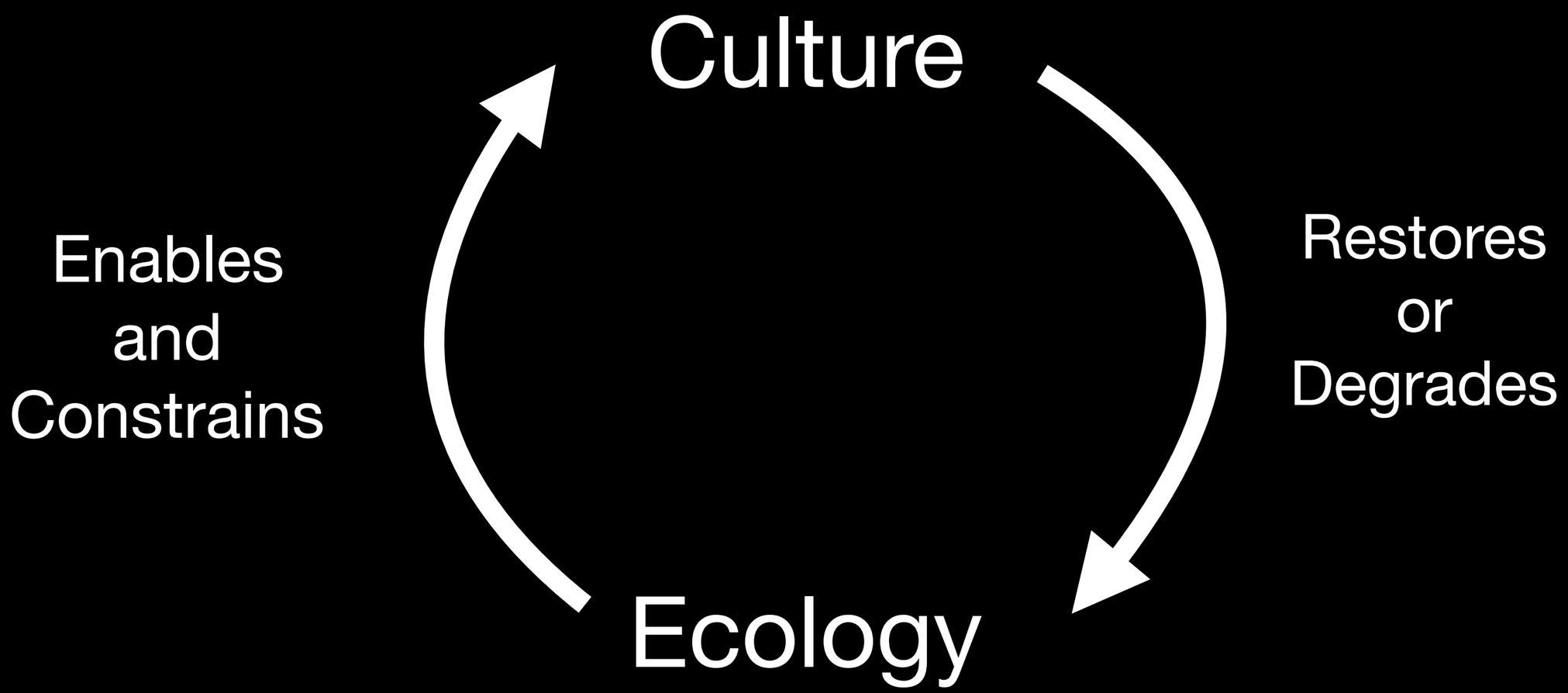
Regenerative Agriculture and Climate Change

Definitions and principles

Regenerative agriculture uses intentional management of natural systems to both produce food and to restore ecosystems/capture carbon



Assessment Criteria For Sustainability

A system is “sustainable” if it can continue indefinitely — dynamic equilibrium

Foundation for assessing sustainability based on understanding of **ecology** and **evolution**

Ecosystems are our model for sustainable systems — human systems to be sustainable should be modeled after natural ecosystems as much as possible.

Organisms are adapted within those ecosystems through evolution, and understanding adaptation and optimization can help understand natural systems.

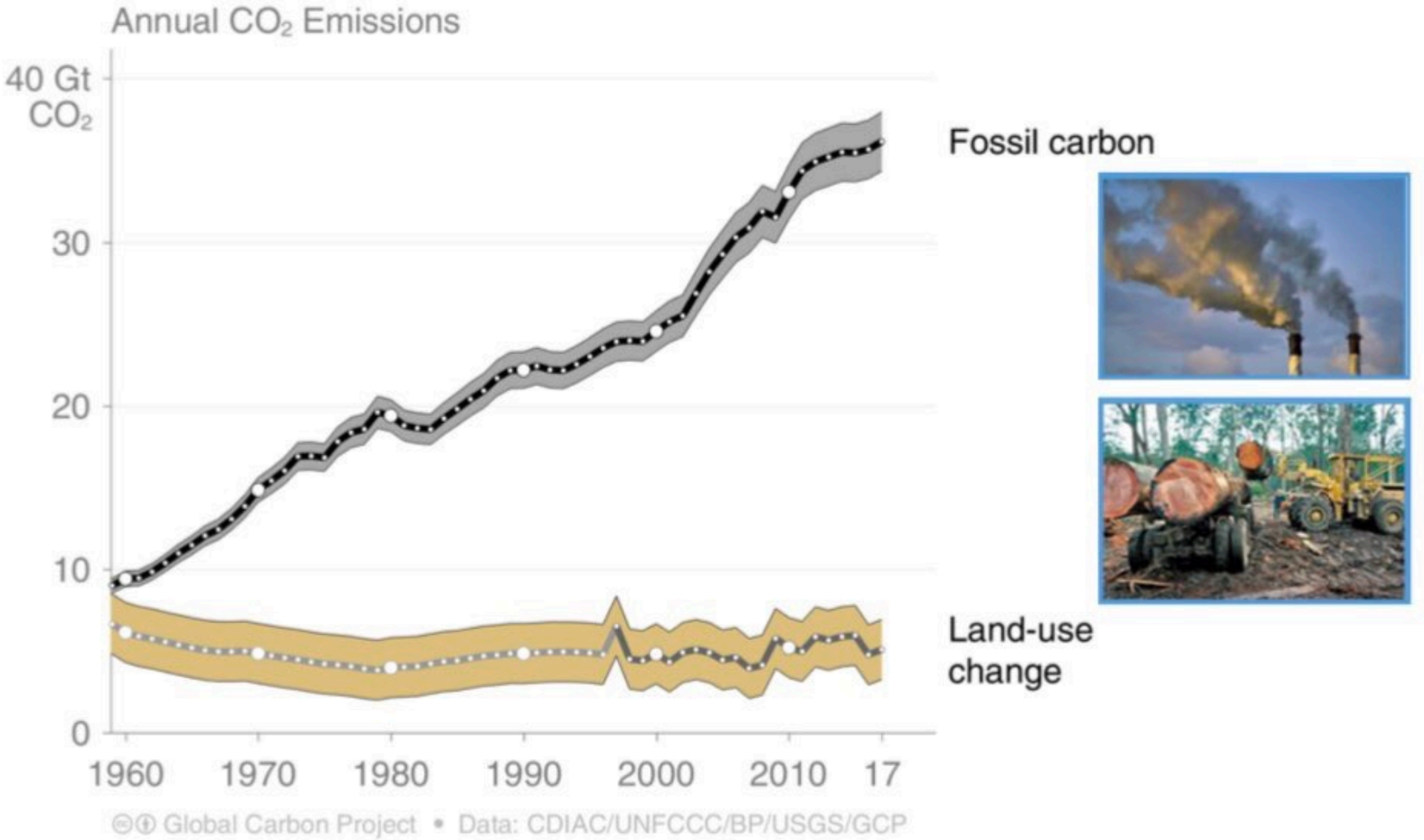
Climate and Carbon Cycle

GLOBAL CARBON PROJECT

Total global emissions

Total global emissions: 41.2 ± 2.8 $GtCO_2$ in 2017, 53% over 1990

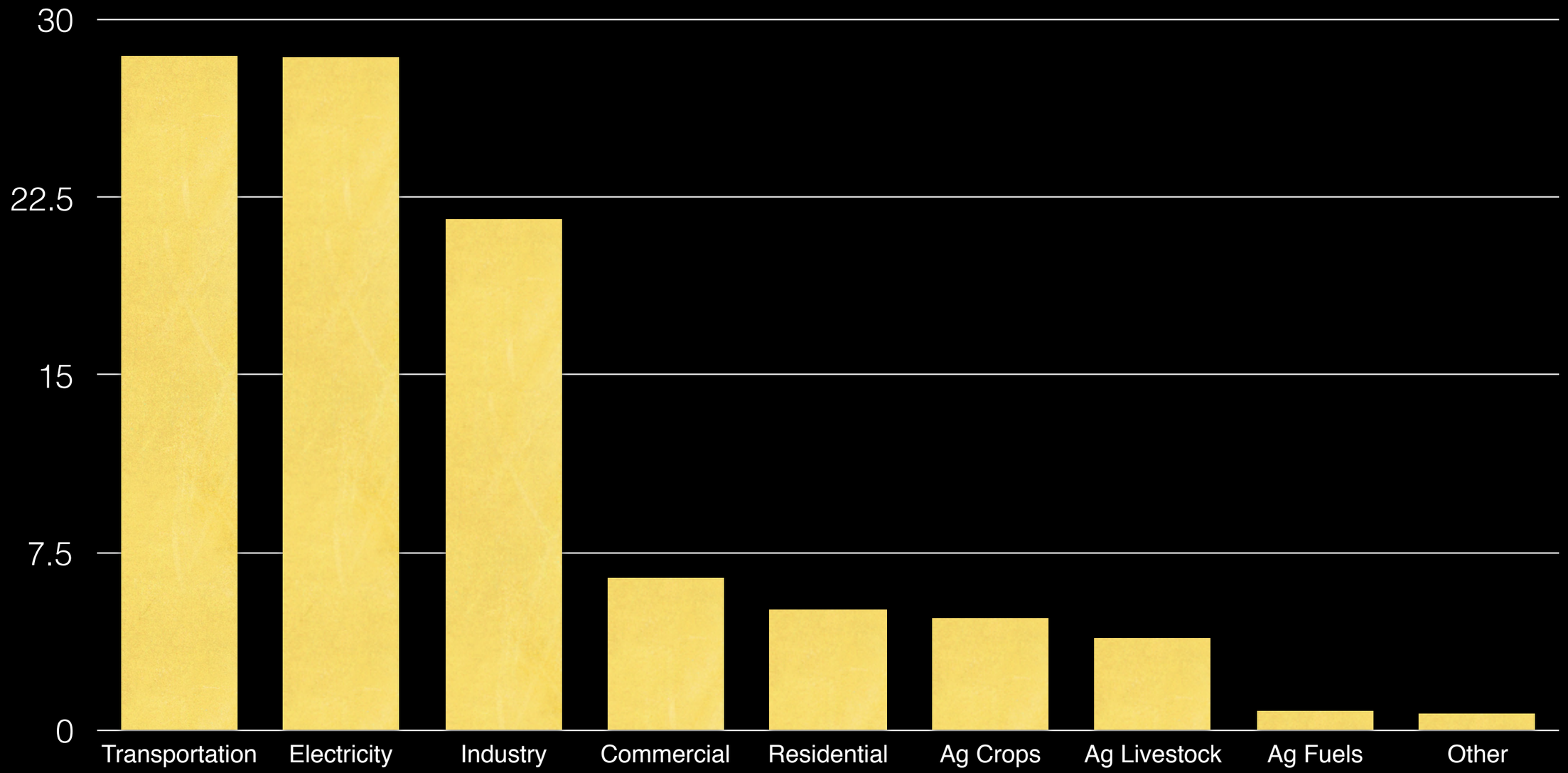
Percentage land-use change: 43% in 1960, 13% averaged 2008–2017



Land-use change estimates from two bookkeeping models, using fire-based variability from 1997

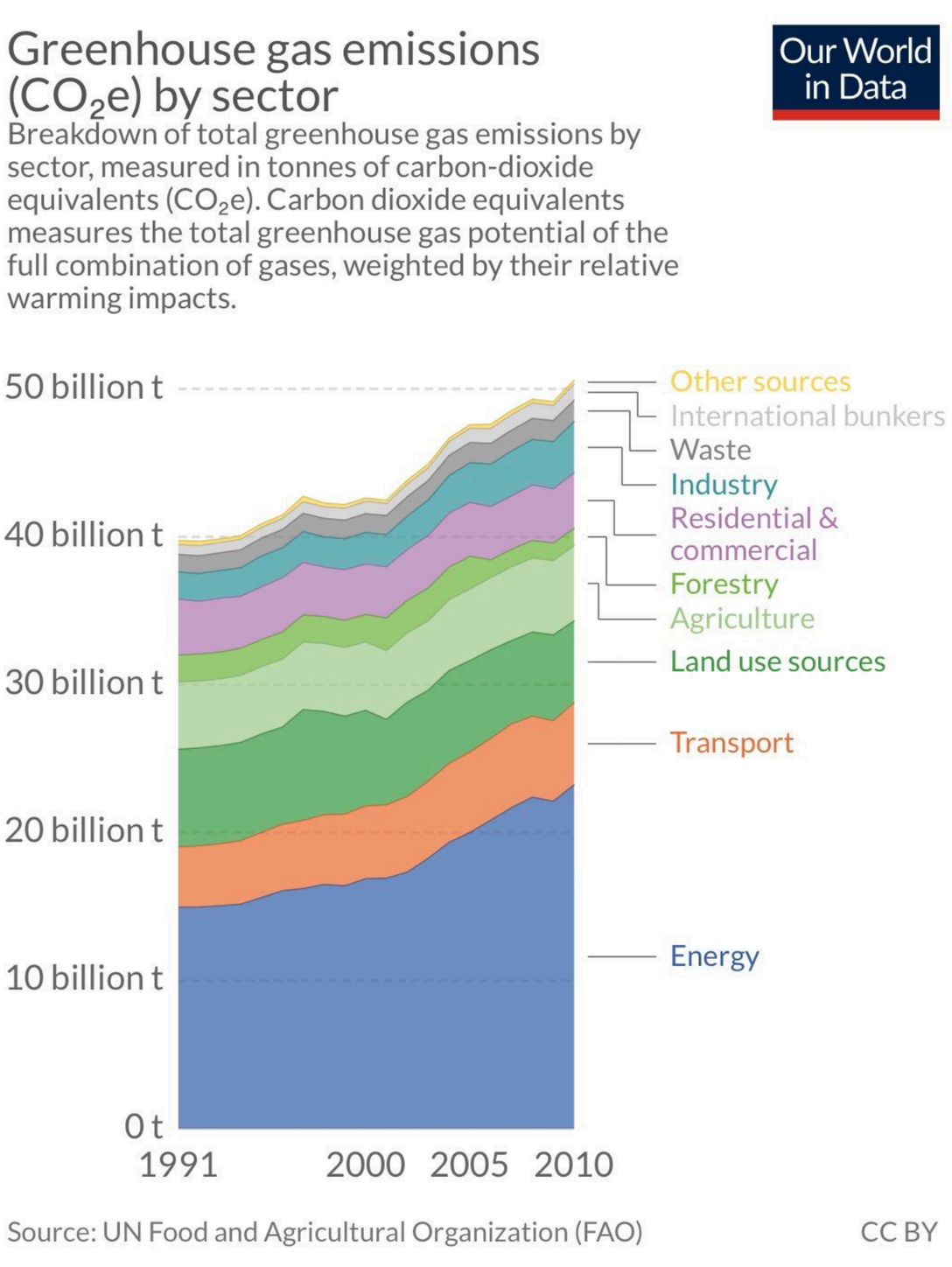
Source: CDIAC; Houghton and Nassikas 2017; Hansis et al 2015; van der Werf et al. 2017; Le Quéré et al 2018; Global Carbon Budget 2018

Share of Greenhouse Gas Emission by Sector



Global figures are essentially the same.

Fossil fuels are by far the largest share of GHG emissions, and agriculture a much smaller share (only about 14% globally)



More recent assessments look at nutrient density, not just calories or kg, for assessing agriculture and agricultural products for their impact on GHG emissions

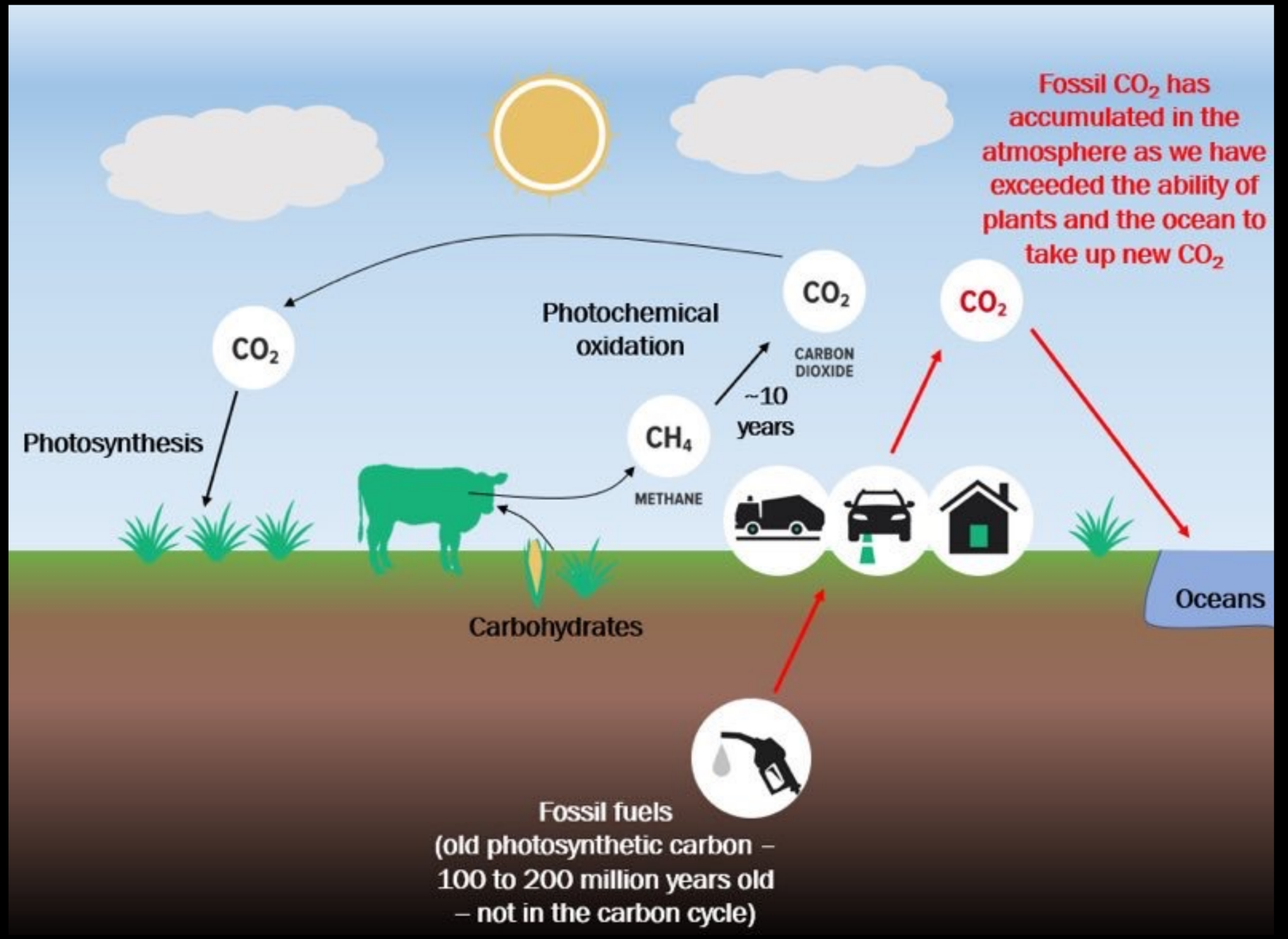
Table 7. Nutrient density in relation to climate impact for solid food items

Solid food items	Number of nutrients ≥15% NNR	% of NNR in 100 g food	Nutrient density	GHGE	NDCI Index
Beef	9	389	166.8	2799	0.06
Rice, polished	3	175	25.0	374	0.07
Bananas	2	115	10.9	122	0.09
Chicken	7	297	98.8	521	0.19
Potatoes	2	138	13.2	57	0.23
Pasta	5	187	44.5	193	0.23
Rice, brown	6	326	93.1	374	0.25
Cheese	11	545	285.5	923	0.31
Pork	10	387	184.4	557	0.33
Fish, Cod	7	465	155.0	447	0.35
Broccoli	4	351	66.8	167	0.40
Carrot	1	187	8.9	22	0.40
Eggs	11	440	230.2	210	1.10
Oatmeal	8	352	134.1	90	1.49
Beans, brown	12	471	269.4	124	2.17

NNR: Nordic Nutrition Recommendations; NDCI index: nutrient density to climate impact index (NDCI = nutrient density/ GHGE); nutrient density = percentage of NNR in 100 g of product × number of nutrients ≥15% NNR/ 21; GHGE: greenhouse gas emission (gram CO_2e per 100 g food items) excluded waste at consumer level.

IPCC Report emphasizes opportunities for mitigation

B6.2. Diversification in the food system (e.g., implementation of integrated production systems, broad-based genetic resources, and diets) can reduce risks from climate change (*medium confidence*). Balanced diets, featuring plant-based foods, such as those based on coarse grains, legumes, fruits and vegetables, nuts and seeds, and animal-sourced food produced in resilient, sustainable and low-GHG emission systems, present major opportunities for adaptation and mitigation while generating significant co-benefits in terms of human health (*high confidence*). By 2050, dietary changes could free several Mkm^2 (*medium confidence*) of land and provide a technical mitigation potential of 0.7 to 8.0 $GtCO_2e\ yr^{-1}$, relative to business as usual projections (*high confidence*). Transitions towards low-GHG emission diets may be influenced by local production practices, technical and financial barriers and associated livelihoods and cultural habits (*high confidence*). {5.3, 5.5.2, 5.5, 5.6}


Fossil CO_2 has accumulated in the atmosphere as we have exceeded the ability of plants and the ocean to take up new CO_2
CO_2
CARBON DIOXIDE
Photochemical oxidation
~10 years
CH_4
METHANE
CO_2
CO_2
Photosynthesis
Carbohydrates
Oceans
Fossil fuels
(old photosynthetic carbon – 100 to 200 million years old – not in the carbon cycle)

Ruminant and agricultural sources of methane are part of the natural carbon cycle.

The methane is short lived, from recent plant grown (sequestration), and can build soil carbon and organic matter.

Not a net increase in carbon.

Fossil fuels ARE a net increase because they are releasing carbon sequestered in the geological past

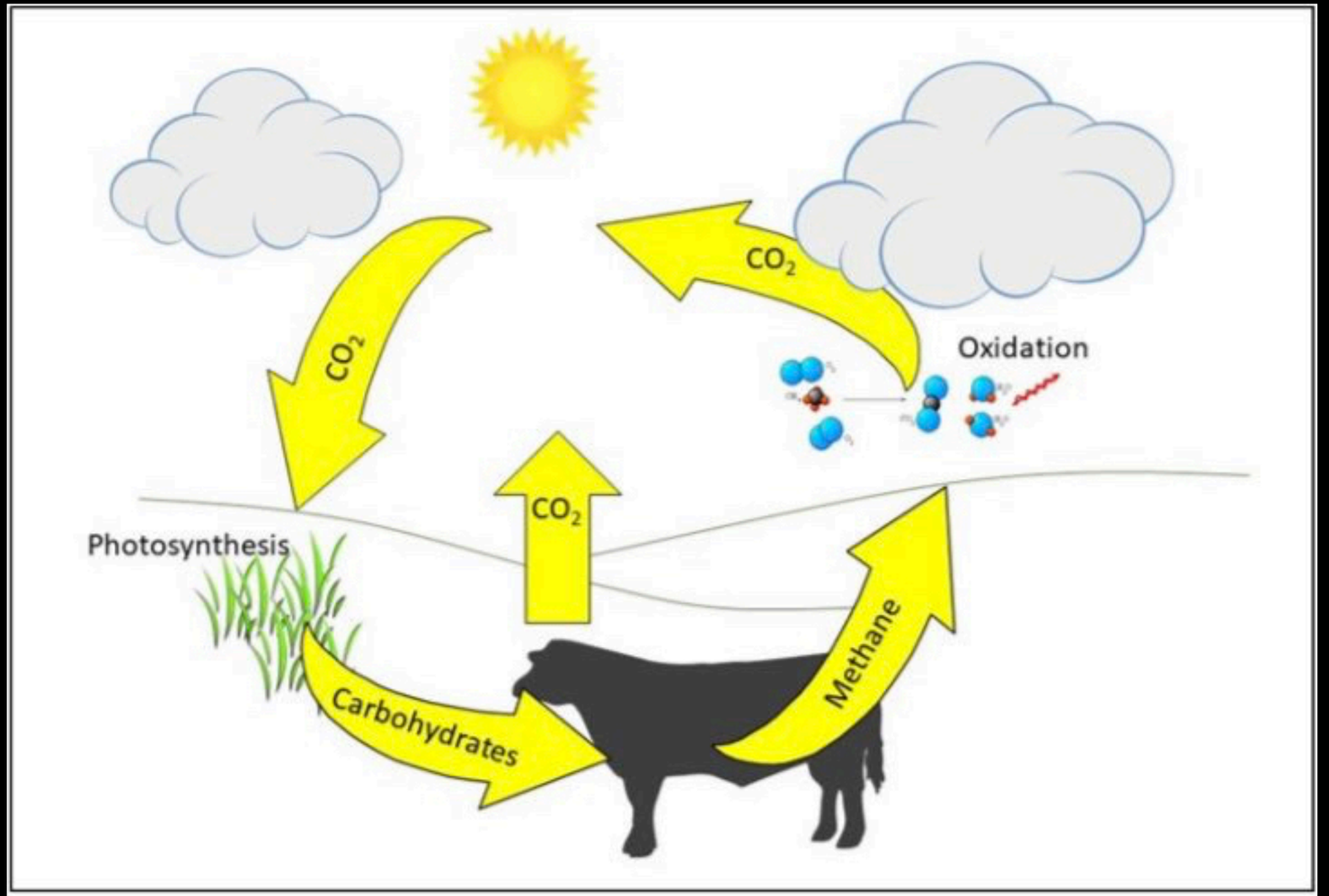
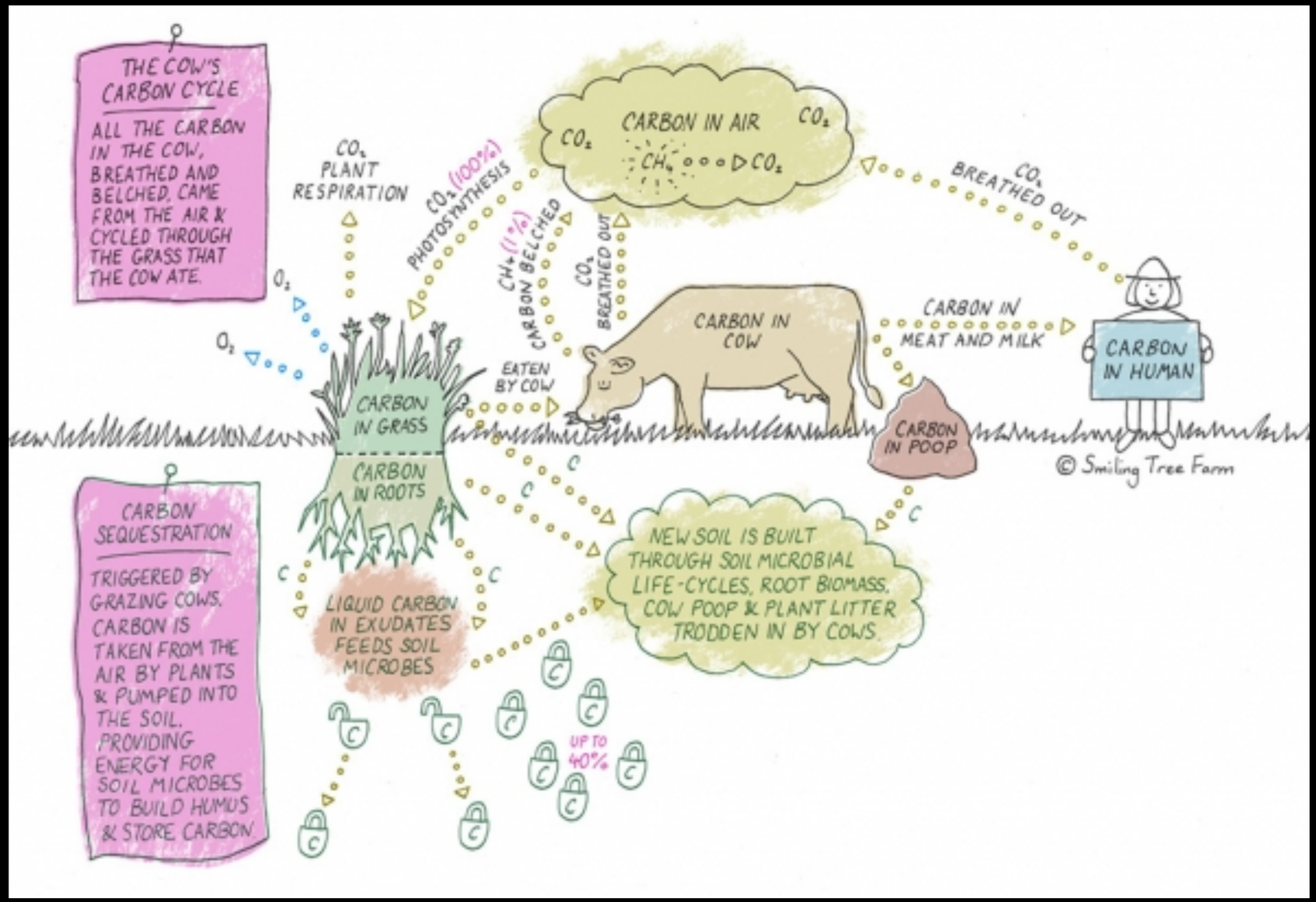
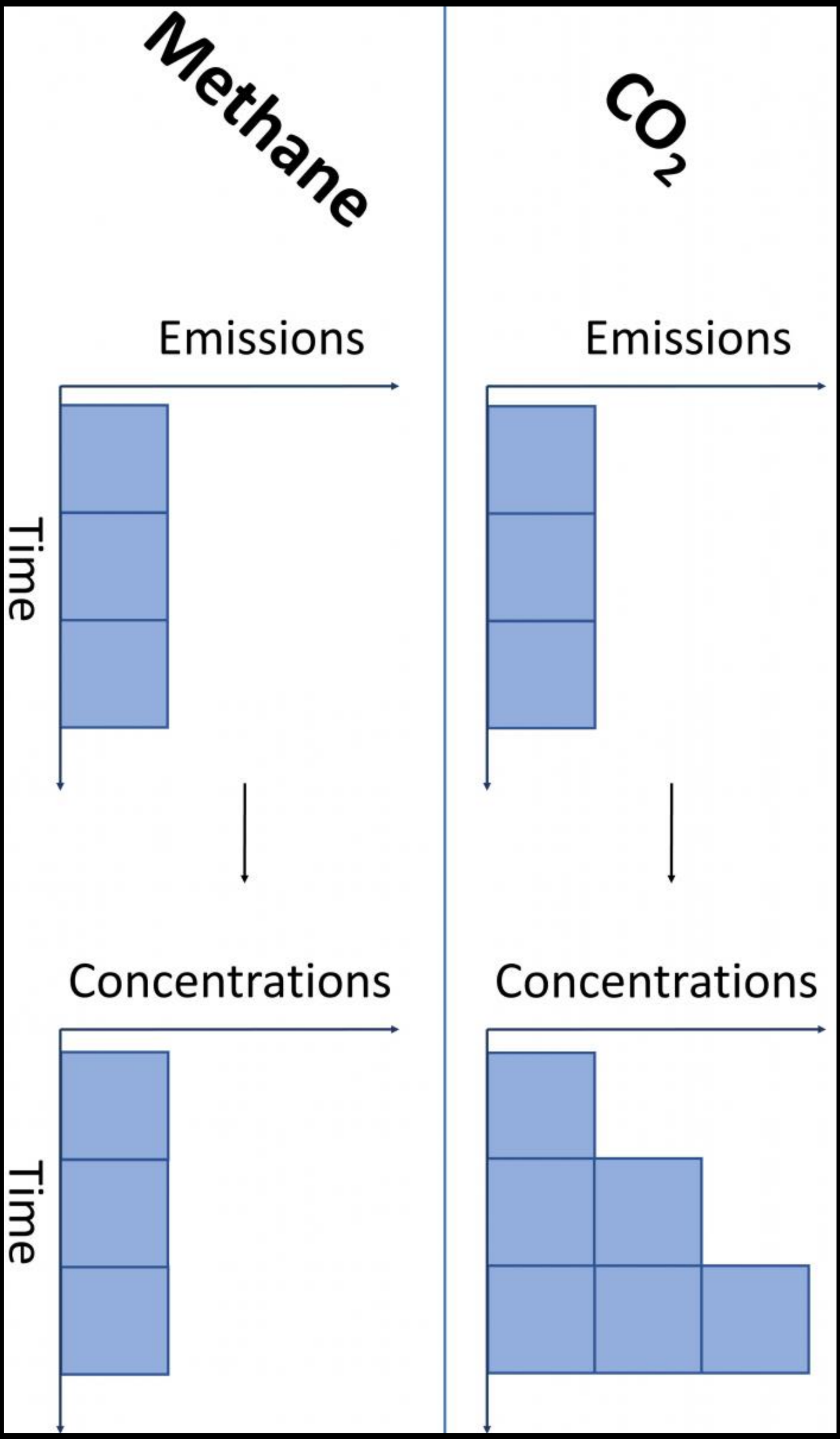


Figure 1. Methane production by cattle is part of a natural carbon cycle where the methane oxidizes in the atmosphere over a period of years converting the carbon to carbon dioxide (CO_2) that can be fixed through plant growth to form carbohydrates in feed. Within this cycle there is no long term impact on climate if methane emissions and oxidation are in balance.

Carbon cycling




Methane
CO_2
Emissions
Emissions
Time
Concentrations
Concentrations
Time

Focus on Soils

"Rebuilding soil fertility is the very basis of sustainable food production and food security. There is no alternative to fertile soil to sustain life, including human life, on Earth. It is our work with living soil that provides sustainable alternatives to the triple crisis of climate, energy, and food."

Dr. Vandana Shiva, in *Soil Not Oil,* 2015

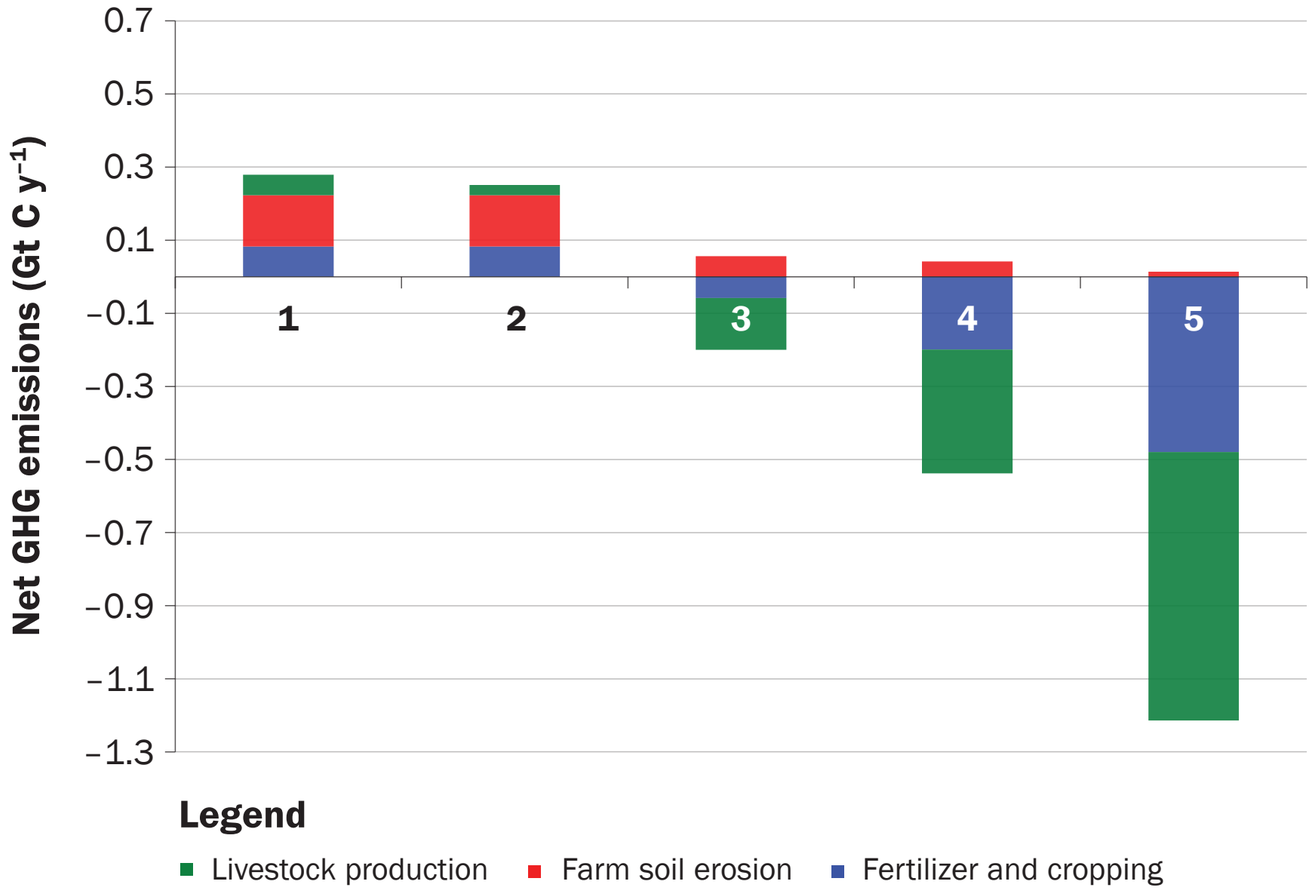
Soil is the Solution

WHY WE NEED TO FOCUS ON HOLISTIC MANAGEMENT IF WE WANT TO SAVE THE PLANET

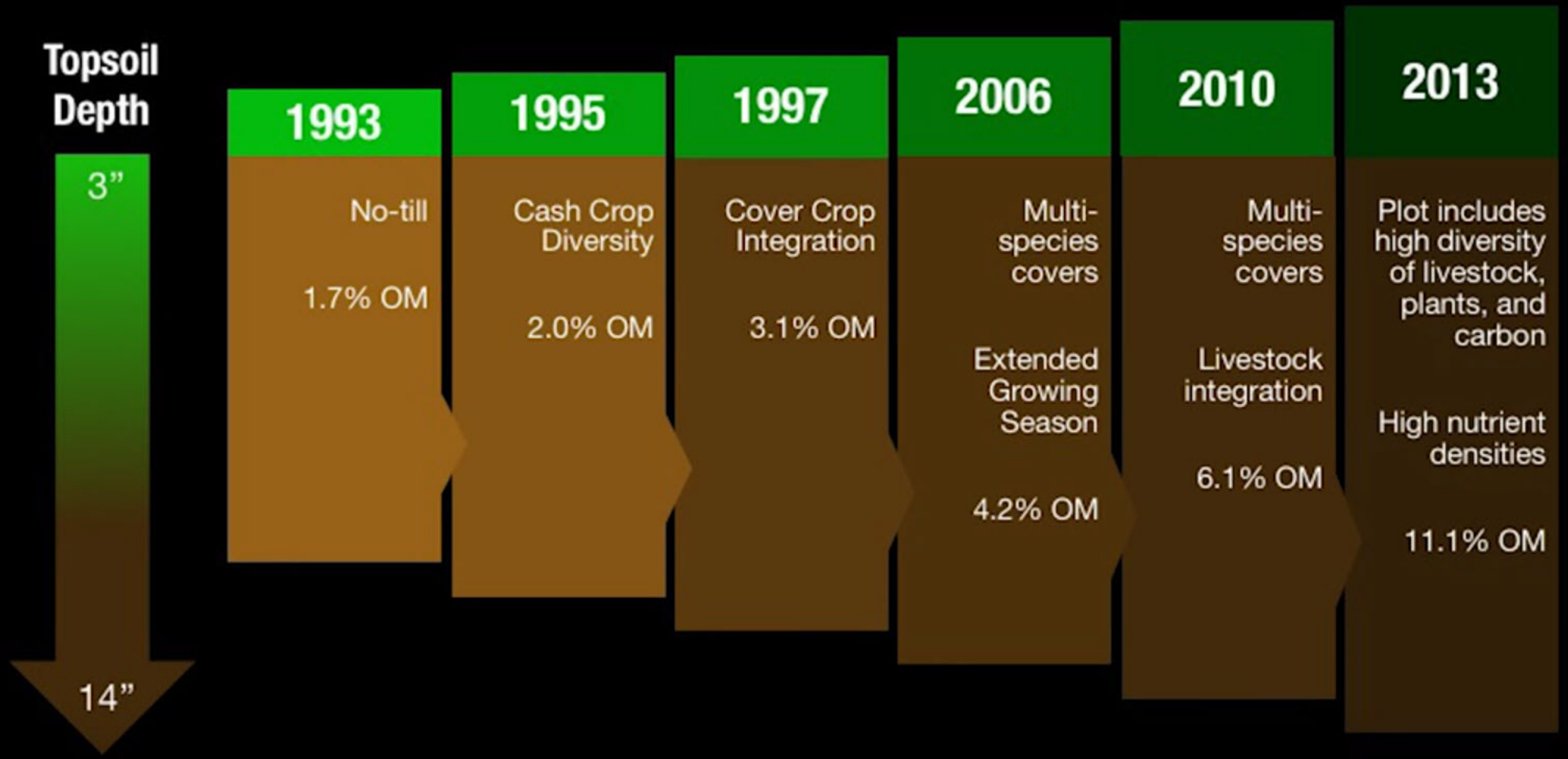
Words by Chris Kerston

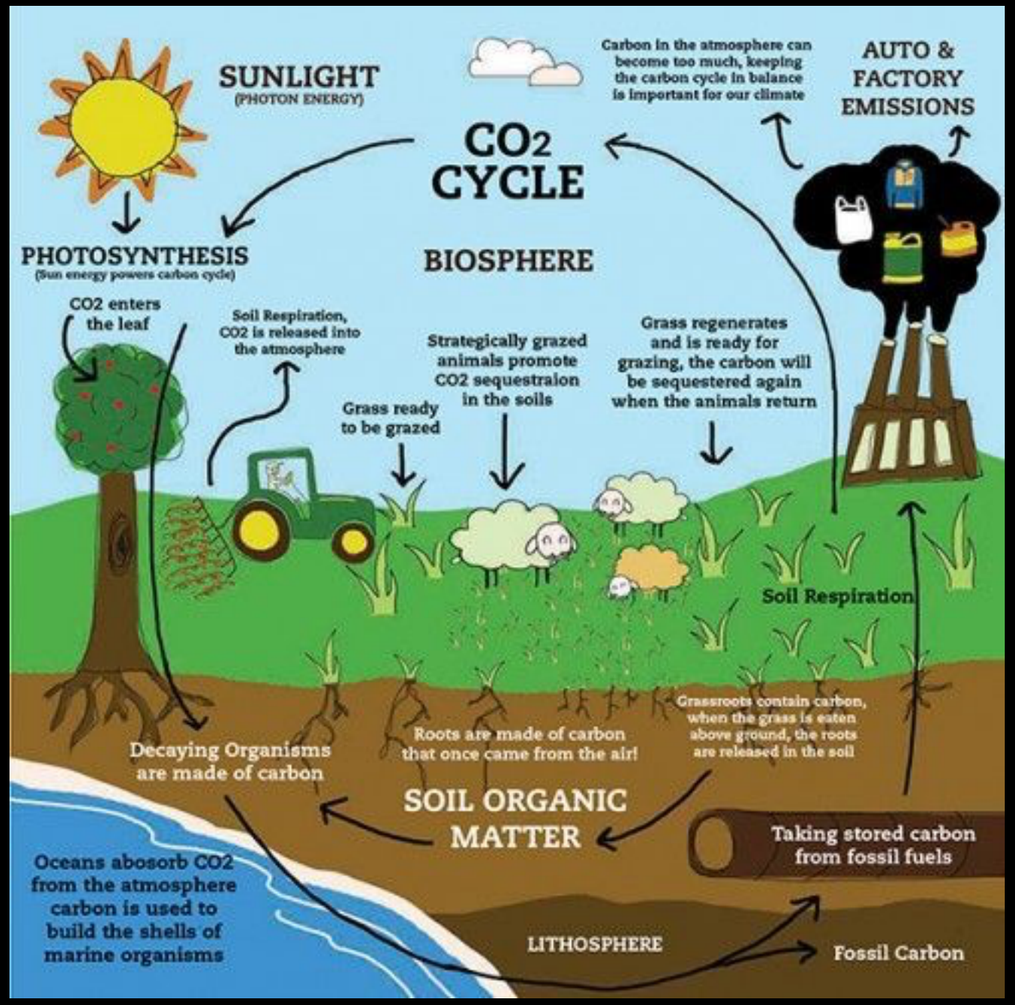
Potential for GHG Sequestration

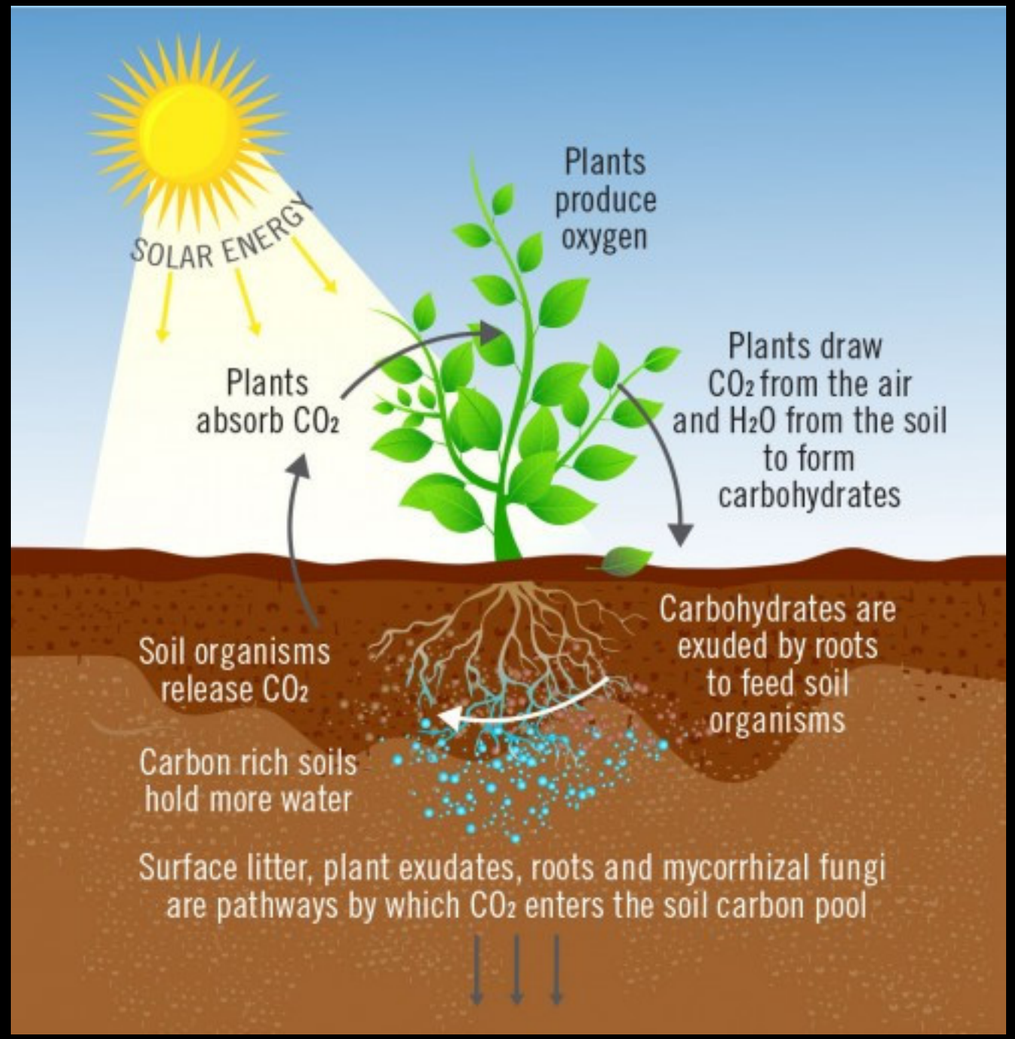
Hypothetical North American net greenhouse gas (GHG) emission scenarios for: (1) current agriculture; (2) current agriculture with 50% current ruminants; (3) 25% conservation cropping and adaptive multipaddock (AMP) grazing with current numbers of ruminants; (4) 50% conservation cropping and AMP grazing with current numbers of ruminants; and (5) 100% conservation cropping and AMP grazing with current numbers of ruminants.



Soil carbon sequestion




SUNLIGHT
(PHOTON ENERGY)
CO2 CYCLE
BIOSPHERE
PHOTOSYNTHESIS
(Sun energy powers carbon cycle)
Carbon in the atmosphere can become too much, keeping the carbon cycle in balance is important for our climate
AUTO & FACTORY EMISSIONS
CO2 enters the leaf
Soil Respiration, CO2 is released into the atmosphere
Grass ready to be grazed
Strategically grazed animals promote CO2 sequestraion in the soils
Grass regenerates and is ready for grazing, the carbon will be sequestered again when the animals return
Soil Respiration
Decaying Organisms are made of carbon
Roots are made of carbon that once came from the air!
Grassroots contain carbon, when the grass is eaten above ground, the roots are released in the soil
SOIL ORGANIC MATTER
Taking stored carbon from fossil fuels
Oceans abosorb CO2 from the atmosphere carbon is used to build the shells of marine organisms
LITHOSPHERE
Fossil Carbon


SOLAR ENERGY
Plants produce oxygen
Plants absorb CO_2
Plants draw CO_2 from the air and H_2O from the soil to form carbohydrates
Carbohydrates are exuded by roots to feed soil organisms
Soil organisms release CO_2
Carbon rich soils hold more water
Surface litter, plant exudates, roots and mycorrhizal fungi are pathways by which CO_2 enters the soil carbon pool

4 PER 1000

CARBON SEQUESTRATION IN SOILS FOR FOOD SECURITY AND THE CLIMATE

The quantity of carbon contained in the atmosphere increases by 4.3 billion tons every year

+ 4.3 bn tons carbon / year

CO_2 emissions

Human activities ⊕⊕⊕⊕

Deforestation ⊕

Forests ⊙⊙

Oceans ⊙⊙

⊙ absorption ⊕ emission

The world's soils contain 1 500 billion tons of carbon in the form of organic material

absorption of CO_2 by plants

storage of organic carbon in soils

1 500 bn tons carbon

While pursuing the indespensible effort to decrease drastically the green house gases (GHG) emissions due to human activities, increasing soil organic carbon sequestration could make a substantial contribution to GHG mitigation efforts. A theoretical annual increase of the world soil organic carbon stock by 0.4% of its value would be larger than the 2015 annual increase in CO_2 in the atmosphere, which is a major contributor to the greenhouse effect and climate change : this is the origin of the "4 per 1000" title of this initiative.

increased absorption of CO_2 by plants :

farmlands, meadows, forests…

+4‰ carbon storage in the world's soils

soils better able to cope with the effects of climate change

= less CO_2 in the atmosphere

HOW CAN SOILS STORE MORE CARBON?

The more soil is covered, the richer it will be in organic material and therefore in carbon.
Until now, the combat against global warming has largely focused on the protection and restoration of forests.
In addition to forests, we must encourage more plant cover in all its forms.

Never leave soil bare and work it less, for example by using no-till methods

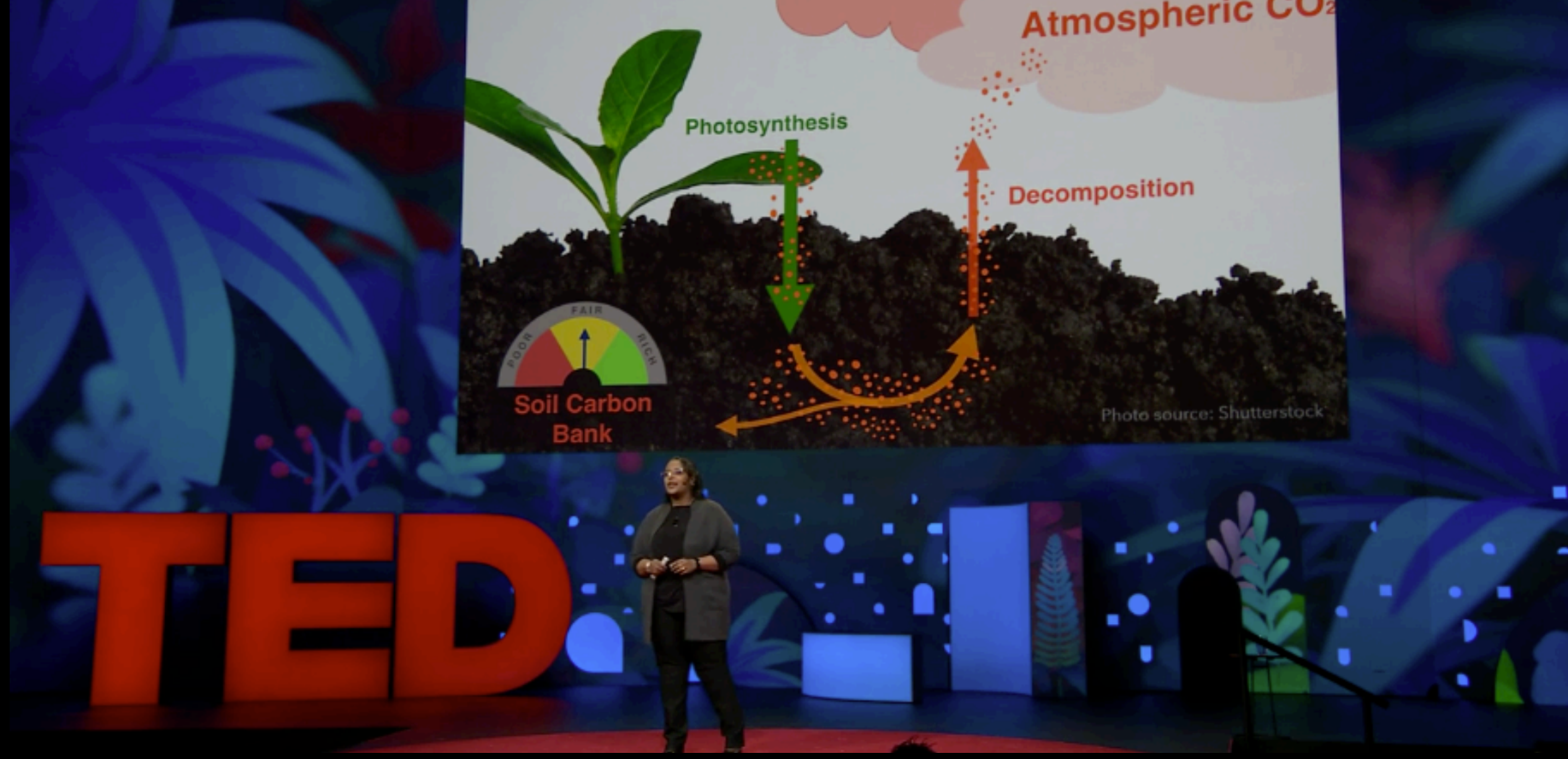
Introduce more intermediate crops, more row intercropping and more grass strips

Add to the hedges at field boundaries and develop agroforestry

Optimize pasture management – with longer grazing periods, for example

Restore land in poor condition e.g. the world's arid and semi-arid regions

Improve water and fertilizers management and use organic fertilizers and compost



"Increasing the amount of carbon stored in soil by 0.4% annually... can offset a third of the global emissions of fossil-fuel-derived carbon into the atmosphere."

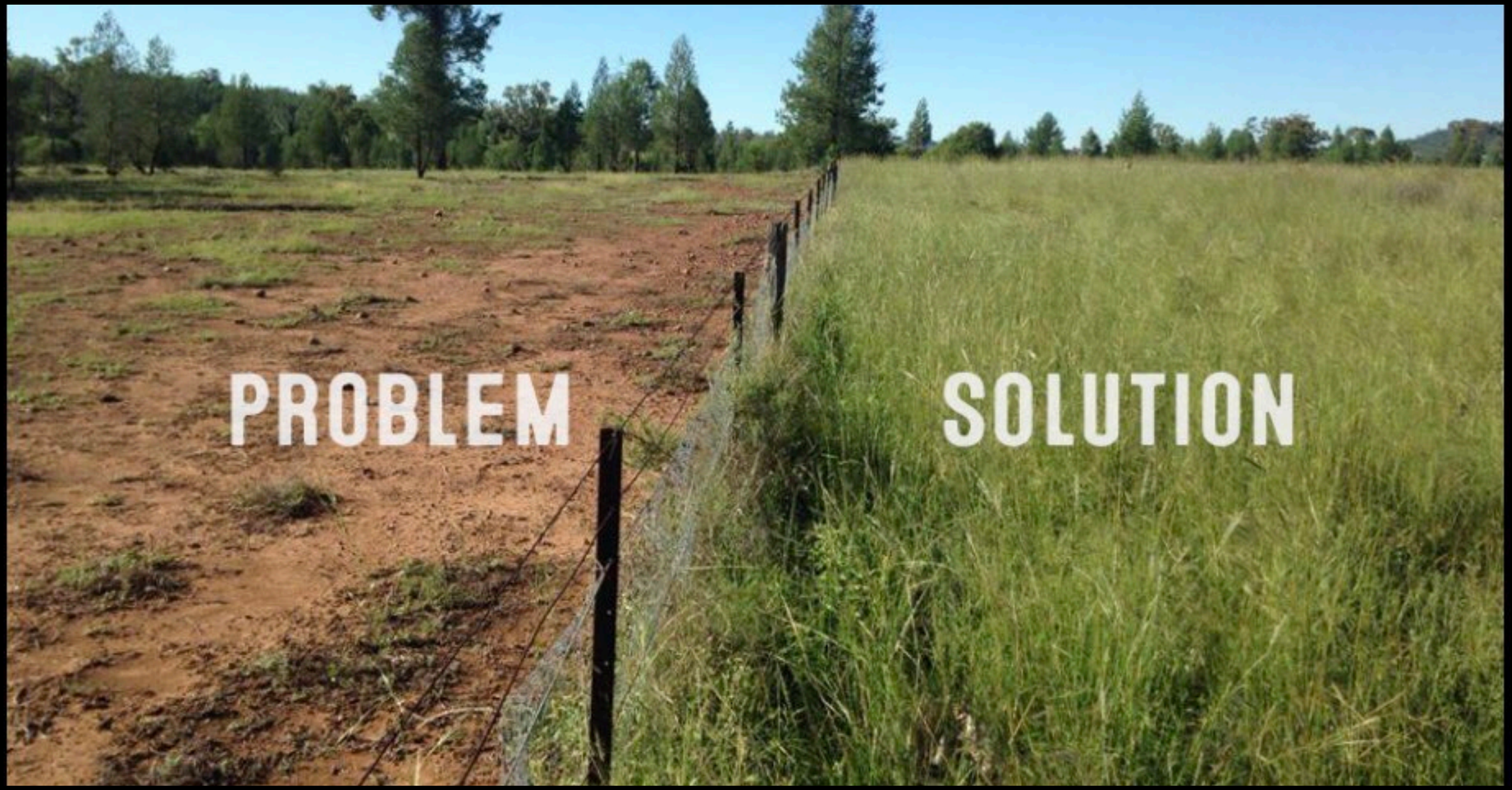
Dr. Asmeret Asefaw Barhe

TED 2019 "A climate change solution that's right under our feet"

High soil organic matter and carbon with regenerative agriculture

Low organic matter and low carbon with conventional monocropping

Successful grassland / habitat restoration through increased ruminant impact



Principles of Regenerative Agriculture

Regenerative agriculture

Uses ecologically appropriate (biome specific) ways to restore ecosystems and produce food

Build on naturally evolved relationships to create productive food ecosystems, using both naturally occurring species or analogue species (e.g. cattle instead of bison)

A set of farming techniques that help regenerate the soil

Regenerative Organic farming practices support healthy soil, animals, and people to build resilient ecosystems and communities. By using RO practices like conservation tillage and cover cropping, RO farmers increase the organic matter in soils over time to replenish the land and sequester carbon from the atmosphere. On RO farms, animals are raised and slaughtered humanely, and workers are treated fairly and ethically.

Regenerative organic represents a set of holistic agricultural practices that support the health of soil, animals, and workers. Regenerative farming aims to not only sustain bu regenerate and rebuild soil health over time.

Source: Regenerative Organic Alliance, regenorganic.com


INCREASING ORGANIC MATTER AND MICROBIOLOGY
GRAZING STIMULATES GRASS GROWTH
HOOVES AERATE SOIL AND COMPOST DEAD GRASS
MANURE FERTILIZES SOIL
INCREASING BIODIVERSITY
GRASS AND HEALTHY SOIL SEQUESTER CARBON
CO_2
INCREASING WATER HOLDING CAPACITY
H_2O

“Our philosophy in grazing is to manage the cattle herd to simulate the large herds of Elk and Antelope which once roamed California’s grasslands. We accomplish this by keeping the herd moving with Holistic planned grazing, so as never to overgraze an area, but to stimulate growth and grass-land health through properly timed grazing. Watershed Stewardship is at the forefront of our management practices.”

– Doniga Markegard

Role of ruminants in food production

86 percent of what livestock eat globally is human-inedible plants and leftovers

More than 85 percent of the land where we graze cattle is not suitable for growing crops because it is too rocky, steep and/or arid to support cultivated agriculture

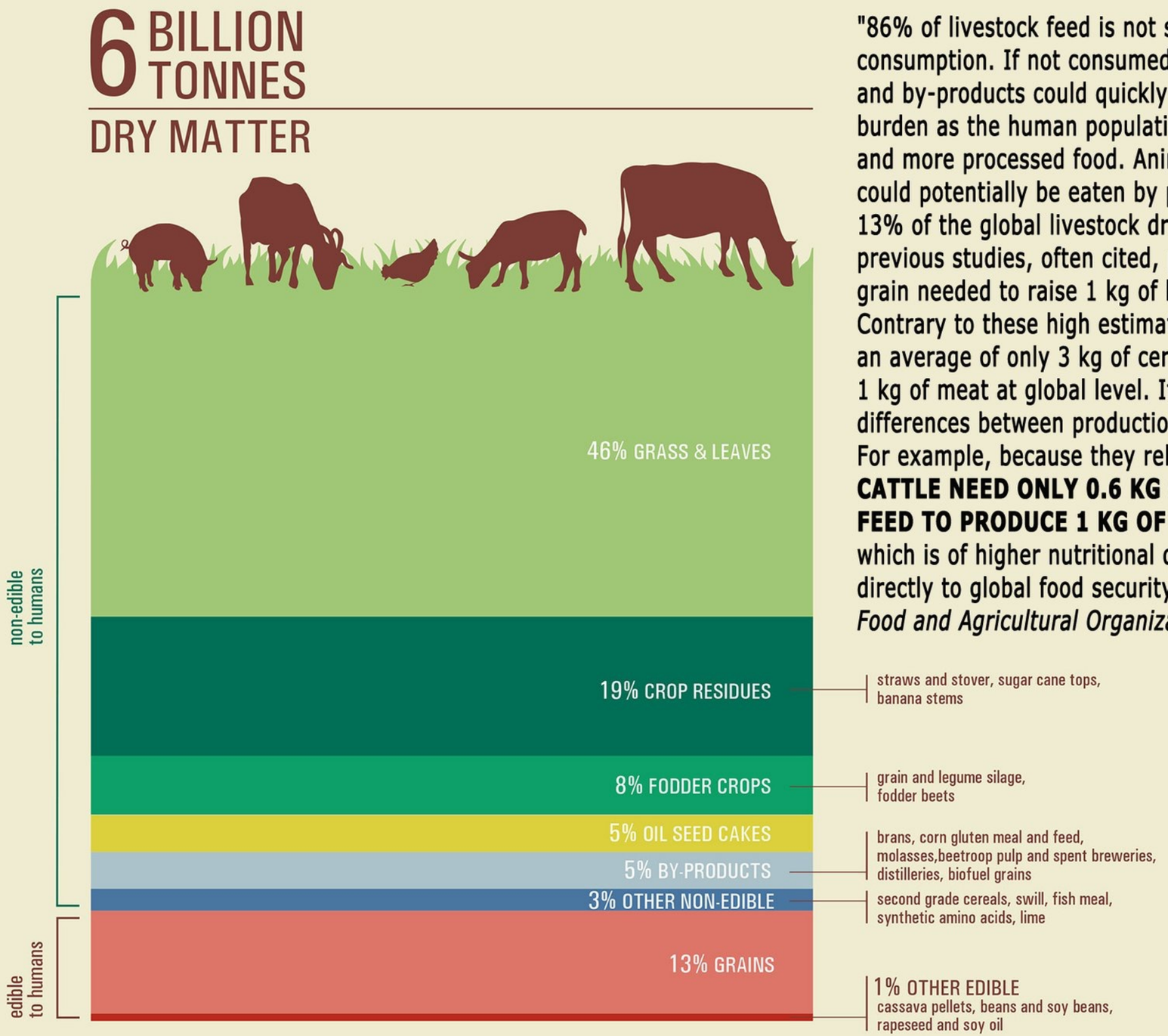
In "typical" cattle production, the green water (rainfall) number is about 92%. In grass-finished beef, the green water number is closer to 97-98%

In the US, only about 2% of GHG are from beef, but varies by production system

Cattle "up cycle" 0.6 kg of protein from edible feed to produce 1.0 kg of protein in milk and meat

Animal manure is a major source of fertilizer for organic vegetables, grains, and other plant foods

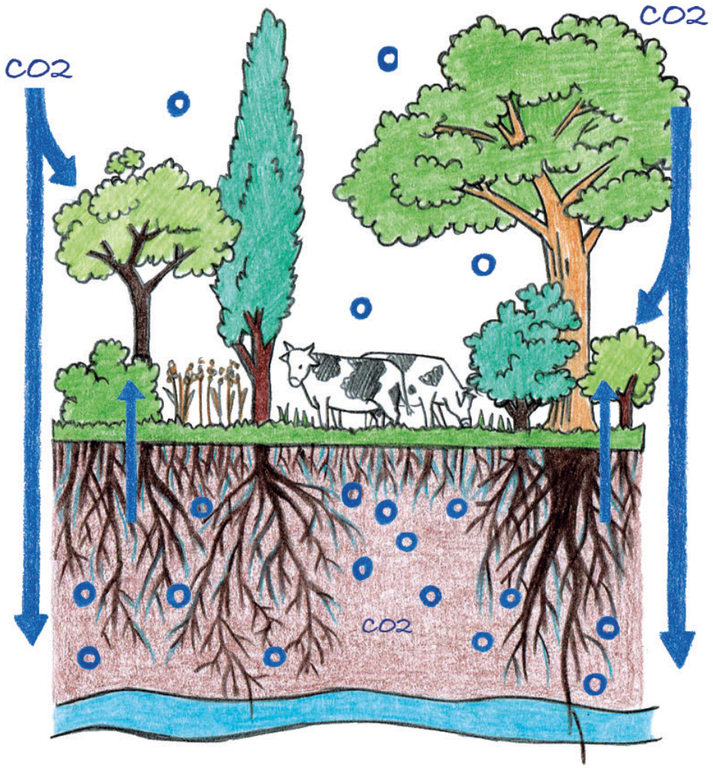
Ruminants critical in up cycling non-edible and farming by-products



"86% of livestock feed is not suitable for human consumption. If not consumed by livestock, crop residues and by-products could quickly become an environmental burden as the human population grows and consumes more and more processed food. Animals also consume food that could potentially be eaten by people. Grains account for 13% of the global livestock dry matter intake. Some previous studies, often cited, put the consumption of grain needed to raise 1 kg of beef between 6 kg and 20 kg. Contrary to these high estimates, this study found that an average of only 3 kg of cereals are needed to produce 1 kg of meat at global level. It also shows important differences between production systems and species. For example, because they rely on grazing and forages, **CATTLE NEED ONLY 0.6 KG OF PROTEIN FROM EDIBLE FEED TO PRODUCE 1 KG OF PROTEIN IN MILK AND MEAT**, which is of higher nutritional quality. Cattle thus contribute directly to global food security." *Source: FAO - Food and Agricultural Organization of the United Nations*

Components of regenerative agriculture

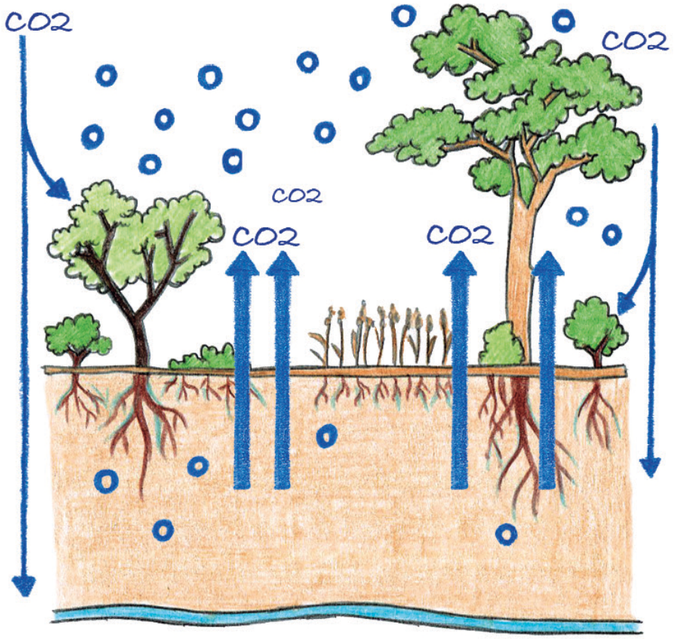
HOLISTIC LAND MANAGEMENT & OTHER TECHNIQUES OF REGENERATIVE AGRICULTURE



Healthy soil as carbon sink

- More ground cover
- More roots
- More carbon stored in soil
- More water retention in top soil
- Recovering groundwater levels
- Less erosion
- More bioproductivity
- More diversity
- Less carbon in the atmosphere

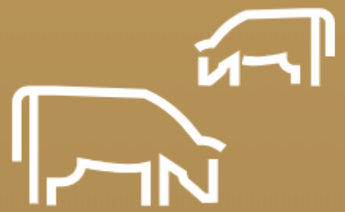
CONVENTIONAL LAND MANAGEMENT & INDUSTRIAL AGRICULTURE



Depleted soil as carbon source

- Less ground cover
- Fewer roots
- Less carbon stored in soil
- Less water retention in top soil
- Depleting groundwater
- More erosion
- Less bioproductivity
- Less diversity
- More carbon in the atmosphere

5 Core Principles of
REGENERATIVE AGRICULTURE



Soil Health

- Builds Soil Organic Matter
- Conservation Tillage
- Cover Crops
- Crop Rotations
- No GMOs or Gene Editing
- No Soilless Systems
- No Synthetic Inputs
- Promotes Biodiversity
- Rotational Grazing

Animal Welfare

- Five Freedoms
  1. Freedom from discomfort
  2. Freedom from fear & distress
  3. Freedom from hunger
  4. Freedom from pain, injury or disease
  5. Freedom to express normal behavior
- Grass-Fed / Pasture-Raised
- Limited Transport
- No CAFOs
- Suitable Shelter

Social Fairness

- Capacity Building
- Democratic Organizations
- Fair Payments for Farmers
- Freedom of Association
- Good Working Conditions
- Living Wages
- Long Term Commitments
- No Forced Labor
- Transparency and Accountability

Source: Regenerative Organic Alliance, regenorganic.com

Structure of regenerative farms

Using biome appropriate trees, shrubs, plants, and animals

Mimic natural animal movement in turn
Large ruminants, small ruminants, fowl, rooters/soil turners

Some regenerative techniques


HOLISTIC GRAZING


SWALES


PASTURE CROPPING


AGROFORESTRY


MULTI SPECIES COVER CROPS

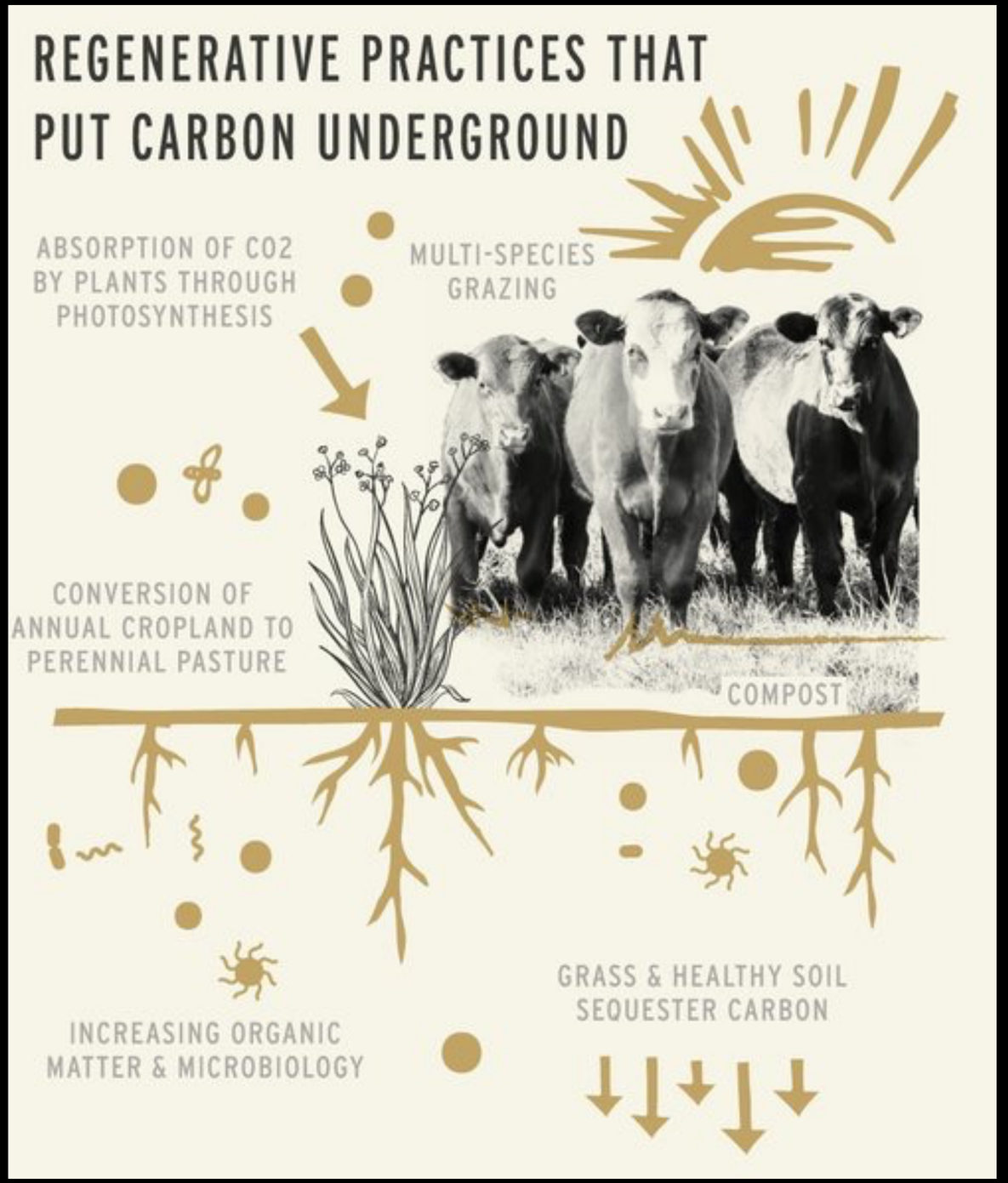

GROUND COVER


KEYLINE DESIGN

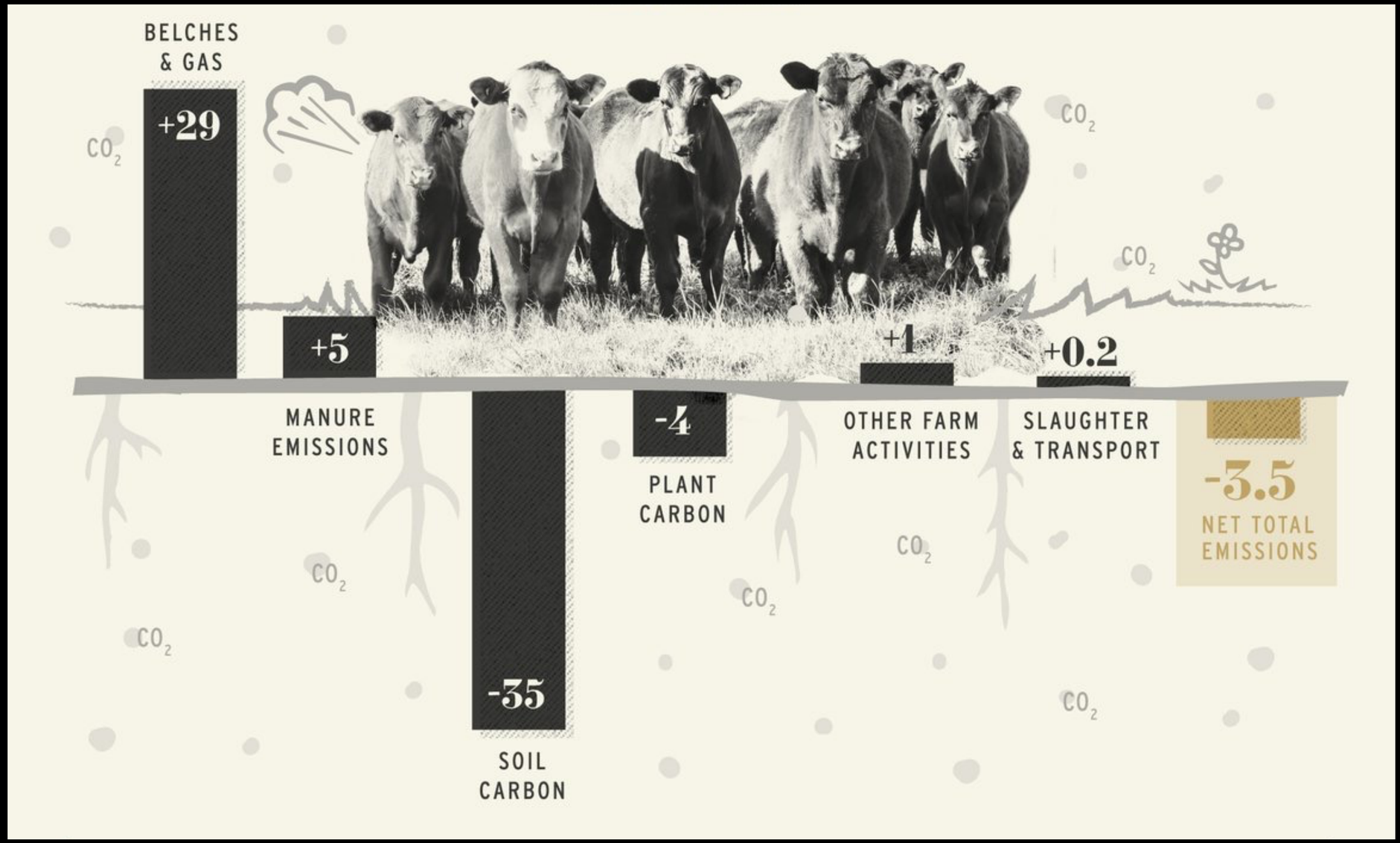

NO-TILL FARMING

Case Studies

Case study: White Oak Pastures



Case study: White Oak Pastures



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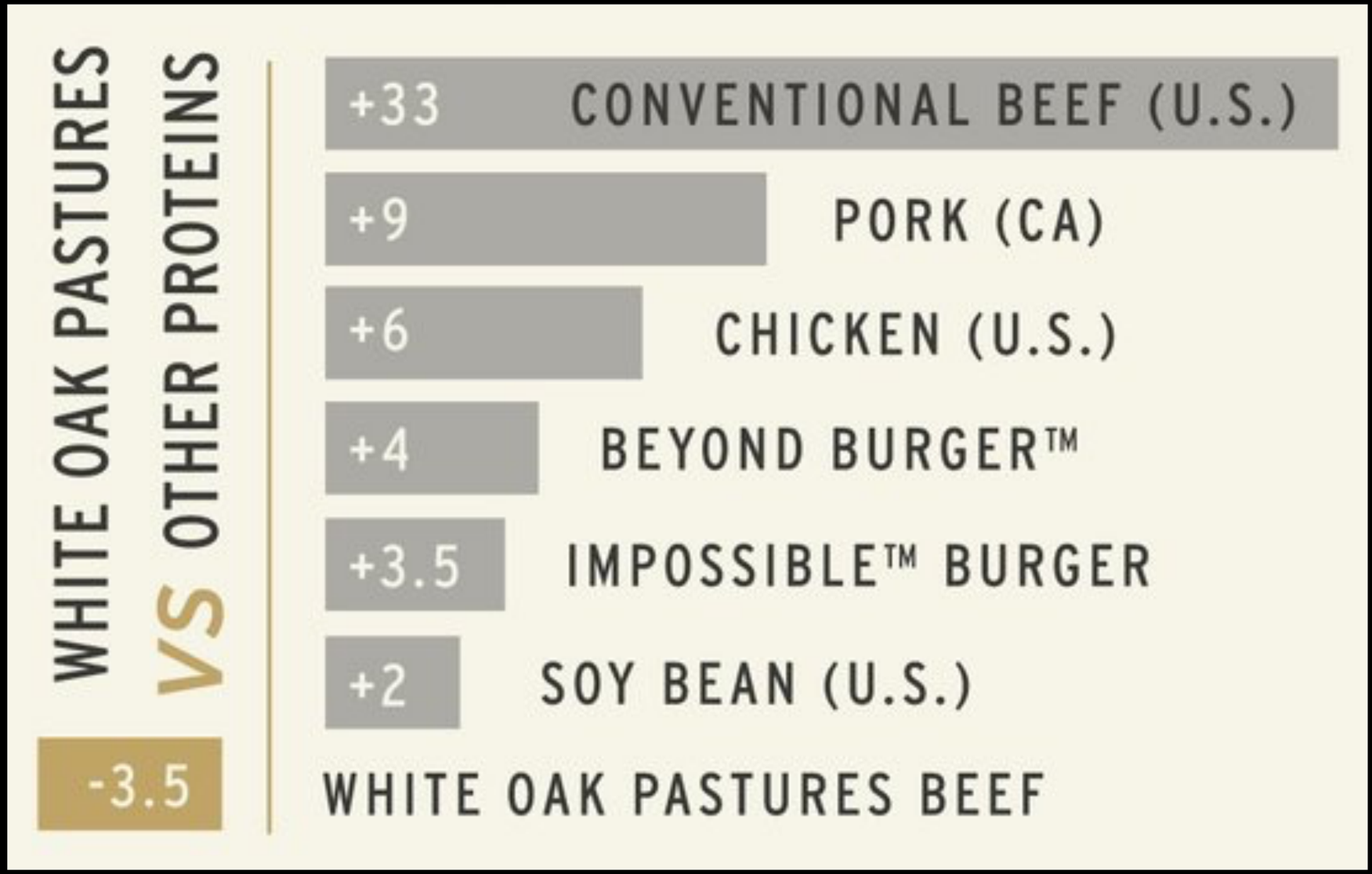


Case studies:

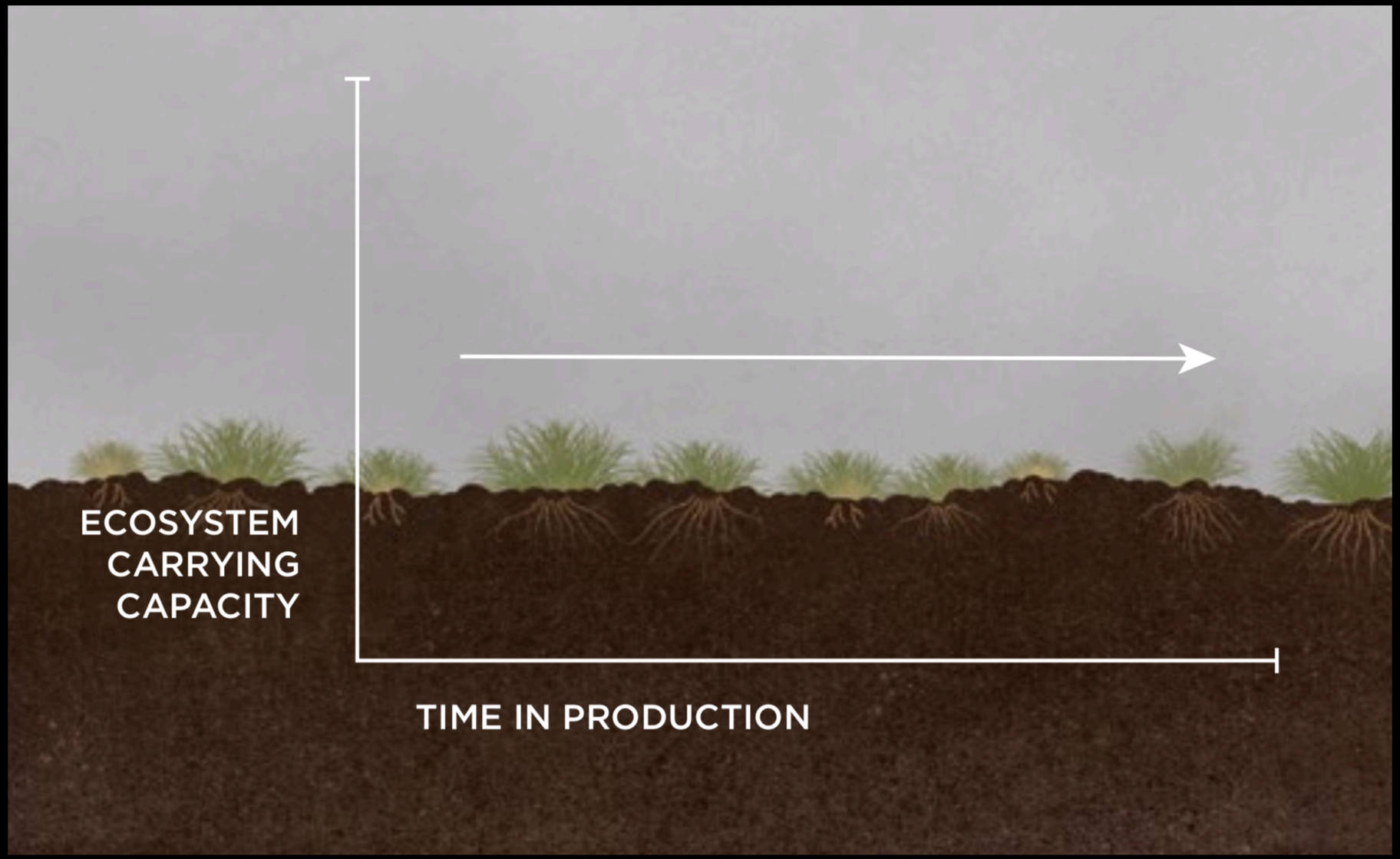
- What systems are being mimicked (ecology & evolution)?
- How are the three criteria (environment, economic, social) reflected?
- What are the parts of each system (plants, animals, nutrient cycles)?

Application to Tropical Smallholder Agriculture

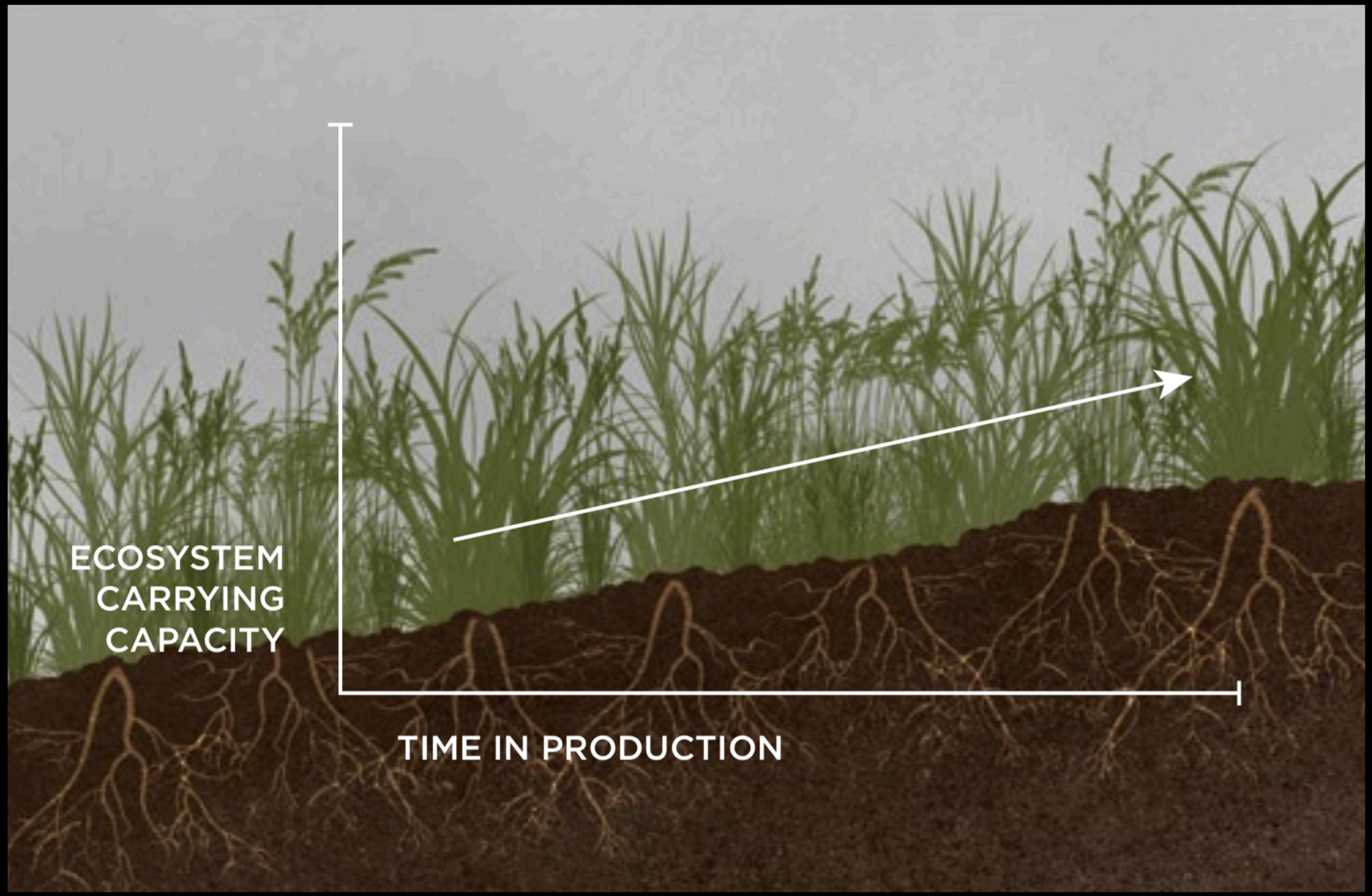
What should this look like in the tropics/sub-tropics?

Conventional Agriculture

Sustainable Agriculture



Regenerative Agriculture



Regenerative organic agriculture is the number one thing humans can do to combat global warming.

Yvon Chouinard
Founder, Patagonia


ISDSI
International Sustainable
Development Studies Institute