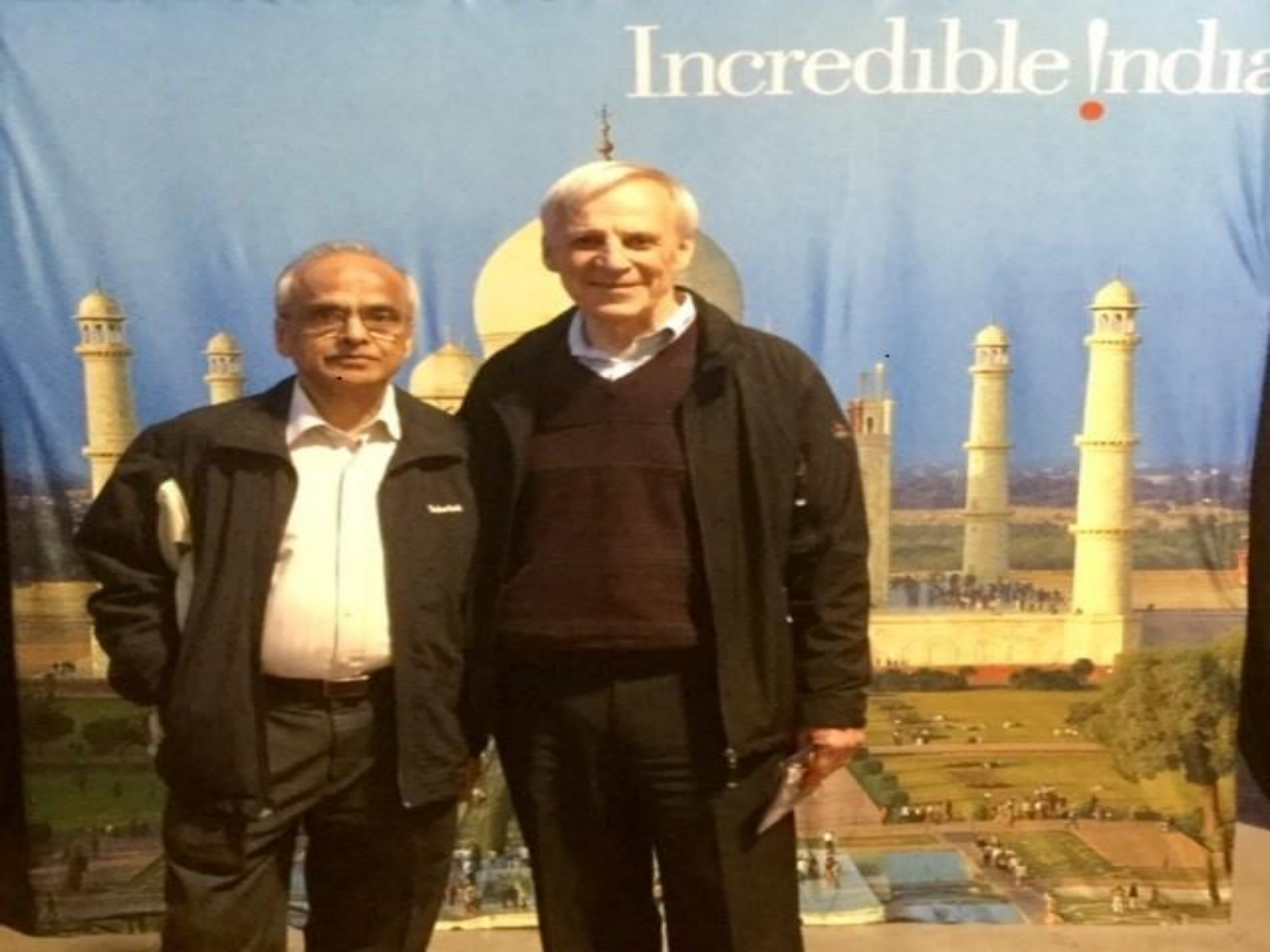

Incredible !ndia

Message that I received from Dr. Sivakumar

I won't forget you in my life
for all your kindness, your love,
your prayers
and
your support.
Because
you are such a lovely
and
caring person,
I am sincerely grateful to you.

Today is
WORLD APPRECIATION DAY
and I want to say
Thank You and God Bless.

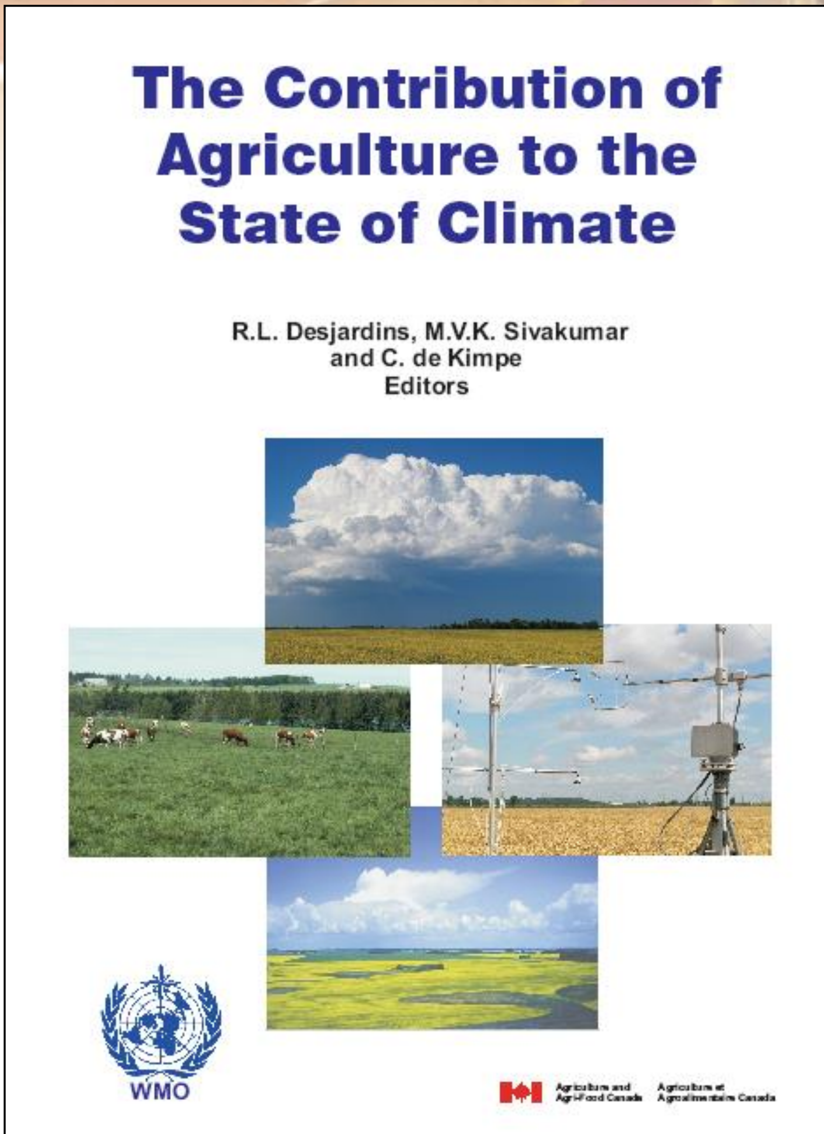
Send this to all your lovely and
caring
people who you won't forget in
your whole life.....including me

The Contribution of Agriculture to the State of Climate-A brief Update

Raymond Desjardins and Jiangui Liu
Agriculture and Agri-food Canada

Webinar on remembrances of Dr. Sivakumar, May 3, 2025

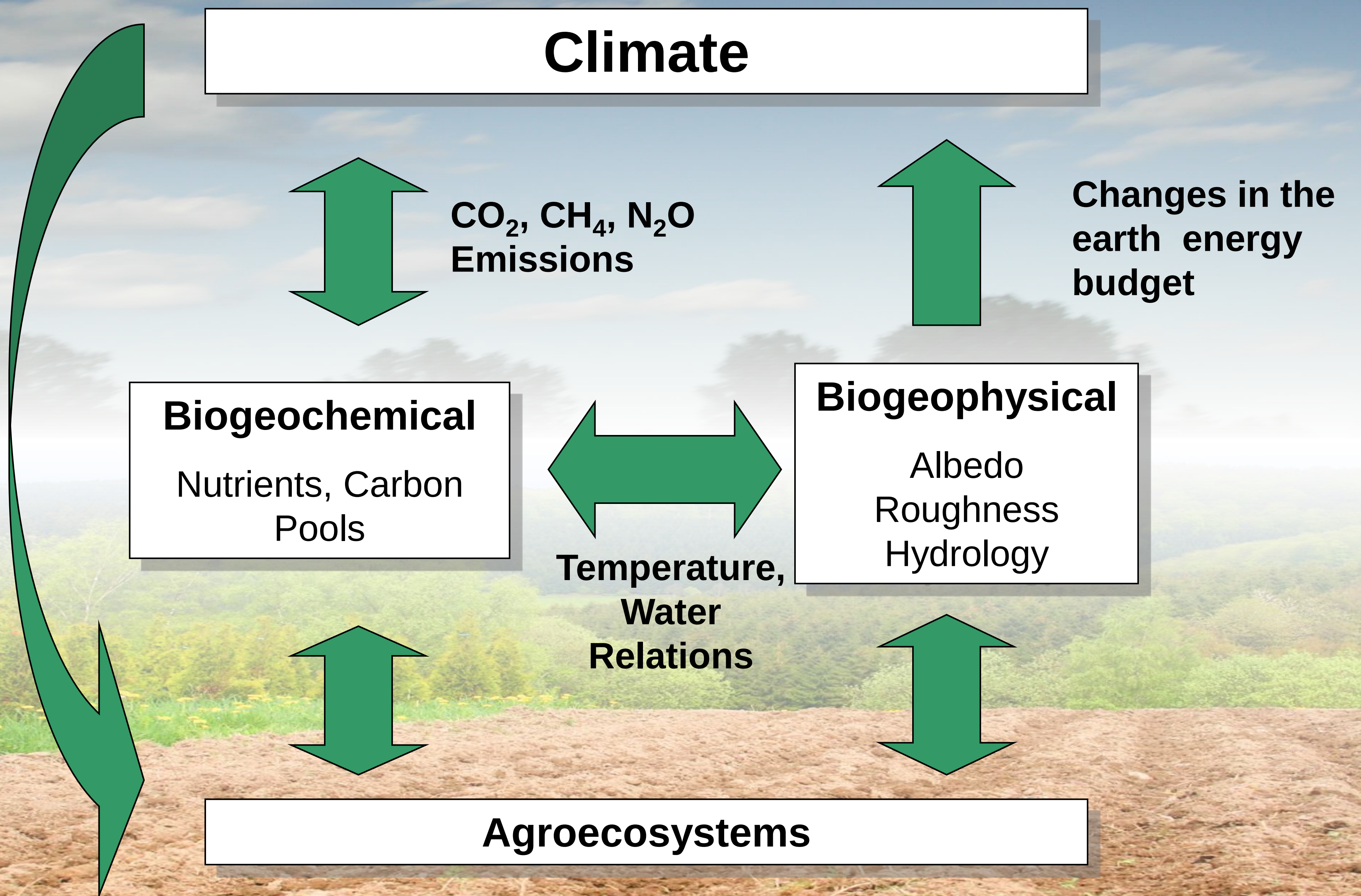
Expert team meeting with CAgM WMO in Ottawa , Canada 2004



Titles of some the talks at the workshop

- Agriculture's influence on climate during the Holocene M.J. Salinger
- Interactions between climate and desertification M.V.K. Sivakumar
- Impact of agriculture, forest and cloud feedback on the surface energy budget in BOREAS A. K. Betts et al.
- Climatic trends associated with summer fallow in the Canadian Prairies S. Gameda et al.
- Impact of climate variations on surface albedo of a temperate grassland S. Wang and A. Davidson
- The contribution of agriculture to the state of climate: Workshop summary and recommendations R.L. Desjardins, M.V.K. Sivakumar and C. de Kimpe

Impact of agriculture on climate



Net Effect on the Earth's Energy Budget due to Agriculture

Practices	Biogeophysical forcing	Biogeochemical forcing	Net Effect
Reduced tillage	–	–	– –
Afforestation	+ +	– –	
Deforestation	–	+ +	+
Planting forage crops	–	– –	– –
Irrigation	–	– +	–
Biochar	+	– –	–
Leaf albedo bio-geoengineering	–	–	– –
Reducing RM consumption		– –	– –
Reduced fallow	–	– –	– – –
Cover crops	–	–	– –
Leave long stubble for snow trapping	–	–	– –

Radiative forcing due to changes in GHG emissions

Radiative forcing & climate change impact:
Metrics for evaluating the biogeochemical processes–
Warming Potential (GWP)

↑

Changes in atmospheric GHG concentrations

↑

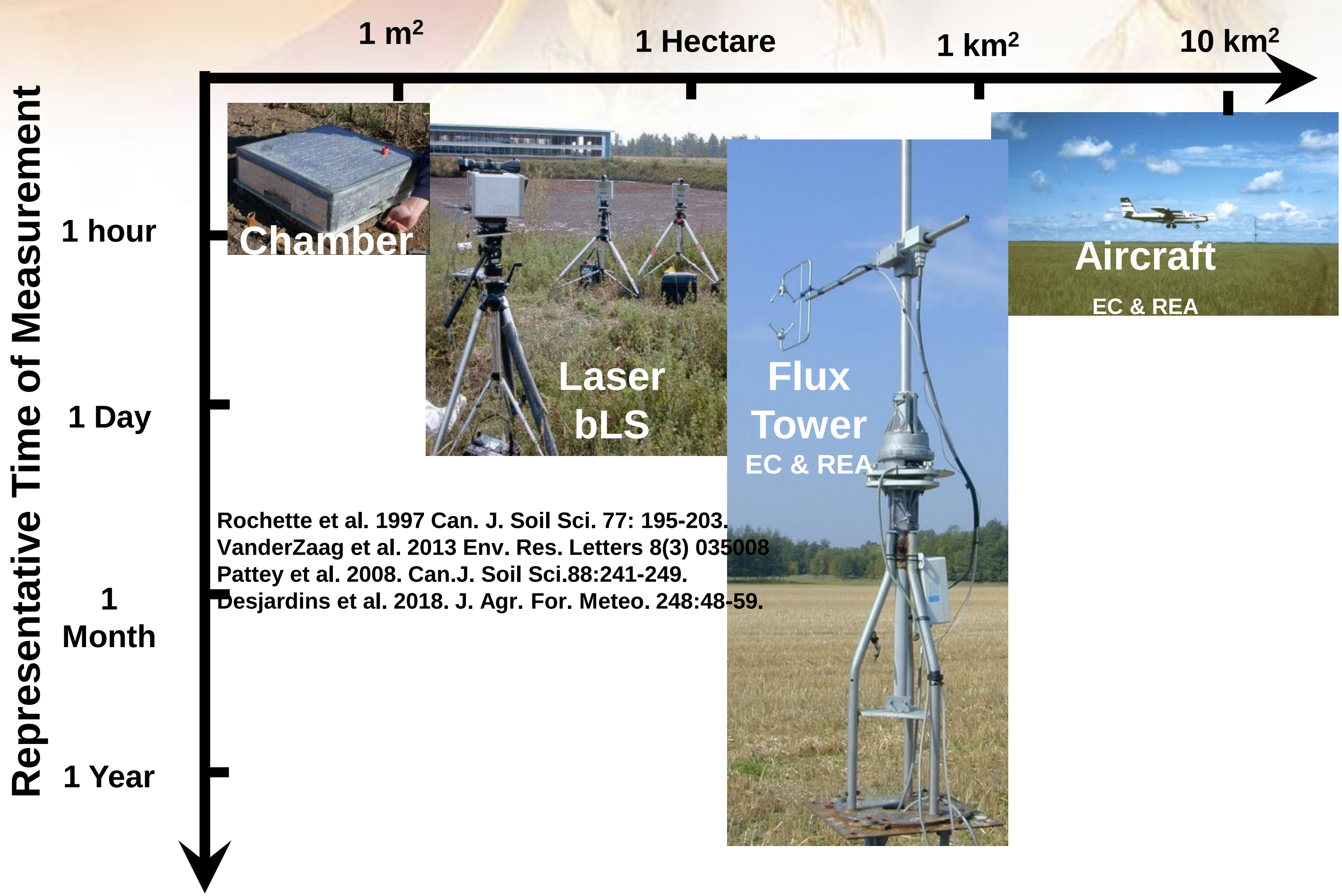
Carbon storage in biomass and soils; GHG emissions

Farm management practice, choice of animal products, etc.

↑

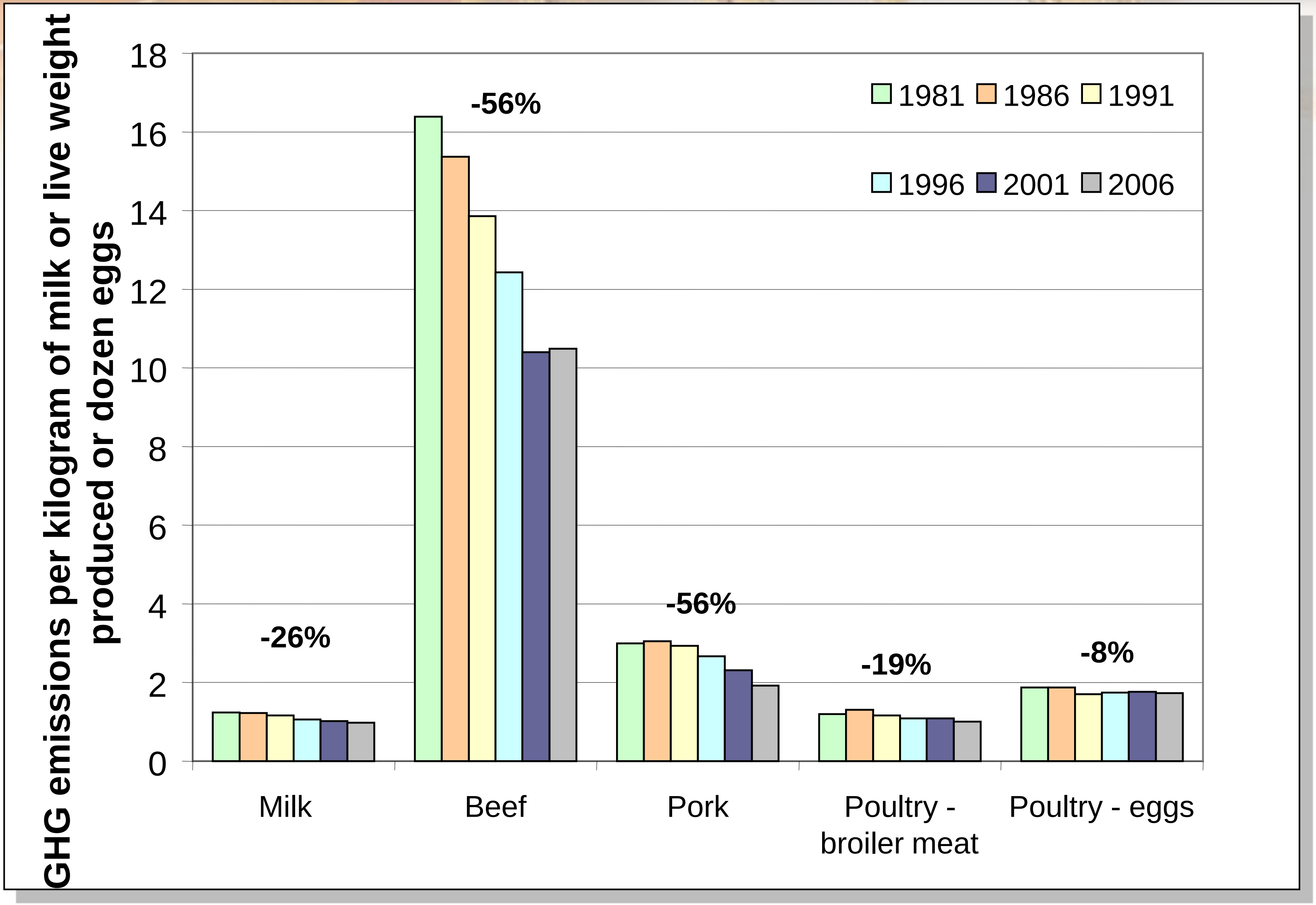
Biogeochemical forcing

Flux measuring systems for a wide range of scales



Rochette et al. 1997 Can. J. Soil Sci. 77: 195-203.
VanderZaag et al. 2013 Env. Res. Letters 8(3) 035008
Pattey et al. 2008. Can.J. Soil Sci.88:241-249.
Desjardins et al. 2018. J. Agr. For. Meteo. 248:48-59.

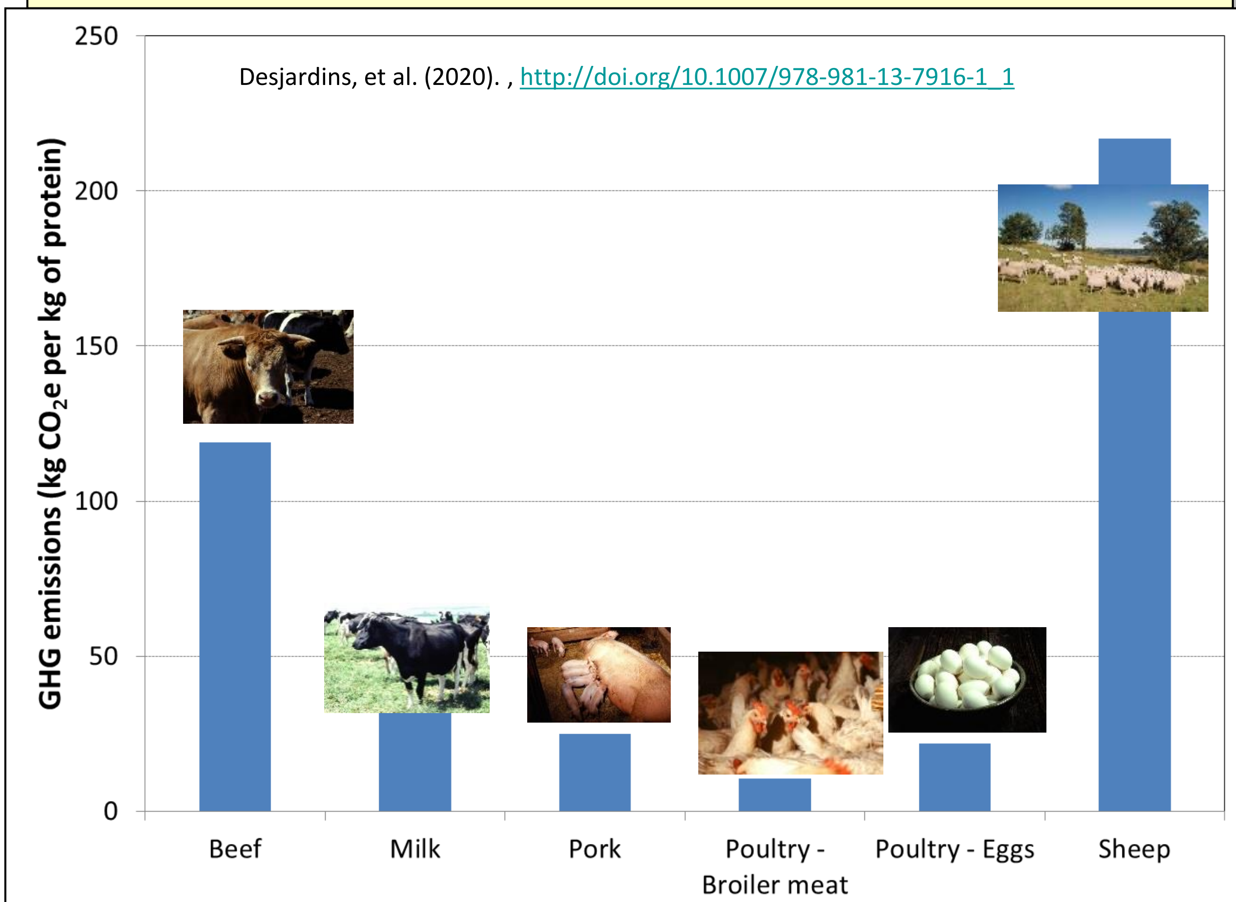
Carbon footprint of livestock products in Canada

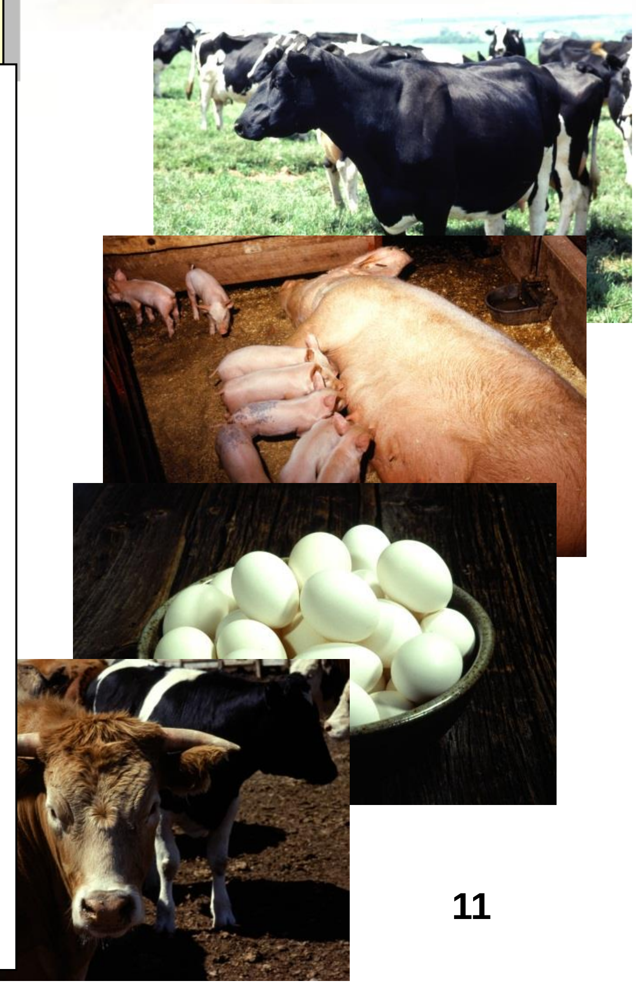


Source: Dyer et al (2008); Vergé et al (2008); Vergé et al (2009a; 2009b)

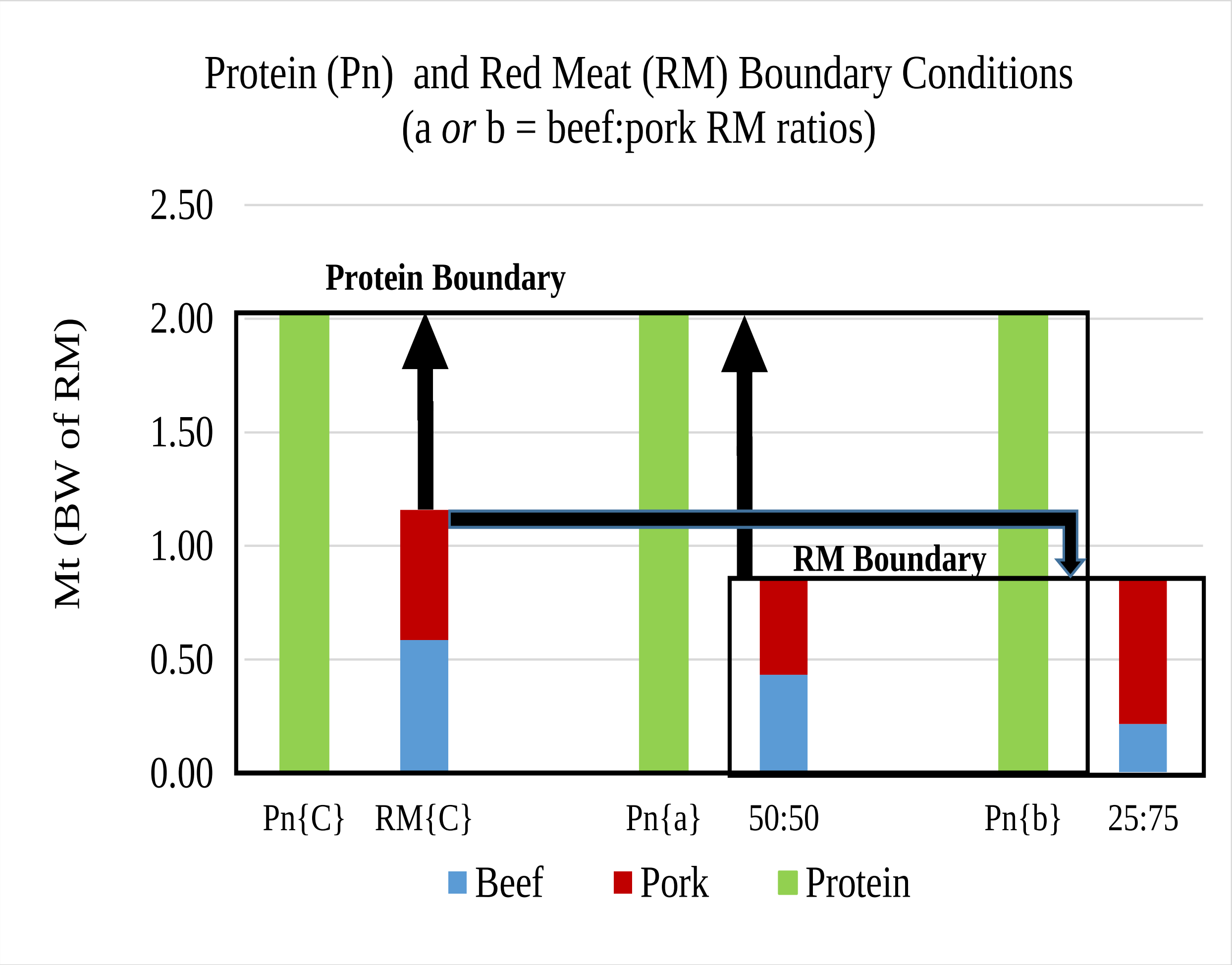
GHG emissions for different animal products

Since the primary functions of animal products is to provide protein for growth, expressing the carbon footprint per unit of protein is the best way to compare emissions between animal products.





Potential role of consumers to reduce Canadian agricultural GHG emissions



391 kt proteins/yr
Reducing RM C by 24%
50-50 split of red meat
4 MT CO2e
Split pork 75%-beef 25%
9 Mt CO2e

Dyer, J.A., Desjardins, R.L (2020). Protein as a unifying metric for carbon footprinting livestock. Earth & Environment Research Outreach Connecting Science with Society Issue 118 pp 142-144.

GHG emissions associated with protein production

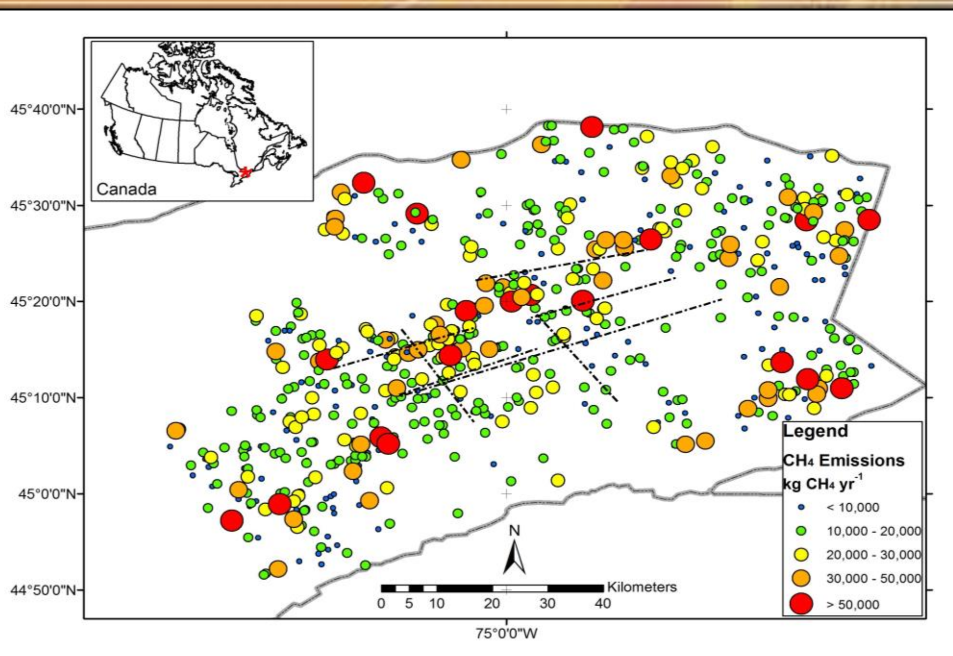
Protein Sources:	tCO_2/ha		Kg (protein)/ha		tCO_2/t (protein)	
Animal:	**East**	**West**	**East**	**West**	**East**	**West**
Ruminants	15.17	11.33	263	103	57.77	109.83
Non-ruminants	3.13	1.82	167	83	18.79	21.97
Plant:	**East**	**West**	**East**	**West**	**East**	**West**
Soybeans	0.30	0.26	1077	630	0.28	0.42
Other legumes	0.41	0.34	207	139	1.98	2.46

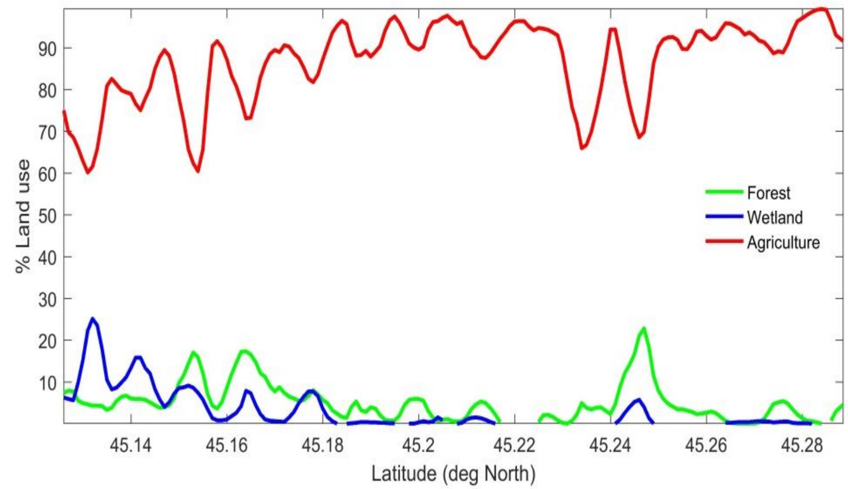
Source: Dyer and Verge (2015)

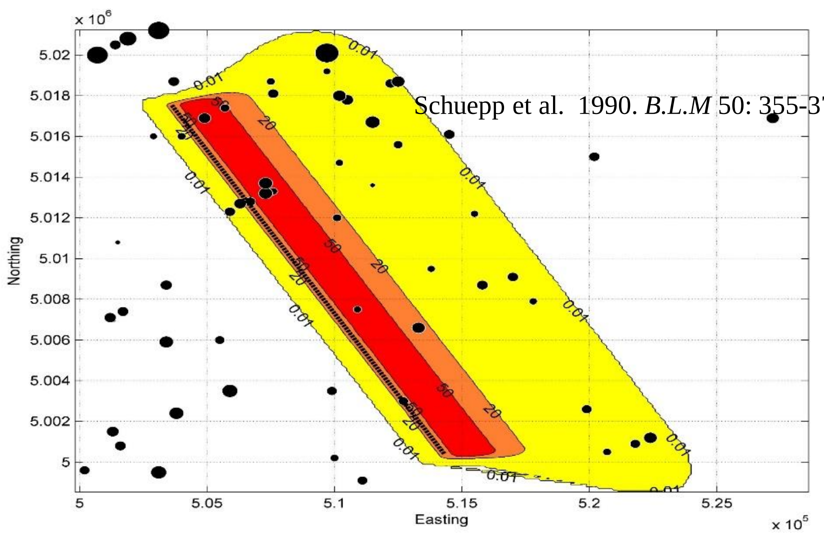
Pulses and soybeans represent a far less carbon intensive method of producing protein, as compared to ruminant and non-ruminant sources. For example, the amount of feed input for ruminants equate to 15 to 30 times the mass of the final meat product.

Verge, X., VanderZaag, A. C., Desjardins, R. L., & McConkey, B. (2018). Synergistic Effects of Complementary Production Systems Help Reduce Livestock Environmental Burden. *Journal of Cleaner Production*, 200: 858-865. https://doi.org/10.1016/j.jclepro.2018.08.016

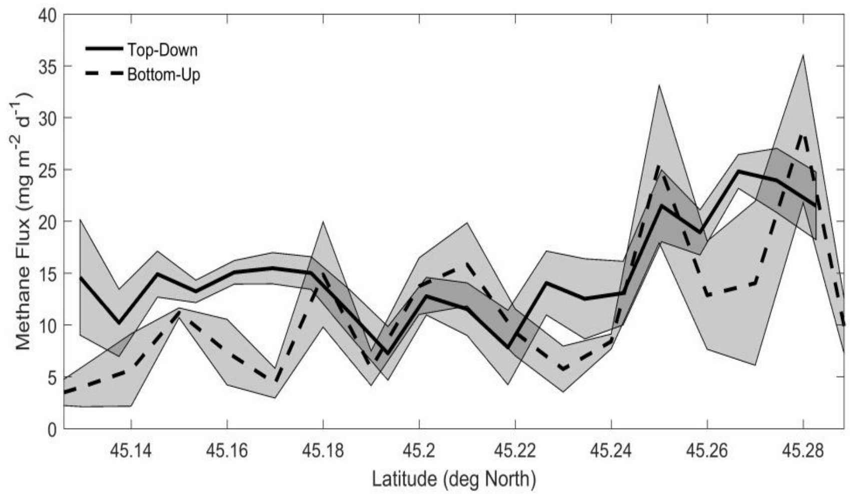
Verification of CH_4 emission inventories using aircraft-based flux measurements







Schuepp et al. 1990. *B.L.M* 50: 355-373.

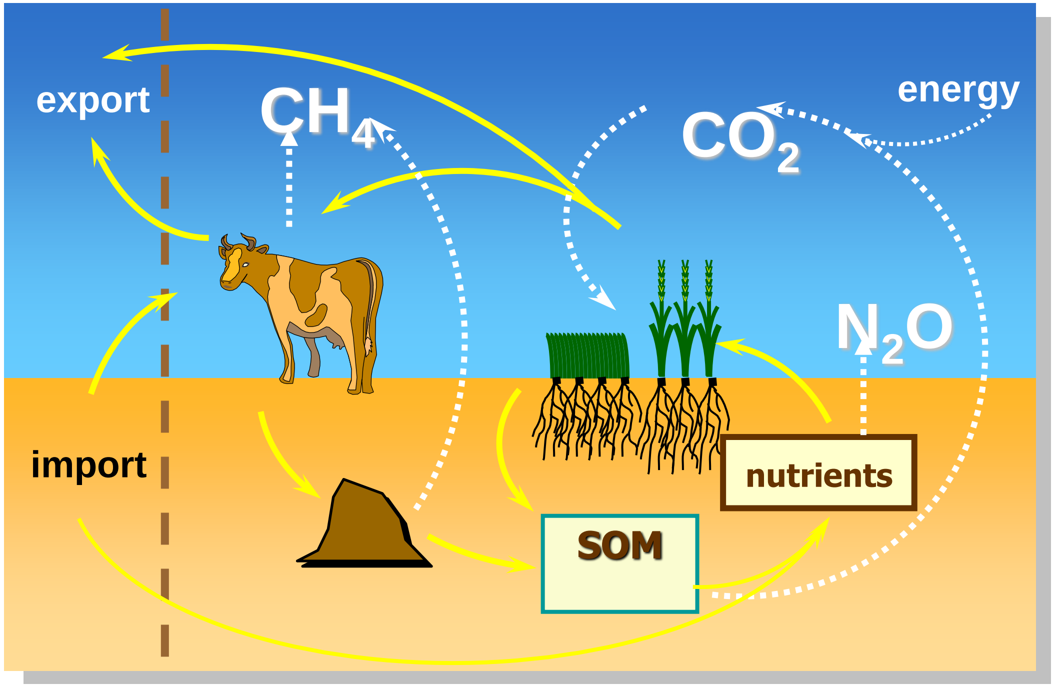


Desjardins et al. (2018). *Agricultural and Forest Meteorology*, 248: 48-59.

Holos

- **Holos is a Window-based program that can be used to estimate greenhouse gas emissions for any farm in Canada (R. Kroebel)**

- **It includes multiple built-in mitigation options and custom farm scenarios which can be used to quantify GHG mitigation potentials**



Relevant publications:

- **Concept: Janzen et al (2006) Can. J. Soil Sci. 86:401-418**
- **Methods: N_2O - Rochette et al (2008a) Can. J. Soil Sci. 88:641-654, Rochette et al (2008b) Can. J. Soil Sci. 88:655-669; soil C – Smith et al (2001) Can. J. Soil Sci. 81: 221-227; CH_4 – Vergé et al Agric. Syst. 94: 683-693.**
- **Application: Beauchemin et al (2010) Agric. Syst. 103: 371-379.**

Pathways to help reduce GHG emissions

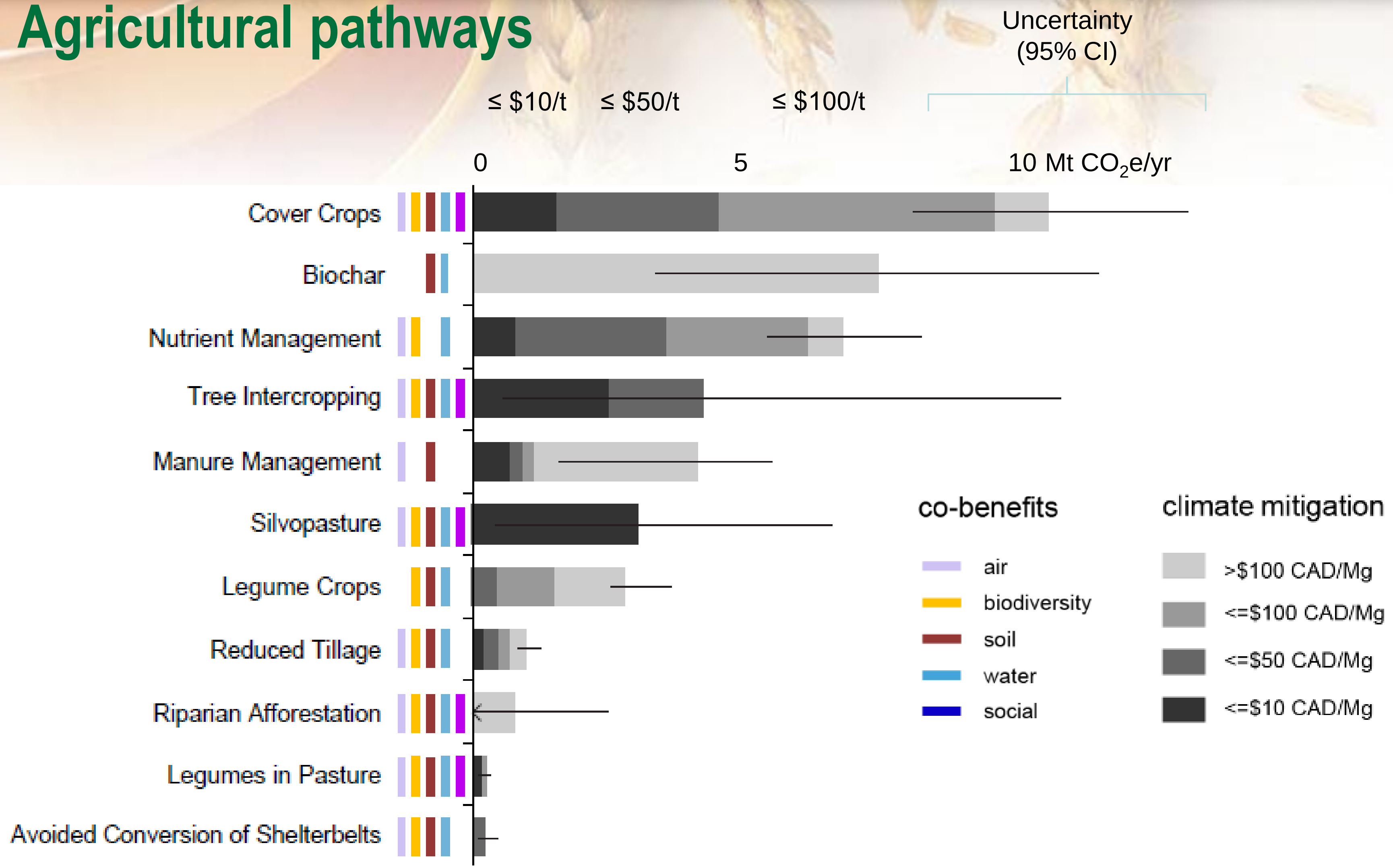
AAFC scientists with a team from Nature United have proposed 11 ‘Natural Climate Solutions’ through agricultural pathways that could result in a reduction of 76 Mt CO_2e/yr by 2030 (Drever et al. 2021)

These pathways include:

- reduced tillage,
- cover crops,
- legume crops,
- legumes in pasture,
- silvopasture,
- nutrient management,
- avoided conversion of shelterbelts,
- tree intercropping,
- riparian afforestation,
- biochar,
- manure management

Climate mitigation potential by 2030 (40 Mt CO_2e/yr)

11 Agricultural pathways



Drever, C.R., Cook-Patton, S.C., Akhter,F., Desjardins, R. ...Yeo, S., Kurz, W.A. 2021. Natural climate solutions for Canada. Science Advances, 2021, 7(23), eabd6034

Manure management

Avoided methane emissions from reduced methanogenesis through acidification of manure in handling facilities of dairy and swine farms (Drever et al. 2021).

Per head mitigation	Total Mitigation Potential
1.1 t CO_2e/yr	0.4 Mt CO_2e/yr by 2030
0.2 t CO_2e/yr	2.6 Mt CO_2e/yr by 2030

Radiative forcing due to differences in albedo

Radiative forcing & climate change impact:
Metrics for evaluating the biogeophysical processes
Equivalent CO2

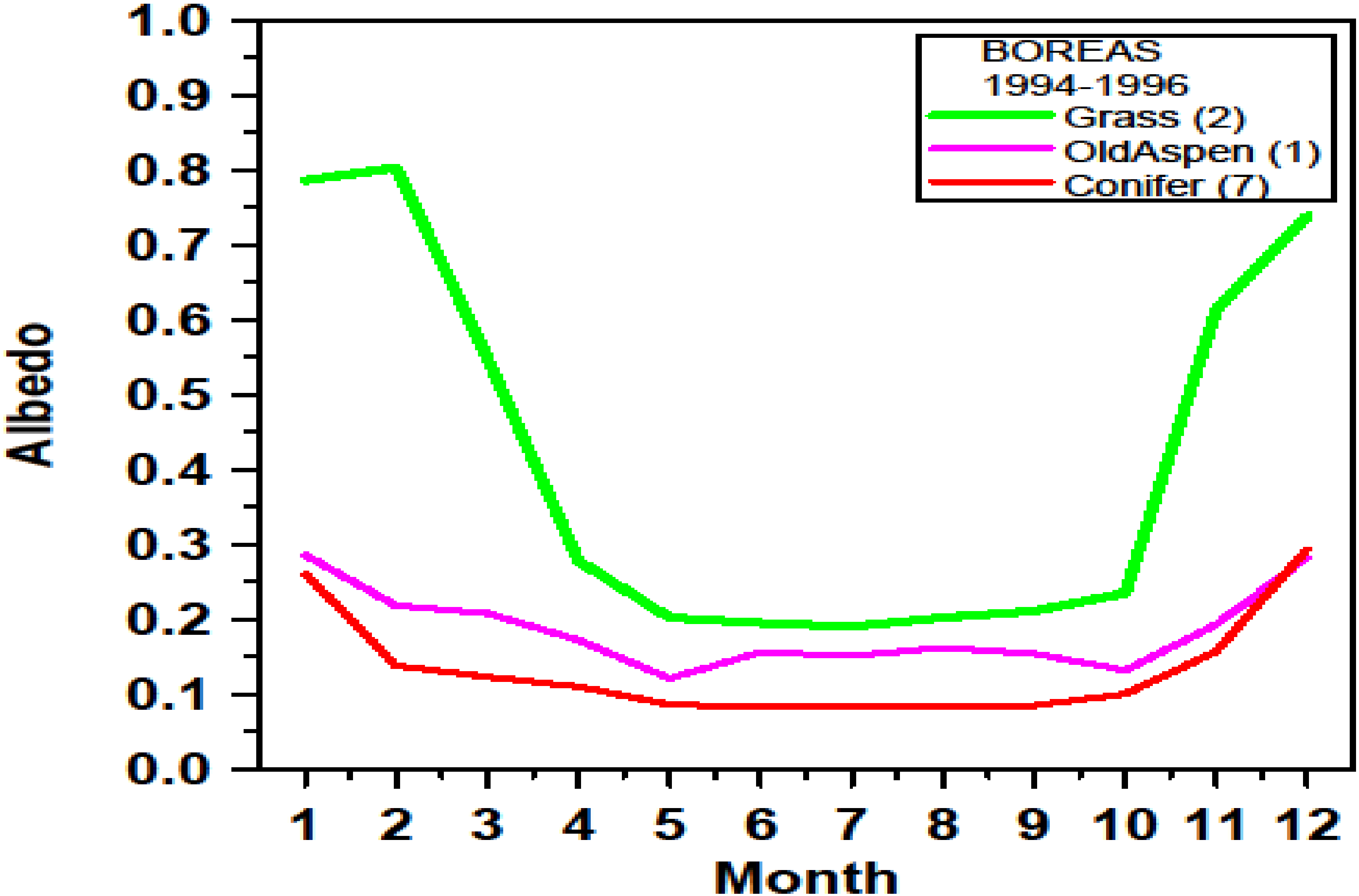
Changes in reflected shortwave radiation

Modulates energy budget - net radiation, ET and H

Changes in surface albedo, roughness, etc.

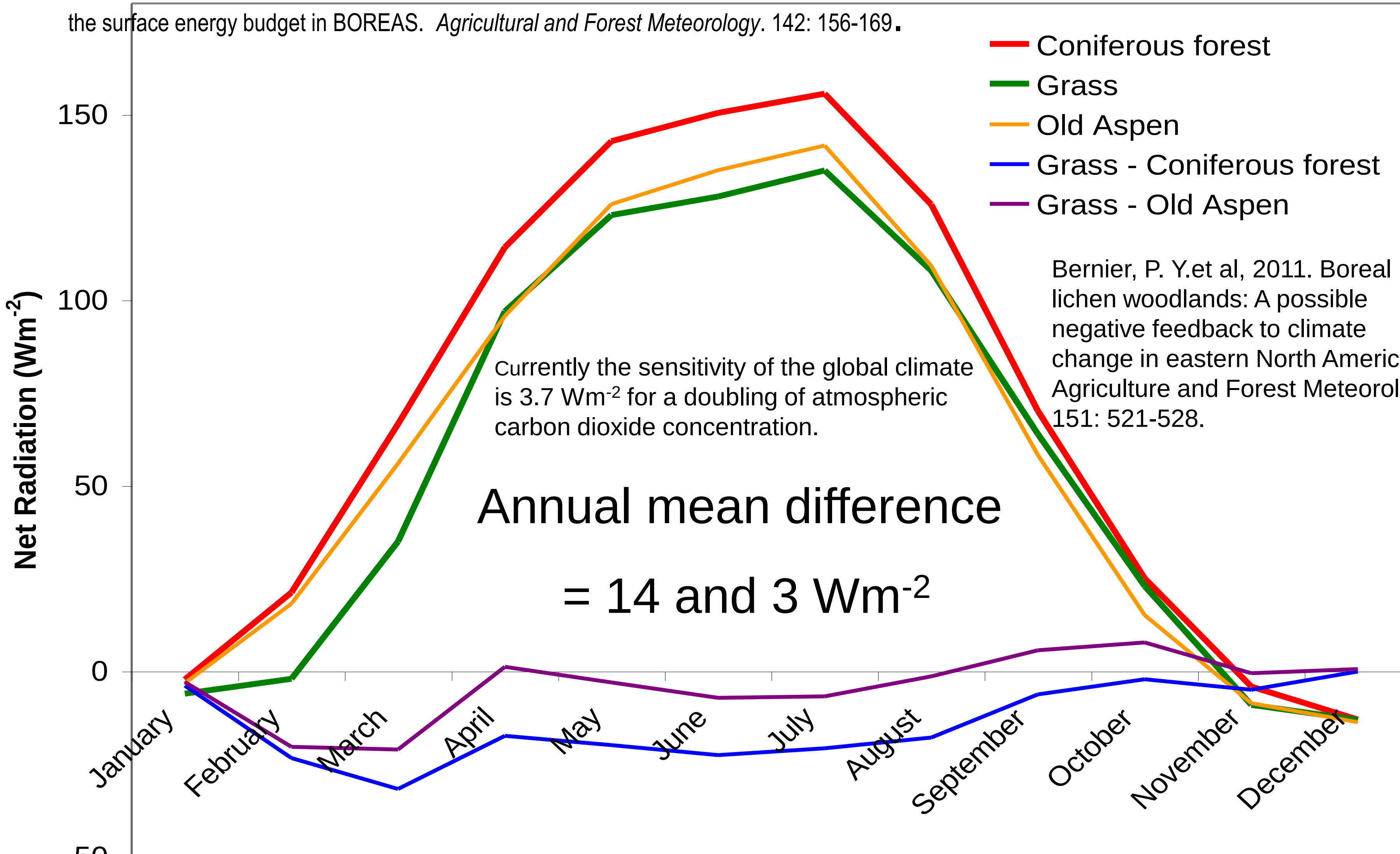
Biogeophysical forcing

Monthly differences in albedo for three types of vegetation



Net radiation budget of three different types of vegetation in Canada

Betts, A.K., Desjardins, R.L., Worth, D. 2007. Impact of agriculture, forest and cloud feedback on the surface energy budget in BOREAS. *Agricultural and Forest Meteorology*. 142: 156-169.



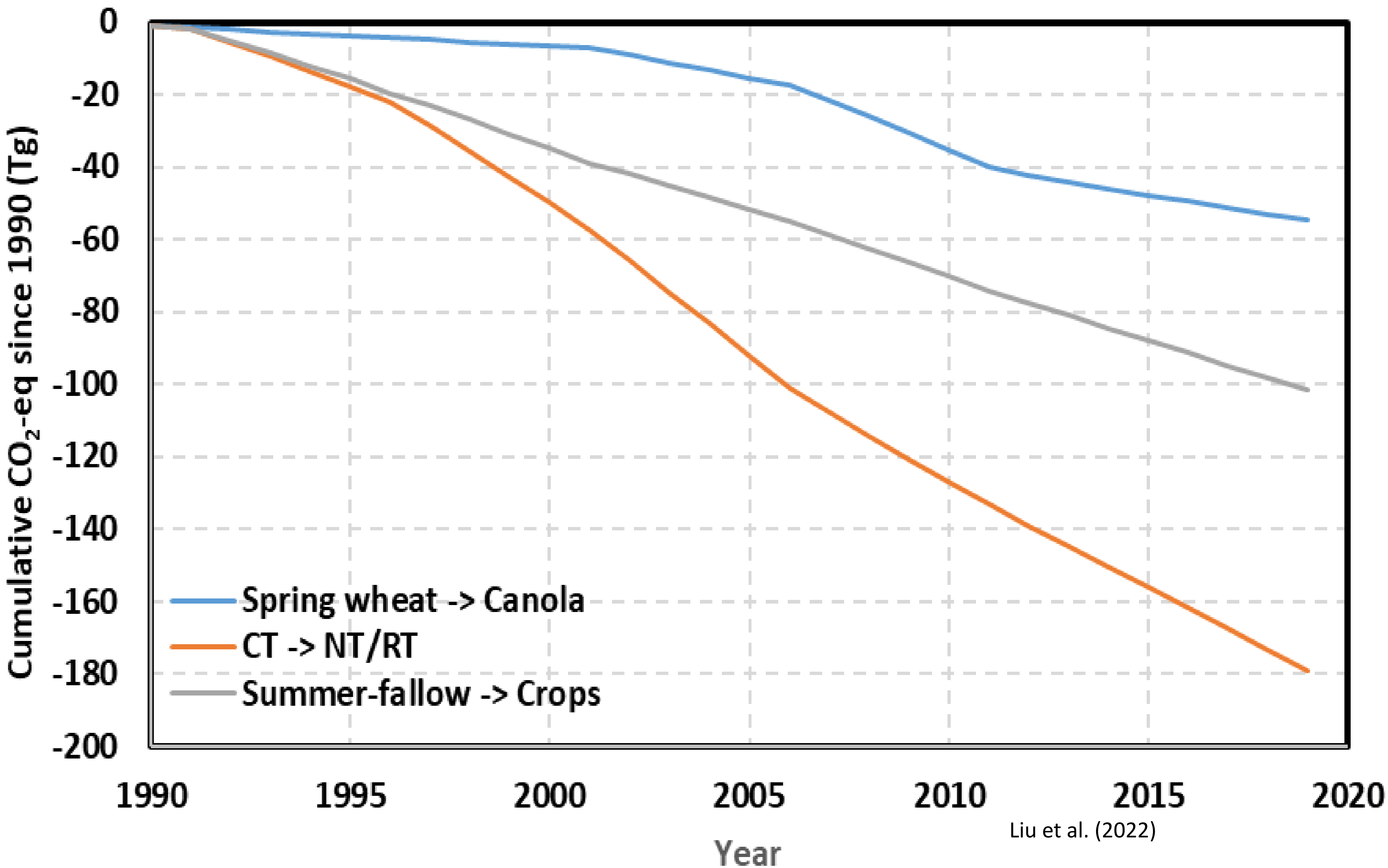
Currently the sensitivity of the global climate is 3.7 Wm^{-2} for a doubling of atmospheric carbon dioxide concentration.

Annual mean difference

= 14 and 3 Wm^{-2}

Bernier, P. Y.et al, 2011. Boreal lichen woodlands: A possible negative feedback to climate change in eastern North America. Agriculture and Forest Meteorology 151: 521-528.

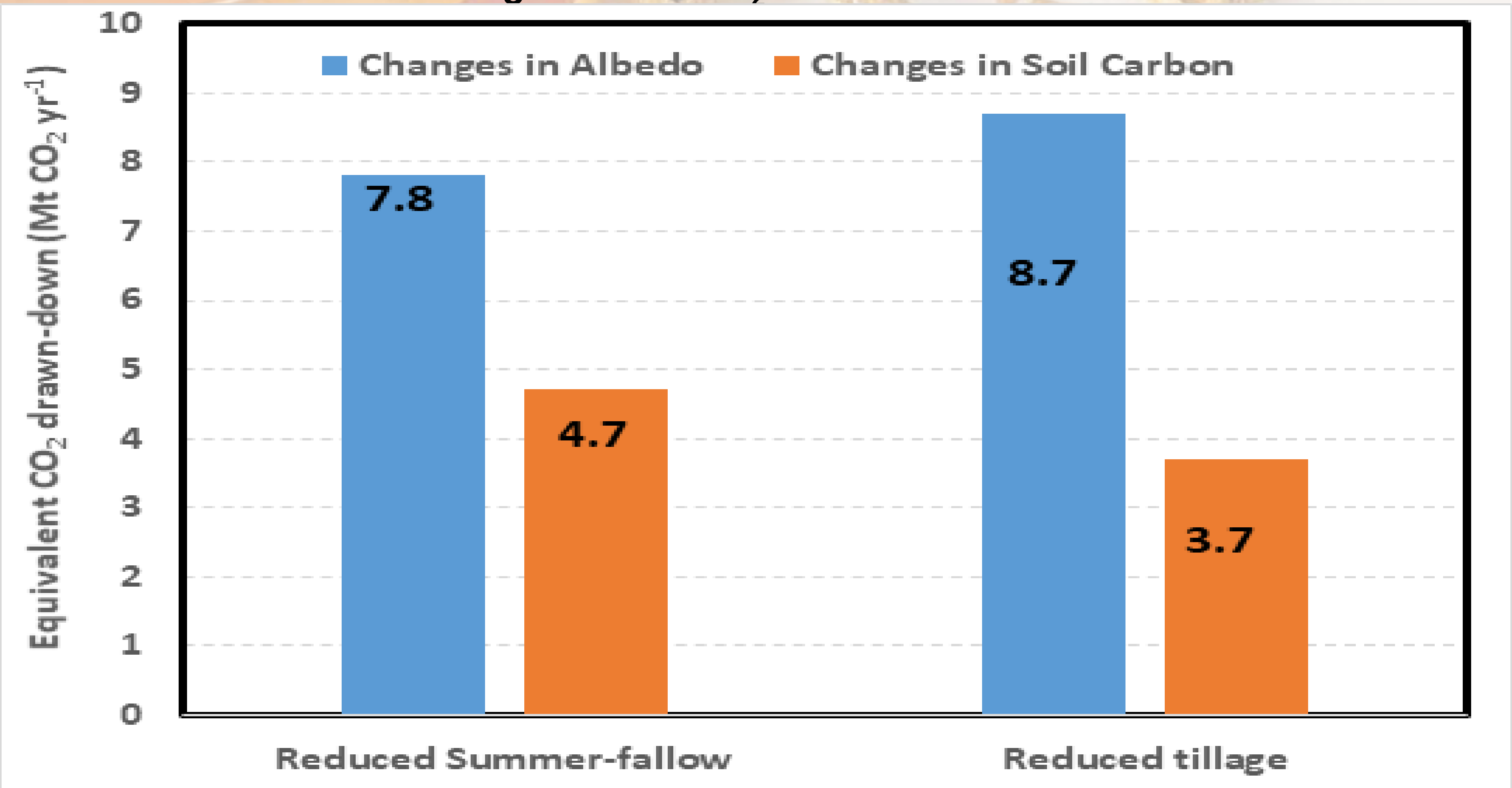
Equivalent CO_2 drawdown in the Prairies from 1990 to 2019 due to albedo change associated with reduced tillage, reduced summer fallowing and a shift to more canola and less wheat. Acreage of canola increased from 2.9 to 8.4 Mha while wheat decreased from 11.6 to 5.7 Mha.



Liu et al. (2022)

Influence of two management practices in the Canadian Prairies on radiative forcing

- Average annual CO_2 drawdown 1981-2016



Albedo effect
RF=62% and RT= 70%

Liu, J., Desjardins, R.L., Wang, S., Worth, D.E., Qian, B., Shang, J., 2022. Climate impact from agricultural management practices in the Canadian Prairies: Carbon equivalence due to albedo change. J. Environ. Manage. 302. https://doi.org/10.1016/j.jenvman.2021.113938

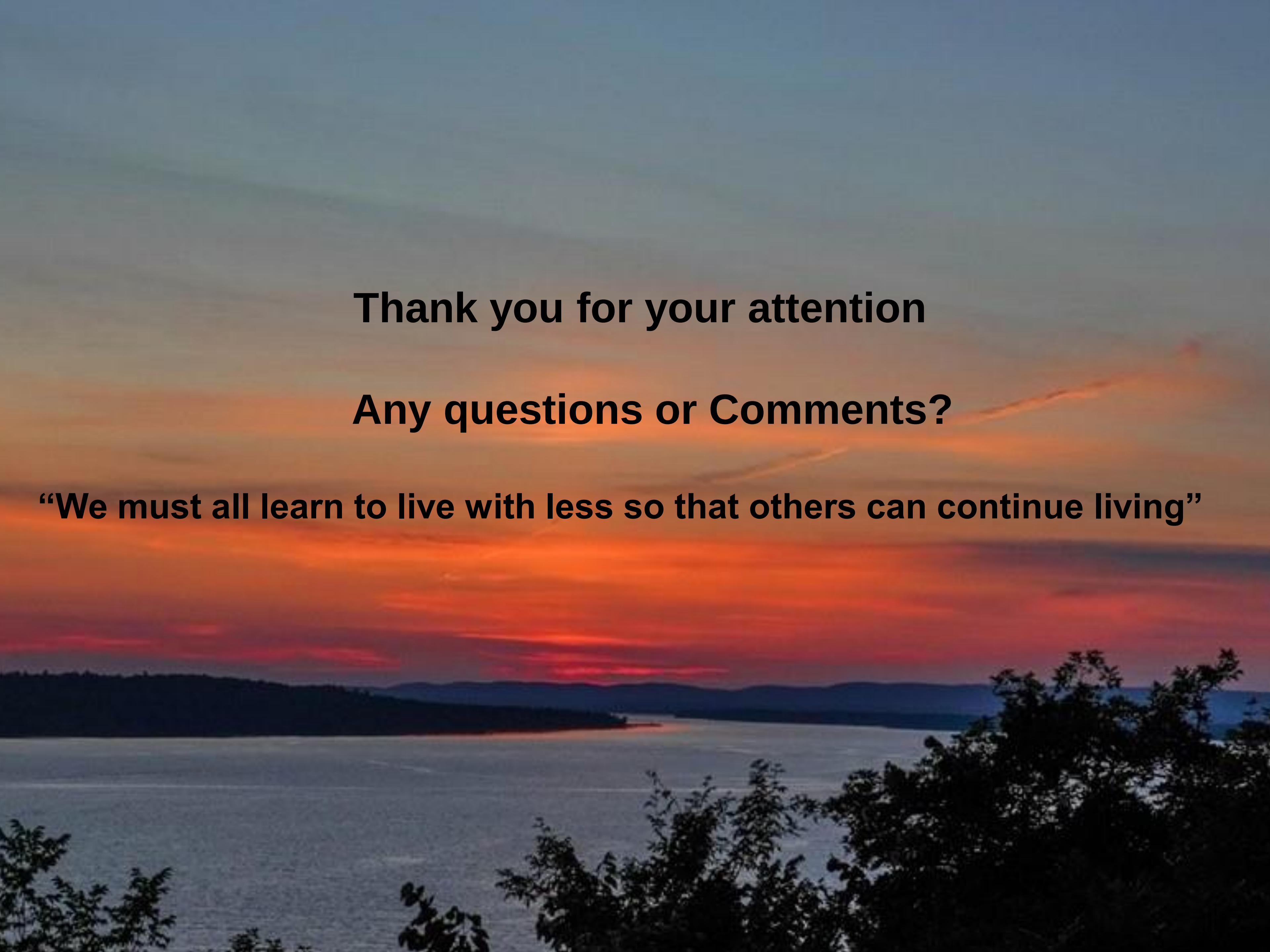
Some of the recommendations suggested at the workshop

Encourage researchers and weather specialists to report biogeophysical and biogeochemical forcing data in similar units (W /m2)

To promote and adopt an ‘‘integrated system approach’’ in assessing the environmental and societal impacts of mitigation strategies, which incorporates all biogeophysical and biogeochemical processes.

This should include linkages among:

1) crop and animal productions, including manure digestion to produce biogas;
2) integrated (CO_2 equivalent)due to albedo change and GHG emissions;
3) land-use change (albedo, etc.) and GHG production/ absorption;
4) model development and verification through measurement programs;
5) provision of scientifically sound ‘‘best estimates’’ for a GHG inventory, and mitigation strategies to alleviate the impact of agricultural activities on climate change


Thank you for your attention
Any questions or Comments?
“We must all learn to live with less so that others can continue living”