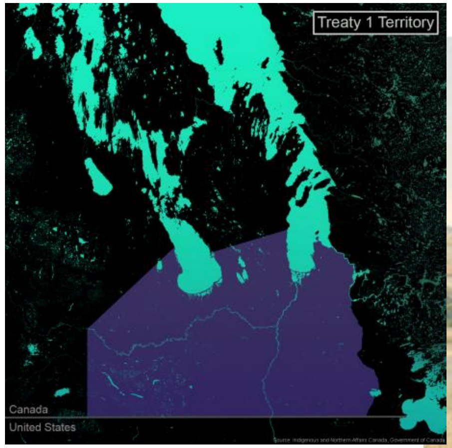
Natural systems agriculture: What does this mean for Plant Agriculture Scientists?

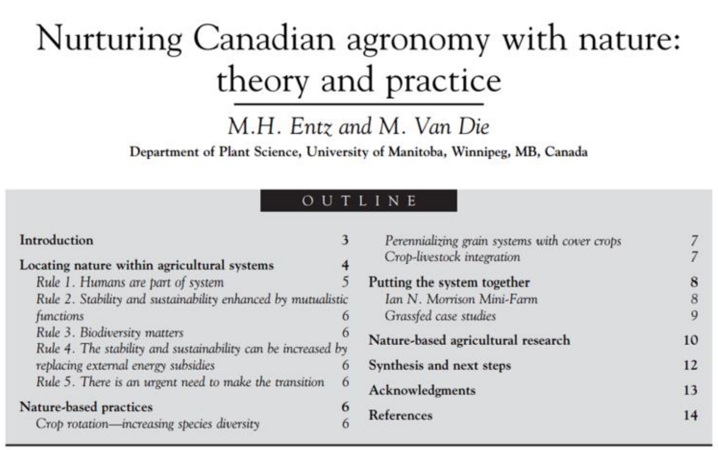
Martin H. Entz, PhD

Jarislowsky Chair in Natural Systems Agriculture for Climate Solutions

Department of Plant Science, University of Manitoba



Les avoines,1886 ~ Oats



Nurturing Canadian agronomy with nature: theory and practice

M.H. Entz and M. Van Die

Department of Plant Science, University of Manitoba, Winnipeg, MB, Canada

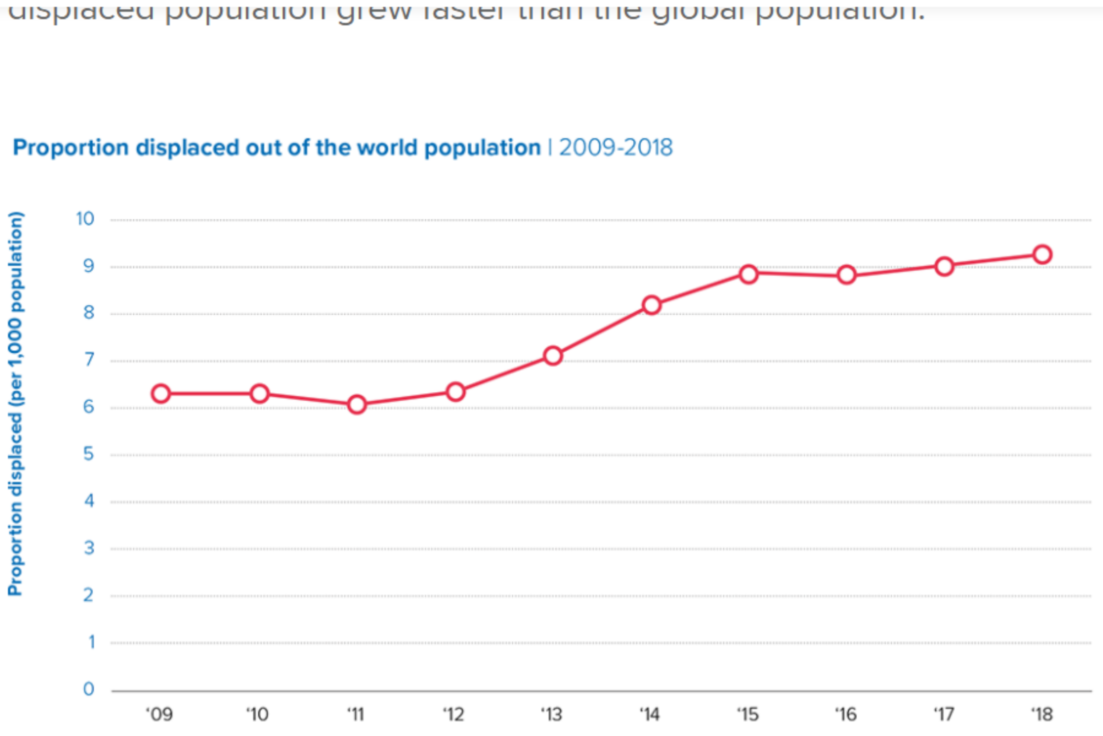
OUTLINE

Advanced Plant Science Seminar Series, March 7, 2024

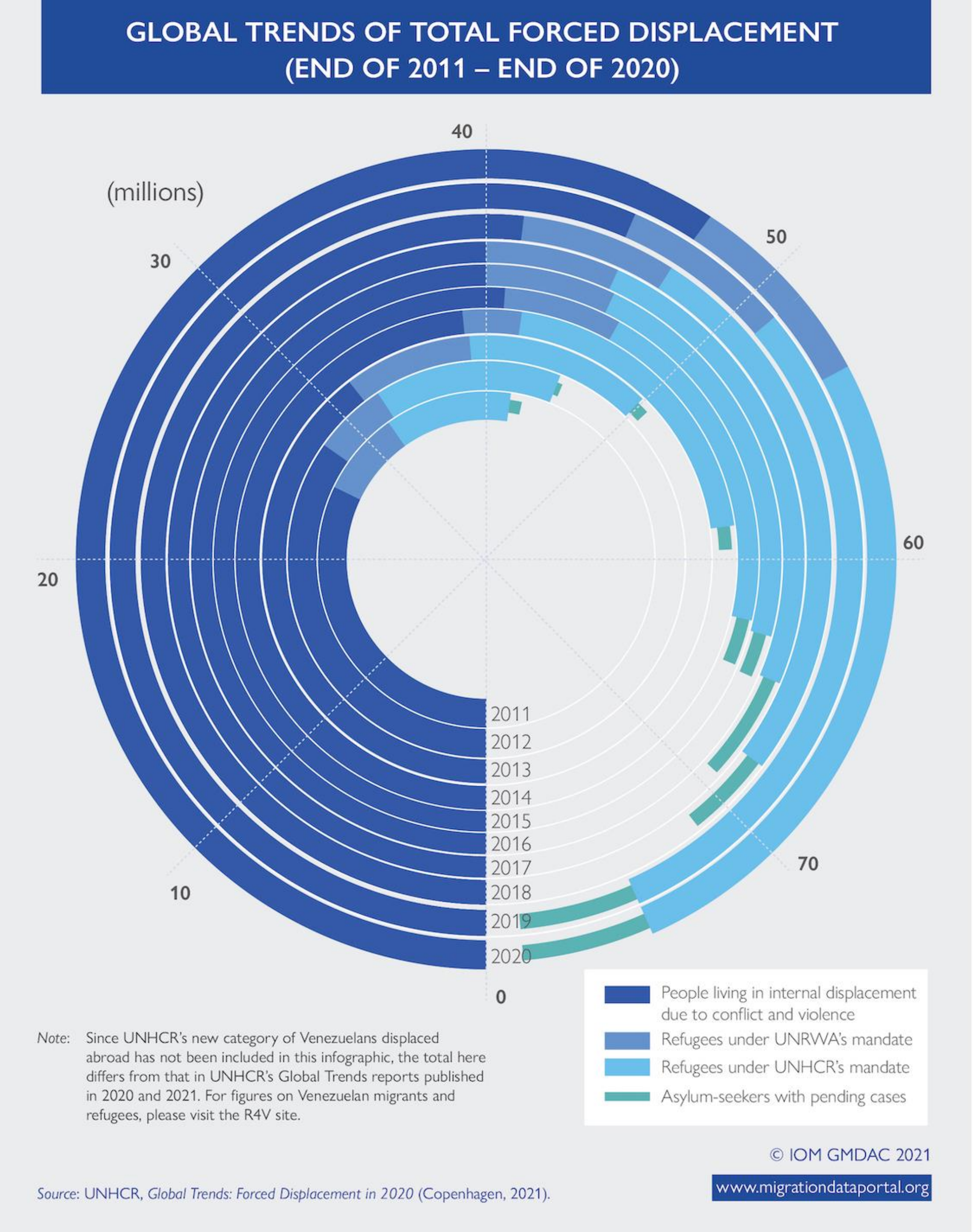
Natural systems agriculture and food security?

Famines overwhelming the result of conflict, resulting in displacement of people

UNHCR The UN Refugee Agency | GLOBAL TRENDS FORCED DISPLACEMENT IN 2018



https://www.unhcr.org/globaltrends2018/



Food insecurity related to lack of educational opportunities for girls and women, and women rights to land and resources

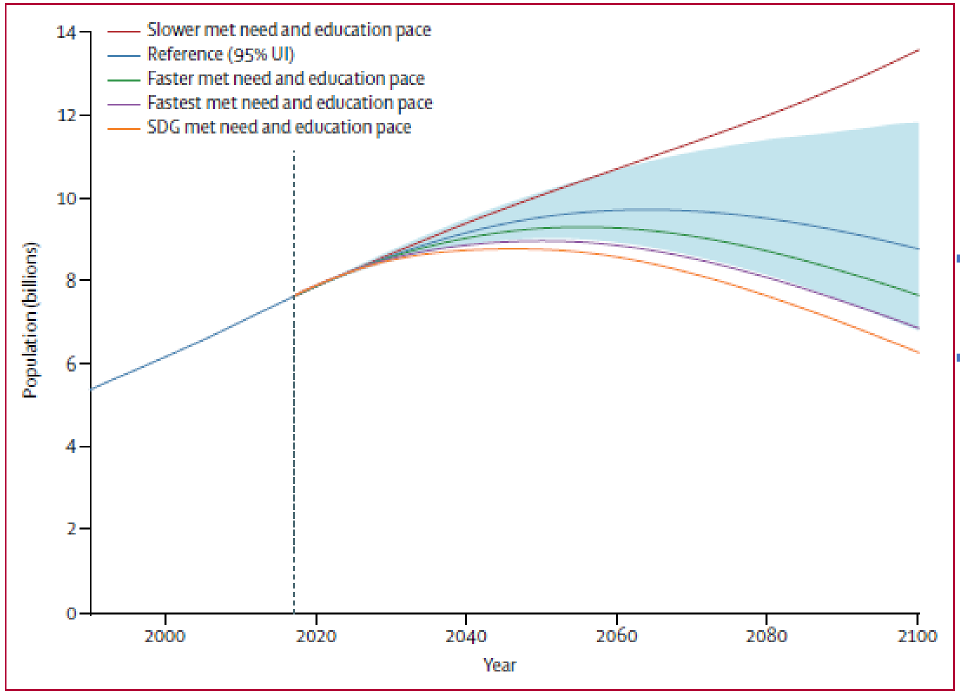
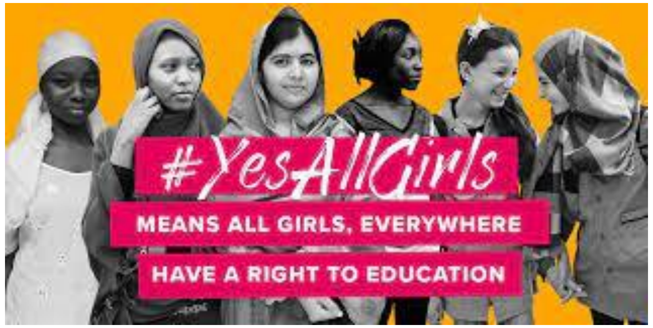


***Figure 5*: Global population in the reference, slower, faster, fastest, and SDG pace scenarios, 1990–2100**
The reference scenario is presented with 95% UIs, which are represented by the shaded area. Past estimates are from GBD 2017, and values are in billions. GBD=Global Burden of Diseases, Injuries, and Risk Factors Study. SDG=Sustainable Development Goal. UI=uncertainty interval.

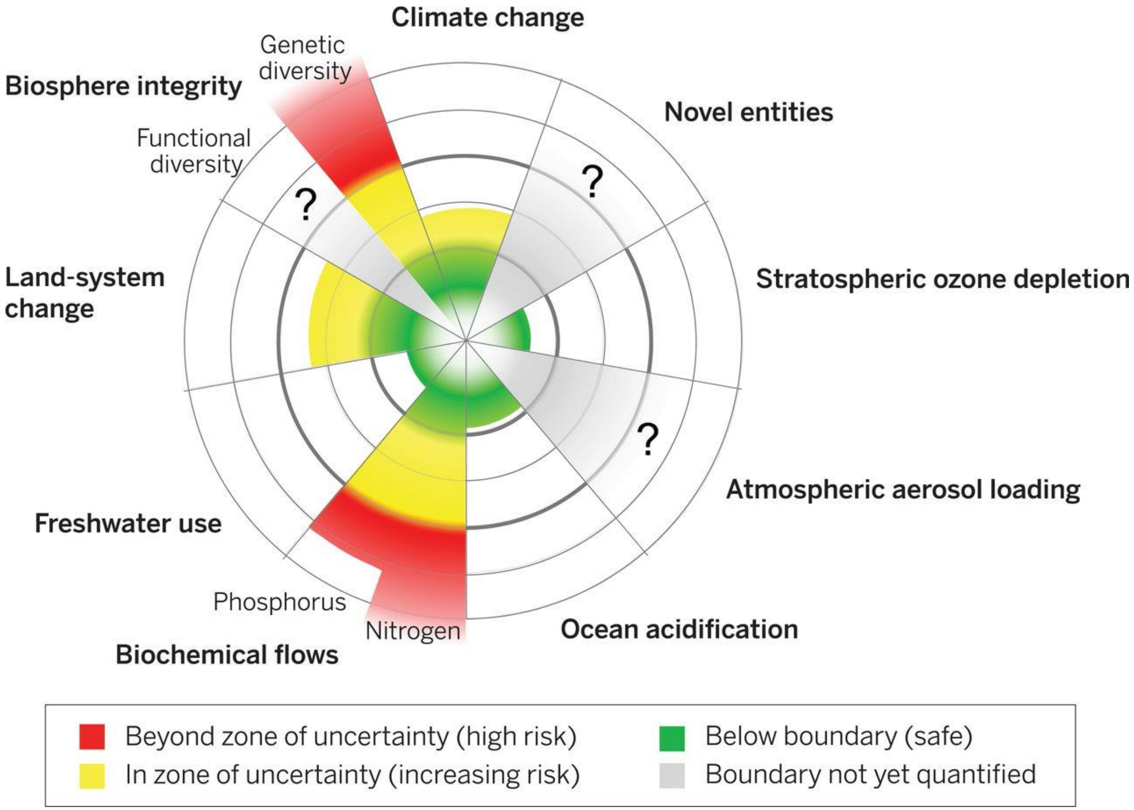


Vollset, S.E., Goren, E., Yuan, C.W., Cao, J., Smith, A.E., Hsiao, T., Bisignano, C., Azhar, G.S., Castro, E., Chalek, J. and Dolgert, A.J., 2020. Fertility, mortality, migration, and population scenarios for 195 countries and territories from 2017 to 2100: a forecasting analysis for the Global Burden of Disease Study. The Lancet, 396(10258), pp.1285-1306.

Samir, K.C. and Lutz, W., 2017. The human core of the shared socioeconomic pathways: Population scenarios by age, sex and level of education for all countries to 2100. *Global Environmental Change*, *42*, pp.181-192.

Nature of response to “Planetary boundaries”?

Steffen, W., Richardson, K., Rockström, J., Cornell, S.E., Fetzer, I., Bennett, E.M., Biggs, R., Carpenter, S.R., De Vries, W., De Wit, C.A. and Folke, C., 2015. Planetary boundaries. *Science*, *347*(6223), p.1259855.



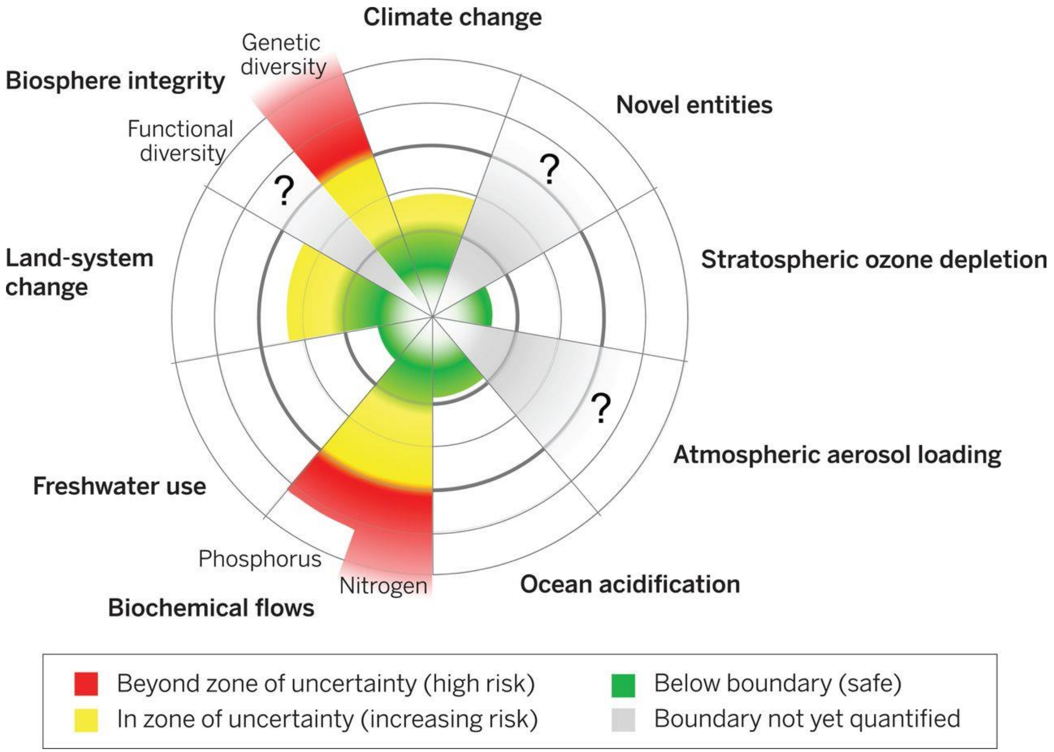
Natural based solutions

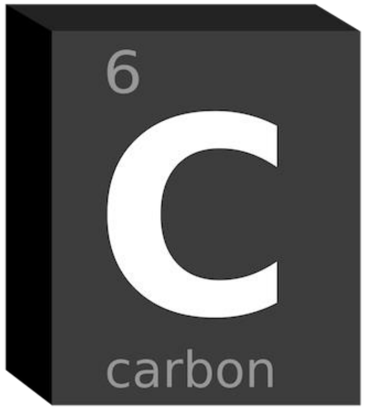
Technology fundamentalism

Combo.

Boundaries and energy

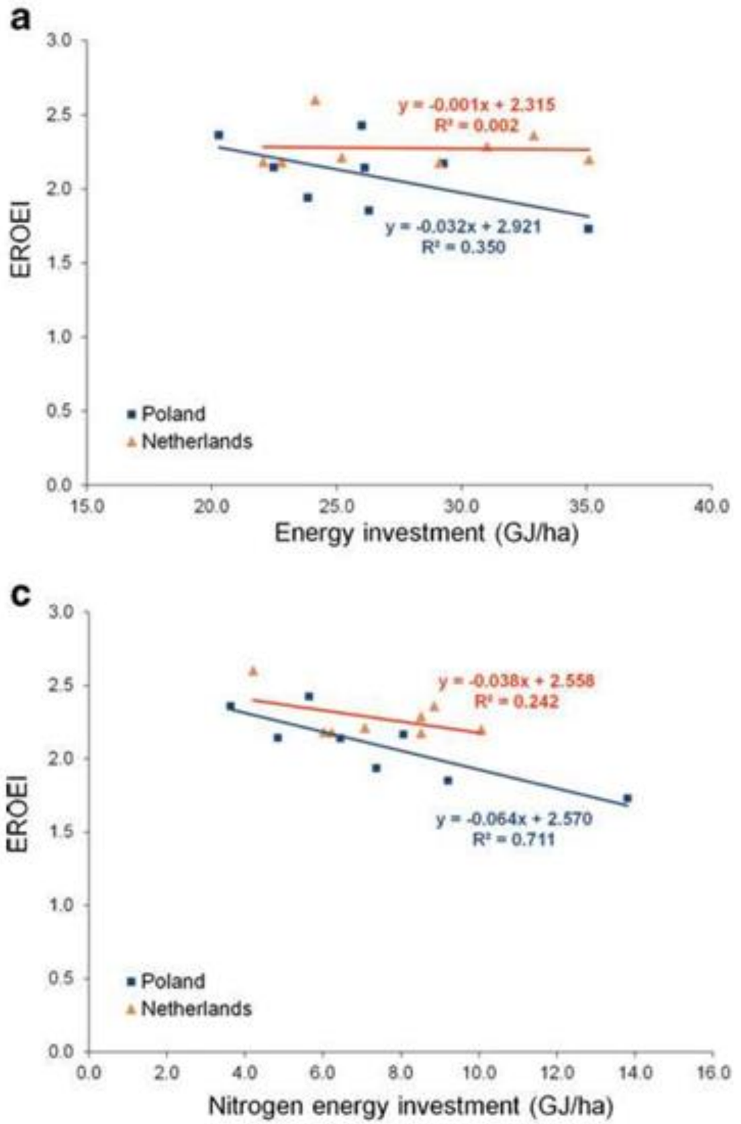
Steffen, W., Richardson, K., Rockström, J., Cornell, S.E., Fetzer, I., Bennett, E.M., Biggs, R., Carpenter, S.R., De Vries, W., De Wit, C.A. and Folke, C., 2015. Planetary boundaries. *Science*, *347*(6223), p.1259855.



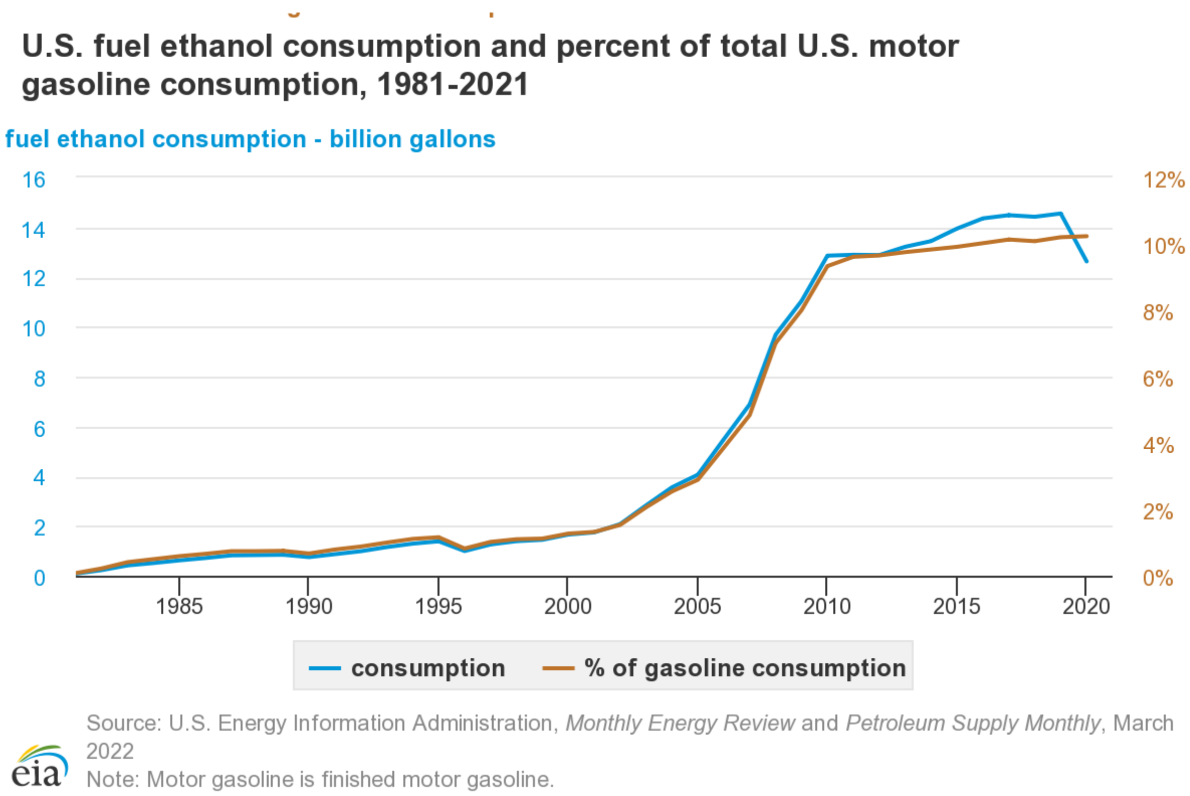


Energy source	Energy efficiency	Carbon emissions?
Oil	20:1 (and declining)	High
Tar sands	5:1	Very high
Ethanol: *Wheat and corn*	1.2:1 to 2.5:1	Medium
Ethanol: *Brazilian sugarcane*	7:1	Low
Ethanol: *Cellulosic (no current production)*	2:1 to 36:1	Low
Biodiesel	2.5:1	Medium
Wind	8:1	Low
Hydro	12:1	Low
Solar	12:1	Low
Nuclear	3:1 to 10:1	Low
Coal (Dirty)	80:1	High
Coal (Cleaned)	10:1	High

From: Cy Gonick (Canadian Dimension publishing, Winnipeg)



Firrisa, M.T., van Duren, I. and Voinov, A., 2014. Energy efficiency for rapeseed biodiesel production in different farming systems. *Energy Efficiency*, *7*, pp.79-95.



- Roughly 25% of the entire US corn crop is used to produce fuel (when accounting for feed co-production (dry distillers grain).
- This fuel accounts for about 10% of all automobile gas used in that country.
- 10% efficiency easily achieved through conservation and energy efficiency.
- Interestingly, a 10% reduction in US gas consumption would free up 20 million acres of land for food production (Note: Manitoba has 17.1 million acres of farmland).

https://news.umanitoba.ca/organic-agriculture-deserves-a-seat-at-the-grown-ups-table/

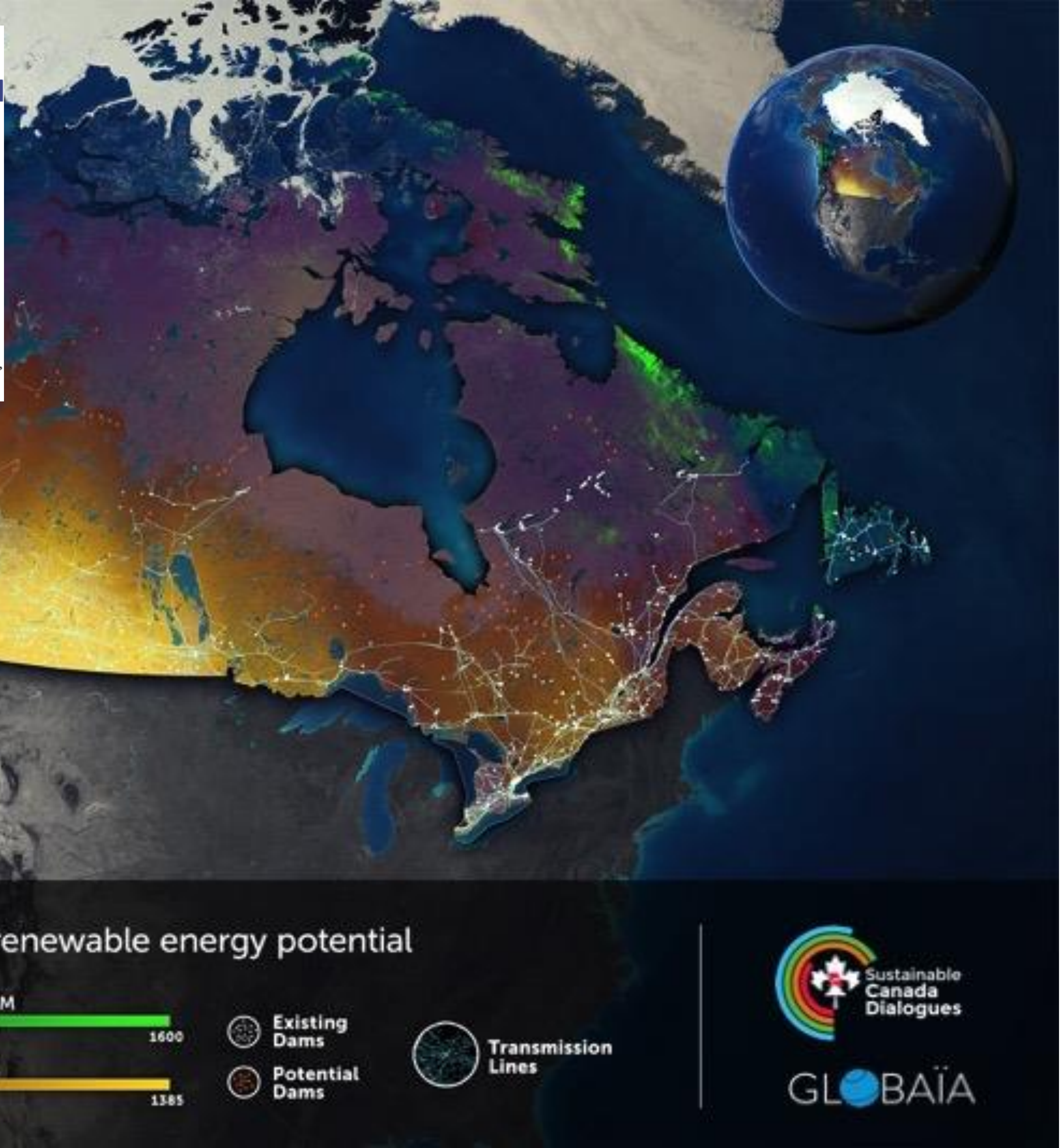
FACETS
a multidisciplinary open access journal

PERSPECTIVE

Stimulating a Canadian narrative for climate

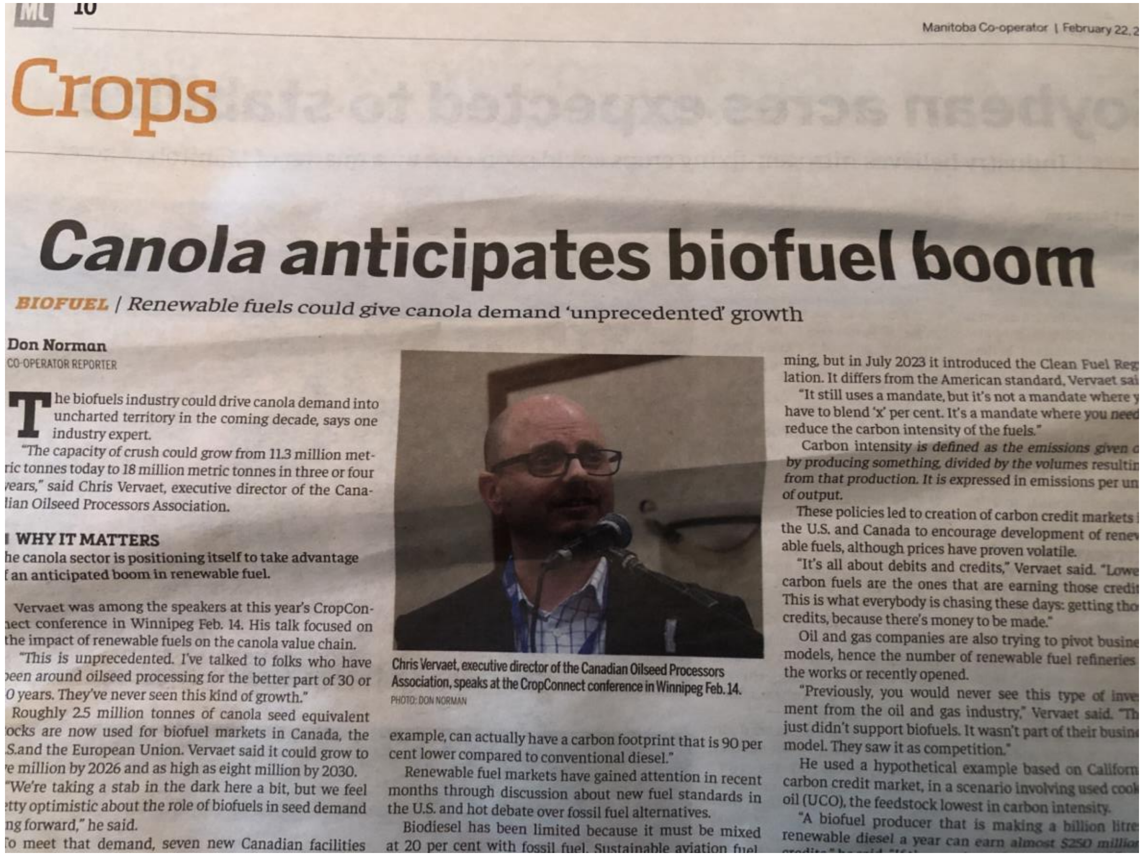
Catherine Potvin[a*], Divya Sharma[a], Irena Creed[b], Sally Aitken[c], François Anctil[d], Elena Bennett[e], Fikret Berkes[f], Steven Bernstein[g], Nathalie Bleau[h], Alain Bourque[i], Bryson Brown[j], Sarah Burch[k], James Byrne[l], Ashlee Cunsolo[m], Ann Dale[n], Deborah de Lange[o], Bruno Dyck[p], Martin Entz[q], José Etcheverry[r], Rosine Faucher[s], Adam Fenech[t], Lauchlan Fraser[u], Irene Henriques[v], Andreas Heyland[w], Matthew Hoffmann[x], George Hoberg[y], Meg Holden[z], Gordon Huang[aa], Aerin L. Jacob[ab], Sebastien Jodoin[ac], Alison Kemper[ad], Marc Lucotte[ae], Roxane Maranger[af], Liat Margolis[ag], Ian Mauro[ah], Jeffrey McDonnell[ai], James Meadowcroft[aj], Christian Messier[ak], Martin Mkandawire[al], Catherine Morency[am], Normand Mousseau[an], Ken Oakes[ao], Sarah Otto[ap], Pamela Palmater[aq], Taysha Sharlene Palmer[ar], Dominique Paquin[as], Anthony Perl[at], André Potvin[au], Howard Ramos[av], Ciara Raudsepp-Hearne[aw], Natalie Richards[a], John Robinson[ax], Stephen Sheppard[ay], Suzanne Simard[az], Brent J. Sinclair[b], Natalie Slawinski[ba], Mark Stoddart[bb], Marc-André Villard[bc], Claude Villeneuve[bd], and Tarah Wright[be]

OPEN ACCESS



Framing the issues of hunger, food vs fuel…

- Social circumstances and conflict play a central role in food security.
- Stay informed about planetary boundaries.
  - Read, read, read….
- Do not live entirely in our own silo – see bigger picture
  - Biofuels good for business? Yes
  - Biofuels good for the planet? Evidence not compelling



10 Manitoba Co-operator | February 22, 2

Crops

Canola anticipates biofuel boom

BIOFUEL | *Renewable fuels could give canola demand 'unprecedented' growth*

Don Norman
CO-OPERATOR REPORTER

The biofuels industry could drive canola demand into uncharted territory in the coming decade, says one industry expert.

"The capacity of crush could grow from 11.3 million metric tonnes today to 18 million metric tonnes in three or four years," said Chris Vervaet, executive director of the Canadian Oilseed Processors Association.

WHY IT MATTERS
he canola sector is positioning itself to take advantage f an anticipated boom in renewable fuel.

Vervaet was among the speakers at this year's CropConnect conference in Winnipeg Feb. 14. His talk focused on the impact of renewable fuels on the canola value chain.

"This is unprecedented. I've talked to folks who have been around oilseed processing for the better part of 30 or 0 years. They've never seen this kind of growth."

Roughly 2.5 million tonnes of canola seed equivalent ocks are now used for biofuel markets in Canada, the S. and the European Union. Vervaet said it could grow to e million by 2026 and as high as eight million by 2030.

"We're taking a stab in the dark here a bit, but we feel etty optimistic about the role of biofuels in seed demand ng forward," he said.

o meet that demand, seven new Canadian facilities

Chris Vervaet, executive director of the Canadian Oilseed Processors Association, speaks at the CropConnect conference in Winnipeg Feb. 14.
PHOTO: DON NORMAN

example, can actually have a carbon footprint that is 90 per cent lower compared to conventional diesel."

Renewable fuel markets have gained attention in recent months through discussion about new fuel standards in the U.S. and hot debate over fossil fuel alternatives.

Biodiesel has been limited because it must be mixed at 20 per cent with fossil fuel. Sustainable aviation fuel

ming, but in July 2023 it introduced the Clean Fuel Reg lation. It differs from the American standard, Vervaet sai

"It still uses a mandate, but it's not a mandate where y have to blend 'x' per cent. It's a mandate where you need reduce the carbon intensity of the fuels."

Carbon intensity *is defined as the emissions given o by producing something, divided by the volumes* resultin *from that production. It is expressed* in emissions per un *of output.*

These policies led to creation of carbon credit markets the U.S. and Canada to encourage development of renew able fuels, although prices have proven volatile.

"It's all about debits and credits," Vervaet said. "Lowe carbon fuels are the ones that are earning those credit This is what everybody is chasing these days: getting tho credits, because there's money to be made."

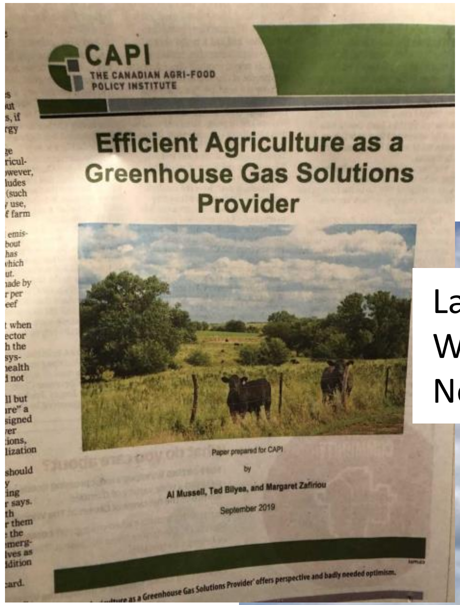
Oil and gas companies are also trying to pivot busine models, hence the number of renewable fuel refineries the works or recently opened.

"Previously, you would never see this type of inve ment from the oil and gas industry," Vervaet said. "Th just didn't support biofuels. It wasn't part of their busin model. They saw it as competition."

He used a hypothetical example based on Californ carbon credit market, in a scenario involving used cook oil (UCO), the feedstock lowest in carbon intensity.

"A biofuel producer that is making a billion litre renewable diesel a year can earn *almost $250 million*

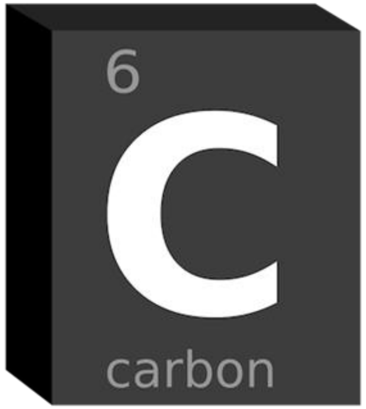
Soil C capture as a natural way to remove atmospheric C

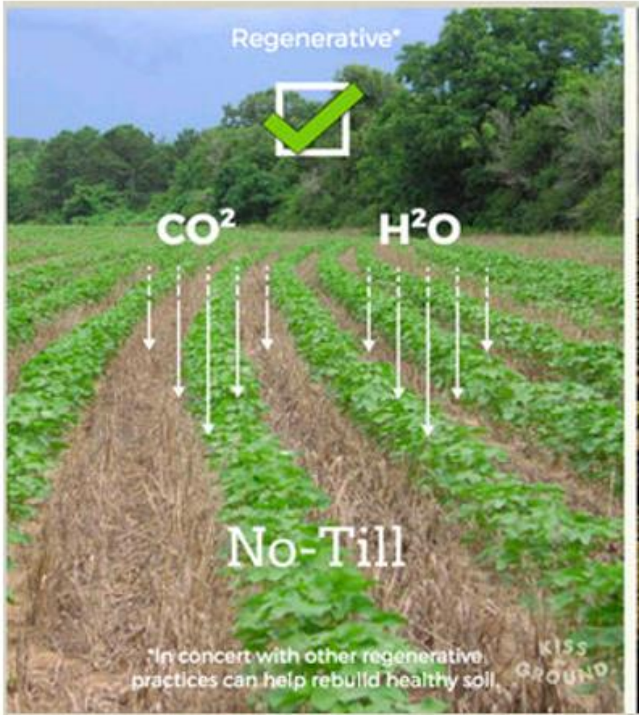

CAPI
THE CANADIAN AGRI-FOOD POLICY INSTITUTE

Efficient Agriculture as a Greenhouse Gas Solutions Provider

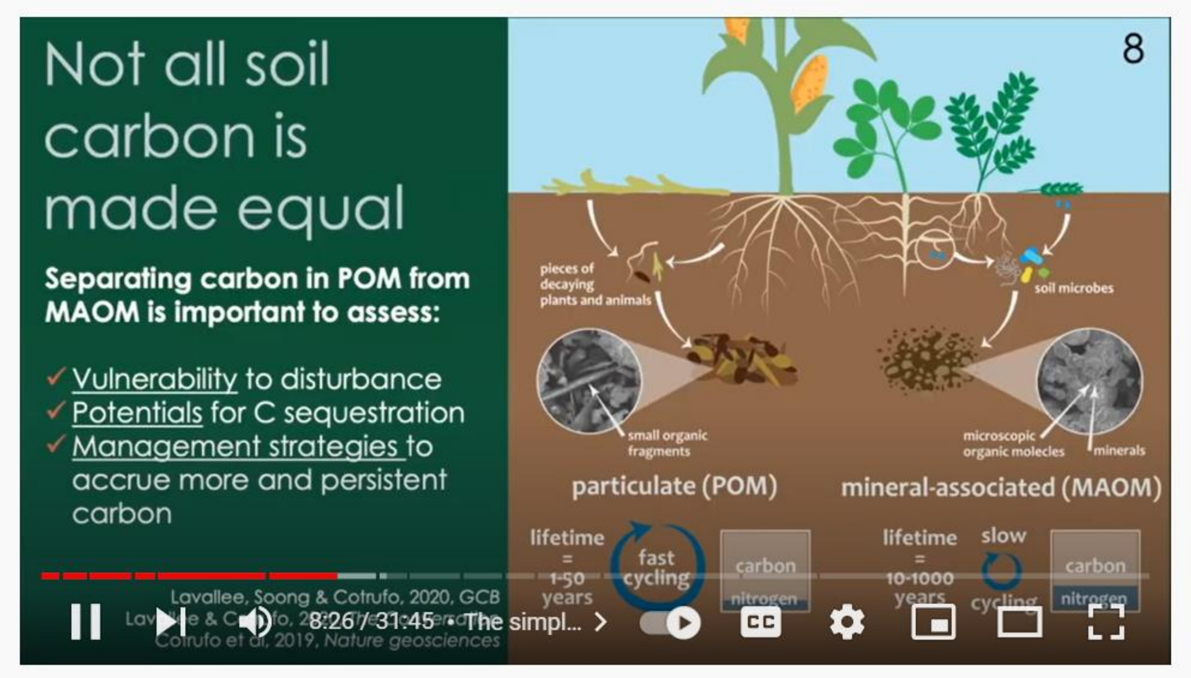
Paper prepared for CAPI
by
Al Mussell, Ted Bilyea, and Margaret Zafiriou
September 2019

Laura Rance,
Winnipeg Free Press
Nov 30, 2019





New understanding of C in soils – that really emphasizes plants (roots)!



Lavallee, J.M., Soong, J.L. and Cotrufo, M.F., 2020. Conceptualizing soil organic matter into particulate and mineral-associated forms to address global change in the 21st century. *Global Change Biology*, *26*(1), pp.261-273.

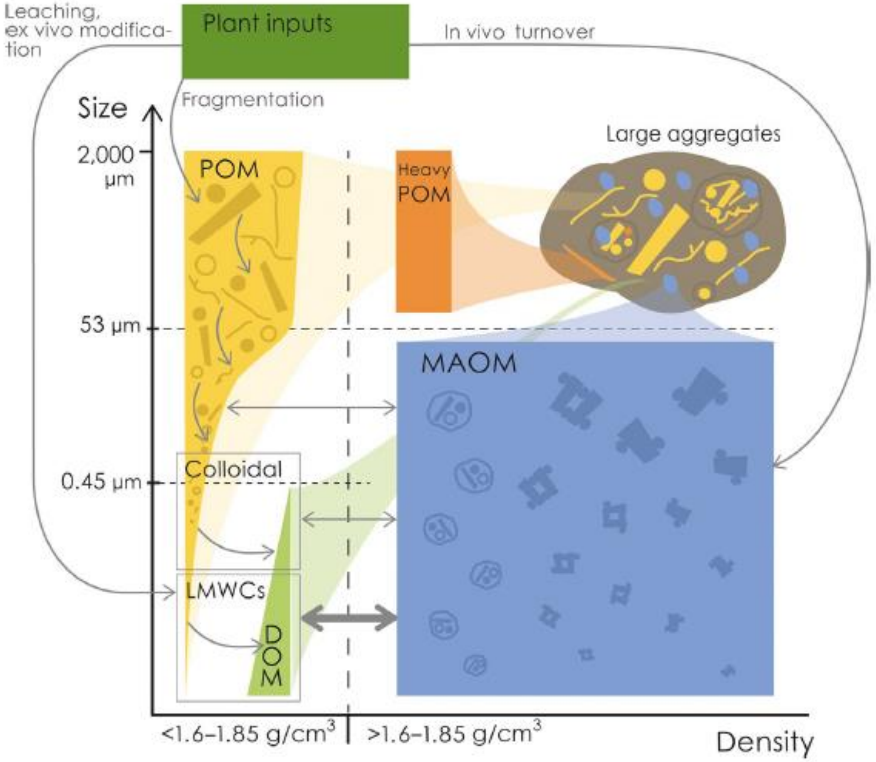
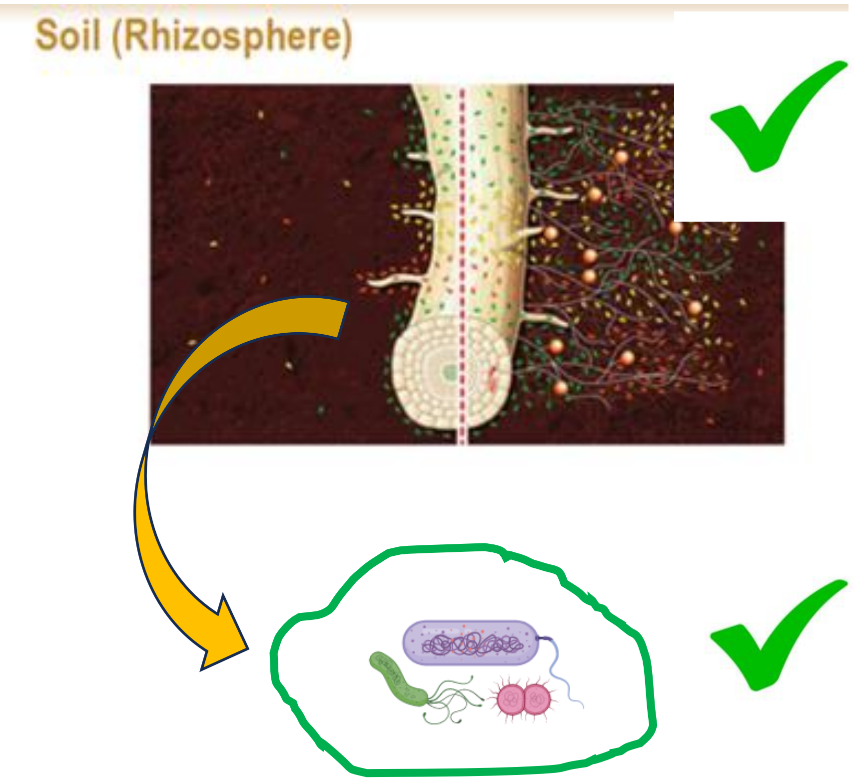


FIGURE 2 Conceptual representation of major soil organic matter (SOM) components discussed in this review. These SOM components are physically defined based on size and density, shown on the y and x axes, respectively. The upper size limit specification for MAOM varies by region, from 20 to 63 µm; we show 53 µm here for simplicity. Dissolved organic matter (DOM) is generally defined as <0.45 µm and water-extractable. Mineral-associated organic matter (MAOM) has multiple forms, including small particulate organic matter (POM)-like structures encapsulated by minerals, organo-mineral clusters, and primary organo-mineral complexes. Large aggregates can contain all other components to varying degrees. LMWCs are low molecular weight compounds. Arrows leading from plant inputs to different components represent hypothesized SOM formation pathways [Correction added on 22 November 2019 after first online publication: the DOM value has been changed from 45 µm to 0.45 µm in Figure 2 and text throughout the article.]

Focus: root growth, and healthy soil microbiome to process root exudates



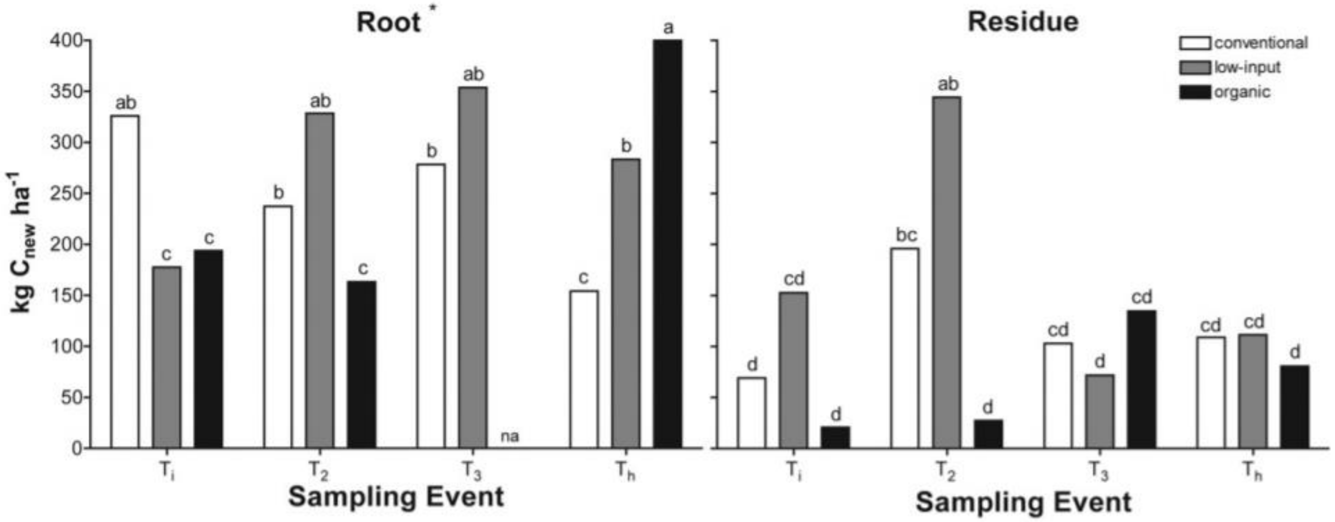
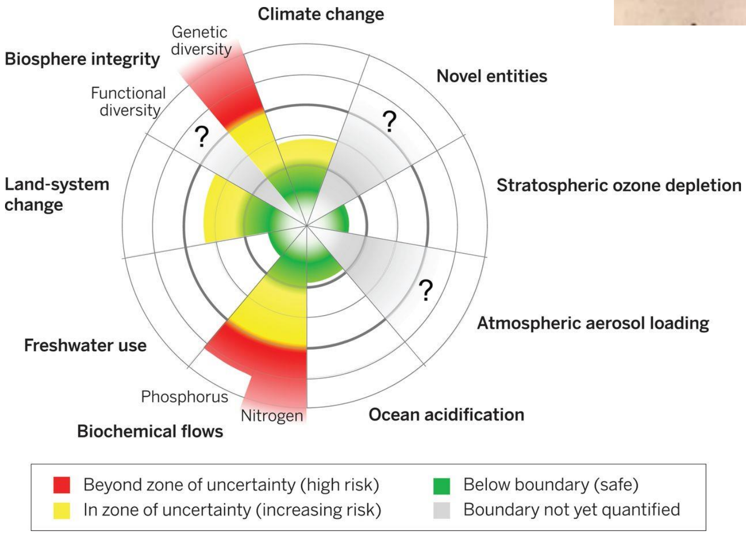


Fig. 1. Concentration of C derived from ^{13}C-labeled root and residue biomass (C_{new}) in whole soil samples collected at four sampling times (T_1–T_h) during the 2006 growing season at the Russell Ranch (Davis, CA). Bars represent the means of three replicates and bars with different letters reflect significant differences associated with a significant C source × sampling event × cropping system interaction. Means that were not available for analysis are marked with na. *Overall significant difference between C sources at $P < 0.05$.

SSSAJ: Volume 74: Number 4 • July–August 2010 1205

Kong and Six (2010) observed that carbon from a winter hairy vetch cover crop in a tomato-corn crop rotation in California was stored more efficiently in SOM under organic than conventional conditions. Also, root C was stored much more efficiently than shoot C.

Kong, A.Y. and Six, J., 2010. Tracing root vs. residue carbon into soils from conventional and alternative cropping systems. *Soil Science Society of America Journal*, *74*(4), pp.1201-1210.



Transformation needed for carbon net-zero

Hope for radical change in farming systems

LAURA RANCE
RURAL REVIVAL

As keynote presentations go, the kickoff speaker's at a virtual conference on the sus-
ainability of Canadian agriculture
his week was a bit of a downer — at
ast initially.

Henry Janzen, a career Agriculture
Agri-Food Canada scientist who
serves as an honourary research
ciate with the department's
bridge research team, is widely
ected by his peers for his ability

to see the big picture in the context of everyday science.

He didn't mince words addressing whether it's possible to get the agricultural sector, which contributes 10 per cent of Canada's greenhouse gas emissions (not counting the emissions from fossil fuels or fertilizer production), to a net-zero position.

"To be b
we can arr
system by
The farm
designed, c
becoming m
and other sp
real and ima
those efficien
policy-maker
numbers by n
of success and
measure.
But in Janze
systems can ne
balance of carb

a sustained period because that is not how they are designed.

"Farming is very deliberately extractive. In other words, the whole point of farming is to generate and then bundle up and export from the farming system as much carbon and as many nutrients as we possibly can to be used remotely from that ecosystem," Janzen said. "So, if that system is to be sustained into perpetuity, those nutrients somehow need to be replaced

ing may, in turn, be lost upon warming. The more carbon we store, the more carbon becomes vulnerable to climate change," Janzen said.

Reducing agriculture's role in the emissions contributing to catastrophic environmental change will require us to change how we value the landscape and pay farmers for what they do.

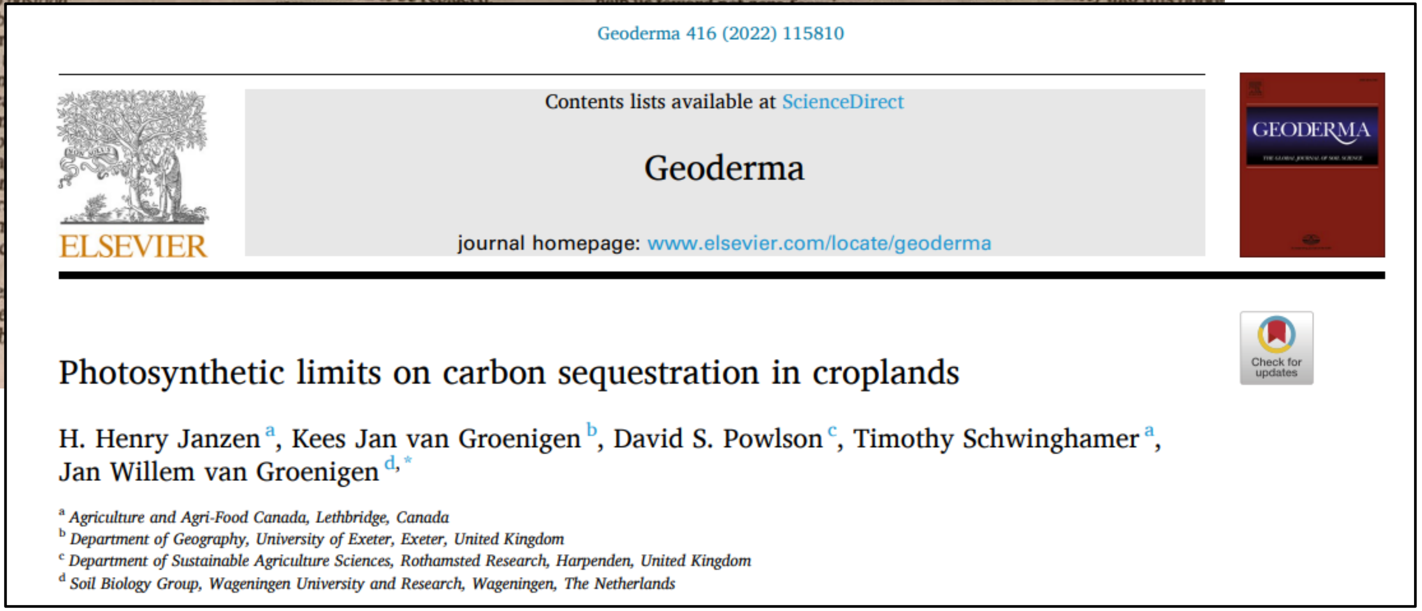
"I think it's fair to say that many of the systems that we envision that might

than neat boxes of monoculture th
see today as "productive" fields.

In other words, don't look to scie
and technology to save the day.

"It means that changing how we farm is a societal undertaking. Th
not something we plot out in scient
conferences or in our laboratories,"
Janzen said.

"What we need is to tell stories t
invite all of society into this oppor



Geoderma 416 (2022) 115810

Contents lists available at ScienceDirect

Geoderma

journal homepage: www.elsevier.com/locate/geoderma

Photosynthetic limits on carbon sequestration in croplands

H. Henry Janzen[a], Kees Jan van Groenigen[b], David S. Powlson[c], Timothy Schwinghamer[a], Jan Willem van Groenigen[d,*]

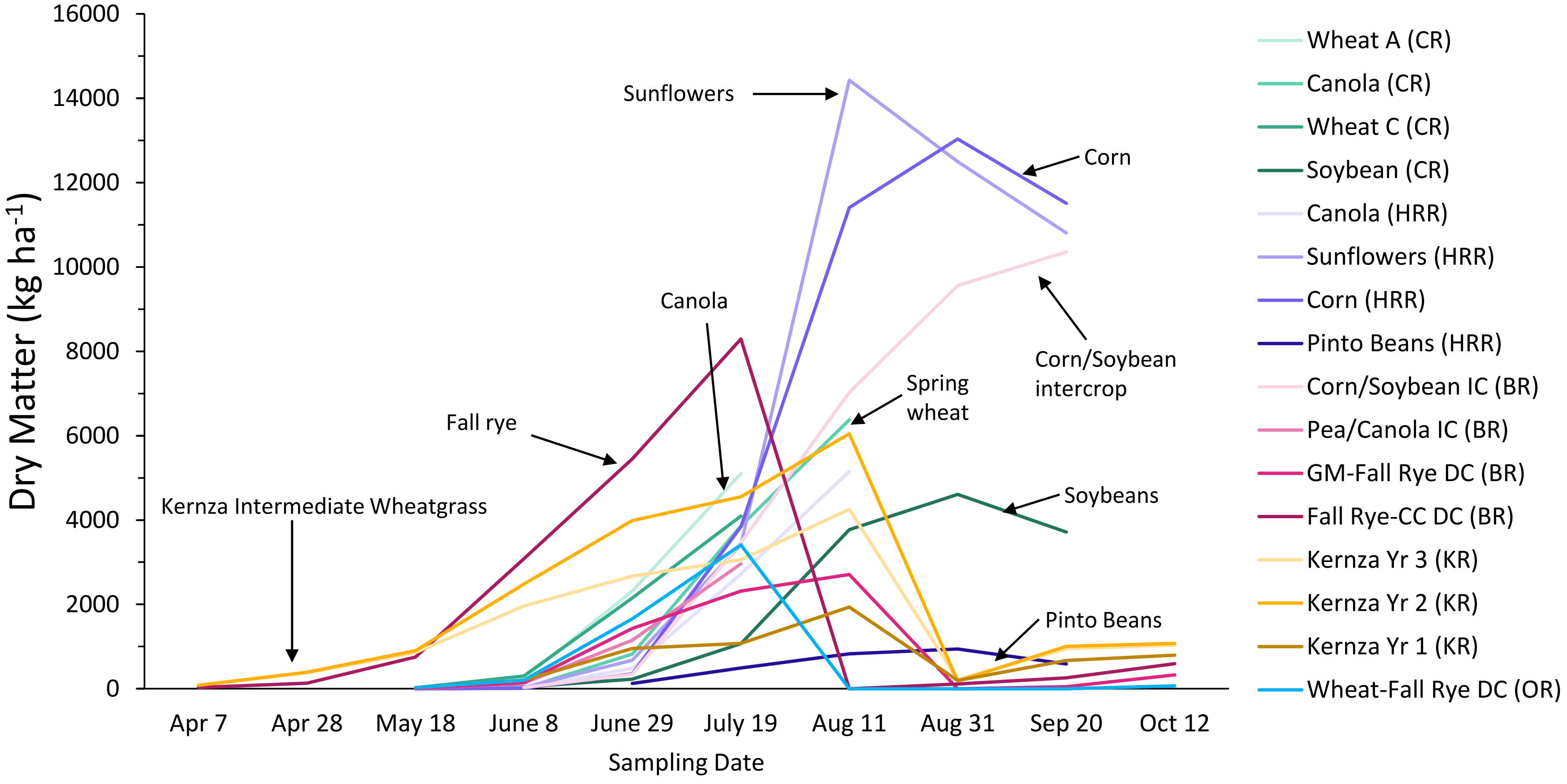
[a] Agriculture and Agri-Food Canada, Lethbridge, Canada
[b] Department of Geography, University of Exeter, Exeter, United Kingdom
[c] Department of Sustainable Agriculture Sciences, Rothamsted Research, Harpenden, United Kingdom
[d] Soil Biology Group, Wageningen University and Research, Wageningen, The Netherlands

Janzen, H.H., 2006. The soil carbon dilemma: shall we hoard it or use it?. *Soil Biology and Biochemistry*, *38*(3), pp.419-424.

Janzen, H.H., van Groenigen, K.J., Powlson, D.S., Schwinghamer, T. and van Groenigen, J.W., 2022. Photosynthetic limits on carbon sequestration in croplands. *Geoderma*, *416*, p.115810.

Crop diversity to increase whole season photosynthesis

Sam Curtis et al. 2024. Can J Plant Science (in review)



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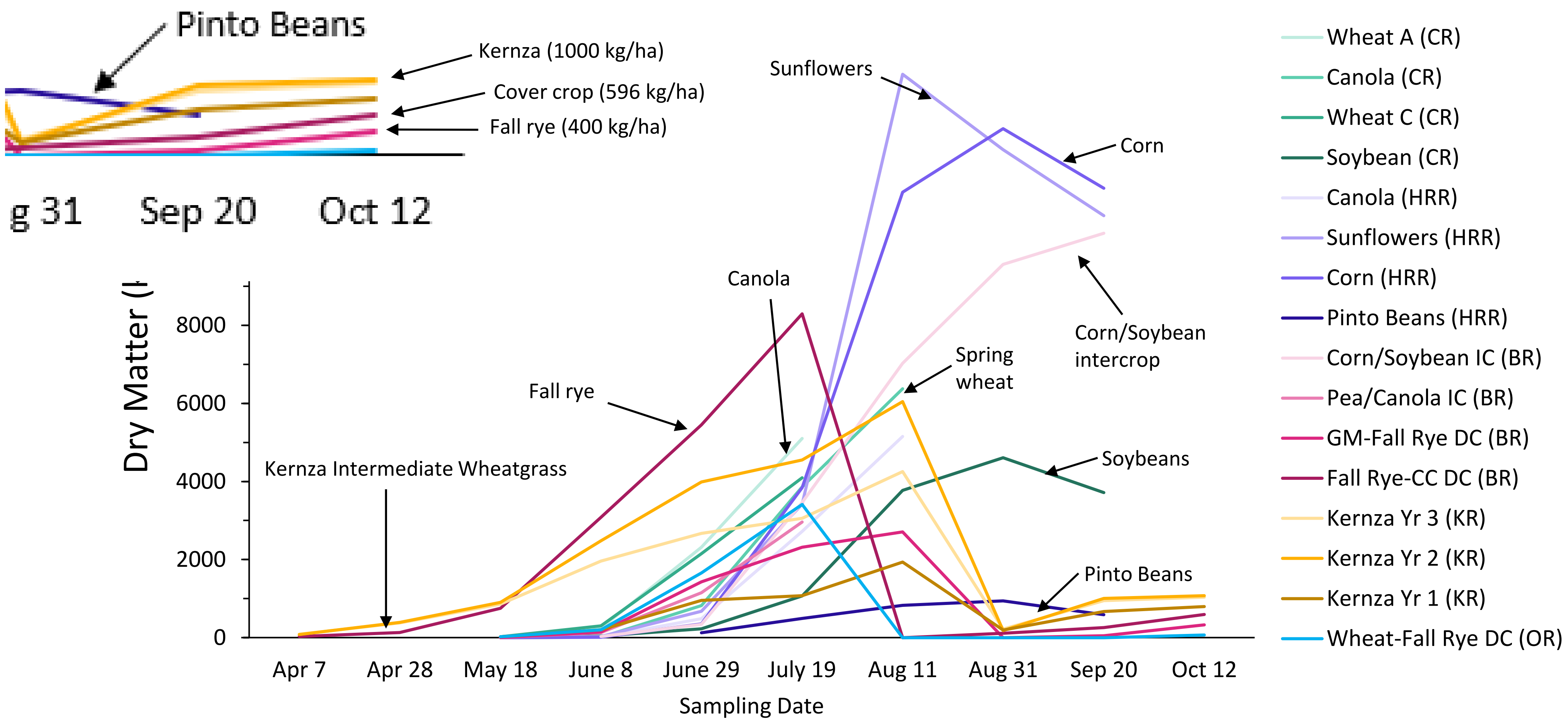
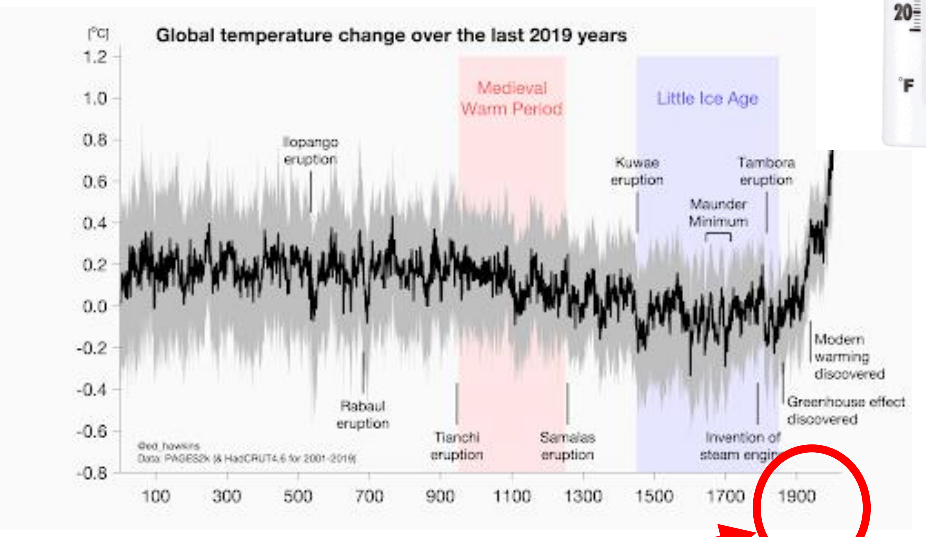
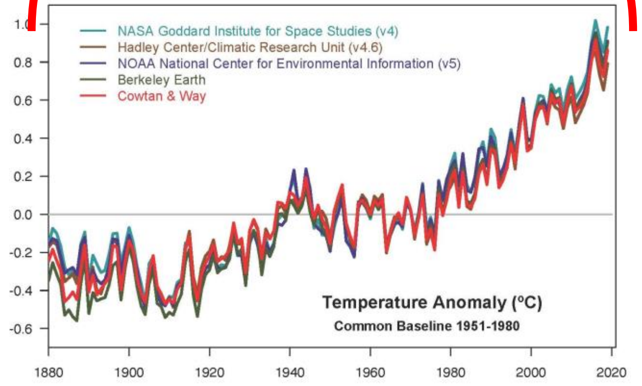


nature geoscience ARTICLES
https://doi.org/10.1038/s41561-021-00744-x
Check for updates

Different climate sensitivity of particulate and mineral-associated soil organic matter

Emanuele Lugato[1✉], Jocelyn M. Lavallee[2], Michelle L. Haddix[2], Panos Panagos[1] and M. Francesca Cotrufo[2]





Cropland MOAM loss by 2080: 10%

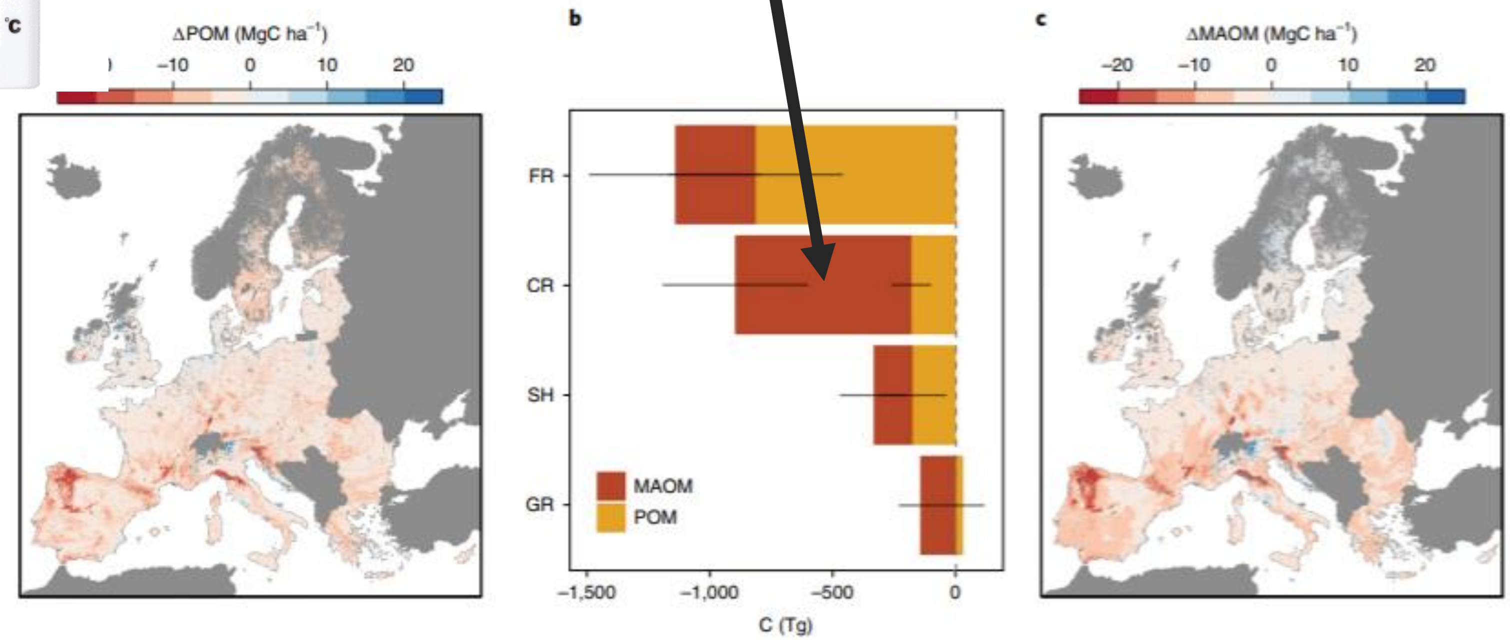
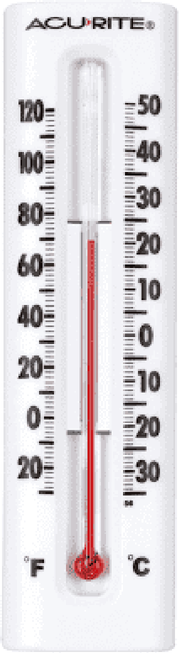
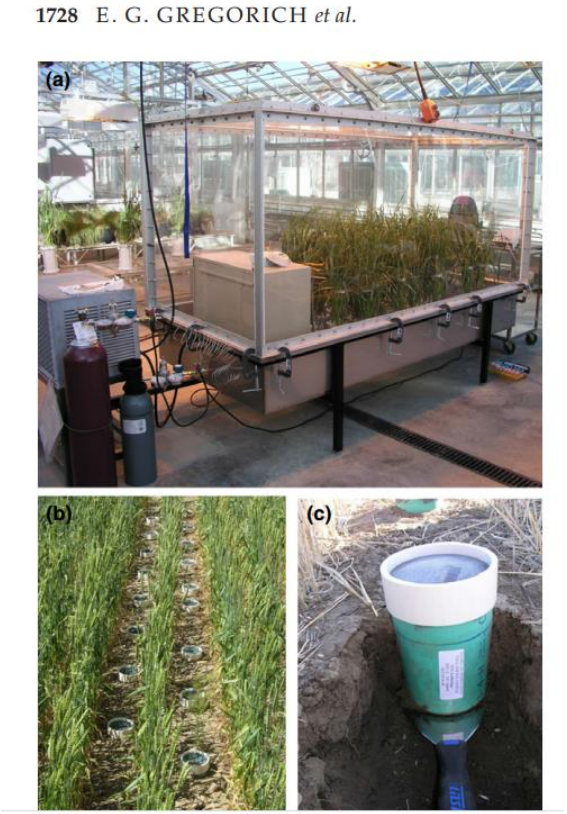


Fig. 4 | Response of SOM fractions to climate change. a–c, Estimated topsoil SOC stock changes by land cover (**b**), and their geographical distribution in POM (**a**) and MAOM (**c**) across the European Union and United Kingdom by 2080. In **a** and **c**, the SOC changes are calculated using temperature and precipitation projections of three downscaled general circulation models under the RCP8.5 scenario. Cumulative SOC stock changes in POM and MAOM (**b**) are aggregated for four land cover classes (FR, forest; CR, cropland; GR, grassland; SH, shrubland). Error bars represent the standard deviation based on future climate variability. In **b**, the relative cumulative C changes compared with those of the actual pools are −20% (FR), −6% (CR), −17% (SH) and +2% (GR) for POM, and −6% (FR), −11% (CR), −10% (SH) and −8% (GR) for MAOM.

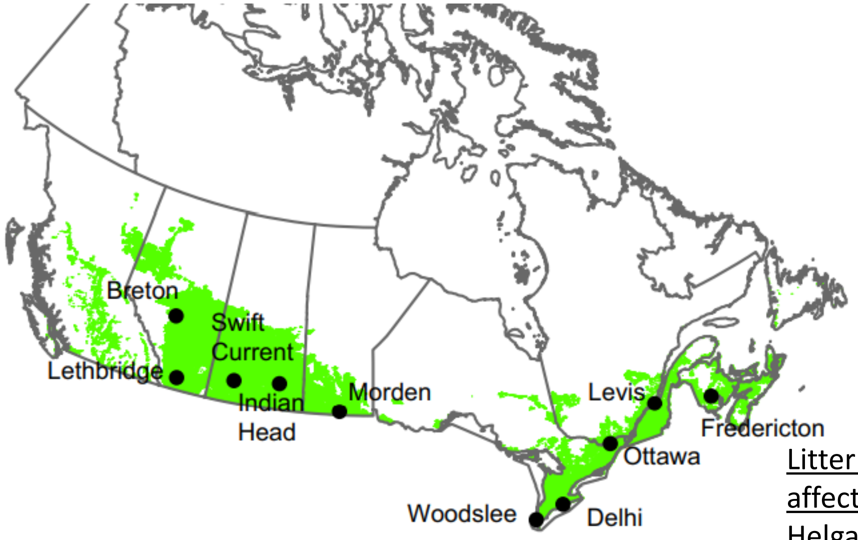
Results confirmed by Canadian scientists





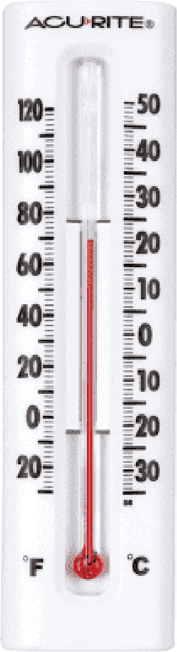
Increasing global temperature defeats soil C capture.

"Our study demonstrates an overriding predominance of temperature in governing the rate of residue decay, superseding that of extreme differences in soil properties and moisture in temperate climates across southern Canada."



Litter decay controlled by temperature, not soil properties, affecting future soil carbon EG Gregorich, H Janzen, BH Ellert, BL Helgason, B Qian, BJ Zebarth, ...
Global Change Biology 23 (4), 1725-1734

Keep soil covered and cooler: Eg. Use of cover crops in Ontario organic corn-soy-wheat system



3Gen Organics
Family Farm Fresh

Faidherbia albida

Reverse phenology: the tree sheds its leaves in the rainy season and goes dormant, reducing competition for light and water while providing valuable nitrogen-rich litter that is also good fodder. (ICRAF).


7
N
14.01
Nitrogen

Chloe MacLaren

Swedish University of Agricultural Science

Verified email at slu.se

Plant ecology agroecology biodiversity

ARTICLES nature sustainability

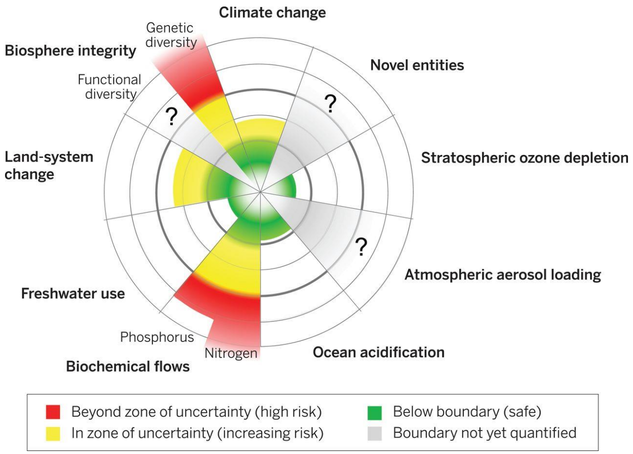
https://doi.org/10.1038/s41893-022-00911-x

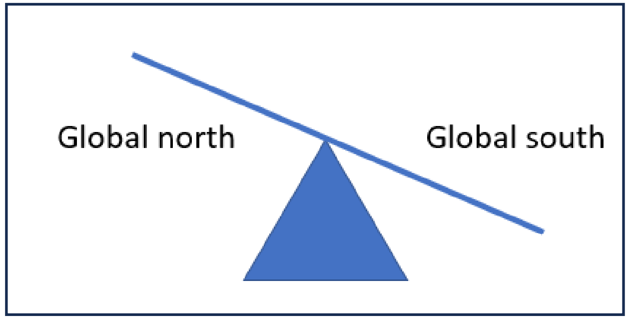
Check for updates

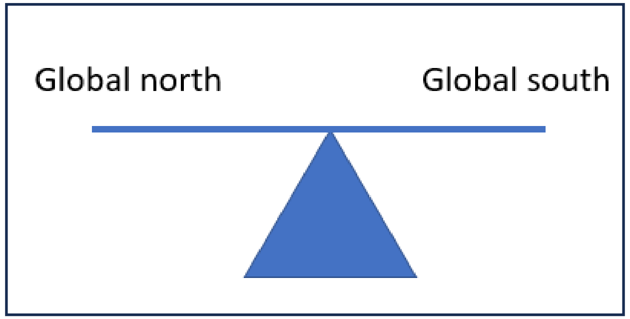
Long-term evidence for ecological intensification as a pathway to sustainable agriculture

Chloe MacLaren[1,2], Andrew Mead[3], Derk van Balen[4], Lieven Claessens[4,5], Ararso Etana[6], Janjo de Haan[4], Wiepie Haagsma[4], Ortrud Jäck[7], Thomas Keller[6,8], Johan Labuschagne[9],

"We show that ecological intensified (EI) practices such as crop rotation, legumes in rotation, manure additions have a largely substitutive interaction with N fertilizer, so that EI practices substantially increase yield at low N fertilizer doses but have minimal or no effect on yield at high N fertilizer doses".



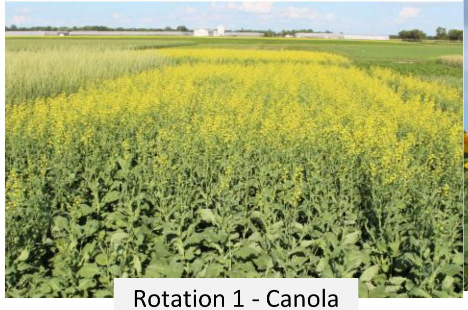




This supports Foley et al. (2011) and Springmann et al. (2018) who both suggest that if fertilizer use is reduced where it is currently high, then fertilizer use could be increased where it is currently low without exceeding planetary boundaries.

Foley, J. A. et al. Solutions for a cultivated planet. Nature 478, 337–342 (2011).
Springmann, M. et al. Options for keeping the food system within environmental limits. Nature 562, 519–525 (2018).

Rotation System	Trt & Code	2019 (year 1)	2020 (year 2)	2021 (year 3)	2022 (year 4)
Conventional rotation system (control)	1a	Wheat	Soybean	Wheat	Canola
	1b	Soybean	Wheat	Canola	Wheat
	1c	Wheat	Canola	Wheat	Soybean
	1d	Canola	Wheat	Soybean	Canola
High-risk, potential high reward innovative system	5a	Corn	Pinto Beans	Canola	Sunflower
	5b	Pinto Beans	Canola	Sunflower	Corn
	5c	Canola	Sunflower	Corn	Pinto Beans
	5d	Sunflower	Corn	Pinto Beans	Canola
Biodiverse rotation (50% N fertilizer reduction)	6a	Fababean/pea/oat GM	Fall rye with cover crop	Corn/soybean intercrop	Pea/Canola (Peaola) intercrop
	6b	Fall rye with cover crop	Corn/soybean intercrop	Pea/Canola (Peaola) intercrop	Hairy vetch/barley GM
	6c	Corn/soybean intercrop	Pea/Canola (Peaola) intercrop	Hairy vetch/barley GM	Fall rye with cover crop
	6d	Pea/Canola (Peaola) intercrop	Fababean/pea/oat GM	Fall rye with cover crop	Corn/soybean intercrop
Perennial grain rotation	7a	Kernza (est. 2018)	Kernza	Kernza	Kernza
	7b	Soybean	Wheat	Canola	Kernza (est. 2021)
	7c	Wheat	Canola	Kernza (est. 2020)	Kernza
	7d	Canola	Kernza (est. 2019)	Kernza	Kernza
Organic system	Org	Millet	Hairy vetch/barley	Wheat	Fall Rye



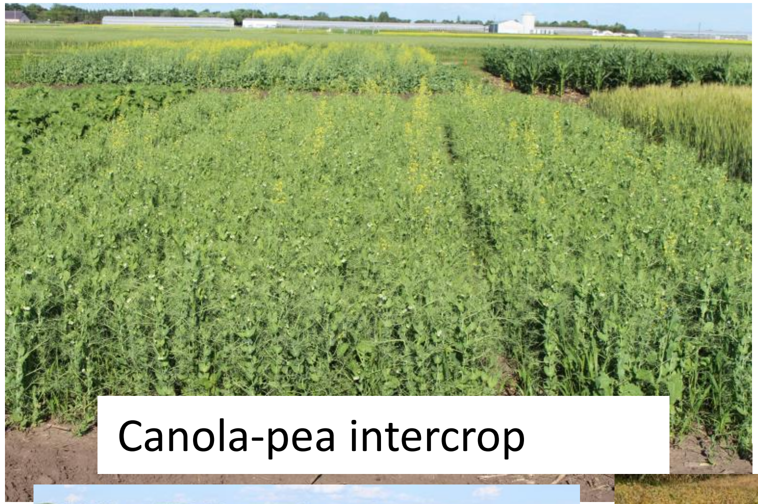
Rotation 1 - Canola


Rotation 6 – Corn/Soy Intercrop

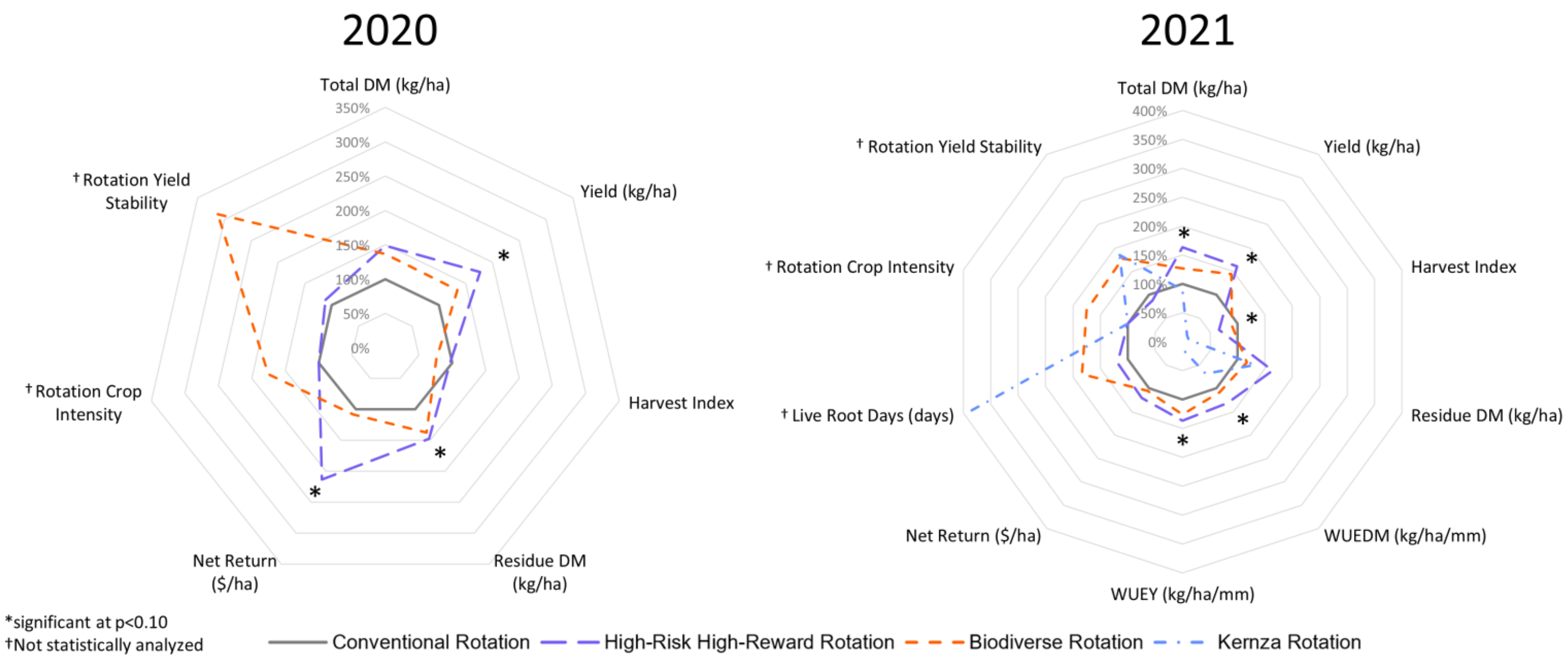


Org Rotation – Hairy Vetch GM & Mulch


Katherine Stanley, Research Associate



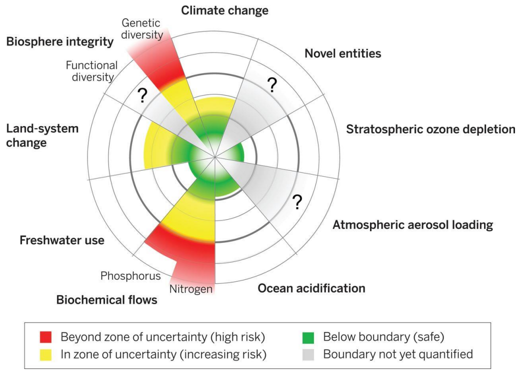
Average Relative Difference Between Base (Conventional) Rotation & Alternative Rotations



Sam Curtis, Water monitoring

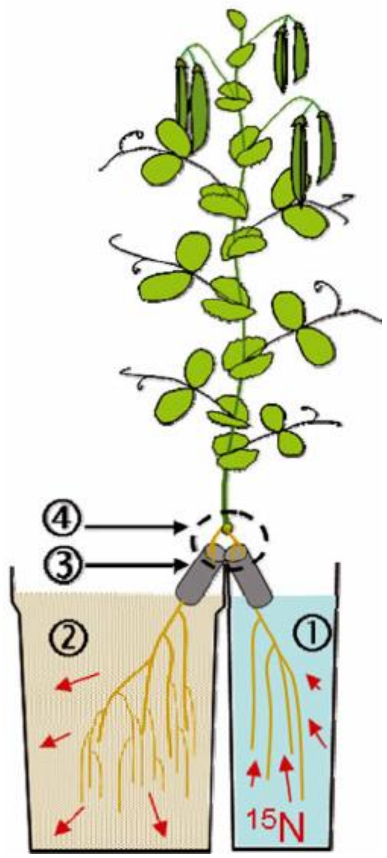
23

Legume-brassica intercrops



Jensen (1996) found barley gets <u>19%</u> of its N from intercropped pea when grown together for 70 days.

Sawatsky and Soper (1991) observed significant amounts of N deposited into the rhizosphere by pea.



Canola-pea intercrop research, 1990

Waterer, J.G., Vessey, J.K., Stobbe, E.H. and Soper, R.J., 1994. Yield and symbiotic nitrogen fixation in a pea-mustard intercrop as influenced by N fertilizer addition. *Soil Biology and Biochemistry*, *26*(4), pp.447-453.

Canola-pea intercrop research, 2020

Fig. 1. Locations of all intercropping experiments that were retrieved from the literature, together with global aridity data in the background. Point size indicates the number of intercrops that were associated to each experimental site. The aridity index increases in humid environments, and decreases in arid environments. The experiments span the globe and include various climates.

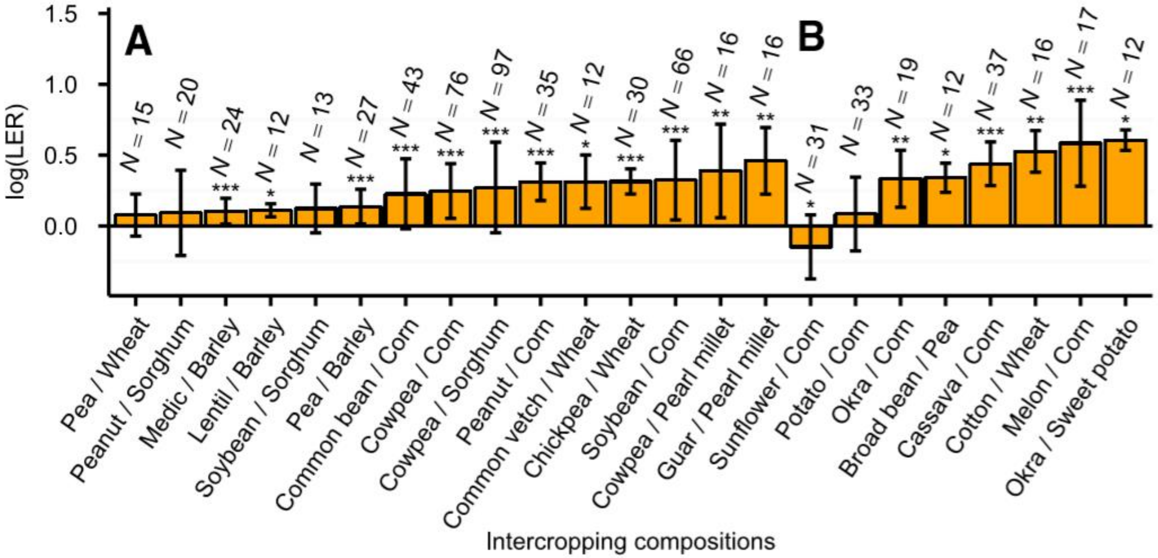
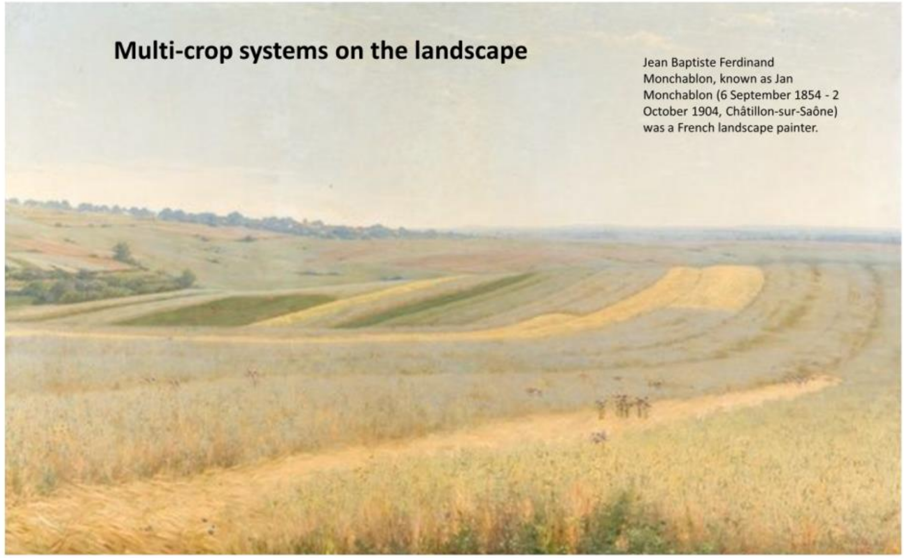


Fig. 3. Average land equivalent ratio (LER) for all distinct intercropping compositions with >10 occurrences in the dataset. A = legume/non legume; B = other intercropping compositions. LER is log-transformed, meaning that positive values represent beneficial intercrops. Even though there is great variability within- and between- compositions, most (18 of the 23) have a clear potential for land sparing. Presence of a legume/non-legume interaction does not seem to influence intercropping performance. Error bars are standard deviation. Above each column, the number of intercrops having each composition is indicated, as well as the result of a conservative Wilcoxon signed-rank test with Bonferroni correction of the significance thresholds. Significance levels are: * $P < 0.002$; ** $P < 0.00004$; *** $P < 0.000004$.

So, what does this mean for Plant Scientists?

- Photosynthesis a priority for C capture. Focus on season long growth, roots and perennials
- Embrace new models for biodiversity of production
- Conduct field-based research at 50% of current N inorganic fertilizer rates
- Conduct your research in multispecies production
  - Because of less fertilizer N, legume intensification needed



JAN-MONCHABLON (Jean Ferdinand MONCHABLON, dit) Les avoines,1886 ~ Oats

Soil pH

Acidic soils called real threat for Prairies

Retired agronomist worries low pH soil could soon become a major headache due to zero tillage and increased nitrogen use

BY ROBERT ARNASON
WINNIPEG BUREAU

Nearly two dozen counties in Montana have problems with acidic soils and a few farmers in the state have bought lime spreaders to increase the pH of their soils.

"(They) growers have seen tremendous yield losses due to acidity and spreading lime has shown great benefits," said Manbir Rakkar, an assistant research professor in Land Resources and Environmental Sciences at Montana State University.

"Montana growers have spent (about) $55,000 to purchase lime spreaders, showing they take it seriously."

That sort of expenditure isn't commonplace, but many farmers across Montana are worried about acidic soils and researchers are keeping a close eye on the problem.

"Montana State University soil scientists... crop advisers, and producers have now identified fields in 23 Montana counties with locations where the top zero to six inches of soil have pH below 5.5, some as low as 3.8," says a Montana State University website.

A number of those counties are next to Montana's border with Canada. So, it's possible that acidic soils are also a problem in southern Alberta.

But few farmers or soil scientists in Alberta are paying attention, says a retired agronomy research scientist with Alberta Agriculture.

Ross McKenzie is worried that low pH soils could soon become a major headache for prairie farmers. That's because the same factors that cause acidic soils, zero tillage and increased use of nitrogen fertilizer are also present in Alberta.

"I've been retired for nine years, it's something we've been pointing out that people need to be (studying)," McKenzie said a few days before Christmas. "It's not something that (anyone) is working on.... It's an issue right now and it's gradually going to become a greater problem."

Decades ago, experts from Alberta Agriculture monitored the soil pH in the grey soils of northern Alberta, which are naturally more acidic than brown and black soils.

That research and recommendations about managing low pH soils eventually faded away.

It's really a matter of watching your soil... Once you see they're at six or less... the ... cerned you should be... Once you're dropping be... you have to take things more seriously.

ROSS MCKENZIE
RETIRED AGRONOMY RESEARCH SCIENTIST

"Since 2000, there really hasn't been any significant work on acid soils," McKenzie said from his home in Lethbridge.

However, over the last 25 to 30 years, with the shift to reduced tillage and increased rates of nitrogen fertilizer, the soils in Alberta and other parts of the Prairies have likely become more acidic.

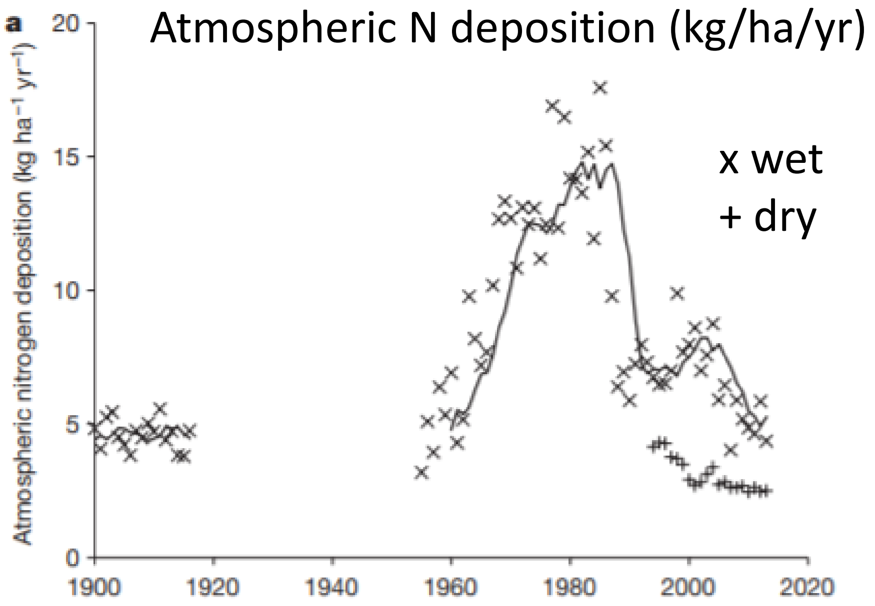
"Really it's a concern for farmers across Western Canada, in my opinion," McKenzie said.

"It's really a matter of watching your soil pH levels. Once you see they're at six or le... concerned you... Once you're drop... then you have t... more seriously."

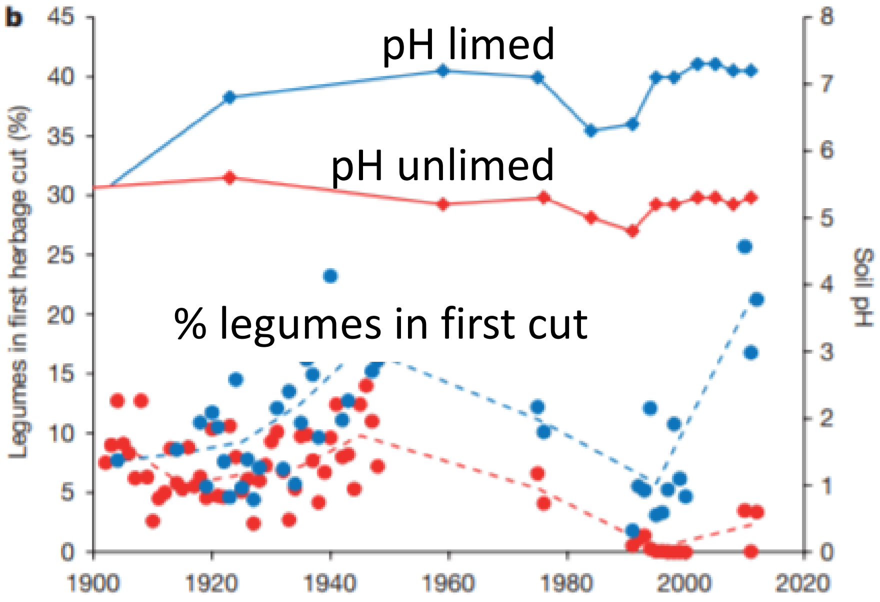
Sometimes, far... pH is a logarithm... ing that a pH of... more acidic than...

"(And) a pH of... more acidic thar... McKenzie said, ... can take a long ... back to neutral.

robert.arnaso...



Evidence from the 160-year-old Park Grass Experiment at Rothamsted Research, that shows a positive response of biodiversity to reducing N addition from either atmospheric pollution or fertilizers.



Storkey, J., Macdonald, A.J., Poulton, P.R., Scott, T., Köhler, I.H., Schnyder, H., Goulding, K.W.T. and Crawley, M.J., 2015. Grassland biodiversity bounces back from long-term nitrogen addition. *Nature*, *528*(7582), pp.401-404.

Organic systems maintain more neutral soil pH

- DOK study in Switzerland, since 1987
- Kellogg study in Michigan, since 1988
- Glenlea study in Manitoba, since 1992
- AAFC Prairie studies (not organic)

<u>pH lower in Conv</u>

Organic 7.46

Conventional 6.47

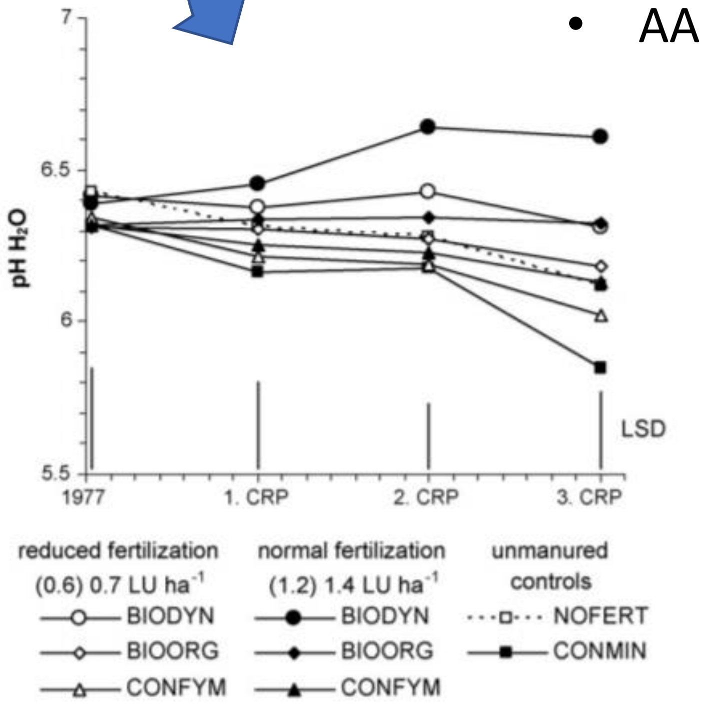
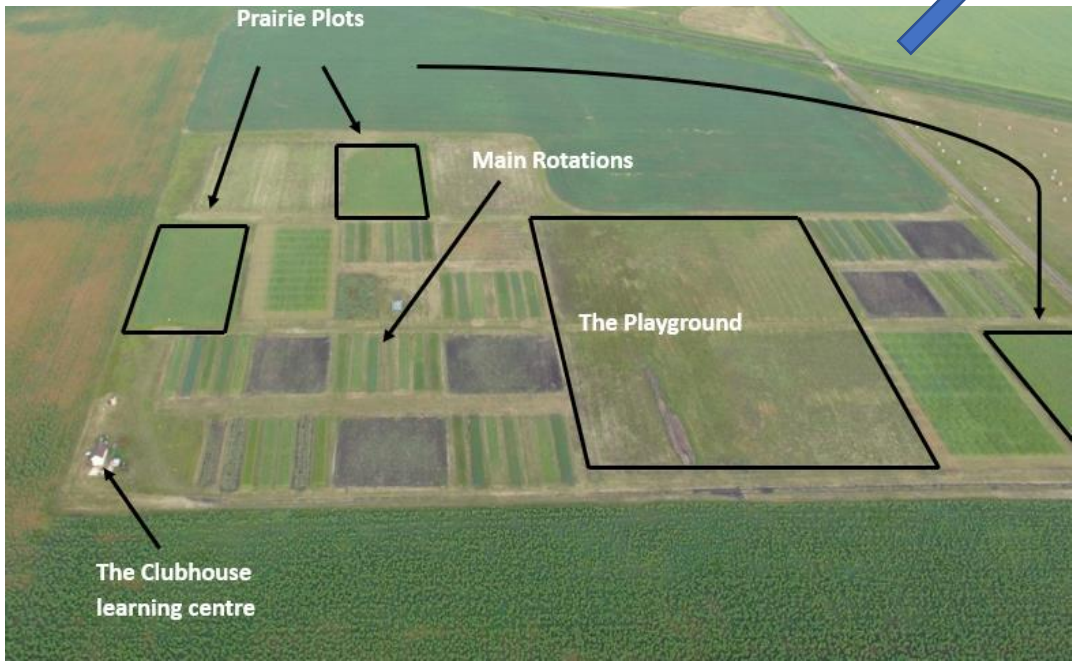
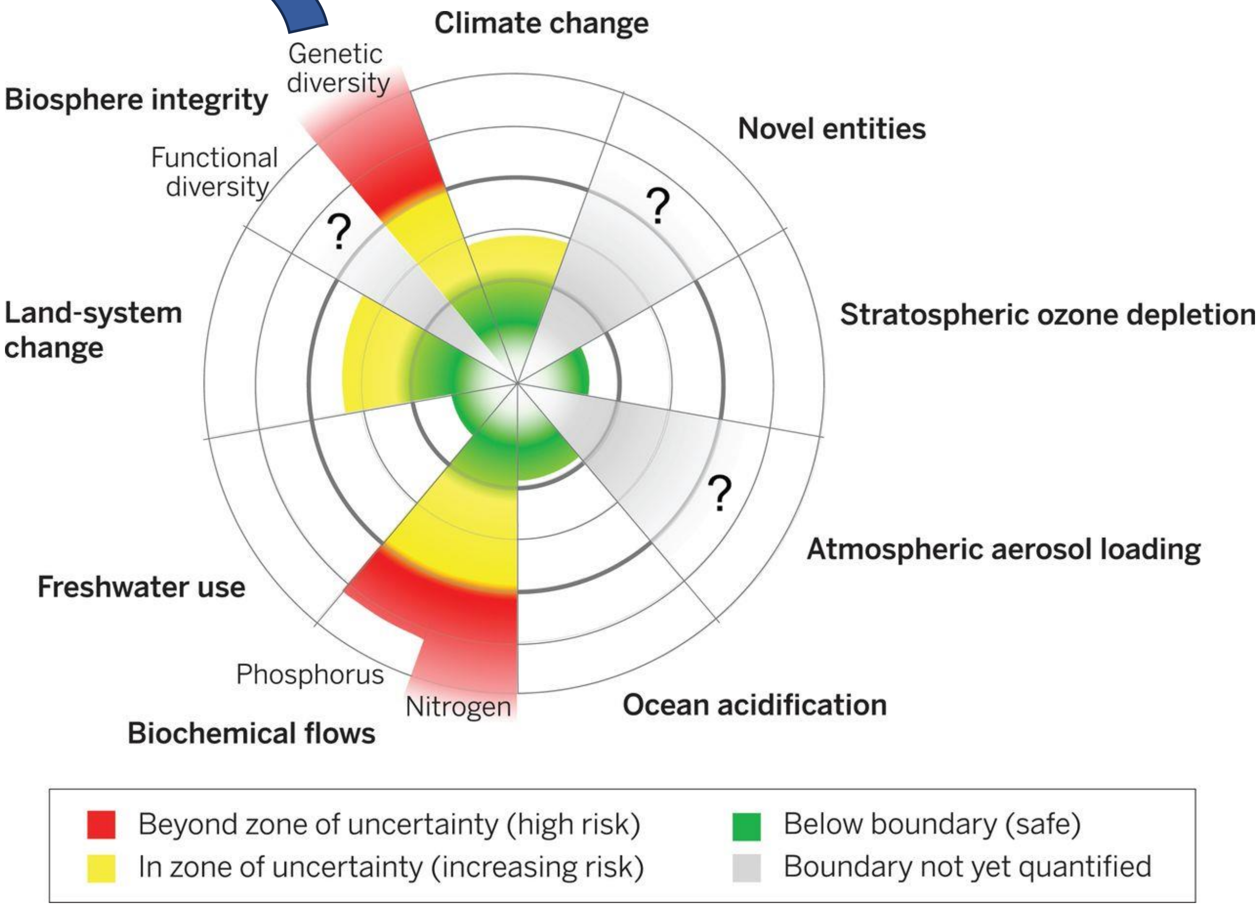


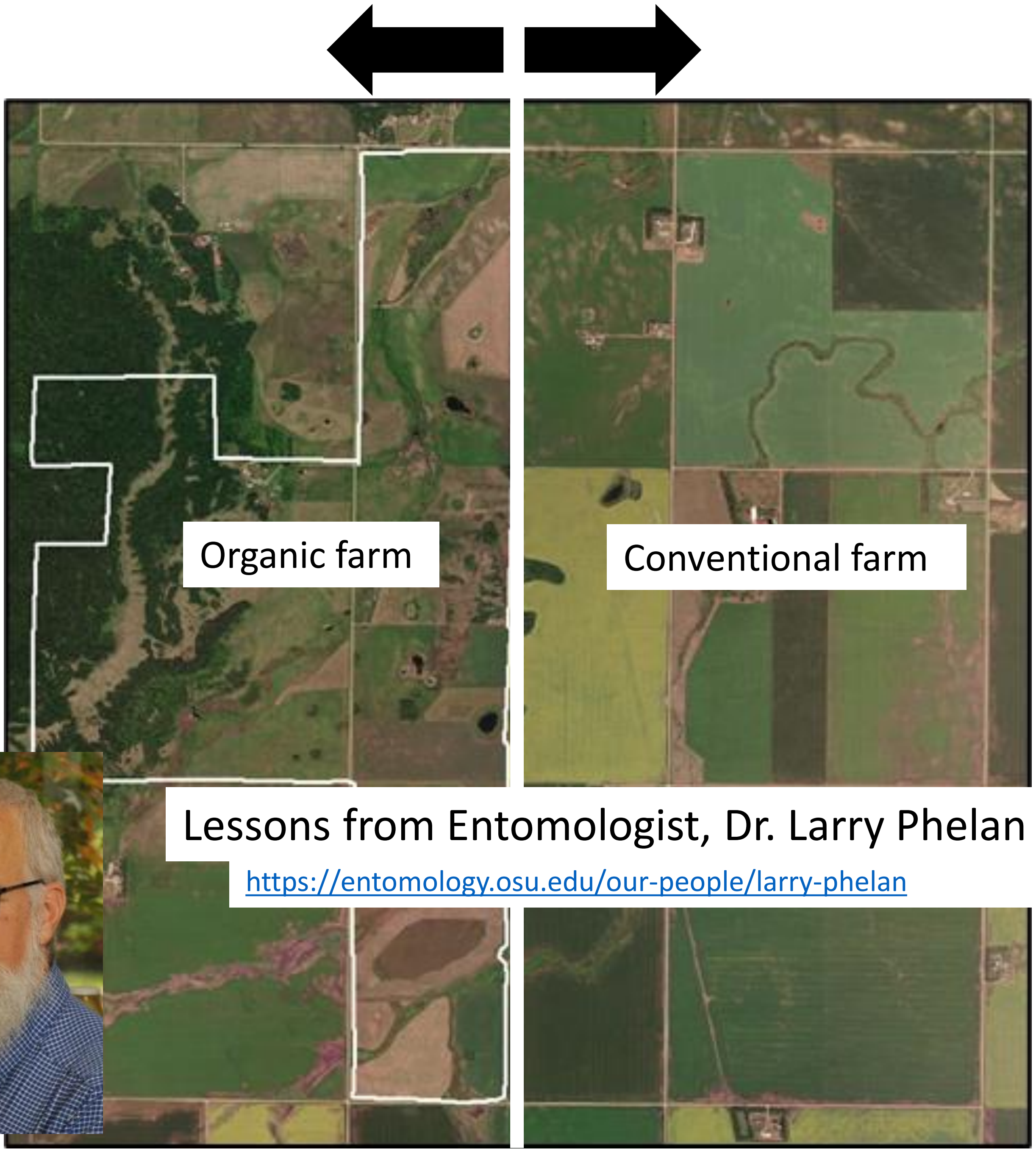
Fig. 4. Average pH (H_2O) values for each crop rotation period (CRP) in comparison to the initial values before the start of the DOK long-term field experiment in 1977. $n = 12$; LSD: least significant difference; LU: livestock units ha^{-1} for the first and second CRP in parentheses and the third CRP.



Agro-Biodiversity



Steffen, W., Richardson, K., Rockström, J., Cornell, S.E., Fetzer, I., Bennett, E.M., Biggs, R., Carpenter, S.R., De Vries, W., De Wit, C.A. and Folke, C., 2015. Planetary boundaries. *Science*, *347*(6223), p.1259855.



Lessons from Entomologist, Dr. Larry Phelan

https://entomology.osu.edu/our-people/larry-phelan

After planting maize (corn), female European corn borers were released into the greenhouse to determine egg-laying preferences. In each of 4 experiments, females consistently laid fewer eggs on corn plants in soil from organic farms than on plants in conventional soil.

Phelan, P.L., 2009. 9 Ecology-Based Agriculture and the Next Green Revolution. SUSTAINABLE AGROECOSYSTEM, p.97.

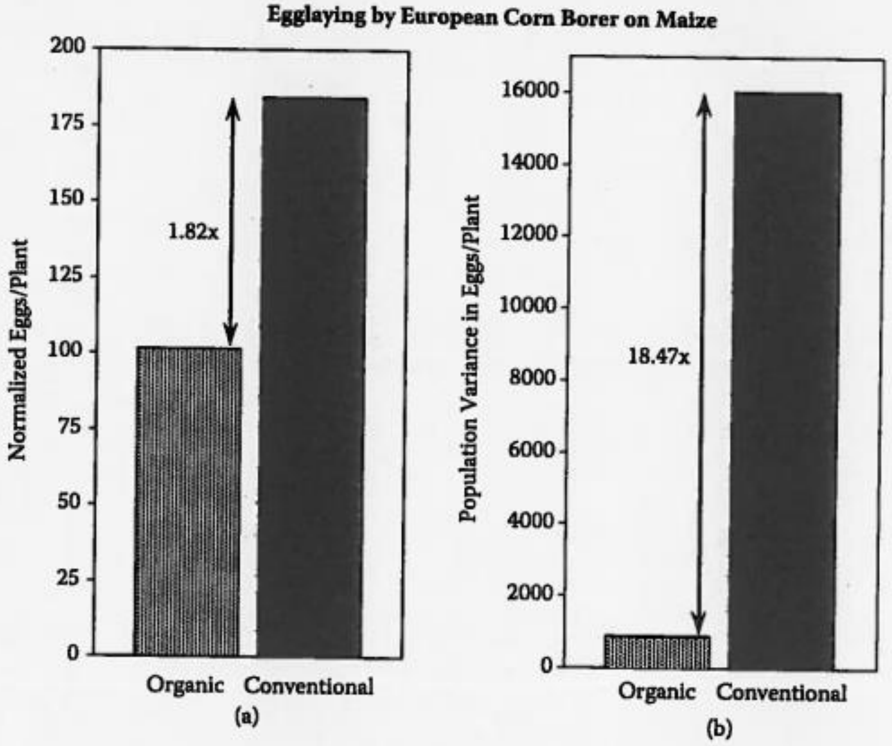


FIGURE 9.2 Meta-analysis of egg laying by *Ostrinia nubilalis*, the European corn borer, on maize planted in the greenhouse in soils collected from neighboring organic or conventional farms. Analysis conducted on results from four replicated factorial experiments with amendments of dairy cow manure, cow manure compost, or chemical fertilizer in each soil type: (a) mean egg laying by soil type across fertilizer treatments, normalized to account for differences in total egg laying among experiments, and (b) variance (sum of squares) in egg laying across fertilizer treatments and experiments.

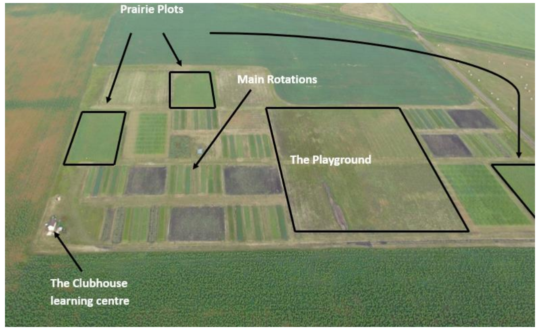
Alyokhin and Atlihan (2005) report that potatoes grown in manure-amended soil were poorer hosts for Colorado potato beetle than potatoes receiving only chemical fertilizer. In a no-choice test, females laid fewer eggs, larvae had lower survivorship to 2nd instar, showed slower development to adult, and consumed less foliage when held on manured plants compared to chemically fertilized plants. Similar patterns were seen in the field, where potato plots fertilized primarily with cow manure had lower densities of Colorado potato beetle than plots receiving only chemical fertilizer (Alyokhin et al. 2005). Potato plants receiving manure were similar in size to chemical-only potatoes, but had higher tuber yields. In support of the mineral balance hypothesis, multiple regression models of leaf-mineral profiles showed strong association with beetle populations, accounting for up to 57 percent of the variation in beetle densities.

Bypassing the detrital food web and maintaining high levels of soil nutrients can also contribute to plant stress by increasing susceptibility to moisture deficits. Because important plant nutrients

Phelan, P.L., 2009. 9 Ecology-Based Agriculture and the Next Green Revolution. SUSTAINABLE AGROECOSYSTEM, p.97.

The nature of nutrient supply matters!

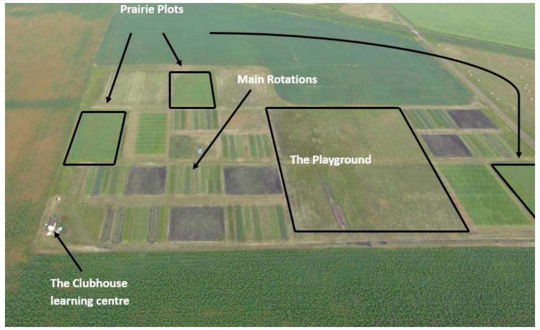
“Biological Soil Fertility”
.....defined by Dr. Lynette Abbott, University of Western Australia



Soil biological soil fertility metrics for the Glenlea long-term study, Manitoba. Data source: The North American Project to Evaluate Soil Health Measurements included 124 sites uniformly sampled across a range of soil health management practices in North America (Soil Health Institute). Glenlea soils sampled in 2019. Other data sources indicated in footnotes.

Cropping System	Total C % (Microbial biomass C)	[2]Potentially mineralizable nitrogen mg N/kg	[3]Water stable aggregates	N-Acetyl β-Glucosaminidase mg pNP kg^{-1} soil hr^{-1}	Phosphomonoesterase (alkaline buffer) mg pNP kg^{-1} soil hr^{-1}	Arylsulfatase	[4]AMF total colonization
Prairie	4.4 [1](1750a)	114 b	87.3 a	127	406 ab	148.7 c	77.0
Grain only conventional	4.5 (1179c)	141 b	79 bc	148	370 b	132.9 c	32.3
Grain only organic	3.7 (1080d)	124 b	76 c	155	361 b	187.2 bc	49.7
Forage-grain conventional	3.9 (1476 b)	140 b	75.3 c	180	364 b	147.2 c	28.0
Forage-grain organic	4.2 (1648a)	135 b	80 bc	176	538 a	252.2 b	45.0
Forage-grain organic plus manure	4.5 (1718a)	189 a	82.6 a	184	561 a	327.9 a	35.7
P value	0.092 (0.0001)	0.0013	0.0001	0.068	0.0024	0.0001	0.05 [5](0.001)*

[1]Values in parentheses (Braman et al. 2016); [2] PMN: NH4 measured after 7 day anaerobic incubation; [3] AS: Percent of aggregates 1-2mm that remain on 0.25mm sieve; [4]Arbuscular mycorrhizal fungi (AMF) data from Welsh, 2007; [5]Prairie vs arable systems - arable system measured AMF in flax and Prairie system measured AMF in prairie grasses. *In:* Nurturing Canadian agronomy with nature: Theory and practice. 2023. M. H. [1]Entz and M. [1]Van Die, 2023. Paper in review.



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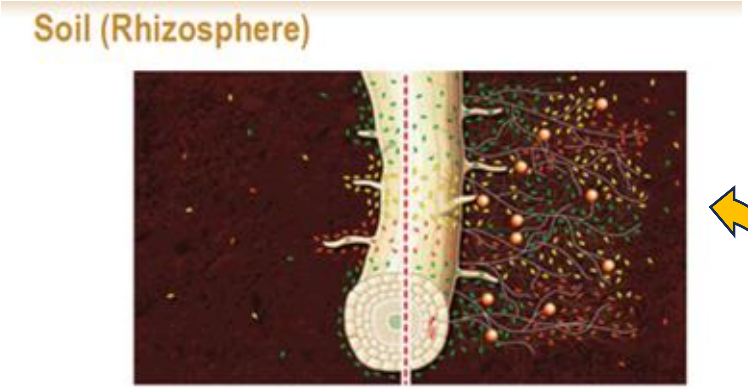
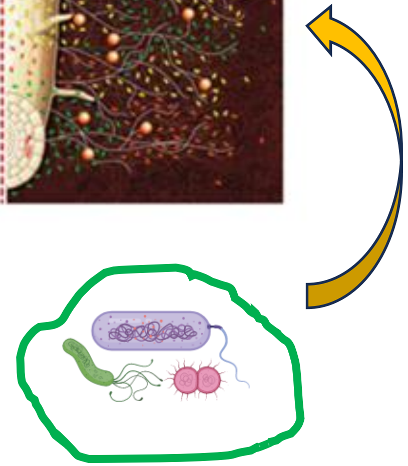
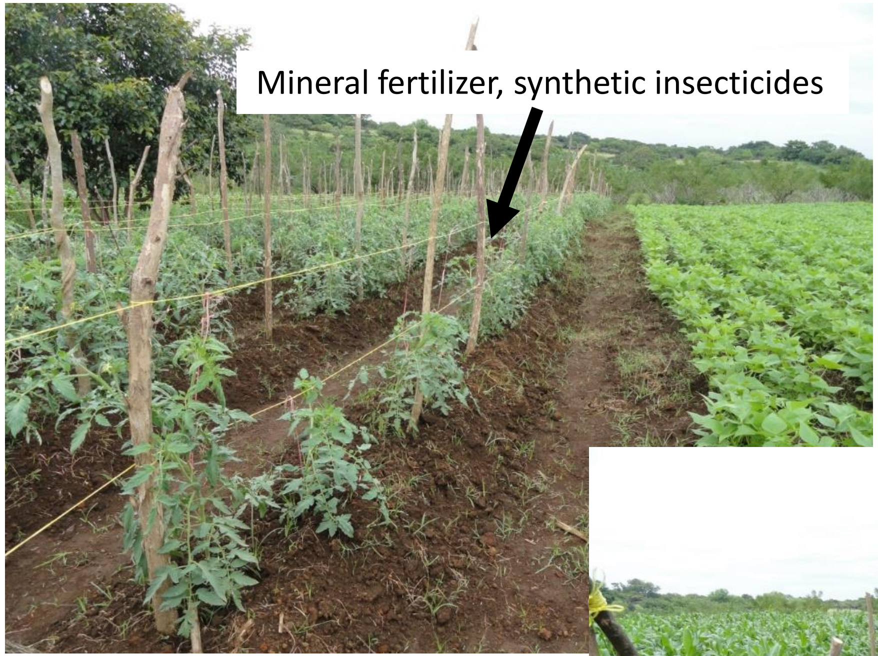
So, what does this mean for Plant Scientists?

- Think about soil microbiome and its effect on nutrient delivery systems to plants.
- Measure "live root days"







Nicaraguan farm family

Organic: Composted manure, cover crop, natural insecticide (neem tree)

Universidad Nacional Autónoma de Honduras

Universidad Nacional Agraria Nicaragua

Community-based Pest Management in Central American Agriculture

Funded by the Canadian International Development Agency (CIDA) through the University Partnerships in Cooperation and Development (UPCD) program.

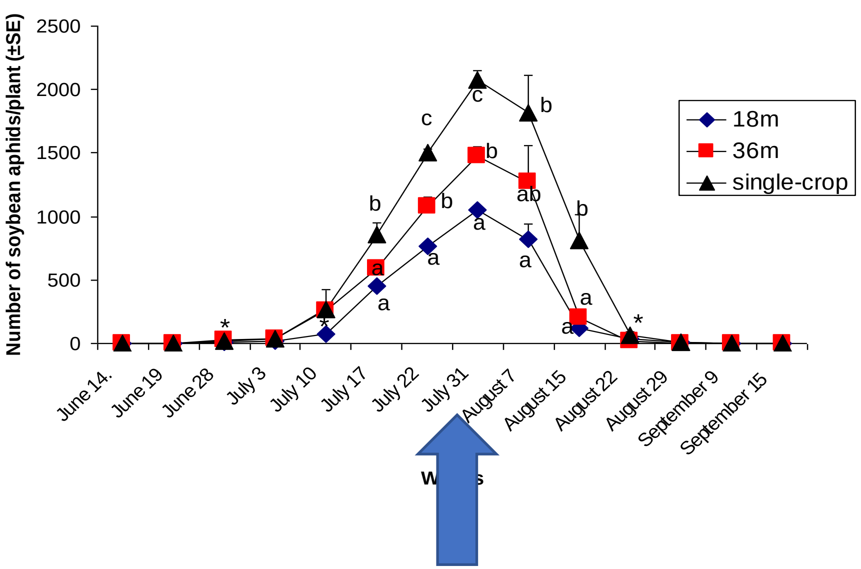
University of Manitoba

Universidad de Costa Rica

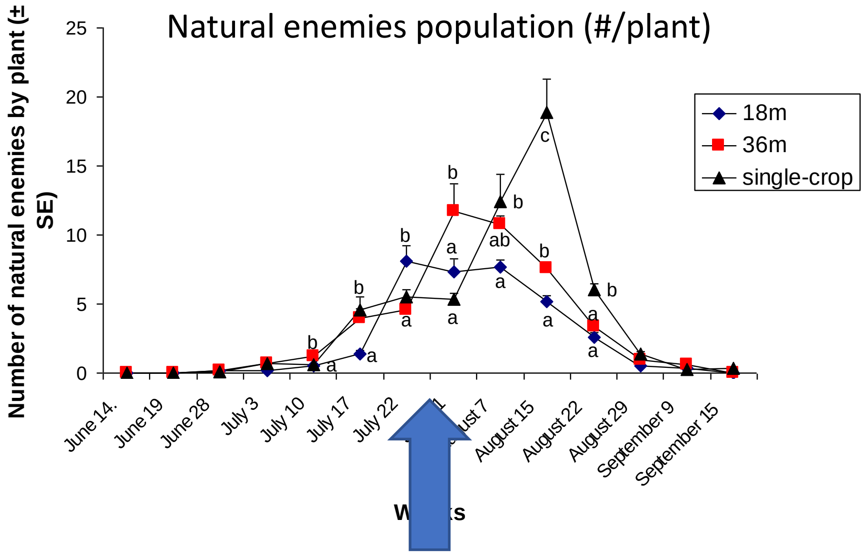
Strip cropping

- 18m/36m strips (200ac)
- Rotation: Corn-Soybeans-Wheat-Fallow
- Prevention of insect pest outbreaks
- Quantified positive effect on insects natural predators diversity

Soybeans aphid pressure (#/plant) in 2008



Natural enemies population (#/plant)



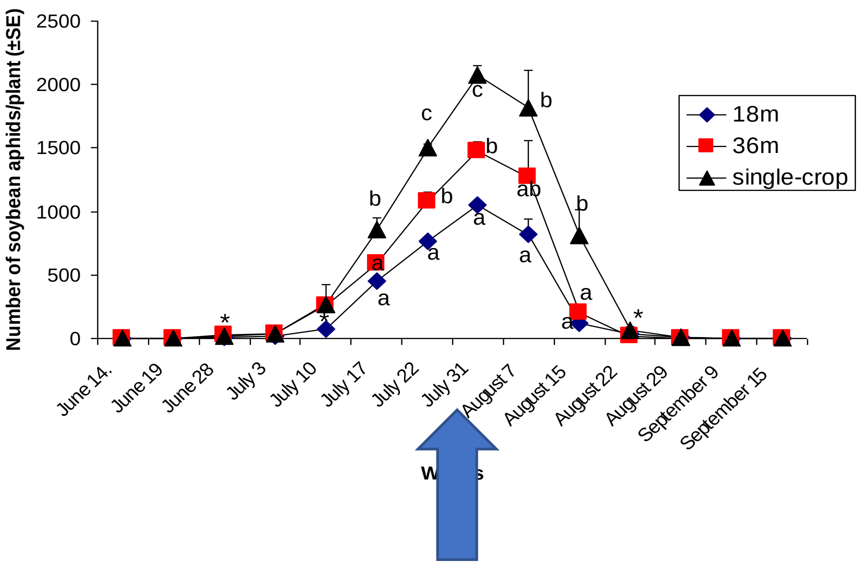
Labrie, G., Estevez, B. and Lucas, E., 2016. Impact of large strip cropping system (24 and 48 rows) on soybean aphid during four years in organic soybean. Agriculture, Ecosystems & Environment, 222, pp.249-257.

Freydier, L. and Lundgren, J.G., 2016. Unintended effects of the herbicides 2, 4-D and dicamba on lady beetles. Ecotoxicology, 25, pp.1270-1277.

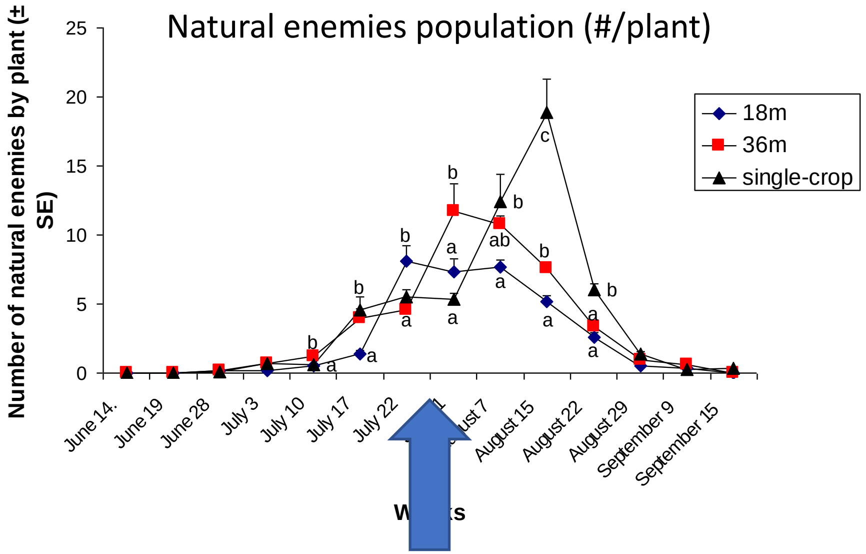
Dr. Jonathan Lundgren, South Dakota

Photo credit: Michelle Carkner

Soybeans aphid pressure (#/plant) in 2008



Natural enemies population (#/plant)



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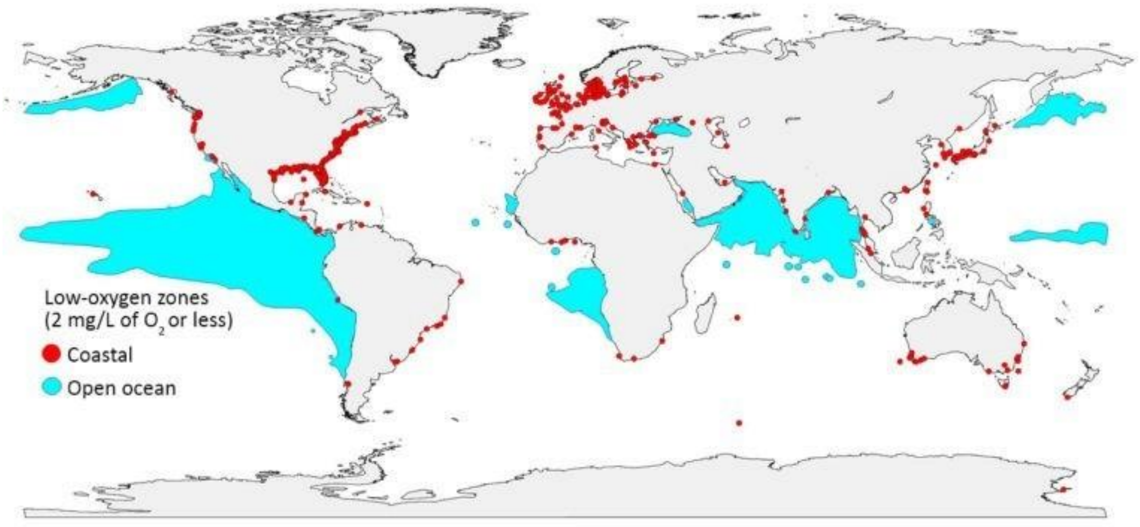
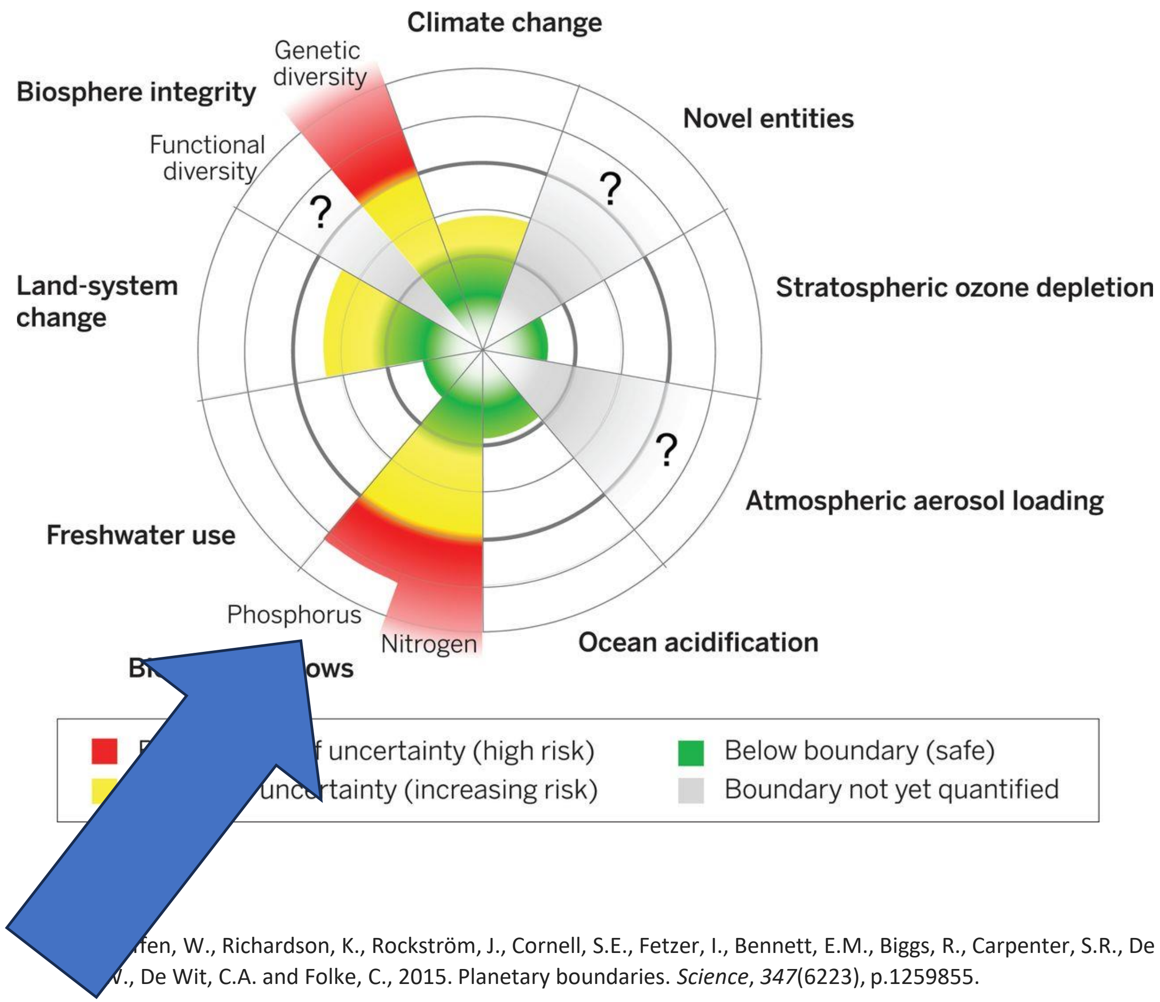
So, what does this mean for Plant Scientists?

- Greater consideration of nutrient supply systems – how do they affect plant growth, development and health
- Design more diverse agroecosystems
- Pesticide-free production systems

Phosphorous can = dead zones





...fen, W., Richardson, K., Rockström, J., Cornell, S.E., Fetzer, I., Bennett, E.M., Biggs, R., Carpenter, S.R., De Vries, ...V., De Wit, C.A. and Folke, C., 2015. Planetary boundaries. *Science*, *347*(6223), p.1259855.

Using recycled P in agriculture that requires “Plant Activation”

Amendments
Photo credit: Jess Nicksy

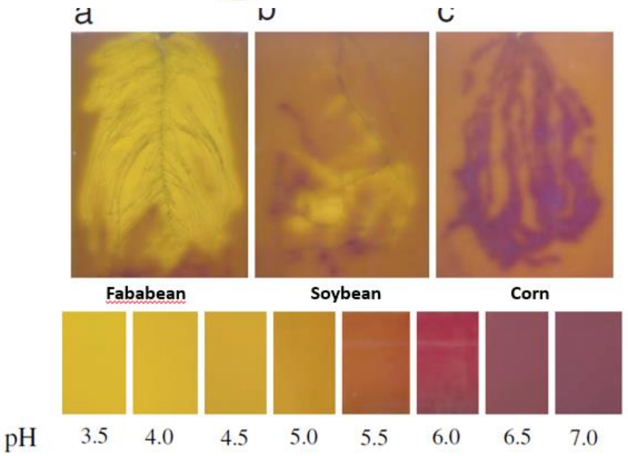
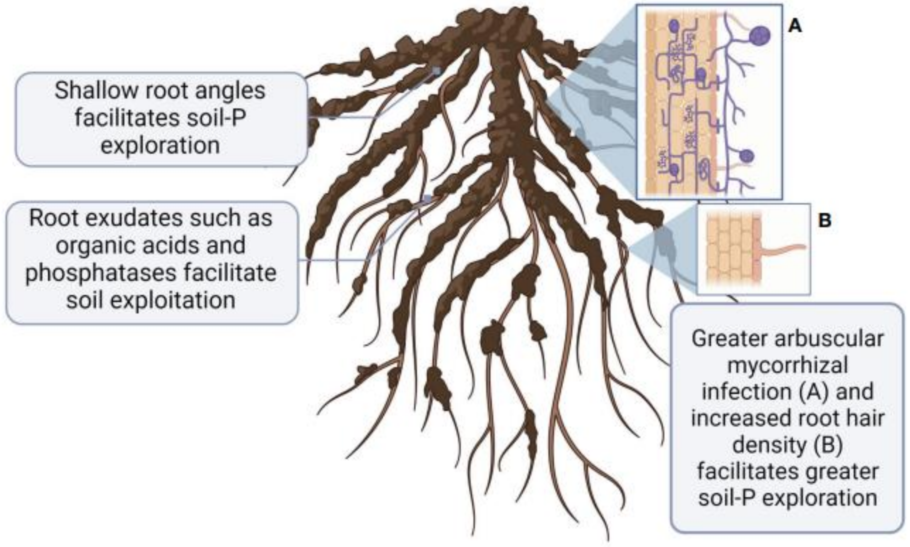


Fig. 2. Visualization of rhizosphere acidification of faba bean (*a*), soybean (*b*), and maize (*c*). The roots were imbedded for 6 h in agar gel containing a pH indicator (bromocresol purple) without P supply (Greenhouse Study 2). Yellow indicates acidification, and purple indicates alkalization.

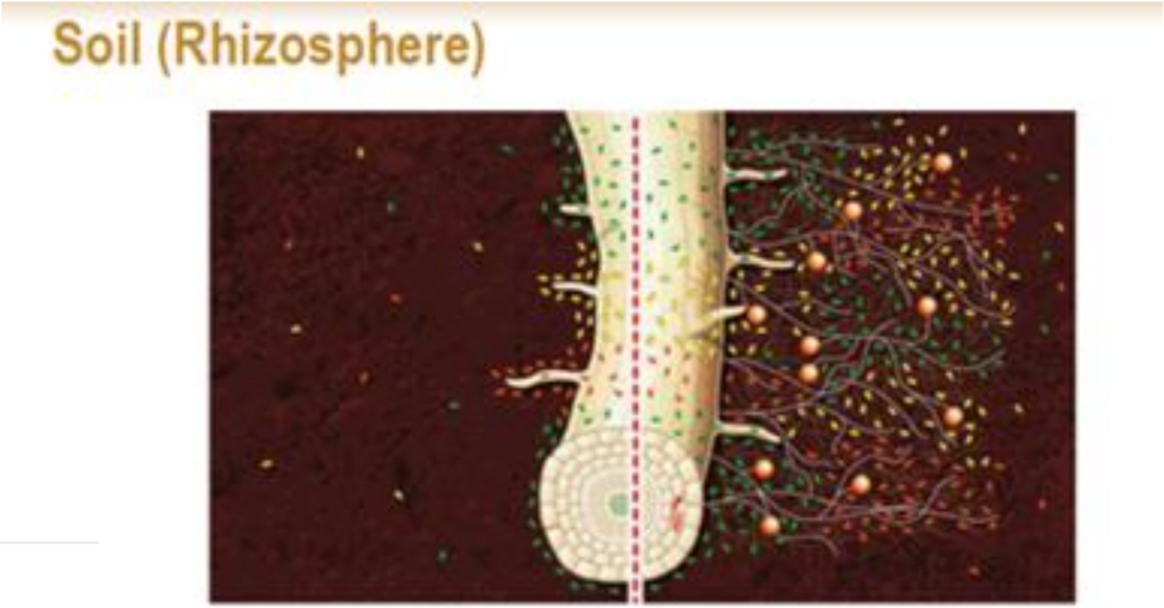


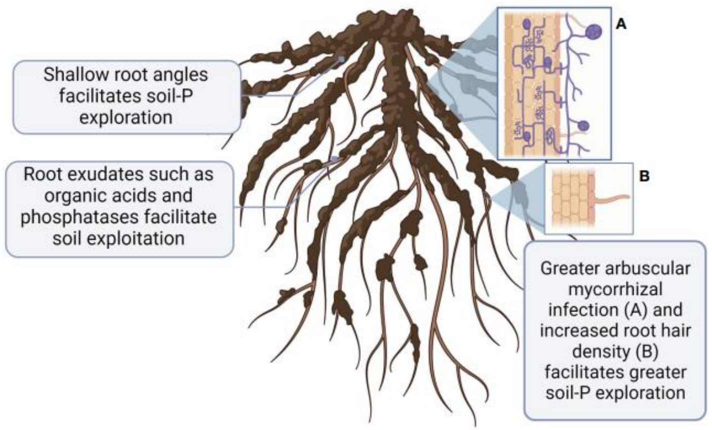
sentation of root characteristics associated with greater P uptake adaptations to low soil P availability. This figure

Carkner, M.K., Gao, X. and Entz, M.H., 2023. Ideotype breeding for crop adaptation to low phosphorus availability on extensive organic farms. *Frontiers in Plant Science*, *14*, p.1225174.

So, what does this mean for Plant Scientists?

- What do we know about the amount and nature of organic acids released by plant roots?

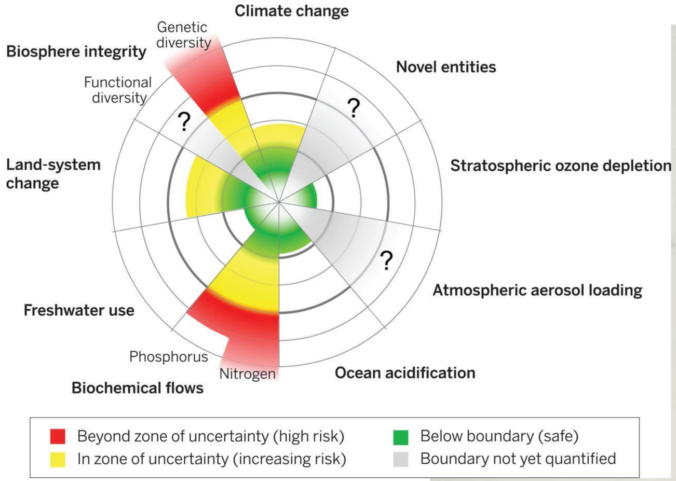


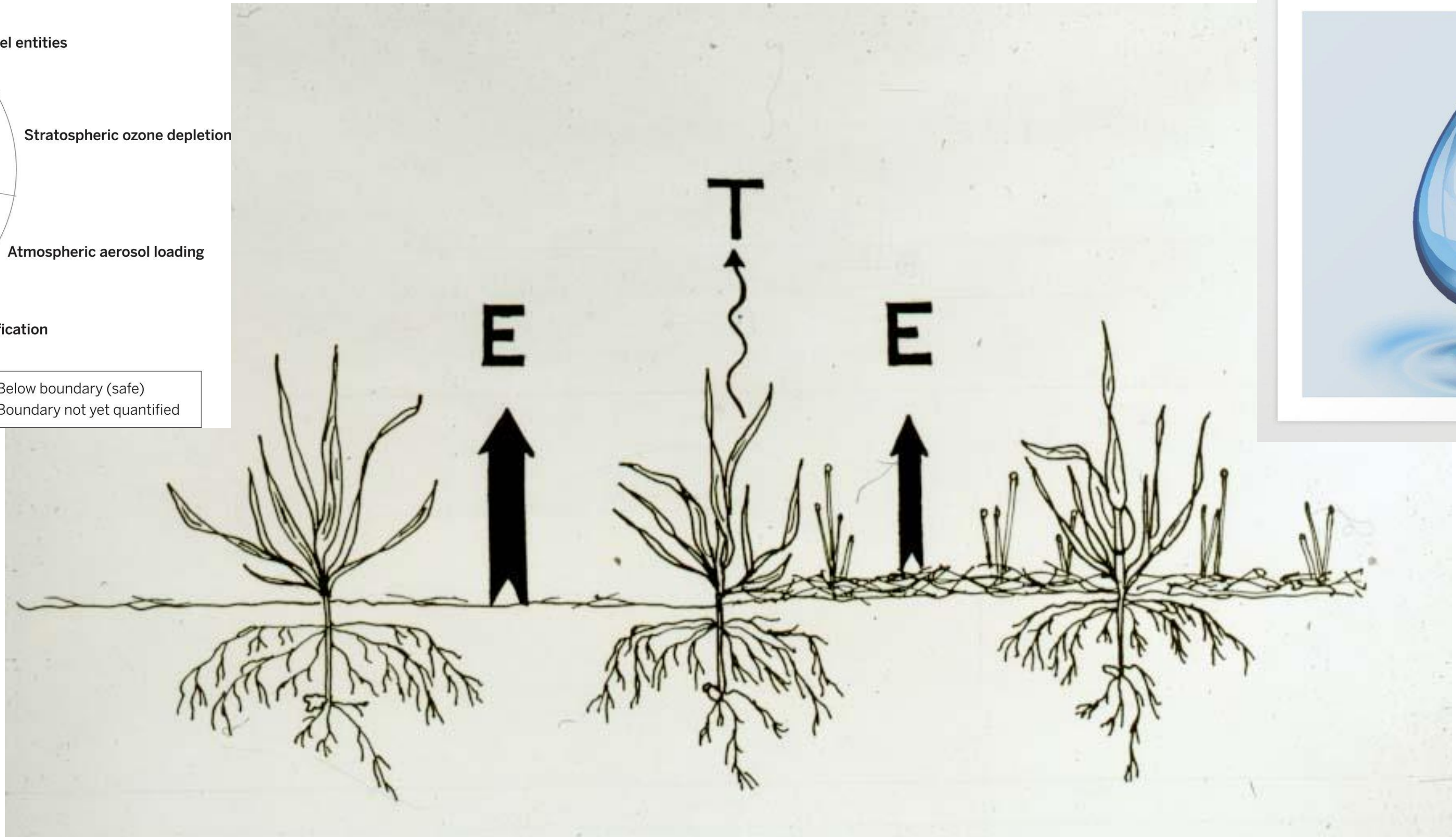


esentation of root characteristics associated with greater P uptake adaptations to low soil P availability. This figure

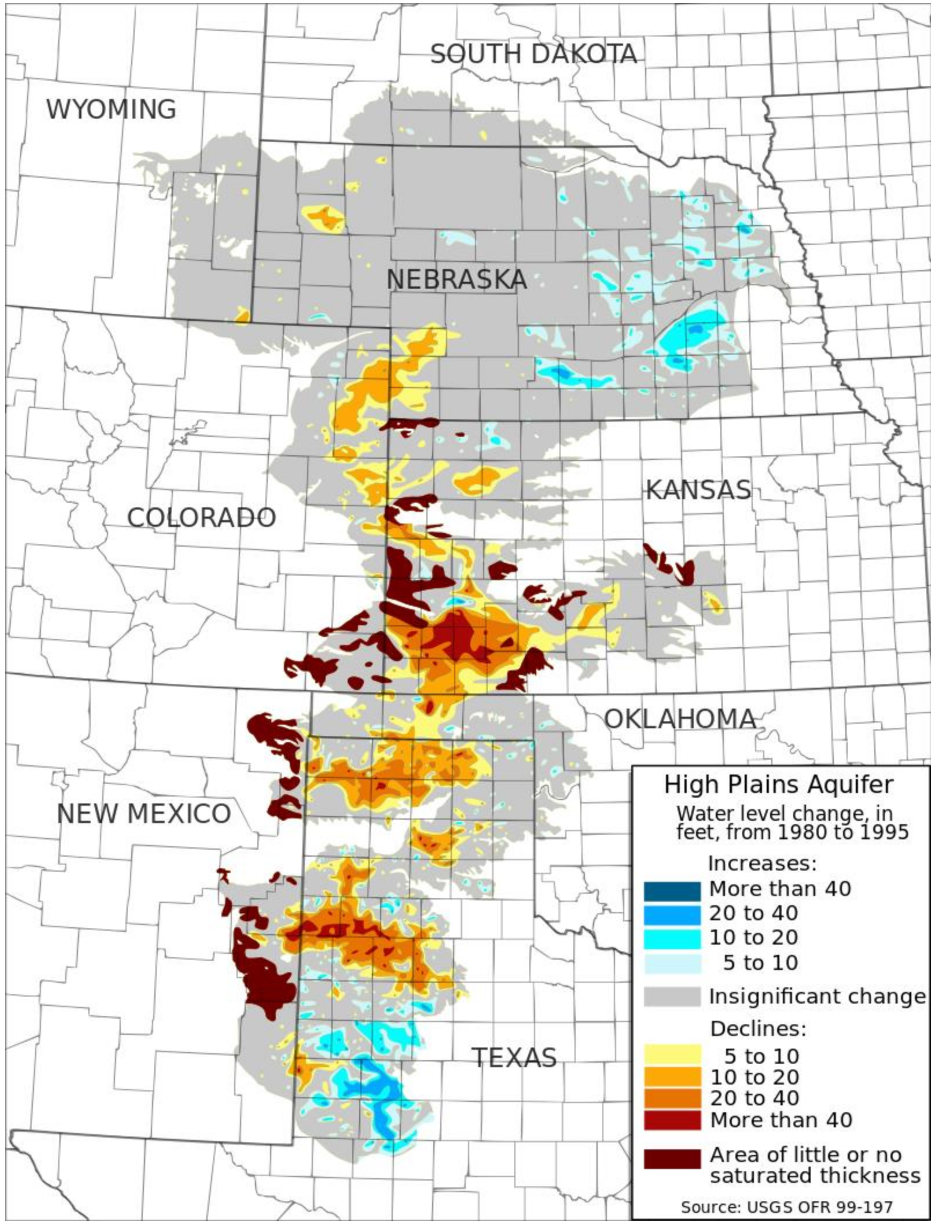
Evapotranspiration = Evaporation + Transpiration

Surface residue increases crop water use efficiency (WUE) by reducing soil evaporation

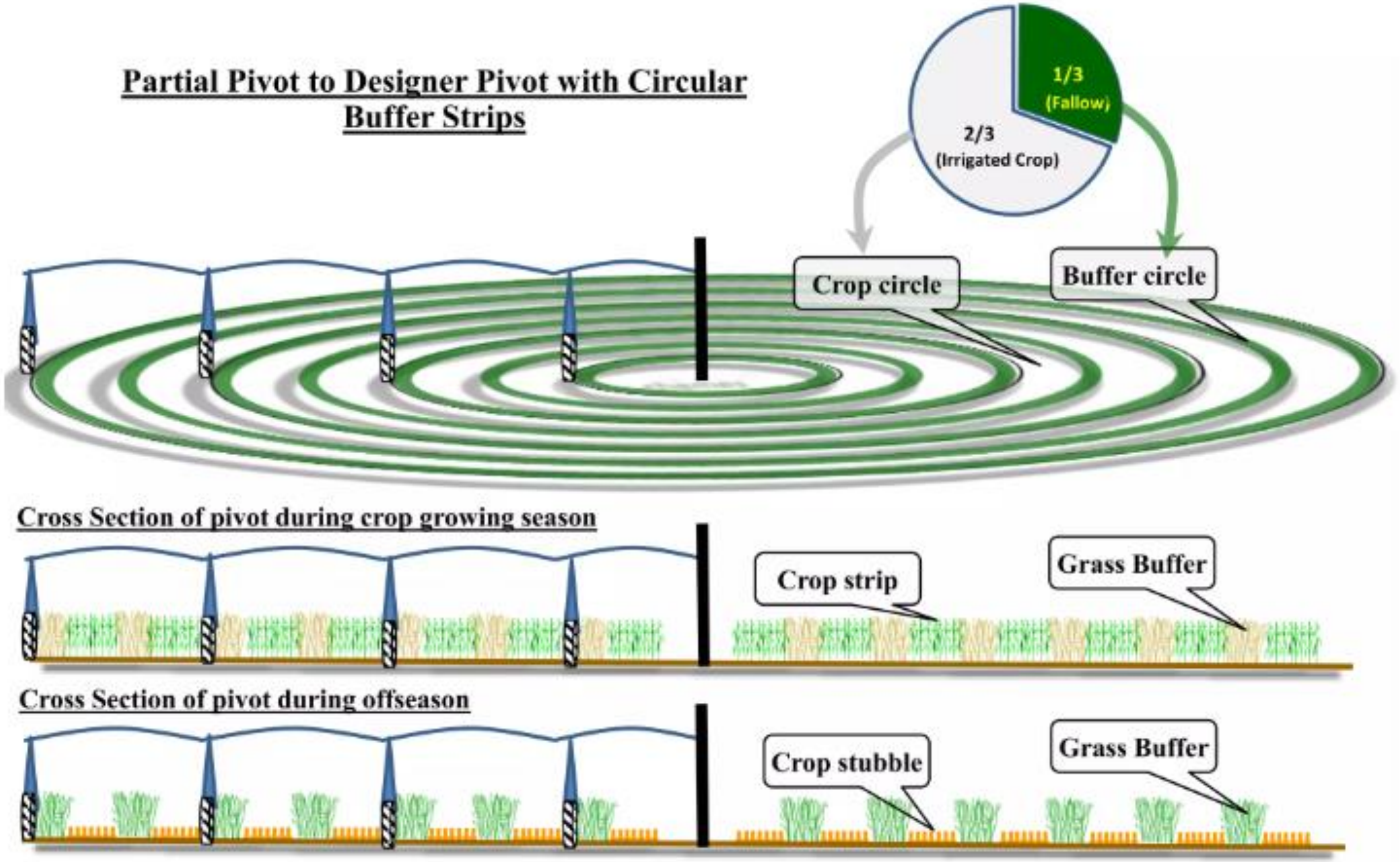


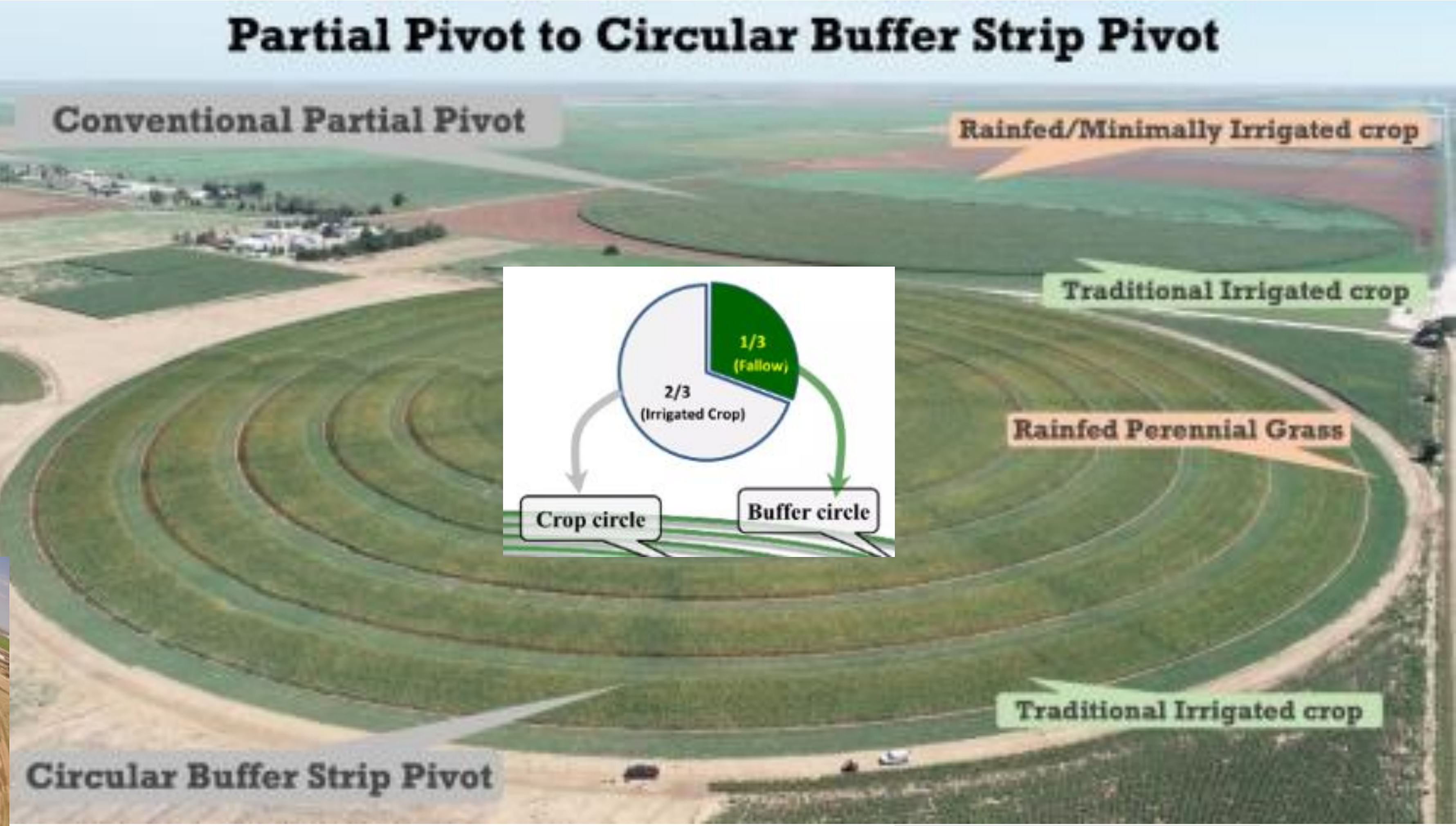


Drawing by Sylvia Borstlap



Partial Pivots:
Can we look this as an opportunity?

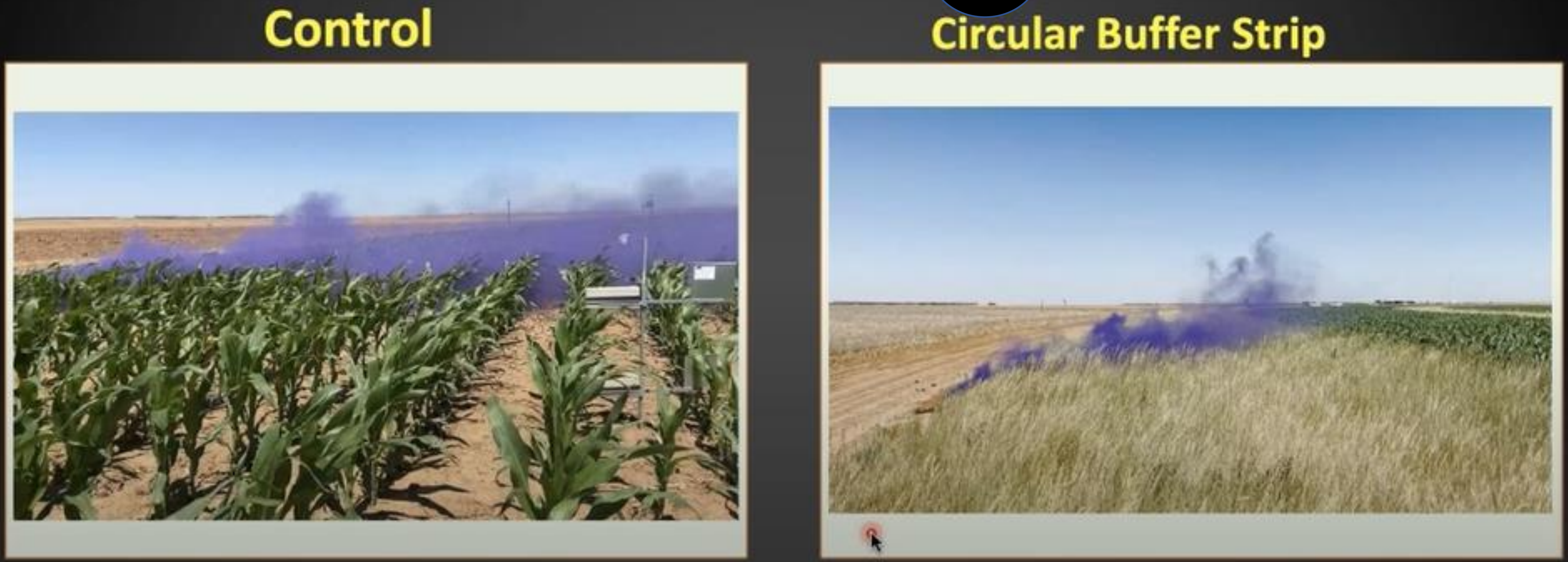


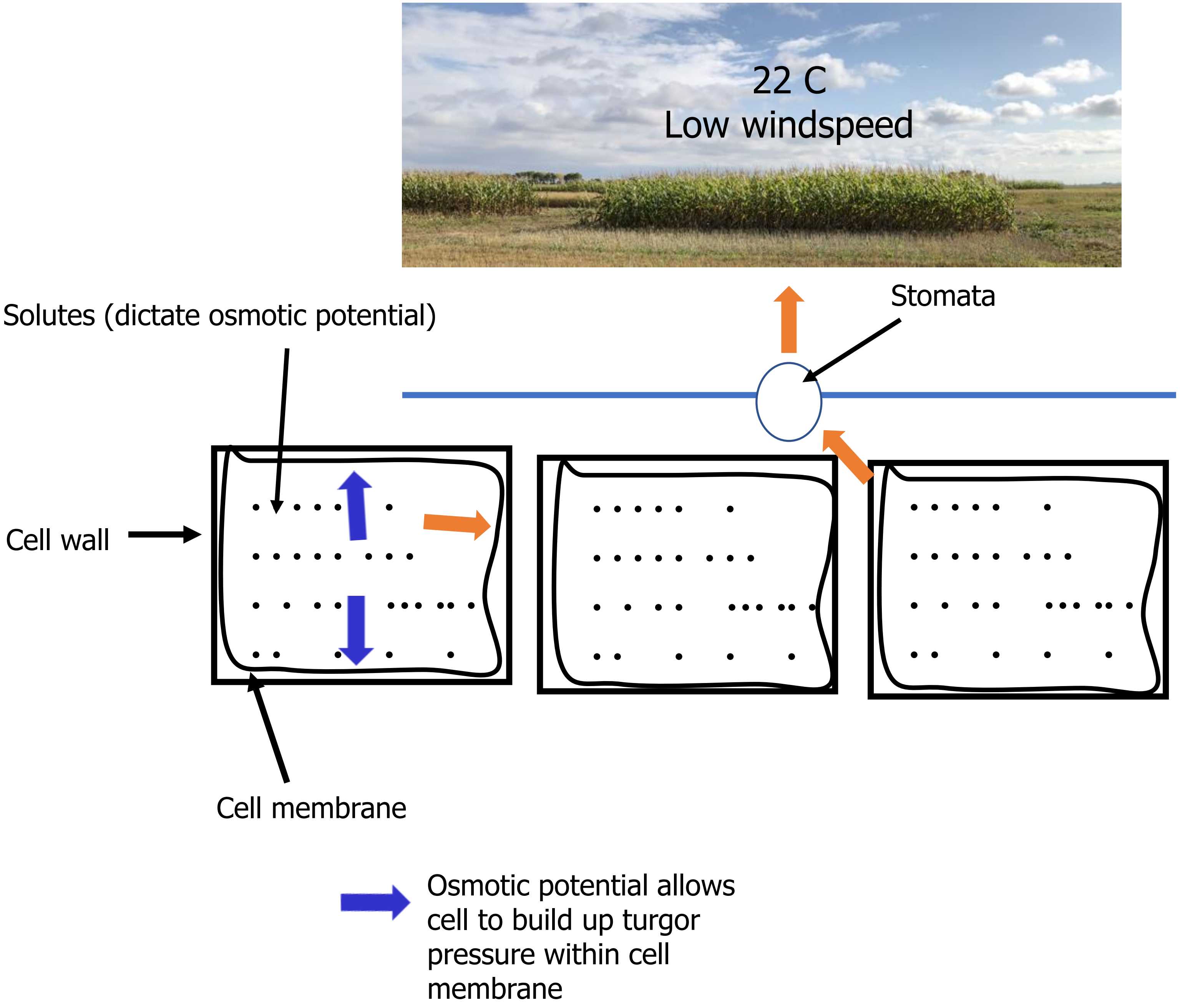


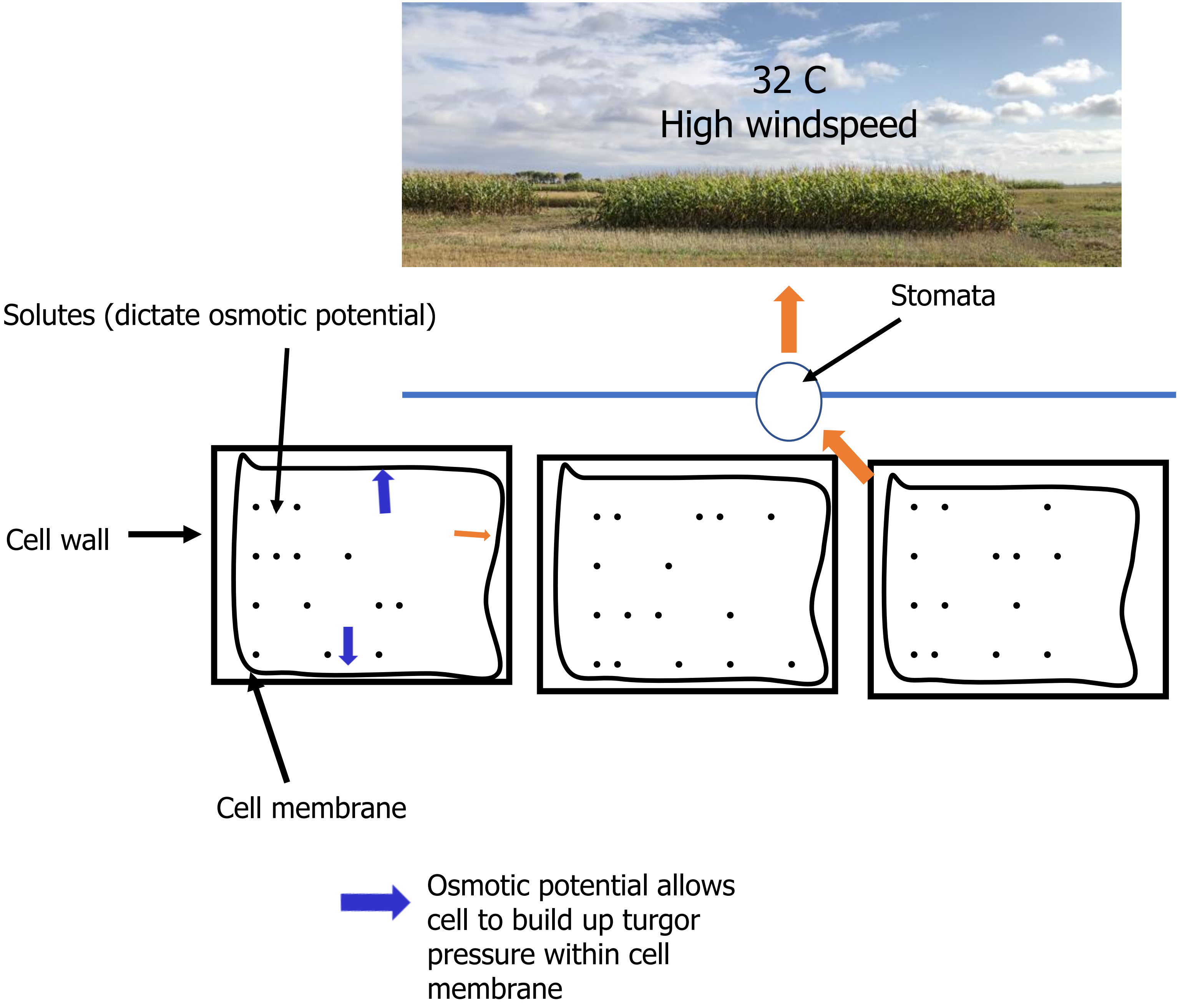
Dr. Sangamesh Angadi

NM STATE UNIVERSITY

Grass strips reduce wind flow through crops, resulting in less evaporative water loss and higher WUE

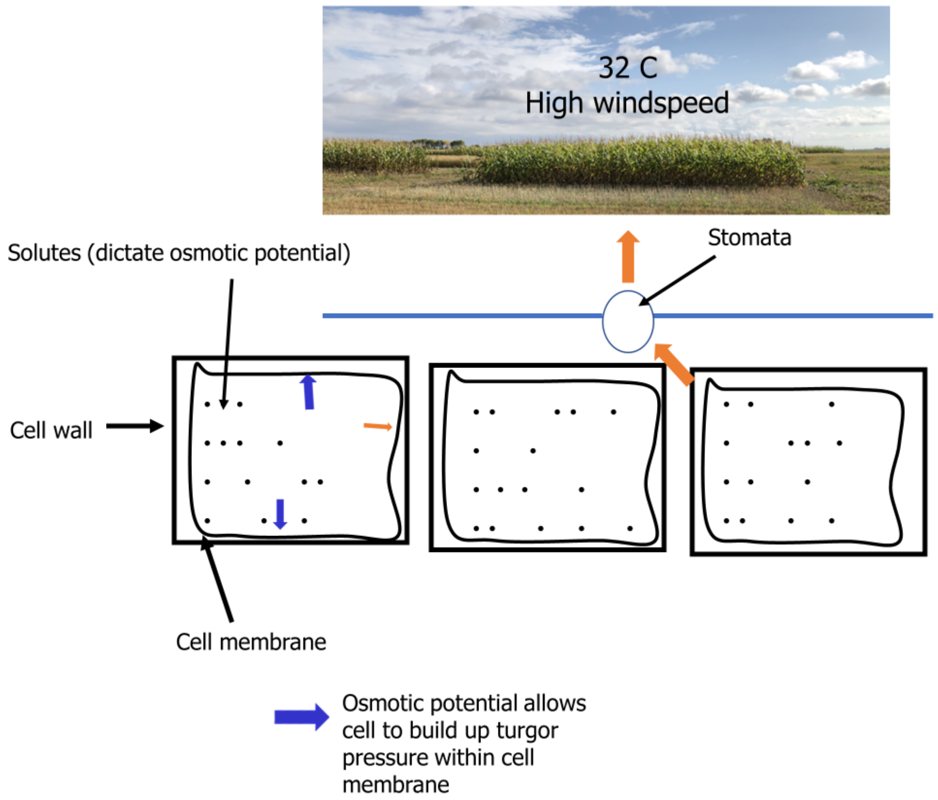



22 C
Low windspeed
Stomata
Solutes (dictate osmotic potential)
Cell wall
Cell membrane
Osmotic potential allows cell to build up turgor pressure within cell membrane

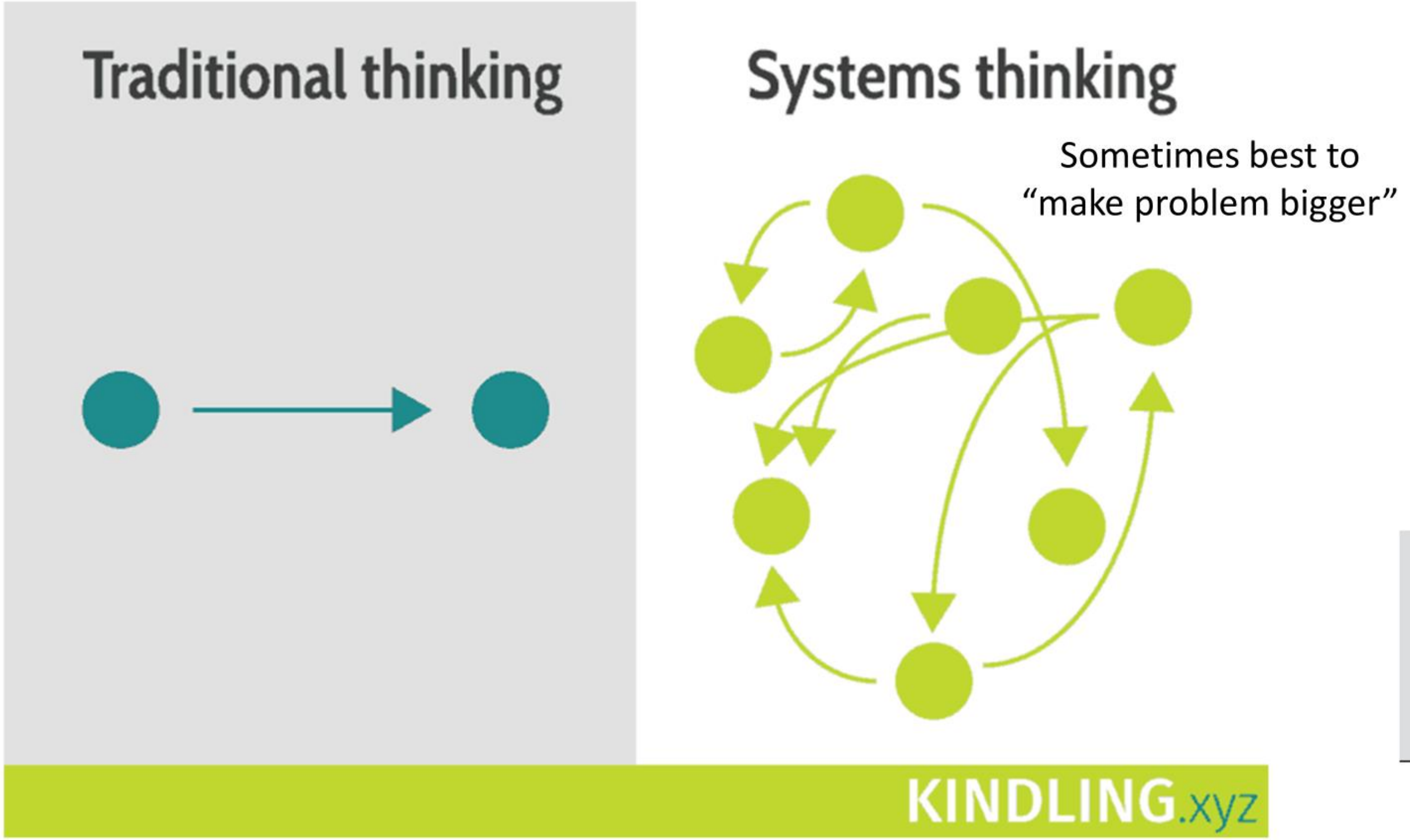

32 C
High windspeed
Solutes (dictate osmotic potential)
Stomata
Cell wall
Cell membrane
Osmotic potential allows cell to build up turgor pressure within cell membrane

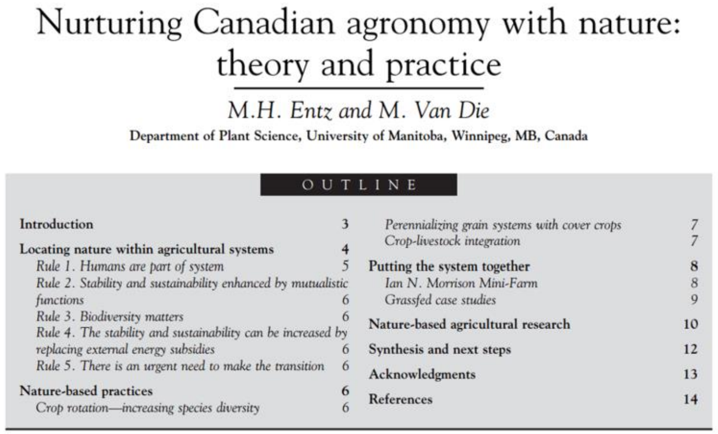
So, what does this mean for Plant Scientists?

- Physiological processes (and their attendant genetic links) on their own have limitations.
- Need to consider more elements of the cropping system when deploying things like “drought tolerant genes”, for example.



In summary, Plant Scientists need to…..





Nurturing Canadian agronomy with nature: theory and practice

M.H. Entz and M. Van Die

Department of Plant Science, University of Manitoba, Winnipeg, MB, Canada

OUTLINE

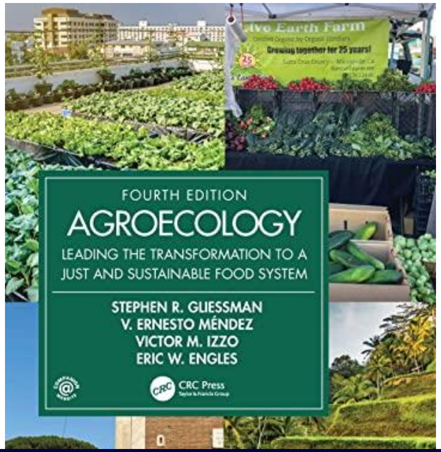
Level 1. Increase efficiency of conventional practices

Level 2. Substitute conventional practices with alternative practices

Level 3. Redesign the system so that it functions on basis of a new set of ecological relationships

Level 4. Re-establish more direct relationship between people who produce and eat food.

Level 3 please



Stephen Gliessman, Ivette Perfecto and others

Develop Ecological Knowledge Proactively

Depletion crisis model

- Experience of limited resources
- Most easily discovered if living on an island
  - Eg. deplete fishery
- Crisis allows societies to learn though this is not always successful (eg. Easter Island)

Ecological understanding model

- Cultural
- Community based
- Indigenous examples
  - Net fishery
  - Bison hunting
  - Fire culture for blueberry production

Berkes, F. and Turner, N.J., 2006. Knowledge, learning and the evolution of conservation practice for social-ecological system resilience. *Human ecology*, *34*(4), p.479.

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University of Manitoba

AGRICULTURAL AND FOOD SCIENCES

FACULTY OF AGRICULTURAL AND FOOD SCIENCES   UNIVERSITY OF MANITOBA EVENTS

VIEW TYPE: SEARCH

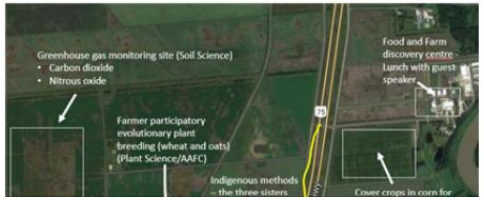
Natural Systems Agriculture Tour

Back to Events

August 1, 2023
9:00 AM - 2:00 PM (CT)

Bruce D. Campbell Farm & Food Discovery Centre
1290 Research Station Road
Glenlea MB R0G 0S0

Martin Entz
m.entz@umanitoba.ca



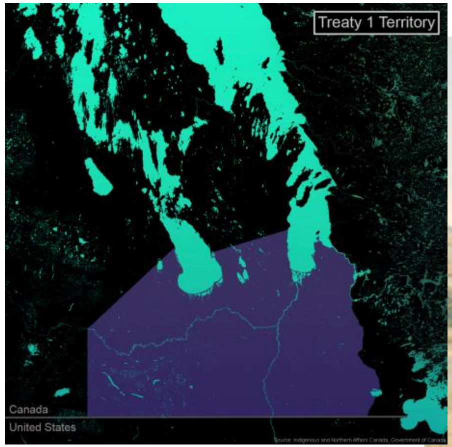
Natural Systems Agriculture Tour

Tuesday, August 1

9:00 am to 2:00 pm (coffee at 9 am, tour begins at 9:30 am sharp)

Thanks for your attention!

Thank you to my research team, supporters and funders



JAN-MONCHABLON (Jean Ferdinand MONCHABLON, dit) Les avoines,1886 ~ Oats

University of Manitoba

Advanced Plant Science Seminar Series, March 7, 2024