POTATO SOIL HEALTH: OPPORTUNITIES AND CHALLENGES

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Oregon State University

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Outline

1) USDA Specialty Crop Research Initiative project
   - 2018-2023 -“Enhancing soil health in U.S. potato production systems”
   - 2024-2028 (or 2029) - “Ensuring Viability of U.S. Potato Production Systems through Management Strategies to Support Soil Health”

2) USDA NCRS Climate-Smart Potatoes from the Pacific Northwest: Managing Soil Health for Climate-Smart Outcomes

Demand for potatoes is increasing (worldwide)

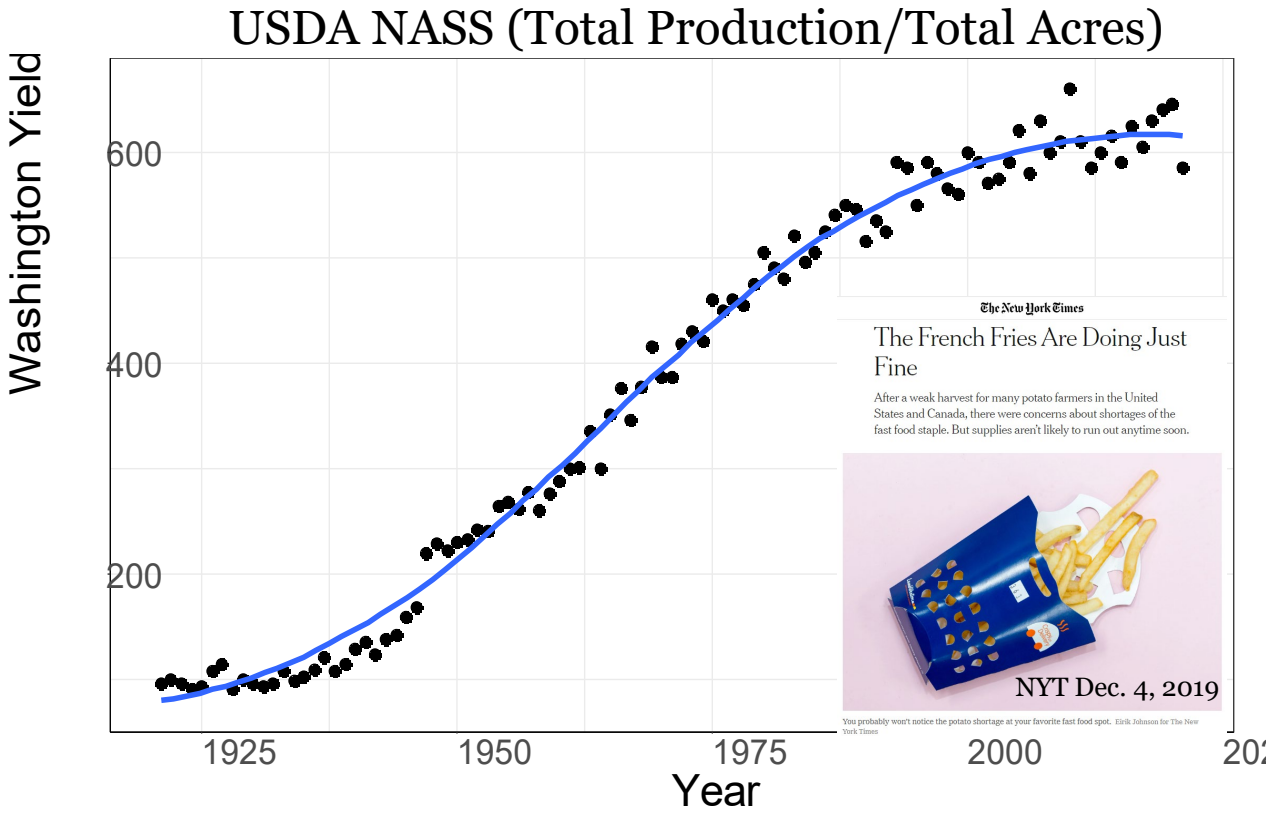
Yields per acre are tapering off

How can we meet that demand (and sell more potatoes)?

Develop new varieties – but takes time

Plant more acreage – but there are land and water limitations; there may be some options!

Shorten rotations – may increase potatoes produced, but not per/acre; increase soilborne disease and reduce soil productivity

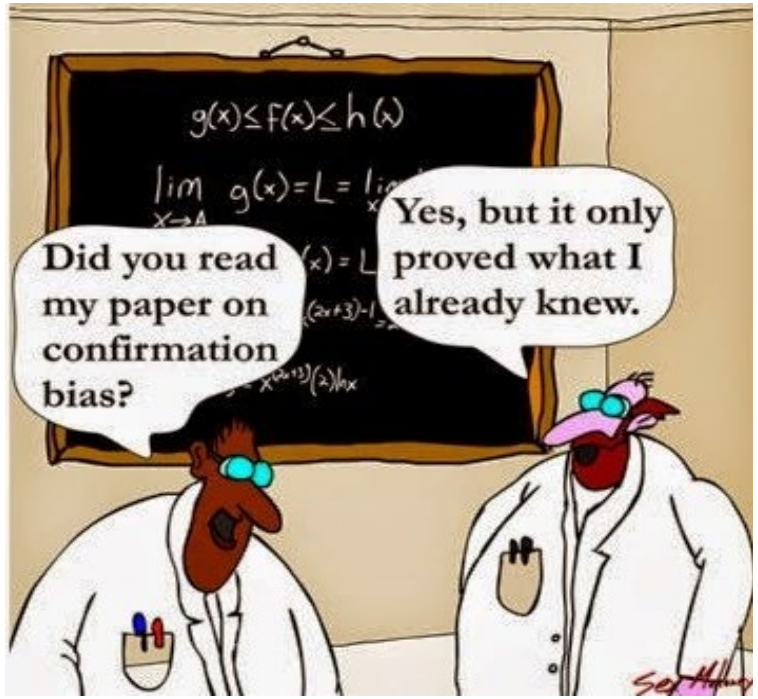


Can improved soil health help to maintain or increase yields?

Potato cropping system challenges

Potato systems cannot just incorporate established soil-conservation practices developed in grain and forage cropping systems

- Significant soil disturbance occurs during potato production
- Lack of residue after potato crop
- Cover crops establishment following potato can be difficult
- Fumigation is commonly used to manage soilborne disease



Future research on potato soil health should:

1) Establish long-term research and demonstration sites in the various potato cropping systems in the US to provide information on economic and agronomic effects of these approaches.
2) Develop a soil health assessment or calibrate an existing assessment for use in potato systems and establish a baseline of understanding of soil health in potato systems.
3) Elucidate the relationship between practices that influence soil health indicators, soilborne pathogens, and potato yield and quality.
4) Gather information to identify and characterize distinct potato cropping systems. Identify specific soil health challenges and opportunities unique to each system.
5) Develop a better understanding of the barriers that prevent adoption of practices known to improve soil health.

Modified from the WSPC commissioned report, 'Safeguarding Potato Cropping Systems in the Pacific Northwest Through Improved Soil Health' (Hills et al., 2018 & Hills et al. 2020)

Enhancing soil health in U.S. potato production systems

https://potatosoilhealth.cfans.umn.edu/

Rosen & Kinkel (Univ. of MN), Rosenzweig, Steinke, & Tiemann (Michigan State Univ.), McIntosh, Schroeder, Thornton, & Maas (Univ. of Idaho), Ruark, Lankau, & MacGuidwin (Univ. of WI), Jahn & Stewart (Colorado State Univ.), Frost & Moore (Oregon State Univ.), Fuller (Montana State Univ.), Gudmestad, Pasche, & Robinson (North Dakota State Univ.), Hao (Univ. of Main), and Gleason (Washington State Univ.) (USDA SCRI 2018-51181-28704; $8.1 M)

POTATO SOIL HEALTH PROJECT

USDA United States Department of Agriculture National Institute of Food and Agriculture

“Coordinated Agricultural Project”

Soil health is a concern of potato producers across the U.S.:

- Farm management practices, disease pressures, and rotation crops vary across the country
- There is benefit to coordinating at the national scale and comparing results across regions
- This project allows us to coordinate and standardize experiments, data collection, and analyses across the U.S.

The multistate experimental design:

- May help explain how or why differences in management may lead to similar or different outcomes across locations (i.e., inform why there are sometimes conflicting recommendations about which management practices are beneficial)
- Enables identification of regionally-appropriate recommendations for biological and physical SHI to optimize yield and nutrient and water use efficiency

Establish long-term research and demonstration sites in the various potato cropping systems in the US to provide information on economic and agronomic effects of these approaches.

"Long-term" potato rotation experiments were established in eight potato-producing regions: CO, ID, ME, MN, MI, ND, OR, (WA), WI

Each region focuses on a few key practices to manipulate soil properties and productivity (i.e., SH indicators, yield, etc.) – soil properties and etc. can take a long time to change

Some common and aspirational practices

These experiments examine mechanisms underlying observed differences

Rotation Considerations

Rotation length
- Number of seasons between potato crops

Crop type
- Crop species (diversity)

Crop sequence
- Order of planting the crop types

Cover crops

Other (goals/functions)
- Standard practice
- Disease suppression
- Soil Conserving (maintaining) or improving (building)
- Economics (balanced with other goals)

SCRI Experiments

Rotation length
- 2- and 3-year

Crop type
- Potato (cultivar varies by state)
- Varies (i.e., small grains, corn, soybean, snapbean, etc.)

Disease Suppression
- Conv. Fumigation
- Biofumigation
- Green manures/cover crops

Amendments
- Organic (compost, residues, manures)
- Chemical (fertilizer, pesticides)
- Biological (biocontrol/inoculants)

Data Collected

Soil biology/ microbiome

Total bacterial community structure (16s amplicon sequencing)

Total fungal community structure (ITS amplicon sequencing)

PLFA (2022)

Soil pathogens

Pathogen inoculum density

- Verticillium dahliae
- Nematode pop. sizes
  - Root lesion
  - Root knot
  - Stubby root
  - Stunt
  - Etc.

Disease

Plant Health

- Vascular discoloration
- Common scab
- Others of regional importance

Potato Yield

Specific gravity

Total yield

Marketable yield

<4 oz.

4-6 oz.

6-10 oz.

10-14 oz.

>14 oz.

US No. 1 & US No. 2

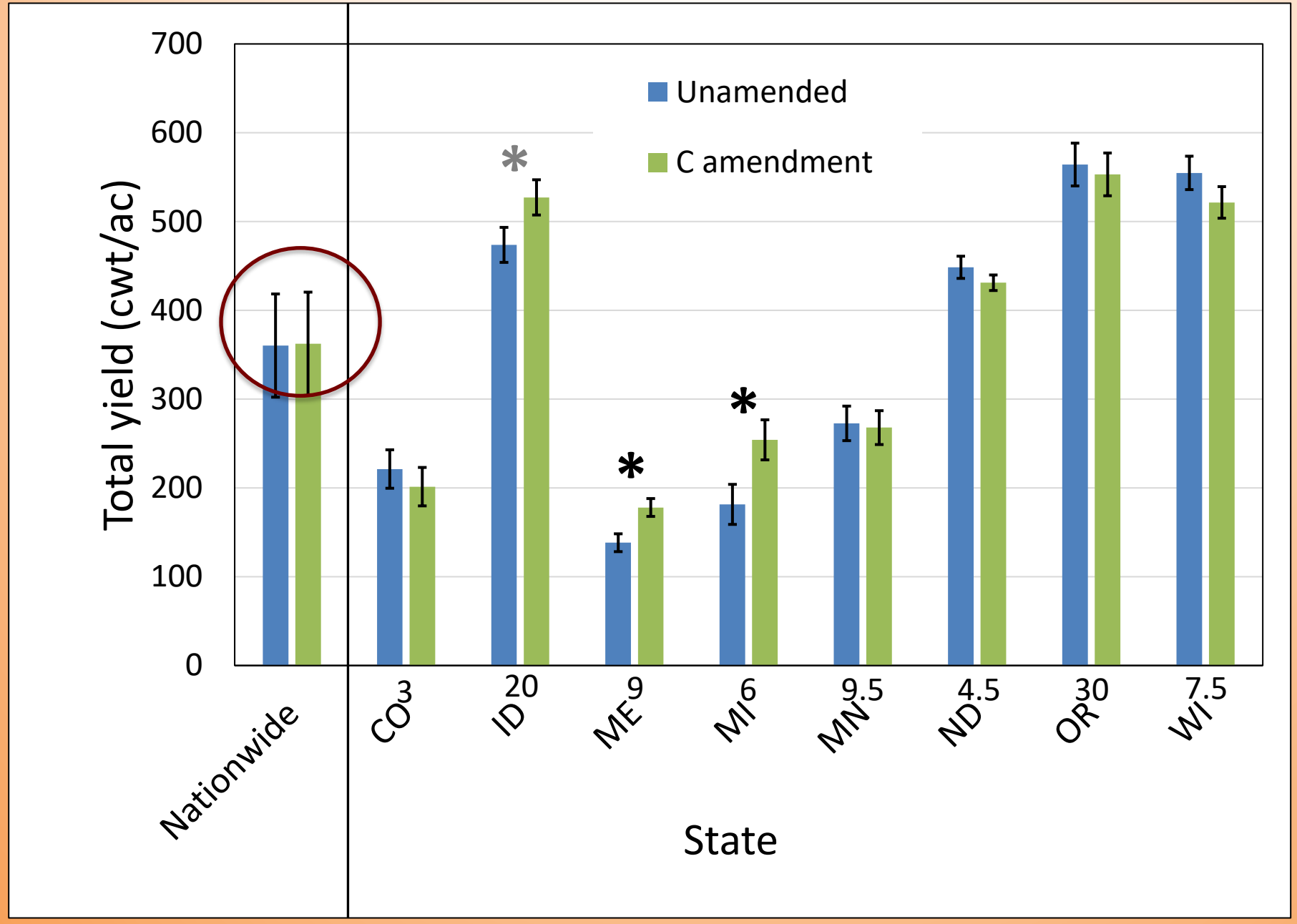
Soil Nutrients

- pH
- Buffer pH
- Organic matter
- EC (Soluble Salts)
- Nitrate-N
- Ammonium N
- Olsen P
- Extractable K, Mg, Na, S, Zn, Fe, Mn, Cu, B
- Base saturation
- Cation Exchange Capacity

Soil Health

- Total organic C
- Active C
- Ace Protein (Mineralizeable nitrogen)
- Solvita (carbon dioxide respiration)
- Wet aggregate stability
- Compaction

Total Tuber Yield as Affected by C Amendments



Mean ± S.D.

Total Yield vs. Soil Health Indicators

Predictors	Versus total yield (z-score)			
	2-year rotation		3-year rotation	
	Slope	Significance	Slope	Significance
VPPG		0.5769		0.5112
RL nematodes	-	**0.0008**	-	**0.0020**
Respiration		0.7426		0.7167
SOM		0.9378		0.9095
POxC		0.2414		0.5257
ACE protein		0.7183		0.8702
Large macroaggregates		0.9960		0.1405
Macroaggregates		0.5059		0.5587
Microaggregates		0.7843		0.5759
Mean first depth above 300 PSI		0.5420		0.6786

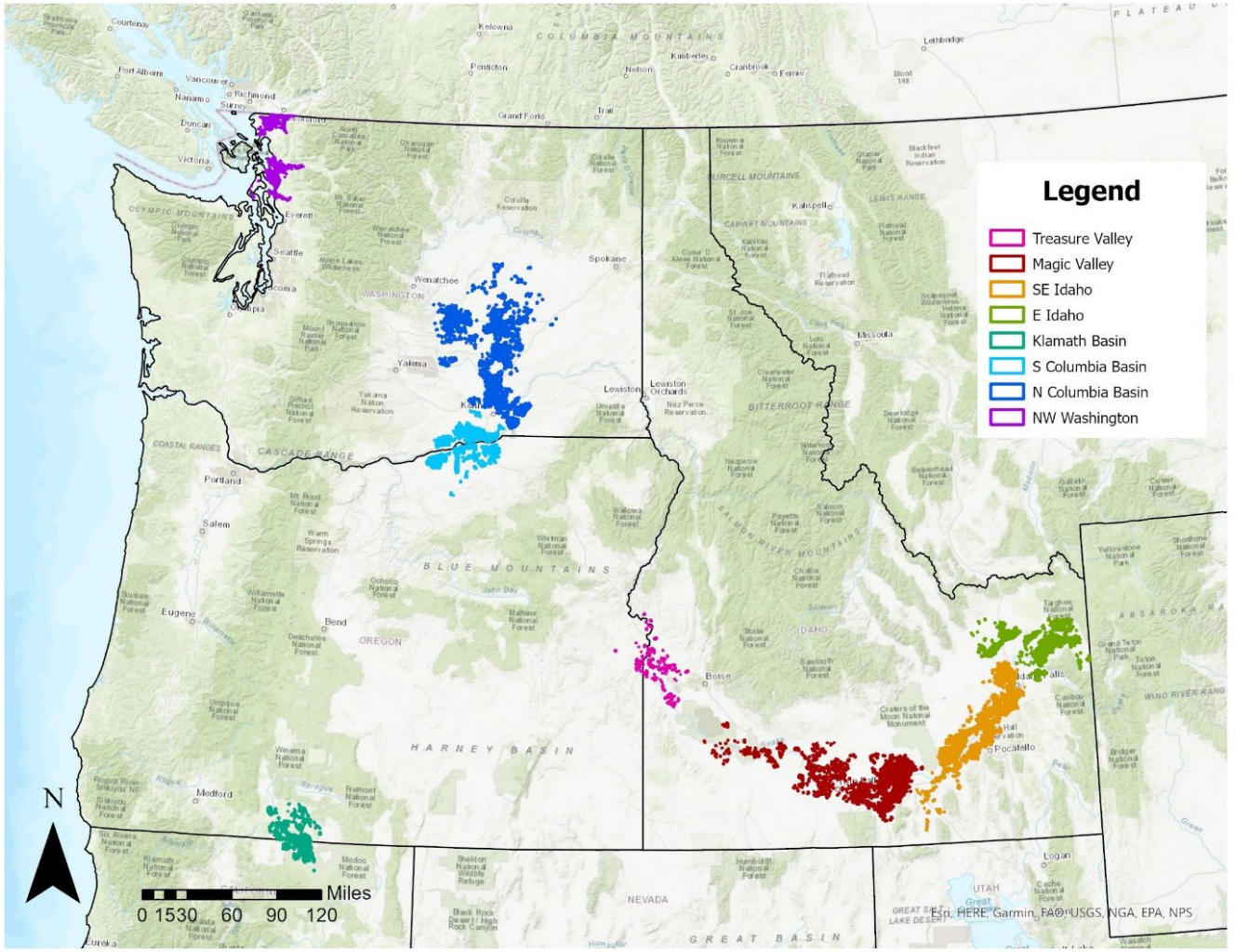
$z = x-\mu/\sigma$

Climate-Smart Potatoes from the Pacific Northwest:

Managing Soil Health for Climate-Smart Outcomes

What are Climate-Smart potatoes?

What are CS management practices?



Partnership for Climate-Smart Commodities. USDA is committed to supporting a diverse range of farmers, ranchers, and private forest landowners through Partnerships for Climate-Smart Commodities. This effort will expand markets for America's climate-smart commodities, leverage the greenhouse gas benefits of climate-smart commodity production, and provide direct, meaningful benefits to production agriculture, including for small and underserved producers.

What are Climate-Smart management practices?

"Climate-smart" agriculture is a relatively new term

C-S Agricultural at its core seeks to:

1) Increase carbon sequestration, environmental resilience, and productivity
2) Reduce/mitigate (GH gas) emissions

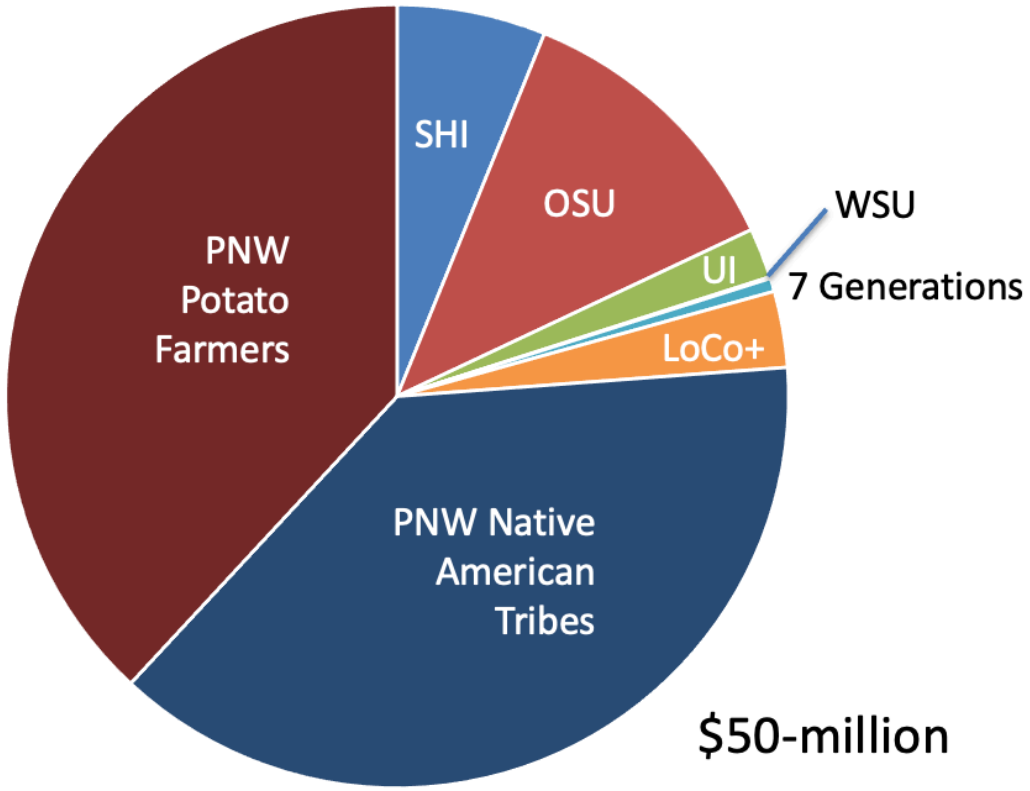
CS ag practices are not new and include:

- conservation management practices already used in potatoes cropping systems
- e.g., conservation tillage, crop rotation, nutrient management, etc.

It can be challenging to figure out how to adopt some of these practices in potato cropping systems

This project provides funds incentivize or remove risk associated with adoption of CS practices

Climate-Smart Potatoes from the Pacific Northwest



Project costs	%	$ (million)
Total Budget	**100**	**50.0**
Direct Payments:	75	37.5
Farms	**37.5**	**18.75**
Tribes	37.5	18.75
Project Management:	25	12.5
Farmer/Tribe Technical Assistance	12.4	6.2
Operations	12.6	6.3

USDA United States Department of Agriculture

Natural Resources Conservation Service

Climate-Smart Agriculture and Forestry (CSAF) Mitigation Activities List[1] FY2023

Climate Change Mitigation Practice Categories	Code	Conservation Practice Standard Name[2] (units)	CSP Enhancement Code	Conservation Stewardship Program (CSP) Bundle and Enhancement Activity
Soil Health			B000BFF1	Buffer Bundle#1*
			B000CPL24	Cropland soil health management system*
			B000CPL25	Climate smart advanced soil health*
	327	Conservation Cover (acres)	E327A	Conservation cover for pollinators and beneficial insects
			E327B	Establish Monarch butterfly habitat
	328	Conservation Crop Rotation (acres)	E328A	Resource conserving crop rotation
			E328B	Improved resource conserving crop rotation
			E328E	Soil health crop rotation
			E328F	Modifications to improve soil health and increase soil organic matter
			E328G	Crop rotation on recently converted CRP grass/legume cover for soil organic matter improvement
			E328N	Intercropping to improve soil health
			E328O	Perennial grain crop conservation rotation
	329	Residue and Tillage Management, No Till (acres)	E329A	No till to reduce soil erosion
			E329B	No till to reduce tillage induced particulate matter
			E329C	No till to increase plant-available moisture
			E329D	No till system to increase soil health and soil organic matter content
			E329E	No till to reduce energy
	332	Contour Buffer Strips (acres)	None Available	
	340	Cover Crop (acres)	E340A	Cover crop to reduce soil erosion
			E340B	Intensive cover cropping to increase soil health and soil organic matter content
			E340C	Use of multi-species cover crops to improve soil health and increase soil organic matter
			E340D	Intensive orchard/vineyard floor cover cropping to increase soil health
			E340F	Cover crop to minimize soil compaction
			E340G	Cover crop to reduce water quality degradation by utilizing excess soil nutrients
			E340H	Cover crop to suppress excessive weed pressures and break pest cycles
			E340I	Using cover crops for biological strip till
	345	Residue and Tillage Management, Reduced Till (acres)	E345A	Reduced tillage to reduce soil erosion
			E345B	Reduced tillage to reduce tillage induced particulate matter
			E345C	Reduced tillage to increase plant-available moisture
			E345D	Reduced tillage to increase soil health and soil organic matter content
			E345E	Reduced tillage to reduce energy use
	386	Field Border (acres)	E386A	Enhanced field borders to reduce soil erosion along the edge(s) of a field
			E386B	Enhanced field borders to increase carbon storage along the edge(s) of the field
			E386C	Enhanced field borders to decrease particulate emissions along the edge(s) of the field
			E386D	Enhanced field borders to increase food for pollinators along the edge(s) of a field
			E386E	Enhanced field borders to increase wildlife food and habitat along the edge(s) of a field
	393	Filter Strips (acres)	E393A	Extend existing filter strip to reduce water quality impacts
	412	Grassed Waterways (acres)	E412A	Enhance a grassed waterway
	484	Mulching (acres)	E484A	Mulching to improve soil health
			E484B	Reduce particulate matter emissions by using orchard or vineyard generated woody materials as mulch
			E484C	Reduce particulate matter emissions by using orchard or vineyard generated woody materials as mulch
	585	Stripcropping (acres)	None Available	
	601	Vegetative Barriers (feet)		
	603	Herbaceous Wind Barriers (feet)		

Identify practices that you want to implement (or may already be implementing)

Decide what works for your farm not limited to potato year

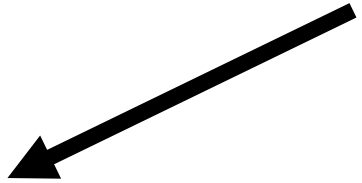
The primary practices we think will be of most interest:

327 Conservation Cover
328 Conservation Crop Rotation
329 Residue and Tillage Management, No-Till
340 Cover Crop
345 Residue and Tillage Management, Reduced Till
484 Mulching
528 Prescribed Grazing
590 Nutrient Management

Table 2. Examples of Climate-Smart Agriculture and Forestry (CSAF) Mitigation Activities List and practice payments. Payments based on PNW regional state CSP payment schedules.

Climate Change Mitigation Practice Category	Code	Conservation Practice Standard Name	CSP Enhancement Code	CSP Enhancement Activity	Payment ($/acre)
Soil Health	328	Conservation Crop Rotation	E328E	Soil Health Crop Rotation	6.38
Soil Health	340	Cover Crop	E340B	Increase soil health and soil organic matter	14.98
Soil Health	345	Residue and Tillage Management, Reduced Till	E345C	Increase plant-available moisture	3.83
Soil Health	345	Residue and Tillage Management, Reduced Till	E345D	Increase soil health and organic matter content	5.10
Soil Health	345	Residue and Tillage Management, Reduced Till	E345E	Reduced tillage to reduce energy use	4.46

Incentive Payment

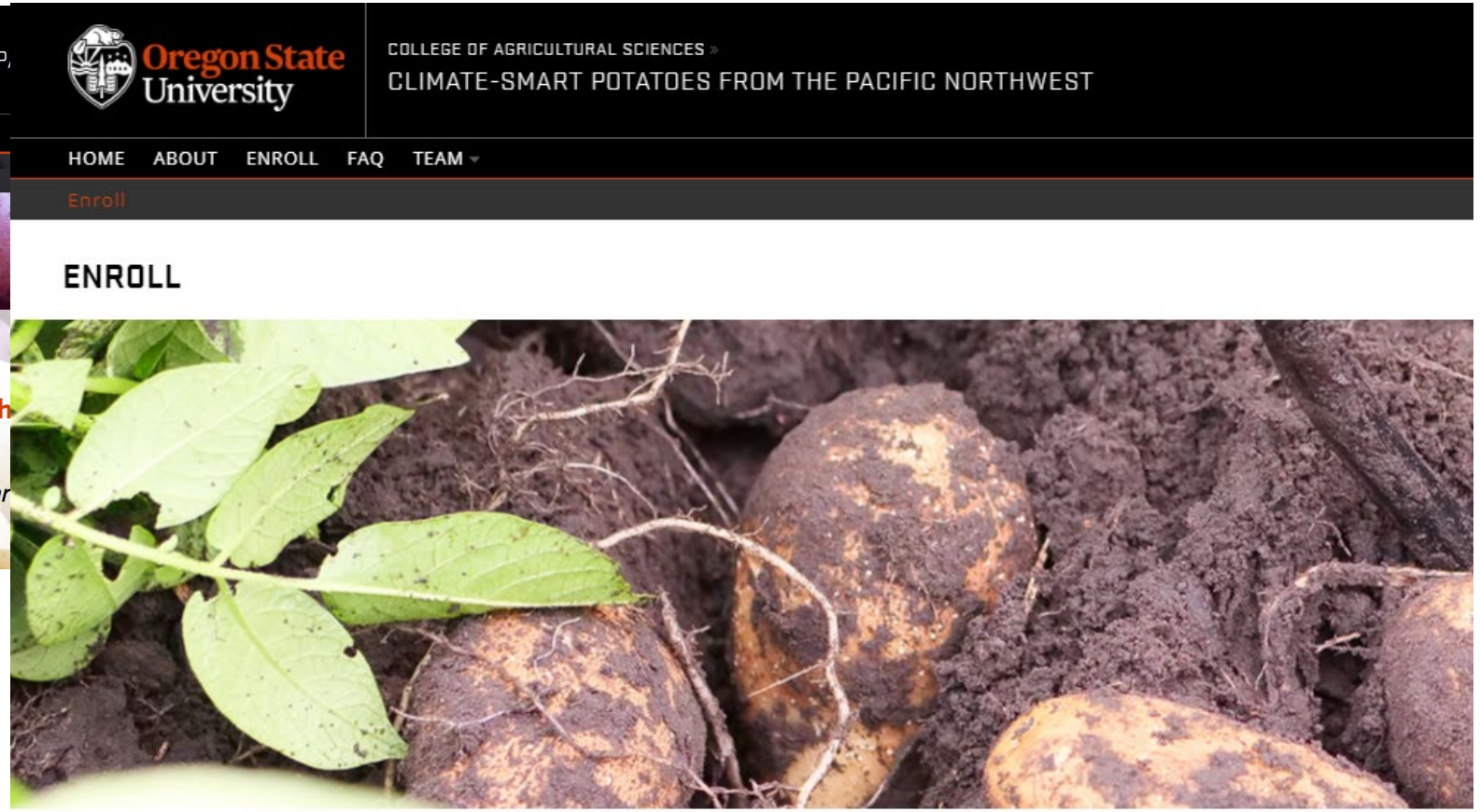


We're still working out the details:

1) There will be a process for enrollment into the program (some requirements must be met).

2) Implementation will have to validated (figuring out what information will be needed for this process).

More info at: agsci.oregonstate.edu/climate-smart-potato



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