Misconceptions About the Sustainability of Canadian Agriculture

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Lanigan Group's Analysis of the Sustainability of Canadian Agriculture

This presentation is the first of a 4-part series of analysis on the Sustainability of Canadian Agriculture:

1. ***Misconceptions About the Sustainability of Canadian Agriculture*** (this report) addresses false assumptions and misconceptions about Canadian agriculture's role in global warming due to lack of attention to on-farm sequestration by policymakers.

2. ***Carbon as a Cash Crop*** addresses why Canada's current narrative for agricultural climate action isn't working and why carbon credits are ineffective as a basis for incentivizing agricultural climate action. It proposes a more effective alternative based on the concept of incentives for excess sequestration services.

3. ***Enteric Emissions are Climate Neutral*** presents a detailed analysis of enteric emissions in Canadian dairy which establishes that enteric emissions in Canada are better than non-additive to global warming because they occur in a biogenic carbon cycle that sequesters more carbon than is emitted.

4. ***Carbon Footprint of Canadian Agriculture*** presents a comprehensive estimate of the net carbon footprint for Canadian agriculture that is otherwise unavailable from official sources. It documents why Canadian agriculture is already sustainable because it is already generating over $3 B in unpaid, excess sequestration services.

Agricultural Emissions In Context

- Agricultural emissions cannot be fully understood without considering interactions between human and natural interactions on land & wetlands.
  - This includes carbon removals via sequestration by perennial vegetation (trees, bushes, grasses) in the areas of the farm that is not cropped

- Carbon removals via sequestration by crops grown is adjusted by:
  - Removal of harvested yield -- not usually counted in carbon footprint models (under the presumption that carbon stored in the edible portion of crops is rapidly released upon consumption (this is misleading for crops grown for livestock feed)
  - Contribution to soil carbon from decomposition of crop residues
  - Emissions from decomposition of crop residues (adjusted for any no-till and cover-cropping practices used to mitigate them)

- Depending on context & extent of disturbance, wetlands are either a sink or source for carbon
  - Decomposition of dead biomass contributes to both soil carbon and emissions
  - Wetlands tend to accumulate biomass via leaves from adjacent trees as well as its perennial vegetation
  - Disturbance of its perennial vegetation (which acts in ways similar to a cover-crop) result in net emissions

- Also, emissions from other farming activities including the use of:
  - Agrichemicals & feed supplements (including upstream emissions in manufacturing them as well as transportation to farms),
  - Livestock emissions (enteric and manure-related),
  - Fuel use (direct on-farm use as well as indirect use for transportation of supplies to farm and farm products to market),
  - Downstream emissions in food processing.

Enteric

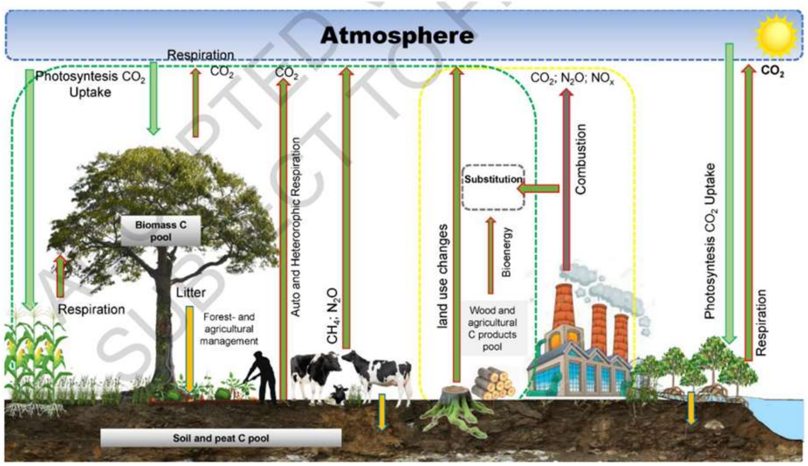
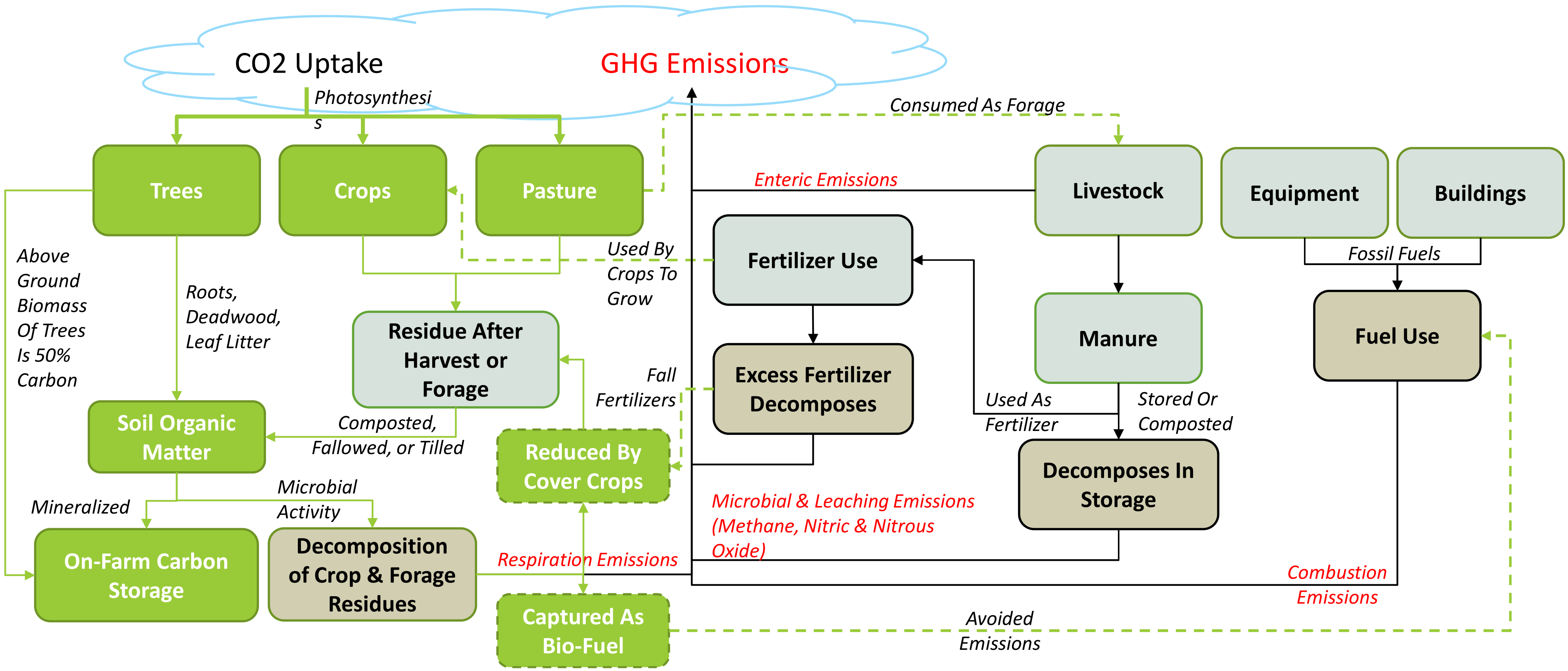


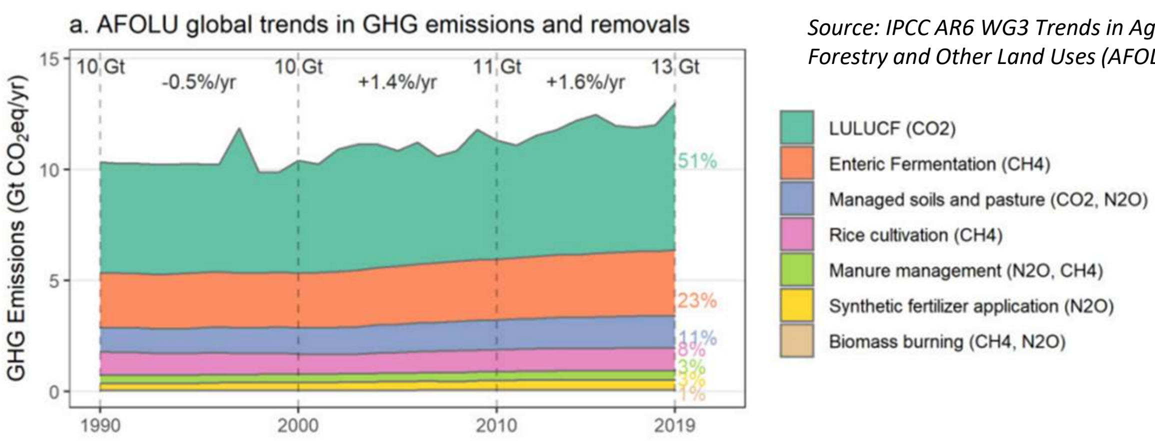
Figure 7.2 Summarised representation of interactions between land management, its products in terms of food and fibre, and land - atmospheric GHG fluxes. For legibility reasons only a few of the processes and management measures are depicted.

Visualizing Farm-Level Carbon Footprint Dynamics (excluding changes in land-use and indirect emissions)



Global Emission Trends In Agriculture

- Much of the misconception surrounding the state of sustainable agriculture in North America is the result of the false application of findings from other regions of the world to a North American context
- According to the IPCC, Agriculture, Forestry and Other Land Use (AFOLU) represents up to 21% of *global* total human-caused (anthropogenic) GHG emissions [AR6 WG3] and deforestation caused by agriculture is 45% of **global** AFOLU emissions
- Based on FAOSTAT data, production of animal products accounts for 69% of *global* agricultural land use and 65% of land use change over the past 50 years – while producing only 10% of total food calories [Alexander 2105]

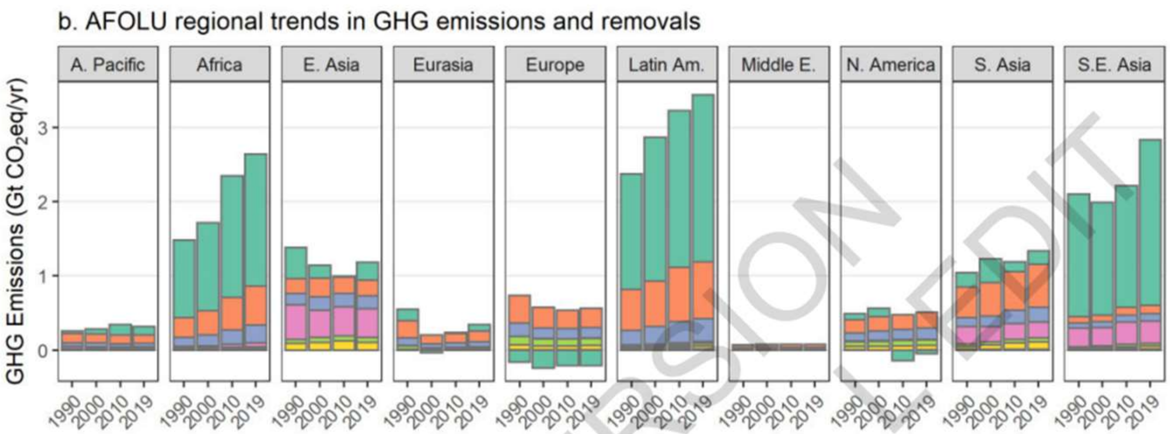


Source: IPCC AR6 WG3 Trends in Agriculture, Forestry and Other Land Uses (AFOLU)

Global Agricultural Emission Trends Vary Greatly by Region

- However, global trends in AFOLU are only correlated at a regional level to the emission dynamics of Africa, Latin America, and SE Asia as evidenced in the charts below
  - **<u>Uncorrelated</u>** for Asia Pacific, Eurasia, Europe, Middle East, and **North America**
  - Weakly correlated at best to trends in East and South Asia

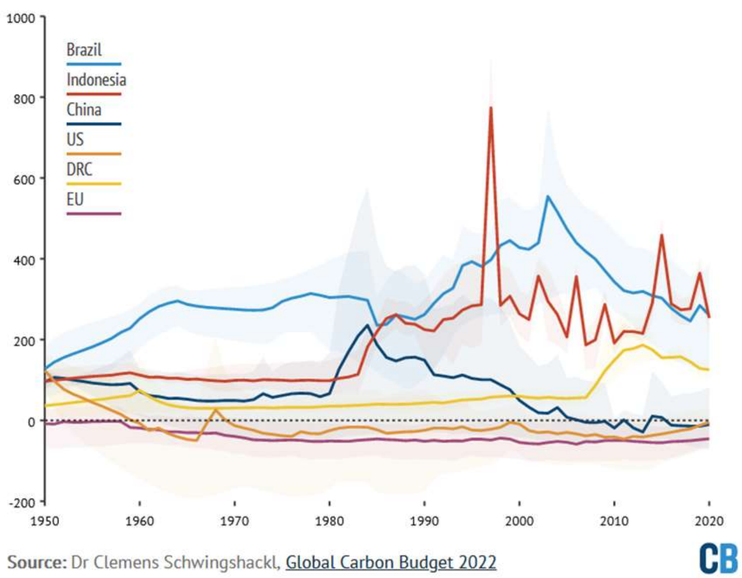
- Even though both the IPCC & FAOSTAT data clearly shows significant variation by region, **a common mistake** is the presumption that global trends (illustrated on previous slide) apply equally to a North American context



Source: IPCC AR6 WG3 Trends in Agriculture, Forestry and Other Land Uses (AFOLU)

Net Emissions of CO2e Due to Land Use Change Varies Greatly at a National Level

Contribution to GHG via Land-Use Change



Source: Dr Clemens Schwingshackl, Global Carbon Budget 2022

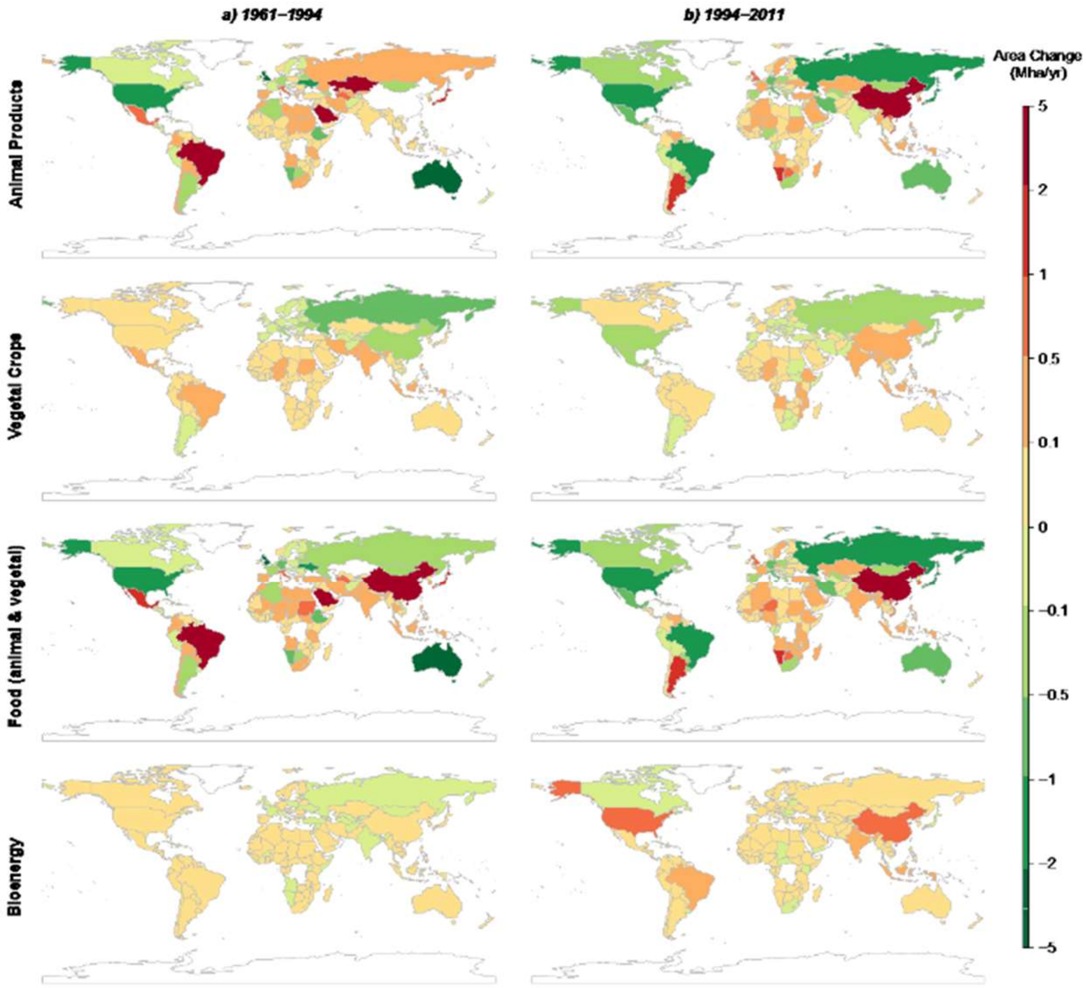
Time series of net land-use CO2 fluxes for Brazil (blue), Indonesia (red), the DRC (yellow), China (dark blue), US (orange), and the EU27 of Europe (purple) over 1950-2020. Lines denote the average land-use CO2 flux estimates and shaded areas represent the uncertainty of these numbers (minimum-to-maximum range, as estimated by three bookkeeping models). Chart by Tom Pearson for Carbon Brief.

USA's Net Emissions of GHG Due To Land-Use Change Have Not increased since 1960

Global Land-Use Assumptions are Invalid for North American Agriculture

As can be seen in the chart (green shows reduced land use and red shows increased use), land use to produce foods & bioenergy feedstock has been falling in North America

- Since 1961, total area used to produce animal products in the USA fell by 124 Mha in sharp contrast to global trends
- Reduced land use occurred even as the USA moved from being a net importer to a net exporter of animal products over the same period
  - A 56 Mha shift in production due to increased yields in animal product production
- Total pastureland has also fallen by over 17 Mha in the USA
- In Canada acreage for crop production has increased both for use as human food as well as bioenergy, generally due to conversion of pasture not forested land.



[Alexander 2015]

Figure S1. Mean annual change in area (Mha/year) used for animal product and vegetal crops for human consumption, and bioenergy feedstock production; a) from 1961 to 1994, and b) from 1994 to 2011.

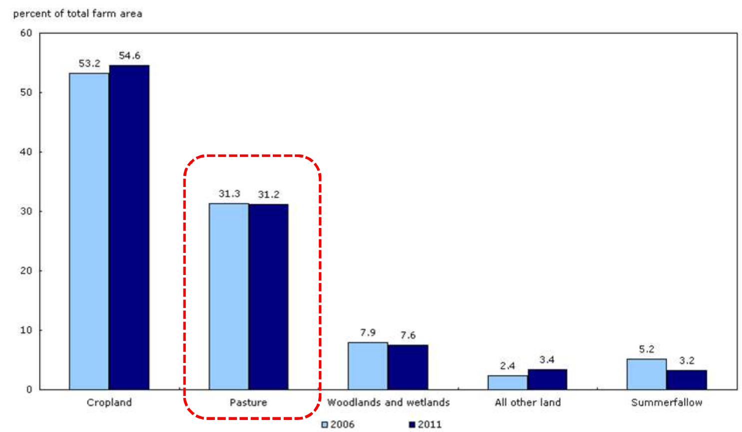
Meanwhile in Canada

- Emissions caused by agriculture are not even in the top 3 sources of GHG Emissions in Canada
  - Sectoral emissions are dominated by oil & gas extraction, followed by its consumption via transportation & buildings
  - According to Canada’s National GHG inventory Report [NIR 2023], all agriculture & forestry emissions are less 10% of *national* GHG emissions
    - Enteric emissions have been flat for over 10 years
- Deforestation due to agriculture is less than 3% of land use change since 2005 in Canada (Table 6-7 from NIR 2023)
  - Rate of forest conversion to cropland has been flat for over 5 years
  - 44x more deforestation occurs due to harvesting of wood for saw lumber & firewood compared to farming-related activities
- According to Statistics Canada, total pasture acreage has fallen by 4.3% since 2006 and represents less than 1/3 of total farm acreage (see chart)
- Livestock cultivation is NOT a driver of GHG emissions growth in Canada
  - Nor is it the dominant use of agricultural land use
  - Nor is it a driver for emissions due to land use change

Canada’s Changes in Agriculture, Forestry and Other Land Uses (AFOLU)

Table 6–7 **Carbon Stocks in the HWP Pool and Emissions Resulting from Their Use and Disposal**

Source Subcategories / Commodities	Land Category	1990	2005	2015	2016	2017	2018	2019	2020
Carbon Stocks (kt C)[a]									
Inputs		**46 000**	**56 000**	**45 000**	**45 000**	**45 000**	**45 000**	**41 000**	**40 000**
Conventional Harvest[b]	Forest Land	40 000	51 000	40 000	40 000	40 000	40 000	36 000	36 000
Forest Conversion[b]	Cropland	1 200	410	550	550	590	580	510	550
	Wetlands	1.8	6.4	17	38	18	0.2	NO	NO
	Settlements	620	770	840	850	810	730	810	720
Residential Firewood[c]	Forest Land	4 200	3 100	3 900	3 700	3 700	3 500	3 200	2 900
	Cropland	230	130	110	160	210	190	150	140
	Settlements	82	83	84	84	84	84	84	84
Exports		**19 000**	**31 000**	**22 000**	**23 000**	**23 000**	**21 000**	**20 000**	**20 000**



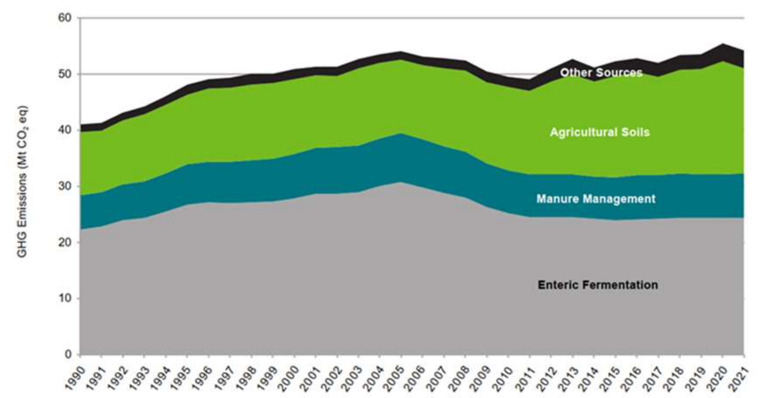
Source: Statistics Canada, Census of Agriculture, 2006 and 2011

What About Agricultural Methane?

- Canada's National GHG Inventory Report identifies enteric emissions as Canada's #2 source of methane emissions after oil & gas extraction [NIR 2022]

- If pasture area and herds were increasing, Canada would have increased methane emissions due to livestock which would be increasing short-term pressure on climate warming
  - But total farm area used for livestock production is falling in Canada
  - Improved yields from livestock production on smaller acreage has resulted in emissions from livestock production being flat since 2011
  - Agricultural methane emission is flat in Canada

Figure 2–18 **Trends in Canadian GHG Emissions from Agriculture Sources (1990–2021)**



Doesn't Methane Build-Up in Atmosphere like CO2?

STOCK GASES BUILD-UP, FLOW GASES DON'T

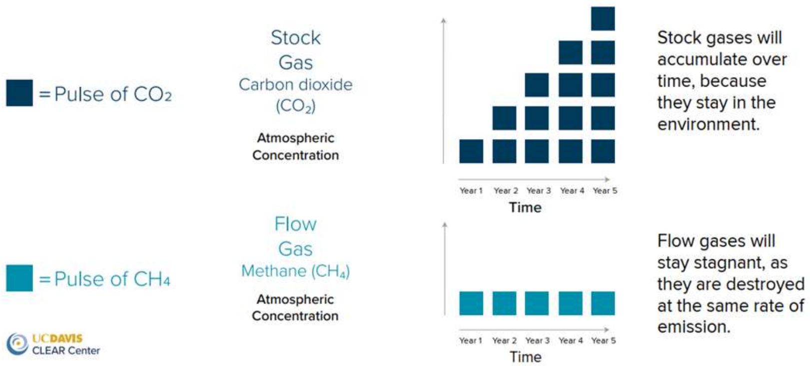


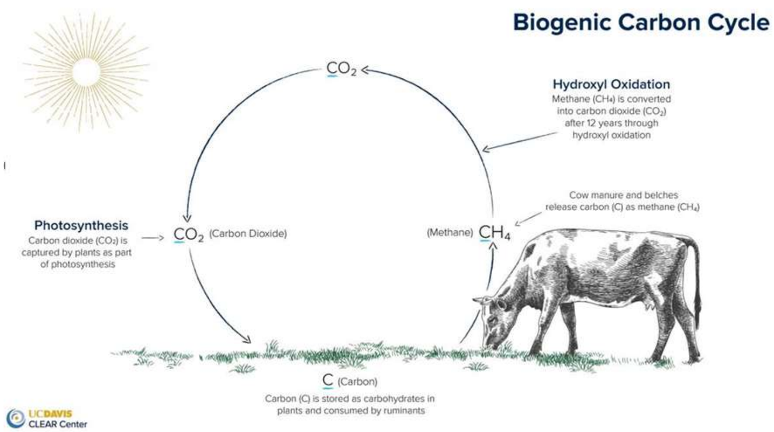
Figure 7. Based on research by Myles R. Allen, Keith P. Shine, Jan S. Fuglestvedt, Richard J. Millar, Michelle Cain, David J. Frame & Adrian H. Macey. Read more here: https://rdcu.be/b1t7S

METHANE DECOMPOSES WITHIN 60 YEARS

- CO2 is a Stock Gas that will persist in the atmosphere for centuries
  - CO2 adsorption by various sinks (trees, oceans, plants, etc.) is not keeping up with total global emissions – causing CO2 to persist in the atmosphere long after emissions are reduced
- Methane is a flow-gas that decomposes naturally into H20 & CO2 at an average rate of ½ every 8.6 years, causing any annual emission of methane to be substantially decomposed 50 – 60 years later (varies due to annual flux in atmospheric ozone levels)
  - Natural decomposition of methane is the source for approx. half of atmospheric water vapour
- So, if methane emission levels are constant, they do not build up in the atmosphere in the same way that CO2 does
  - Agricultural emission of methane has been constant in Canada
  - Fossil-fuel extraction and use is the cause for increased methane emissions in Canada and must be addressed
  - ANY decrease in methane emissions can result in short-term global cooling
    - Including decrease in annual agricultural methane emissions in Canada
    - Hence reduction of agricultural methane emission in Canada is better seen as an **Opportunity** rather than a Problem causing global warming

What About The Short-Term Impact of Agricultural Methane?

- Enteric emissions are produced in the context of a biogenic cycle in which the crops grown to feed cattle capture CO2, cattle produce methane which decomposes over time to be reabsorbed by crops grown to feed cattle
- First Law of Thermodynamics states that energy cannot be created or destroyed
  - Energy out (via methane emissions) cannot exceed energy in (via daily energy intake of food)
  - Even with chemical transformation from CO2 into CH4, it is impossible for enteric emissions to result in higher emission of carbon than the sequestration of carbon in the plants eaten
- In our companion analysis of Enteric Emissions, we demonstrate that this remains true for enteric emissions even when we account for:
  - CH4 having a 25x worse impact as a GHG affecting climate change
  - The molecular balance of carbon within all livestock-related emissions (manure-related emissions as well as enteric emissions)
  - Livestock respiration of CO2 which is not usually counted as an agricultural emission
  - Soil-related emissions from the decomposition of residues from crops harvested for livestock
  - Manure decomposition causing N2O emissions that are ~300x worse impact than CO2
- Our analysis of Canadian dairy indicates that each dairy cow participates in a natural cycle of carbon capture and storage (illustrated) that produces excess *sequestration* of 5 – 10 Mg CO2e per head of cattle per year



Carbon Credits are Unsuitable as a Policy-basis for Reducing The Carbon Intensity of Canadian Agriculture

- Carbon credits arose out of regulatory cap & trade systems in which an industry sector's emissions were capped with the emissions limit allocated to each firm governed by regulation
  - If a firm could not meet its regulatory limit, it was obligated to purchase an offset from other firms that were able to lower their emissions, or face significant financial penalties
  - Any reduction in emissions provided additional headroom under the regulatory cap that could be used to offset any increases by others
- Carbon credit trading soon expanded into unregulated industries, in which *additionality* became a core criteria for a carbon credit:
  - In other words, a carbon credit could only be used to offset carbon emissions by one firm, it the source of the carbon credit represented a removal of CO2e from the atmosphere that would not have occurred otherwise
  - For example, an afforestation project that planted trees might be uneconomical and would not have occurred without funding as a carbon credit development project
  - This introduced significant overheads for carbon credit project justification, implementation, and verification, as well as the various fees and charges from middlemen who provide the carbon trading markets
    - These overheads currently consume approx. 30% of the value generated by carbon credits
  - Depending on the carbon credit project, various contingency reserves are also established to buffer the carbon removal from reversals
- These overheads & contingencies create a practical limit on the extent to which a carbon credit development project can scale-down
  - Our companion report on carbon credits examines in detail why carbon credits are unsuitable as an incentive for Canadian agriculture

Additionality is a Murky Criteria for Managed Land

- The concept of *additionality* breaks down when it is applied in industries such as Agriculture & Forestry that also manage areas where natural sequestration occurs
  - Trees are the most proven and effective "technology" for sequestering carbon -- even a young mature tree 10" in diameter has sequestered a metric tonne of CO_2 to reach that size
  - A strict interpretation of *additionality* ascribes no value to the sequestration of existing trees, while recognizing value from newly planted trees
    - i.e. would promote net loss of sequestration due to deforestation followed by afforestation of trees qualifying for carbon credits
- A broader interpretation of *additionality* establishes that existing sequestration is additional, if it would not have continued to occur without the benefit of carbon credit funding
  - For example, a woodlot might decide to harvest trees less frequently over a 10-year period, resulting in a higher level of sequestration that might otherwise have occurred
  - Many carbon credit protocols do not allow credits for deferred harvesting based on shorter periods of time
  - Others may question whether the trees would have been harvested even over any arbitrary time period
- It is not difficult to imagine how this might become a slippery slope, because when human activities (such as agriculture) occur in areas having existing, natural sequestration, many interactions occur between natural & human-based activities
  - For example, farm trees may benefit from the application of fertilizer or insecticides on adjacent fields and, in turn, have been proven to improve soil productivity on adjacent fields
  - The farm chooses which trees to retain and which to clear for farm, timber, or firewood purposes
  - The farm may also choose to retain or plant trees for agricultural product purposes (maple syrup, nuts & seeds, Christmas trees, etc.)

The IPCC's Definition of Managed Lands

- In 2003, the IPCC determined that "*The scientific community cannot currently provide a practicable methodology to factor out direct human-induced effects from indirect human-induced and natural effects for any broad range of land use, land use changes and forestry activities and circumstances*."

- The IPCC formalized a **Managed Land** land-use designation which requires that ALL emission and sequestration-driven removals from managed lands to be reported and attributed to human activities
  - **Managed land** : Land where human interventions and practices have been applied to perform **production, ecological or social functions**
  - *"Managed land may be distinguished from that unmanaged by fulfilling not only the production but also ecological and social functions."* [2003 IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry]

- The IPCC designated land-use category of **Cropland** "*includes arable and tillage land, and agro-forestry systems where vegetation falls below the thresholds used for the forest land category, consistent with national definitions."* [2003 IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry]
  - Cropland is presumed to be Managed Land by the IPCC best practices as, unlike Forest Land, Grassland, and Wetlands, there are no provisions for subdividing it into manage and unmanaged sub-categories.

- Thus, the sequestration services of existing trees on cropland is deemed to be anthropogenic removals of carbon to be reported under the Cropland land-use category for Managed Lands in each country's National Inventory Report of GHG Emissions
  - I.E. **the sequestration of existing trees on farms should be accounted for as carbon removals when accounting for farm emissions**

Farms are Managed lands per IPCC Criteria

<table>
<tr><th rowspan="2">Farm Component</th><th colspan="3">Farm Functional Benefits</th></tr>
<tr><th>Production Value</th><th>Ecological Value</th><th>Social Value</th></tr>
<tr><td>Cropland</td><td rowspan="2">✓ Used to produce food</td><td>✓ Habitat for ground-nesting birds</td><td rowspan="2">✓ Food is a social necessity</td></tr>
<tr><td>Pasture land</td><td>✓ Tall Grasses retain nutrients in soil</td></tr>
<tr><td>Fallow land</td><td>N/A</td><td>✓ Cropland Regeneration</td><td>✓ Recreational Area</td></tr>
<tr><td>Silvopasture</td><td>✓ Increases livestock unit density
✓ Improves livestock health & growth</td><td>✓ Wildlife habitat (esp. birds)</td><td rowspan="5">✓ Mitigates climate change impact
✓ Provides shade for farm workers & livestock
✓ Stress reduction in farm workers
✓ Basis for pastoral scenes in art, photography, videos</td></tr>
<tr><td>Treed Fence Line / Isolated Trees in Fields</td><td rowspan="4">✓ Wind protection for crops & livestock;
✓ Increases nutrient content in adjacent soils via nutrient cycling;
✓ Increases soil carbon content & nitrogen fixation;
✓ Reduces losses from fertilizer application;
✓ Reduces water consumption;
✓ Increases pollinator and other beneficial insects necessary for increasing crop yields</td><td rowspan="3">✓ Retains moisture via microclimate effect;
✓ Wildlife habitat;
✓ Increases beneficial ground organisms such as fungi & bacteria necessary for improving soil quality
✓ Contains chemical drift after application of herbicides & pesticides</td></tr>
<tr><td>Windbreak / Shelterbelt</td></tr>
<tr><td>Tree Intercropping</td></tr>
<tr><td>Riparian Buffer</td><td>✓ Protects adjacent water resources;</td></tr>
<tr><td>Woodlot / Treed Ravines</td><td>✓ Harvesting foods (mushrooms, leeks, nuts, seeds) for human & livestock consumption, maple syrup, game meats
✓ Harvesting fuel and other forest products</td><td>✓ Wildlife habitat (often critical habitat for biodiversity)
✓ Protects species-at-risk
✓ Wildlife eco-corridor promoting natural transportation of genetic matter</td><td>✓ Recreational Area for walking, skiing, snowmobiling, hunting, and other recreational pursuits</td></tr>
<tr><td>Buildings / Silos / Yards</td><td>✓ Operational use for equipment & livestock;
✓ Storage of crops, manure & other crop inputs</td><td>N/A</td><td>✓ Residential use
✓ Provides protection from elements for farm workers</td></tr>
<tr><td>Wetlands / Streams</td><td>✓ Harvesting aquatic foods such as cranberries, fish, duck & other aquatic-based game</td><td>✓ Regulates water, humidity & temperature
✓ Wildlife habitat & critical water supply</td><td>✓ Recreational Area for fishing
✓ Source for fire suppression</td></tr>
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National Designations of Managed Land Area in Canada & USA

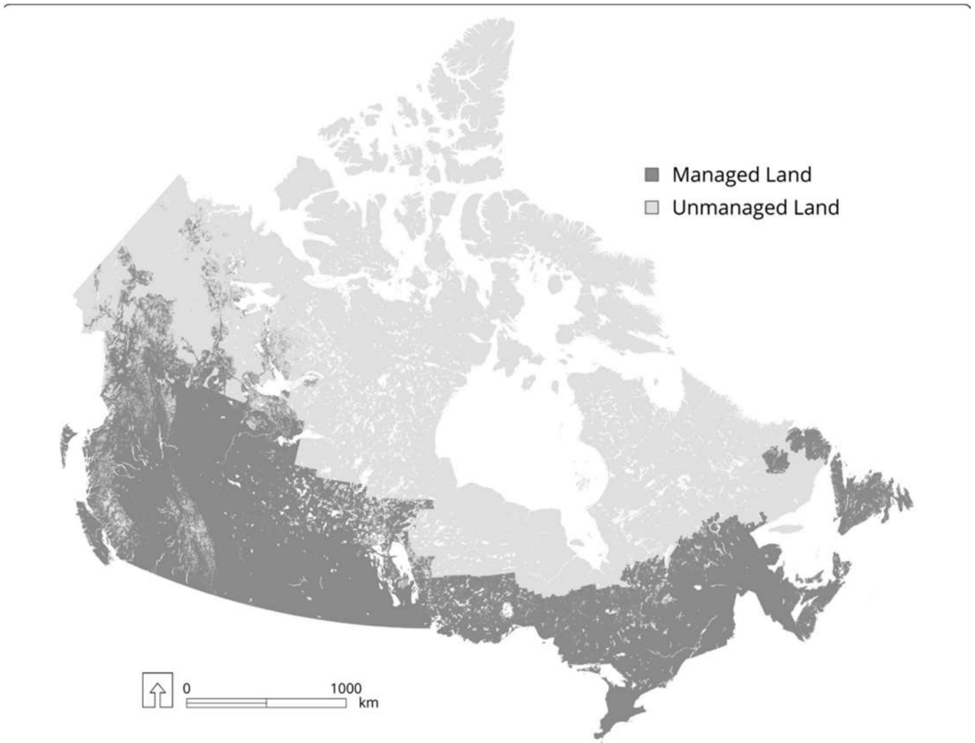


Fig. 2 Distribution of managed and unmanaged land in Canada. The light gray areas are unmanaged and the darker gray areas are managed

Fig. 4 Distribution of managed and unmanaged land in the United States. The gray areas are unmanaged and the blue areas are managed

[2018 Ogle et al]

All Agricultural Land is Designated as Managed Land in Canada

CANADA'S MANAGED LAND DESIGNATION

Fig. 2 Distribution of managed and unmanaged land in Canada. The light gray areas are unmanaged and the darker gray areas are managed

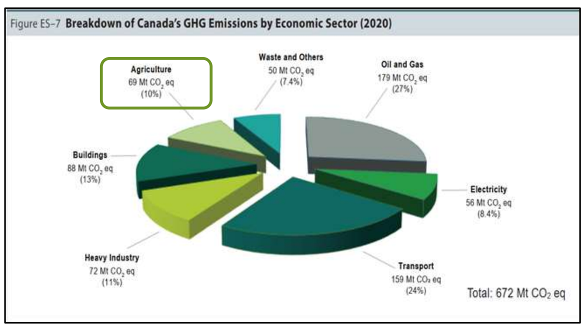
LOCATION OF FARMS IN CANADA

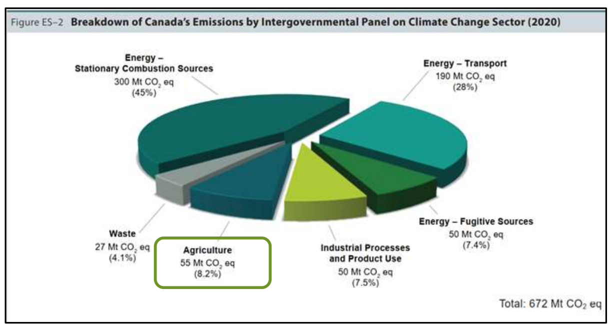
Map showing the agricultural extent of Canada *(Source: AAFC, 2013)*.

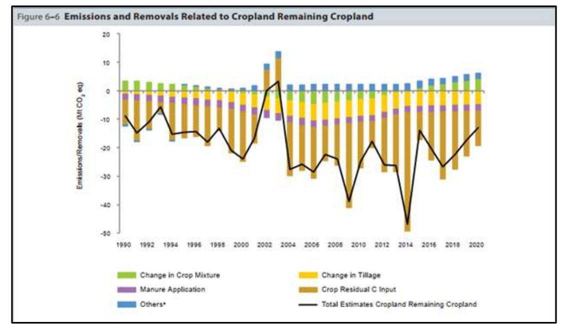
To be Consistent with IPCC Best Practices for Carbon Accounting Natural Sequestration on Agricultural Land Must be Included Along With Emissions

The format of the National Inventory Report of GHGs makes it easier to see all agricultural emissions than any removals due to natural factors

- Emissions are highlighted in the Executive Summary, and enumerated in detail in Chapters 1 – 5 of Canada's National Inventory of GHG
  - Agricultural emissions due to stationary and off-road use are comingled with fishing and forestry emissions
  - Biogenic emissions related to livestock are not distinguished from anthropogenic emissions
- Removals for all sources, as well as fluxes caused by changes in land use are comingled in Chapter 6
  - Agricultural sequestration on cropland is included in Canada's National Inventory of GHG, but currently only shelterbelts are included in the accounting for sequestration by perennial vegetation (e.g. trees) – understating removals of carbon on farmland







Why Is There No Attention Given to Natural Sequestration on Farms?

- A common misconception is that there are not enough trees on farms to warrant analysis
  - However, trees and other perennial vegetation grow in areas of the farm that cannot be cultivated or used as pasture
    - Fencelines, ravines, steep slopes, drains, riparian buffers, rocky soils, …
  - In a companion report we document two farms that have enough existing treesd acreage (over 25%) to offset all of their farm emissions
  - We also conservatively estimate there are 30 M perennial acres on farms (12.5 Mha), of which 8 M acres are treed (3.2 Mha)

Statistics Canada 2021 Census	Average Farm Land Use (Acres)						Province-Wide Total Perennial Acreage			
Province	Cropland	Pasture	Fallow	Perennial	Remainder	% Perennial	Perennial Acres	Grassland	Woody Perennials	Treed
Alberta	775	344	157	356	184	20%	11,795,139	4,529,333	6,546,302	719,503
British Columbia	116	123	21	197	101	35%	2,498,158			2,498,158
Manitoba	945	251	96	275	141	16%	3,067,949	1,178,092	1,702,711	187,145
New Brunswick	219	53	8	147	76	29%	224,604			224,604
Newfoundland	72	48	5	76	39	32%	19,108			19,108
Nova Scotia	116	42	5	132	68	36%	296,401			296,401
Ontario	**126**	**42**	**17**	42	21	17%	1,519,122			1,519,122
Prince Edward Island	351	52	10	84	44	16%	75,362			75,362
Quebec	225	50	13	83	43	20%	1,926,716			1,926,716
Saskatchewan	1353	508	268	399	206	15%	9,468,522	3,635,913	5,255,030	577,580
						24%	**30,891,082**	**9,343,338**	**13,504,044**	**8,043,700**
						Hectares	12,501,188	3,781,118	5,464,897	3,255,173

Facts vs Myths Regarding Farm Trees (and other perennial vegetation)

- Fact: Trees are the most cost-effective means of carbon capture and storage and present a significant opportunity as a natural climate solution to mitigate climate change

- Myth: Sequestration of carbon by trees is limited by tree mortality resulting in release of stored carbon
  - Over 1/3 of the carbon sequestered by trees is below ground and less prone to loss in non-organic forest soils found in most of Canada
  - Release of carbon from organic rainforest soils on the coast of BC are not indicative of the likelihood of carbon loss in mineral soils elsewhere
  - Only in old-growth forests, is release of above ground carbon in balance with sequestration in above ground bio-mass
  - Woodlots on farms and sugarbushes are NOT old-growth forests and are actively managed to not have a closed canopy to maximize tree biomass growth (e.g. for saw lumber or sugarbush production value)

- Myth: Sequestration by trees on farms is prone to reversal
  - Reversal in forest environments is chiefly caused by fire and to a lesser extent invasive insects and disease
  - The incidence of forest fires on farms is close to zero due to improved fire suppression
  - The effect of invasive insects and diseases in farm woodlots is less due to reduced connectivity with adjacent forests

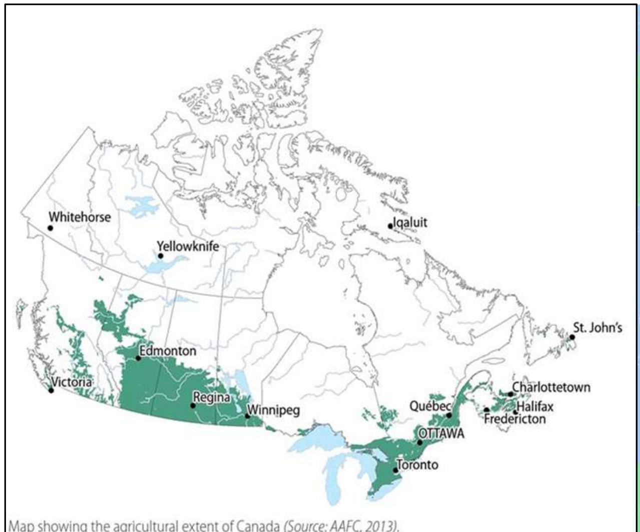
- Myth: Farmers won't plant trees and prefer to remove them
  - Most farms in eastern Canada already have trees on them (15 – 30%), growing primarily in unworkable farm areas and in woodlots
  - In Western Canada, 15% of farm areas are perennial vegetation (shrubs and prairie grasses) also growing in unworkable farm areas
  - Farmers are increasingly interested in agroforestry due to the opportunity to improve livestock density and health

Risk of Sequestration Reversal is Far Less for Farm Trees Compared to Forests

Not surprisingly, the incidence of wildfires is significantly reduced in farm areas:

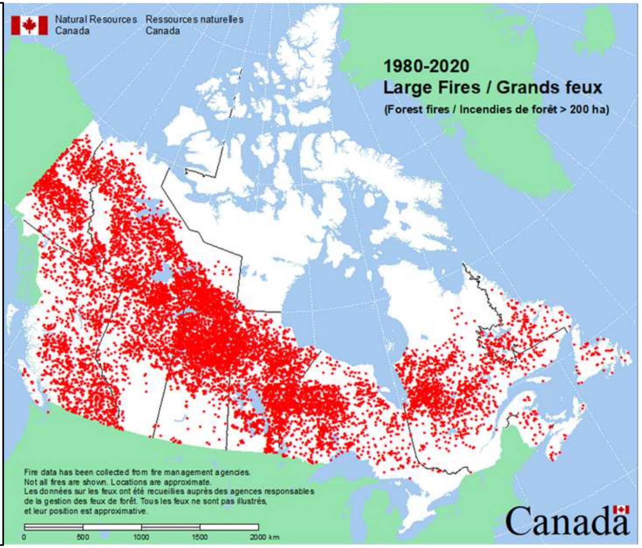
- ❖Fewer trees
- ❖Non-contiguous woodlots and treed compartments within croplands and pasture lands
- ❖Better access to fires started by lightning strikes
- ❖Farm awareness of fire risks due to use of farm chemicals, manure management systems, etc.
- ❖Improved fire suppression capabilities via on-farm and farm community resources

Farm Tree Locations
Based on Farm Locations



Map showing the agricultural extent of Canada *(Source: AAFC, 2013)*.

Forest Fire locations 1980 – 2020
From Canadian National Fire Database



Key Takeaways

- It is inaccurate to assume that global level trends regarding the land use change apply to all regions and nations
  - Global land use change assumptions are invalid for USA and Canadian agriculture
- The IPCC definition of Managed Land must be applied when considering the sustainability of agricultural land
  - The carbon footprint of agriculture requires considering sequestration by natural processes as well as emissions
- The presumption that all carbon sequestered in the harvested yield of crops is rapidly released is largely untested scientifically
  - This presumption is inaccurate for crops grown to feed livestock
- The presumption that there are no trees on farms (or insufficient trees to matter) is absolutely false in Canada
  - Particularly for Eastern Canada and BC
    - In Southwest Ontario, which is widely presumed to have “no trees on farms””, we documented a farm that has 35% of its area producing natural sequestration services
  - In the Prairies, significant perennial vegetation (woody perennials and grassland) exists that provides valuable sequestration services (largely unmeasured)
    - We have documented that a 1000 ha sample of farmland immediately east of Weyburn Sask, has 15% perennial vegetation in an area that is widely presumed to be pure cropland

Annex

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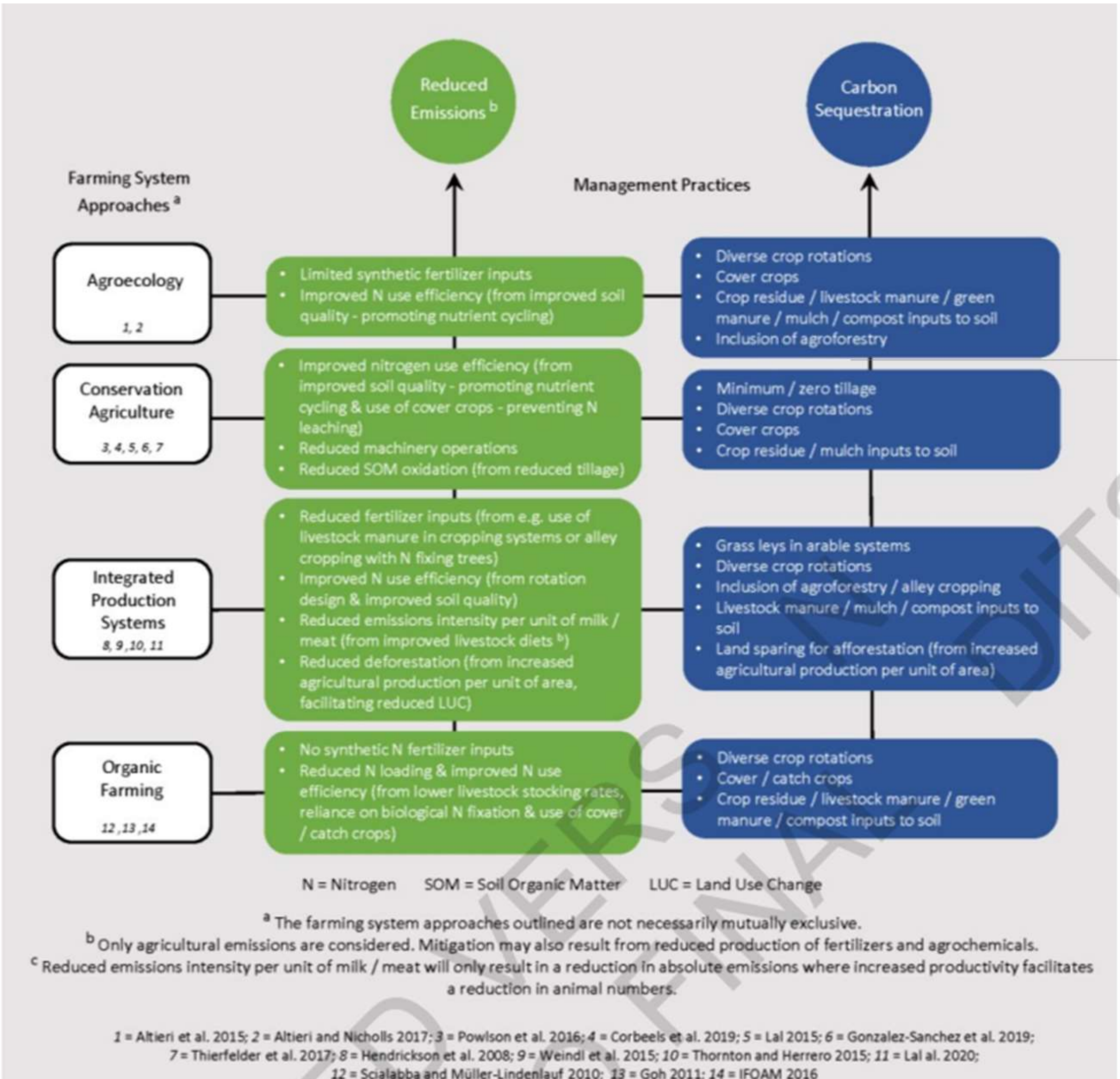


Recommended Initiatives for Reducing Climate Footprint in Livestock Production

- ✓Note that IPCC recommended practices address increasing sequestration on farms as well as emissions reduction (IPCC AR6 WG3)
- ✓Reducing enteric emissions via improved diet is helpful in reducing agricultural methane emissions
- ✓Use of livestock manure to reduce synthetic fertilizer use is helpful in reducing N2O emissions from fertilizer as well as the upstream agrichemical emissions from manufacturing fertilizers
- ✓Crops grown to feed livestock sequester even more carbon when conservation agriculture methods are used to grow them
- ✓Agroforestry methods (such as silvopasture and alley cropping) are helpful in reducing fertilizer use (trees act as nitrogen pumps) for crops grown as well as provide sequestration benefits

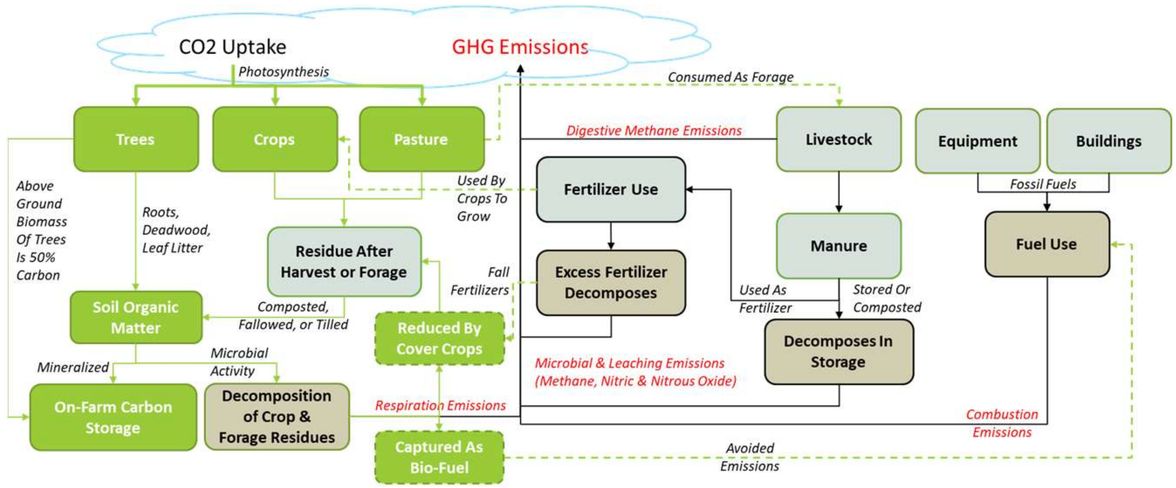
Our Farm-Level Carbon Footprint Modeling

Sequestration

- Models gains/losses In IPCC-defined carbon pools:
  - Above Ground Biomass
  - Below Ground Biomass
  - Soil Organic Carbon
  - Organic Litter & Deadwood
- Includes trees, crops, grasses

Emissions

- Models all 3 Scopes (ISO 16047)
- Direct Emissions
  - Crops & Livestock
  - Fuel & Fertilizer use
- Indirect Emissions
  - Electrical use
  - Upstream
    - Fuel extraction & processing
    - Input chemical manufacturing
    - Feed & other input deliveries
  - Downstream
    - Transport Harvest to Market
    - Export of manure and other by-products to other farms



The carbon content in harvested crops is not considered to be a carbon pool because it is either consumed or wasted, ultimately releasing any stored carbon in the process.

As this is not true for crops consumed by livestock our farm-level carbon modeling calculates it but keeps it separate in carbon footprint calculations,