# Cover Cropping in Potato Rotations

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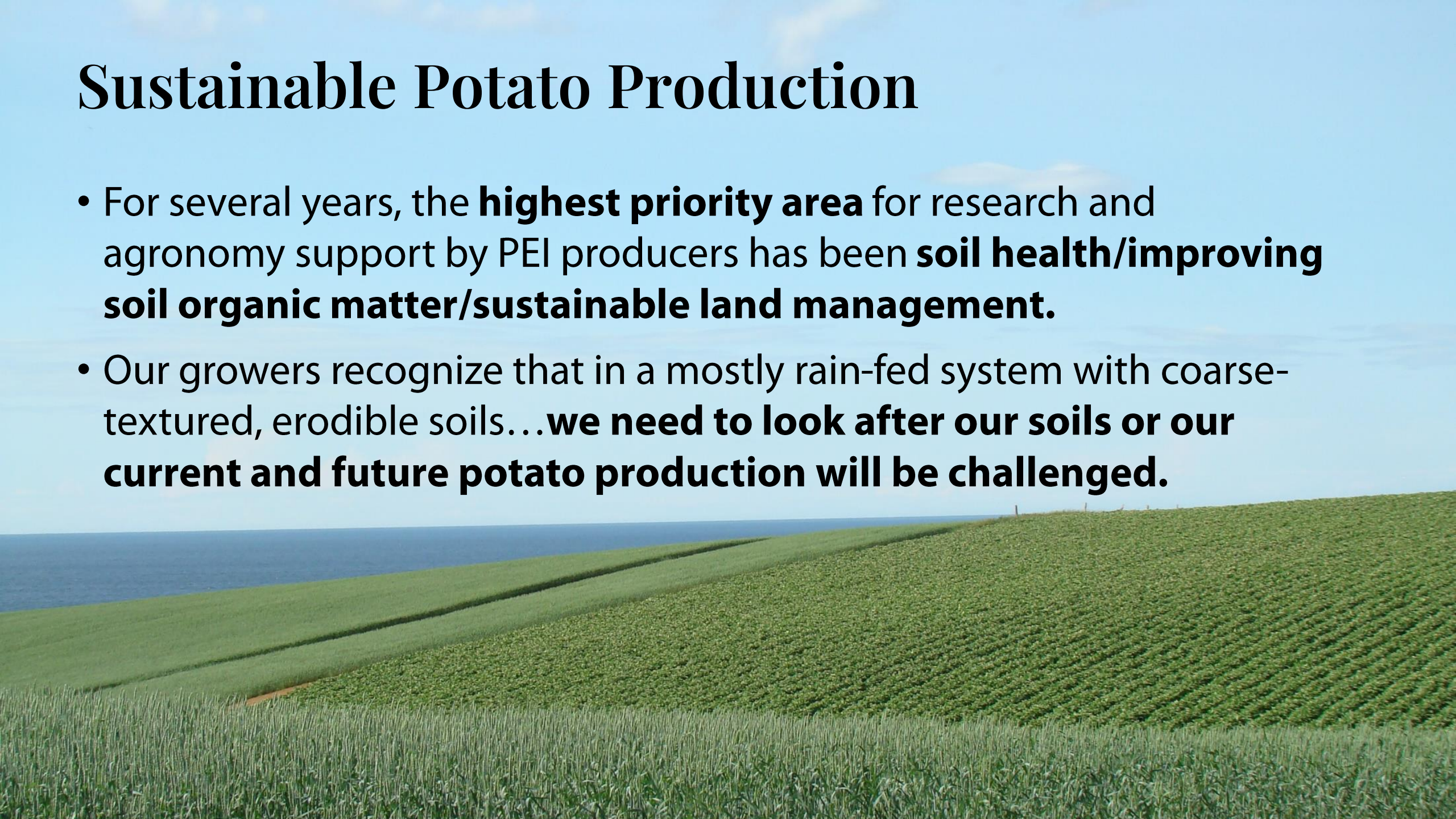
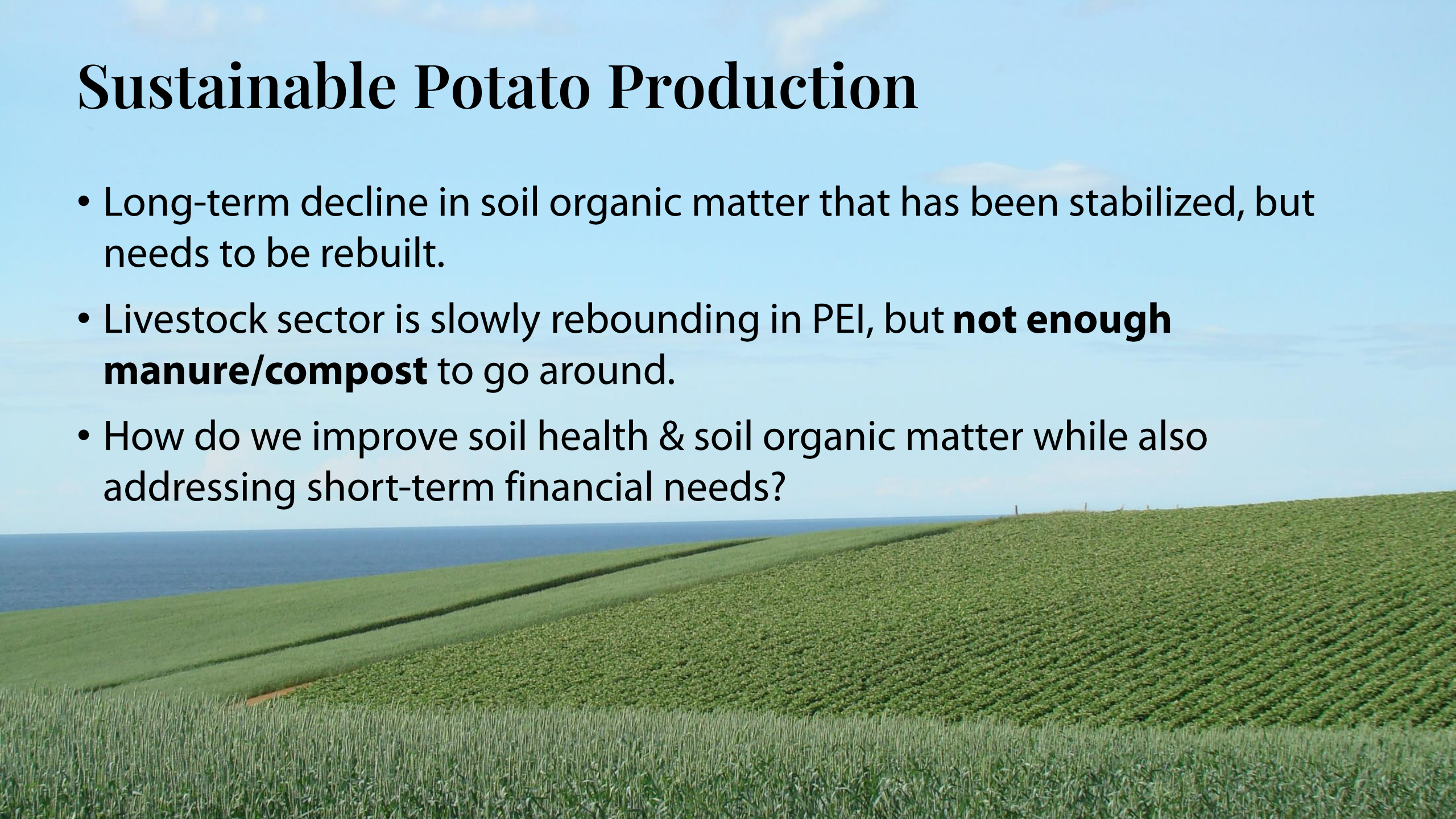
# Sustainable Potato Production

- 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.**



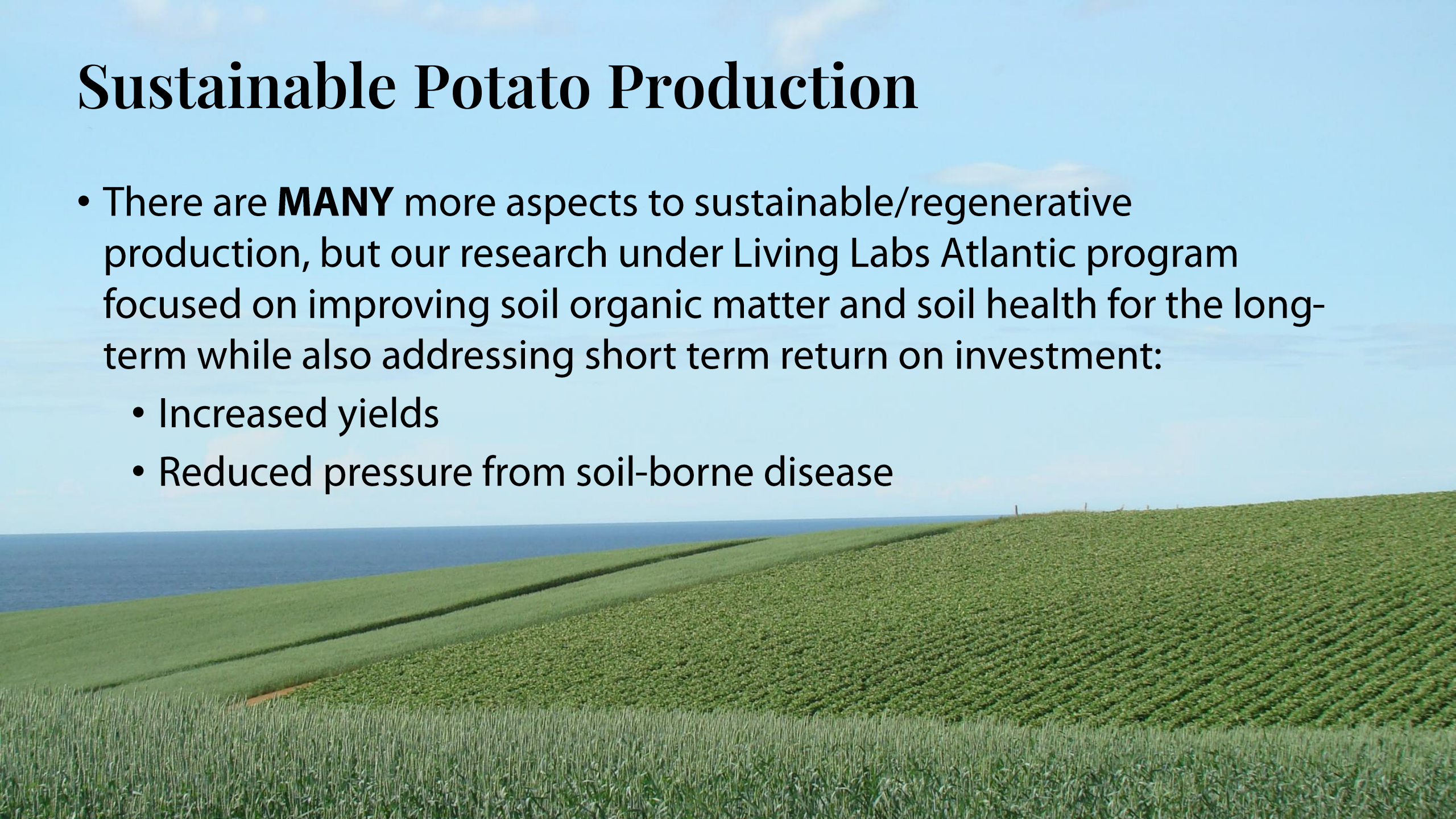
# Sustainable Potato Production

- 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.
- 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

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# 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

# 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.

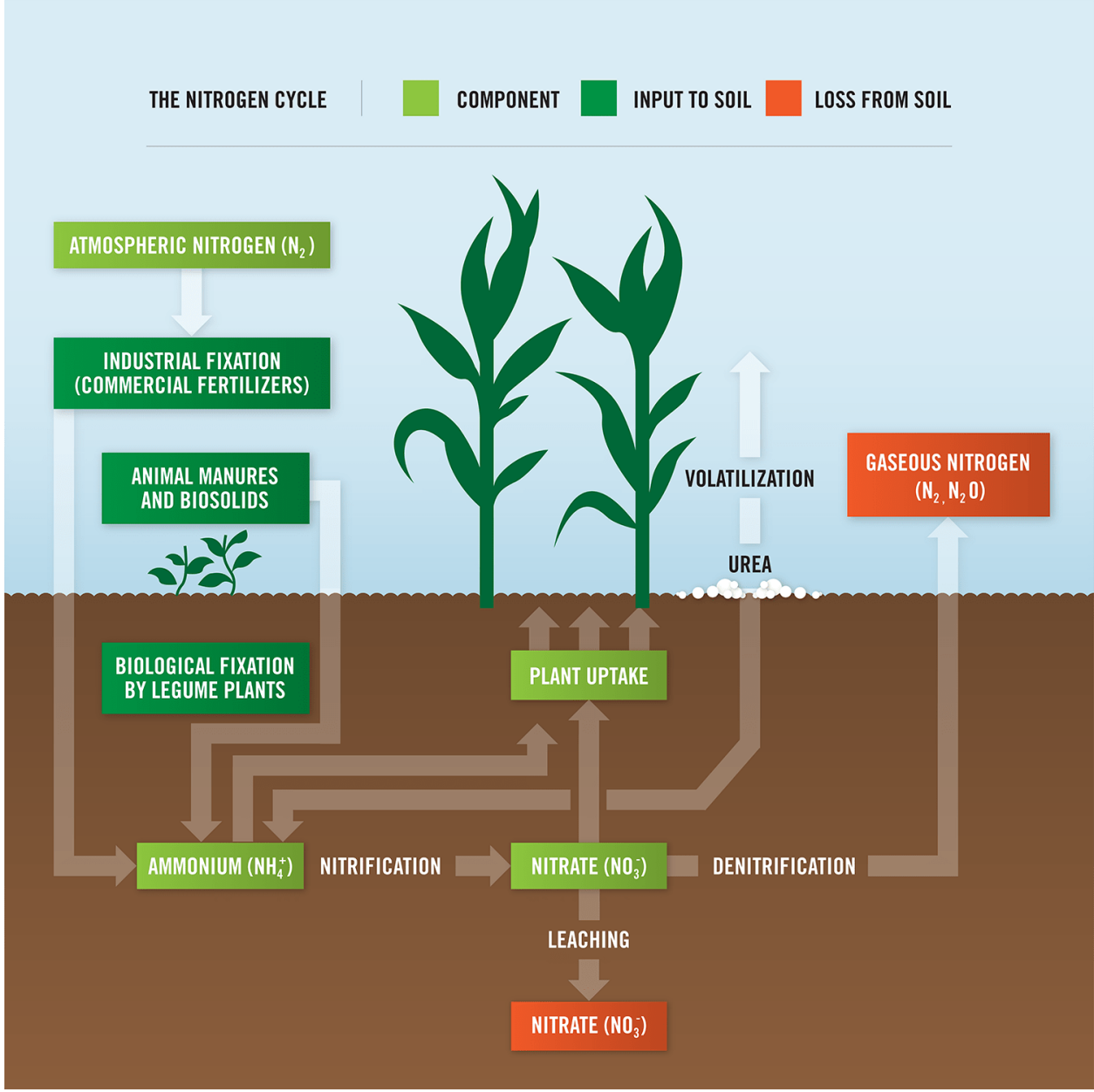



Image: https://kochagronomicservices.com/

# 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

- Results from 2021/2022 fields indicate a positive trend on short-term building of soil OM, but more longer-term monitoring would be needed to verify.

- Building soil OM is a long-term process, and we would not expect to see much improvement in only one year.

Catherine Ulitsky, USDA/Flickr

# 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 | 352.7 | 4.8 | 6.9 | 16.9 | 1.088 | 316.6 | 4601 |
| No Cover | 318.5 | 4.1 | 8.5 | 15.9 | 1.086 | 284.7 | 4065 |
| Diff: | **34.2** | 0.7 | **-1.6** | 1.0 | 0.002 | **31.9** | **$536** |
| p value | **0.002** | 0.490 | **0.049** | 0.651 | 0.268 | **0.006** | **0.005** |

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

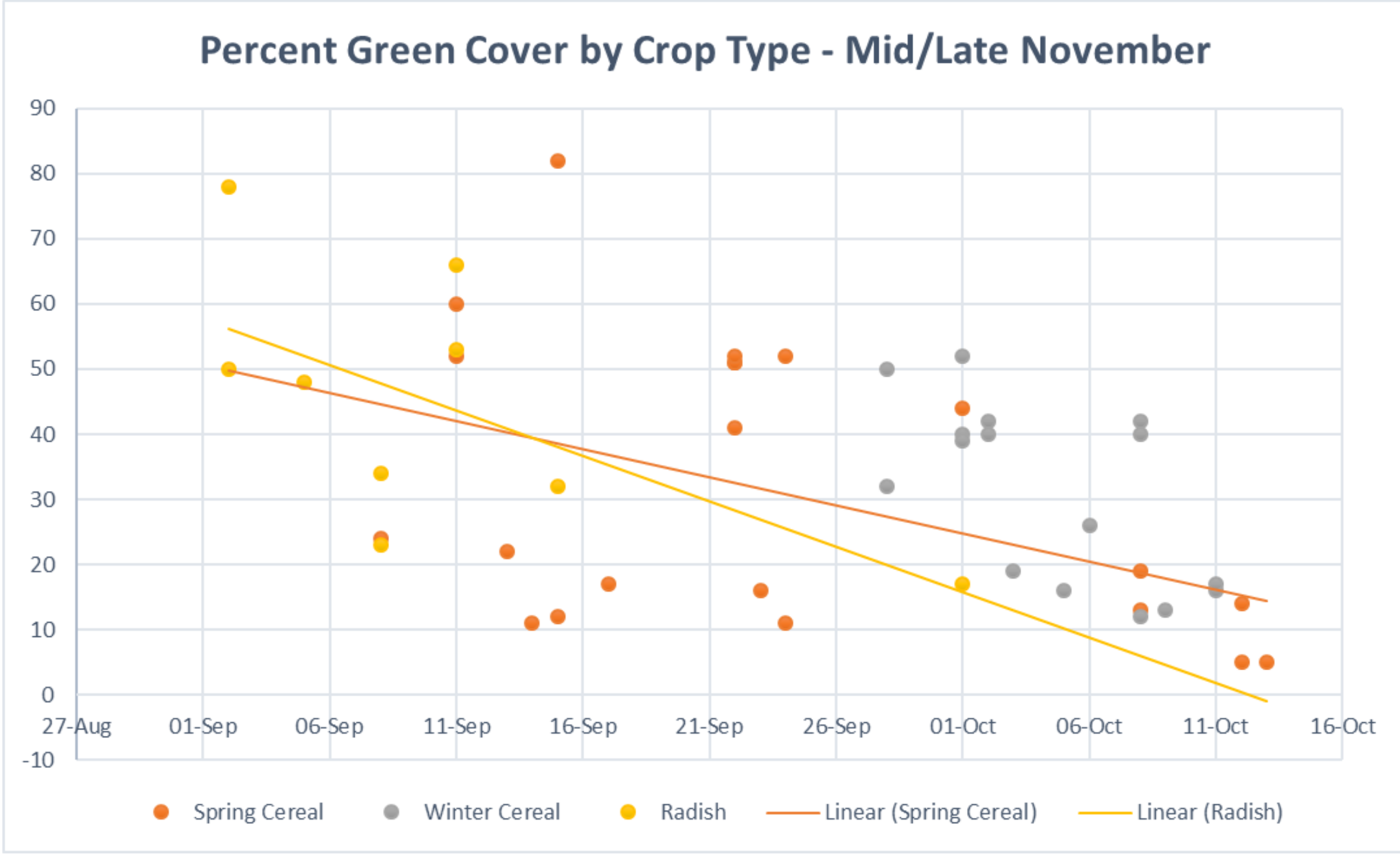
# Increasing Yields following Cover Crops

- Over 3 cropping cycles, we saw a **32 cwt/ac yield improvement** (11% increase) when planting a winter-killed 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 (ie. alfalfa)
  - 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 Mid-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

# Mid-September to Early October:

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

# After mid-October:

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

- Barley and Oats don't consistently establish later in October in PEI…even at high seeding rates. Prioritize winter cereals for later seeding.

# 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 usually 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 or broadcast at leaf drop (rye)

# 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?

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# Thank You!

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