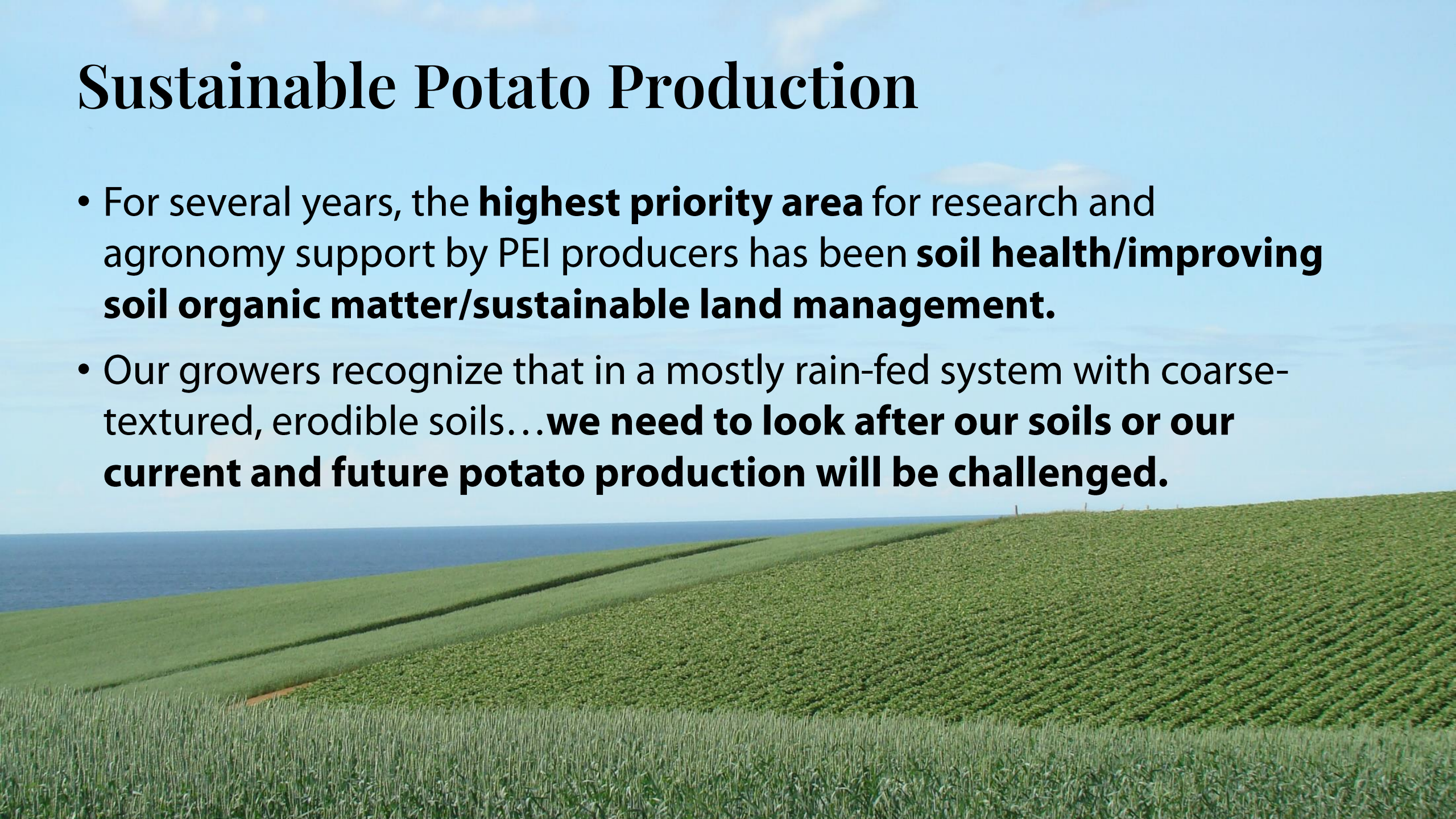
Optimizing Potato Rotations for Productivity and Sustainability

Ryan Barrett, P. Ag., CCA
Prince Edward Island Potato Board

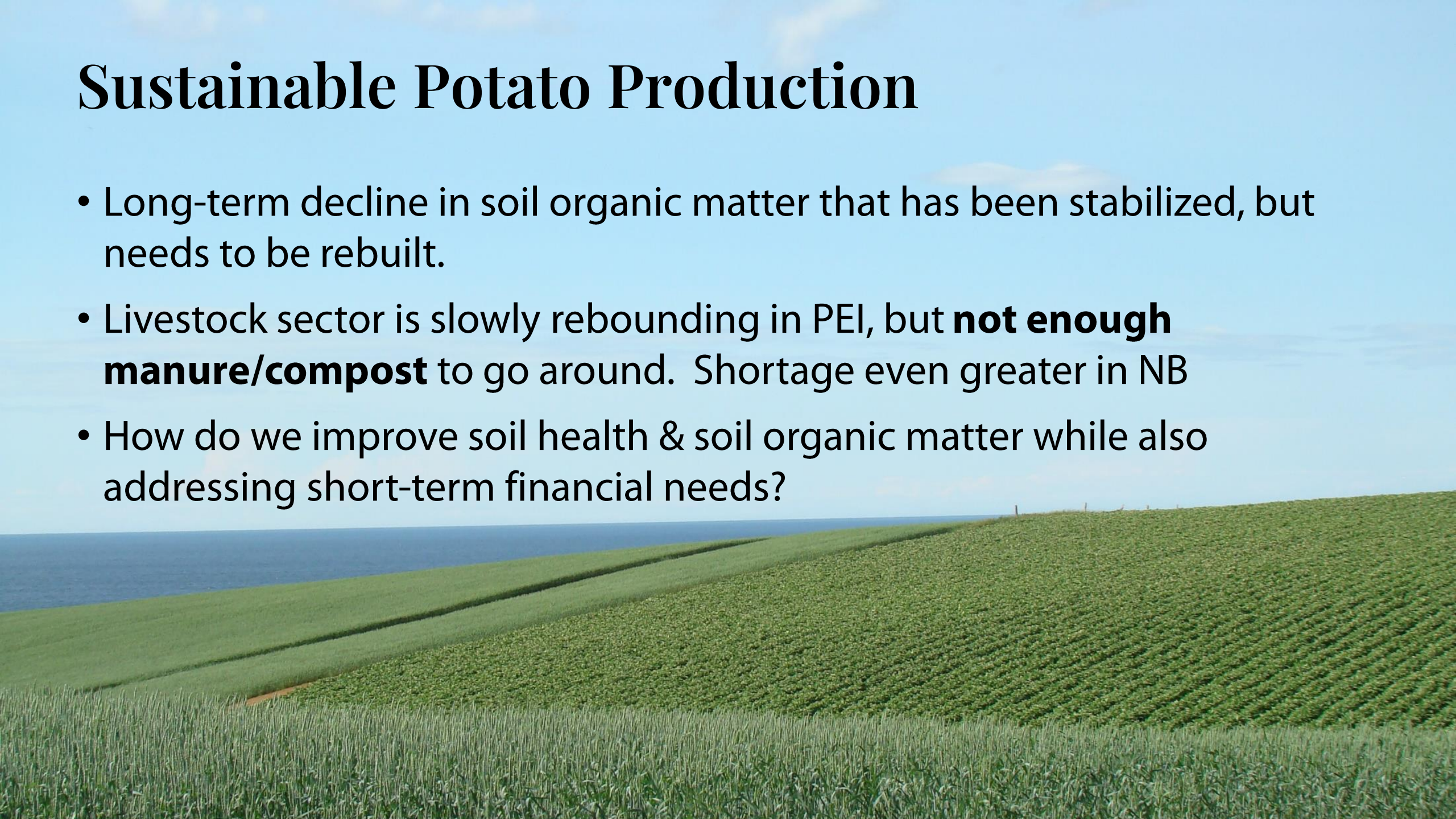
Sustainable Potato Production

- For several years, the **highest priority area** for research and agronomy support by PEI producers has been **soil health/improving soil organic matter/sustainable land management.**
- Our growers recognize that in a mostly rain-fed system with coarse-textured, erodible soils…**we need to look after our soils or our current and future potato production will be challenged.**



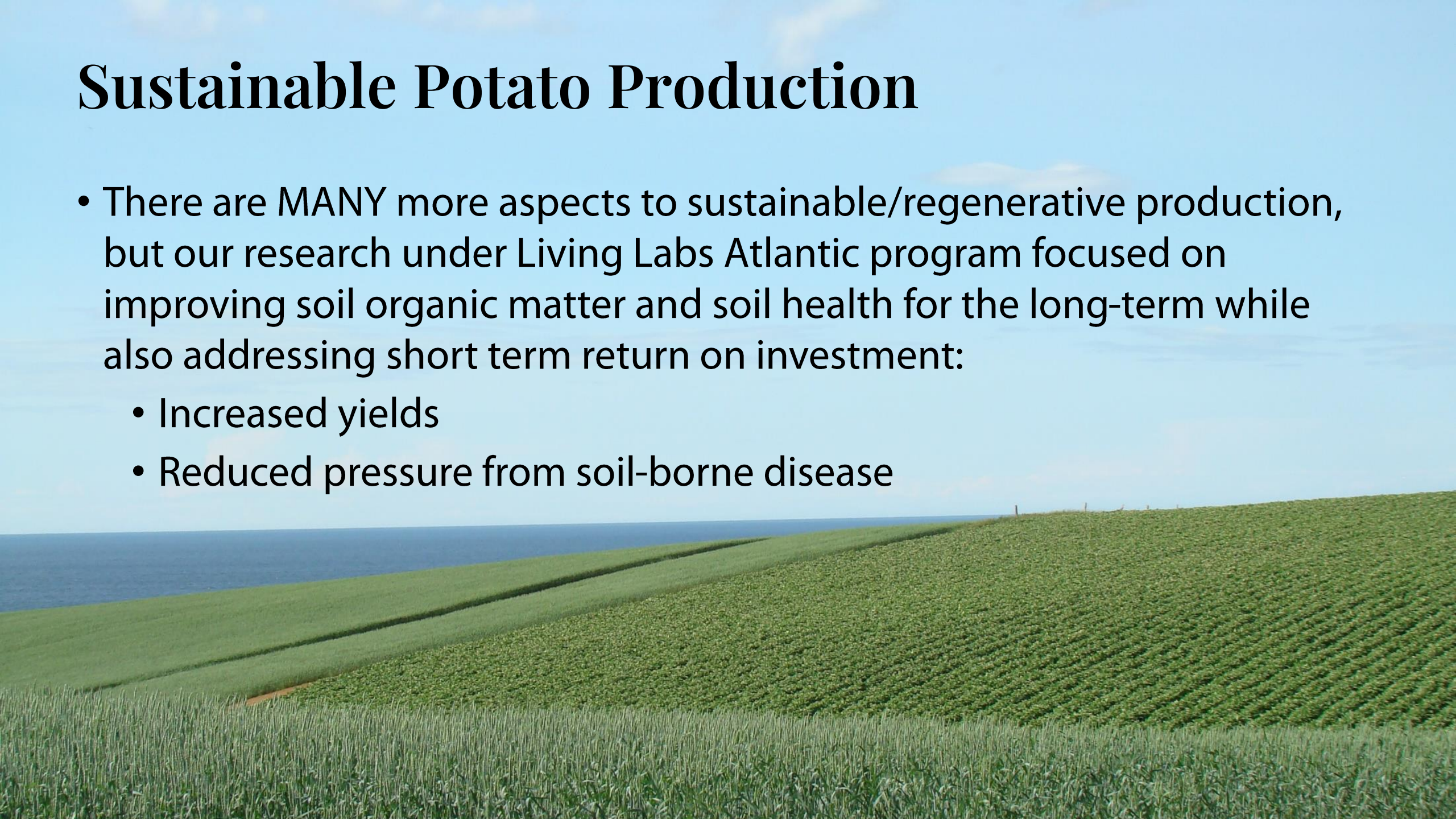
Sustainable Potato Production

- Long-term decline in soil organic matter that has been stabilized, but needs to be rebuilt.
- Livestock sector is slowly rebounding in PEI, but **not enough manure/compost** to go around. Shortage even greater in NB
- How do we improve soil health & soil organic matter while also addressing short-term financial needs?



Sustainable Potato Production

- There are MANY more aspects to sustainable/regenerative production, but our research under Living Labs Atlantic program focused on improving soil organic matter and soil health for the long-term while also addressing short term return on investment:
  - Increased yields
  - Reduced pressure from soil-borne disease



Living Lab Atlantic – PEIPB Projects:

BMP1: Fall Cover Crops in the year before potatoes (following tillage)

BMP2: Fall Cover Crops following potato harvest

BMP3: Full-Season Soil Building Crops in the year before potatoes

Agriculture and Agri-Food Canada

Agriculture et Agroalimentaire Canada

Why Fall Cover Crops?

- Prevent Soil Erosion
- Reduce N Losses from Soil
- Build Soil Carbon
- Weed Suppression
- Disease Suppression
- Feed the Soil Microbiome
- Increase Yields?

Preventing Soil Erosion

- Left side: Barley cover crop that largely winter killed but grew enough to hold soil. Right side: No cover

- While we had limited number of sites with erosion measurement, we generally saw **25-33% decrease in accumulated topsoil with use of a fall cover crop.**

Preventing Soil Erosion

Late January 2023. Fall rye broadcast before potato harvest.

Reduce N Losses from Soil

- By having a cover crop following harvest or legume plow-down, you can keep nitrates from leaching.
- Also prevents loss of N as nitrous oxide (powerful GHG)
- Covers before potatoes:
  39% reduction in NO_3 at 6”
- Covers after potatoes:
  31% reduction in NO_3 at 6”
- Both based on 3 years of data, 20+ fields in each trial.

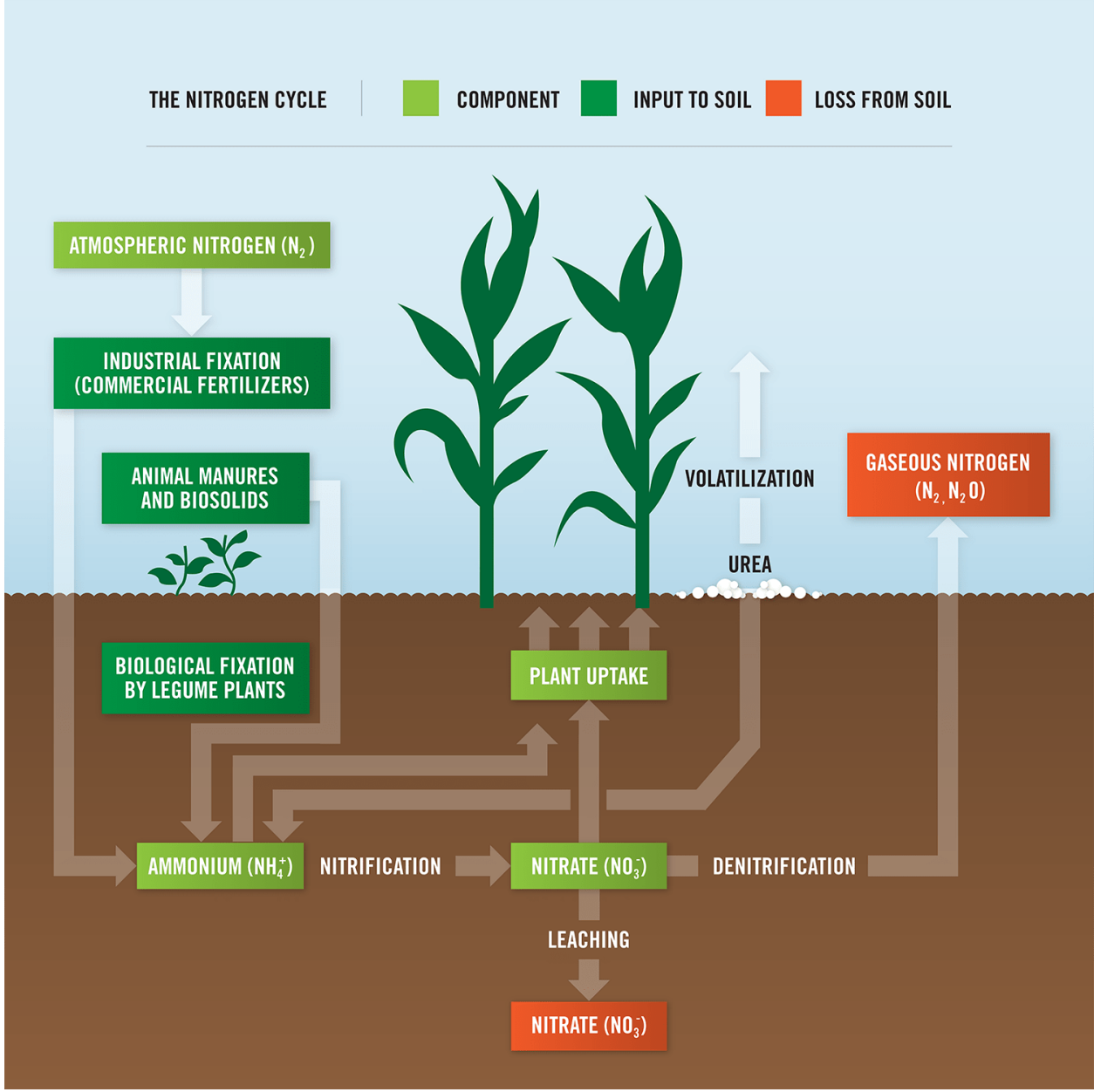


Image: https://kochagronomicservices.com/

Building Soil Carbon

- Recent research has shown that **the majority of soil C comes from root exudates and microbial biomass**, not above-ground residue.
- Having actively growing roots for as long as possible each year will do more to build soil C than “lots of trash”.
- Establishing cover crops with limited or no tillage can give you an extra 2-3 months of actively growing plants.

Catherine Ulitsky, USDA/Flickr

Building Soil Carbon with fall cover crops

Comparison	Soil OM % No Cover Crop	Soil OM % Cover Crop
All cover crops	**2.18%**	**2.31%**
Radish/Mustard	2.22%	2.44%
Spring Cereals	2.16%	2.23%

- 13 check/cover crop comparisons across 8 fields in spring 2022 ($p = 0.057$)
- Cover crops established fall 2021. Soil sampling in spring 2022
- 4 samples per treatment
- Living Labs BMP1 – 2021/2022

Weed Suppression

- Fall Rye and Buckwheat – Allelopathy

- Mustard and Radish – outcompete weeds if planted early.

In this trial field, the left hand side was daikon radish planted early September, compared with no cover crop on the left.

Increasing Yields?

- Other studies in other areas have shown increased crop yields following cover crops, but response differs by area, cropping system, etc. Wanted to assess under PEI conditions and rotations.

- Can we get all of the long-term benefits of cover cropping while also getting some immediate payback on the costs of cover cropping?

Increasing Yields following Cover Crops

	Total Yield cwt/ac	Total Defects %	Smalls %	> 10 oz %	Specific Gravity	Market. Yield cwt/ac	Crop Value $/acre
Cover	344.5	5.5	7.0	17.8	1.088	306.8	$4414
No Cover	318.5	5.7	8.8	16.8	1.088	277.8	$3969
Diff:	**26.0**	-0.2	**-1.8**	1.0	0.000	**29.0**	**$445**
p value	**0.017**	0.883	**0.044**	0.682	0.974	**0.014**	**0.023**

Comparison in bold: Statistically significant at $p < 0.05$

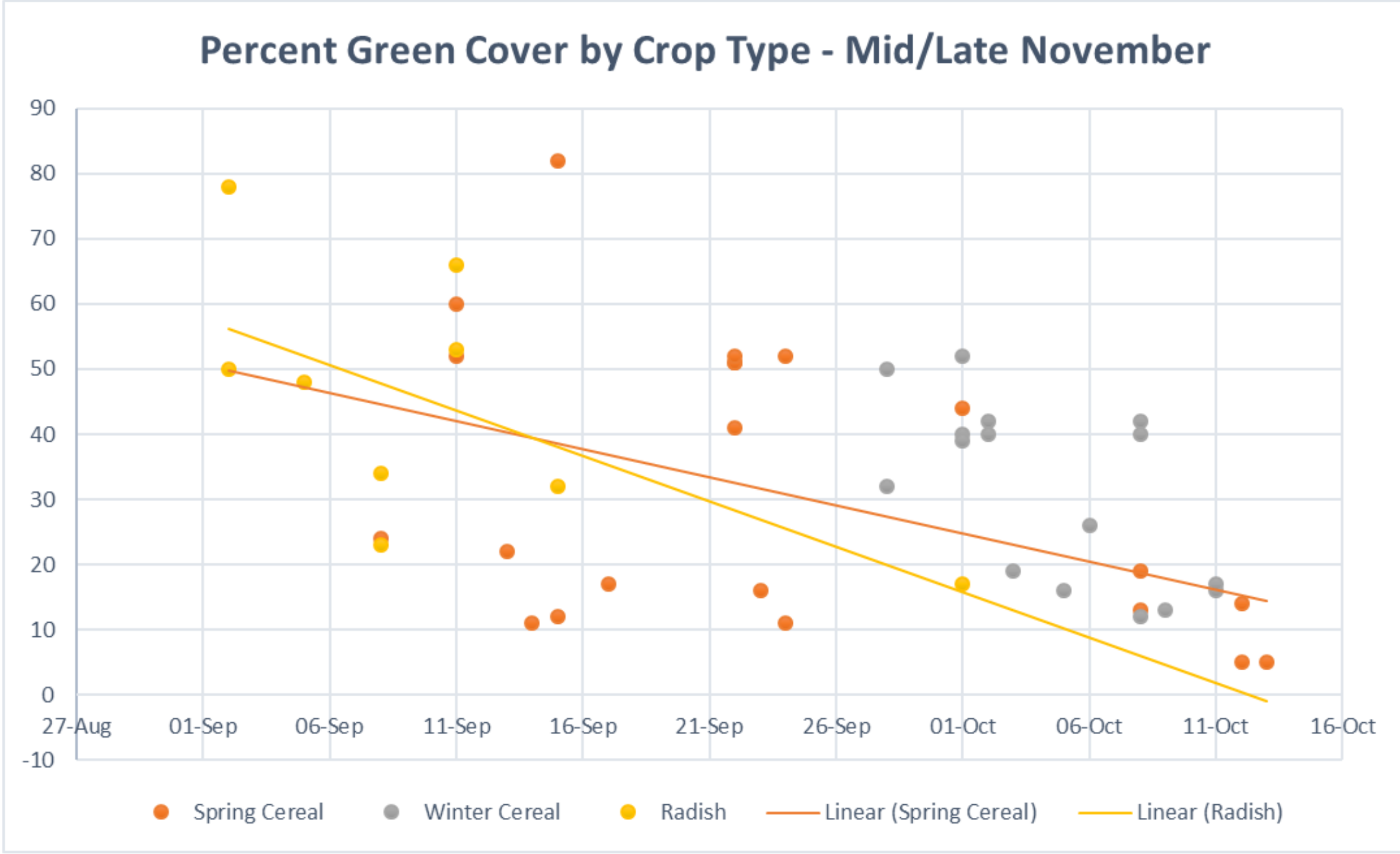
Increasing Yields following Cover Crops

- Over 3 cropping cycles, we saw a **29 cwt/ac yield improvement** (10% increase) when planting a cover crop in the fall ahead of potatoes compared with no cover.

- Historically, majority of PEI fields were tilled in late fall ahead of potatoes. By moving up tillage to late summer/early fall, we can:
  - Increase potato yields
  - Terminate legumes earlier, accelerating N release
  - Prevent soil and nitrate losses
  - Move tillage operations up to a less busy time?

Lots of Cover Crop Options…how to choose?

- What crop am I following?
- What crop am I planting next year?
- Establishment window
- Available equipment
- Seed and establishment cost


Percent Green Cover by Crop Type - Mid/Late November
90
80
70
60
50
40
30
20
10
0
-10
27-Aug
01-Sep
06-Sep
11-Sep
16-Sep
21-Sep
26-Sep
01-Oct
06-Oct
11-Oct
16-Oct
Spring Cereal
Winter Cereal
Radish
Linear (Spring Cereal)
Linear (Radish)

Mid-August to Early September:

- Oilseed/Daikon Radish
- Brown Mustard
- Spring Cereals (Barley, Oats, etc)
- Winter Canola (cash crop)
- Winter Barley (cash crop)
- Oats & Peas (grazing option)
- Annual Ryegrass (grazing option)
- Kale (grazing option)
- Mixes of brassicas and cereals

Early September to Early October:

- Daikon Radish (until Sept 10)
- Spring Cereals
  - Barley
  - Oats
  - Spring Wheat
- Winter Cereals
  - Winter Wheat
  - Winter Barley (September ideally)
  - Winter Triticale (hybrid of rye & wheat)
  - Fall Rye

After the first week of October:

- Winter Wheat (differs by region)
- Fall Rye (until October 15-18 in most years)

- Barley and Oats don't consistently establish after the first week of October in most years. High seeding rates don't make up for the cool soil temperatures. Will also die quickly if they don't have time to establish more than 8-10 inches

Making the right fall cover choice:

- Fall rye has become popular in some areas ahead of corn or soybean. Can no-till into rye as a "relay crop." Rye can also be harvested for silage.
- May not want to use fall rye on very wet land if worried about being able to get on the land to terminate rye.
- Ahead of potatoes, brassicas or spring cereals will winter kill, won't slow down land prep in the spring.

Moving Forward with Fall Covers:

- Adoption rate of fall cover cropping in PEI potato rotations, based on PEIPB grower surveys:

	2019	2020	2021	2022
After Potato Harvest	47.8%	37.4%	52.6%	50.6%
Before Potato Planting	24.0%	45.0%	51.2%	48.7%

- Lots of upward momentum for cover cropping in PEI. Financial incentives from On-Farm Climate Action Fund should help drive adoption even higher.

Full-Season Soil-Building Crops

- Majority of PEI potato acres are preceded by a forage crop. Some are harvested for hay/silage, many are just mulched.
- Used to be mostly red clover…now there is increasing diversity of choice
- What is the best choice, looking at multiple factors:
    - Pests & Diseases
    - Soil Compaction
    - N fixation
    - Building soil OM/soil health

Full-Season Soil-Building Crops

- "Soil Building Crops" versus Annual Ryegrass:
  - **+25 cwt/ac, +$407/acre**
  - 13 fields over 3 years. Significant at p = 0.10
- "Soil Building Crops" versus Red Clover:
  - +6 cwt/ac, +$22/acre
  - 5 fields over 3 years. No sig. diff.
  - In these fields…Red Clover established the year previous by underseeding, so "control" treatments had less soil disturbance than the "treatment" crops.

Full-Season Soil-Building Crops

- None of the individual crops we looked at were statistically better than the check crops for most metrics (yield, soil health, soil OM)
- Root lesion nematodes were highest following red clover, lowest following mustard, radish, and pearl millet.
- We may need more samples or more rotations to see true effects of these crops. However, increased tillage frequency may counter-act some of the value of these crops. Options for no-till seeding may hold value in exploration
- From our research, **it's less important what you grow than how often land is tilled** and if a green manure crop is grown vs a cash crop.

Full-Season Soil-Building Crops

- From research that we've done, benefits from **using mustard as a biofumigant crop are not consistent**. Only seems to show payback on really compromised fields and Vert-susceptible varieties

- In multi-year trial, potatoes following **alfalfa out-yielded** red clover by 43 cwt/ac and ryegrass by 57 cwt/ac. Increased N, reduced nematodes, decreased compaction.

Full-Season Soil-Building Crops

- We've seen **no evidence that ultra-diverse mixtures improve yields or soil health** more than a single species or a simple 2-3 species mixture. This is supported by meta-analyses over hundreds of trials.

- Pick crops that fit your rotation, fit your region, won't become a weed issue, don't require too much extra management cost, and won't multiply pests/diseases ahead of potatoes.

- Take advantage of crops that may have both soil-building characteristics as well as economic value (ie. mustard for seed, alfalfa for hay, etc)

Find the crop that works for you!

Biggest Issue:	Crop Options:
Compaction	Alfalfa, Daikon Radish, Sudangrass, Pearl Millet
Wireworm	Brown Mustard, Buckwheat (don't have to be tilled in)
RL Nematodes	Pearl Millet (the best), Sudangrass, Radish/Mustard, Alfalfa
Fixing Nitrogen	Alfalfa, Red Clover, White Clover, Annual Clovers/Faba Beans
Building Soil OM	Whatever you can grow with the most biomass with the least amount of tillage! Root biomass more important than above-ground biomass!

Cash Crop-Only Rotations:

- If you can't manage having a non-cash crop option in the year before potatoes, the key to improving soil health and reducing GHG emissions are maximizing cover crops and minimizing tillage.
- Grain corn
  - No-till planting, strip-till, interseeding covers at V4-V5 stage
- Small grains
  - Winter wheat or winter barley after potatoes, frost seeding forages, cover crops after harvest, underseeding spring barley/oats
- Pulses or oilseeds
  - No-till planting, plant as early as possible to harvest early, cover crops after harvest.

Looking ahead:

- We want to look at how much **N credit** we can truly expect following legumes like alfalfa and red clover, and how that is affected by termination date and presence of a cover crop.

- What effect can **rotational grazing** have on soil health and soil OM? Research underway with two farms, expanding in 2023.

- What are the **cumulative effects of cover cropping and reduced tillage** on soil organic matter over 1-2 rotations?

Acknowledgements:

AIM Funding Partners:

Prince Edward Island POTATOES

Prince Edward Island CANADA

Les Fermes Cavendish Farms

Agriculture and Agri-Food Canada

Agriculture et Agroalimentaire Canada

Living Labs Partners:

East Prince Agri-Environment Association Inc.

Kensington North Watersheds Association

Souris and Area Branch PEI Wildlife Federation

Dalhousie University Faculty of Agriculture

Thank You!

Ryan Barrett, P. Ag., CCA-AP
Research & Agronomy Specialist
PEI Potato Board
Tel: (902) 439-9386
Email: ryan@peipotato.org
@rbarrettPEI
www.peipotatoagronomy.com

PAA ANNUAL MEETING
Prince Edward Island
JULY 23-27, 2023

Delta Hotel by Marriott
Prince Edward Island