

Welcome to this week's presentation & conversation hosted by the **Canadian Association for the Club of Rome**, a Club dedicated to intelligent debate & action on global issues.



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Sustainable Aviation Fuel (SAF): Farmland, Biomass Demand, and Planetary Boundaries.

Description: To reach its 2050 net zero target, the global aviation sector proposes shifting the fuel source for the jet fleet from oil fields to farm fields. Billions of tonnes of grain, straw, and energy crops will be needed from an already oversubscribed global farmland base. However, Sustainable Aviation Fuel (SAF) is just one new mega-demand among many. What are the limits? How do these new demands intersect with issues surrounding farmland, fertilizer, emissions, extinctions, biomass removals, and planetary boundaries?

Biography: Darrin Qualman is Director of Climate Crisis Policy and Action for the National Farmers Union. He has been active in agricultural policy development for 25 years. He is the author of the book *Civilization Critical: Energy, Food, Nature, and the Future* and the report *Tackling the Farm Crisis and the Climate Crisis*. Darrin farmed for two decades and has academic degrees in history, biology, and political studies.

The presentation will be followed by a conversation, questions, & observations from the participants.

CACOR acknowledges that we all benefit from sharing the traditional territories of local Indigenous peoples (First Nations, Métis, & Inuit in Canada) and their descendants.



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2025 Feb 12 Zoom #232



Sustainable Aviation Fuel (SAF): Farmland, Biomass Demand, and Planetary Boundaries

Darrin Qualman

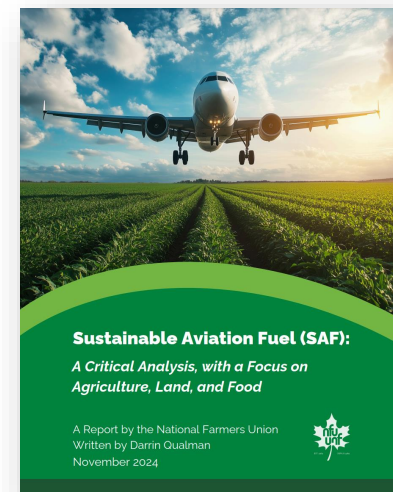
Canadian Association for the Club of Rome (CACOR) Feb 12, 2025

Strong Communities. Sound Policies. Sustainable Farms.

Overview of this talk

- Shift the aviation fuel supply from oil fields to farm fields
- This will affect fertilizer use, ag emissions, soil carbon
- Primary force in restructuring 21st c. agriculture
- Creates impossible demands for biomass
- Just one of MANY new demands on farmland
- Drive multiple breaches of Planetary Boundaries

This talk is based on the NFU's Nov. 2024 report: "Sustainable Aviation Fuel (SAF): A Critical Analysis, with a Focus on Agriculture, Land, and Food"



What is Sustainable Aviation Fuel?

What are SAFs?

Sustainable Aviation Fuels (SAFs) are “drop-in” jet fuels—functionally identical (and almost chemically identical) to current fuels: “Jet A.”

On a full life cycle analysis (LCA) basis, many SAFs (probably) produce lower combustion emissions, compared to fossil fuels.

Airlines have committed to net zero emissions by 2050.

Airlines have no other medium-term options. Battery-electric planes are too heavy. Straight hydrogen will require a redesign of planes, engines, fuel systems, etc.

Types of SAFs

Type 1. SAF from crops: soybeans, corn, canola (and very limited quantities of used cooking oil). Near term.

Type 2. SAF from residues: straw (and some forest waste). The long-awaited “cellulosic” fuels. Medium term?

Type 3. SAF from purpose-grown energy crops: trees and grasses. Again, cellulosic. Medium term?

Type 4. Electro-fuels: from water, air, and renewable electricity. The long term? The very long term? Or never?

Types of SAFs

Type 3. SAF from purpose-grown energy crops?

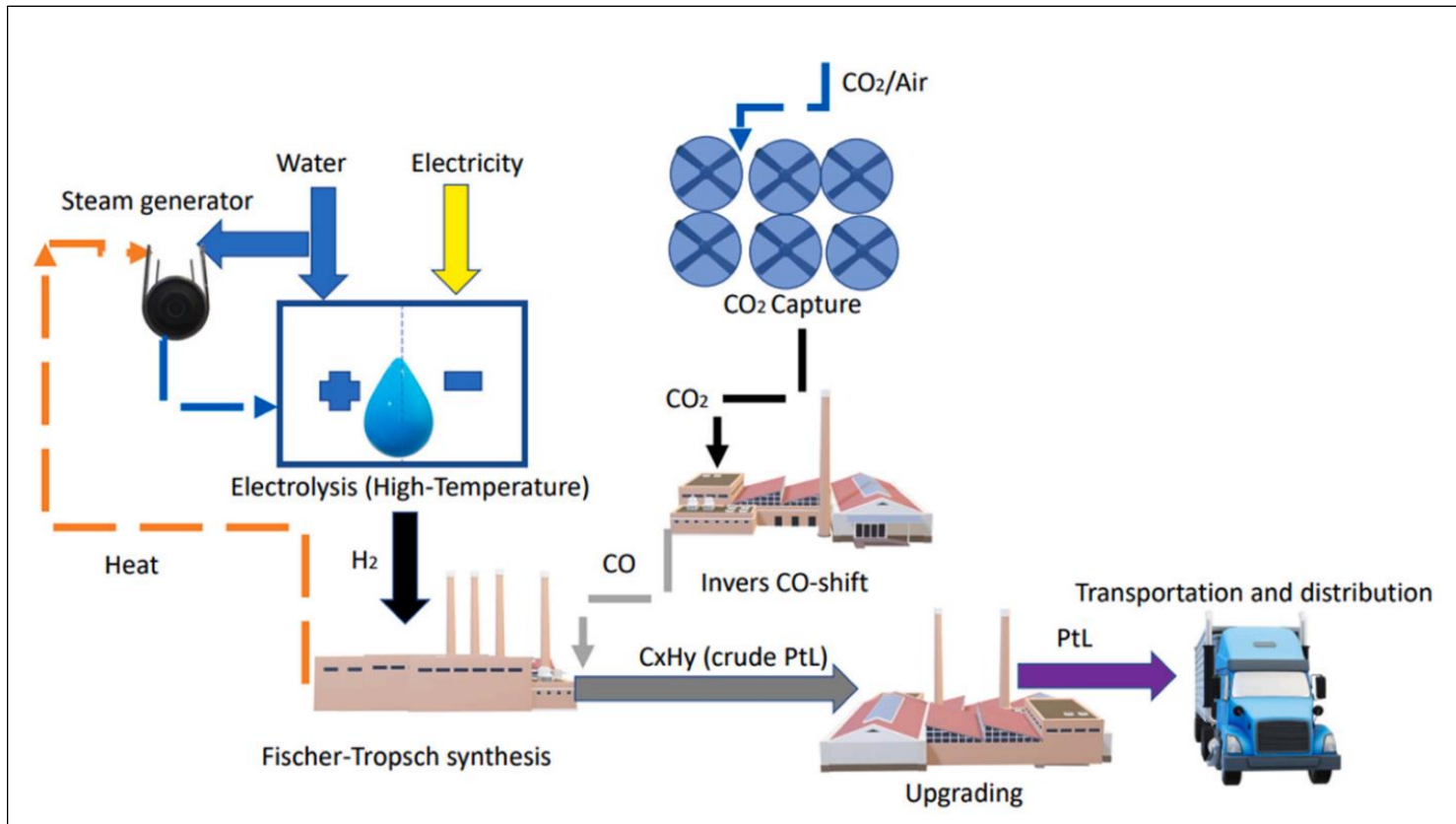
Grasses: switchgrass, miscanthus, etc.

Trees: poplars or willows—potentially coppiced

Most to be grown on current cropland

Types of SAFs

Type 4. Electro-fuels?

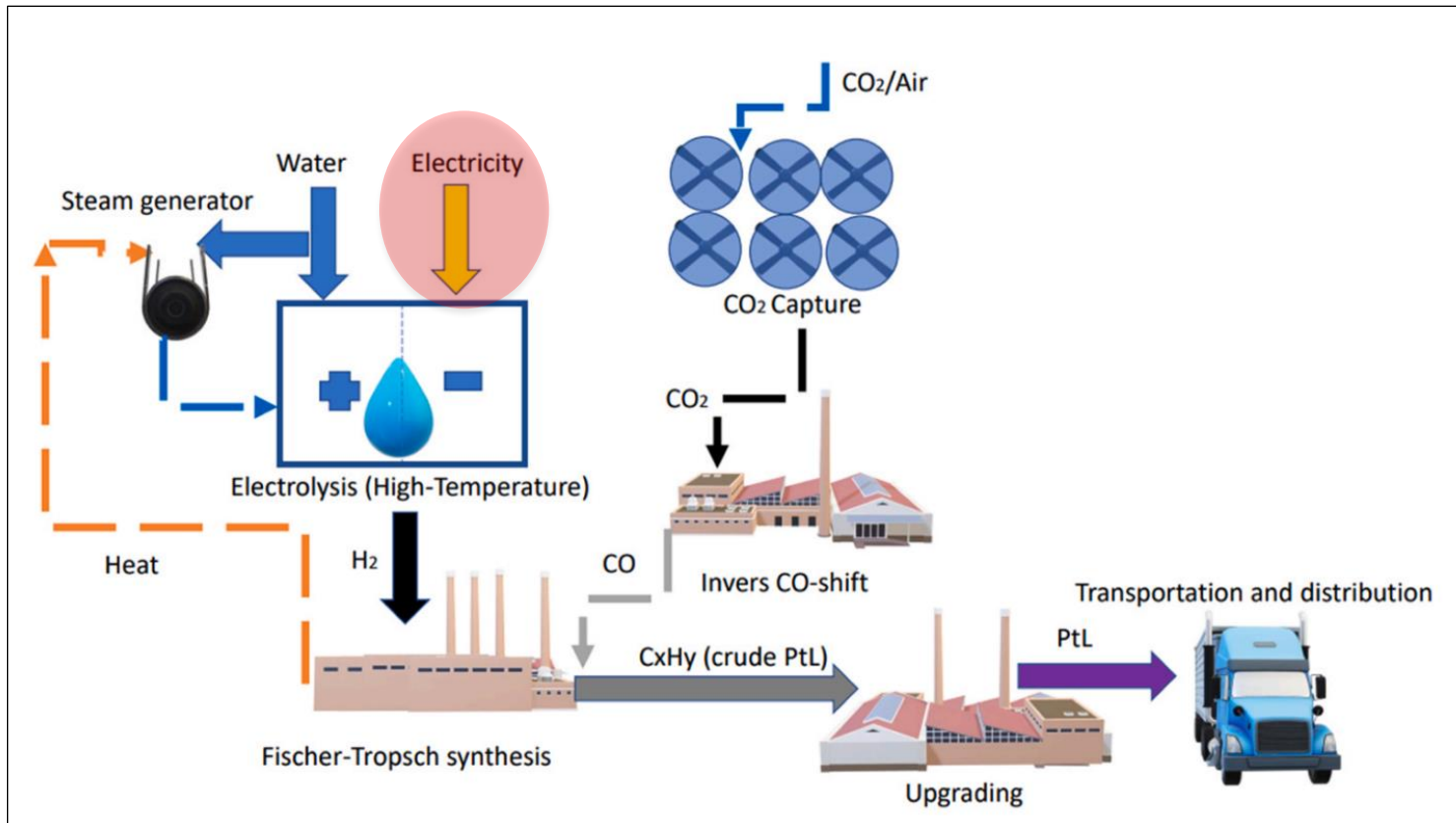


Unburning fuels. Running entropy backwards.

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Types of SAFs

Type 4. Electro-fuels?

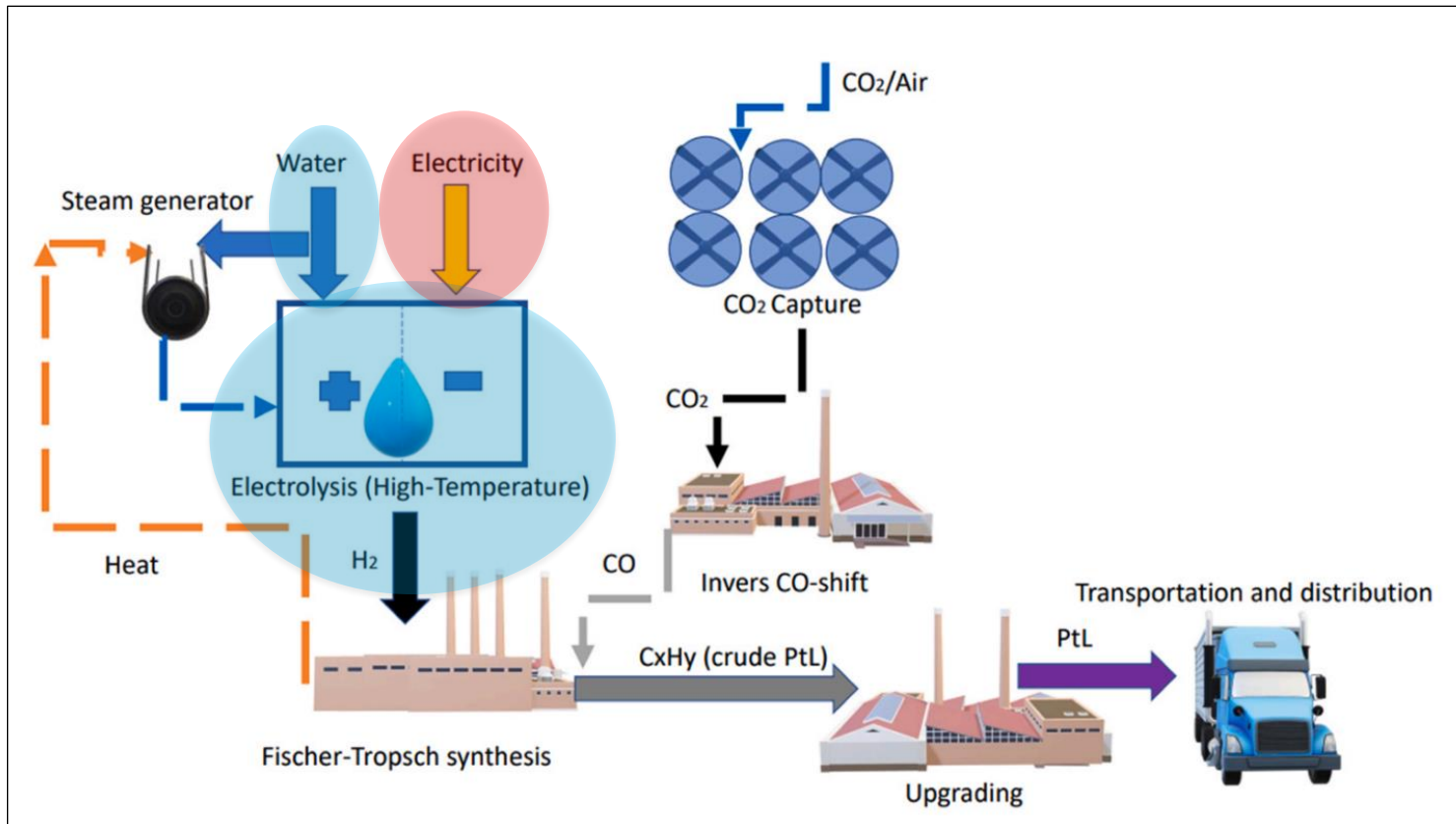


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Types of SAFs

Type 4. Electro-fuels?

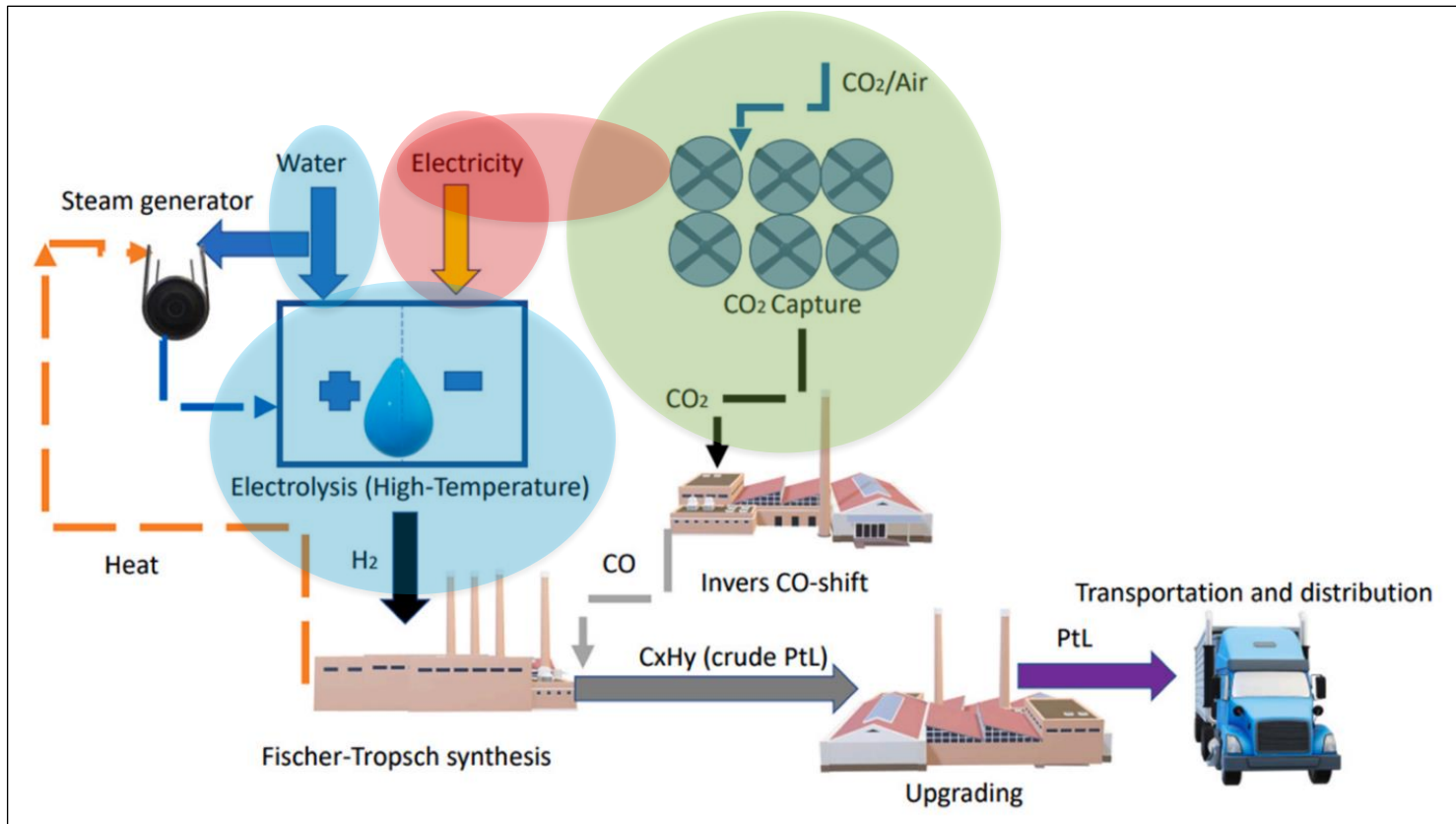


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Types of SAFs

Type 4. Electro-fuels?



Unburning fuels. Running entropy backwards.

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Electro-fuels: are they scalable?

As they try to scale up Electro-fuels, SAF makers will face crippling competition for clean electricity and green hydrogen.

“...estimates suggest an energy intensity on the order of 100 kWh required per gallon of CO₂-derived SAF. This implies that 35 billion gallons of SAF [the U.S. 2050 target] would require 3,500 TWh, ***about 85% of the current total U.S. electricity generation*** of 4,100 TWh” [italics added].

—U.S. Department of Energy, 2024.

Electro-fuels: are they scalable?

As they try to scale up Electro-fuels, SAF makers will face crippling competition for green hydrogen and clean electricity.

- Probably too good to be true
- Inefficient: reversing entropy takes lots of energy
- Probably never be cost-competitive: 3x – 4x
- Most likely a distraction
- SAFs likely to be biofuels—farmland-sourced agro-fuels

"...estimates suggest an energy intensity on the order of 100 kWh required per gallon of CO₂-derived SAF. This implies that 3 billion gallons of SAF [the U.S. 2050 target] could require 300 TWh, *about 85% of the current U.S. electricity generation* of 4,100 TWh [italics added]."
—U.S. Department of Energy, 2024.

How much SAF do we need?

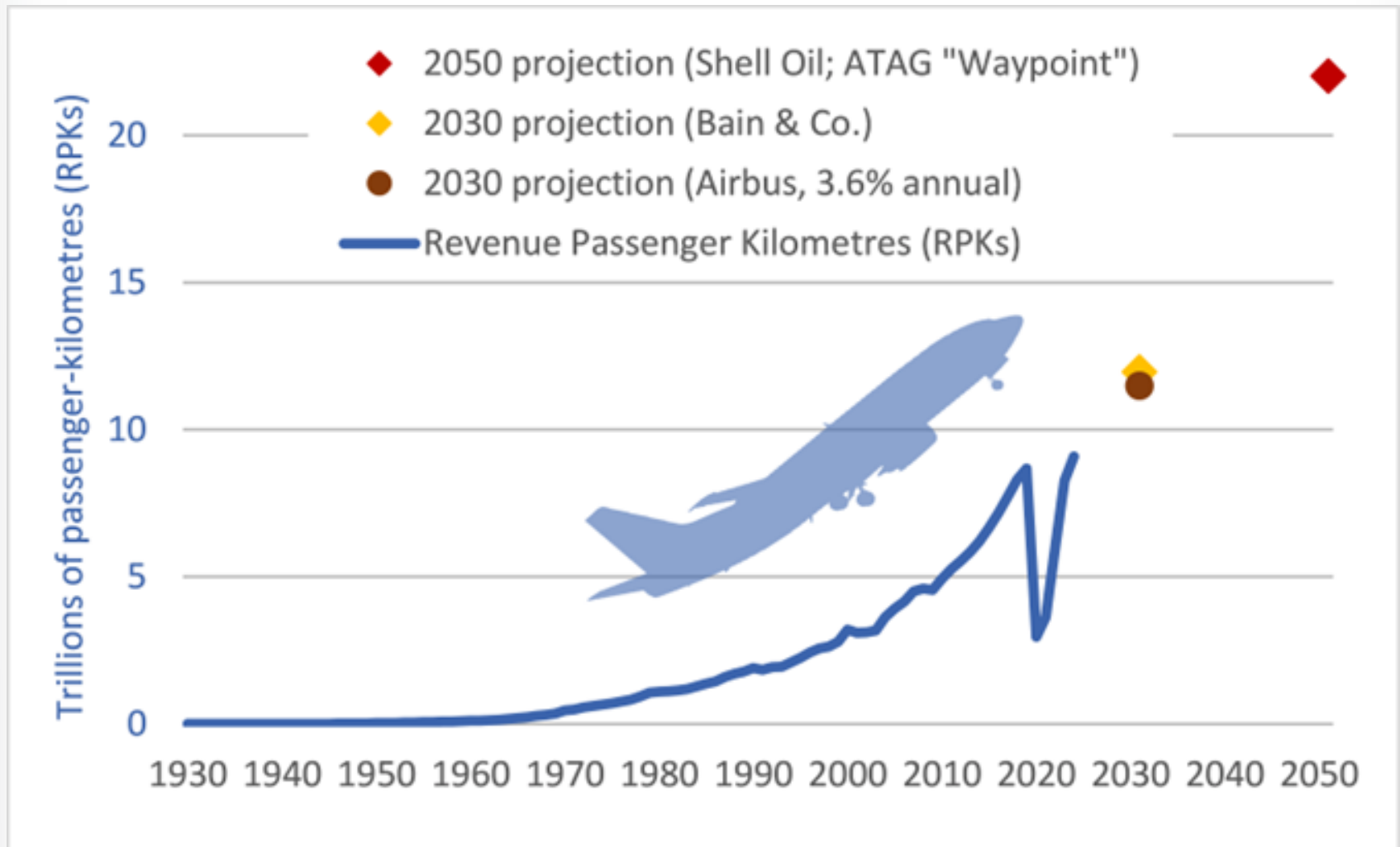
How much SAF is needed?

“In 2052, global passenger traffic is expected to reach close to 25 billion [RPKs], approximately **2.5 times** the 2024 projection.” —Airports Council International, 2024.

“Airbus and Boeing expect that manufacturers will deliver more than **40,000 new commercial aircraft** over the next 20 years.” —Aviation International News, 2023.

“Demand for jet fuel [is] expected to **more than double by 2050** and **triple by 2070....**” —US DoE, 2024.

How much SAF is needed?



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How much SAF is needed?

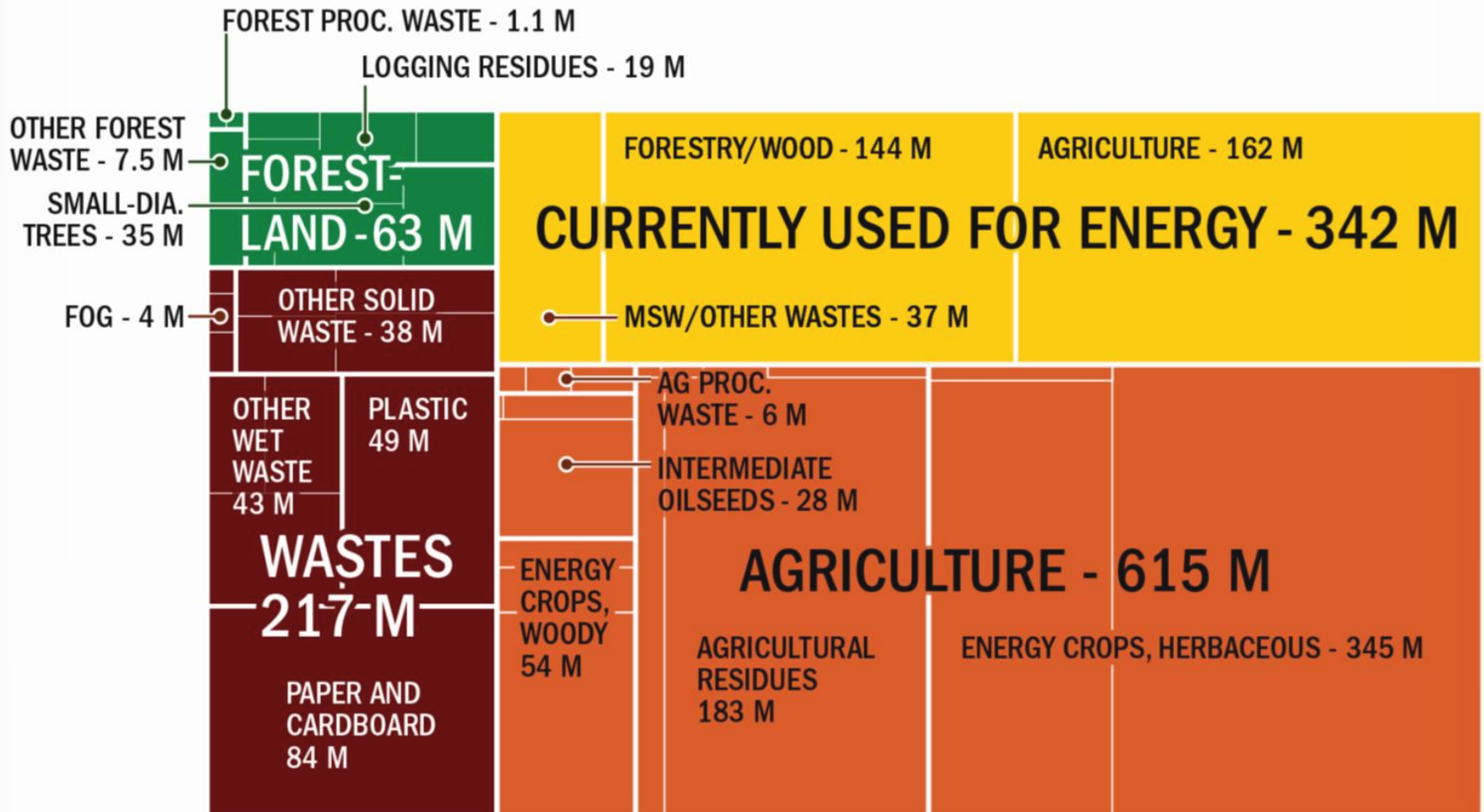
Two-thirds of trillion litres per year by 2050

and > one trillion litres per year by 2070

What are the SAF feedstocks?

What is the SAF feedstock plan?

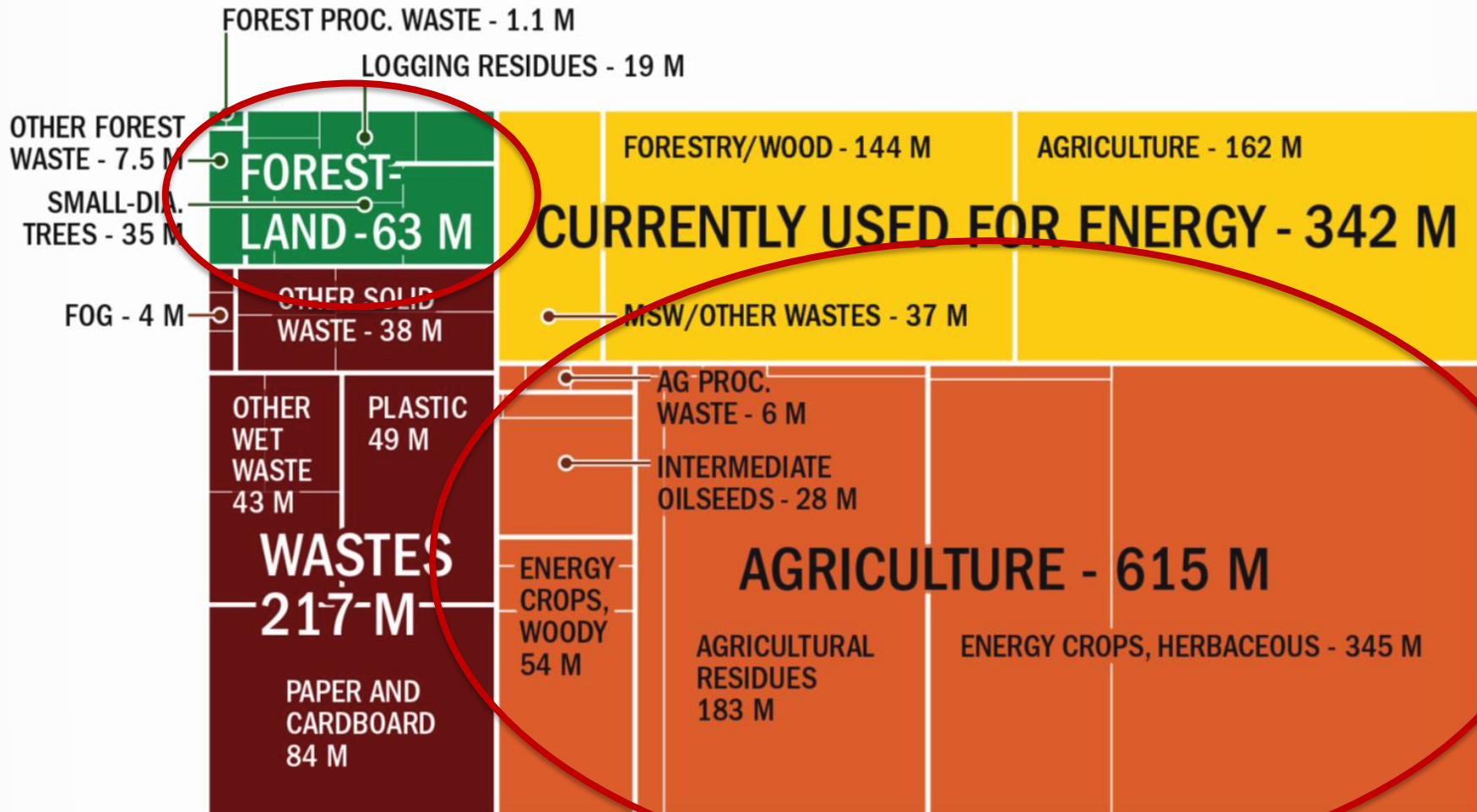
Millions of tons



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What is the SAF feedstock plan?

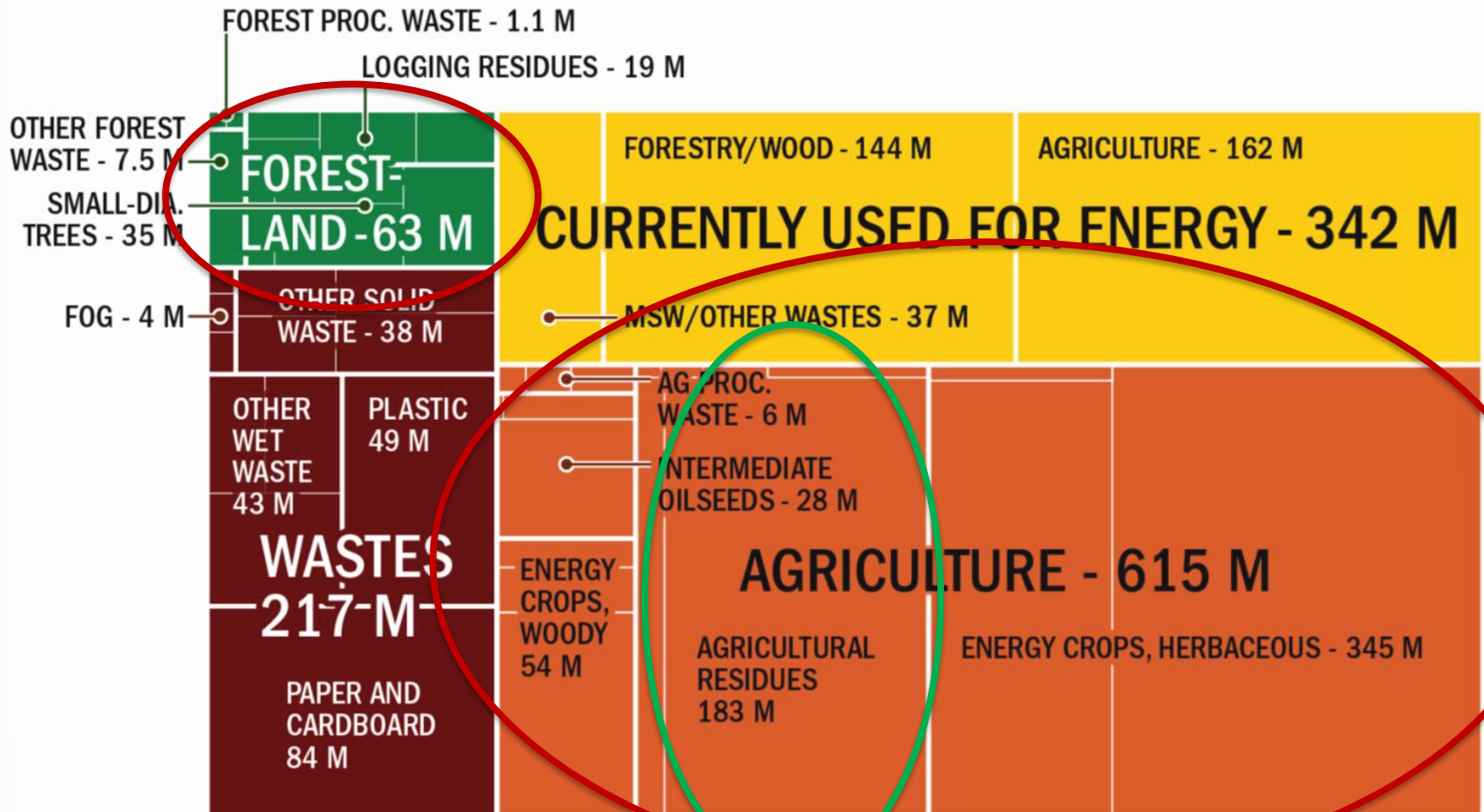
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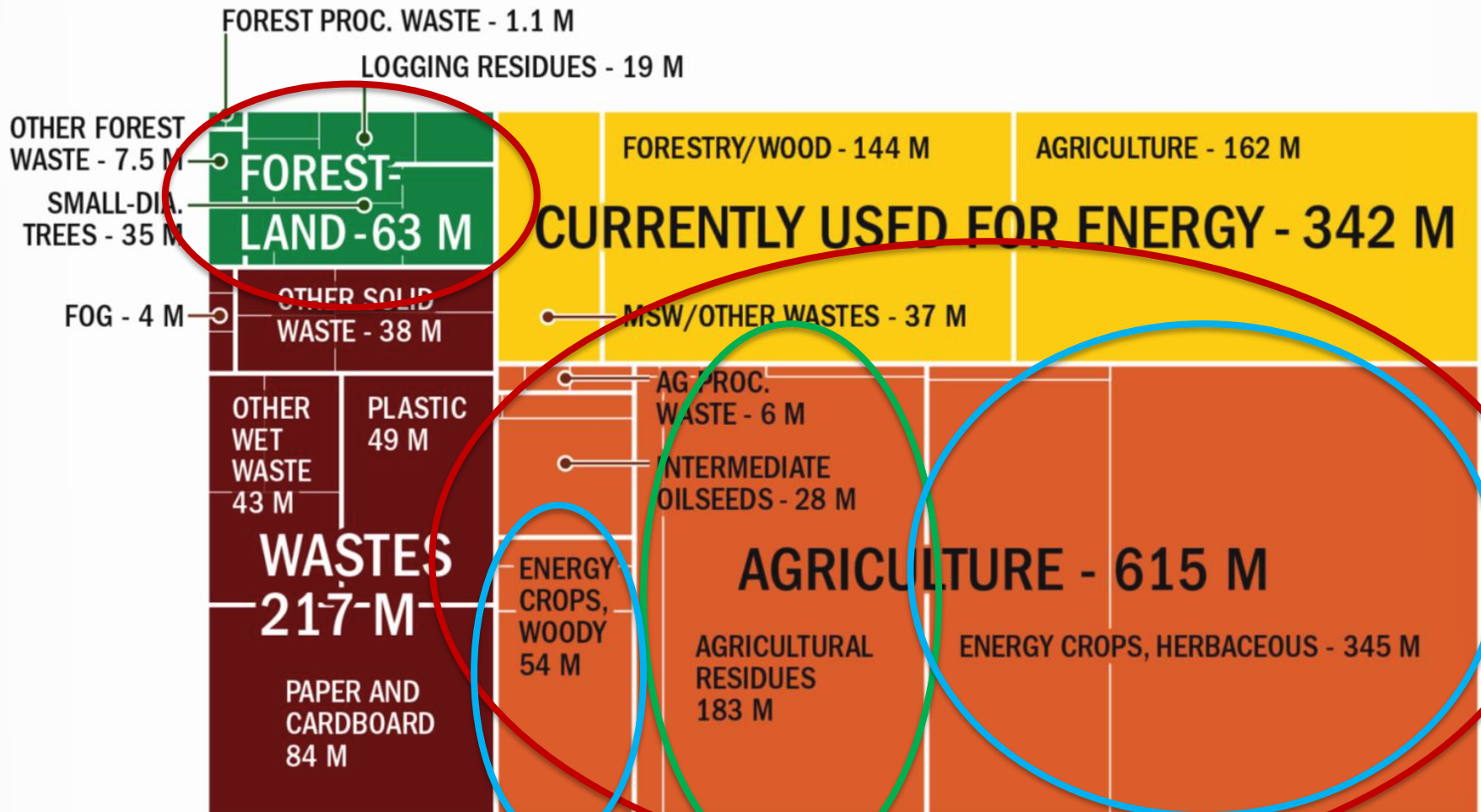
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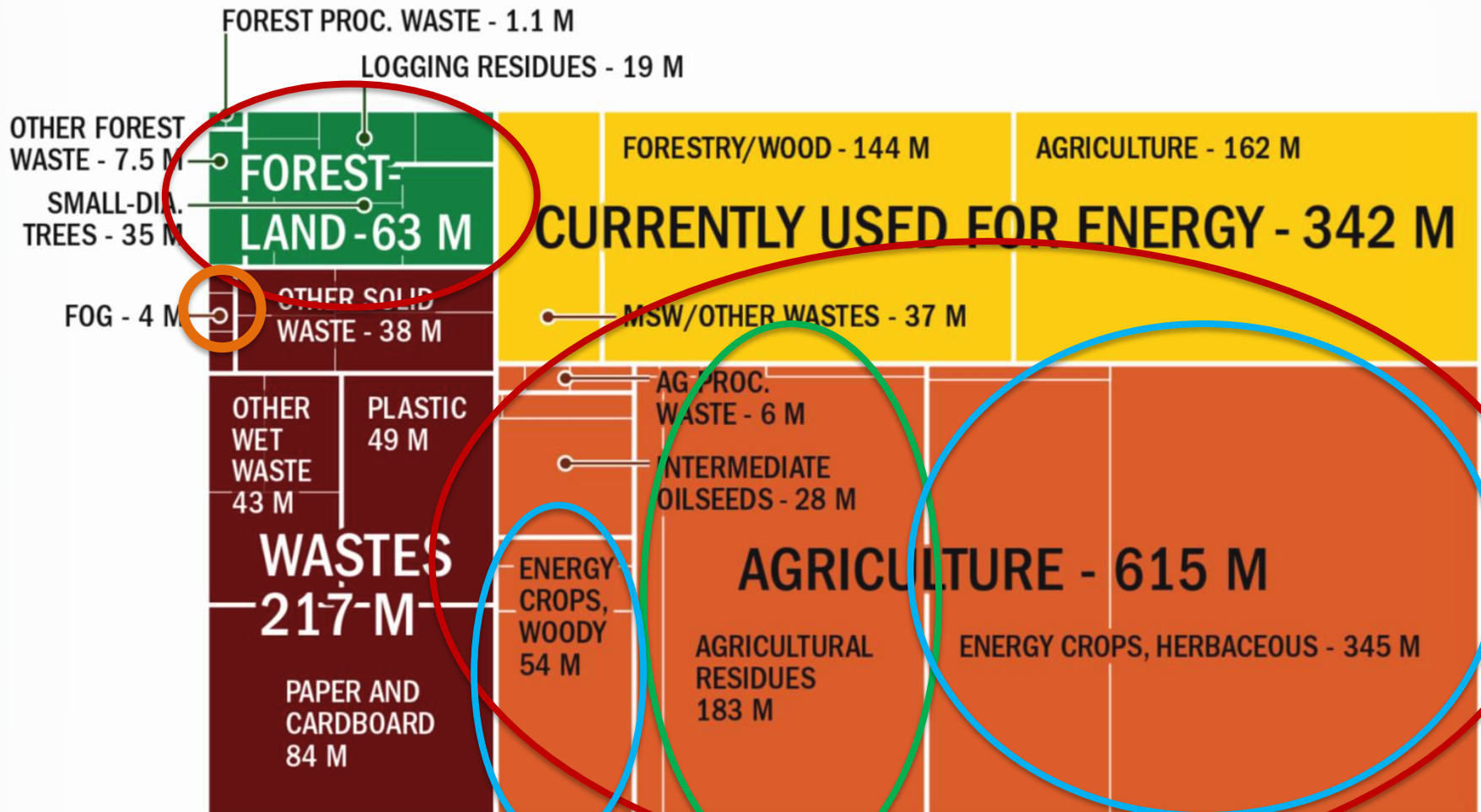
Millions of tons



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What is the SAF feedstock plan?

Millions of tons



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How much crop tonnage would be needed to meet 2050 SAF demand?

Thought experiment #1: How much land needed if we produce all SAFs from crops? ...corn, soy, canola, etc.?

The 400 million tonnes of SAF needed globally in 2050...

would require about 2.1 billion tonnes per year of corn/soy/canola feedstock...

and this would require about 2.1 billion acres of farmland.

That's **21 times the cropland area of Canada**—more than five times the cropland area of the United States.

Should we attempt even a fraction of SAFs from crops?

How much crop tonnage would be needed to meet 2050 SAF demand?

Thought experiment #1: How much land needed if we produce all SAFs from crops? ...corn, soy, canola, etc.?

The 400 million tonnes of SAF needed globally in 2050...

would require about 1.7 billion tonnes per year of corn/soy/canola feedstock...

and this would require about 1.4 billion acres of farmland.

That's **14 times the cropland area of Canada**—almost four times the cropland area of the United States

Should we attempt even a fraction of SAFs from crops?

What will be the impacts of even a fraction of these new demands?

“SAF” = “Sacrificing Affordable Food”?

How much biomass would be needed to meet 2050 SAF demand?

Thought experiment #2: From biomass???

Clearly, only a tiny fraction of SAF can come from crops.

So what about biomass? ...straw, stover, energy crops, etc.?

If the 2050 SAF supply came from agricultural straw and energy crop feedstocks, how much would be needed?

Approx. 7 billion tonnes of biomass per year, globally.

That's nearly 2 tonnes of agricultural residue removed from every acre of cropland on Earth every year. (But wait! There's more! BECCS!)

Effects on ag. emissions and soil carbon sequestration?

How will a global SAF megaproject affect soil health and carbon sequestration?

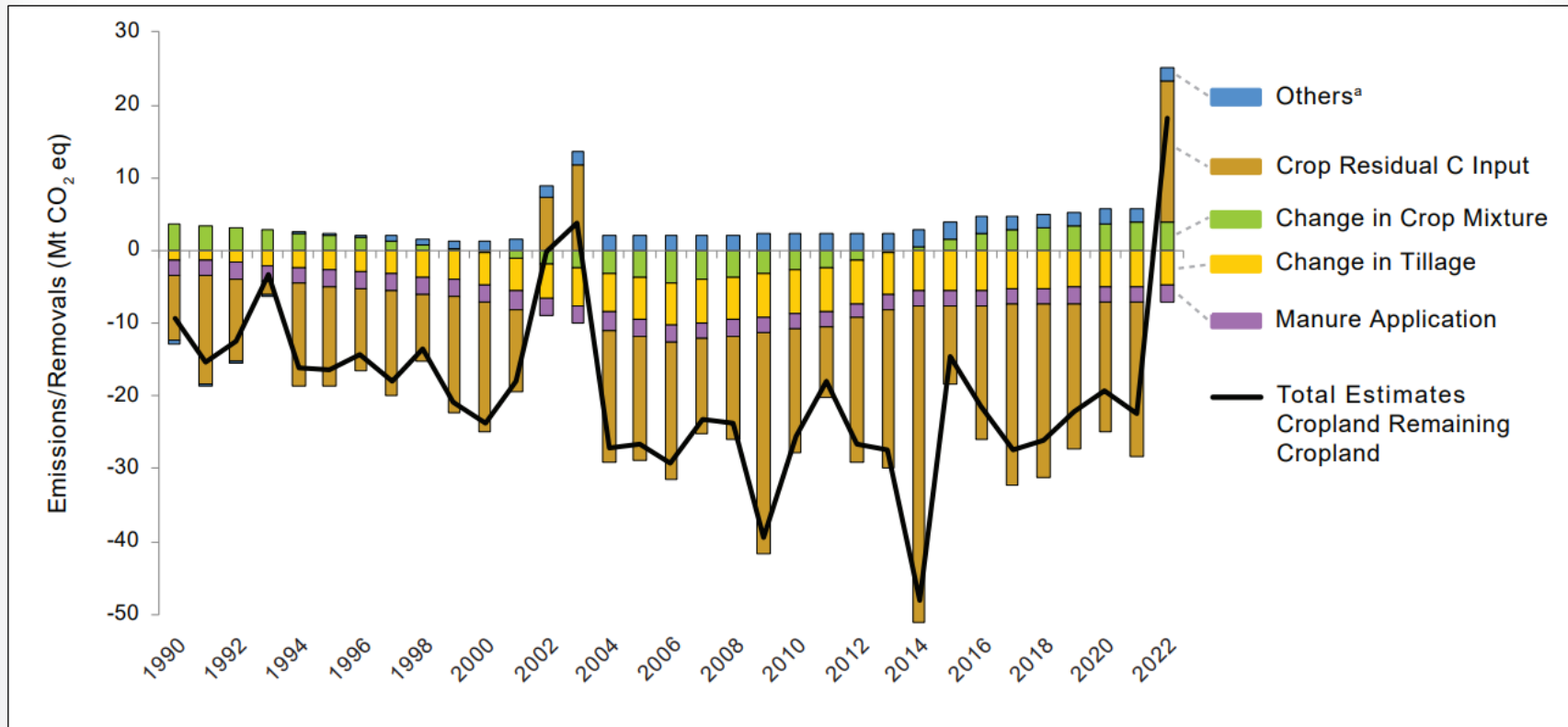
Soil carbon levels and soil carbon sequestration are key to soil health.

Soil carbon gains are largely a function of carbon inputs—a function of the mass of biomass produced and left on fields.

Removing straw and other residue/biomass will slow or reverse soil carbon sequestration. It will impact soil health.

Slowing soil carbon sequestration also slows the removal of CO₂ from the air, exacerbating climate change.

How will a global SAF megaproject affect soil health and carbon sequestration?



Graph reproduced from Canada's National Inventory Report (NIR)

How will a global SAF megaproject affect agricultural GHG emissions?

The main cause of rising agricultural GHG emissions in Canada is increasing use of nitrogen fertilizer.

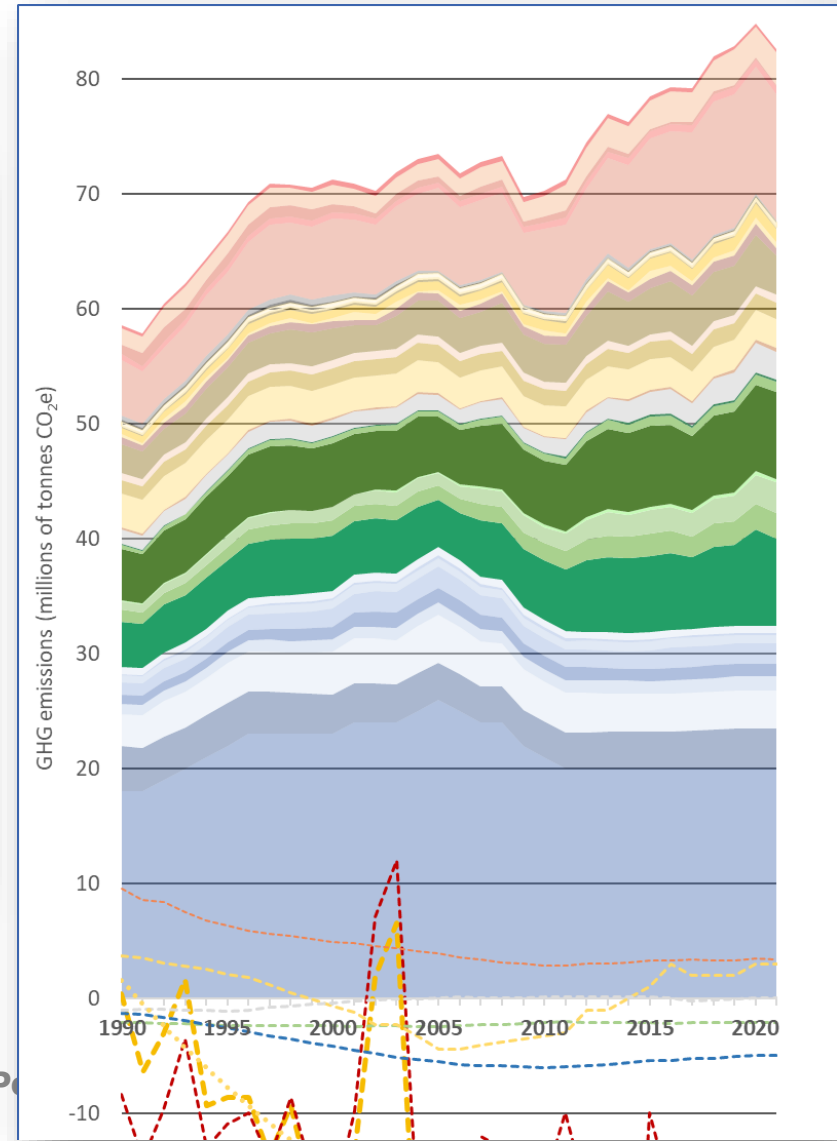
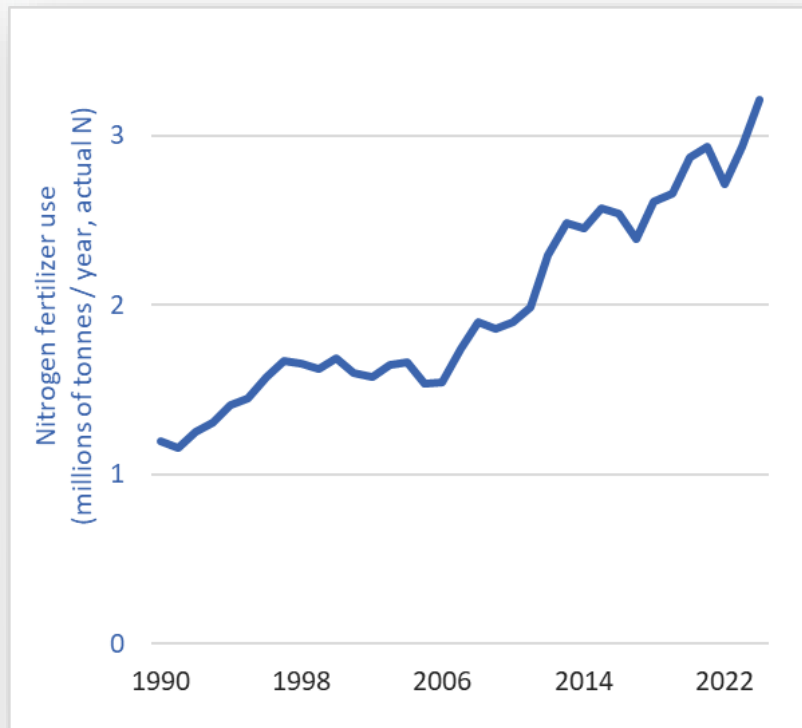
SAF production will require increased production of crops and other biomass (straw and energy crops)...

and that will drive increased nitrogen fertilizer use...

and that will increase agricultural emissions.

The airline industry's emissions "solution" will create an agricultural emissions *problem*.

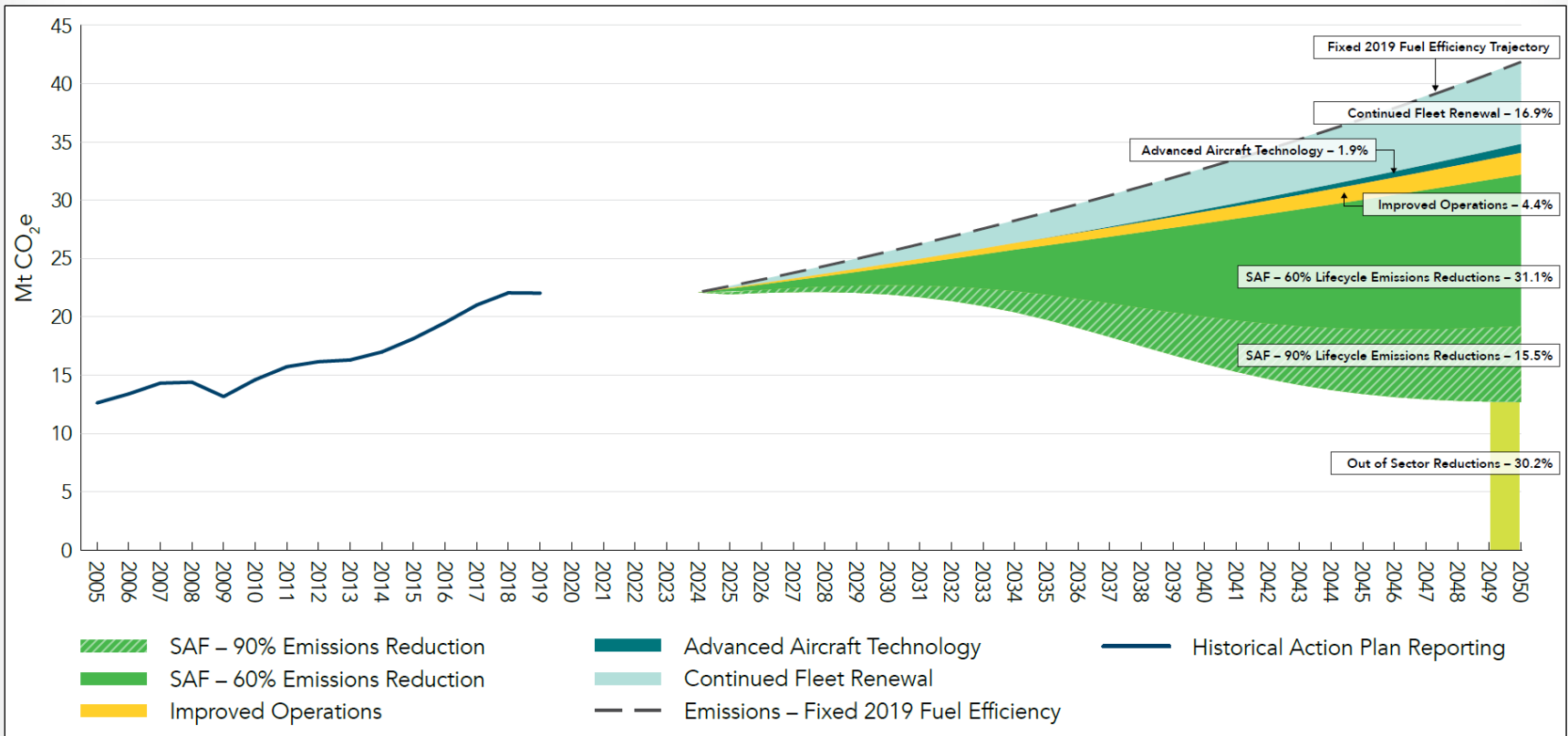
How will a global SAF megaproject affect agricultural GHG emissions?



Effects on overall aviation emissions?

Net zero is not zero: offsets

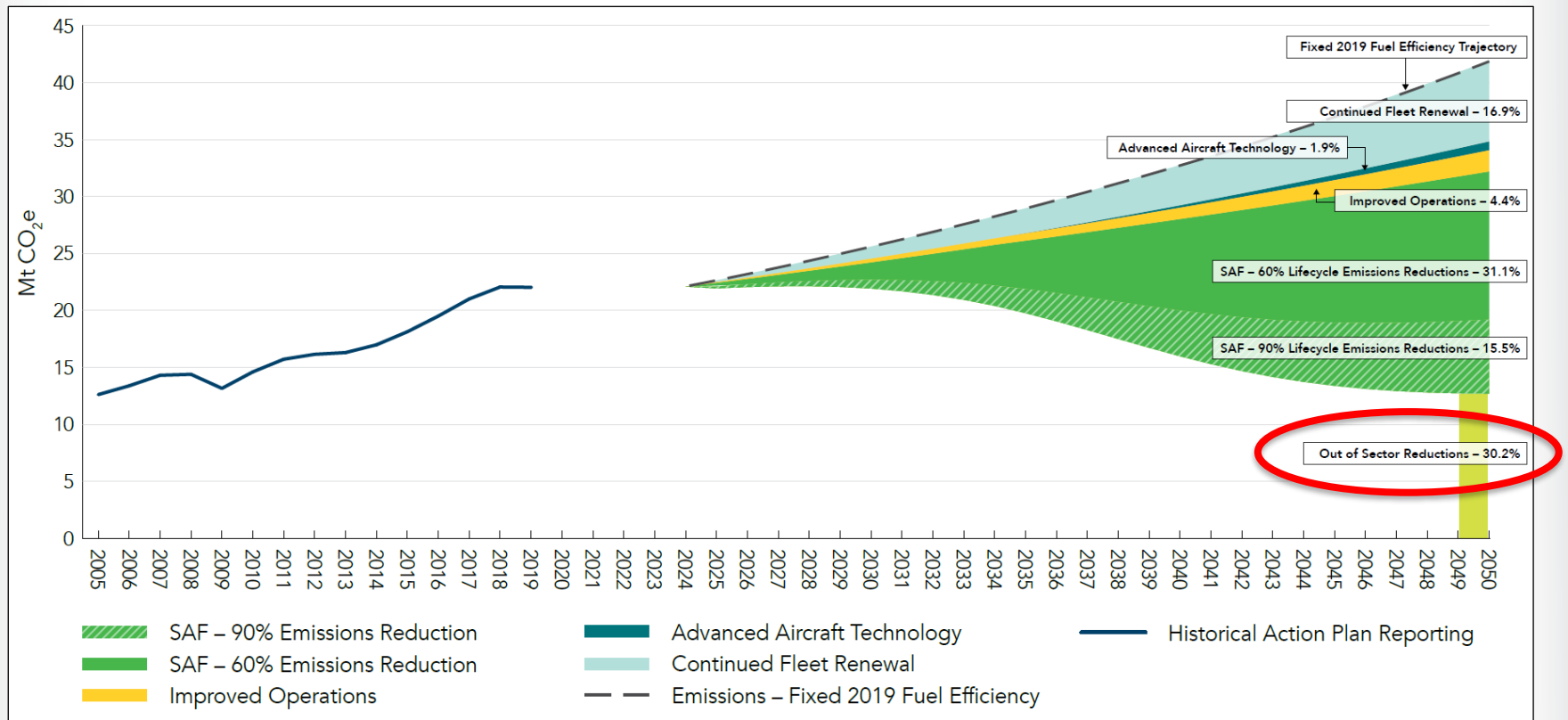
Canadian aviation emissions, with projections to 2050



Graph reproduced from Transport Canada, "Canada's Aviation Action Plan: 2022-2030"

Net zero is not zero: offsets

Canadian aviation emissions, with projections to 2050



Graph reproduced from Transport Canada, "Canada's Aviation Action Plan: 2022-2030"

Net zero is not zero: non-combustion emissions

“Aviation’s [combustion] **CO₂ emissions account for one-third** of its overall effective radiative forcing...

while **the remaining two-thirds are estimated to arise from non-CO₂ components** such as contrail cirrus, nitrogen oxides (NO_x), particulate matter, and stratospheric water vapour emissions.”

—Teoh et al., *Atmospheric Chemistry*, 2024.

At scale, are SAFs even possible?

Is any of this scalable?

Fuel volumes: approaching a trillion litres per year

Number of production facilities needed by 2050: 3,400–6,700 (<10,000 days until end of 2050)

Cost of production build-out: up to \$14 trillion Cdn.

Source of funds: Majority from governments/taxpayers

“From now ‘til 2050, you need a **1,000-times increase in the production of SAF....** And if you break that in terms of plant size of average of 50-70,000 tonnes per annum, you need almost **300 plants per year.**” —IATA, 2024.

Are SAF proponents aware of BECCS (bio-energy with carbon capture and storage)?

BECCS is an electricity generation and negative emissions technology (NET). NETs are now built into most IPCC climate models, i.e., BECCS and other NETs are now assumed essential to avoid damaging climate change.

BECCS and SAFs draw on exactly the same feedstocks: forest residues, crop residues, energy crops.

So, to the 7 billion tonnes per year of biomass needed for SAFs, we must add 8 billion tonnes per year for BECCS.

That's 15 billion tonnes per year—4 tonnes from every acre of cropland on Earth every year. Not possible.

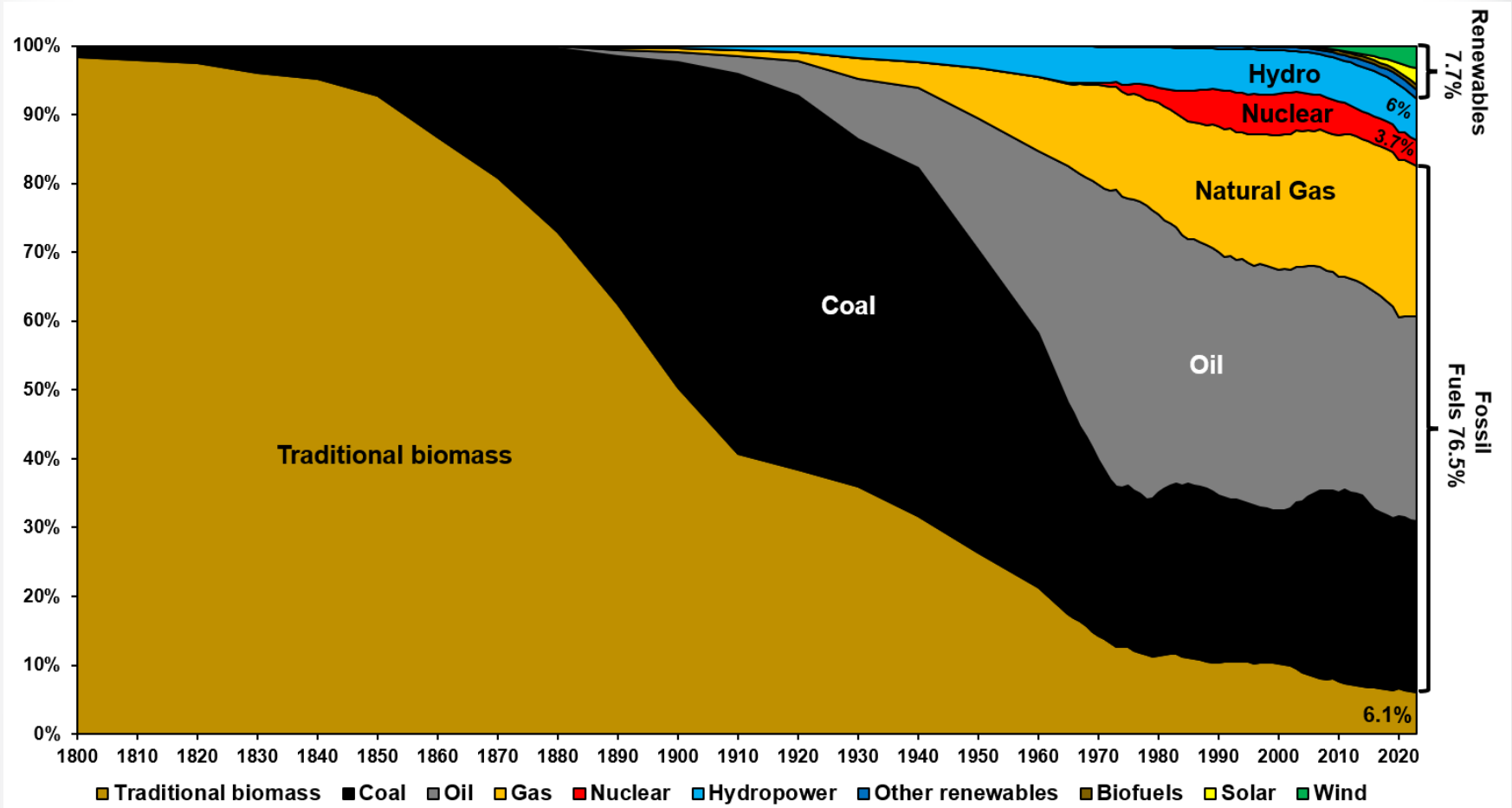
Is there enough land on Earth?

“The Plan” for our farmland base in the 21st Century:

- Feed those hundreds-of-millions hungry today and
- Add two billion mouths to our global population and
- Extend meat- and dairy-heavy diets to billions and
- Produce biomaterials to replace petro-plastics and
- Produce more land-sourced bio-fibres (cotton, etc.) to replace petro-fibres and clothe more people and
- Produce billions of tonnes of biomass for BECCS and
- Produce billions of tonnes of biomass for SAFs and
- Find land to plant trees to draw down CO₂ and
- Do the preceding while reducing N fertilizer use and
- Do all this even as climate impacts intensify, making it harder and harder to *maintain* agricultural production and
- Do all the preceding while trying to use less farmland, in order to slow accelerating extinctions.

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Reversing history? Reverting to a biomass-fuelled world? ...to a land-fuelled civilization?

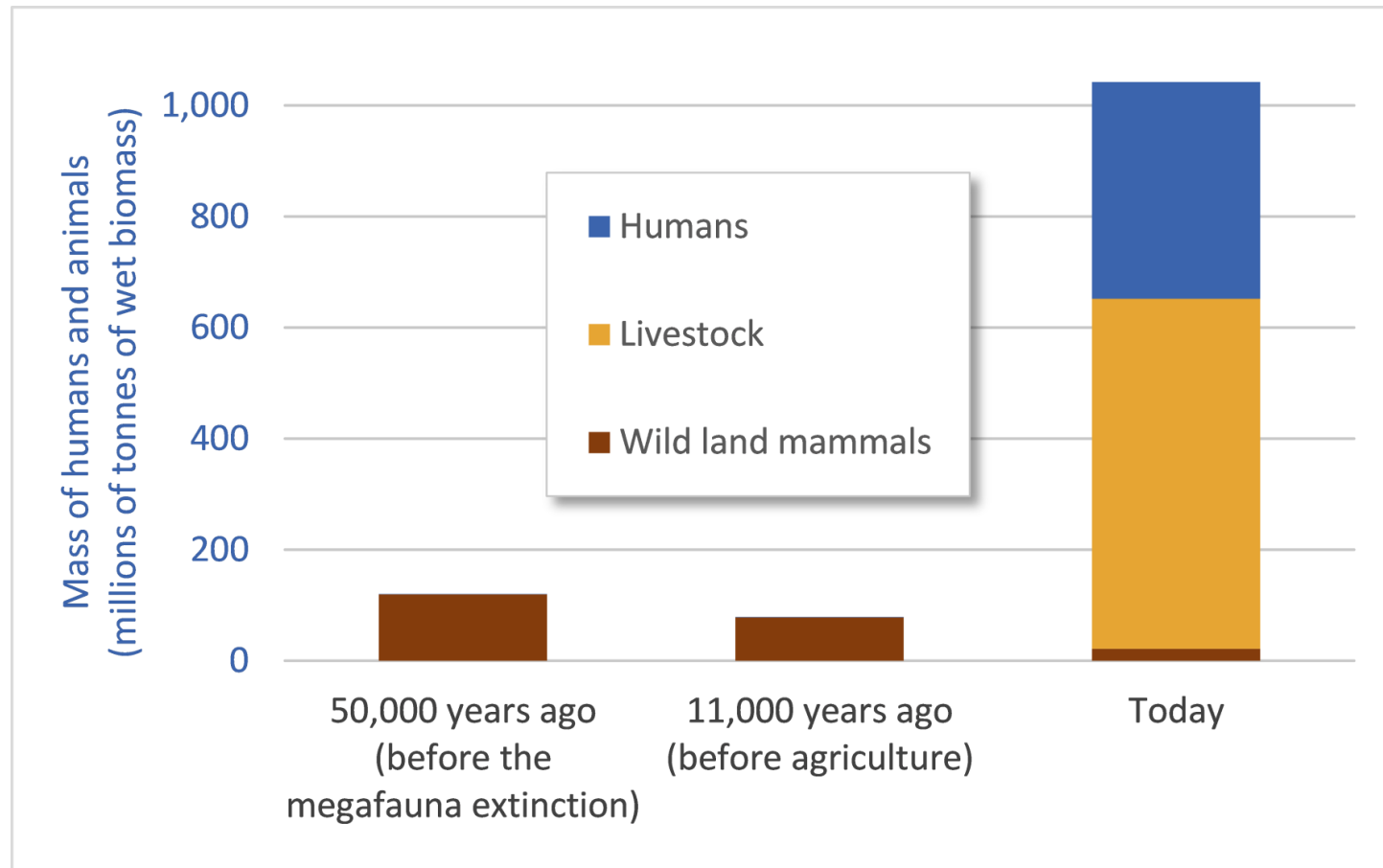


Graph courtesy of David Hughes, Global Sustainability Research Inc., with data from Energy Institute and Vaclav Smil

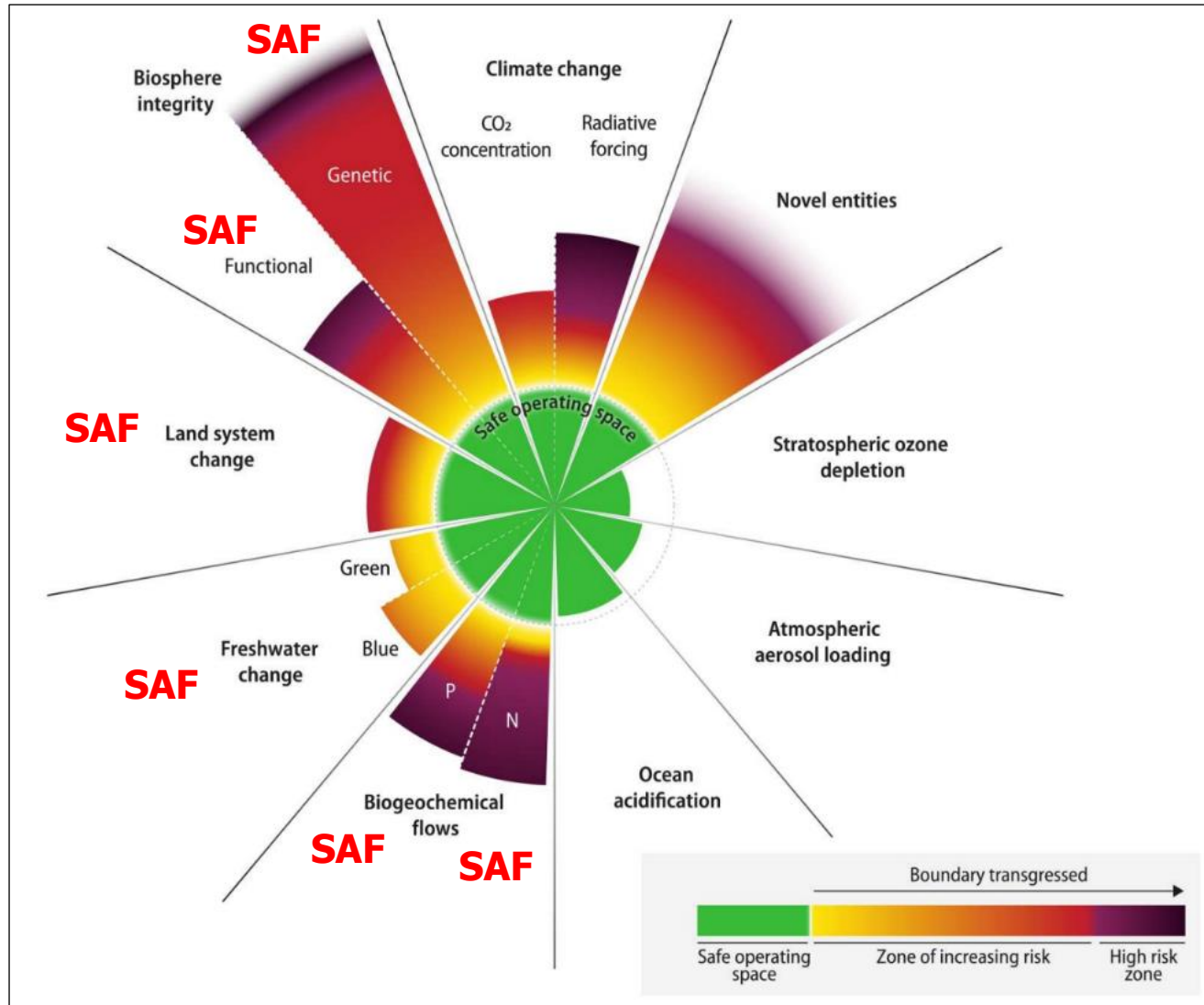
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Are humans already taking too much from the Earth and its farmlands?

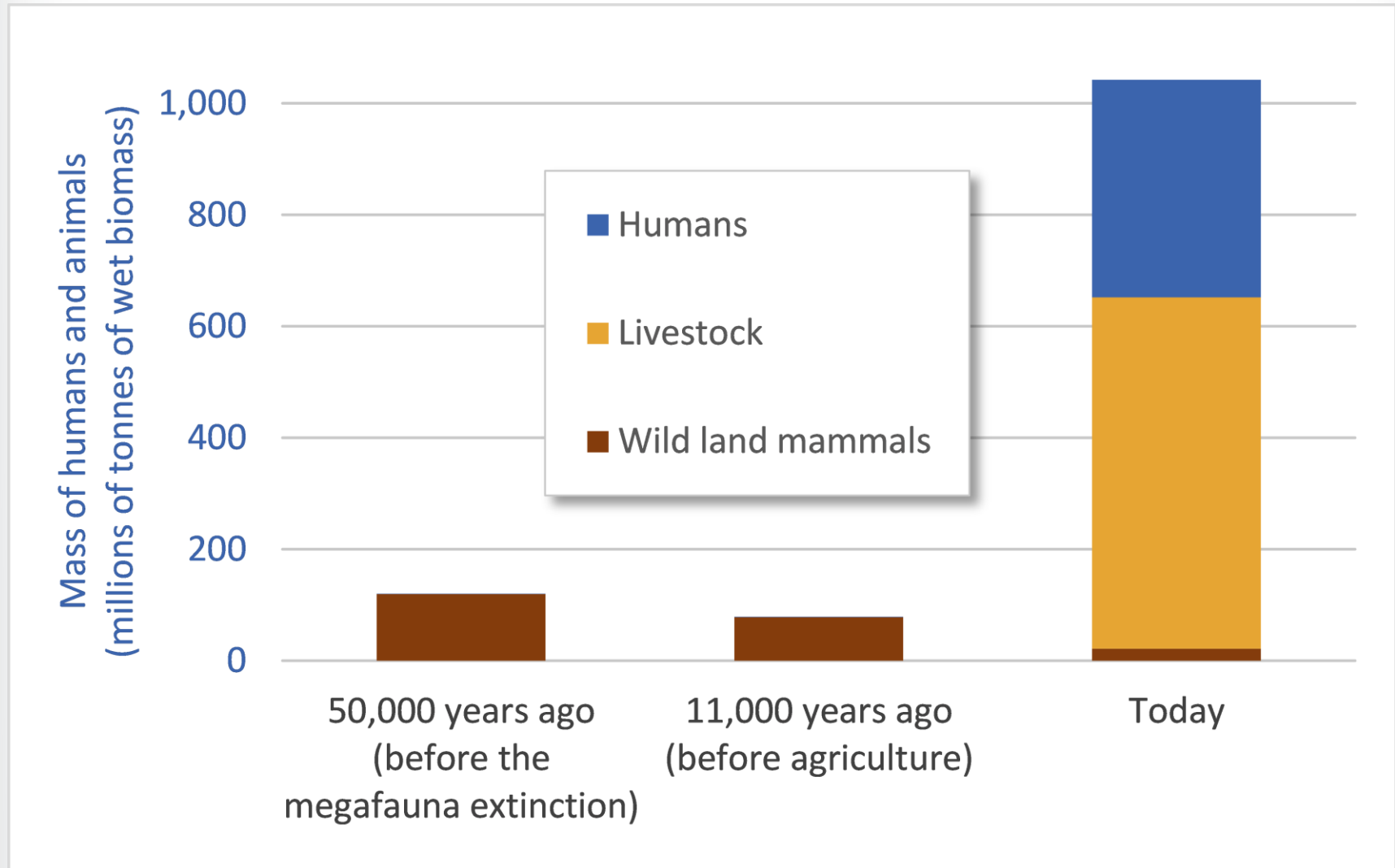
We're in the fastest extinction event in 65 million years, driven by humans taking too much from the Earth.



Are Sustainable Aviation Fuels “sustainable” in a world far outside planetary boundaries?



Are humans already taking too much from the Earth and its farmlands?



Recommendations for governments

Don't evaluate the impacts or sustainability of the first litre of SAF, but rather the last litre—the trillionth litre....

and evaluate SAFs in their full context: as one among many competing, conflicting biomass-hungry megaprojects.

Don't funnel public funds to SAF to subsidize air travel.

Instead, invest in transport options that can actually attain zero emissions: trains, buses, active transport.

Call the airlines' bluff: push them toward Electro-Fuels, and avoid stranded-asset investments in biofuels.

Recommendations

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and evaluate SAFs in their full context: as one among many competing, conflicting big-ass-hungry megaprojects.

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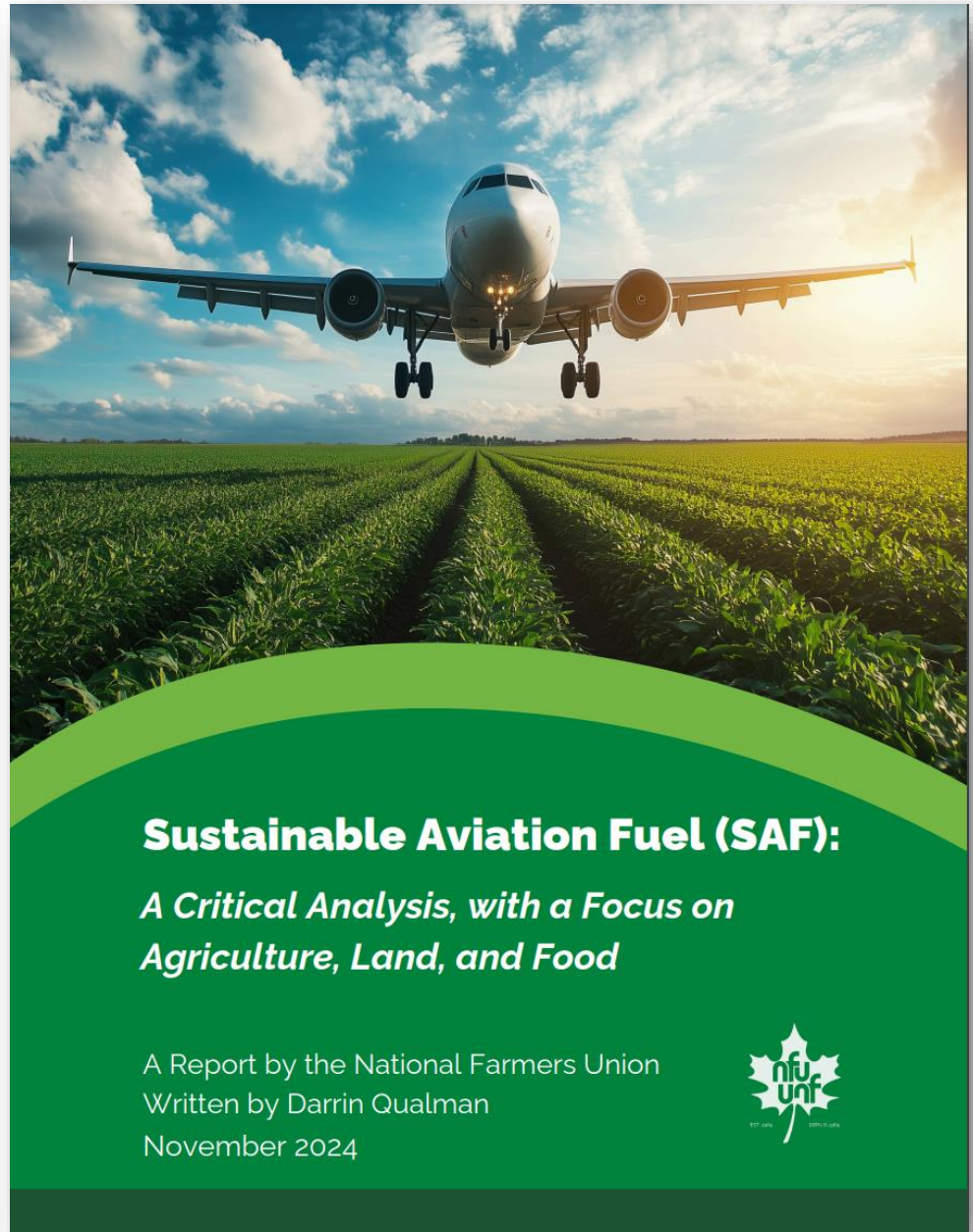
Instead, invest in transport options that can actually attain zero emissions: trains, buses, active transport.

Call the airlines' bluff: push them toward Electro-Fuels, and avoid stranded-asset investments in biofuels.

No serious, adult understanding of the climate crisis is compatible with a plan to double air travel.



Thank you
www.nfu.ca
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Sustainable Aviation Fuel (SAF):

*A Critical Analysis, with a Focus on
Agriculture, Land, and Food*

A Report by the National Farmers Union
Written by Darrin Qualman
November 2024



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Thank you
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Tackling the Farm Crisis and the Climate Crisis:
A Transformative Strategy for Canadian Farms and Food Systems

A discussion paper
by Darrin Qualman
In collaboration with the National Farmers Union

The NFU acknowledges its Farming Climate Solutions supporters and collaborators:
IVEY FOUNDATION Prairie Climate Centre SeedChange

Imagine If....
A Vision of a Near-Zero-Emission Farm and Food System for Canada

A report by the National Farmers Union
March 2021

Agricultural GHG Emissions in Canada:
A New Comprehensive Assessment—Second Edition

A Report for National Farmers Union
Written by Darrin Qualman

June 2022

Nitrogen Fertilizer:
Critical Nutrient, Key Farm Input, and Major Environmental Problem

A discussion paper by
the National Farmers Union

August 30, 2022

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