



“The Magic of Soil”

by

Phil Gregory

Professor Emeritus

Physics & Astronomy

University of British Columbia

March 13, 2019

**To Environhub Sustainable Backyards, Bay of Plenty & Tauranga
The Orchard, Te Puke, New Zealand**

March 9, 2019

**To Titoki Farm, Environhub and Kai Rotorua
Rotorua, North Island, NZ**

**Jackie in our
garden**





SUSTAINABILITY

Only 60 Years of Farming Left If Soil Degradation Continues

Generating three centimeters of top soil takes 1,000 years, and if current rates of degradation continue all of the world's top soil could be gone within 60 years, a senior UN official said

By Chris Arsenault (Thomson Reuters Foundation), Dec. 5, 2014

In Oct. 2017

UK environmental secretary, Michael Gove, warned that the UK is 30-40 years away from eradication of soil fertility.

<https://www.theguardian.com/environment/2017/oct/24/uk-30-40-years-away-eradication-soil-fertility-warns-michael-gove>

<https://www.theguardian.com/environment/2018/mar/21/europe-faces-biodiversity-oblivion-after-collapse-in-french-bird-populations>

The primary causes of soil degradation include:

Plowing or tilling,

Chemical-intensive farming,

Current livestock management,

Deforestation,

Industrial or urban uses

About 1/3 of the world's soil has already been degraded.

Soil degradation

R

**For every ton of food produced
we lose 7 tons of soil**

<http://www.farmlandlp.com/2012/01/one-acre-feeds-a-person/>

<http://www.cornandsoybeandigest.com/soil-health/economics-soil-loss>

<https://www.youtube.com/watch?v=c4p-kQ6D8aA>

Proceedings of the National Academy of Sciences, 08/2007, Volume 104, Issue 33, pp. 13268-13272

[https://www.amazingcarbon.com/PDF/JONES-OurSoilsOurFuture\(8July08\).pdf](https://www.amazingcarbon.com/PDF/JONES-OurSoilsOurFuture(8July08).pdf)

My Investigation

A fascinating 4 year journey into current agricultural practices, soil biology, climate change, and human health

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A fascinating 4 year journey into current agricultural practices, soil biology, climate change, and human health.

I learned about some amazing advances that have been made in the last 20 to 30 years and especially in the arena of soil biology and understanding nature's complexity.

I benefitted from 4 courses that I completed from one of the pioneers of this new revolution, Dr. Elaine Ingham.

The 'Good News' which is what my talk is all about

If we change the way we do agricultural in response to the recent revolution in soil biology, we can:

- 1) rapidly reverse soil degradation,
- 2) avoid the looming collapse of agriculture,
- 3) reduce chronic disease epidemics,
- 4) and go a long way to solving global warming.

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They are all connected and the solution may not be that expensive as nature can do a lot of the work.

The real challenge is to re-educate ourselves in the limited time frame available.

The Washington Post

The world has barely a decade to avoid disaster. We need to combat climate change — now.

OCT 8, 2018

An Astronomer's Perspective

This short video features another astronomer, Dr. Laura Danly of California's Griffith Observatory. She is helping the U.S. Department of Agriculture promote its "healthy soils" campaign.

Permission granted by USDA Natural Resources Conservation Service

<https://www.youtube.com/watch?v=6tJlAjDjjo&index=6&list=PL4J8PxoprGZ-uMTxScBBn9nYT6CMX8aD>

Laptop link

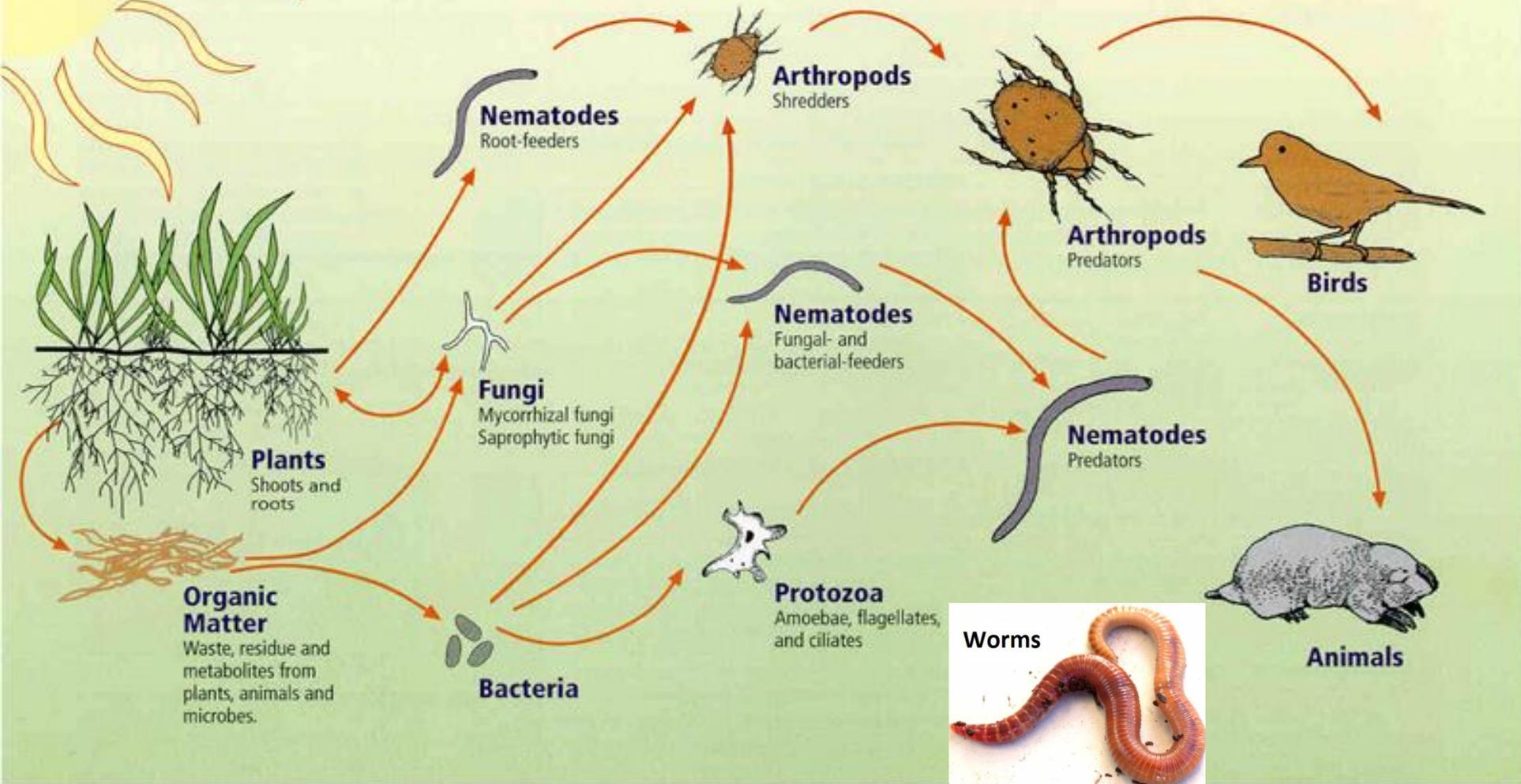
Microbes are the secret behind healthy soil.

Each teaspoon of healthy soil contains as many microbes as the population of humans on earth.



The Soil Food Web

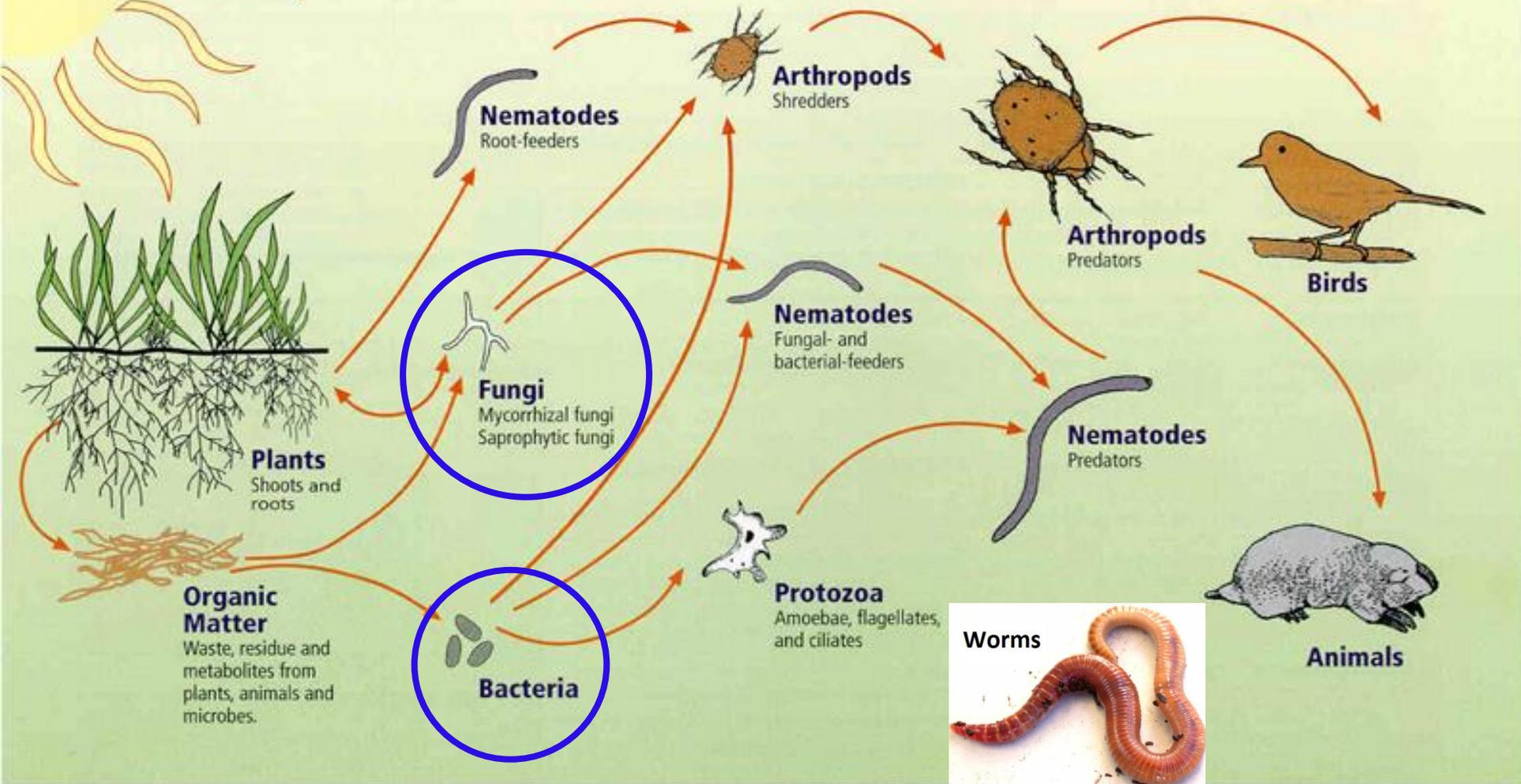
Image courtesy of USDA Natural Resources Conservation Services
<http://www.nrc.usda.gov/wps/portal/nrcs/main/soils/health/biology>



Here are some of the microscopic and visible actors in the soil food web
 Understanding their roles is key to appreciating the new revolution in soil biology

The Soil Food Web

Image courtesy of USDA Natural Resources Conservation Services
<http://www.nrc.usda.gov/wps/portal/nrcs/main/soils/health/biology>



Bacteria and fungi are at the base of this predator-prey relationship

THE SCIENCES MIND HEALTH TECH SUSTAINABILITY EDUCATION VIDEO PODCASTS BLOGS STORE

<https://blogs.scientificamerican.com/artful-amoeba/the-world-s-largest-mining-operation-is-run-by-fungi/>

By Jenifer Fraser on November 5, 2015

The World's Largest Mining Operation Is Run by Fungi



Thin-section micrograph of a tunneled feldspar.

Box 4 l(c) from [Landeweert et al. 2001](#)

Ref: Renske Landeweert et al. "Linking plants to rocks: ectomycorrhizal **fungi mobilize nutrients from minerals.**"

[*Trends in Ecology & Evolution* 16, no. 5 \(2001\): 248-254.](#)

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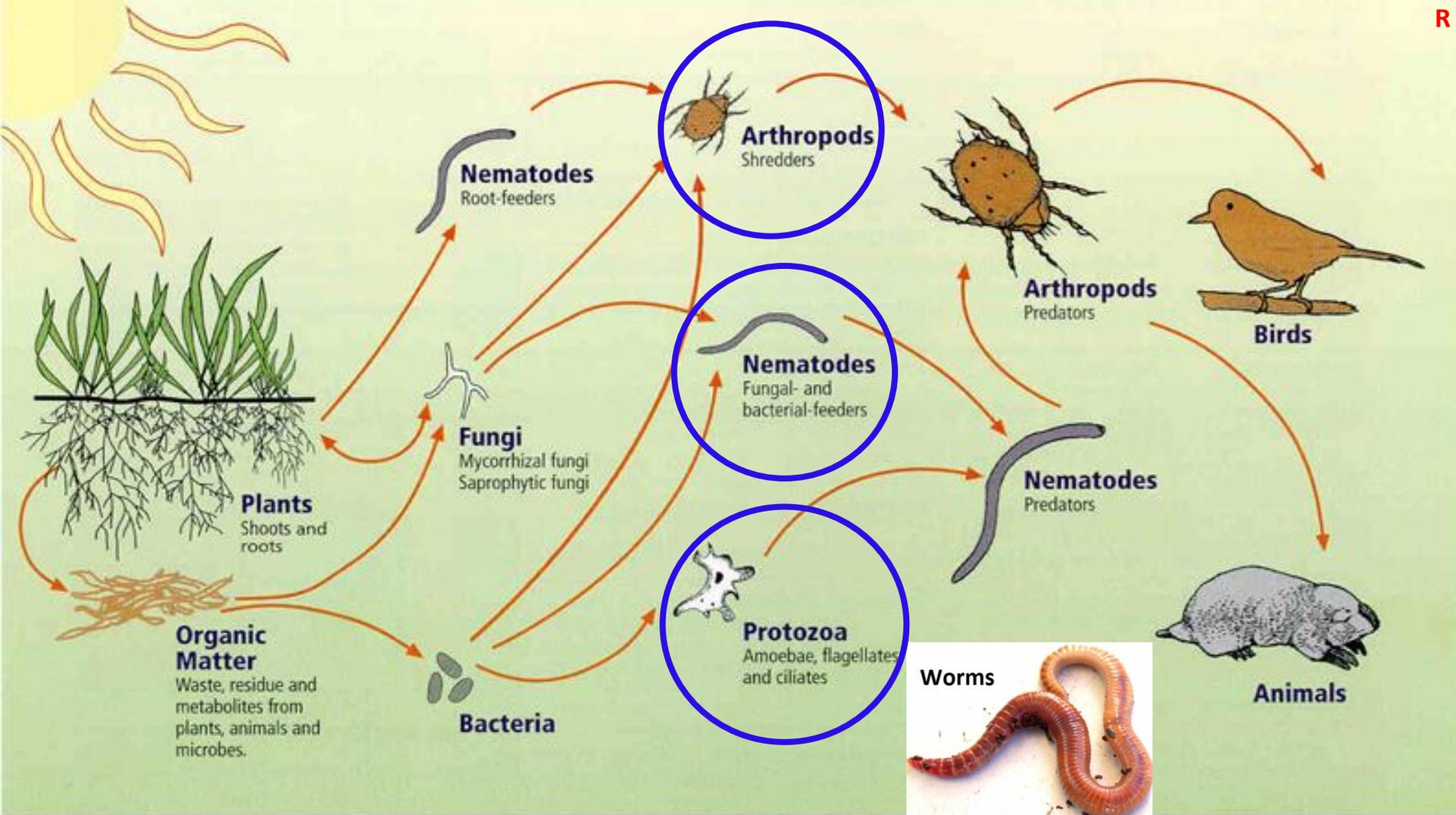
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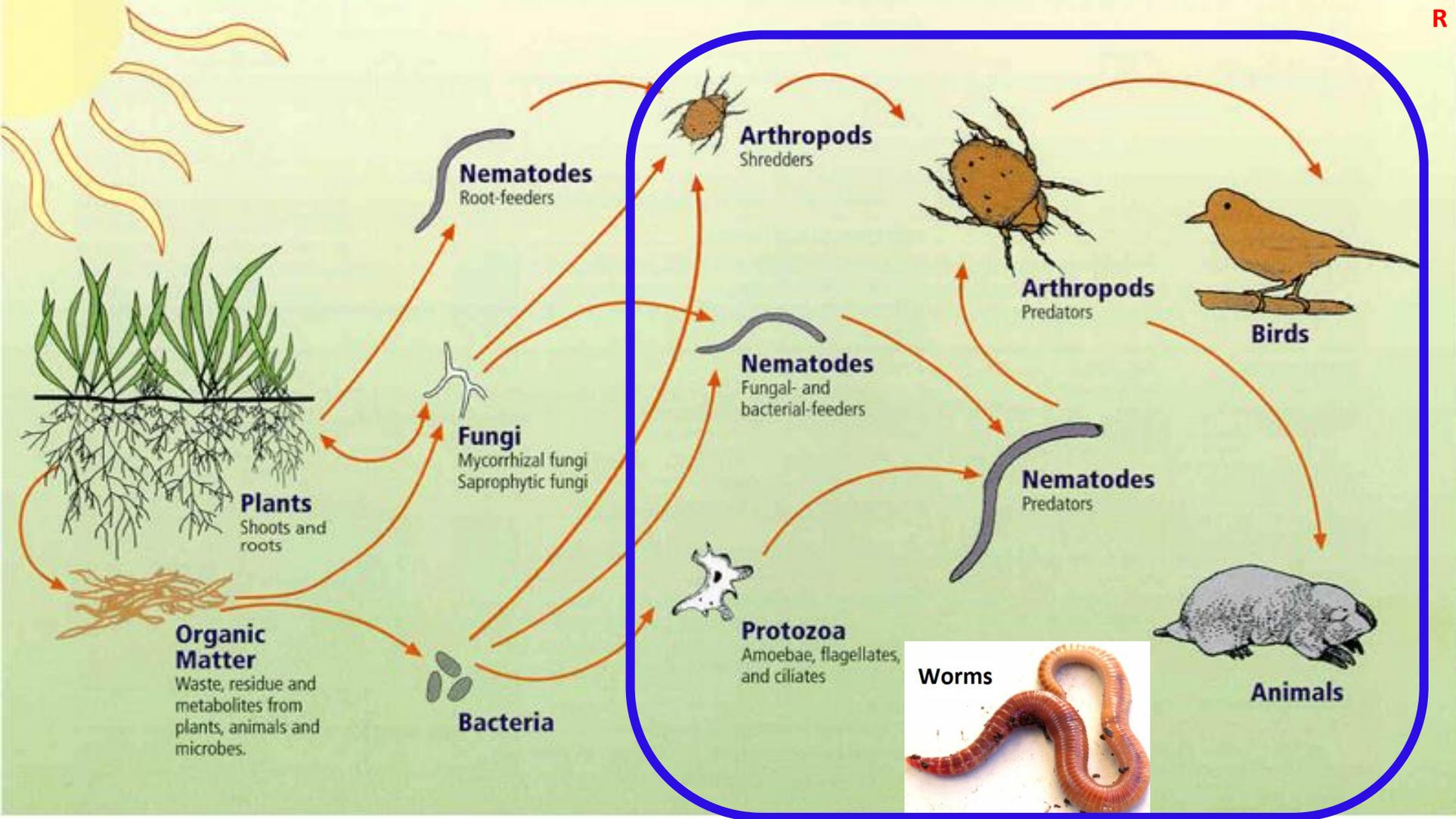
When we kill off the soil microbes with current agricultural practices, we shut down nature's mining operation and turn living soil into dirt.



The important role of the microscopic predators

The bacteria and fungi store the nutrients in high concentrations in their bodies because they need them for life.

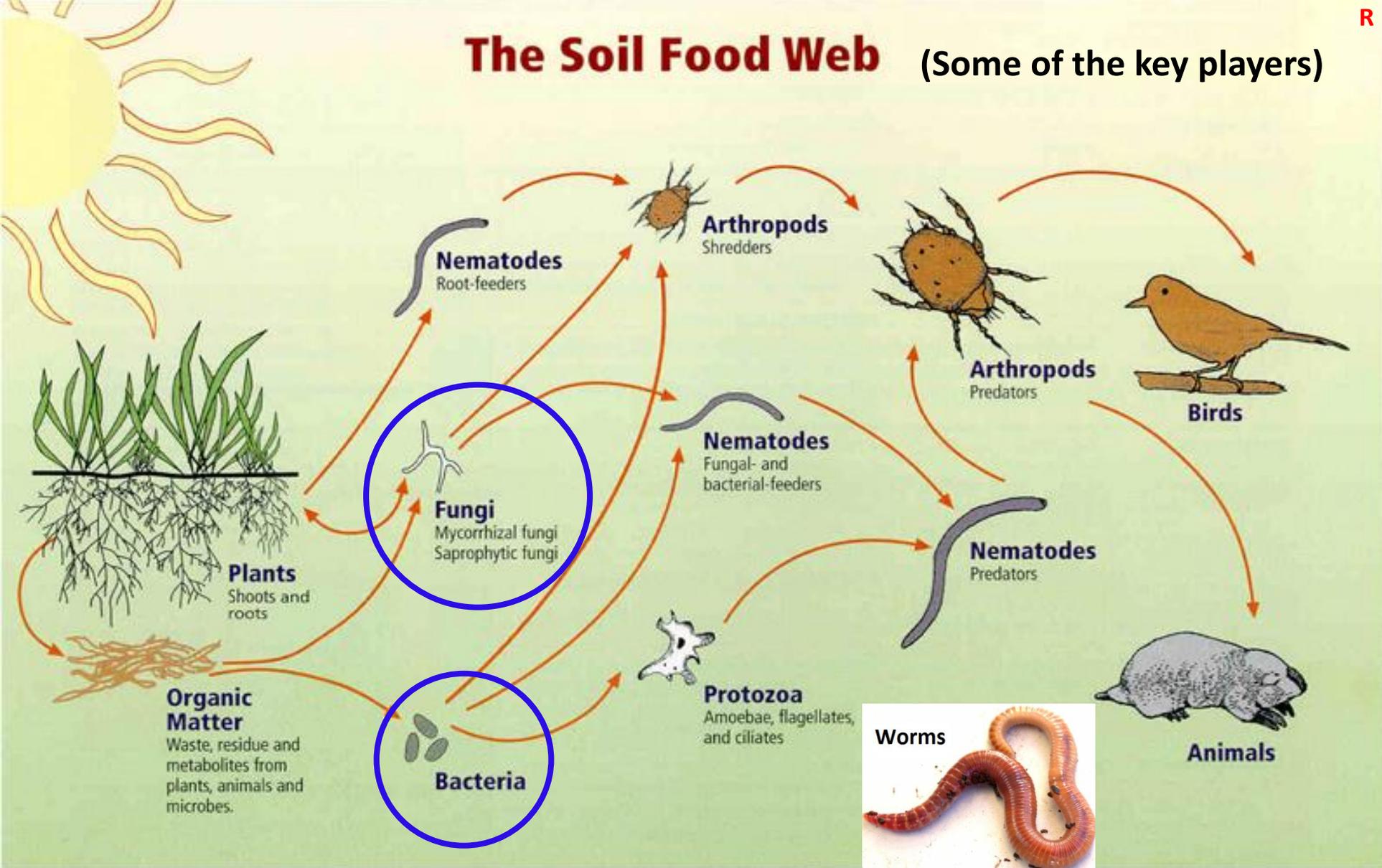
Their predators don't need such high concentrations of the nutrient and poop out the excess in a plant available form.



We need a hierarchy of predators to preserve a stable balance of predators and prey.

In Nature high biodiversity translates to population stability.

The Soil Food Web (Some of the key players)



The bacteria and fungi are concentrated right next to the plant root because the plants attract and feed them

Plants are the
conductors of
this symphony
of nature

How do they do it?



Credit: Argan tree at Agadir by lgt 1400 CC BY SA 4.0

https://commons.wikimedia.org/wiki/File:Argan_tree_@_Agadir.jpg

Plants are the conductors of this symphony of nature

Up to 40% of the sugars, carbohydrates and proteins that plants produce are released from their roots to attract and feed the microbes the plant requires.

Called root exudates.



“What do you make when you mix sugar, a carbohydrate like flour, and protein like eggs and milk?”

That’s a recipe for cakes and cookies. So the plant is putting out cakes and cookies to attract the microbes.”

Dr. Elaine Ingham



Plants also release exudates through their foliage.

In healthy soil conditions leaf surfaces are covered by microbes held to the plant by the strong biotic glues. That protective layer is one of nature's way of achieving disease suppression.



Credit: Argan tree at Agadir by lgt 1400 CC BY SA 4.0

https://commons.wikimedia.org/wiki/File:Argan_tree_@_Agadir.jpg

Bacteria and fungi build soil structure

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Together they build underground cities for the microbes to live in.

Image credit UN FAO.

microaggregate (too small to see by eye)

Bacteria secrete biotic glues that stick soil minerals and organic matter together in what are called microaggregates.

Fungal strands (right) tie microaggregates together forming aggregates (2-5 mm)

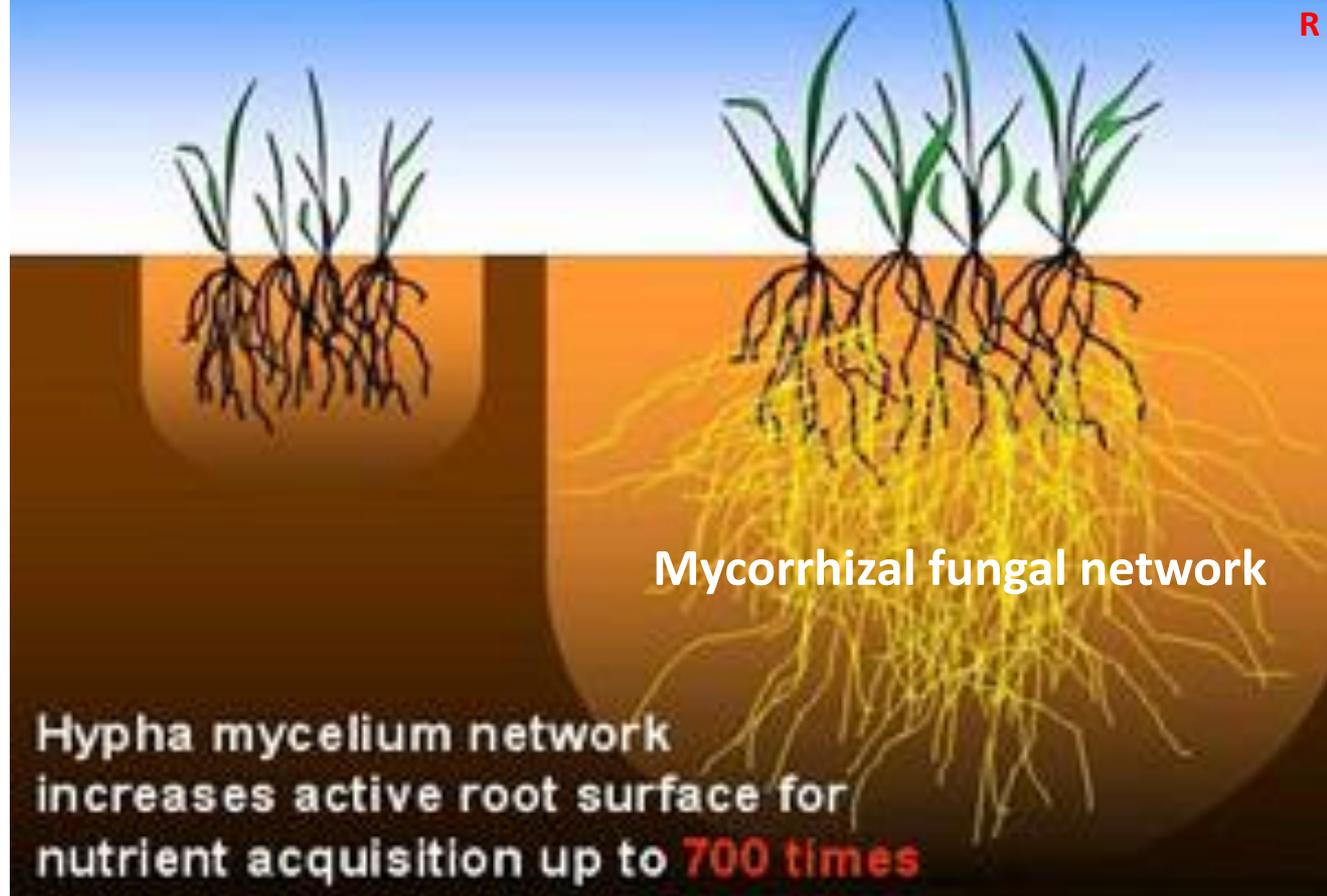


Largest organism

Mycorrhizal Fungal Network

Fungal hyphae are long thin strands, invisible to the naked eye.

Mycelium is a visible network or bundle of hyphae, for example mold on spoiled food.



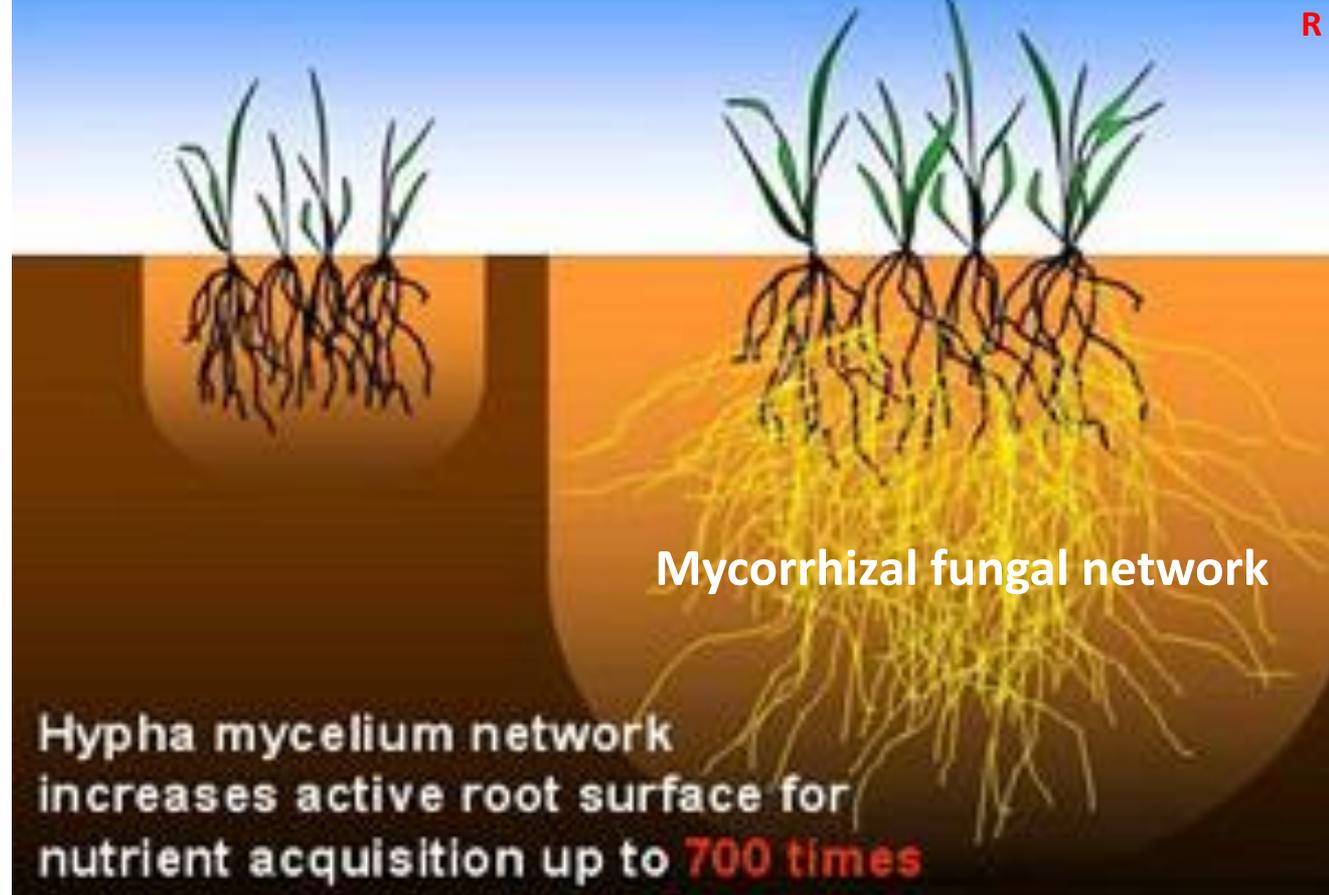
The panel above depicts the root systems of two identical plants.

The one on the left is planted in dirt.

The one on the right is planted in soil with a healthy food web giving rise to a mycorrhizal fungal network.

The network greatly extends the root area for extracting nutrients & water

Mycorrhizal Fungal Network



Through the work of researchers like Professor Suzanne Simard of the University of British Columbia, we now know that fungal networks can link plants together in a **Wood Wide Web** allowing them to exchange signals as well as nutrients.

Current Agricultural Practices

- Plowing or tillage
- Growing of monocultures in the belief that diversity means competition.
- Application of chemical fertilizers, herbicides and pesticides



- Livestock in confinement (from poultry battery cages to feed lots)



Public Domain
<http://www.epa.gov/region7/water/cafo/images/hogssm2.jpg>



Credit: SlimVirgin U.S. EPA, Public Domain
<https://commons.wikimedia.org/wiki/File:Confined-animal-feeding-operation.jpg>

Plowing slices and dices the soil structure built by bacteria and fungi with their biotic glues - turning living soil into dirt.



Credit: Aalang (CC BY-SA 3.0)

https://commons.wikimedia.org/wiki/File:Plowing_ecomat.jpg

Credit: Trish Steel, (CC BY-SA 3.0)



https://commons.wikimedia.org/wiki/File:Feeding_Frenzy,_Faulston_Farm_-_geograph.org.uk_-_702677.jpg



Credit: Aalang (CC BY-SA 3.0)

https://commons.wikimedia.org/wiki/File:Plowing_ecomat.jpg

Credit: Trish Steel, (CC BY-SA 3.0)



Those underground cities were home to a diverse ecosystem capable of providing all the nutrients plants required without the need for chemical fertilizers.

https://commons.wikimedia.org/wiki/File:Feeding_Frenzy,_Faulston_Farm_-_geograph.org.uk_-_702677.jpg

About 20 years ago it was discovered that plowing releases additional soil carbon into the atmosphere as climate warming CO₂



Credit: Aalang (CC BY-SA 3.0)

https://commons.wikimedia.org/wiki/File:Plowing_ecomat.jpg



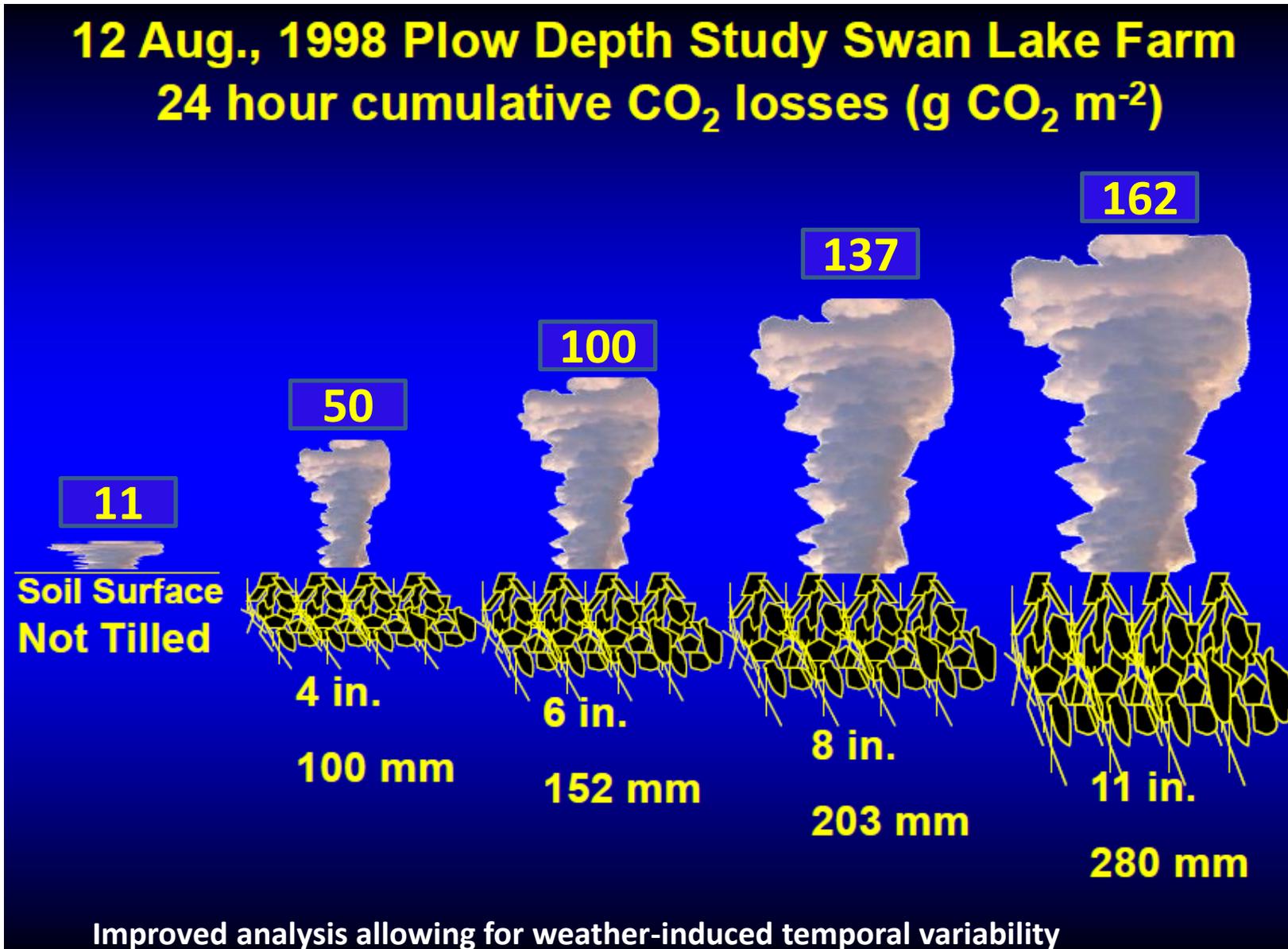
Credit: Trish Steel, (CC BY-SA 3.0)

https://commons.wikimedia.org/wiki/File:Feeding_Frenzy,_Faulston_Farm_-_geograph.org.uk_-_702677.jpg

Effect of tilling on CO₂ emission

Dr. Don Reicosky , USDA
Agricultural Research Services

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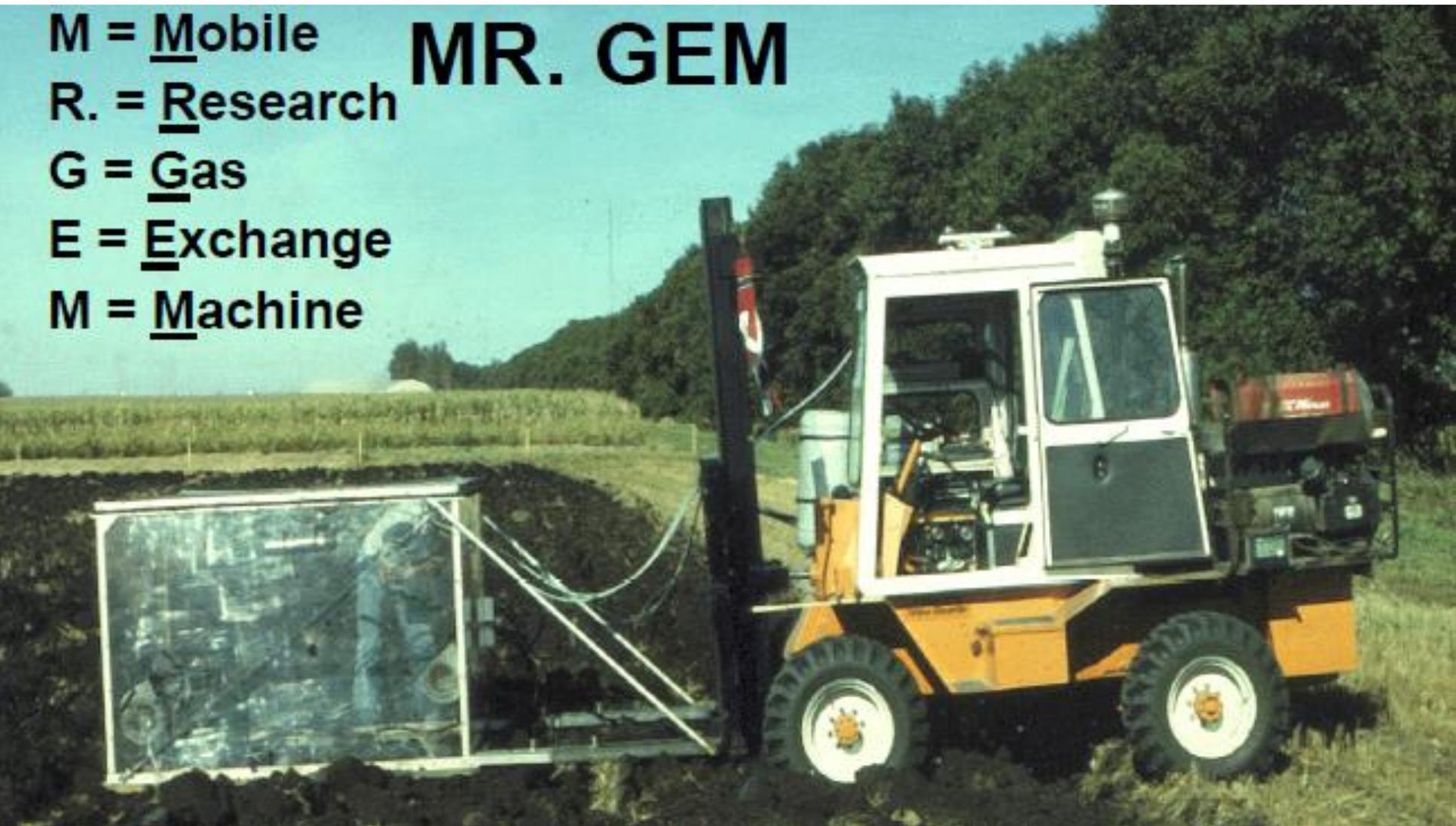
D.C. Reicosky and D. W. Archer, Soil and Tillage Research, Vol. 94, Issue 1, pp. 109–121, 2007

Tillage and planting: impact on carbon and soil quality

Dr. Don Reicosky USDA-ARS

M = Mobile
R. = Research
G = Gas
E = Exchange
M = Machine

MR. GEM



<http://www.fairfieldswcd.org/Attachments/Soil%20Quality.pdf>

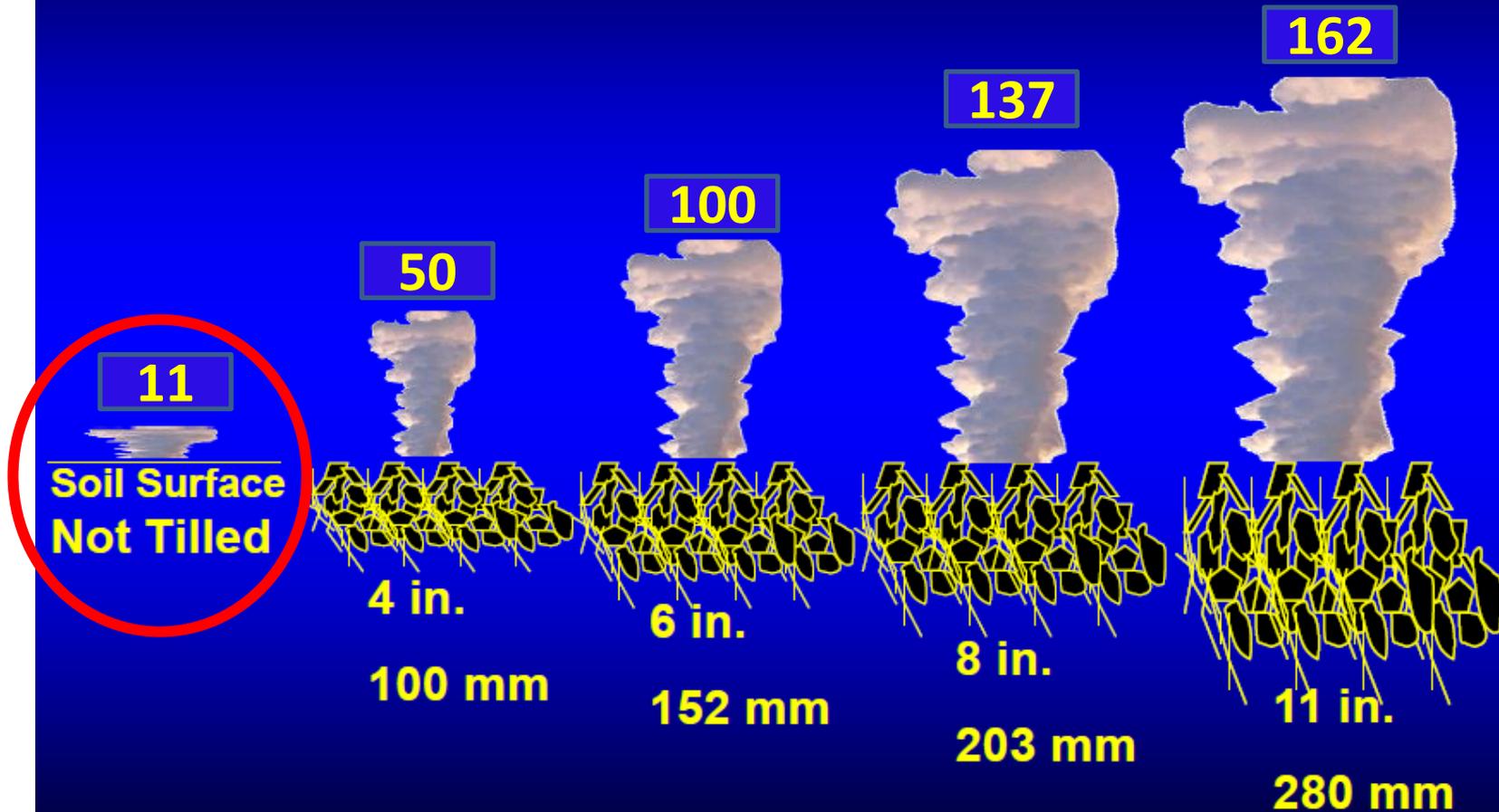
1 min soil videos

Effect of tilling on CO₂ emission

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**12 Aug., 1998 Plow Depth Study Swan Lake Farm
24 hour cumulative CO₂ losses (g CO₂ m⁻²)**

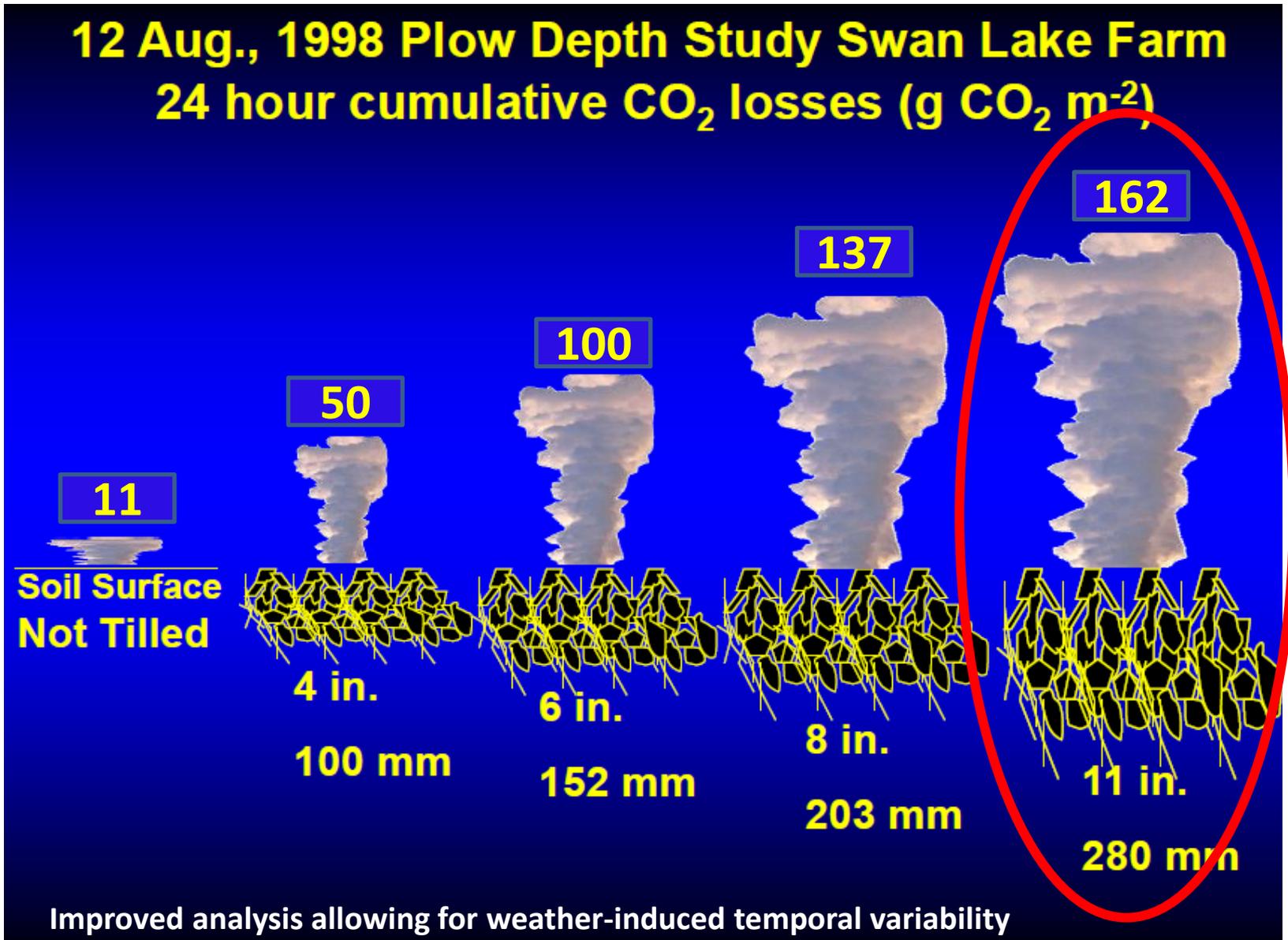


Improved analysis allowing for weather-induced temporal variability

Effect of tilling on CO₂ emission

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D.C. Reicosky and D. W. Archer, Soil and Tillage Research, Vol. 94, Issue 1, pp. 109–121, 2007

Soil health lessons in a minute

by Ray Archuleta, USDA

Water infiltration test: shows how healthy soil can infiltrate and capture much more of the rainfall and store it in the soil. This alleviates drought and prevents soil erosion

Permission granted by USDA Natural Resources Conservation Service

https://www.youtube.com/watch?v=Rpl09XP_f-w

Laptop link

Each soil sample used in the demonstration was air dried

Soil health lessons in a minute

by Ray Archuleta, USDA

Soil stability test: comparison of healthy soil with lots of microbes creating biotic glues and fungal strands that hold the soil together, to soil that has been turned to dirt by repeated plowing.

Permission granted by USDA Natural Resources Conservation Service

https://www.youtube.com/watch?v=9_ItEhCrLoQ

Laptop link

Each soil sample used in the demonstration was air dried

Soil Erosion

Without the biotic glues and living plant roots, soil is easily washed away by rain or blown away during periods of drought, creating massive dust storms.

Dust storm approaching Stratford, Texas 1935.

R



Back in the 1930's we had no idea how plowing upset the work of soil biology

Credit: NOAA George E. Marsh Album (Public Domain)

<https://commons.wikimedia.org/w/index.php?title=Special%3ASearch&profile=default&search=2015+dust+storm+Colorado&fulltext=Search&uselang=en>

Dust storm Phoenix 5 July 2011

R



Credit: Roxy Lopez (CC BY – SA 3.0)

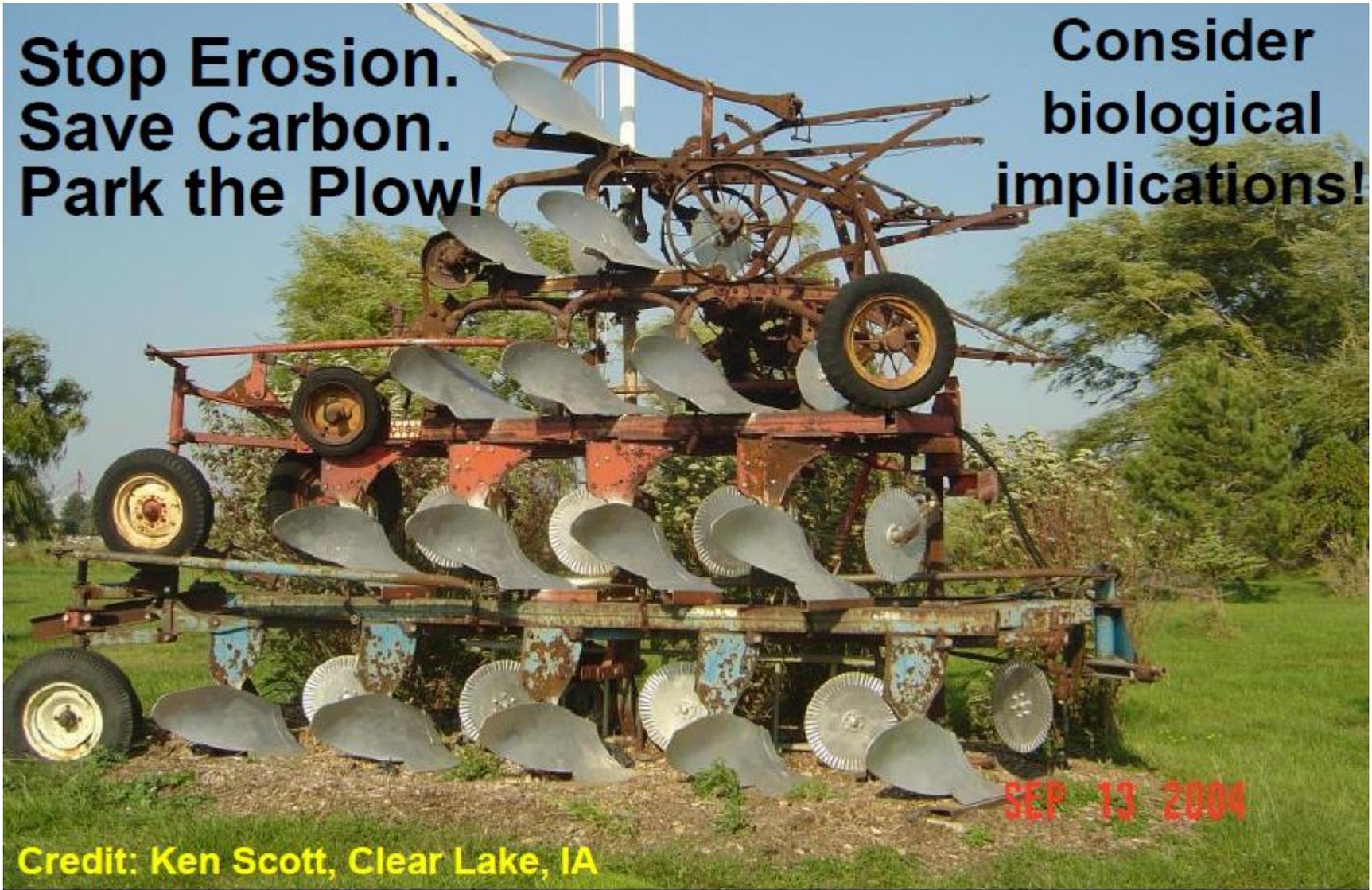
<https://commons.wikimedia.org/wiki/File:Duststorm.jpg>

Retire the plow

Time to Retire the Plow

**Stop Erosion.
Save Carbon.
Park the Plow!**

**Consider
biological
implications!**



Credit: Ken Scott, Clear Lake, IA

SEP 13 2004

**Much of current agricultural is about killing:
weeds, fungi, insects, biodiversity, and even the farmer's profit**

https://www.youtube.com/watch?v=_t3zlg00ZvU



In Nature, there are 1700 beneficial or indifferent insect species, for ever 1 pest species. We're focused on killing that one pest but meanwhile we're killing everything else.

According to Entomologist, Dr. Jonathan Lundgren, the cause is our current monoculture model of production.

**We try to keep monoculture production
and the factory-farming of livestock viable
through chemistry, drugs, machinery,
genetic engineering and
ultimately cash subsidy.
(Allan Savory, Holistic Management)**



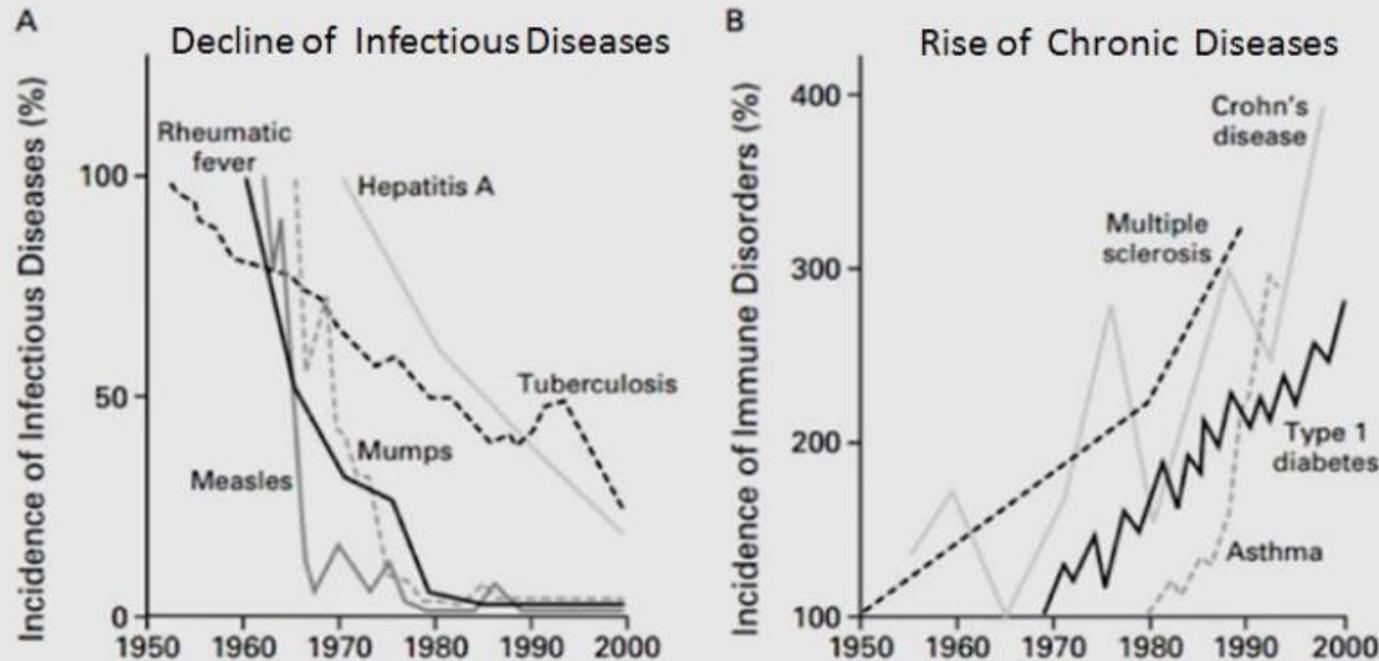
Current agricultural model uses 10 calories of fossil fuel energy to produce one calorie of food.

<https://blogs.scientificamerican.com/plugged-in/10-calories-in-1-calorie-out-the-energy-we-spend-on-food/>

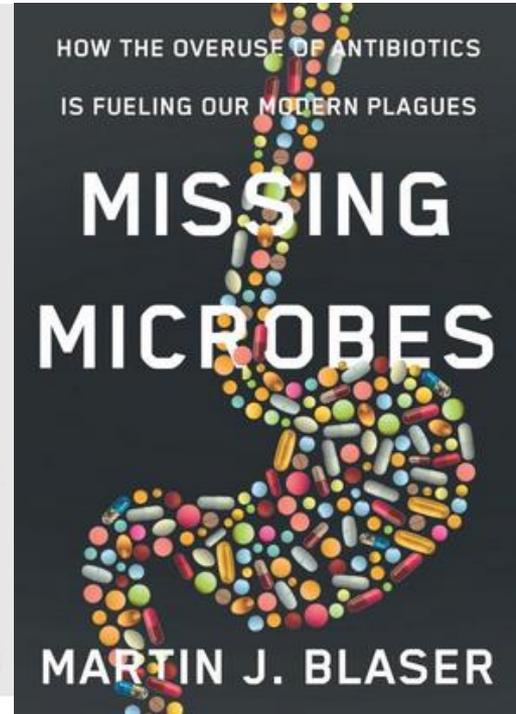
**For too long we have relied on technology to carry out
chemical warfare against microbes, weeds, insects,
and nature,
only to discover we are killing ourselves.**

The Largest Use of Antibiotics Occurs in Agriculture

Glyphosate, the active ingredient in herbicides like Roundup™, is a broad spectrum antibiotic. 39 times more Glyphosate is used than all the antibiotics in medicine (US).



J. F. Bach (2002) N Engl J Med, Vol 347, 911



Dr. Zach Bush <https://www.youtube.com/watch?v=HL6OPzQe9Is>

<http://winewaterwatch.org/2018/01/glyphosate-5-billions-pounds-of-this-poison-sprayed-last-year/>

Dr. Rob Knight <https://www.youtube.com/watch?v=2iKHMMyWzclM>

The Human Microbiome

Back in 2000 we didn't know about our gut microbiome

We didn't know that our health is dependent on 3 pounds of microbes living in our gut

That these microbes outnumber the cells in our body by 10 times

We depend on these microbes

- **to help digest our food**
- **produce certain vitamins**
- **make neurotransmitters for our brain**
- **regulate our immune system**

Now we know!

but are our antibiotics destroying them?

Top 9 First World Epidemics

(Jan. 2019 Dr. Zach Bush)

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Data for the US

<https://www.youtube.com/watch?v=HL6OPzQe9Is>

Autism 1:36 (in 1975 one in 5000 children with autism, by 2010 one in 100)
by 2035 expect to hit 1:3 children with autism

Asthma 1:10

Attention deficit 1:8

Allergy 1:4

Diabetes 1:4

Obesity 1:3

Major depression 1:2

Cancer 1:2 (expect this to reach 70% by 2035, does not include skin cancers)

Infertility 1:4 females infertile 1:3 men infertile

In 1965, 4% of the US population had a chronic disease

Today, 46% of the children have chronic disease

We clearly have to change the way we do agriculture.

If we use our new knowledge of soil biology we can farm in ways that don't require all these chemicals that are killing us.

Alternative Agricultural Model

Nature's way (biomimicry)

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-Natural soil is full of living microbes

They provide all the nutrients plants need, protect against disease, and increase soil carbon. Adding fertilizers upsets this ecology.

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They provide all the nutrients plants need, protect against disease, and increase soil carbon. Adding fertilizers upsets this ecology.

-Nature has plants covering the ground year round

-Nature's way is sustainable and more profitable for the farmer

Move to **regenerative agriculture where we
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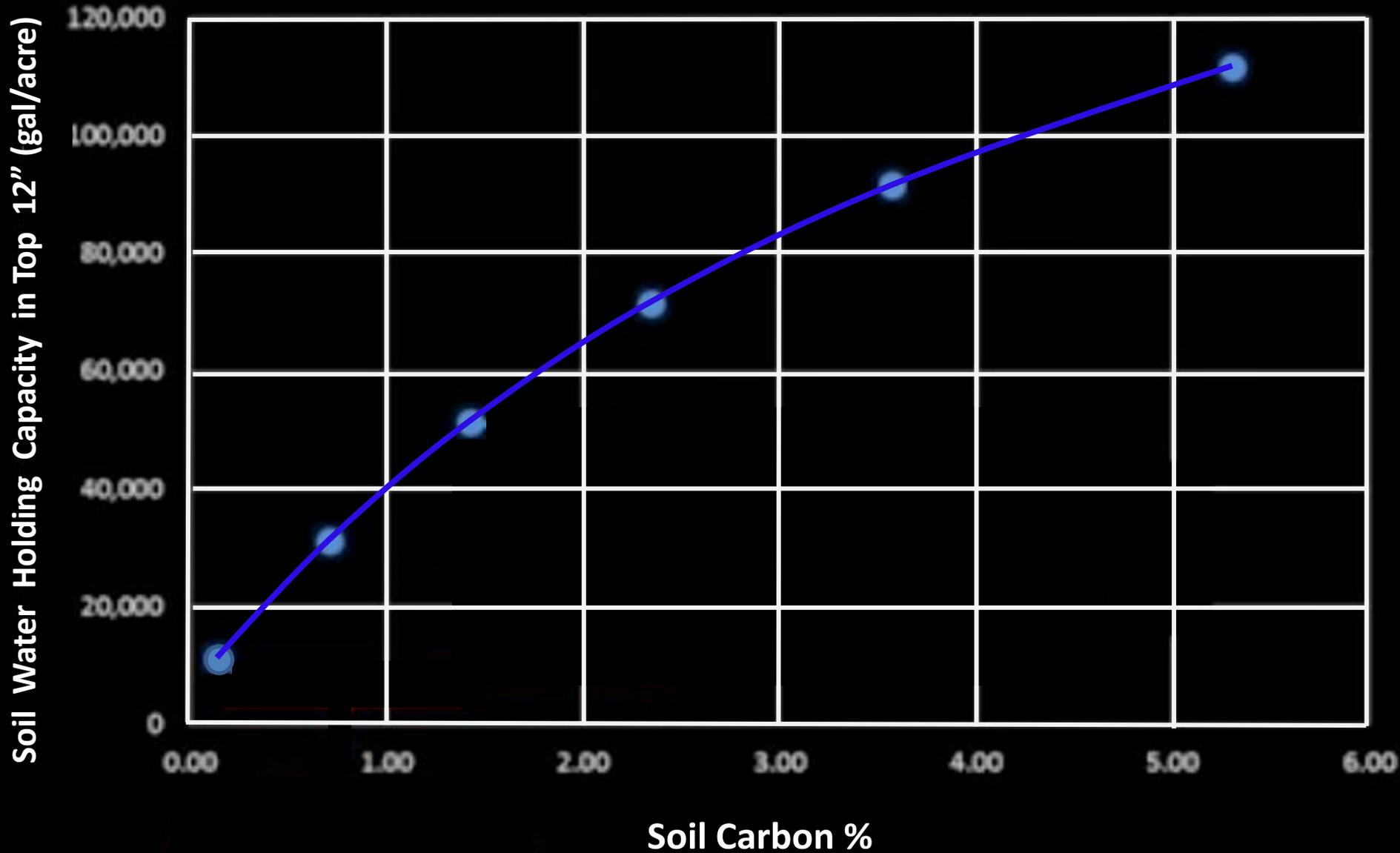
Since most agricultural soils have been degraded this is not a situation we want to sustain – so we need to move beyond sustainability to regenerative agriculture.

Some useful examples:

- Gabe Brown's story: a farmer ahead of his time
<https://www.youtube.com/watch?v=GxlyKfWf9kU>
- Gabe Brown's Book 'Dirt to Soil'
- Jeff Moyer, Rodale Institute 2014 , 'Terminating Cover Crops for Maximum Benefits'
<https://www.youtube.com/watch?v=FBt1OH6yIP4>

Soil water holding capacity depends on soil carbon

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How to rebuild the soil biology?

- By inoculating the dirt with a thin layer of compost or by spraying with a compost extract or compost tea made from the compost.

It is important to ensure the compost is teeming with a good selection of soil microbes using a soil microscope.



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- Ensure a good cover of plants providing root exudates to feed the microbes.
- Stop plowing and stop using synthetic fertilizers, herbicides and pesticides.

What about livestock grazing?

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According to the UN Food and Agriculture Organization 62% of agricultural land is used for grazing.



The areas in brown are dryland regions that are the current and former grasslands of the world which are turning or have turned to desert.

video

Desertification

Conventional wisdom has it that one of the main causes of desertification is overgrazing by herbivores like cattle, sheep and goats. This is especially true in drought prone regions.

Desertification

According to the African biologist Allan Savory, we were once just as certain that the earth was flat.

**He has shown, it is not about the number of animals,
it is all about timing.**

Desertification

It's our failure to manage plant recovery time that leads to overgrazing and land desertification.

Continuous grazing is a common practice in which livestock have unrestricted access throughout the grazing season.



Cattle grazing on farm, Gruyere, Victoria by Nick Pitsas, CSIRO (CC BY 3.0)

https://upload.wikimedia.org/wikipedia/commons/b/b7/CSIRO_ScienceImage_6866_Cattle_grazing_on_farm.jpg

Aerial view of a herd of wildebeest^R



Credit: by T. R. Shanker Raman (CC BY 3.0) http://commons.wikimedia.org/wiki/File:Wbeest_Mara.jpg



**Wilbeests only safe
inside the herd.**

Credit: Kevin Pluck (CC BY 2.0)
[https://commons.wikimedia.org/wiki/
File:Lion_waiting_in_Namibia.jpg](https://commons.wikimedia.org/wiki/File:Lion_waiting_in_Namibia.jpg)



Credit: by Guido Appenzeller (CC BY 2.0)
https://commons.wikimedia.org/wiki/File:Spotted_hyena_gnawing_gnu.jpg

Wilbeest close up

Herd has to keep moving to avoid eating their own waste so don't get to eat grass as it regrows

By the time herd returns from their migration the grass is fully grown and ready to be eaten.

So timing is the key!

How can humans imitate nature?

One method: use electric fence to emulate the predators



Regenerative or Holistic Grazing

Saskatchewan rancher Neil Dennis spends about 20 minutes each day setting up the electric fence for the next paddock.



Soil carbon measurements in 2011 and 2014 showed an increase of 25.4 tonnes C per hectare for a carbon sequestration rate of 8.5 t C/ha/year

**Alternative method using herders provides employment
where work is scarce**

**Savory experienced a 400% increase in the number of cattle
the land would support under Holistic Planned Grazing**



Credit: Savory Institute

Managing for plant recovery time can increase plant biomass by a factor of 3 - 4 leading to :

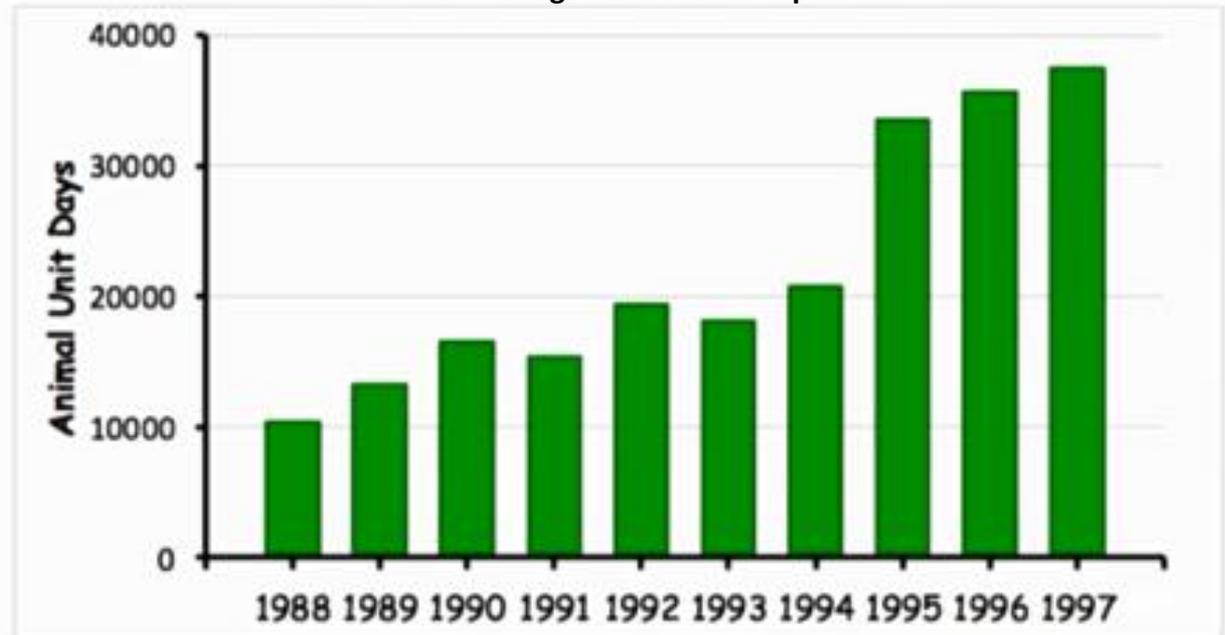
- increase in meat production and farm profitability
- reduced need to clear forests to grow grains for feedlots

Regenerative Grazing

Noble Foundation, Coffey Ranch, Oklahoma

Charles Griffith, Hugh Aljoe, Russell Stevens

D. Joyce Coffey Resource Management and Demonstration Ranch –
Ten Years of Management and Its Impact



An **Animal Unit Day (AUD)** is the amount of forage required by one AU for one day.

An **Animal Unit (AU)** is generally one mature cow of approximately 1,000 pounds and a calf as old as six months, or their equivalent.

Savory Global Training Hubs



<https://www.savory.global/our-network/>
<https://www.savory.global/regional-hub/>

Wait a minute - aren't we supposed to eat less meat?

Methane green house gas (GHG) emissions from ruminants

Wait a minute - aren't we supposed to eat less meat?

Methane green house gas (GHG) emissions from ruminants

But we have been ignoring a whole other side to this story.

When herbivores are adaptively grazed to emulate nature there is a net reduction in GHG. The GHG emission of methane is more than compensated for by the amount of atmospheric carbon sequestered in the soil.

Some of the recent science.

P. L. Stanley & Jason E. Rowntree et al., *Agricultural Systems* 162, p.249, 2018

W. R. Teague et al., *Journal of Soil and Water Conservation*, 71, #2, p. 156, 2016

Tong Wang et al., *Sustainability* **2015**, 7(10), 13500-13521

<https://www.youtube.com/watch?v=crG4L4J-OEg>

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But we have been ignoring a whole other side to this story.

When herbivores are adaptively grazed to emulate nature there is a net reduction in GHG. The GHG emission of methane is more than compensated for by the amount of atmospheric carbon sequestered in the soil.

Some of the recent science.

P. L. Stanley & Jason E. Rowntree et al., *Agricultural Systems* 162, p.249, 2018

W. R. Teague et al., *Journal of Soil and Water Conservation*, 71, #2, p. 156, 2016

Tong Wang et al., *Sustainability* 2015, 7(10), 13500-13521

Grass fed cattle, sheep and goats can be a big part of the solution if we manage plant recovery time (regenerative grazing).

See the TED talk by Allan Savory at

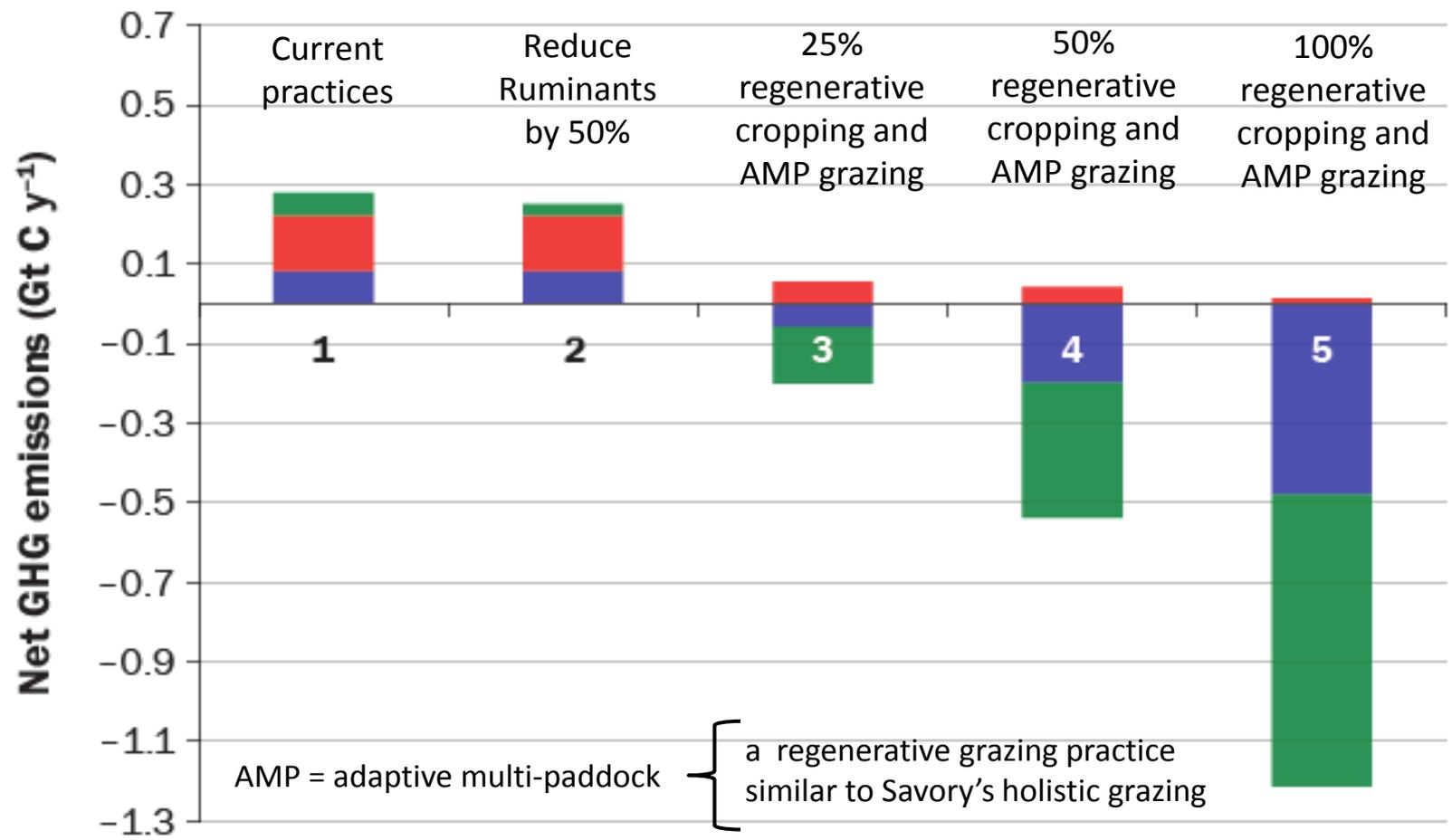
https://www.ted.com/talks/allan_savory_how_to_green_the_world_s_deserts_and_reverse_climate_change?language=en

https://www.youtube.com/watch?v=BOJdz_LgDBE&feature=youtu.be

What is the evidence that regenerative agriculture leads to carbon sequestration?

Best working hypothesis for North American net agricultural greenhouse gas (GHG) emissions for a transition to regenerative cropping and regenerative grazing practices

Based on: W.R. Teague + 11 authors, Journal of Soil and Water Conservation, 71, #2, p. 156, 2016
 See also Quivira Conference presentation <https://www.youtube.com/watch?v=crG4L4J-OEg>

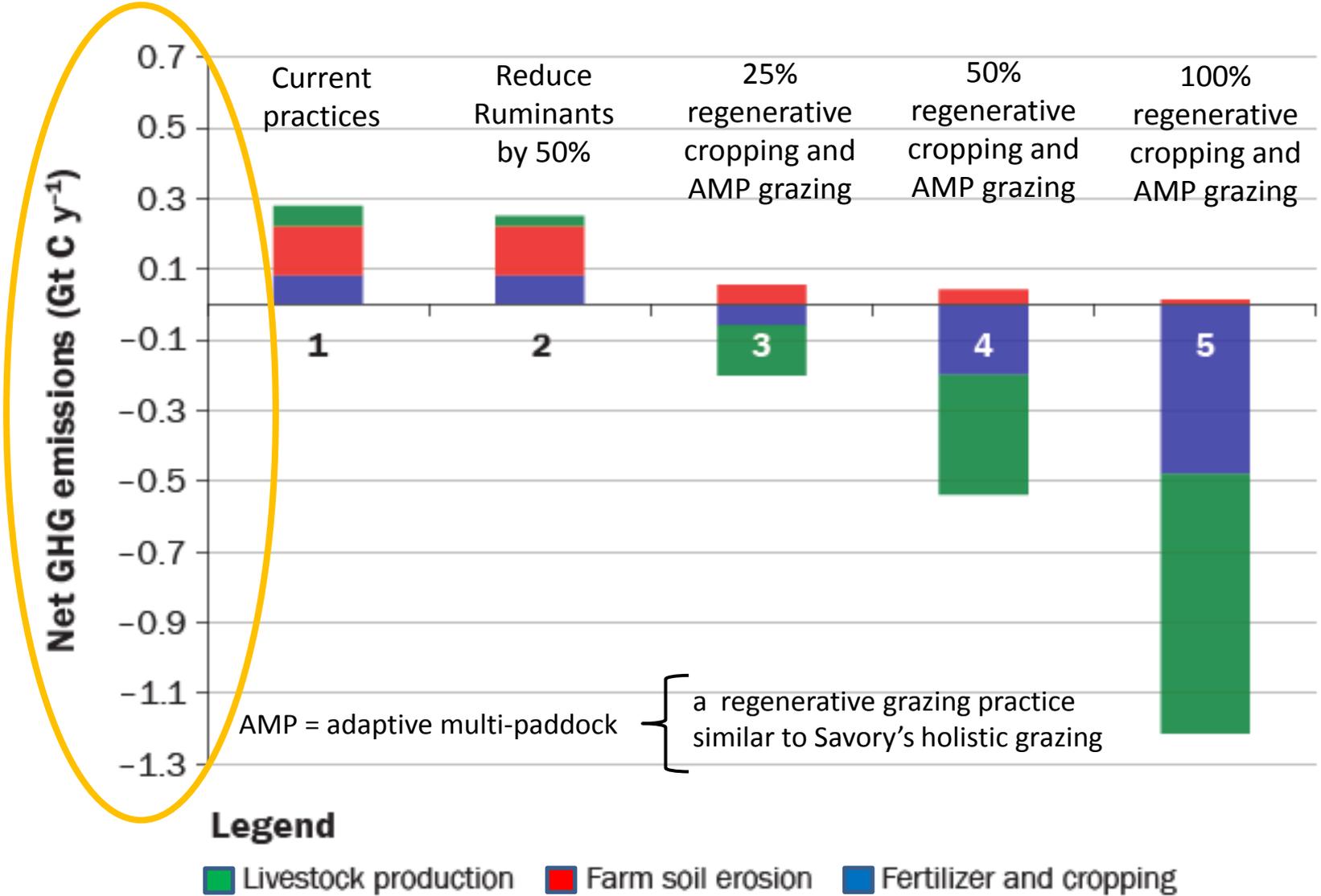


Legend

- Livestock production
- Farm soil erosion
- Fertilizer and cropping

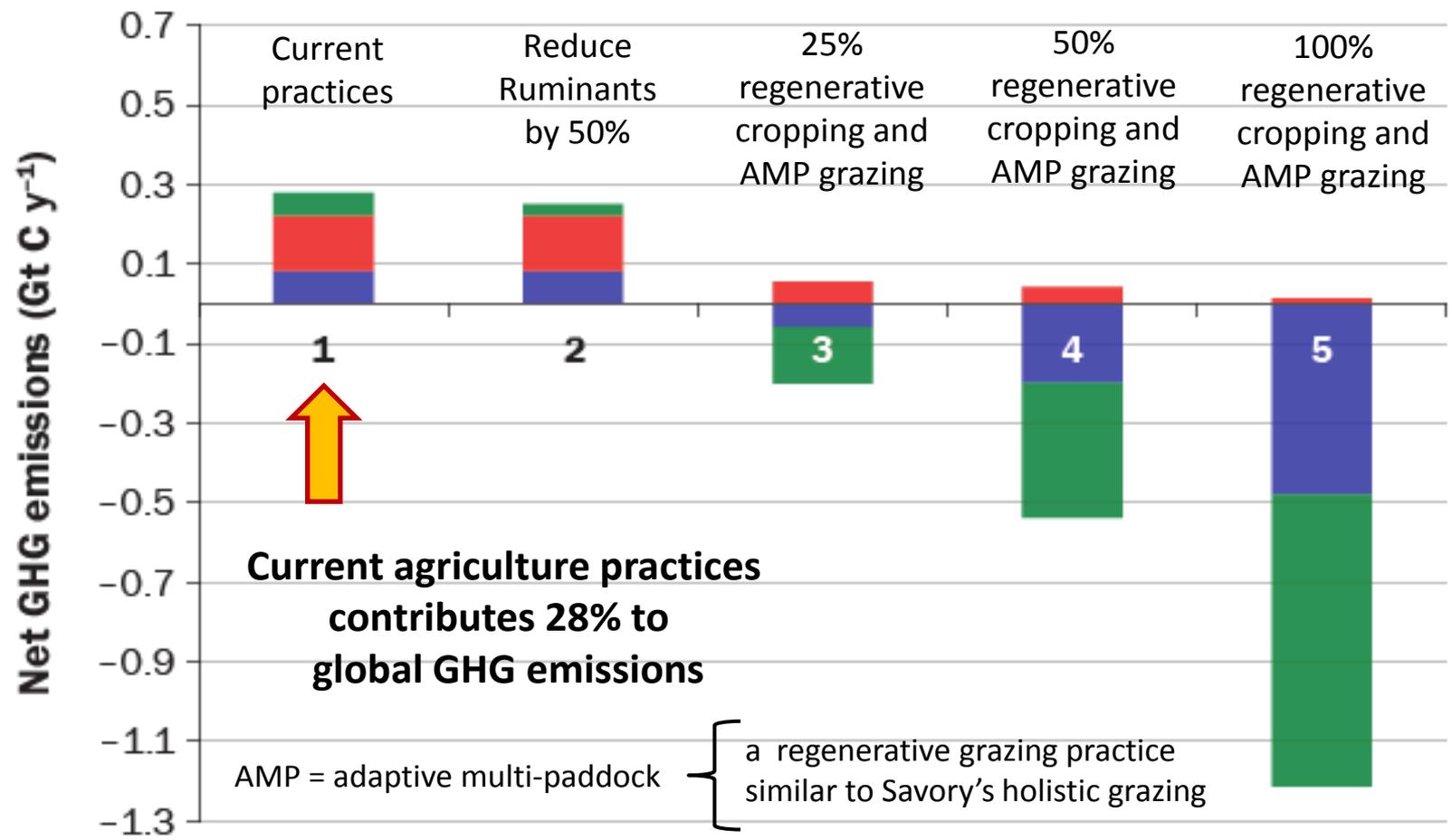
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Current agriculture practices contributes 28% to global GHG emissions

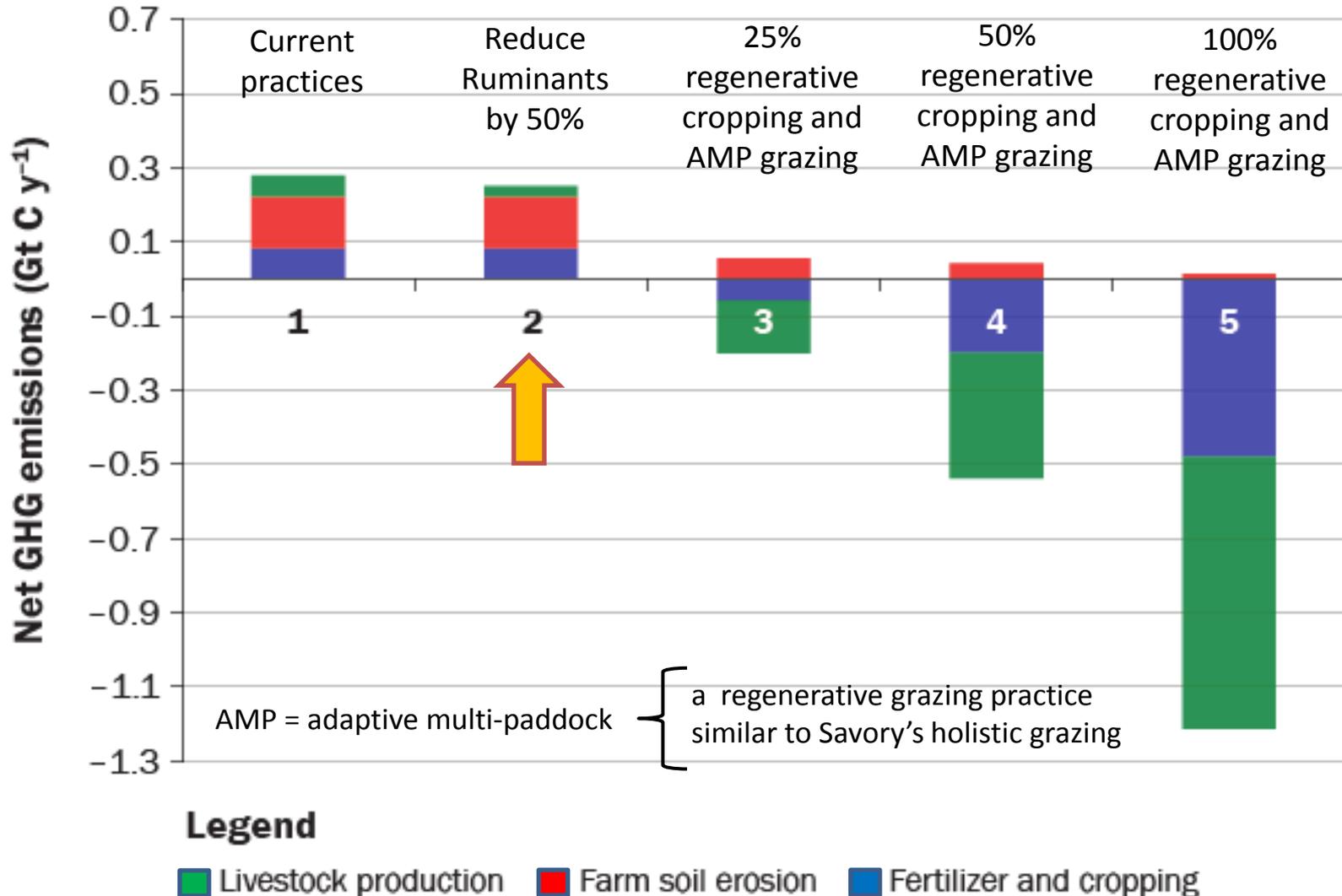
AMP = adaptive multi-paddock { a regenerative grazing practice similar to Savory's holistic grazing

Legend

- Livestock production
- Farm soil erosion
- Fertilizer and cropping

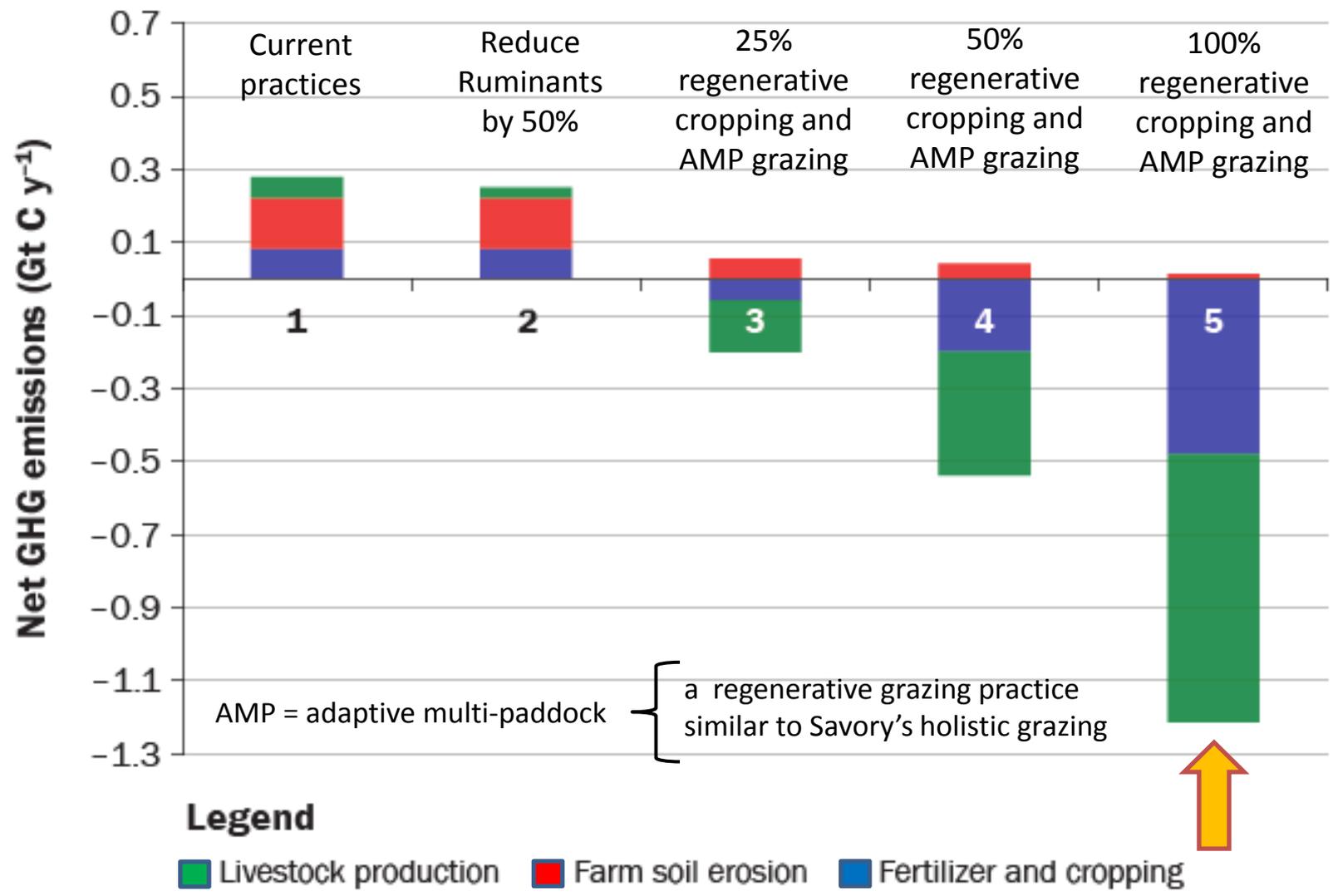
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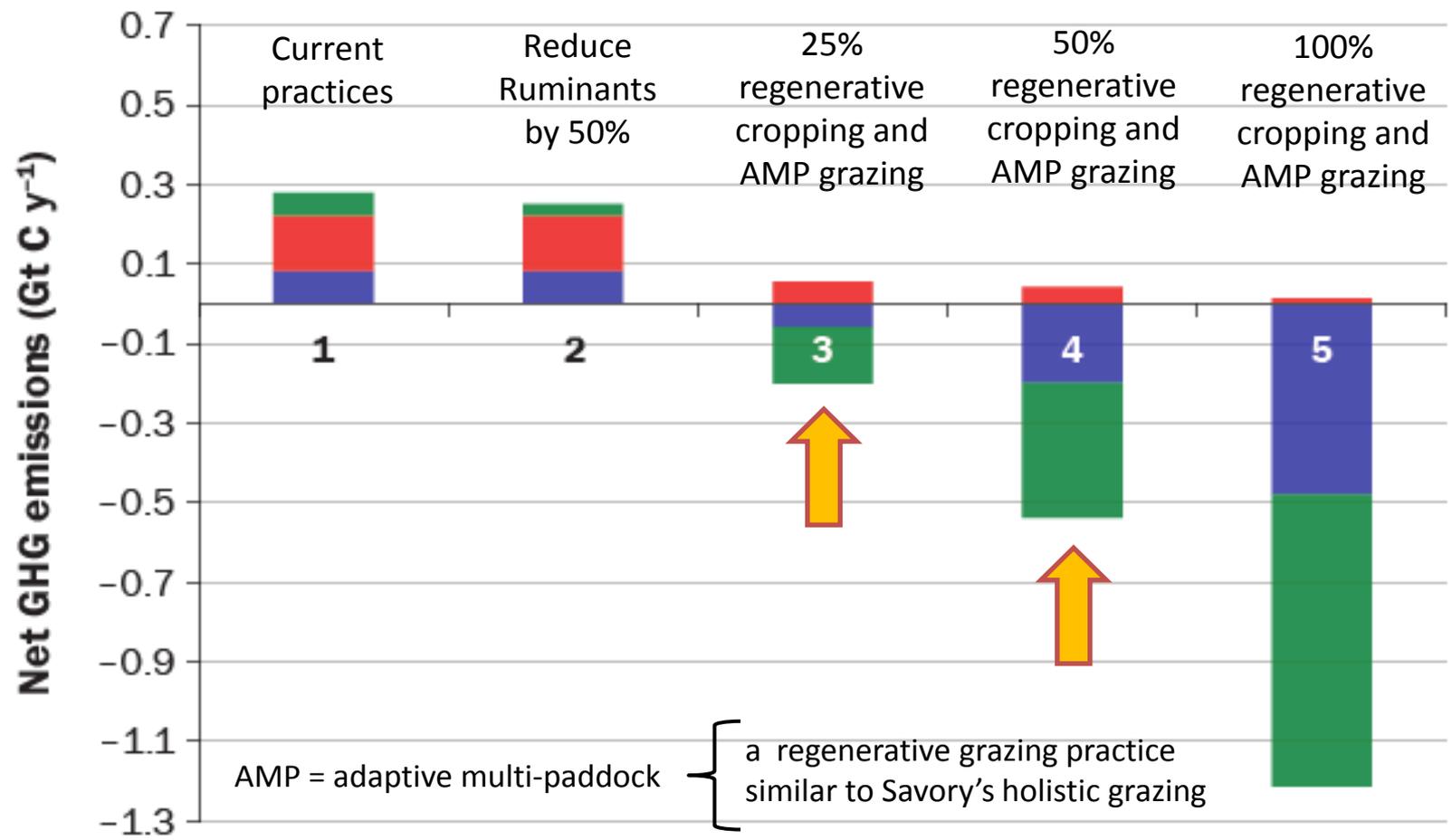
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Legend

- Livestock production
- Farm soil erosion
- Fertilizer and cropping

IT'S NOT THE COW



IT'S THE HOW



Potential for Improved Data

Over the next 4 years we may also acquire a lot more data as the French Government has embarked on a regenerative agriculture program aimed at sequestering large amounts of atmospheric carbon with improved soil monitoring.

French Government's '4 per 1,000' Initiative proposed at the Paris Climate meeting COP 21

France is committed to ensuring that at least 50% of its agricultural holdings will have adopted this approach by 2020.

4 PER 1000

CARBON SEQUESTRATION IN SOILS FOR FOOD SECURITY AND THE CLIMATE

Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt 

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

+4.3 bn tons carbon / year

↑↑
CO₂ emissions



Forests ⊖⊖

Oceans ⊖⊖

Human activities ⊕⊕⊕⊕

Deforestation ⊕

⊖ absorption ⊕ emission

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

absorption of CO₂ by plants



storage of organic carbon in soils

1500 bn tons carbon

If we increase by **4‰** (0.4%) a year the quantity of carbon contained in soils, **we can halt the annual increase in CO₂ in the atmosphere**, which is a major contributor to the greenhouse effect and climate change

increased absorption of CO₂ by plants :



farmlands, meadows, forests...



+4‰ carbon storage in the world's soils

= more fertile soils
= soils better able to cope with the effects of climate change

Countries participating in the French “4 pour 1000” initiative (as of Nov. 2016)

Australia	Mexico
Austria	Morocco
Bulgaria	Netherlands
Costa-Rica	New Zealand
Croatia	Philippines
Denmark	Poland
Estonia	Portugal
Ethiopia	Slovenia
Finland	Spain
France	Sweden
Germany	Tunisia
Hungary	Ukraine
Iran	United Kingdom
Ireland	Uruguay
Japan	Andalusia
Latvia	Wallonie Region
Lithuania	

**Hopefully more countries
will join this important
initiative**

Video on the connections between Soil Carbon, Climate Change, and Food Security

“The Soil Story”

was produced by Kiss the Ground and is narrated by the Carbon Underground President Larry Kopald.

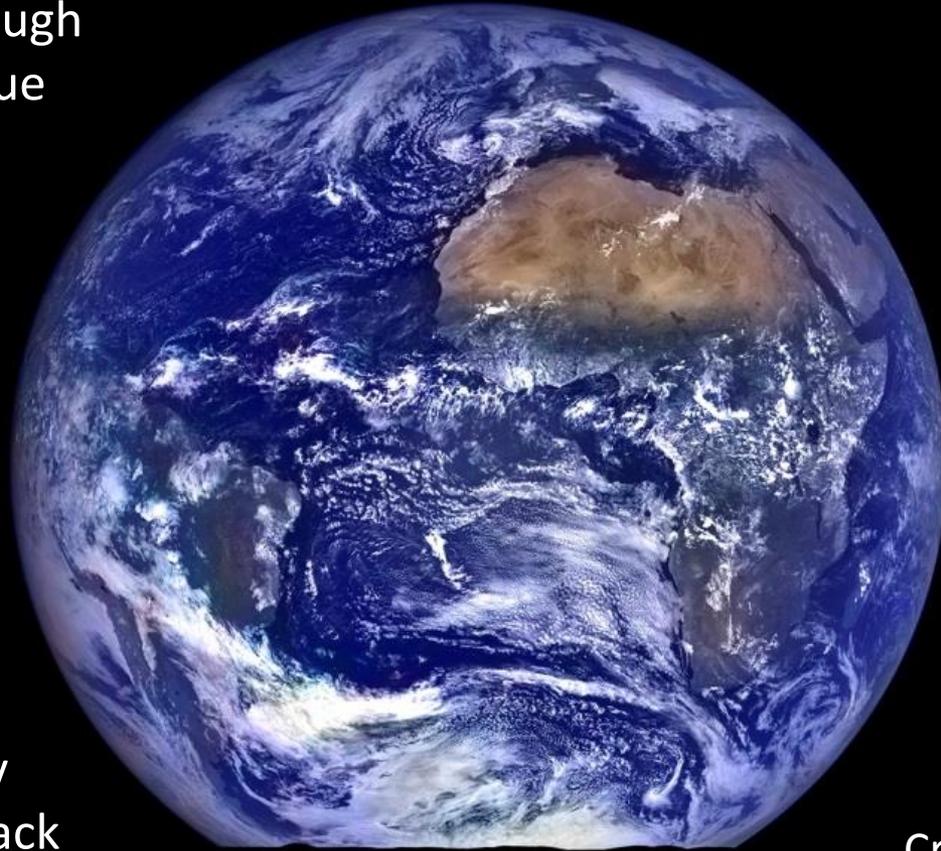
It is open source and free to use for educational purposes.

<https://thecarbonunderground.org/the-carbon-underground-president-larry-kopald-narrates-the-soil-story/>

Laptop link



Drifting together through space on our small blue lifeboat called Earth, guided by our new understanding of soil biology and nature's complexity, we urgently need to pull together to survive and prosper. So lets get started rebuilding soil biology and putting carbon back in the soil.



Credit NASA
Earthrise seen from the moon

A 39 minute YouTube version of my presentation is available at

<https://www.youtube.com/watch?v=AWILIYSf5ts>

Phil Gregory's website with other recent presentations

<https://www.phas.ubc.ca/~gregory/gregory.html>

**Supplementary material for soil talk by Dr. Phil Gregory,
Physics and Astronomy Dept., University of British Columbia**

R

How are seeds planted in no-till farming

<https://www.youtube.com/watch?v=V5uK-1dclRY>

Gabe Brown's story: a farmer ahead of his time **Gabe's 2018 book "Dirt to Soil"**

<https://www.youtube.com/watch?v=GxlyKfWf9kU>

Singing Frogs Farm <https://www.youtube.com/watch?v=zAn5YxL1PbM>

Call of the Reed Warbler by Charles Massey 2017

Kiss the Ground by Josh Tickell 2017

The Hidden Half of Nature: The Microbial roots of Life and Death
by David R. Montgomery and Anne Bilké 2016

Carbon cowboys https://www.youtube.com/results?search_query=Carbon+cowboys

Soil Food Web (Dr. Elaine Ingham)

https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/soils/health/biology/?cid=nrcs142p2_053868

We need regenerative farming, not geoengineering

<https://www.theguardian.com/sustainable-business/2015/mar/09/we-need-regenerative-farming-not-geoengineering>

Oxford Real Farming Conference keynote talk by Dr. Elaine Ingham

<https://www.youtube.com/watch?v=x2H60ritjag>

Slides for this talk are online here

<https://drive.google.com/file/d/0B6tV3TorfmstbXIIUU5yMXB2MWM/view>

Supplementary material continued

R

French initiative 4 per 1000 to sequester C in the soil for food security and climate

<http://4p1000.org/understand>

<https://concilium.digital/wp-content/uploads/2016/11/Leaflet-4per1000-GB.pdf>

Scientific talk on 4p1000 program

<https://www.youtube.com/watch?v=sBeCHZNf2L4>

Dr. Elaine Ingham's Soil Foodweb Lectures (updated recordings in progress available in 2019)

<https://www.soilfoodweb.com/>

Introduction to gardening with nature by Dr. C. A. Rollins and Dr. Elaine Ingham

<http://www.soilfoodweb.com/Article.html>

Industrial Farming Threatens Food Security in the US, Dr. Mercola, 10 Jan 2017

http://articles.mercola.com/sites/articles/archive/2017/01/10/industrialization-versus-regenerative-agriculture.aspx?utm_source=dnl&utm_medium=email&utm_content=art1&utm_campaign=20170110Z1&et_cid=DM132724&et_rid=1836044384

What If the World's Soils Run Out?

<http://world.time.com/2012/12/14/what-if-the-worlds-soil-runs-out/>

Water in Plain Sight: Hope for a Thirsty World, by Judith D. Schwartz 2016

Dr. David Johnson 2018 EcoFarm Keynote <https://www.youtube.com/watch?v=dmj611RfBgs>

Dr. Johnson on rapid carbon sequestration https://www.youtube.com/watch?v=Fdh_j_KOMrY

Cover Crop Management in your Garden <http://cru.cahe.wsu.edu/CEPublications/FS119E/FS119E.pdf>

Terminating Cover Crops for Maximum Benefits - Jeff Moyer, Rodale Institute 2014

<https://www.youtube.com/watch?v=FBt1OH6yIP4>

TEDx Collingwood "Eating our way out of this Mess," Gillian Flies of The New Farm

<https://www.youtube.com/watch?v=O2bNVHbp3vM>

Supplementary material continued

R

My 39 minute YouTube version of “The Magic of Soil” presentation 2017

<https://www.youtube.com/watch?v=AWILIYSf5ts>

How to Green the deserts and Reverse Climate Change, Allan Savory TED talk

http://www.ted.com/talks/allan_savory_how_to_green_the_world_s_deserts_and_reverse_climate_change

The Savory Institute <http://savory.global/>

Eating Our Way To A Healthy Planet with Allan Savory, Allan Savory 5 Jun 2013

<https://www.youtube.com/watch?v=sNDCMUgNQtg>

Holistic Management: A Common Sense Revolution To Restore Our Environment

by Allan Savory with Jody Butterfield published by Island Press , 3rd Edition, 2016.

Co-creating with Nature – An Exploration of Holistic Management by Phil Gregory

<http://www.phas.ubc.ca/~gregory/papers/HolisticManagement%20BowenGregory10Jun2018Sum.pdf>

Dr. Christine Jones ‘Digging Deeper’ soil biology in Ag. (published Dec 17, 2017)

<https://www.youtube.com/watch?v=EKHchVlwNRg>

What Gets Me Up in the Morning, Joel Salatin TEDxUVA, 28 Feb. 2017

Pasture Cropping - Profitable Regenerative Agriculture, by Colin Seis, 18 Aug. 2013

Australian farmer in NSW. Fascinating account of the farm’s evolution from 1886 to date.

<https://www.youtube.com/watch?v=AAei0NBVBIM>

Treating the Farm as an Ecosystem with Gabe Brown Part 1

<https://www.youtube.com/watch?v=uUmldq0D6-A>

The following is a fictional story that I created for my granddaughter when she was 10 after I learned about regenerative agriculture. Please share it with any young person in your life. <https://www.youtube.com/watch?v=fQ4hm1N1mVw>

What can you do to help?

Gardeners and Farmers :

- Check out the supplementary material to learn more about regenerative agric. practices
 - Try it out on a portion of your garden or farm to start with
 - It takes time (several yrs.) to re-establish the soil microbial populations.
Soil is like a drug addict, have to wean it slowly off of synthetic fertilizers (Gabe Brown)
- Learn how to add the soil biology back with compost or compost extract
 - have your soil biology tested (better if you can learn how to do it yourself)
 - consult on a good source of soil with active biology

Urbanites :

- Help increase awareness of soil biology and its role in food security (share my video)
<https://www.youtube.com/watch?v=AWILIYSf5ts>
- If you have a personal connection with an organization that would appreciate my message please connect us
- **Use your purchase power to support organic agriculture and grass-fed meat production**
- Join a community supported agriculture (CSA) program = a "share" of the vegetables a local farm produces. During the growing season receive a weekly delivery of fresh food.
- Start a garden or volunteer at a community garden
- Become a supporter of the Savory Institute <https://www.savory.global/>
- Become more informed about how your food is produced and how strongly agricultural practices effect our health and future.

<https://articles.mercola.com/sites/articles/archive/2018/05/15/glyphosate-in-food.aspx>

<https://www.theguardian.com/business/2018/aug/10/monsanto-trial-cancer-dewayne-johnson-ruling>

<https://articles.mercola.com/sites/articles/archive/2017/01/10/industrialization-versus-regenerative-agriculture.aspx?>

Gabe Brown's 5 Tenets of Soil Health

- 1. Least amount of soil disturbance possible, preferably no-till.**
- 2. No bare soil.** The role of plants is to cover soil whether dead or alive. It's litter (or as Brown refers "armour") which insulates soil surfaces against weather, preventing drying out and erosion of sediment. Litter also stimulates soil fungi which pull litter into soil and stop movement. This provides a bed and breakfast for other organisms to enhance soil function, including earthworms
- 3. Diversity; nature never has monocultures.** Dr Ademir Caligari a Brazilian scientist and a leading expert on cover crops inspired Brown to go beyond 2-3 species companion plant mixes to sowing 15-25 simultaneously.
- 4. Keep a living root in the ground for as long as possible.** Brown extend his 100-day growing season in North Dakota by sowing species from all four groups - cool season grasses and broadleaves, warm season grasses and broadleaves. Living plants produce exudates to feed soil life which renew soil aggregates that normally break down after four weeks.
- 5. Livestock integration** Livestock grazing significantly increases the availability of major nutrients versus crop land where livestock are absent. The animal bite stimulates production of more root exudates (carbon secretions) to attract more microbes to provide the nutrients to heal the bite wound.

END