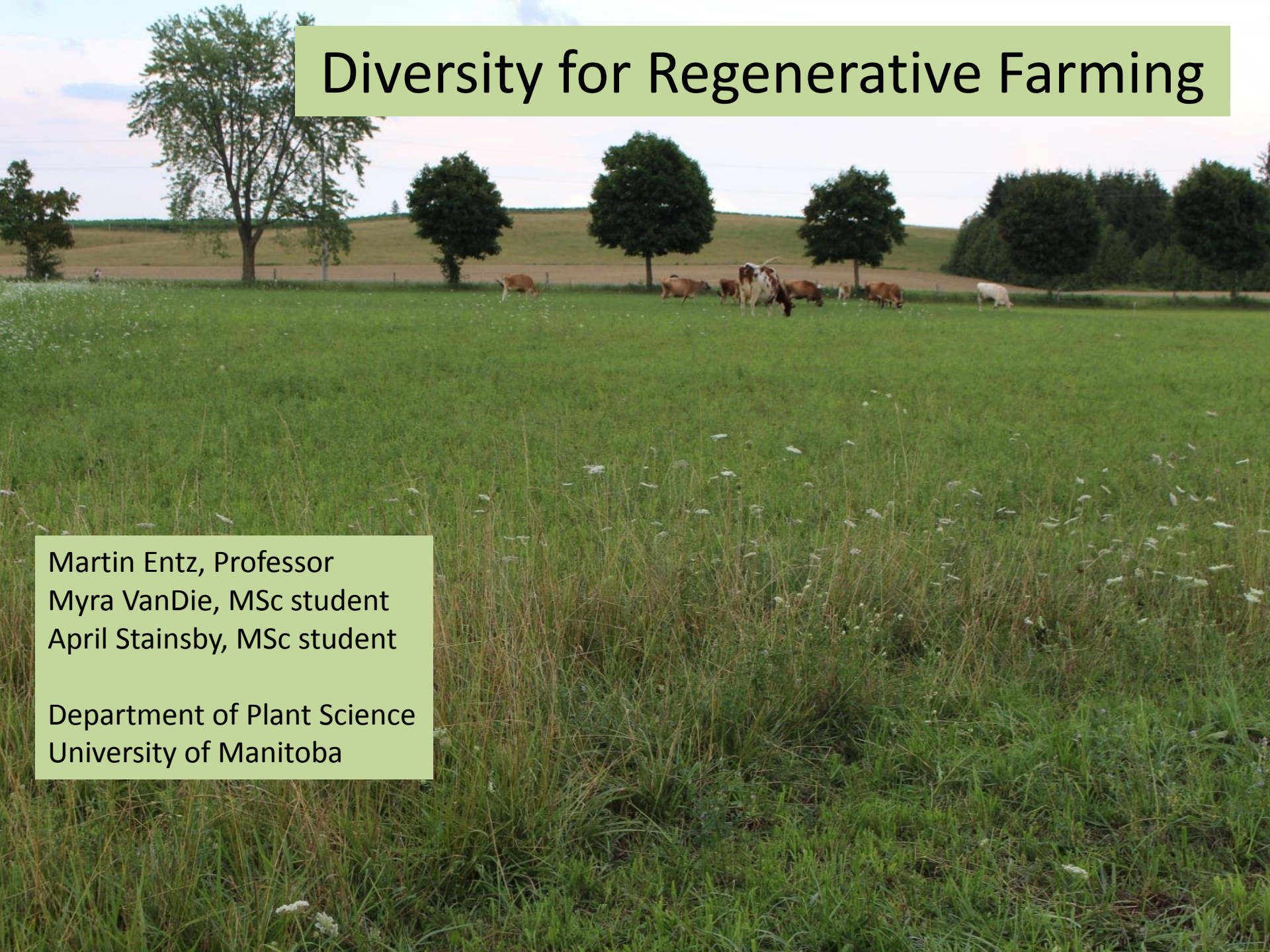
Diversity for Regenerative Farming

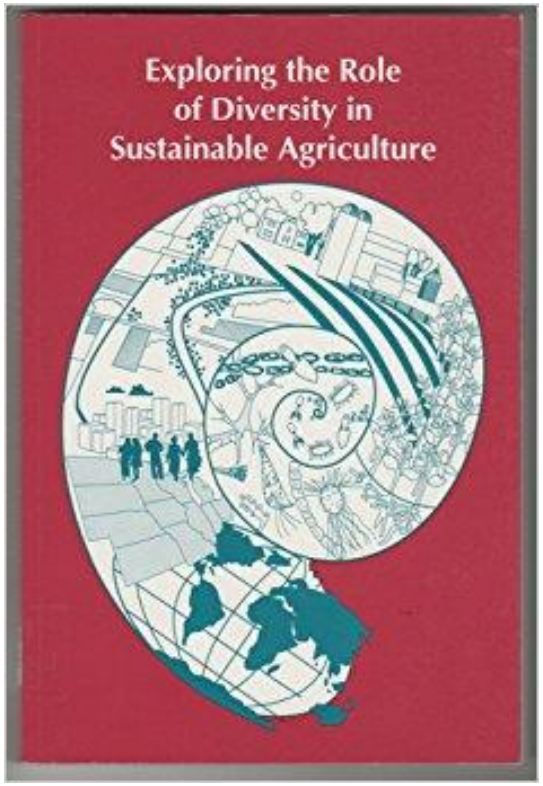


Martin Entz, Professor
Myra VanDie, MSc student
April Stainsby, MSc student

Department of Plant Science
University of Manitoba

Diverse structures improve agricultural system <u>function</u>

"<u>Diversity</u> lends stability"



Progress in Physical Geography 31(6) (2007) pp. 659–666

Classics in physical geography revisited

Elton, C.S. 1958: *The ecology of invasions by animals and plants*. London: Methuen.

The study of invasions of organisms following their transfer by humans to areas far outside the reach of natural dispersal mechanisms has grown enormously in recent decades and is now a prominent subdiscipline of ecology (Simberloff, 2004; Davis, 2006; Pyšek *et al.*, 2006; Richardson and Pyšek, 2006; Lockwood *et al.*, 2007). The rapid growth in interest in invasion biology has mirrored the escalation in the extent of invasions and the magnitude of impacts attributable to invasive species. Increasingly, however, invasions are studied as experiments in biogeography – to gain insights on factors and processes that control diversity and distributions at different spatial scales and where manipulative experiments are impractical (Richardson, 2006; Palmer, 2006).

Figure 1 Charles Sutherland Elton (1900–1991) (reproduced courtesy of the Zoology Department, University of Oxford)

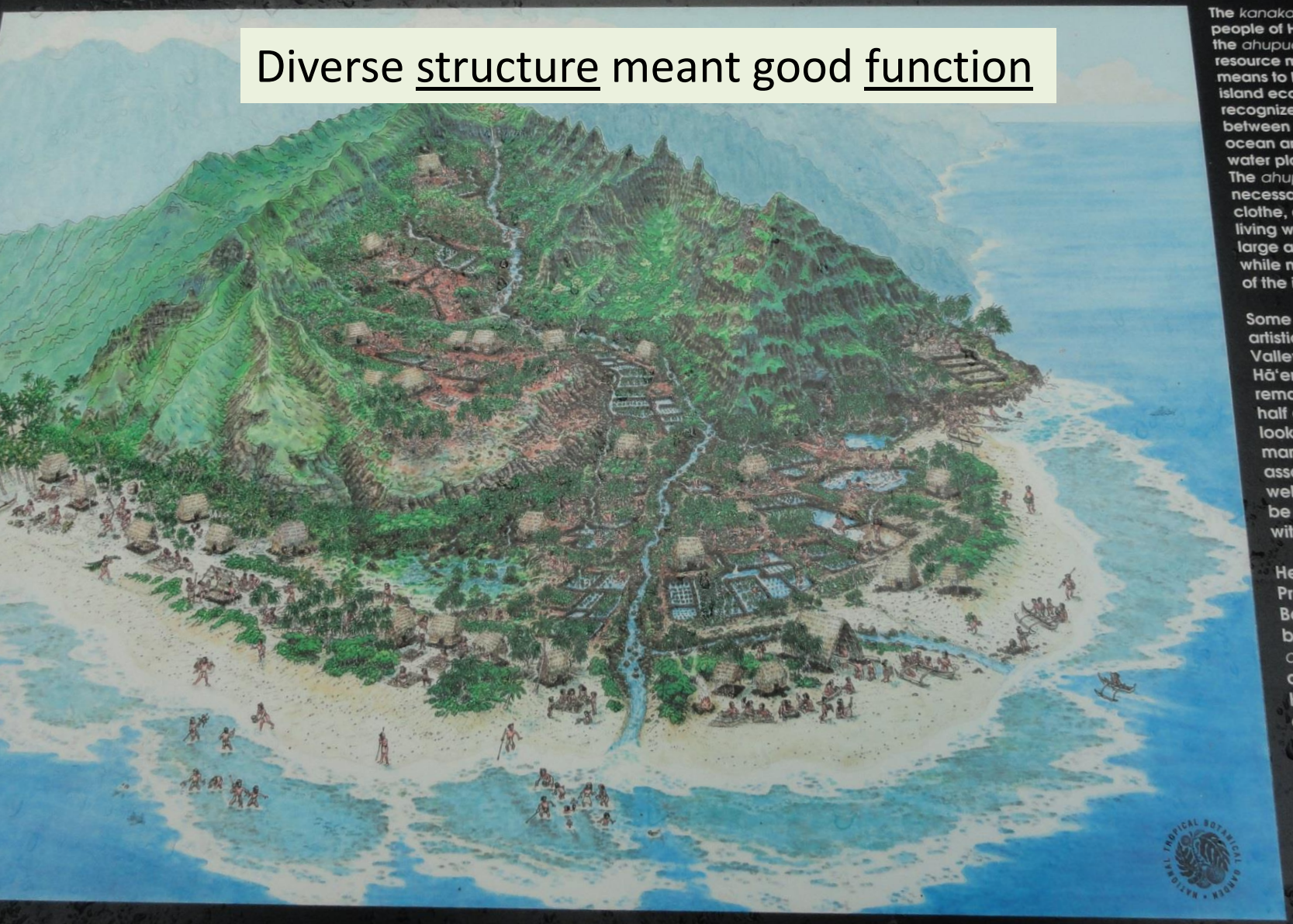
In the nineteenth century, several pioneering naturalists – notably Darwin, De Candolle, Hooker and Lyell – mentioned invasive species in their writings. Naturalized and invasive species were, however, essentially curiosities at the time and not a major threat to global biodiversity. Charles S. Elton's (1958) book *The ecology of invasions by animals and plants* is recognized as the starting point for focused scientific attention on biological invasions. The book, noted for its 'clarity of ... writing, the wonderful and quaint illustrations, and the importance of the message' (Mooney, 1998; see also Simberloff, 2000) has been acclaimed variously as 'an accessible and enduring classic', the ' bible of invasion biology', a 'classic book', 'the cornerstone work in [invasion ecology]', an 'invasion classic', a 'magisterial book', 'one of the most forward-looking publications in ecology', a 'pioneering work' and a 'seminal work'. It has been cited more than 1500 times in the international literature listed on the Web of Science to date, more than any other publication on invasions (Pyšek *et al.*, 2006). It is still regularly cited – at least 117 times a year since 2000. Like invasions themselves, the growth of publications on invasions has been explosive. The lofty status and longevity of Elton's book is perhaps surprising, given the style of the writing. It is essentially a short popular science book that grew from a series of radio talks on the BBC in 1957. What ingredients have made it so influential and does it deserve this status?

Here, we explore briefly the extent to which Elton's (1958) book set the agenda

DOI: 10.1177/0309133307087089

The Ahupua`a System of Resource Management

Diverse structure meant good function



The *kanaka maoli* (indigenous people of Hawai'i) developed the *ahupua'a** system of resource management as a means to live sustainably in an island ecosystem. This system recognized the interconnection between the mountains and the ocean and the role that fresh water planted in linking the two. The *ahupua'a* contained all the necessary resources to feed, clothe, and shelter the people living within it. It nourished a large and healthy population while maintaining the integrity of the islands' natural resources

Some *ahupua'a*, like that of th artistic rendering of Limahuli Valley in the *ahupua'a* of Hā'ena, Halele'a, Kaua'i, remained intact up to the lat half of the 20th century. By looking to this system of reso management and the value associated with it, inspiratio well as practical methods be found for living in balan with nature.

Here at Limahuli Garden Preserve of the National Botanical Garden we ho be an example of a mo *ahupua'a*, illustrating h concept can benefit con Hawai`i by caring for t and supporting empo of its indigenous com

* Pronounce

The mission of the National Tropi is to enrich life through scientific research, conservati by perpetuating the survival of and cultural knowledge of

www.ntbg

Replica of “Mandan Field”, USDA, 1990’s

Integrated Farm

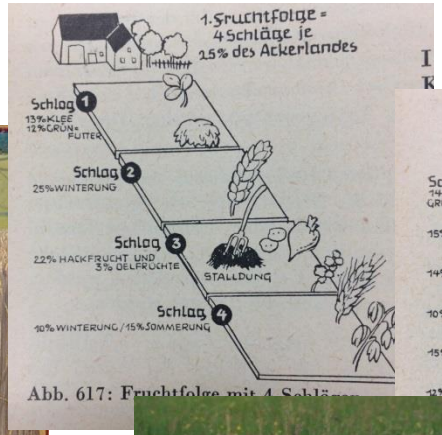
Costa Rica

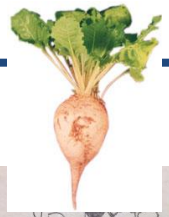
Photo credit: Laura Sims


Worms to compost cattle manure - Nicaragua

Northern European farming history

1600 1800 1900 1944





3 crop rotation

7 year crop rotation

2 crop rotation

Norfolk 4 year crop rotation

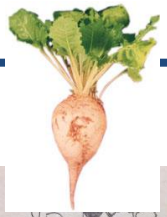
Fertilizer instead of rotation

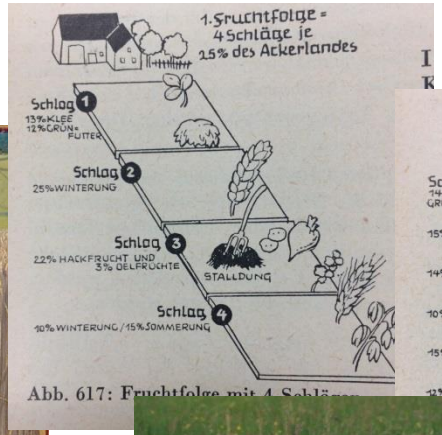

7 fields for a 7 year crop rotation
- planned diversity
2
1
3
3
6
7
4
5
200 m
Nidowo
Harvest-Canola-1937
Niedau H.R.
This Fohl we bought
Bartel 1942

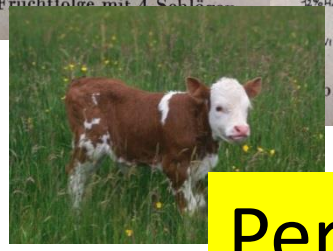

Niedau Farm, 2000

Northern European farming history

1600 1800 1900 1944





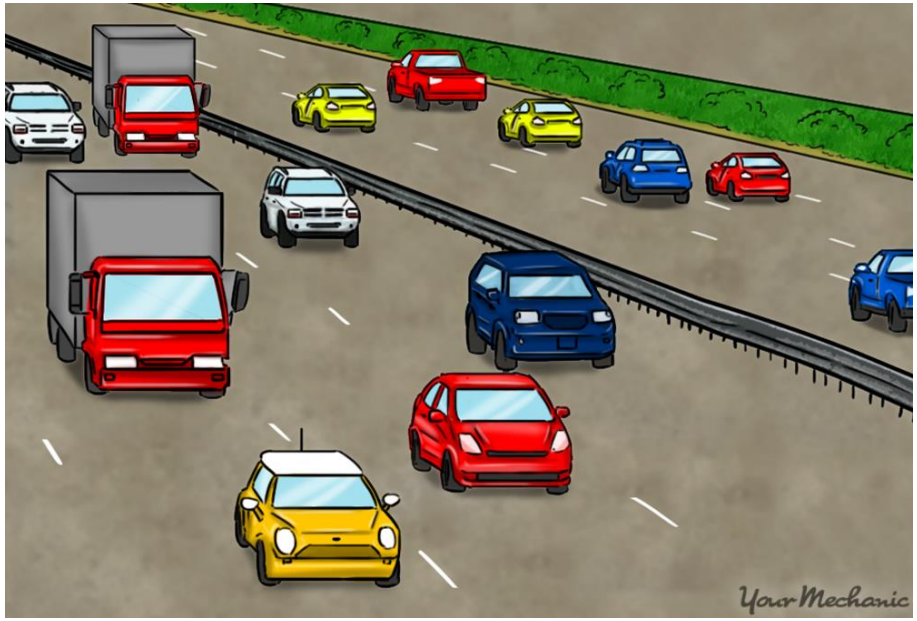


3 crop rotation

2 crop rotation

Norfolk 4 crop rot ation

Perhaps there was a time when we were wiser than we are today.....



Spend some time on the ecology lane

natural systems agriculture

University of Manitoba | Faculty of Agricultural and Food Sciences | Department of Plant Science

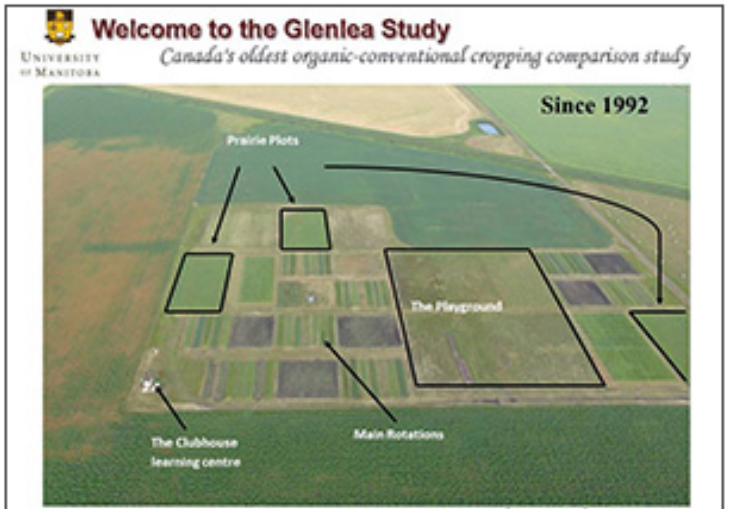
Welcome to Natural Systems Agriculture

Welcome! The Natural Systems Agriculture website is produced by a team of researchers and students in the Plant Science Department at the University of Manitoba. This team includes professors, graduate students, undergraduate students, technicians, research associates and a very helpful group of collaborating farmers.

The research work conducted by our team includes both long-term and short-term studies. Our field studies include the Glenlea crop rotation study, Canada's oldest organic vs conventional study and the Organic Crops Field Laboratory at Carman, Manitoba.

Being an educational institution, we place the highest priority on graduate and undergraduate student education. Current graduate student projects include:

- assessment of grass-finished livestock production in Manitoba and Ontario;
- farmer participatory plant breeding for organic wheat and oat production;

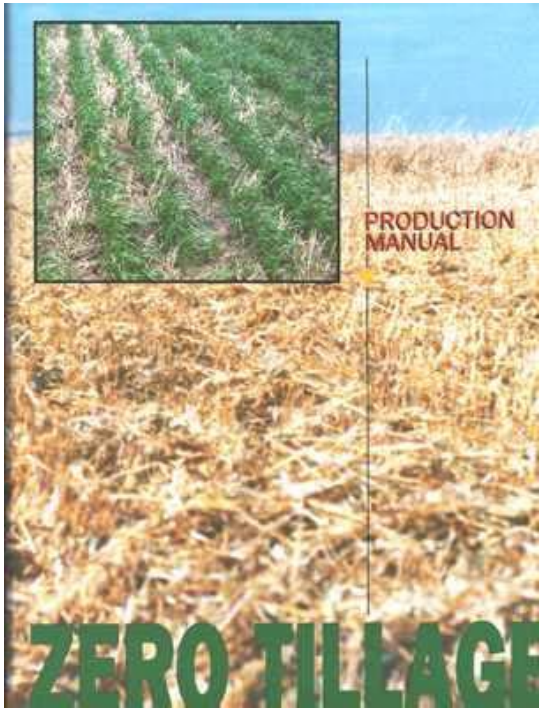


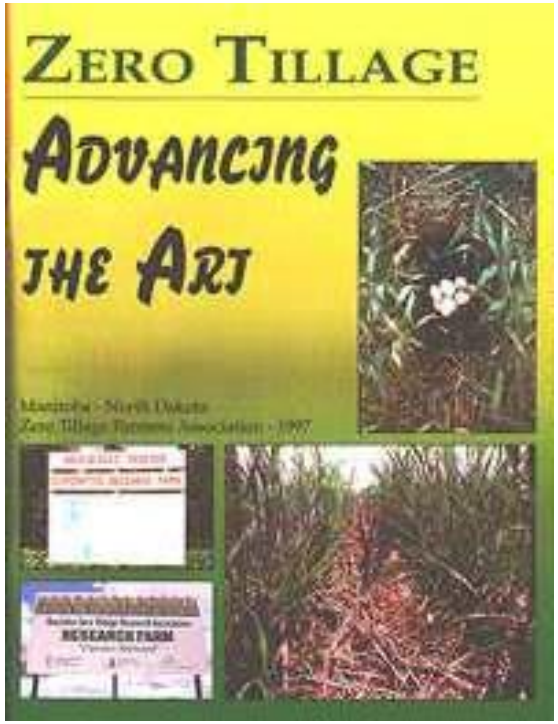
- Crop rotation
- Tillage management
- Livestock integration
- Cover crops
- Landscape management
- Organic production
- Agroforestry

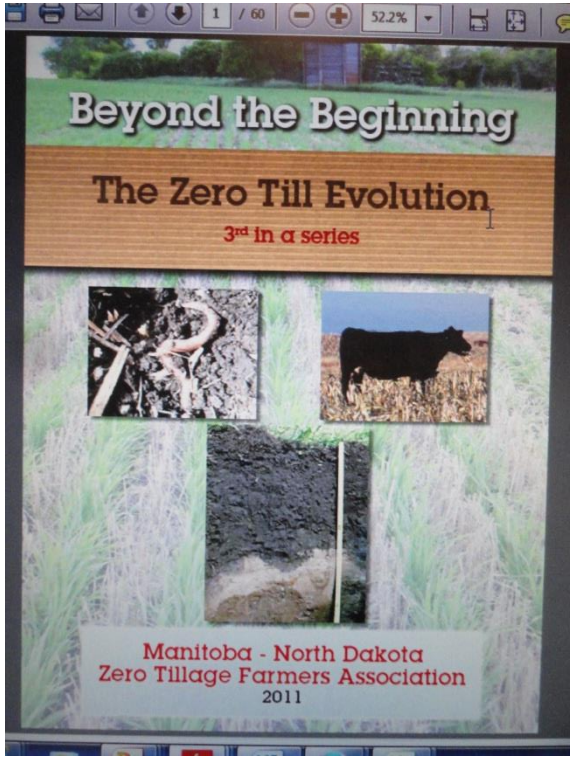
Studying ecological tools together with farmers

From basic no-till to ecological farming

1991 1997 2011



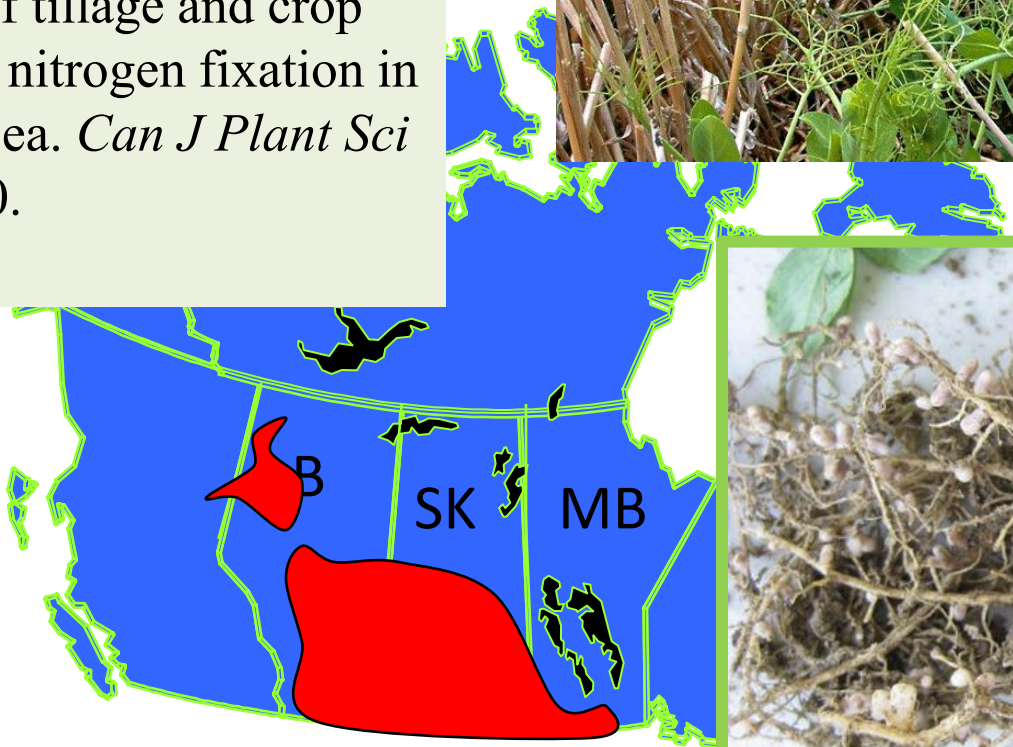




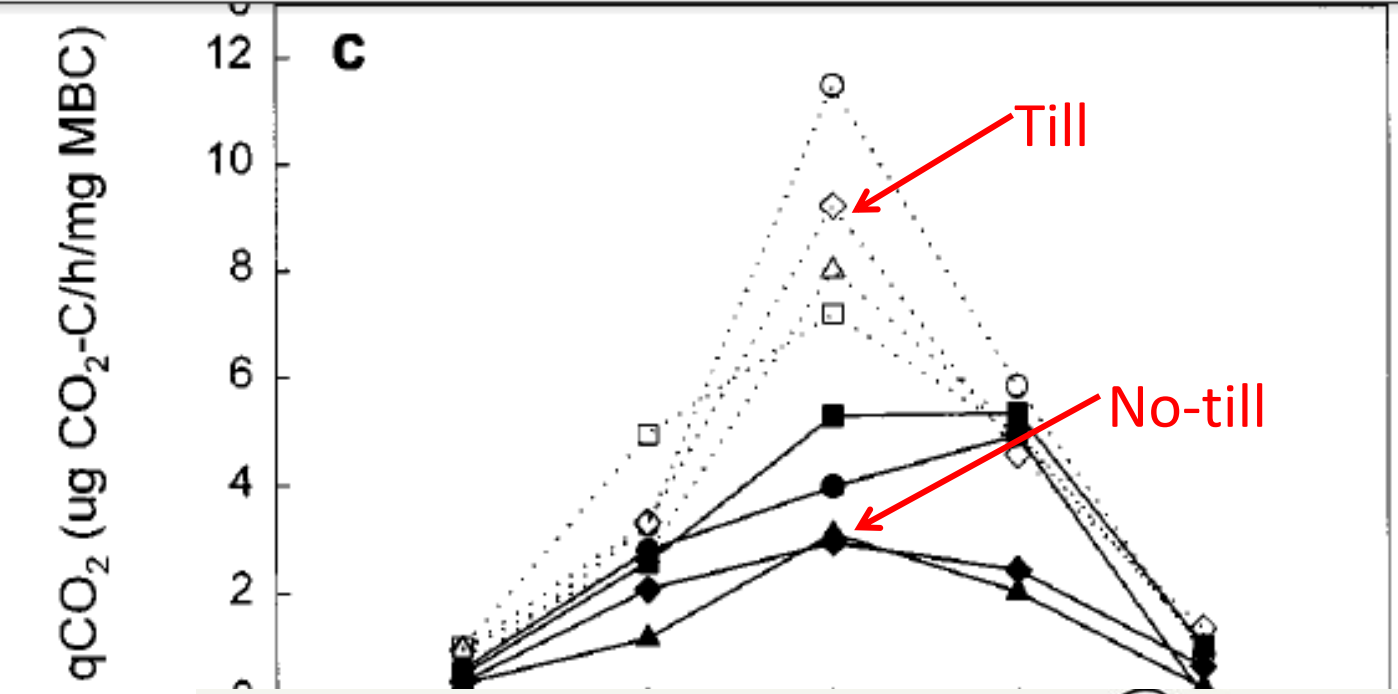
Adapting crops to no-till

BNF higher in no-till: pea 31%; lentil 10%.

Matus, Derksen, Walley, C. van Kessel. 1997. The influence of tillage and crop rotation on nitrogen fixation in lentil and pea. *Can J Plant Sci* 77:197-200.



Borstlap, S. and Entz, M.H., 1994. Zero-tillage influence on canola, field pea and wheat in a dry subhumid region: Agronomic and physiological responses. *Canadian journal of plant science*, *74*(3), pp.411-420.



Lupwayi, N.Z., Rice, W.A. and Clayton, G.W., 1999. Soil microbial biomass and carbon dioxide flux under wheat as influenced by tillage and crop rotation. *Canadian* *nal of soil* *nce*, *79:*273-280.

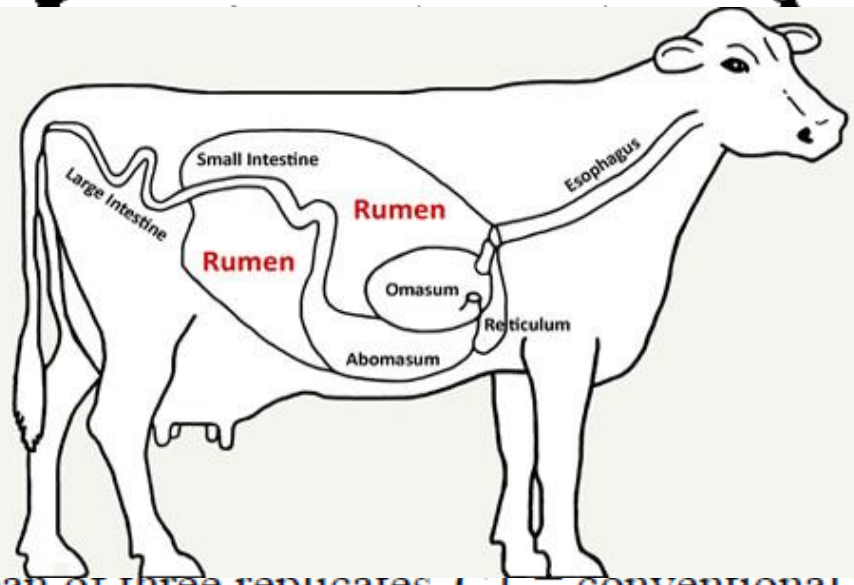


Fig. 3. I
al variat
tion (b),
Each point is a mean of three replicates. CT = conventional tillage, ZT = zero tillage, SF = summer fallow, CW = continuous wheat, RC = red clover, FP = field peas. See Tables 1 and 2 for other statistics

- Crop rotation
- Tillage management
- Livestock integration
- Cover crops
- Landscape management
- Organic production
- Agroforestry

Studying ecological tools together with farmers

Welcome to the Glenlea Study

University of Manitoba

Canada's oldest organic-conventional cropping comparison study

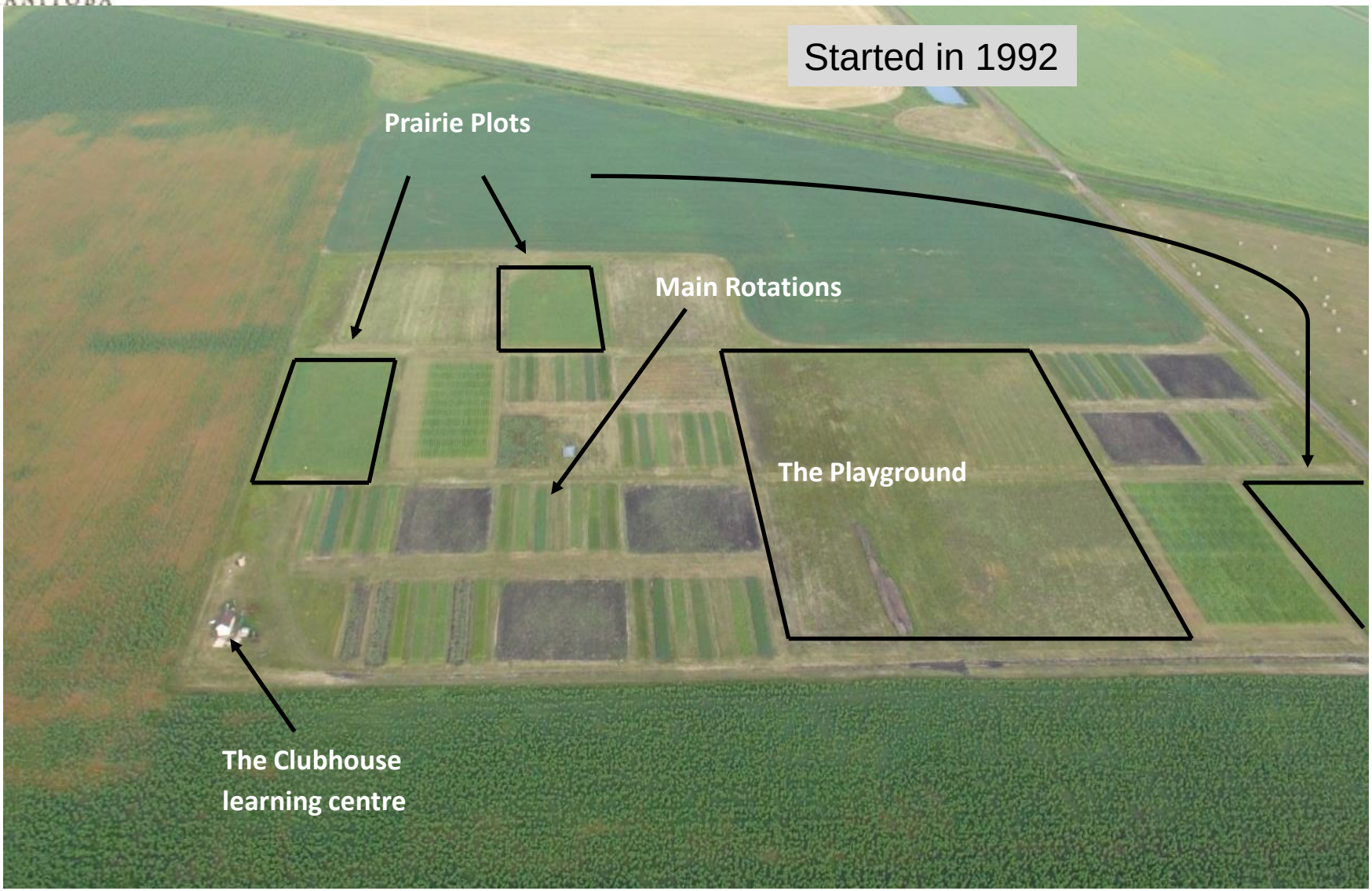
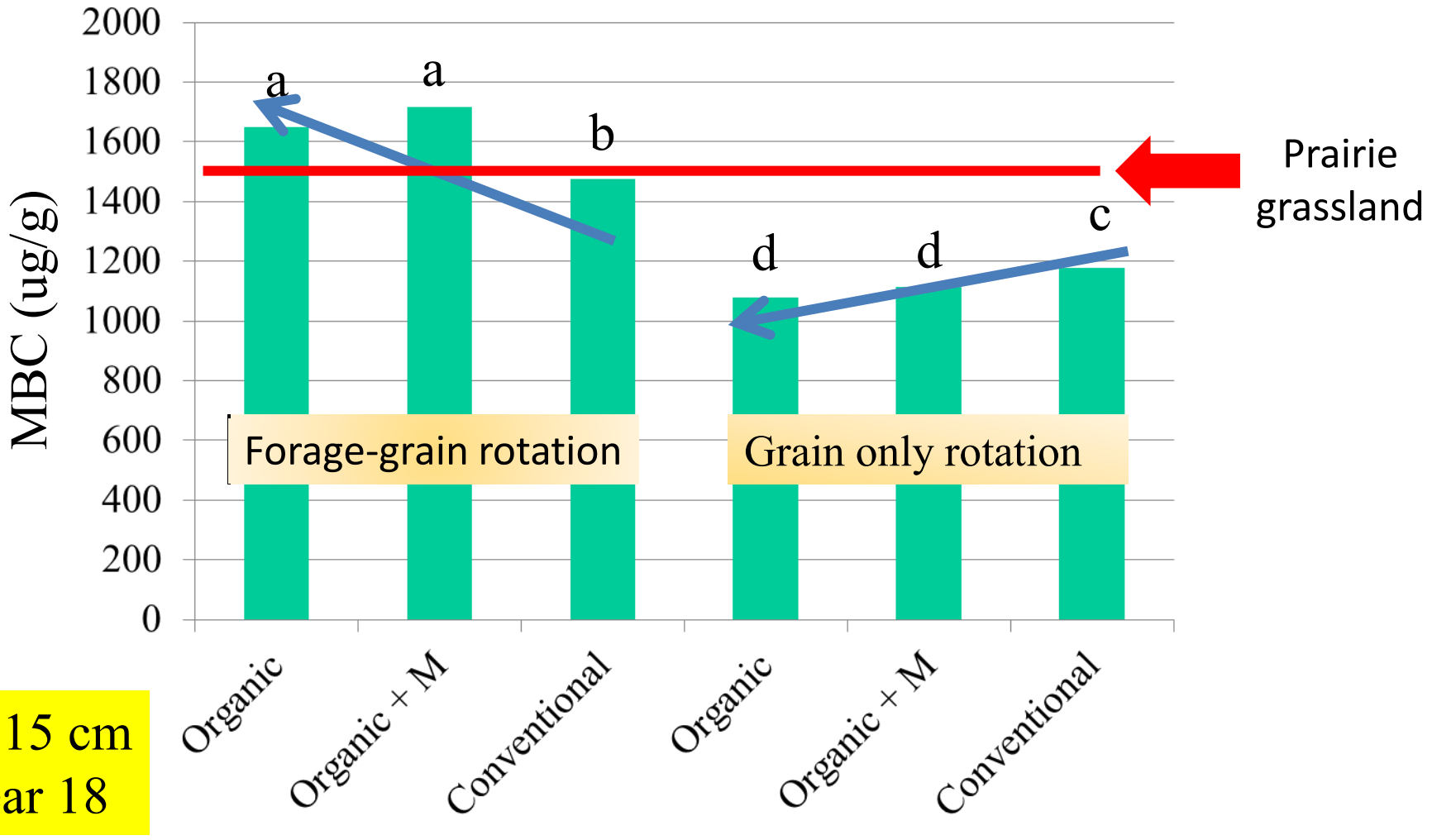


Photo credit: Gary Martens

Fig 1. Origin of the study sites included in the meta-analysis.

Lori M, Symnaczik S, Mäder P, De Deyn G, Gattinger A (2017) Organic farming enhances soil microbial abundance and activity—A meta-analysis and meta-regression. PLOS ONE 12(7): e0180442. https://doi.org/10.1371/journal.pone.0180442
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0180442

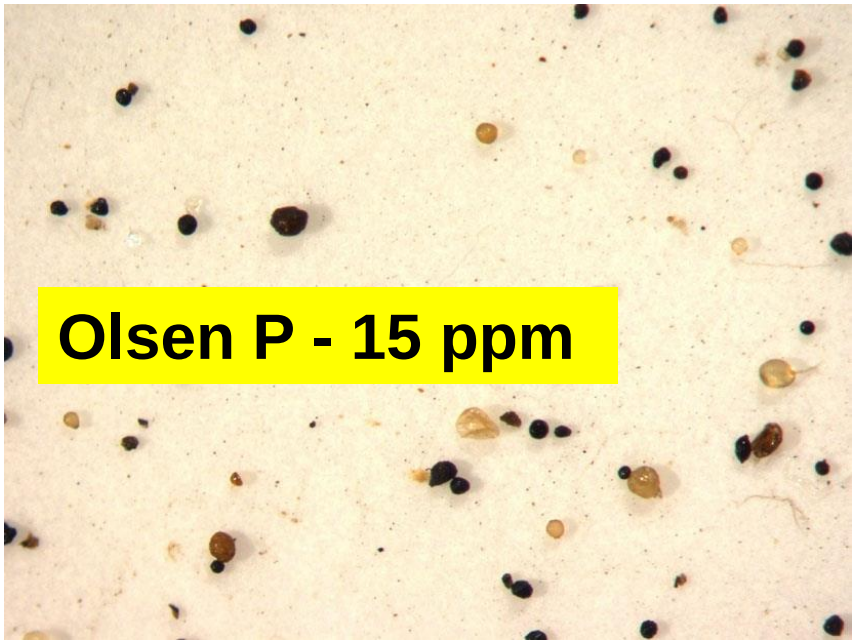
Figure 1 Microbial biomass carbon under organic (Org), Org with manure added and conventional (Conv) management for forage-grain (FG) and annual-grain (AG) rotations across all sampling dates.



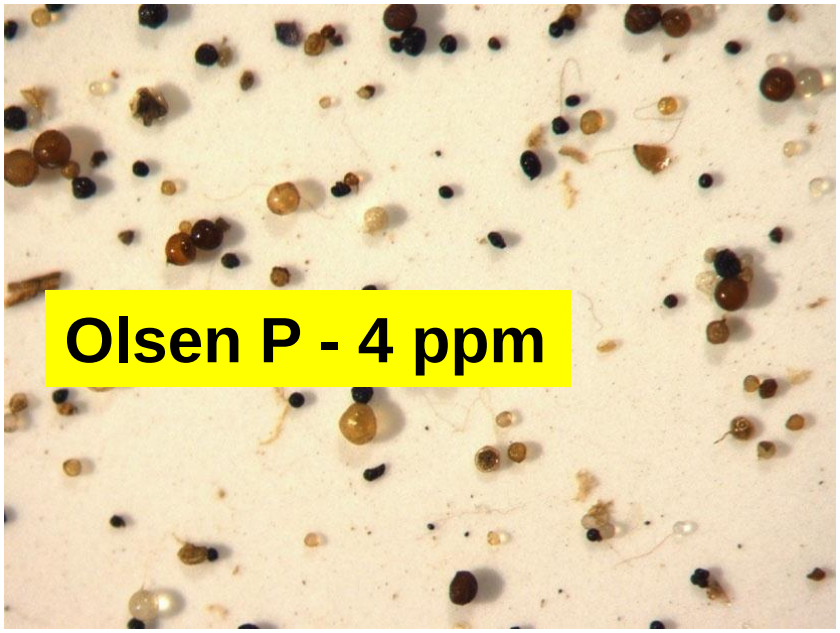
Braman, S., Tenuta, M. and Entz, M.H., 2016. Selected soil biological parameters measured in the 19th year of a long term organic-conventional comparison study in Canada. *Agriculture, Ecosystems & Environment*, *233*, pp.343-351.

Mycorrhizal spore density and diversity (100g soil)

Welsh et al. 2006. U of M Soil Science, unpublished.



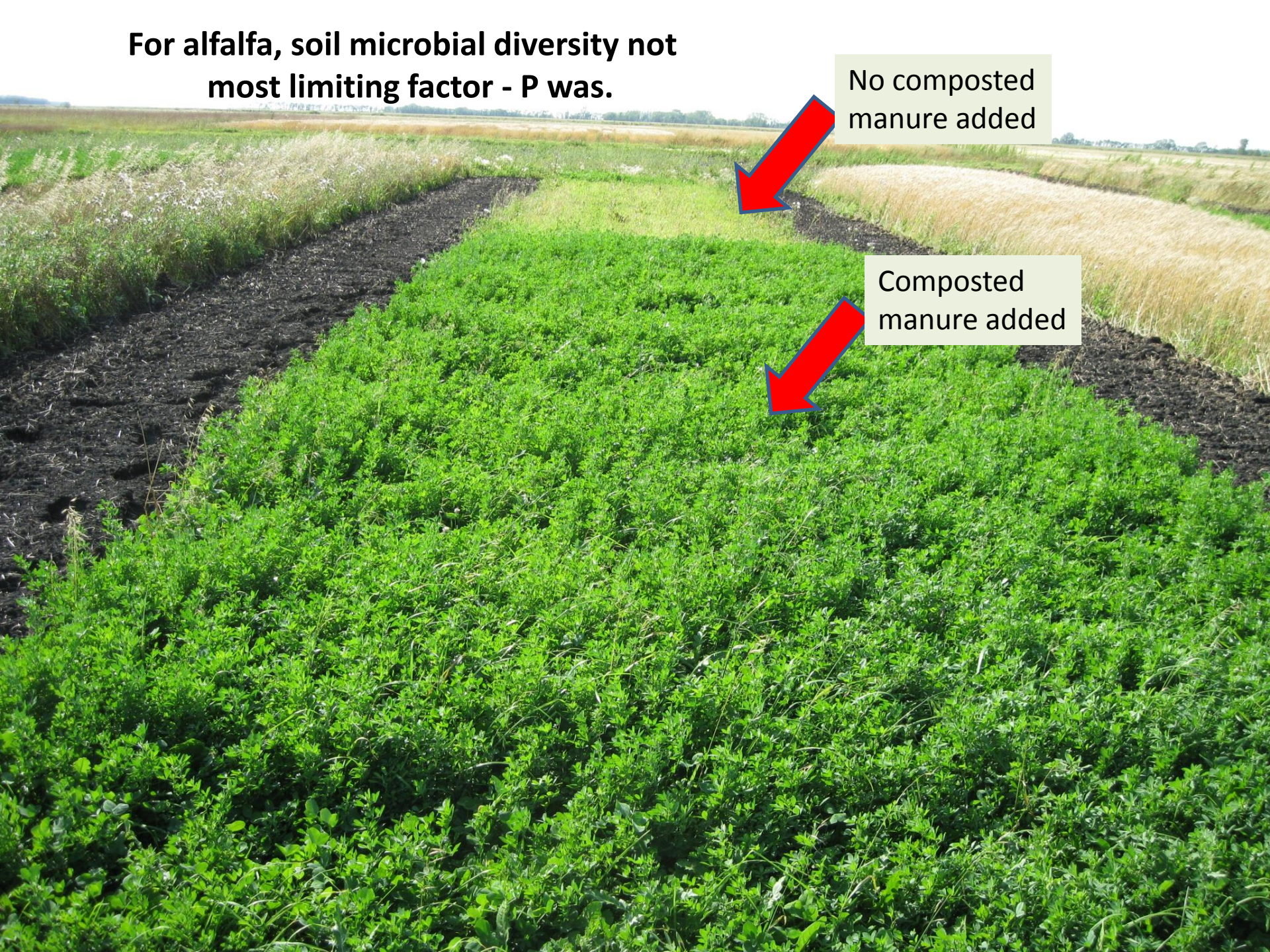
Conventional



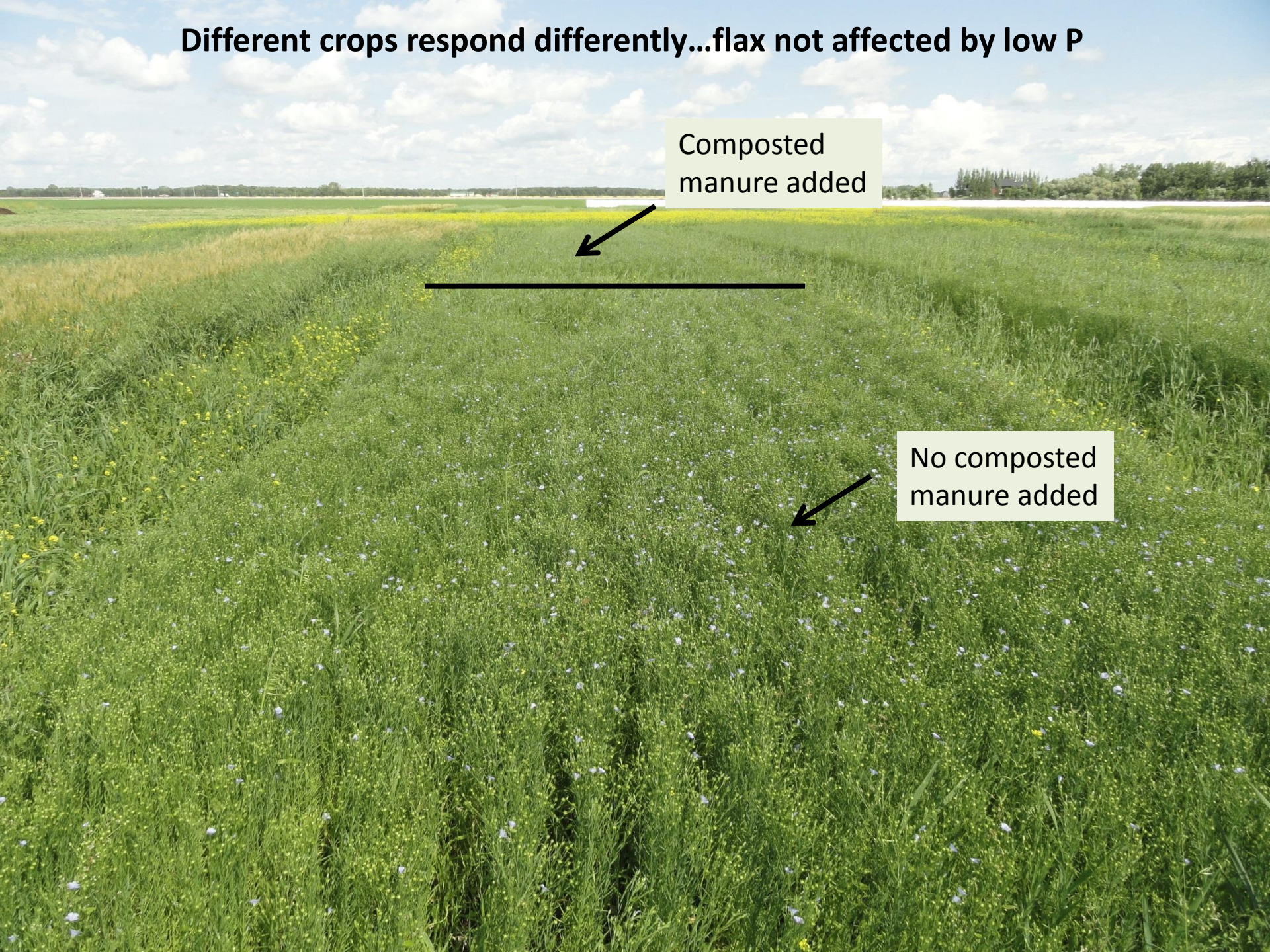
Organic

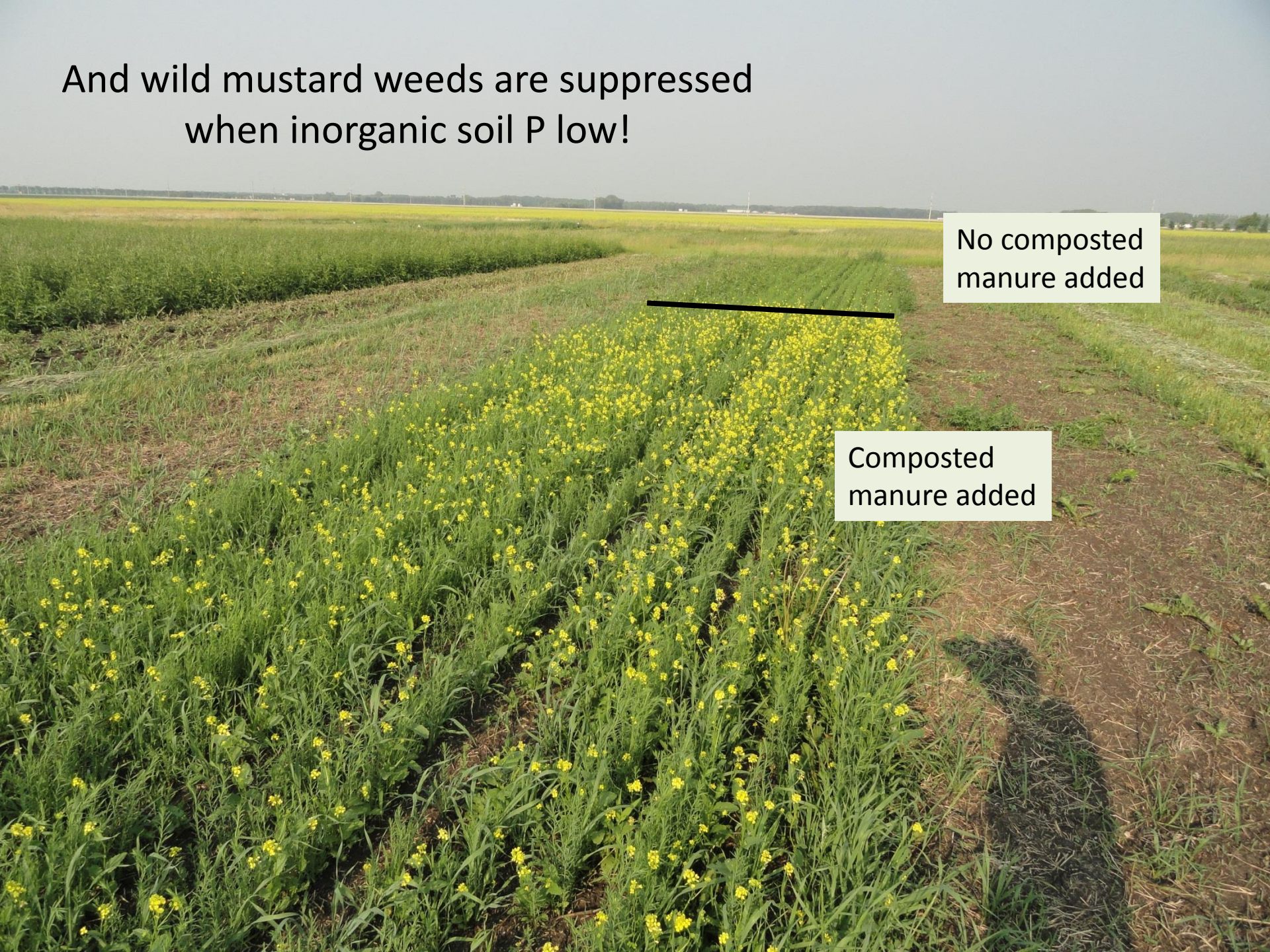
Glenlea rotation – year 13

For alfalfa, soil microbial diversity not most limiting factor - P was.

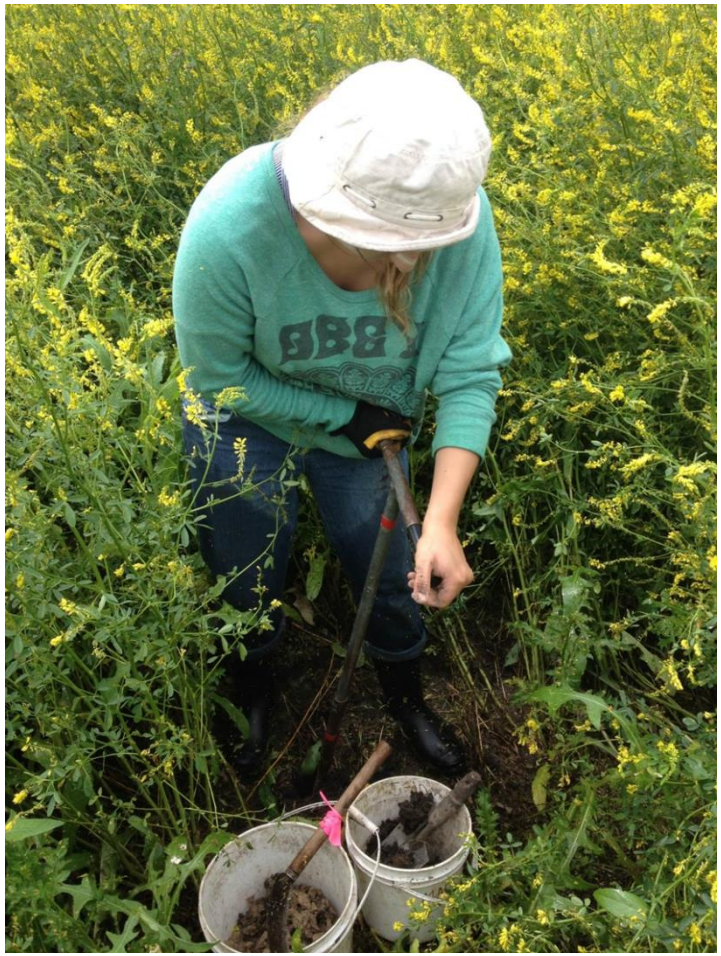


Different crops respond differently…flax not affected by low P




And wild mustard weeds are suppressed when inorganic soil P low!
No composted manure added
Composted manure added

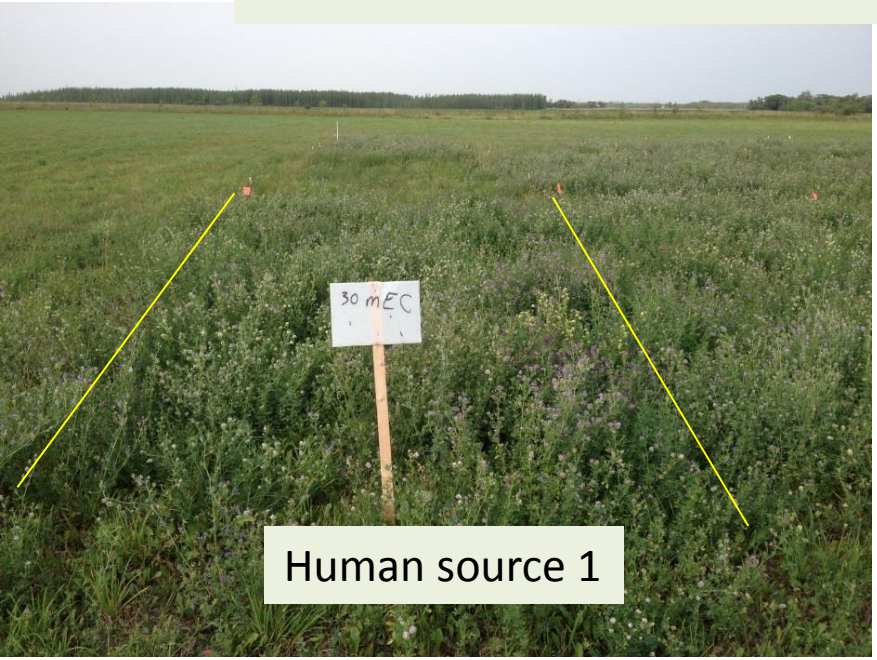
We needed a simpler way to measure nutrient sufficiency in alternative farming systems



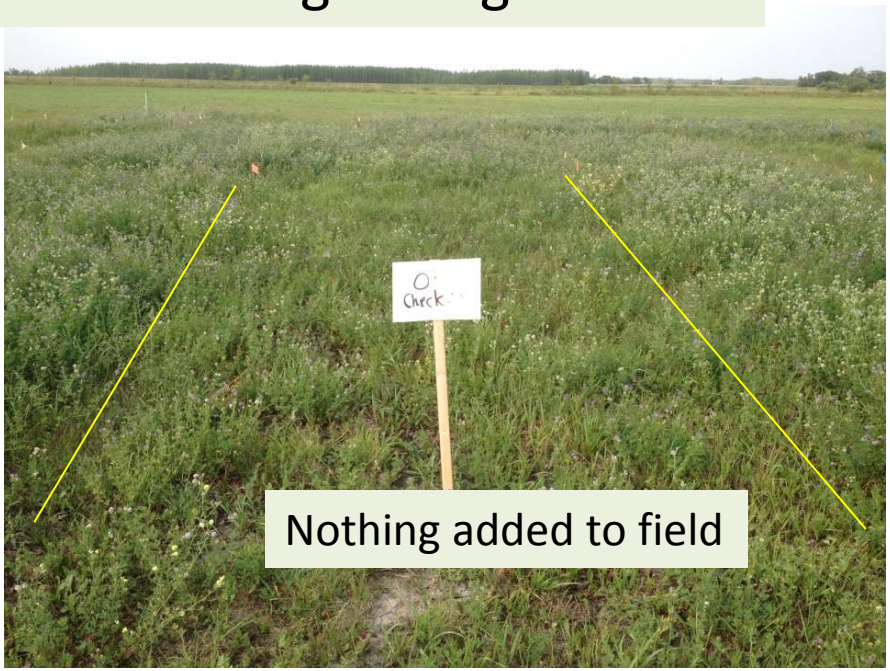
Cover crops sampled on 17 organic farm fields in 2015.	
Parameter	**Mean**
Crop biomass (kg/ha)	3830
Proportion legume (% by weight)	47
Soil P (Olsen; ppm)	11
Plant tissue P conc.	**0.17**

Determining nutrient sufficiency…watch your animals

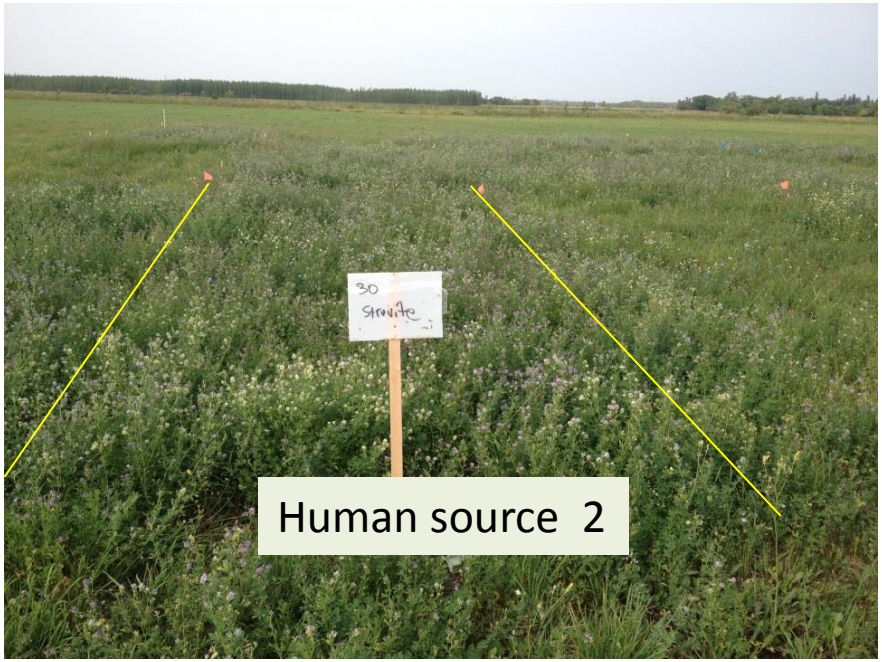
Research on alternative P sources in organic agriculture



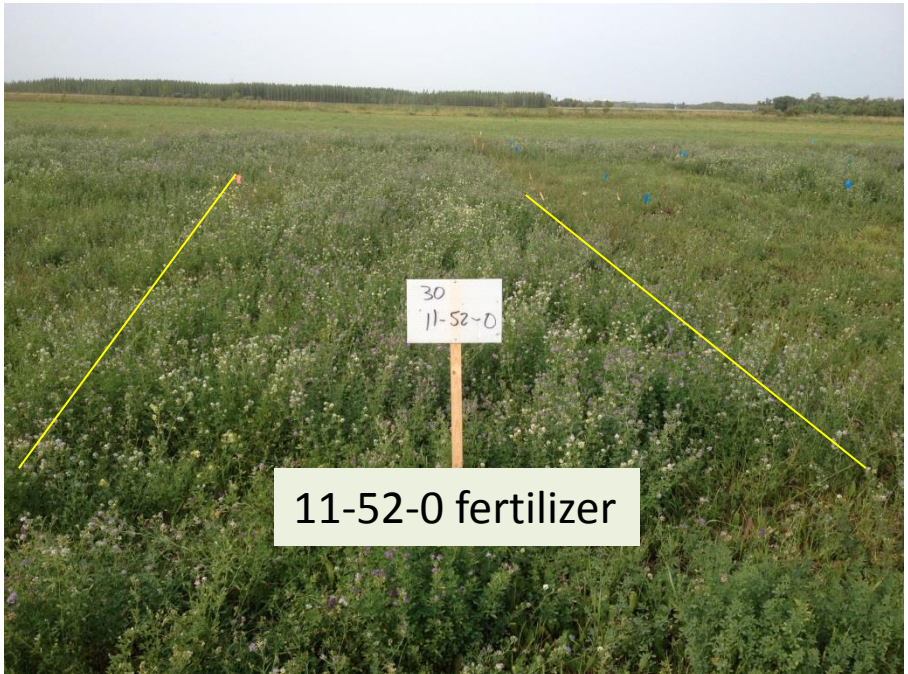
Human source 1



Nothing added to field



Human source 2



11-52-0 fertilizer

- Crop rotation
- Tillage management
- Livestock integration
- Cover crops
- Landscape management
- Organic production
- Agroforestry

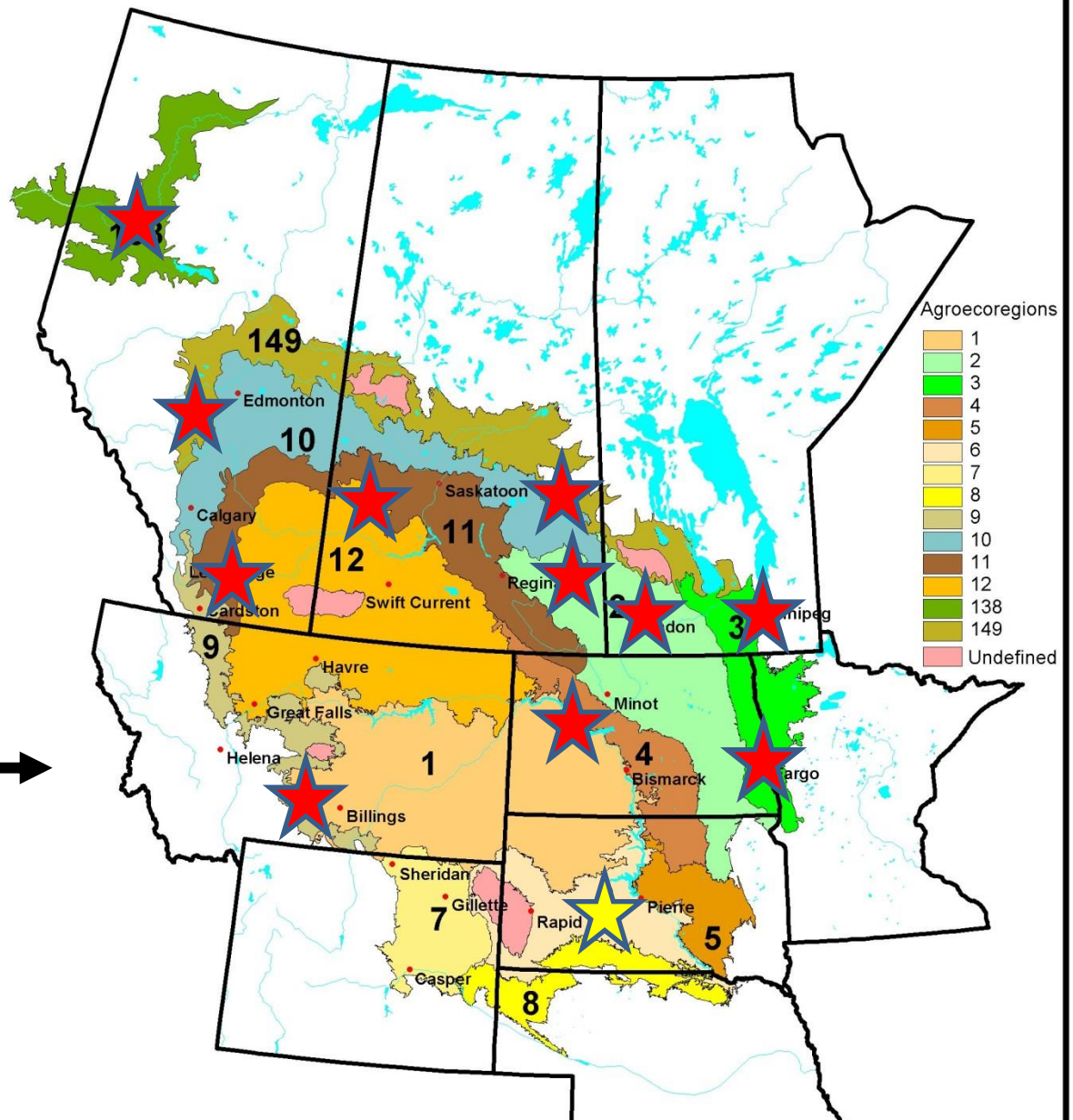
Studying ecological tools together with farmers

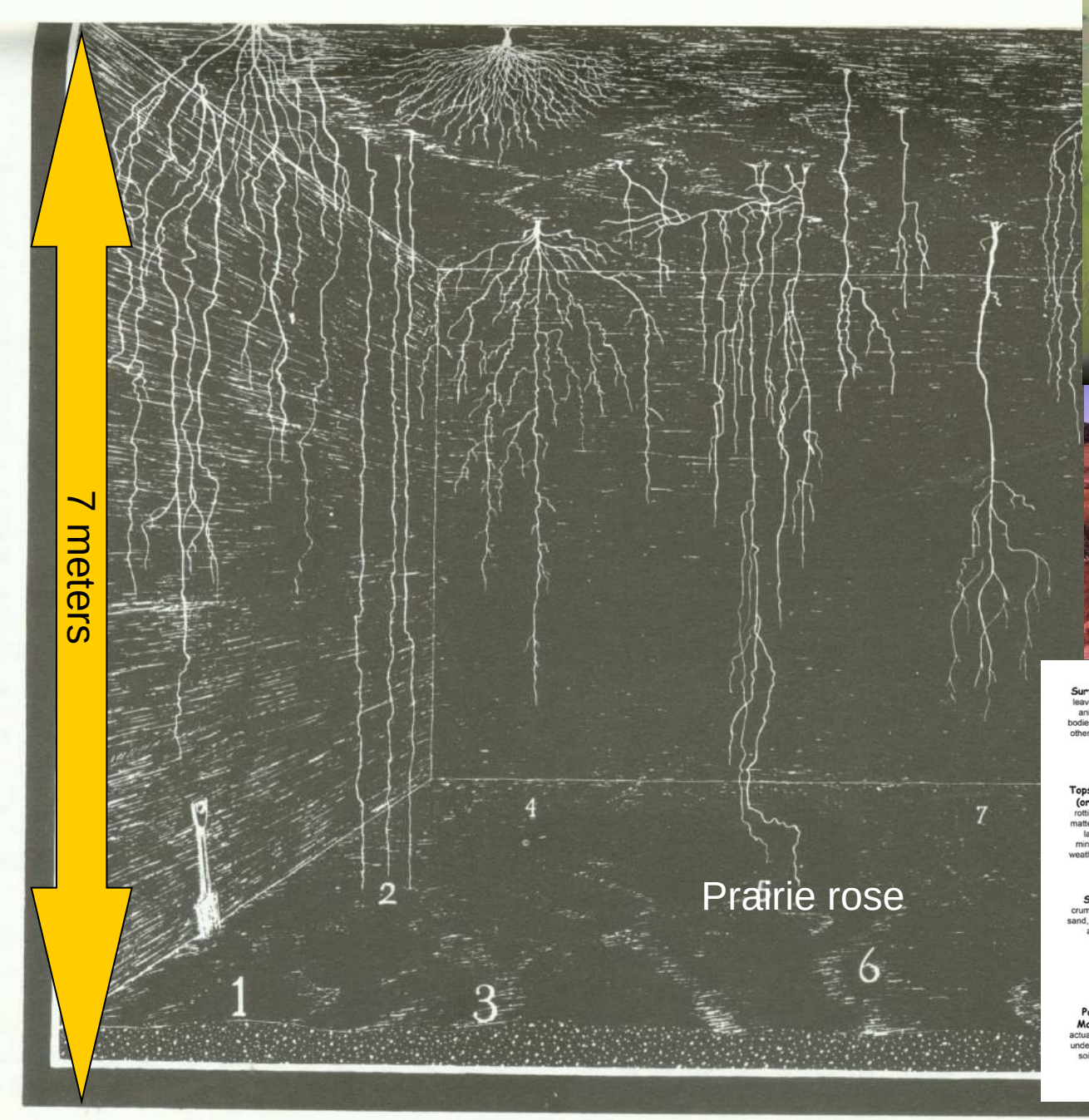
Agronomic benefits of perennial hay phases in grain-based cropping systems

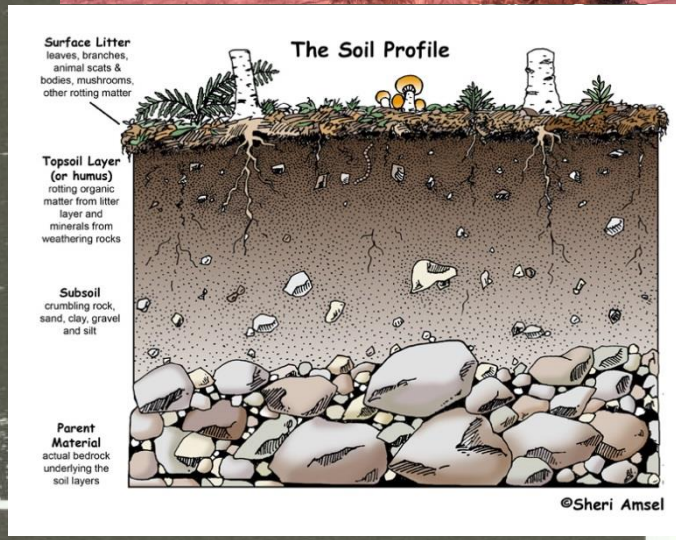
Entz, M.H., Baron, V.S., Carr, P.M., Meyer, D.W., Smith, S. and McCaughey, W.P., 2002. Potential of forages to diversify cropping systems in the Northern Great Plains. *Agronomy Journal*, *94*(2), pp.240-250.

Canada

USA




7 meters
Prairie rose
1
2
3
4
6
7


The Soil Profile
Surface Litter
leaves, branches, animal scats & bodies, mushrooms, other rotting matter
Topsoil Layer (or humus)
rotting organic matter from litter layer and minerals from weathering rocks
Subsoil
crumbling rock, sand, clay, gravel and silt
Parent Material
actual bedrock underlying the soil layers
©Sheri Amsel

Weaver, 1919

TABLE: ROTATION IMPACT ON INCREASING SOIL ORGANIC MATTER[1].

Rotation[2]	Estimated Carbon Sequestration (lbs/acre/year)	Estimated Time[4] to increase SOM 1% (years)
C-C-C-C	--	--
C-C-Sb-Sb	-240	not possible with only rotation
C-C-Sb-W	425	81
C-C-Sb-Wrc	555	62
C-C-A-A	945	36
A-A-A-A	1,680	21

1 extrapolated information using "Cost efficient rotation and tillage options to sequester carbon and mitigate GHG emissions from agriculture in E. Canada", Meyer-Aurich, A., Janovicek, K., Deen, B., Weersink, A., 2006

2 C=Corn, Sb=Soybean, W=Winter Wheat, Wrc=Winter Wheat underseeded Red Clover; A=Alfalfa

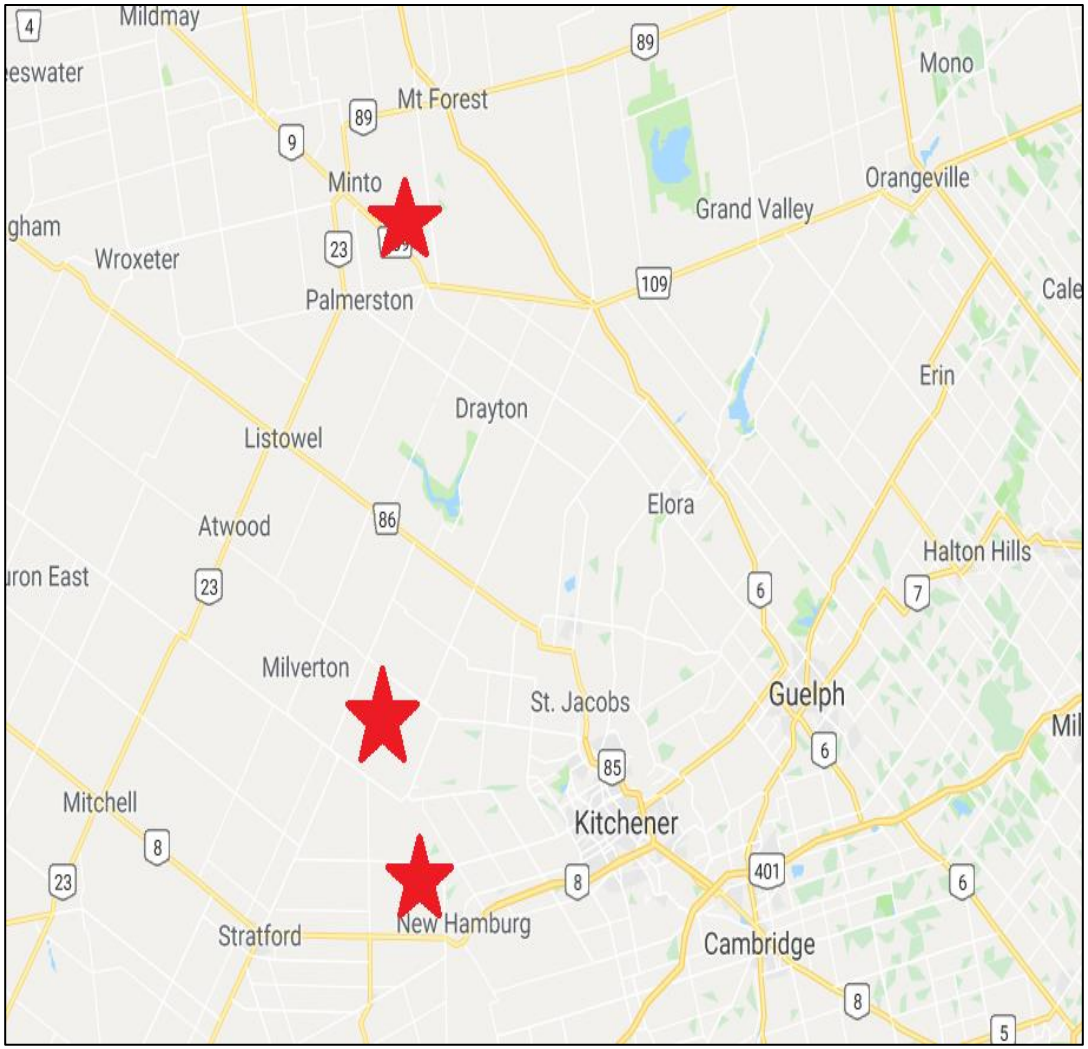
3 Assumes 58% of SOM is made up of organic carbon

Grass-Fed Livestock Systems

Myra VanDie, MSc student

Project 1 – Grazing Trial

Project 2 – Case Studies



Organic Grass-Fed Dairy

Milk Collection

- Specific organic grass-fed run
- Milk truck only goes to three farms

Grazing Management

Next Steps

Solar-powered agriculture

Canada's vast renewable energy potential

WIND ENERGY (W/m²) AT 50M

50 — 1600

SOLAR ENERGY (kWh/kW)

758 — 1385

Existing Dams

Potential Dams

Transmission Lines

Sustainable Canada Dialogues

GLOBAÏA

Natural systems agriculture group at U of M buys C offsets for all airline travel

- Crop rotation
- Tillage management
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- Cover crops
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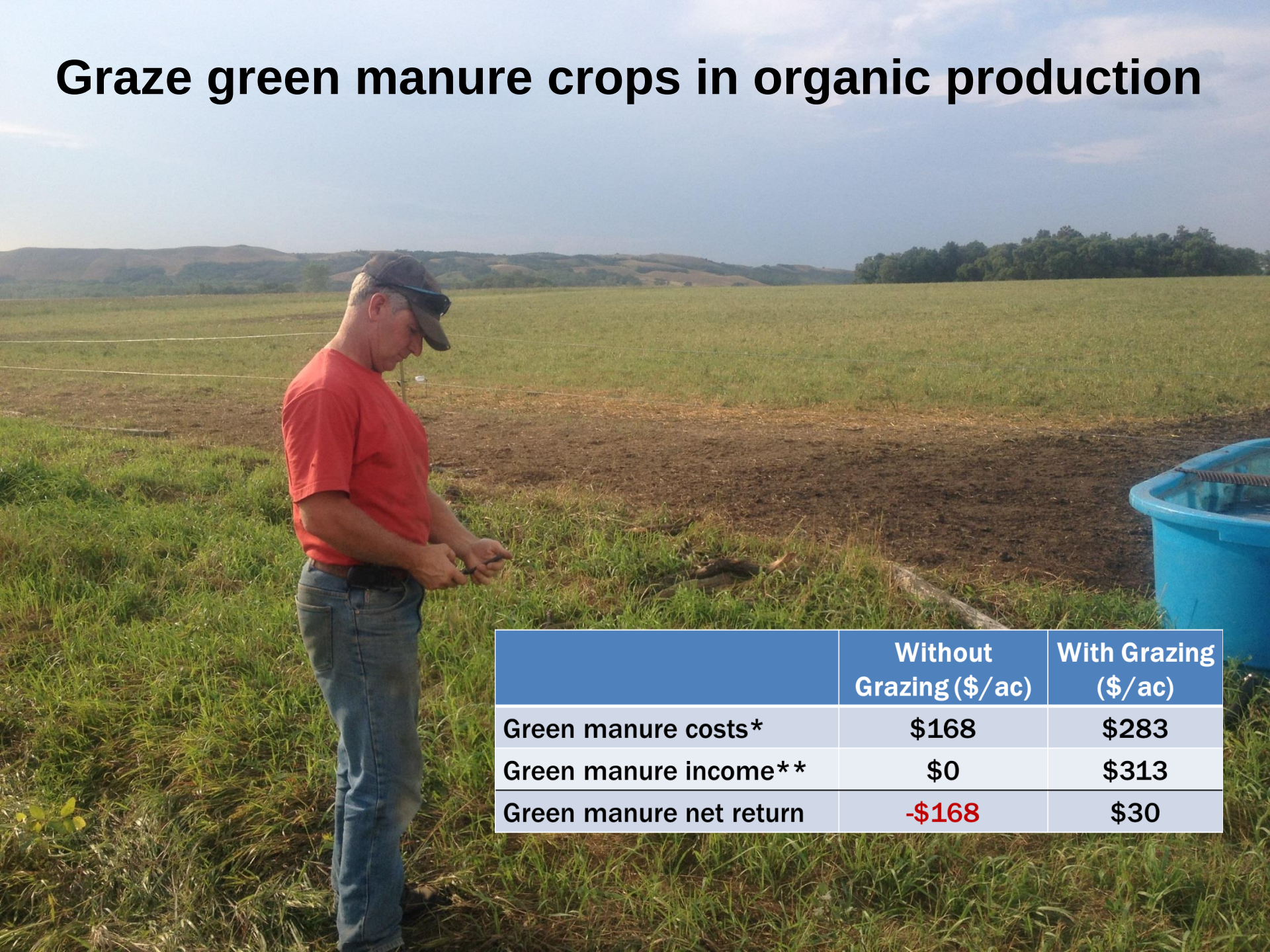
- Organic production
- Agroforestry

Studying ecological tools together with farmers

Graze green manure crops in organic production



	Without Grazing ($/ac)	With Grazing ($/ac)
Green manure costs*	$168	$283
Green manure income**	$0	$313
Green manure net return	-$168	$30

Agriculture and AgriFood Canada, Indian Head – Since 2007

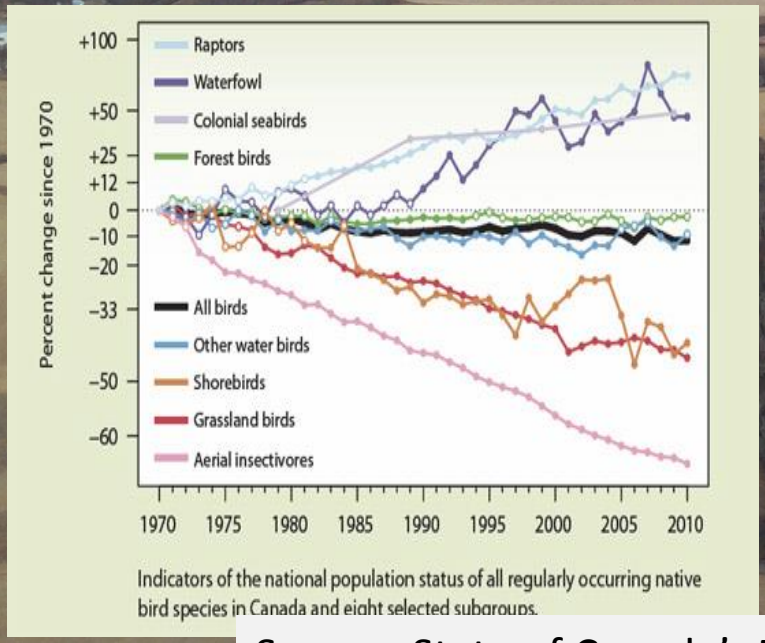
Self-seeding cover crop – medic

- Crop rotation
- Tillage management
- Livestock integration
- Cover crops
- Landscape management
- Organic production
- Agroforestry

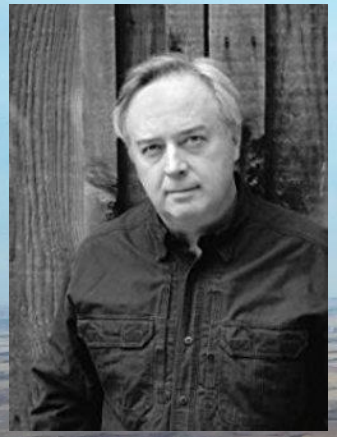
Studying ecological tools together with farmers

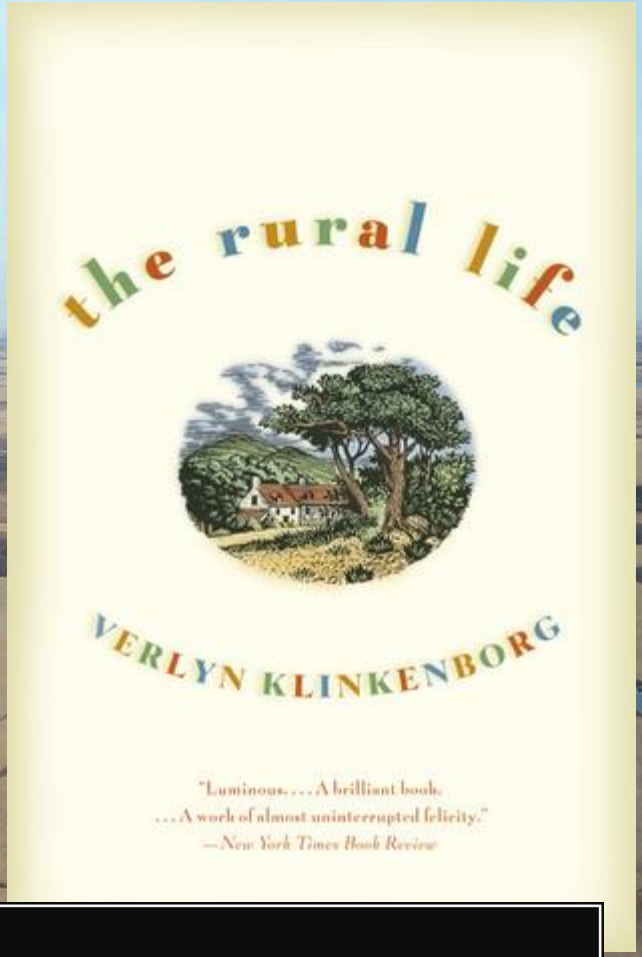
Farmscaping/Landscaping

Aesthetic beauty, places of recreation, places of restorative retreat



Source: State of Canada's Birds 2012





A depopulated landscape is a democratised landscape

Verlyn Klinkenborg

A reasonable agriculture would do its best to emulate nature. Rather than change the earth to suit a crop... it would diversify its crops to suit the earth

— Verlyn Klinkenborg —

AZ QUOTES


Agroforestry

Best wishes embracing the future!