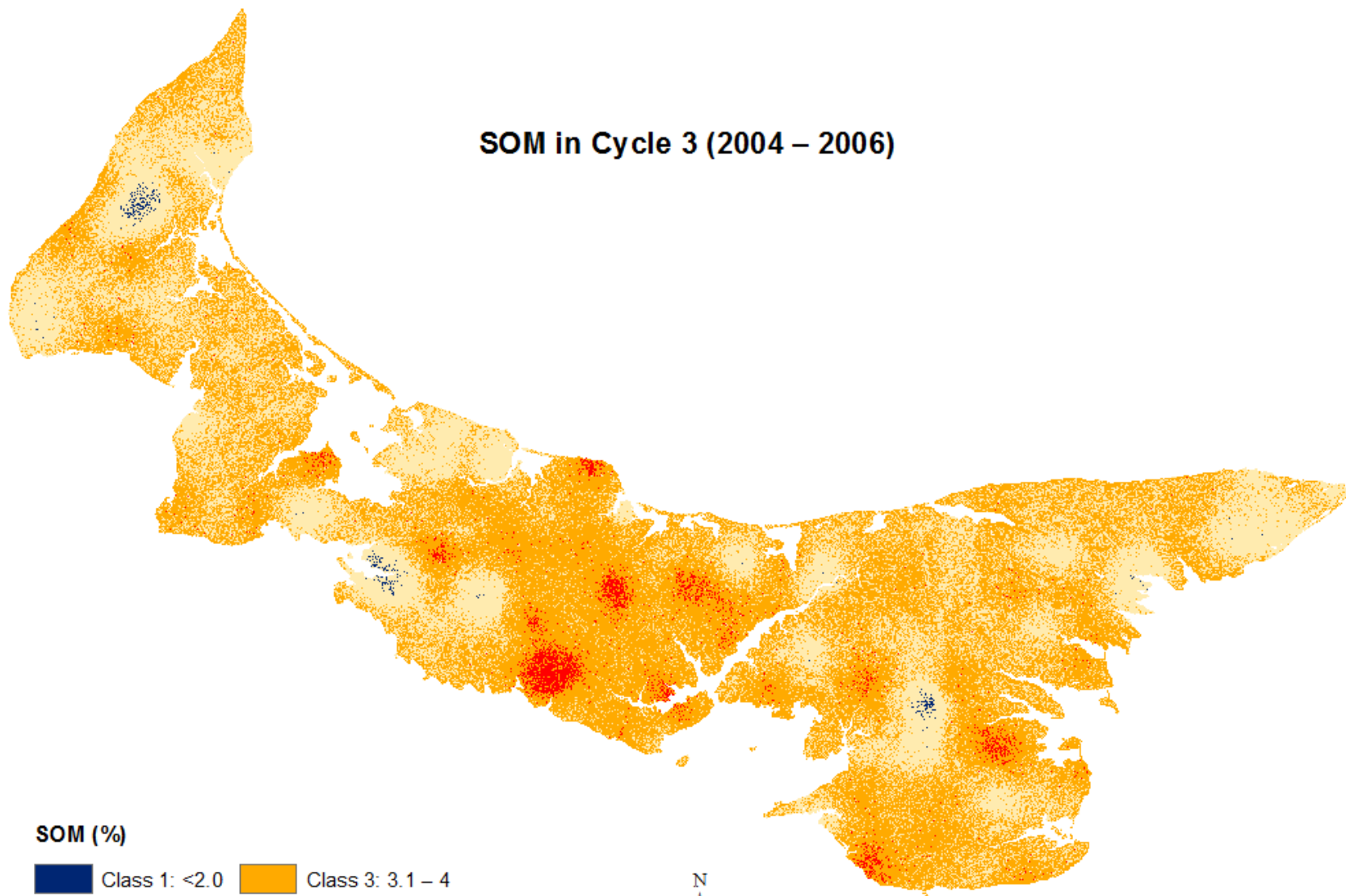
SOM in Cycle 2 (2001 – 2003)



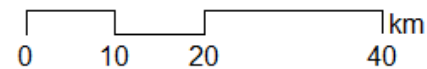
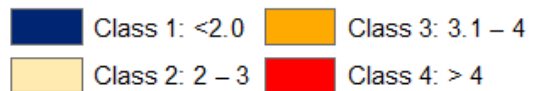
SOM (%)



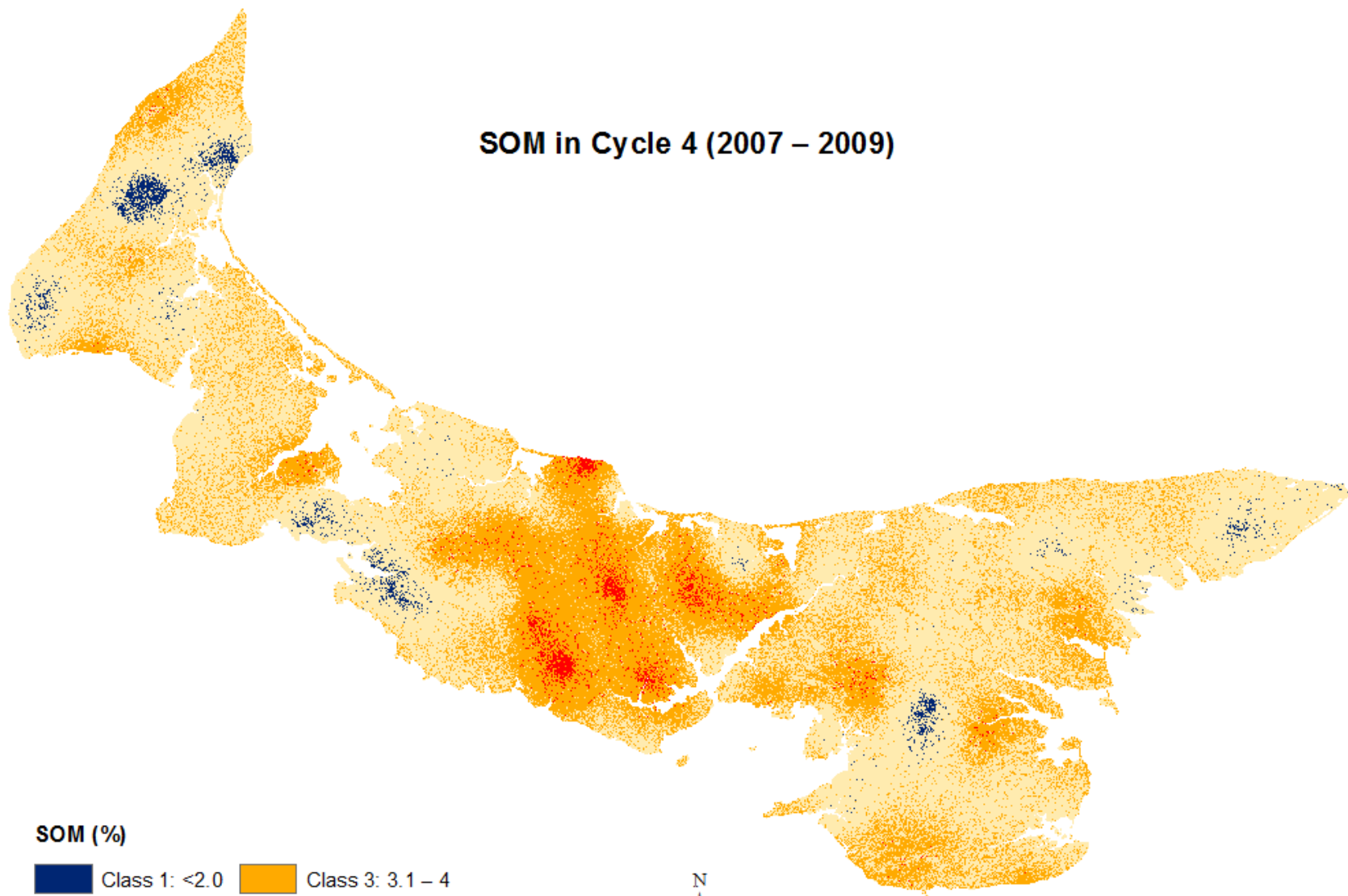
SOM in Cycle 3 (2004 – 2006)







SOM (%)



SOM in Cycle 4 (2007 – 2009)



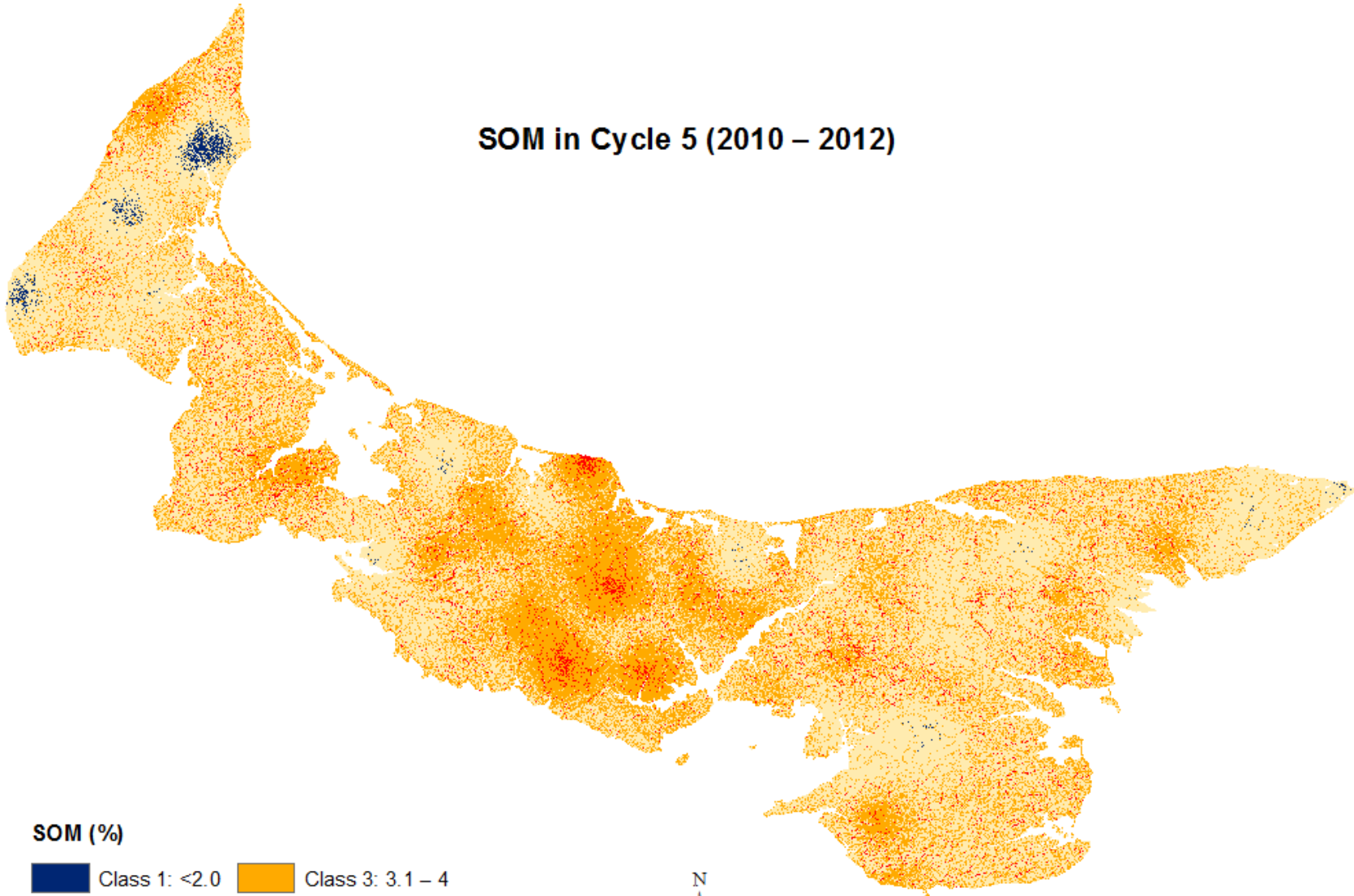
SOM (%)

- | | |
|--|--|
|  Class 1: <2.0 |  Class 3: 3.1 – 4 |
|  Class 2: 2 – 3 |  Class 4: > 4 |



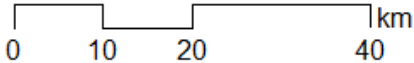
0 10 20 40 km

SOM in Cycle 5 (2010 – 2012)

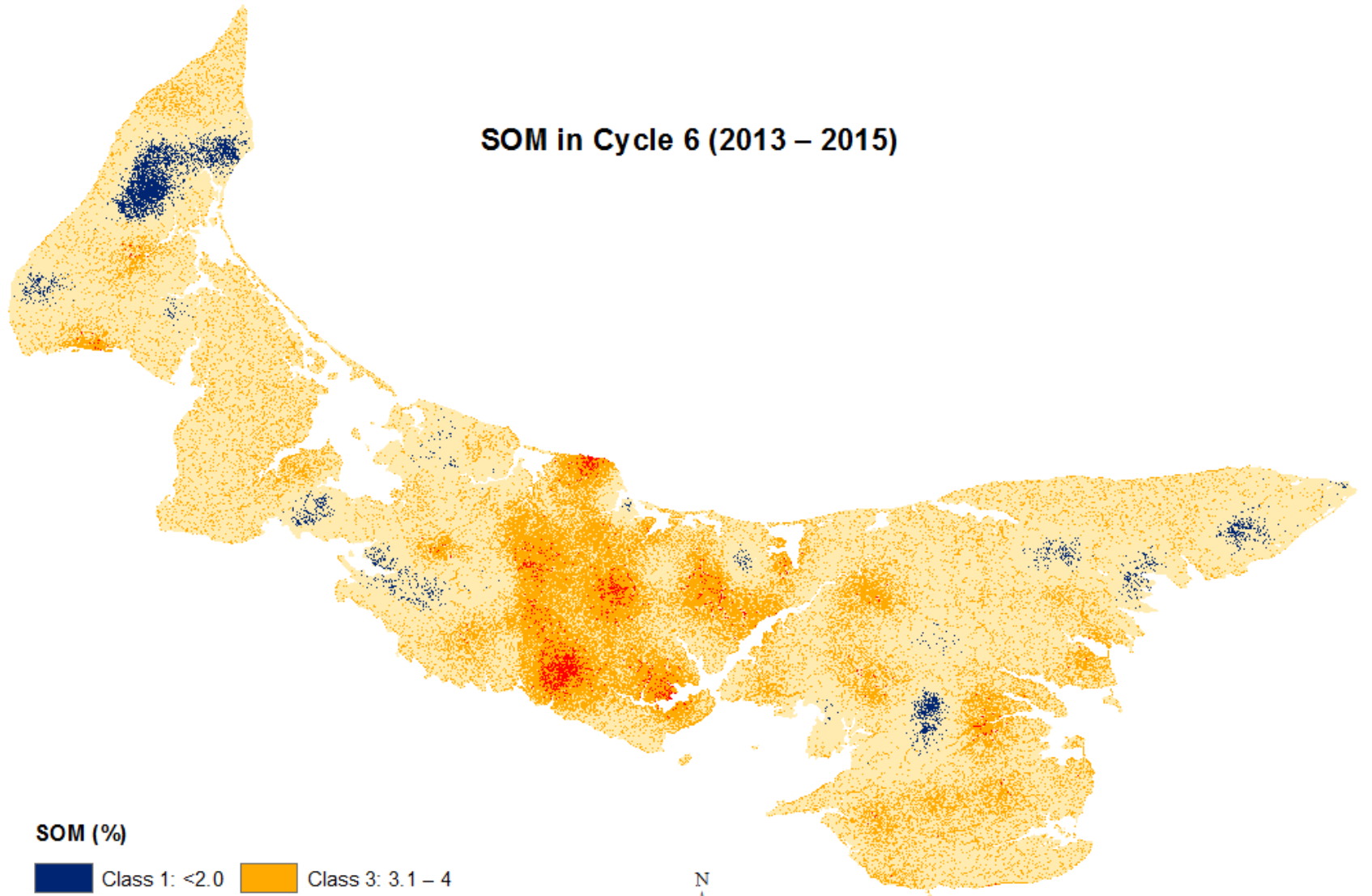


SOM (%)





- Class 1: <2.0
- Class 2: 2 – 3
- Class 3: 3.1 – 4
- Class 4: > 4

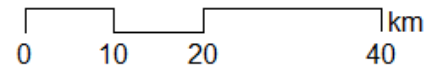


SOM in Cycle 6 (2013 – 2015)

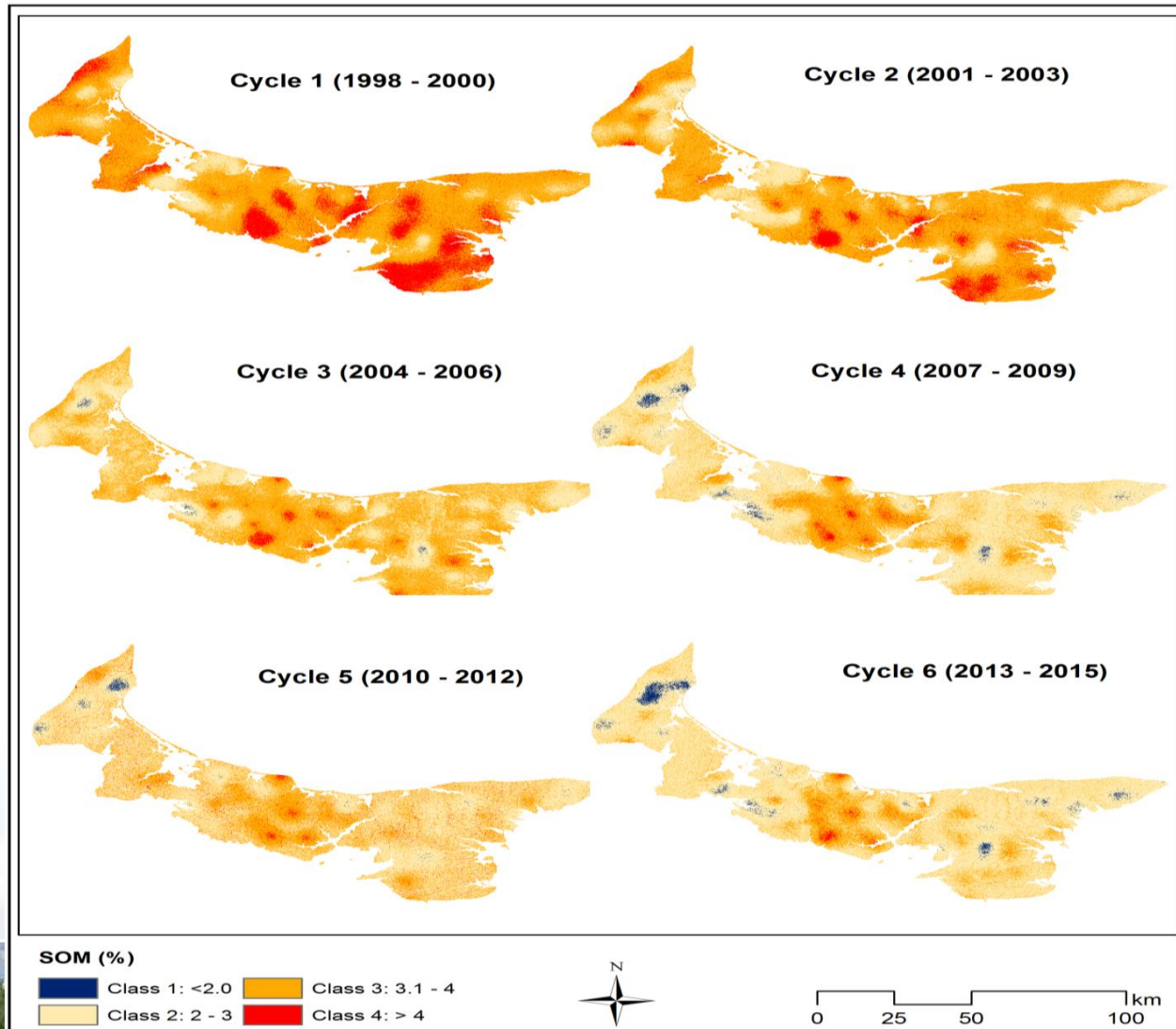


SOM (%)

- | | |
|---|--|
|  Class 1: <math>< 2.0</math> |  Class 3: 3.1 – 4 |
|  Class 2: 2 – 3 |  Class 4: > 4 |

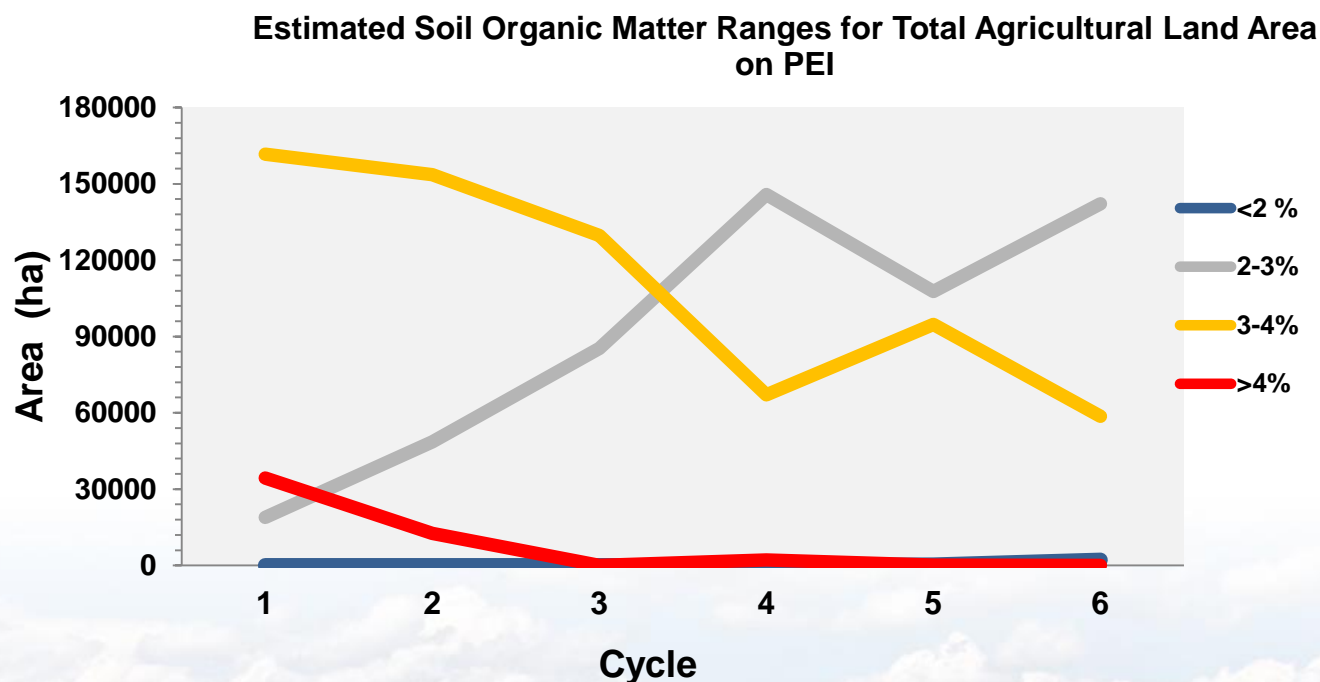


SOM trend over 18 years



Results

- Land acreage with SOM ranging from 2-3% has been increasing, and in the same time, areas with SOM between 3-4 and above 4% have been declining



2017, PEIDAF. "Soil OM Status on PEI" Factsheet.



Causes that can explain the trends

- ❖ **Intensive soil cultivation**(tillage intensity and frequency)
- ❖ **Changes in “traditional” crop rotations**
- ❖ **Reduced organic inputs (i.e manure)**
- ❖ **Nature of PEI soils**
- ❖ **PEI Climate**



Agricultural practices to maintain/enhance SOM

- ❖ **Enhances C inputs or reduce C losses:**
 - **Enhance ground cover, minimize the time the soil is left bare**
 - **Return crop residues to the soil**
 - **Incorporate manure and compost if possible**
 - **Implement reduced tillage and soil conservation practices**
 - **Let the soil rest with perennial forages**



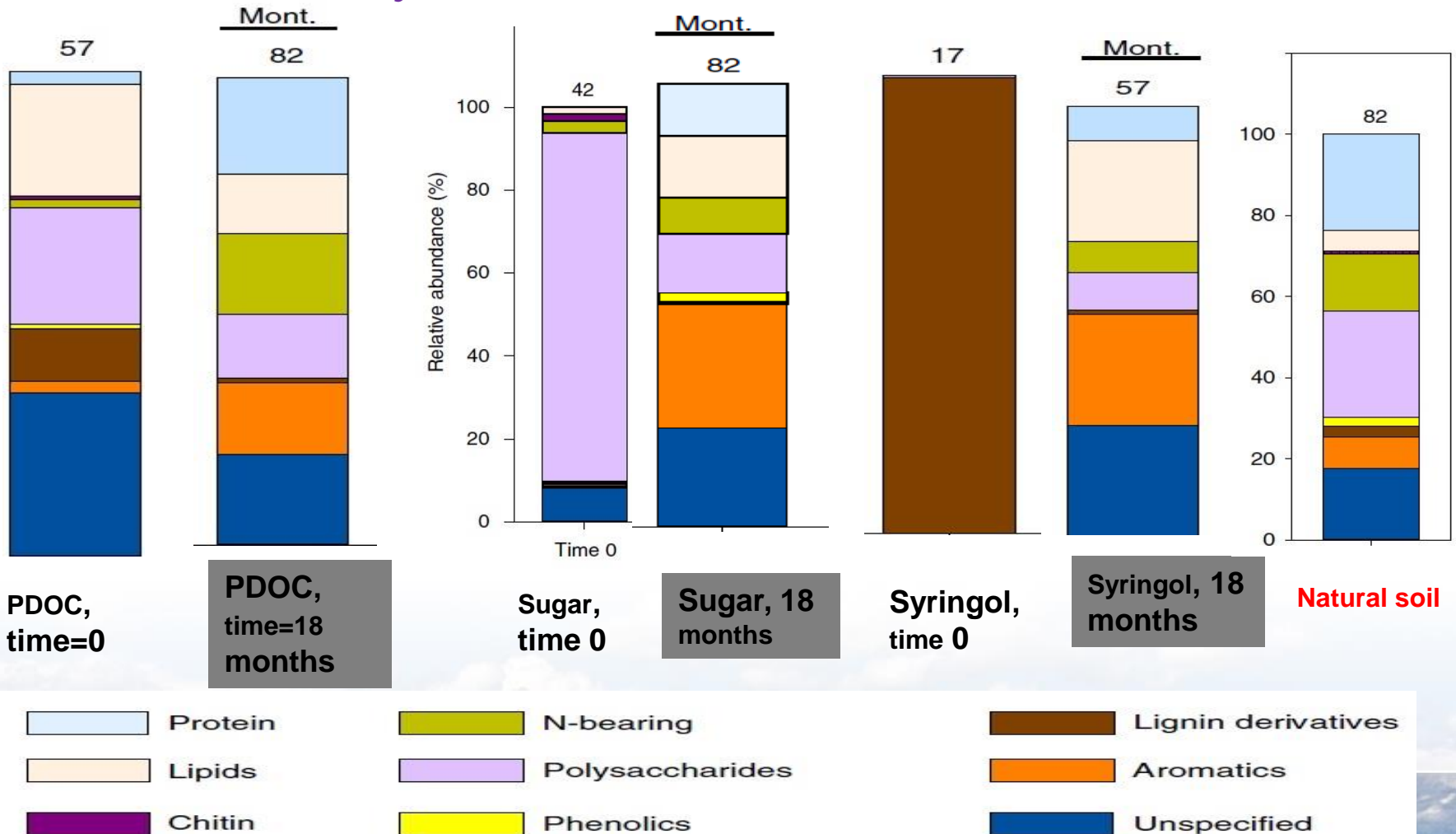
Building the SOM by feeding the soil microbes

Does the C input quality matter?



Does the C input quality matter?

Different C substrates+sterile clay minerals+multinutrient solution+ soil inoculum from soil slurry. Incubation for 18 months.



Summary from Kallenbach et al. study

- « **Stable SOM originates from microbes per se rather than the substrate they utilize** ».
- **Accumulated SOM was mainly composed of microbial products (proteins, non proteinaceous N compounds and lipids).**
- **After the incubation, > 75% of total substrate C- lost via respiration.**
- **Most of C was accumulated in the clay mineral having higher CEC that received slow decaying product (syringol).**







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SOIL EROSION
COSTS CANADIANS
\$3.1 BILLION
ANNUALLY

 **95%**
OF THE FOOD
WE EAT COMES
FROM THE EARTH'S
SOIL

9 BILLION
PEOPLE WILL NEED
HEALTHY SOIL
BY 2050


Soil Conservation Council of Canada
<https://soilcc.ca/>



Thank you for listening
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Canada 