Importance of Crop Rotation

Léa Vereecke, CCA

2023 Ohio Organic Grain Conference,

Archbold, Ohio

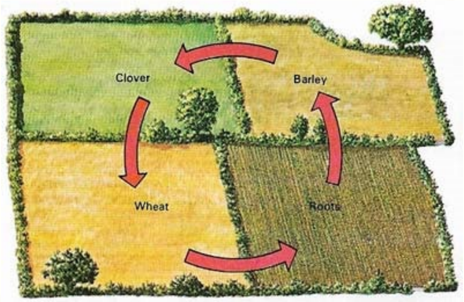
RODALE INSTITUTE

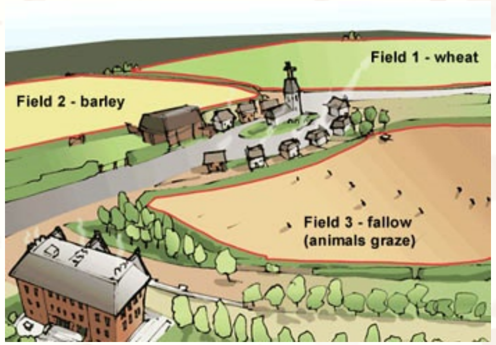
"Though people often deride those who change their mind as hypocrites, Grant and others think it's a mark of integrity. It's a sign that you're not committed to an idea; you're committed to the truth."

Crop Rotation

Growing a planned sequence of multiple crop species in recurring succession on the same area of land.

- Chinese three-field system
- European Norfolk four-course system
- Indigenous American three-sisters





Multi-Cropping

Use of one piece of land for different purposes in a single time period, usually growing season or calendar year.

- Double cropping and Relay cropping
- Cover cropping
- Integrated crop-livestock systems
- Woodland-based systems such as woodland pasture and agroforestry

Table 4 Definitions in crop rotation terminology.

Crop rotation	Carefully designed sequence of crops in which the succession is highly beneficial
Cropping plan	The partitioning of crops over the available area in a given year, often represented as % of the area for each crop (space)
Crop sequence	The succession of crops in time on one field in particular (time)
Crop frequency	The frequency of cropping the same crop on the same field, usually expressed as once in a number of years, for instance 1 out of 3, 1:3, meaning once every three years
Crop rotation block (course)	One year of the crop rotation succession and the crop(s) in that specific crop rotation year
Agro-ecological layout of the farm	The layout of the farm over the available space, the partitioning of the area over fields, their shape and size, the spatial crop rotation and the ecological infrastructure of the farm
Ecological infrastructure	The network of natural and specifically managed areas on the farm to provide habitats and (transport) corridors for flora and fauna

Olesen et al, 1999

	HEL			Non-HEL	
	South 30ac	Hillside 50ac	North 32ac	West 49ac	Bottom 70ac
2019	Alfalfa seedling	*10T cattle manure*		*10T cattle manure*	
2020	*10T cattle manure* Alfalfa	(UAN) Wheat		Oats	July fungicide Corn
2021	Limed in May Alfalfa	Limed in May Alfalfa seedling	Corn	Peas	Oats (800lbs PPM) cc rye
2022	O1 - Alfalfa	Alfalfa	Oats/ u-s clover (foundation seeds)	O1 - Soybeans	Rye (no fall PPM) cc rye
2023	White Corn (Confirming w/buyer)	O1 - Alfalfa (Small square bales)	Sprayed Corn	(PPM February) Oats/ clover (Food grade or Certified seeds)	O1 - Rye or Soybeans
2024		Alfalfa	T1	Corn	
2025		Alfalfa	T2		

§ 205.205 Crop rotation practice standard.

The producer must implement a crop rotation including but not limited to sod, cover crops, green manure crops, and catch crops that provide the following functions that are applicable to the operation:

(a) Maintain or improve soil organic matter content;

(b) Provide for pest management in annual and perennial crops;

(c) Manage deficient or excess plant nutrients; and

(d) Provide erosion control.

USDA ORGANIC

2.2	●	Crop Rotations	Operations shall demonstrate use of crop rotations or perennial systems. Annual crop rotations should include a green manure.

Regenerative Organic Certified™

Bronze: 3 crop rotations, Silver: 4 crop rotations, Gold: 7 crop rotations

Weed Control

What are we trying to achieve with a crop rotation regarding weed pressure?

- Reduce overall weed seed bank and avoid selecting specific species.
- Better off with a little bit of everything, than a lot of one thing.
- More diverse systems have a lower density of problem weeds but a greater diversity of weed species.

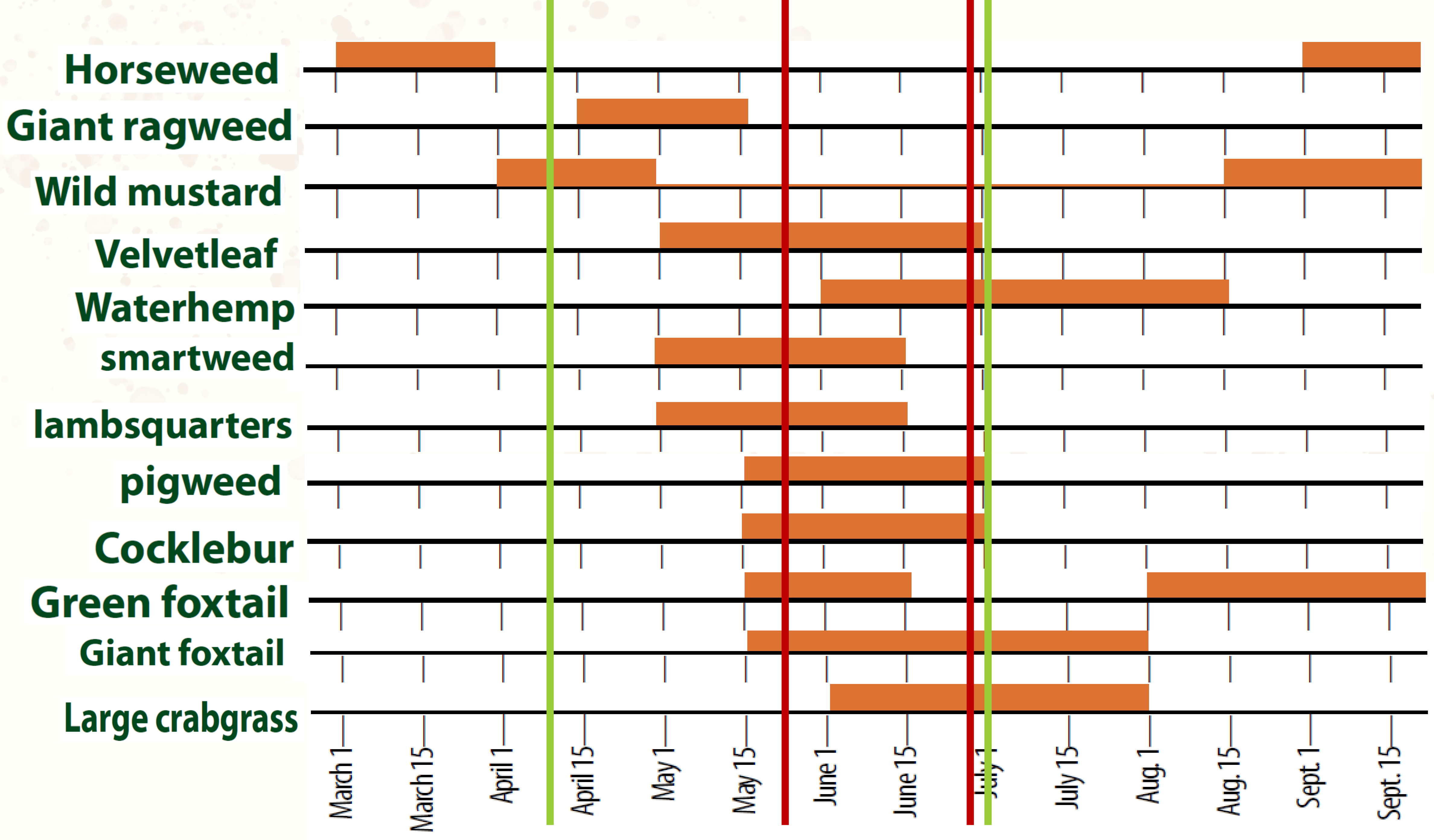
Weed Control

- How do we achieve such goal? By creating opportunities for a diversified set of control options.
- Control options:
  - Crop competitiveness
  - Cover crop competitiveness
  - Tillage timing
  - Mechanical and thermic weeding
  - Mowing
  - Seed decay
  - Etc.

Weed Control

(1) Rotate between **crops with varied lifecycles** to enhance the natural loss of weed seeds in the soil, reduce weed establishment, and minimize weed seed production

- Planting and harvest timing: fall- or winter-planted crops can control annual summer weeds
- Nutrient building vs. nutrient depleting
- Annuals and perennials: perennial crops can effectively antagonize annual weeds; mowed system will favor prostrate and help control erect weeds



Horseweed
Giant ragweed
Wild mustard
Velvetleaf
Waterhemp
smartweed
lambsquarters
pigweed
Cocklebur
Green foxtail
Giant foxtail
Large crabgrass
March 1
March 15
April 1
April 15
May 1
May 15
June 1
June 15
July 15
Aug. 1
Aug. 15
Sept. 1
Sept. 15

+

Inherent Competitivity Against Weeds

Alfalfa, Pasture, Clover
Vetch, Winter peas
Winter small grain

Fava beans
Lentils

Spring small grains
Sunflower
Soybean, Corn
Spring peas

−

(2) Follow weed-prone crops with crops in which weeds can easily be prevented from going to seed.

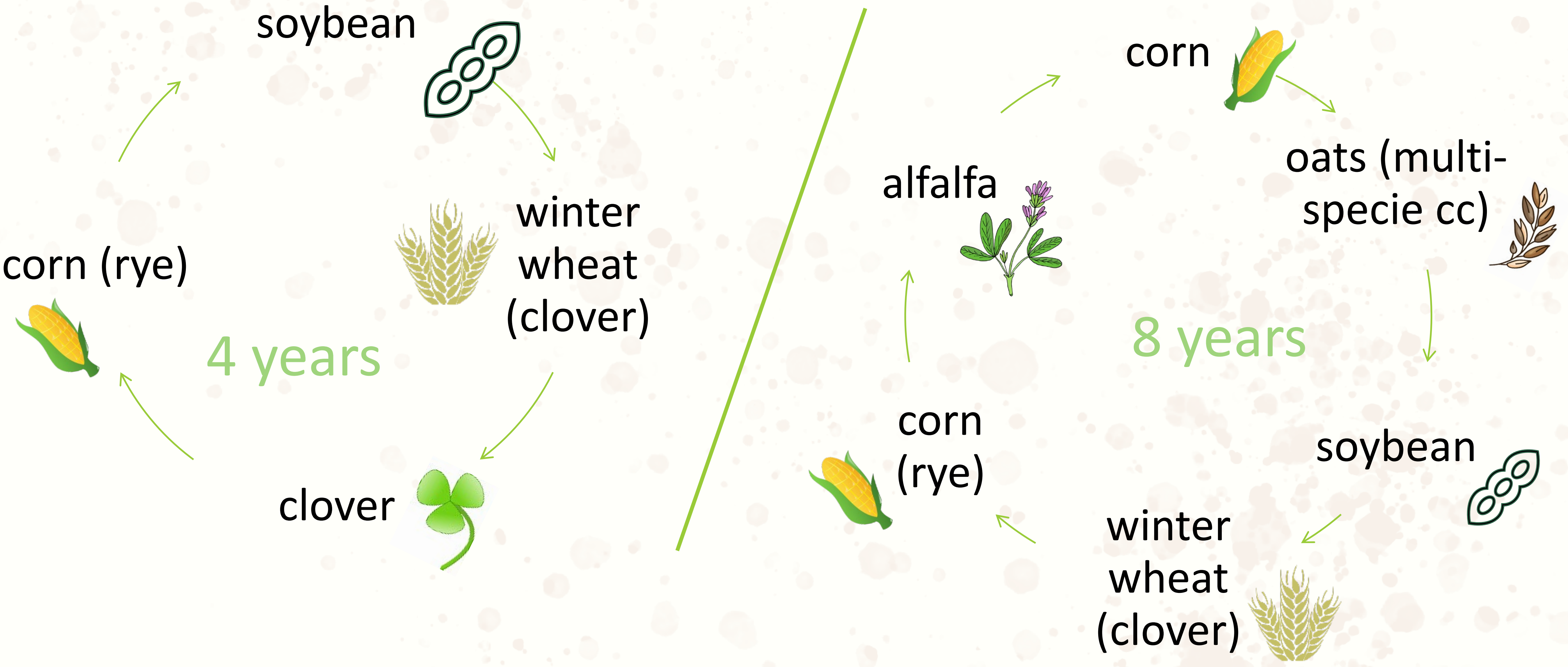
Inversely, plant crops in which weed seed production can be prevented before crops that are poor competitors.

Weed Control

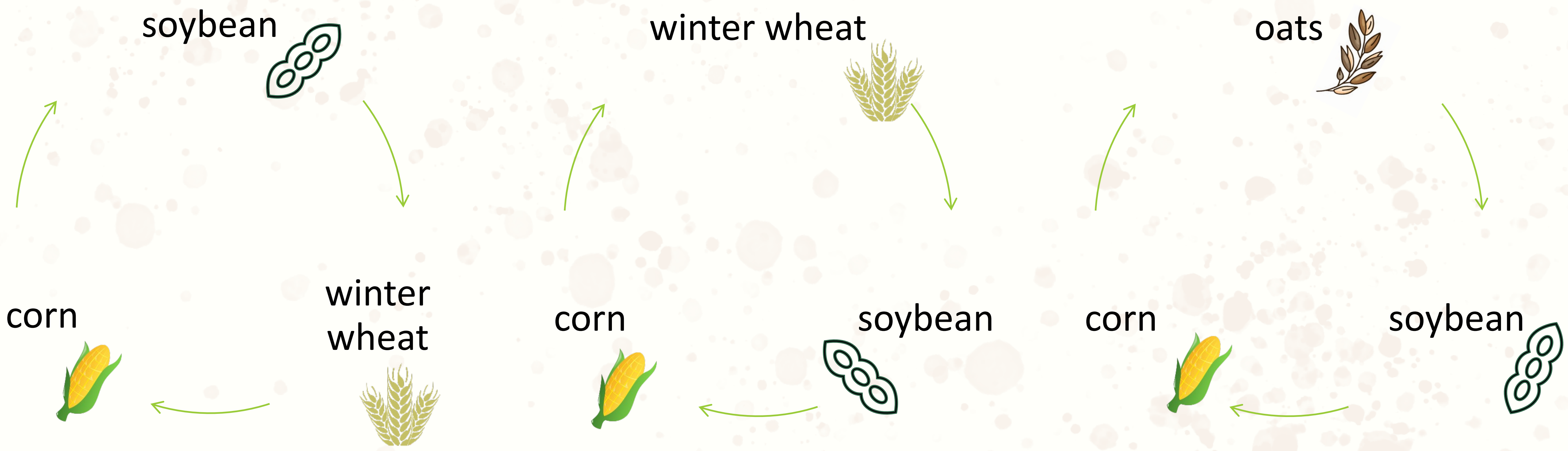
(3) Work **cover crops** into the rotation between cash crops at times when the soil would otherwise be bare.

Avoid cover crop species and cover crop management that promote weeds – seeding clover alone, poor establishment, mustard, hairy vetch etc.

Increasing diversity and length



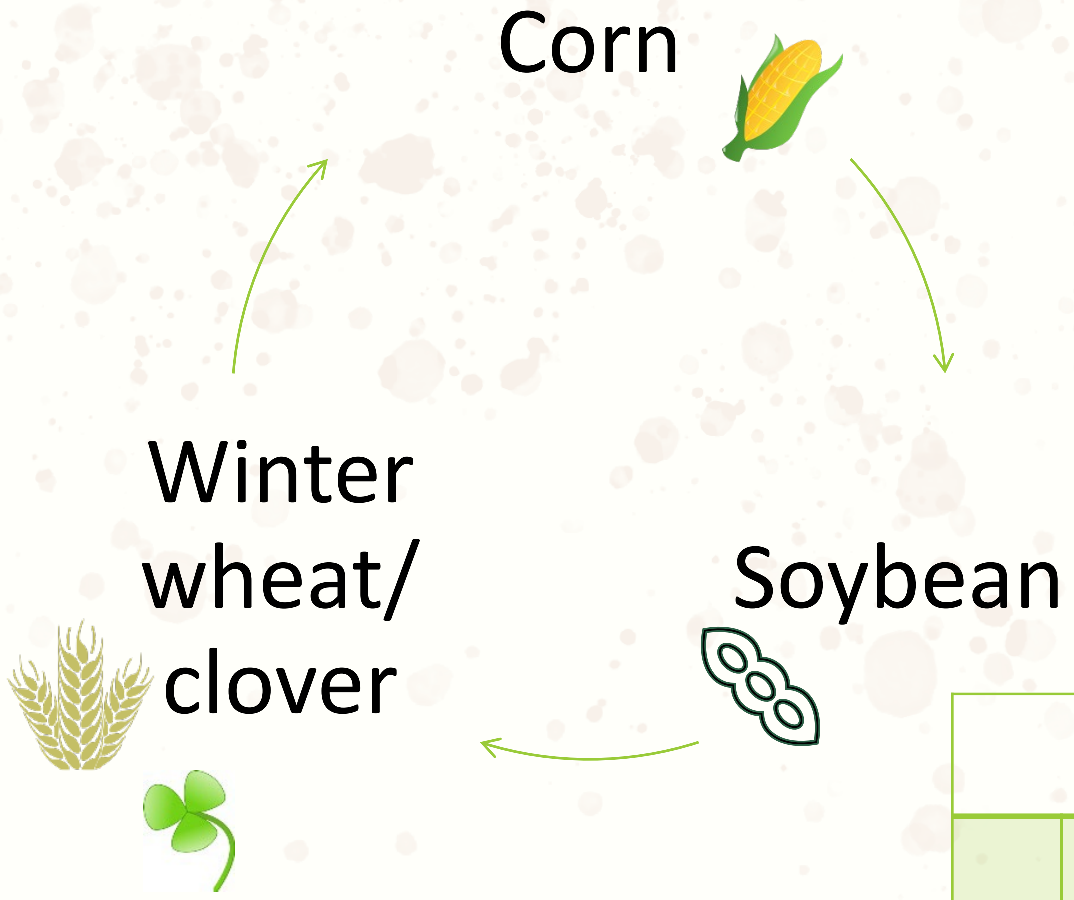
Crop Rotation with No-till Soybeans



Avoid

- Corn as the preceding crop
- Winter wheat as the following crop
- Following corn with winter wheat

Short season crops: peas, oats, sunflower, buckwheat, millet etc.



Nutrient cycling

Nutrient needs			
	Corn (150bu/ac)	Winter wheat (90bu/ac)	Soybean (40bu/ac)
N	150	110	
P	50	45	32
K	30	22	46

Organic Matter

Table F-1. Minimum estimated nitrogen contributed to the crop from mineralization of soil organic matter.

Soil Test Organic Matter (%)	Nitrogen Contributed to Crops From Mineralization (lb/acre/yr)
1	20 - 30
2	40 - 55
3	60 - 70

Irrigation and Nitrogen Management. User Education/Certification Program. UNL Extension

Table 1.3 Available Nitrogen from a Previous Legume Cover Crop [a]

Legume Cover Crop	Dry Matter (lb/A/yr)	Total N[c] (lb/A)		Available N (lb/A)[b]		Available N (lb/1,000 sq ft)[b]	
		low	high	low	high	low	high
Berseem Clover	6,000-10,000	75	220	30	88	0.7	2.0
Cowpeas	2,500-4,500	100	150	40	60	0.9	1.4
Crimson Clover	3,500-5,500	70	130	28	52	0.6	1.2
Field Pea	4,000-5,000	90	150	36	60	0.8	1.4
Hairy Vetch	2,300-5,000	90	200	36	80	0.8	1.8
Medics	1,500-4,000	50	120	20	48	0.5	1.1
Red Clover	2,000-5,000	70	150	28	60	0.6	1.4
Subterranean Clover	3,000-8,500	75	200	30	80	0.7	1.8
Sweet Clover	3,000-5,000	90	170	36	68	0.8	1.6
White Clover	2,000-6,000	80	200	32	80	0.7	1.8
Wooly Pod Vetch	4,000-8,000	100	250	40	100	0.9	2.3

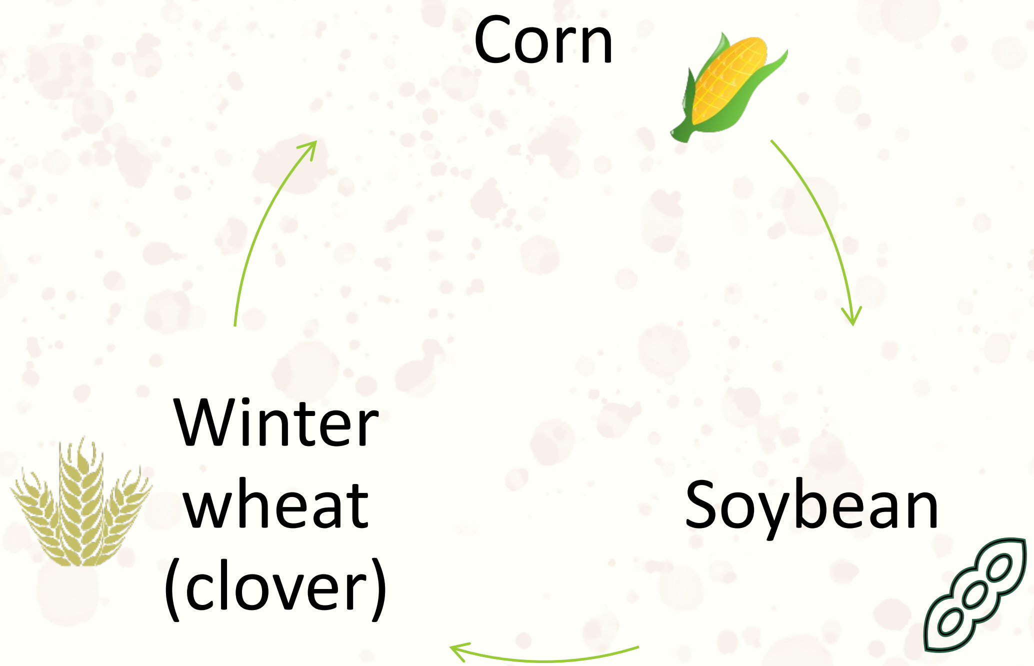
Needs after Organic Matter	
Corn (150bu/ac)	
N	100
P	*50*
K	*30*

Penn State Extension, 2011

Animal manure

Needs after clover and OM	
Corn (150bu/ac)	
N	60
P	50
K	30

	Dairy, liquid, per 1000 gal			Hog, liquid, per 1000 gal			Chicken, solid, per ton		
	N	**P**	**K**	**N**	**P**	**K**	**N**	**P**	**K**
1	10	6	17	12	5	17	27	35	26
2	20	12	34	24	10	34	54	70	52
3	30	18	51	36	15	51	81	105	78
4	40	24	68	48	20	68	108	140	104
5	50	30	85	60	25	85			
6	60	36	102	72	30	102			
7	70	42	119	84	35	119			
8	80	48	136	96	40	136			
9				108	45	153			
10				120	50	170			



Needs after Organic Matter	
Winter wheat (90bu/ac)	
N	60
P	45
K	22

Table 1.4 Available Nitrogen Contributed from Previous Leguminous Crop[a]

Previous crop[b]	Percent Stand	High productivity fields	Moderate productivity fields	Low productivity fields
First year after soybeans harvested for grain	1 lb N/bu soybeans - avg yield in PA = 46 bu/A 2009			

Penn State Extension, 2011

Animal manure

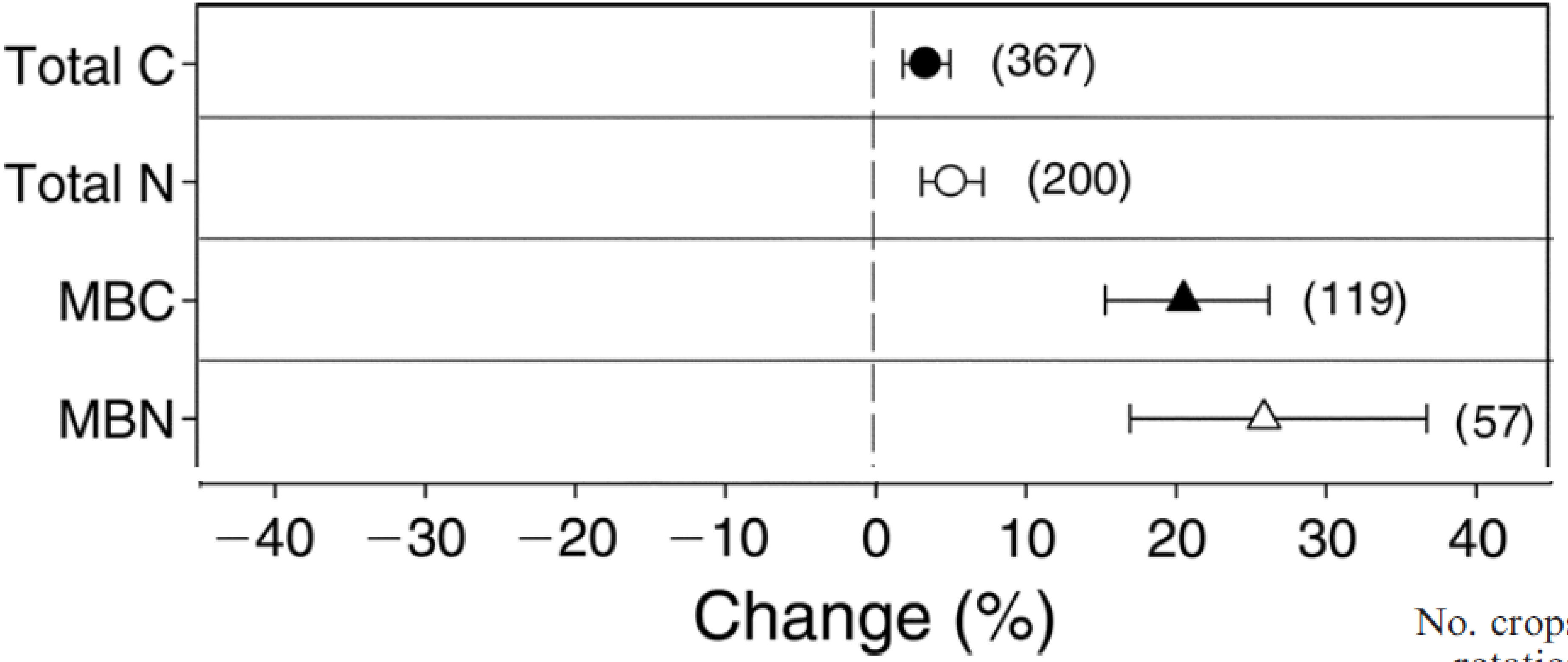
	Dairy, liquid, per 1000 gal			Hog, liquid, per 1000 gal			Chicken, solid, per ton		
	N	P	K	N	P	K	N	P	K
1	10	6	17	12	5	17	27	35	26
2	20	12	34	24	10	34			
3	30	18	51	36	15	51			
4	40	24	68	48	20	68			
5	50	30	85	60	25	85			
6	60	36	102	72	30	102			
7	70	42	119	84	35	119			
8	80	48	136	96	40	136			
9				108	45	153			
10				120	50	170			

Needs after soybean and OM	
Winter wheat (90bu/ac)	
N	20
P	45
K	22

Soil health

- **Alfalfa** is the main driver for improved soil health:
  - increased soil organic C and higher soil biological activity
  - greater numbers of water-stable aggregates
- **Cover crops**, “crops that are not harvested but produced to enrich the soil and capture inorganic N”, do have the potential to increase SOC
- No strong evidence that simply **increasing rotation length** beyond 3 years improves soil health.
- **Tillage** influences soil organic carbon, and soil health more broadly

Does agricultural crop diversity enhance soil microbial biomass and organic matter dynamics?



McDaniel et al, 2014

No. crops in rotation	2	239
	3	78
	4	25
	5+	26

Carbon sequestration in agricultural soils via cultivation of cover crops

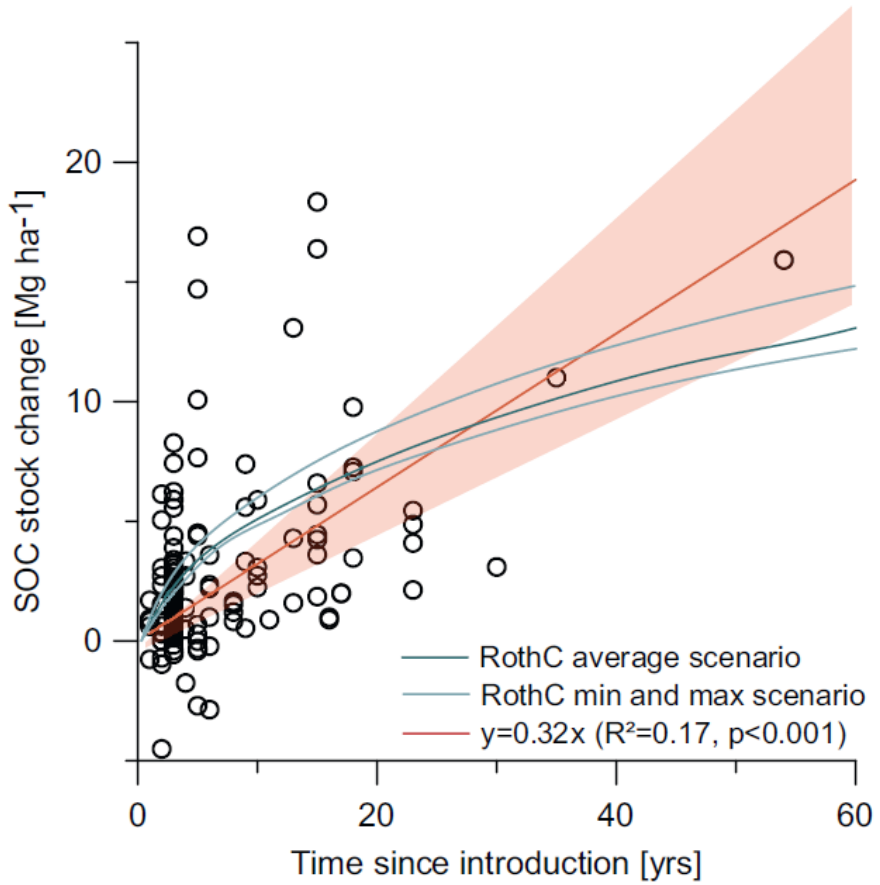
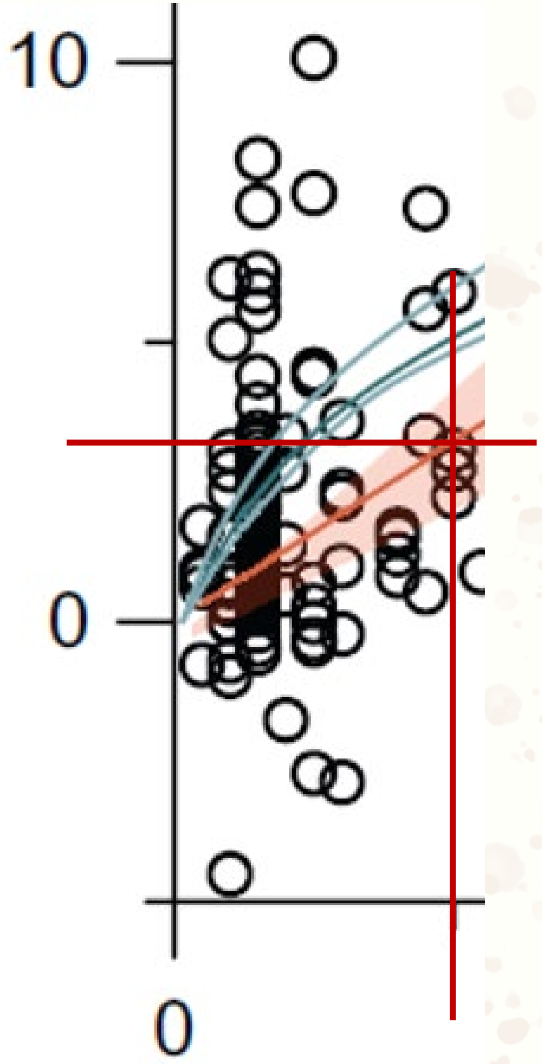


Fig. 2. SOC stock change after cover crop introduction as a function of time with linear regression (with 95% confidence interval) and the RothC simulated average cropland (with min and max scenario).

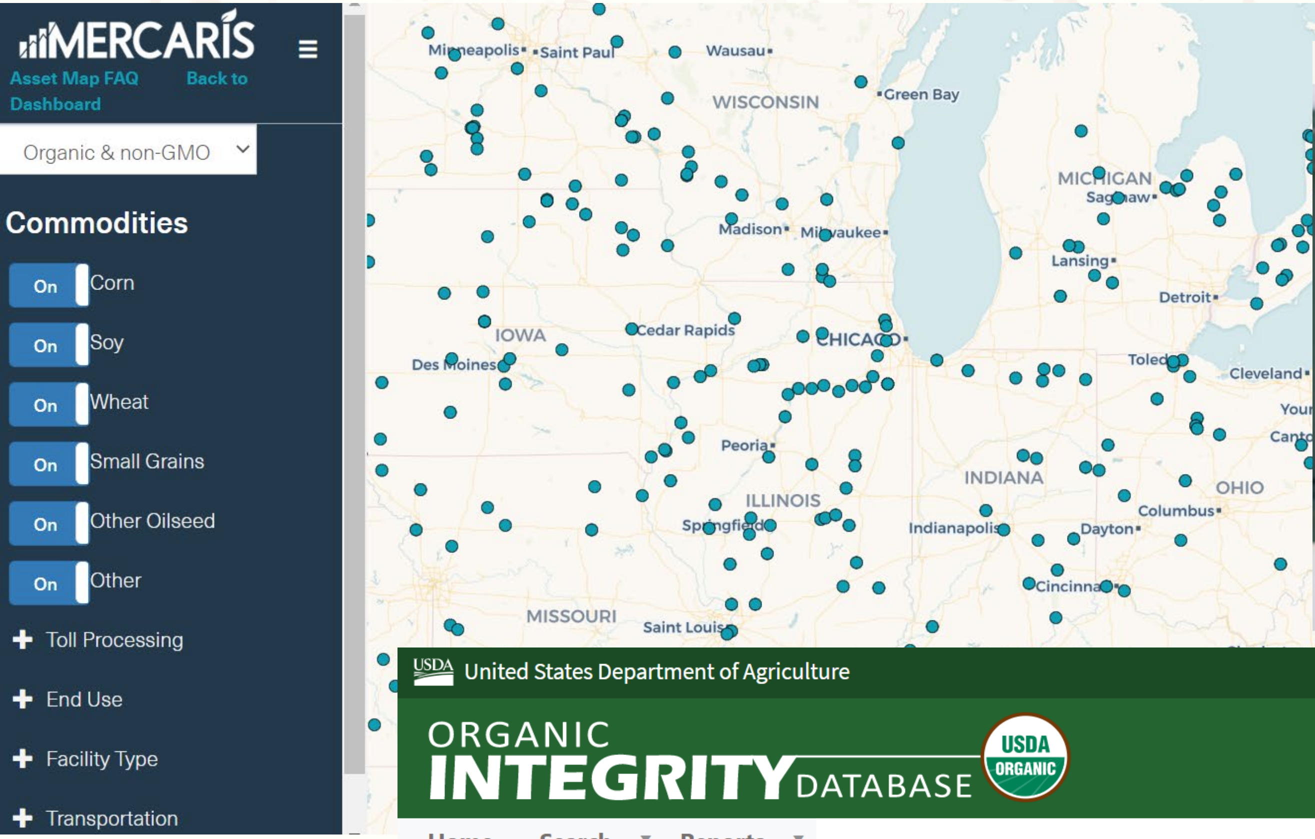


Gained 1.3 tons of SOC per ac in 10 years

Poeplau and Don, 2014

Context and economic sustainability

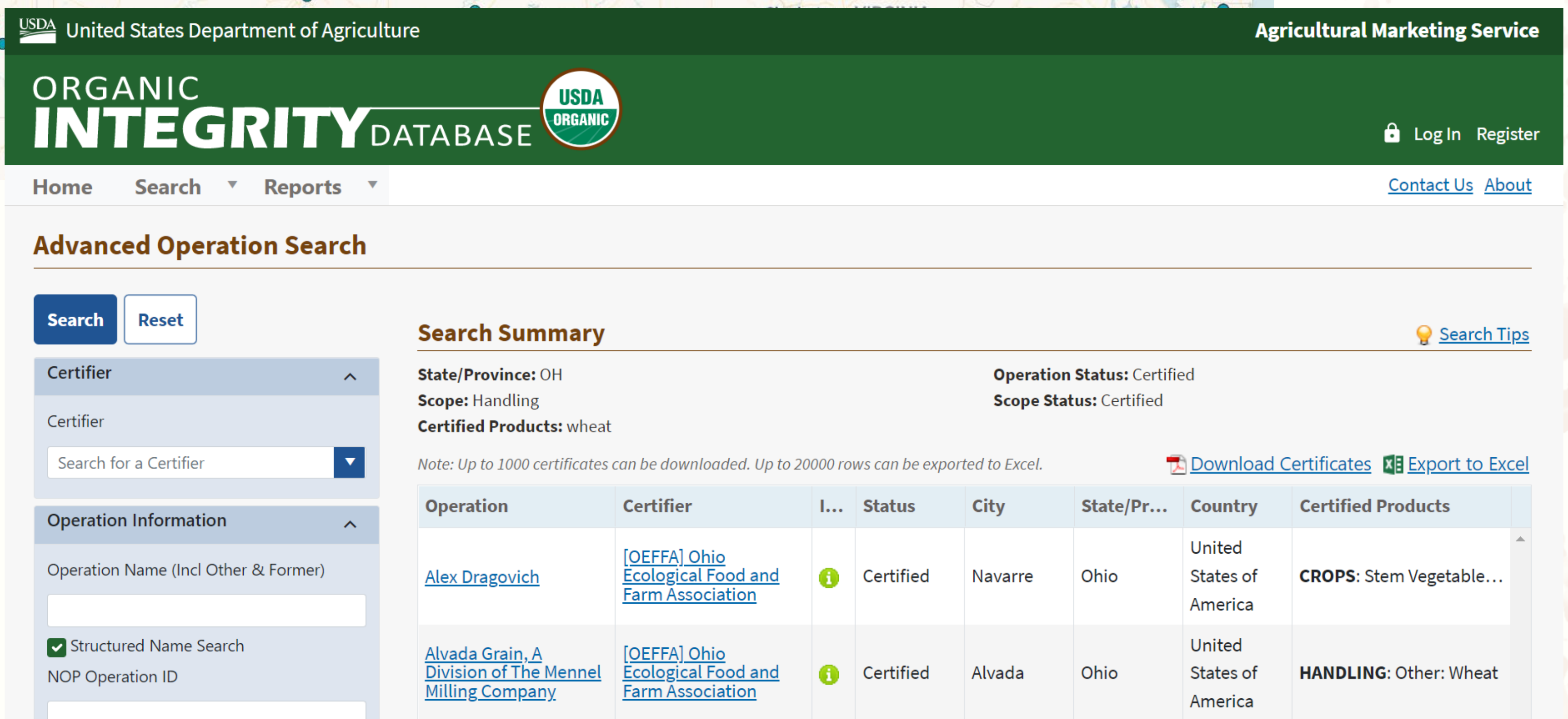
- **Environment** - soil types, topography, climate etc.
- **Farm** – equipment, livestock, time etc. crop rotation helps spread the work-load
- **Economy** – Crop rotation reduces economic risk
  - Letting the market guide you vs. guiding the market
  - Farmer coops, power of collaboration
  - Missing middle



Bridget Gilmore

Organic & ROC Market Coordinator

Bridget cultivates connection between farmers and between buyers and producers. She grew Ethics, & Organizational Sustainability at Sain experiences in different parts of the world witl distributor. She is thrilled to propel her passio joined the team in February 2022. She lives in



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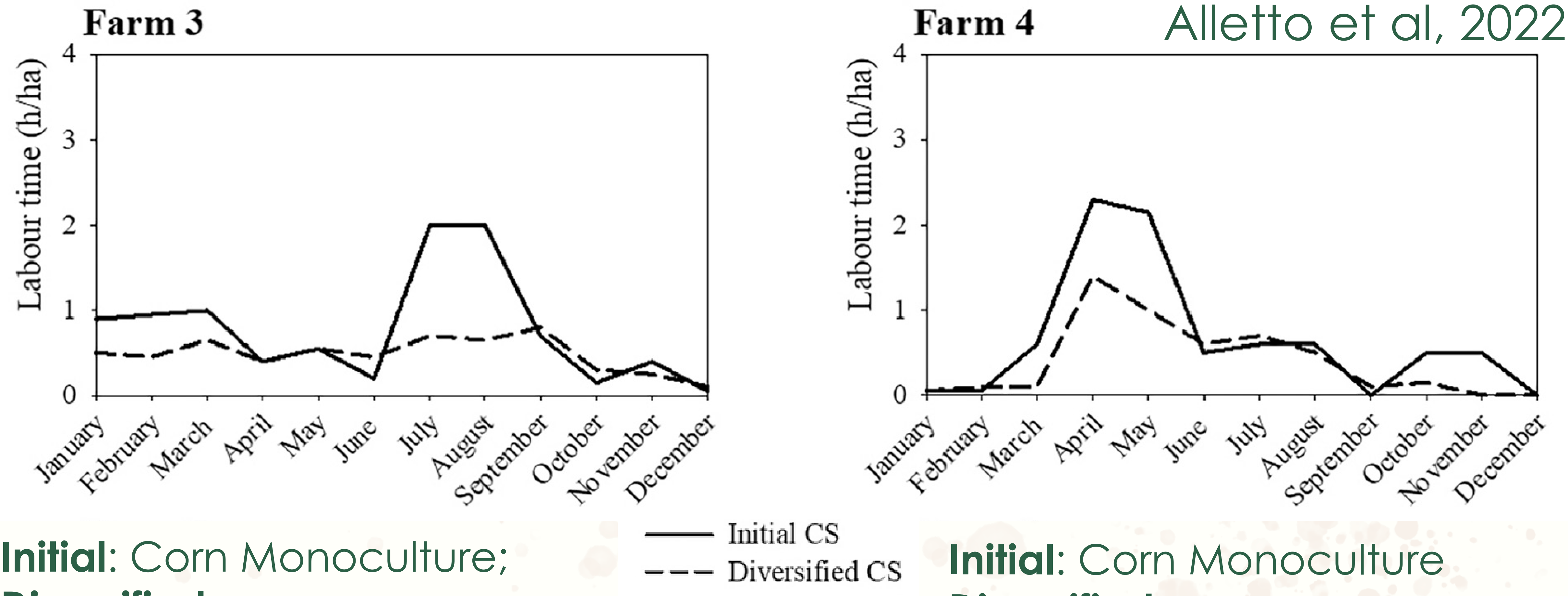
Alletto et al, 2022



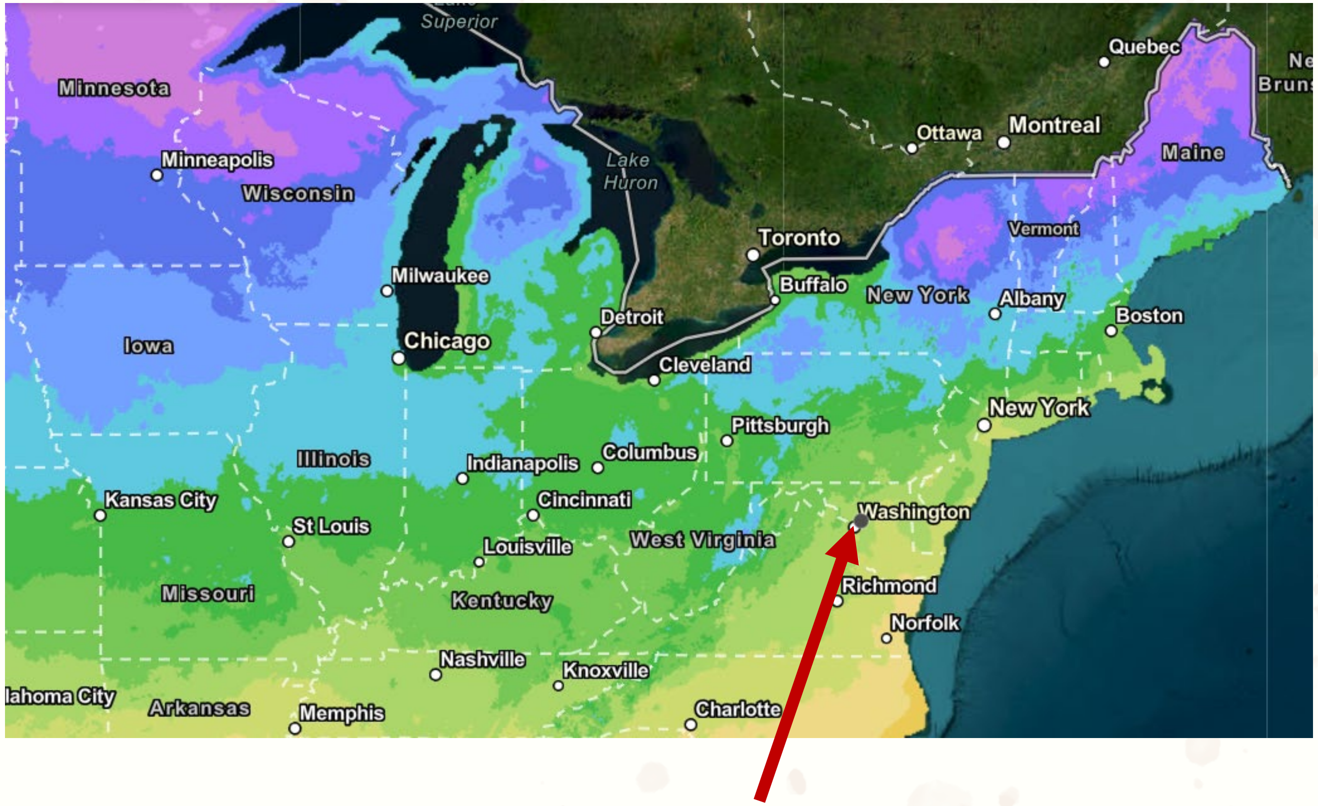
Initial: Corn Monoculture;
Diversified:
Corn/ cover crop
> Sunflower
> Winter Wheat/ cover crop
> Soybean
> Winter Wheat/ cover crop

Initial: Corn Monoculture
Diversified:
Corn/ cover crop
> Soybean
> Winter Wheat/ cover crop

Indicator	Farm 3			Farm 4		
	Initial CS	Diversified CS	Δ (%)	Initial CS	Diversified CS	Δ (%)
Mean semi-net margin (€/ha/year)	632	570	-9.8	218	632	+190
Economic efficiency of inputs	2.6	1.8	-30.8	0.1	0.5	+400
Nitrogen indicator	7.9	8.1	+2.5	3.1	7.9	+155
Organic matter indicator	7.4	6.4	-13.5	7.1	8.5	+19.7
Duration of bare soil period (%/year)	12	10	-9.5	10	6	-37.1
Energy consumption (MJ/ha/year)	8 050	4 762	-40.8	17 706	9 040	-48.9
Greenhouse gas emissions (kg CO_2 eq./ha/year)	499	346	-30.6	1 146	603	-47.4
Labour time (h/ha/year)	9.3	5.8	-37.6	7.9	4.7	-40.1

Alletto et al, 2022

The Long-Term Agroecosystem Research (LTAR) Network



Farming Systems Project (FSP, est. 1996), The Lower Chesapeake Bay (LCB) LTAR, Beltsville, MD

"The LTAR network is composed of 18 locations distributed across the contiguous United States working together to address national and local agricultural priorities and advance the sustainable intensification of U.S. agriculture."

USDA Agricultural Research Service ltar

Farming Systems Project (FSP), Beltsville, MD

3 Organic Systems:

Name	Rotation
Org2	Corn – Soybean
Org3	Corn – Soybean – Wheat
Org6	Corn – Soybean – Wheat – 3 years alfalfa

Poultry little for:

- Corn N needs
- Wheat N needs
- All P needs

All: rye cover crop after corn, before soybean

Org2 and Org3: hairy vetch cover crop after soybean or wheat, before corn

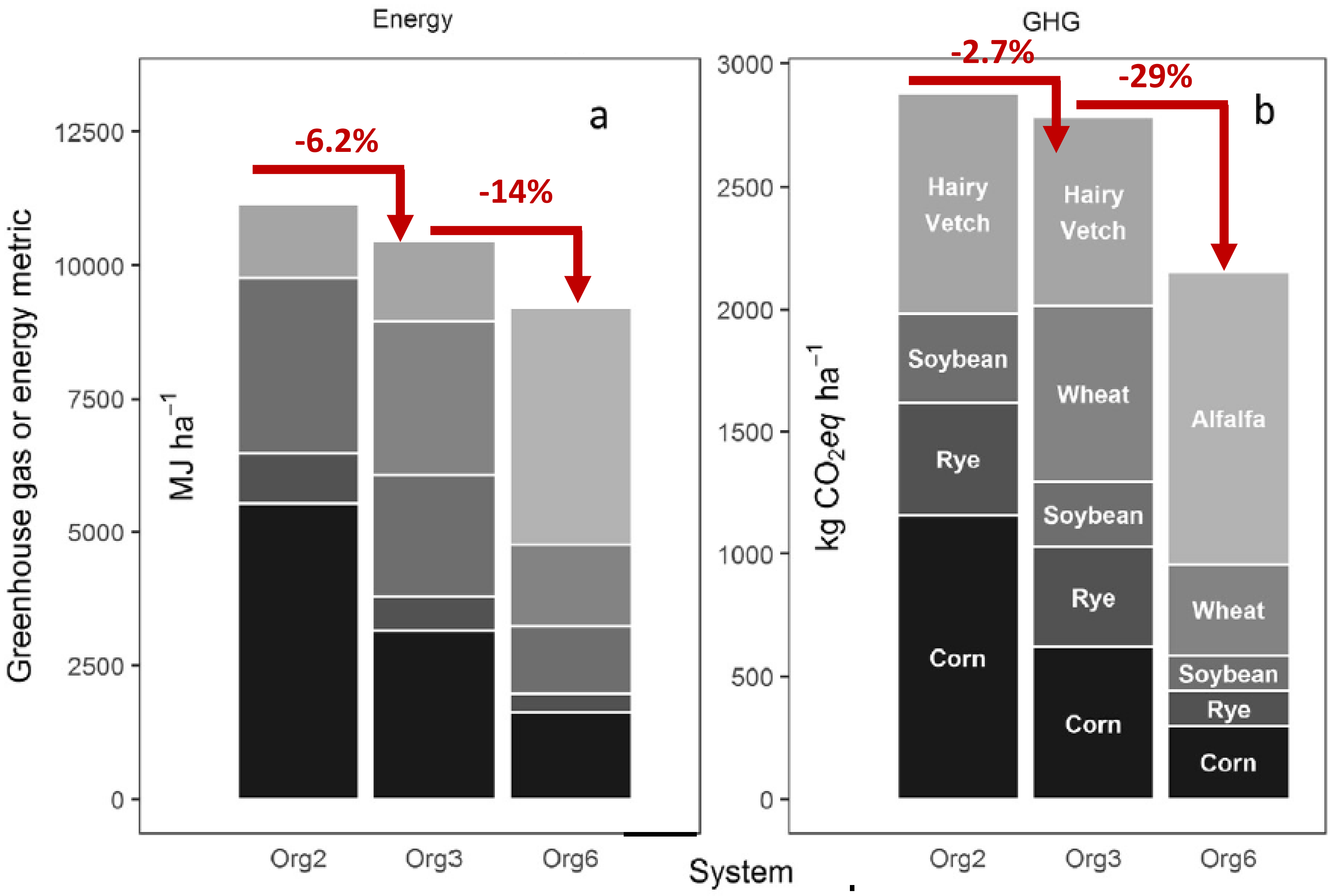
Value of net returns (2014 basis) for the three cropping systems during the study period 2006 to 2014. Means within a system and year followed by the same letter are not significantly different ($P < 0.05$) by LSD.

System	2014 value of net returns (US$ ha^{-1}) 2006	2007	2008	2009	2010	2011	2012	2013	2014	Cumulative	Mean	Standard deviation
Org2	380a	–605b	941a	820a	–597c	–367c	653a	1917a	2127a	5269bc	585b	1006
Org3	246a	–725b	1243a	483a	–378c	70bc	574a	1805a	1980a	5298bc	589b	929
Org6	668a	381a	976a	665a	131b	983a	930a	1696a	1290b	7719a	858a	468

White et al, 2019

Hoffman et al, 2018

Energy expenditures and GHG emissions



Questions?

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https://rodaleinstitute.org/consulting/

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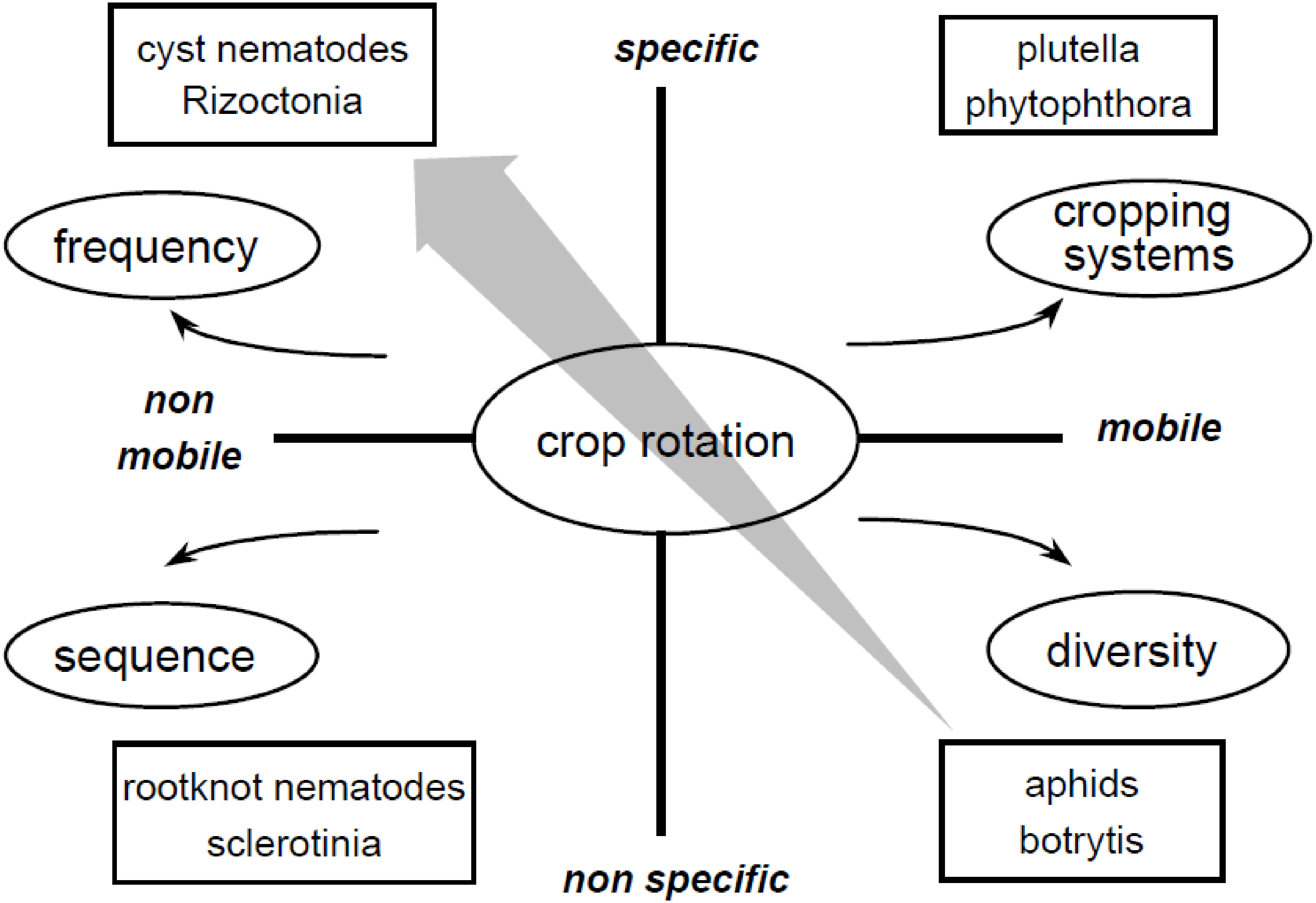
Pests and diseases



Olesen et al, 1999

Figure 3 Crop rotation in relation to mobility and specificity of pests and diseases.

Pests and diseases

Olesen et al, 1999

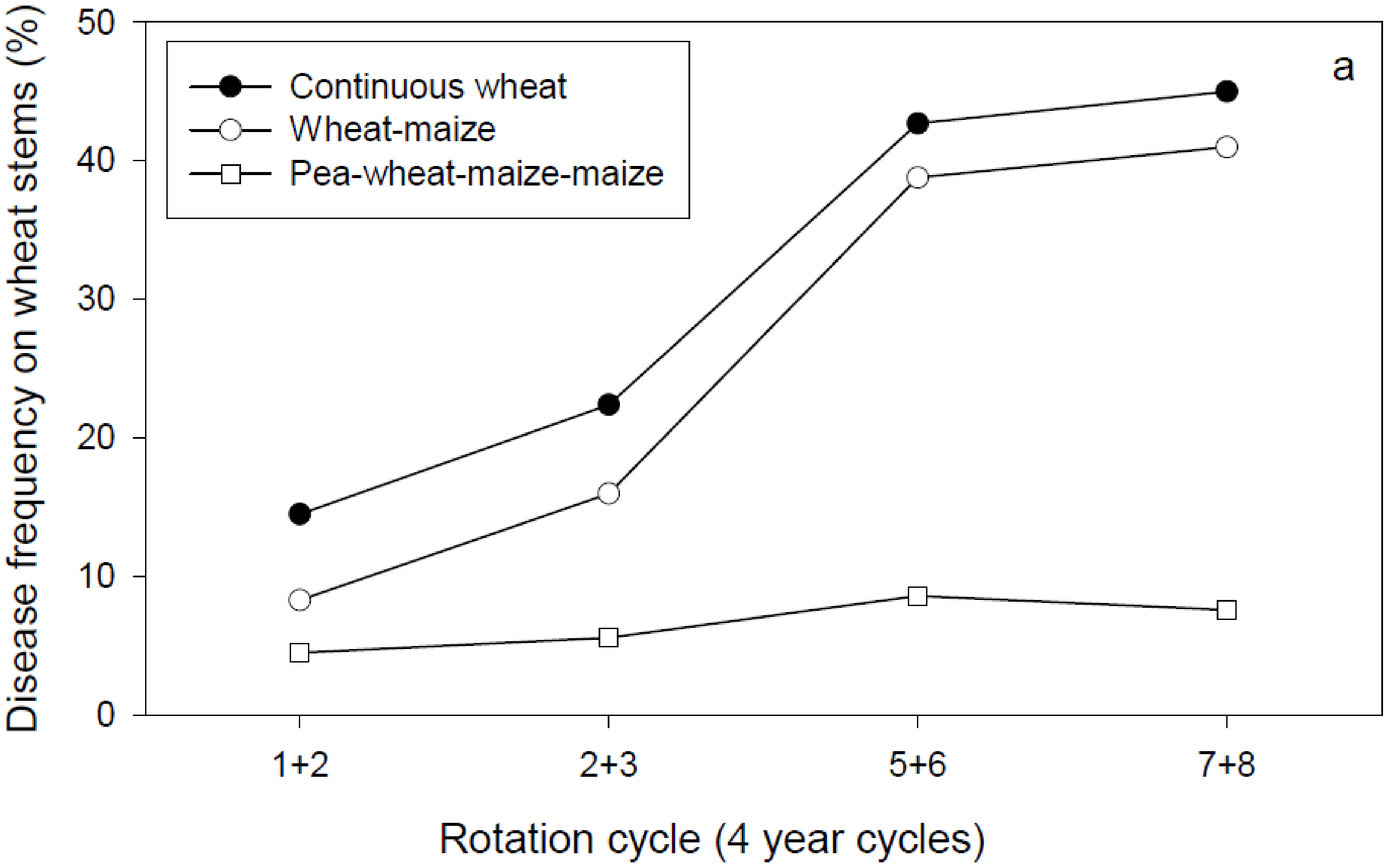


Figure 5 Development in frequency of Fusarium attack on stems and ears.