ADDRESSING PERSISTENT MARKET FALLACIES

in the Agriculture Space

Investments in farmland.

INTRODUCTION:

Let's attempt to address the large number of commonly held, but generally incorrect, beliefs surrounding the agriculture sector. Just a glance at the news on any typical day would lead a layperson to believe farming is a low tech, unproductive, inefficient, environmentally destructive, unnecessary, climate imperilled and unnecessary activity… however nothing could be further from the truth. Here is a sample:

- Canadian farming will be negatively impacted by global warming
- Cutting fertilizer use will not impact production
- Canadian farmers *"over-apply"* fertilizer
- Farming is low-tech
- Food demand growth is slowing
- Biofuel mandates don't affect food prices
- Large scale farmers damage the land
- Ruminants are environmentally unfriendly and an unnecessary part of the food system.
- Sanctions on Russian agriculture products are consequence free
- Farming is inefficient with low productivity growth

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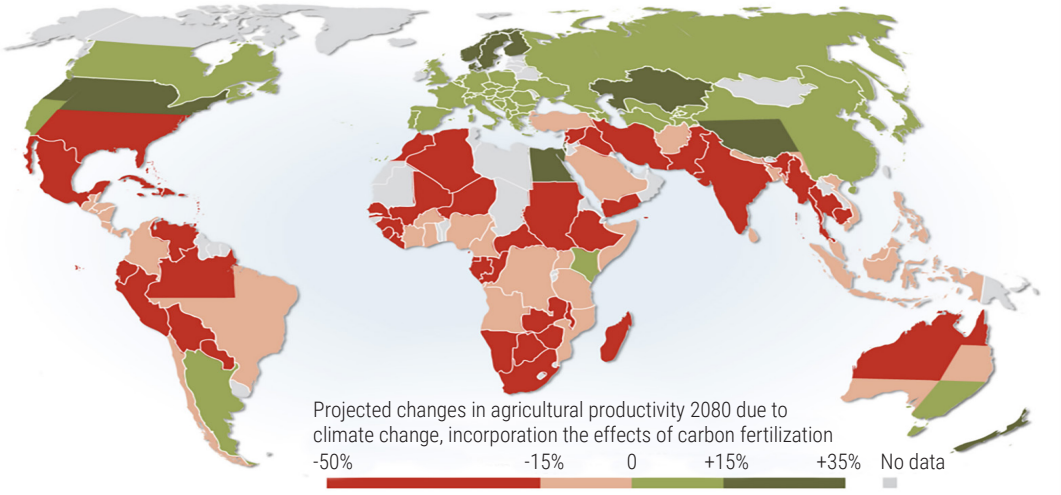
CANADIAN FARM PRODUCTIVITY WILL BE POSITIVELY IMPACTED BY GLOBAL WARMING:

Canada is forecast to experience increased agricultural productivity from global warming while at the same time there will be a decrease in competing mid-latitude regions as can be seen from the heatmap below:

Table 1: Projected Change in Agricultural Productivity in 2080 Due to Climate Change



Source: Hugo Ahlenius, UNEP/GRID-Arendal, Cline, W.R. 2007. Global Warming and Agriculture: Impact Estimates by Country. Washington D.C., USA: Peterson Institute

Why is this forecast to take place?

- Longer Growing Seasons: Global warming is expected to result in longer summers, allowing farmers to plant crops earlier and harvest them later. This extended growing season also creates opportunities to introduce new crops that were previously unsuitable for the region. For instance, heat-loving crops such as corn, soybeans, and cotton could potentially be cultivated in Canada's northern regions, replacing traditional crops like wheat and barley. *"As growing seasons lengthen in response to climate change, Canadian farmers are exploring new crop options, like corn and soybeans, that were previously limited by shorter seasons and cooler temperatures."* – Dr. Dean Spaner, Professor in the Department of Agricultural, Food, and Nutritional Science at the University of Alberta.
- Higher Temperatures: Warmer temperatures can promote crop growth rates, enhance seed germination, and increase photosynthesis, ultimately leading to higher crop yields. Additionally, warmer temperatures may reduce the risk of frost damage. Consequently, farmers could potentially save on expensive frost protection measures, such as heaters or crop covers, resulting in lower production costs.
- Increased Precipitation: A sufficient water supply is essential for crop growth. The projected increase in rainfall due to climate change could lead to higher yields and more consistent output in Canadian agriculture. "*Climate change projections indicate that some regions in Canada may experience increased precipitation, which can help meet the water demands of agriculture and contribute to higher crop yields.*" – Dr. Howard Wheater, Canada Excellence Research Chair in Water Security at the University of Saskatchewan.
- Increased Carbon Dioxide: Increased levels of carbon dioxide in the atmosphere have a fertilization effect on crops, potentially improving crop yields in northern latitudes. *"The elevated CO2 levels in the atmosphere can provide a fertilization effect that enhances crop productivity, particularly in regions where other environmental factors, such as temperature and precipitation, are also becoming more favorable for agriculture."* – Dr. Elizabeth Ainsworth, Plant Biologist at the USDA-ARS and the University of Illinois.

AMMONIA BASED FERTILIZER HAS NO CURRENT REPLACEMENT:

Nitrogen fertilizer is not an optional component of the global food production system. *"With average crop yields remaining at the 1900 level* (ie without the use of the Haber process to produce nitrogen fertilizer – addition mine) *the crop harvest in year 2000 would have required nearly 4 times more land and the cultivated area would have claimed nearly half of all ice-free continents, rather than under 15% of total land area that is required today"* - Vaclav Smil. Nearly 50% of the nitrogen currently found in human beings originated from the Haber process and it enabled the global population to increase from 1.6 billion in 1900 to approximately 8 billion today. There is NO known process with the efficiency and scale to replace the ammonia-based fertilizers produced by the Haber-Bosch process so it must continue to be the primary source of nitrogen for agriculture.

It then follows almost axiomatically that current plans to arbitrarily reduce nitrogen/ammonia-based fertilizer use by 30% by 2030 would lower crop yields and have a significant impact on the availability and affordability of food for consumers. For example, analysis by the International Maize and Wheat Improvement Center (CIMMYT) found that a 30% reduction in nitrogen fertilizer use in wheat production in South Asia could lead to a 13% reduction in yield.

Moreover, reducing ammonia-based fertilizer use will also lead to a decrease in soil fertility, which will have long-term negative effects on agricultural productivity. If nitrogen is not replaced, the soil will become less able to support plant growth, leading to reductions in crop yields. It could also lead to the need to expand the amount of land in agricultural use potentially by converting timber or pastureland.

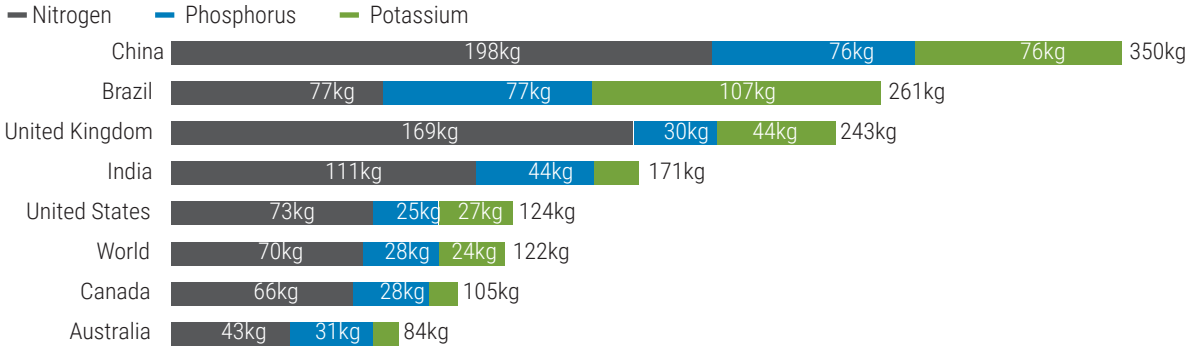
The Haber process is a crucial industrial method for producing ammonia, a key ingredient in nitrogen-based fertilizers. In simple terms, it involves combining nitrogen and hydrogen gases under high pressure and temperature in the presence of a catalyst. Nitrogen is obtained from the air, which is about 78% nitrogen, while hydrogen is typically sourced from natural gas. The resulting ammonia is then used to create fertilizers that help plants grow by providing them with essential nitrogen. The importance of the Haber process cannot be overstated, as it has played a vital role in global food production and population growth. Before the development of this process, obtaining nitrogen for fertilizers was limited and inefficient. The Haber process revolutionized agriculture by significantly increasing crop yields and allowing farmers to produce more food on less land.

Despite claims to the contrary, there is no substitute for ammonia-based fertilizer at the scale of the Haber-Bosch process that can match its effectiveness in increasing crop yields. Alternative methods of fertilization, such as organic fertilizers, have serious limitations in terms of their availability and effectiveness in comparison to ammonia-based fertilizers. For example, chicken manure typically contains around 3% nitrogen, while synthetic nitrogen fertilizers such as urea contain up to 46% nitrogen. This means that a vastly larger volumes of organic fertilizer would be needed to provide the same amount of nutrients as synthetic fertilizers.

CANADIAN FARMERS USE FERTILIZER EFFICIENTLY:

Despite being recognized as highly efficient in their use of nitrogen/ammonia-based fertilizer, Canadian farmers are now facing potential reductions in nitrogen-based fertilizer use mandated by the federal government. Nitrogen Use Efficiency ("NUE") is an important measure of how effectively crops use nitrogen fertilizer, with a NUE of 60% indicating that the crops used 60% of the nitrogen that was added as inputs. Canadian farmers achieve an average NUE of approximately 60%, which is significantly higher than the global average of around 40%. This is attributed to Canadian farmers focus on sustainable agriculture practices, including precision fertilization, use of nitrogen-fixing crops, and adoption of technologies such as controlled-release fertilizers.

Chart 1: Fertilizer Use Per Hectare of Cropland, 2019



Source: FAO

Canadian farmers are also low absolute users of fertilizer per hectare of cropland, which is a testament to their sustainable farming practices. However, reductions in nitrogen-based fertilizer use could lead to challenges for farmers in maintaining their crop yields and productivity levels. As nitrogen is a critical nutrient for plant growth, reducing its use could result in lower crop yields and decreased agricultural productivity, leading to potential food shortages and higher food prices. While larger scale farmers may be able to invest in technology and adopt precision farming practices to reduce their fertilizer use, smaller farmers may not have the same level of resources available to them.

Given its critical and irreplaceable role in feeding the global population, nitrogen/ammonia-based fertilizer price increases are going to impart upward real pressure on agricultural commodity prices. This in turn is creating a compelling ROI for large scale farmers who adopt the technology (precision farming, variable rate application etc) to reduce fertilizer use materially as its one of their biggest operating costs. While smaller farmers have a similar incentive, they lack the scale and may not have access to the capital to fully capture the returns. Will this mean greater profits for larger farms and reduced profits for smaller farms?

FARMING IS HIGH TECH:

Precision farming is a management concept which utilizes modern technology, such as GPS, Geographic Information Systems and data analytics, to accurately measure, monitor, and manage soil and plant production. Precision farming enables farmers to apply the right amount of fertilizer, water, and other inputs at the right time and place, resulting in more efficient and effective use of resources.

Variable Rate Technology (VRT) is an advanced agricultural approach that optimizes resource usage and enhances crop yield, quality, and sustainability. By leveraging GPS, sensors, and software to collect and analyze data on field-specific needs, VRT enables precise application of inputs like water, fertilizers, and pesticides.

Autonomous farm vehicles are self-driving, intelligent machines designed to perform various agricultural tasks without human intervention. These vehicles use a combination of sensors, GPS, cameras, and machine learning algorithms to navigate, identify crops or obstacles, and execute operations such as planting, fertilizing, and harvesting. By automating labor-intensive tasks, autonomous farm vehicles improve efficiency, reduce labor costs, and enable farmers to manage larger areas.

Precision farming also allows for the optimization of crop yields by taking advantage of site-specific variations in soil, climate, and topography. By understanding the unique characteristics of a particular field, farmers can tailor their crop management strategies accordingly. For example, they can apply fertilizers and pesticides only where needed, based on precise measurements of soil fertility and pest pressure. This not only reduces production costs but also minimizes the environmental impact of farming.

Table 2: Current planned use by region of precision technology tools:

Precision Agriculture		Yield monitoring and mapping	Fertilizer application	Sprayer section controllers	In-field soil sensors
Global	18	69	67	67	45
North America	28	76	76	70	37
South America	27	79	79	77	56
Europe	21	40	40	53	47
Asia	4	42	42	44	47

1Q: What is your level of adoption on the following trends? (n=5,675); Asia includes China and India; Europe includes Germany, France, Netherlands, and Spain; North America includes Canada and the United States; South America includes Argentina and Brazil.
2Q: What is your level of adoption on the following precision agriculture hardware? (n=887).
Source: Farmers Global Insights Survey, McKinsey, May 2022

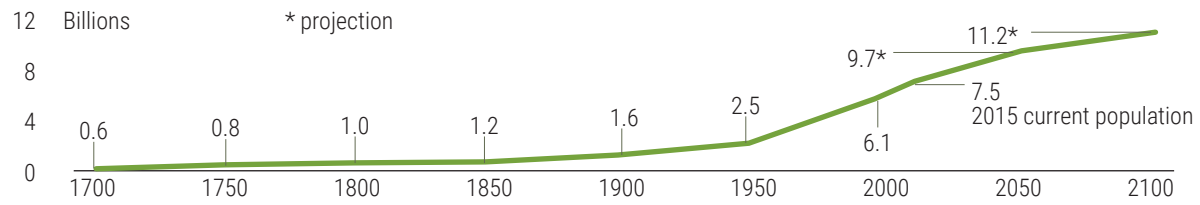
North American farmers are at the forefront of the high-tech adoption trend. According to a recent survey, most Canadian farmers (77%) say they are using at least one type of precision agriculture technology, while nearly half (47%) say they are using multiple precision agriculture technologies. This is due in large part to the increased availability of precision agriculture technology, as well as the growing recognition of its potential to improve yields and reduce costs.

Advanced data analytics help collect and analyze data on soil conditions, crop yields, and other factors. This information helps farmers make informed decisions about planting, fertilization, and harvesting. By identifying patterns and trends in their fields, farmers can optimize their operations for maximum efficiency.

FOOD DEMAND WILL CONTINUE TO GROWTH RAPIDLY:

By 2050 there will be over two billion more people (26% increase) and billions more in the middle class – creating the multiplying effect of more people to feed and greater protein consumption per capita.

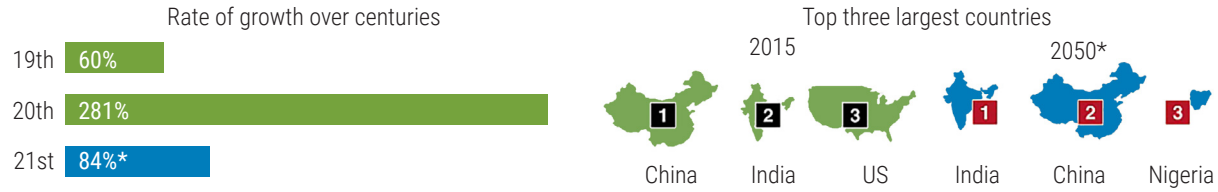
Chart 2: World Population to Reach 9.7 billion by 2050



Source: United Nations

Population and socio-economic growth will overwhelming be in emerging markets which have not gone through the dietary transition to higher protein consumption – which is a crop consumption multiplier.

Chart 3: Rate of Population Growth by Three Largest Countries to 2050



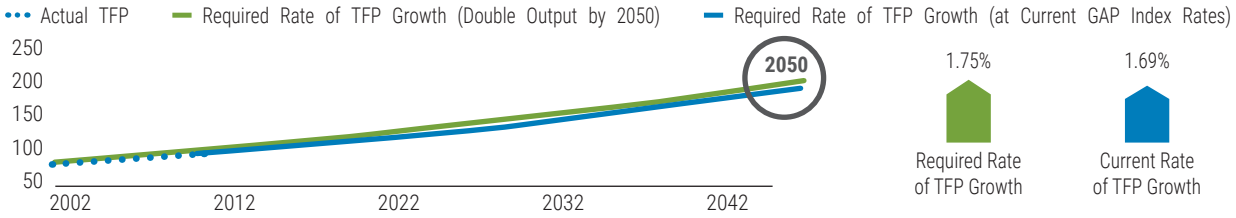
Source: United Nations

Chart 4: Crop Equivalent Calories Analysis – Developed versus Developing Market Diets

Source: Beef Cattle Research Council (8), World Health Organization (9), Nation Master Website (4), FAO (5), Veripath analytics

The result is that the projected food demand growth rate exceeds the currently projected agricultural productivity growth rate – leaving a "*gap*" which will be closed with absolute per capita consumption drops or substitutions.

Chart 5: Global Agricultural Productivity Gap



Source: 2014 Global Agricultural Productivity Report

BIOFUEL MANDATES ARE INCREASING AGRICULTURAL COMMODITY PRICES:

According to a 2018 report by the World Bank, biofuel mandates and subsidies have led to a significant increase in the price of food commodities. The report found that between 2004 and 2011, biofuel mandates and subsidies accounted for about 30% of the increase in food prices.

One reason for this is that biofuel production often involves using land and crops that would otherwise be used for food production, leading to competition for resources and driving up food prices. For example, in the United States, the production of corn-based ethanol has been criticized for diverting large amounts of land and corn away from food production, leading to higher food prices.

Another factor is the effect of biofuel mandates on global commodity markets. As more countries adopt biofuel mandates, the demand for biofuels increases, leading to higher prices for the crops used to produce them. This increased demand can also spill over into other crops, leading to higher prices for food commodities.

Table 3: Land Requirement for Biofuel Production:

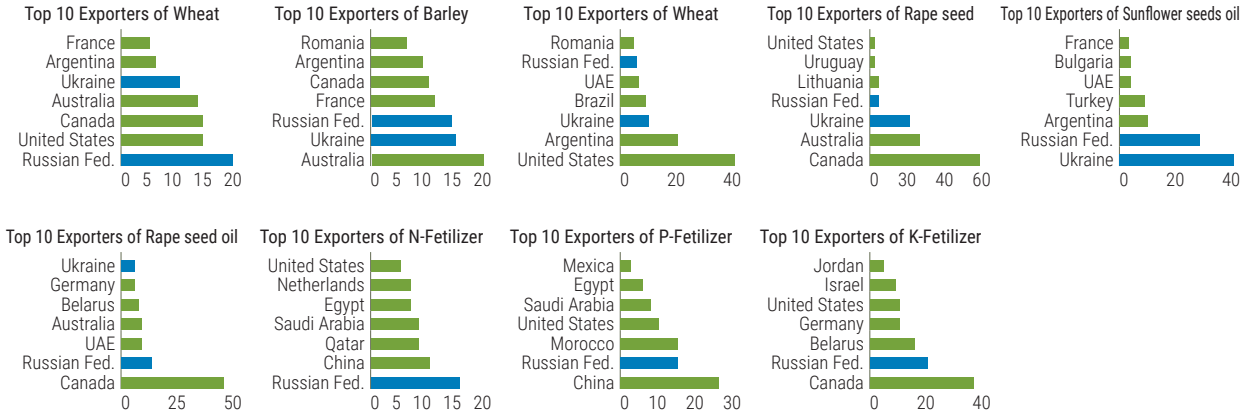
	2004[1]		2030[2]		2030[3]		2030[4]	
	Million hectares	% arable	Million hectares	% arable	Million hectares	% arable	Million hectares	% arable
The United States & Canada	8.4	1.9	12.0	5.4	20.4	9.2	22.6	10.2
European Union	2.6	1.2	12.6	11.6	15.7	14.5	17.1	15.7
OECD Pacific	Neg.	Neg.	0.3	0.7	1.0	2.1	1.0	2.0
Transition economics	Neg.	Neg.	0.1	0.1	0.2	0.1	0.2	0.1
Developing Asia	Neg.	Neg.	5.0	1.2	10.2	2.5	11.5	2.8
Latin America	2.7	0.9	3.5	2.4	4.3	2.9	5.0	3.4
Africa & Middle East	Neg.	Neg.	0.8	0.3	0.9	0.3	1.1	0.4
Global	13.8	1.0	34.5	2.5	52.8	3.8	58.5	4.2

Source: FAO, International Energy Agency. 1 Land used for biofuel production in 2004 and as a percentage of total arable land. 2 Situation in 2030 if current trends remain unchanged. 3 Situation if countries adopt all of the policies they are currently considering related to energy security and CO_2 emissions. 4 Situation which some biomass for biofuel production comes from non-arable land and residues, reducing arable land requirements.

SANCTIONS ON RUSSIA ARE INCREASING AGRICULTURAL COMMODITY PRICES:

Over and above direct food production, Russia is the global leader in fertilizer supply….

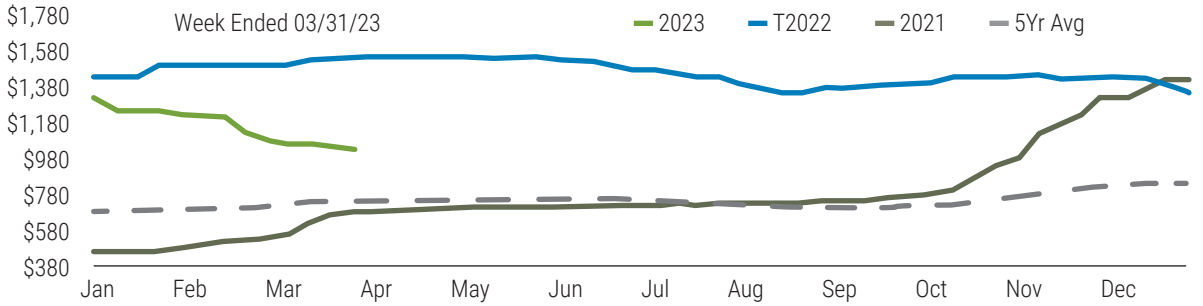
Table 4: Russia and Ukraine – Key Commodity Export Rankings



Source: FAO

"High European natural gas prices forced curtailment in European fertilizer production in the fall of 2021. Russia's invasion of Ukraine further increased European energy prices, leading to 70% of EU ammonia production being idled in the fall of 2022. Fertilizer prices have come off recent highs yet remain historically elevated, given uncertainties in global nitrogen capacity." FCC

Chart 6: Average Weekly Retail Anhydrous Prices

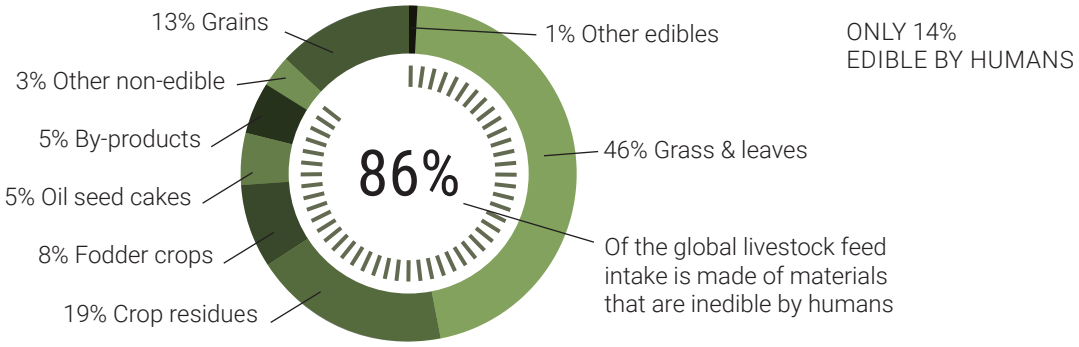


Source: DTN

LIVESTOCK DO NOT HARM THE ENVIRONMENT:

Ruminants, through their evolution over millennia, have developed a symbiotic relationship with plants that allows for the conversion of cellulose into valuable animal protein and fats. Furthermore, a significant portion of global livestock feed is composed of materials indigestible for humans, with grass alone comprising nearly half. These factors highlight the efficiency and sustainability of livestock production within the agriculture industry.

Chart 7: Analysis of Global Livestock Feed Intake



Source: www.sacredcow.info

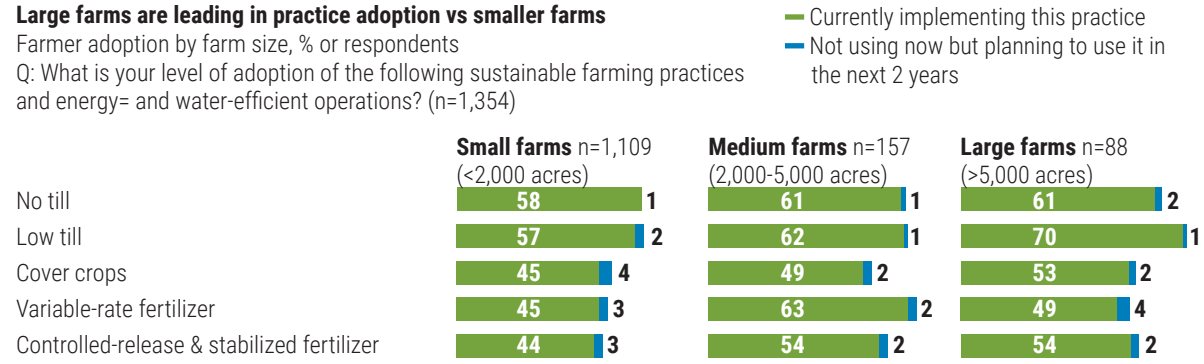
In addition, not all land can be cropped, and pasture raised cattle are a large and efficient source of high-quality protein (animal sources are complete as they contain all the amino acids required by humans) in the food system. *"Removing cattle doesn't mean we'll free up more land for crop production. More than 60% of agricultural land globally is pasture and rangeland that is too rocky, steep, and/or arid to support cultivated agriculture – yet this land can support cattle and protein upcycling"* Source Sacredcow.info. There are also less well-known benefits of ruminant protein production:

- Carbon sequestration: Pasture-fed cattle can help to sequester carbon in the soil through their manure and hoof action. This can increase soil organic matter and improve soil health, which can reduce greenhouse gas emissions and help to mitigate climate change.
- Reduced use of fossil fuels: Pasture-fed cattle systems often require less energy-intensive inputs, such as fertilizer and fuel, compared to conventional grain-fed systems. This can reduce the carbon footprint of beef production and help to conserve natural resources.
- Water conservation: Grazing animals on pasture can help to conserve water resources by improving soil structure and reducing runoff. This can lead to increased water infiltration and groundwater recharge.
- Soil health: Grazing animals can help to improve soil health by increasing nutrient cycling, reducing erosion, and improving soil structure. This can lead to increased productivity and resilience of pasture ecosystems.

LARGE SCALE FARMERS ARE MORE LIKELY TO USE CONSERVATION AGRICULTURE PRACTICES:

Larger farms are generally better for the soil because they are more able to adopt soil management practices that improve soil health. For example, larger farms can implement more advanced soil conservation practices such as contour plowing, crop rotations, and cover crops. These practices help to increase the organic matter content of the soil, improve soil fertility, and reduce erosion. Additionally, larger farms are better able to access the resources necessary for soil management, such as machinery and irrigation systems. This helps to ensure that soil management practices are implemented properly and consistently, which further improves soil health. According to McKinsey *"Across all markets, large farms—more than 5,000 acres—are the most willing to adopt agtech solutions (81 percent), with 76 percent of medium farms (2,000 to 5,000 acres) and 36 percent of small farms (fewer than 2,000 acres) using or planning to use at least one technology in the next two years".*

Table 5: Farm Practices Adoption Survey



Source: McKinsey US Farmer Insight 2022-2023 (n=1354)

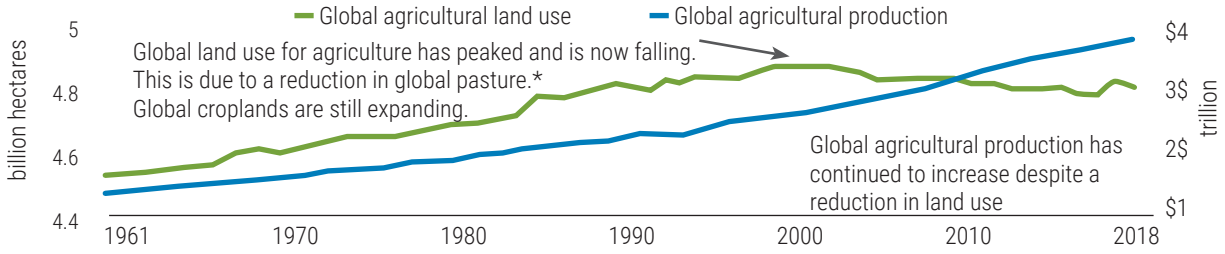
There are many more examples:

- In the midwest region of the US larger farms had higher soil organic matter content than smaller farms. Specifically, farms over 2,000 acres had an average soil organic matter content of 3.5%, compared to 2.9% for farms under 500 acres - source: University of Minnesota Extension.
- In Europe, larger farms are more likely to adopt practices such as crop rotation, intercropping, and reduced tillage. Specifically, farms over 100 hectares were found to use reduced tillage on 71% of their land, compared to 47% for farms under 20 hectares - source: European Environment Agency.
- in the Great Plains region of the US larger farms had lower erosion rates than smaller farms. Specifically, farms over 5,000 acres had an average soil erosion rate of 2.5 tons per acre per year, compared to 5.5 tons per acre per year for farms under 500 acres - source: University of Nebraska-Lincoln.

FARMING IS HIGHLY EFFICIENT:

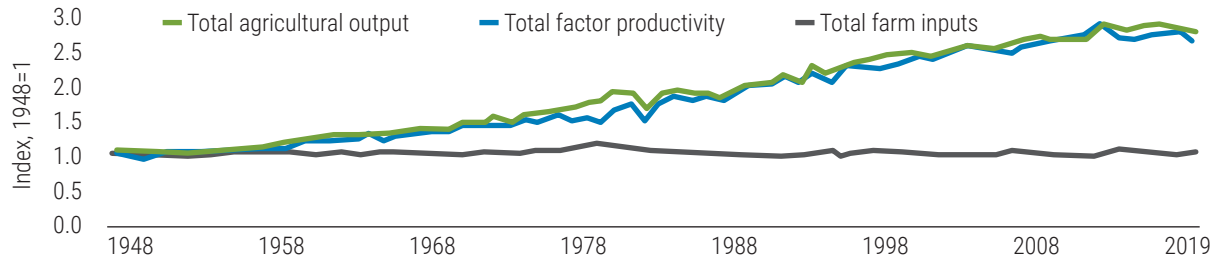
When either total factor productivity or simply overall productivity are considered farmers have shown remarkable and consistent gains over the last 40 years.

Chart 8: Global agricultural land versus food production



Source: Our World in Data

Chart 9: US Agricultural Productivity (outputs, inputs, and total factor from 1948-2019, 1948 = 1)



Source: USDA Economic Research January 2022

To put this efficiency into more concrete terms with examples:

- The average corn yield in the U.S. has increased from 75 bushels per acre in 1980 to 177 bushels per acre in 2020, representing a 135% increase – source USDA
- The global use of nitrogen fertilizer per hectare of cropland has decreased by 11% since 2002 – source International Fertilizer Association
- The adoption of conservation tillage practices has increased in the U.S., from 17% of total cropland in 1990 to 67% in 2017 – source USDA
- The average rice yield in Asia has increased from 2.2 tons per hectare in 1970 to 4.5 tons per hectare in 2018, representing a 105% increase - source International Rice Research Institute
- The amount of water needed to produce a kilogram of wheat in India has decreased from 4,240 liters in 2005 to 3,654 liters in 2014, a 14% decrease - source International Water Management Institute
- The use of pesticides in the EU decreased by 21% between 2011 and 2018 - source European Commission
- The average milk yield per cow in the United States has increased from 6,989 pounds per year in 2000 to 9,327 pounds per year in 2020, a 33% increase - source USDA
- In 2019, the global food production per capita reached 3,011 kcal per day, which is 22% higher than in 1961 – source FAO.
- The number of undernourished people worldwide has decreased from 1.02 billion in 1990-1992 to 690 million in 2019 – source FAO

CONCLUSION:

What could 2-3 billion more people, 1-2 billion people switching from emerging market to developed market diets, high fertilizer prices, growing biofuel mandates, downward pressure on mid-latitude farm productivity (improvements in northern hemisphere productivity) mean for Canadian farmland? We believe real price increases. Why? The question can be answered by considering demand elasticity of the various farm level inputs and outputs – fuel, fertilizer, and crops.

Table 6: Estimates of Elasticity of Demand of Critical Agriculture Inputs versus Wheat

	Short Term (<1 year)	Price Increase for 10% Demand Reduction
Fertilizer	-1.30	7.7%
Diesel	-0.36	27.8%
Gasoline	-0.26	38.5%
Wheat	-0.04	250.0%

Sources: USDA, Molly Espey – Journal of Energy, Korea Department of Energy, various, Veripath analysis

"Demand elasticity is a measure of how sensitive the demand for a product or service is to changes in the price of that product or service. The formula for demand elasticity is: Elasticity = % Change in Quantity / % Change in Price. How does demand elasticity work? Let's assume that when gas prices increase by 50%, gas purchases fall by 25%. Using the formula above, we can calculate that the demand elasticity of gasoline is: Elasticity = -25% / 50% = -0.50. Thus, we can say that for every percentage point that gas prices increase, gas demand decreases by half a percentage point." Source: Investing Answer. Therefore, the pertinent question becomes, what is more inelastic, demand for food, or demand for fertiliser and fuel? Globally this can be resoundingly answered as food. While this may seem counter-intuitive to us well-fed inhabitants of the developed world you must consider the ~4 billion people in the emerging world who are effectively at or near minimum calorie levels. The "spread" between the two demand curves is going to be a material driver for farmland returns over the medium to long-term.

Agriculture has for a long time suffered from lack of appreciation and understanding from a large part of the general population that, ironically, relies on it for their very existence. While we don't expect this paper to bridge this divide, we do hope that it provides some counter-factuals to the public discourse and clears up a few critical misconceptions.

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