Emma Howcroft

Sustainable Procurement Pledge

Nature & Biodiversity

Why Procurement needs to care about fungi

Emma Howcroft

Fungi ambassador, amongst other things

Agenda

- Short intro to the Sustainable Procurement Pledge
- Fungi feature at COP 16
- What are fungi and why are they important
- How fungi can help us stay within our planetary boundaries
  - Fungi as a solution to our agricultural and food challenges
  - Fungi as a nature-based solution
  - Fungi as an alternative material
  - Fungi as a solution to pollution
- Recap on how fungi can help us stay within our planetary boundaries
- How to be fungi inclusive
- A few other good sources of information
- Q&A

Sustainable Procurement Pledge | Nature & Biodiversity

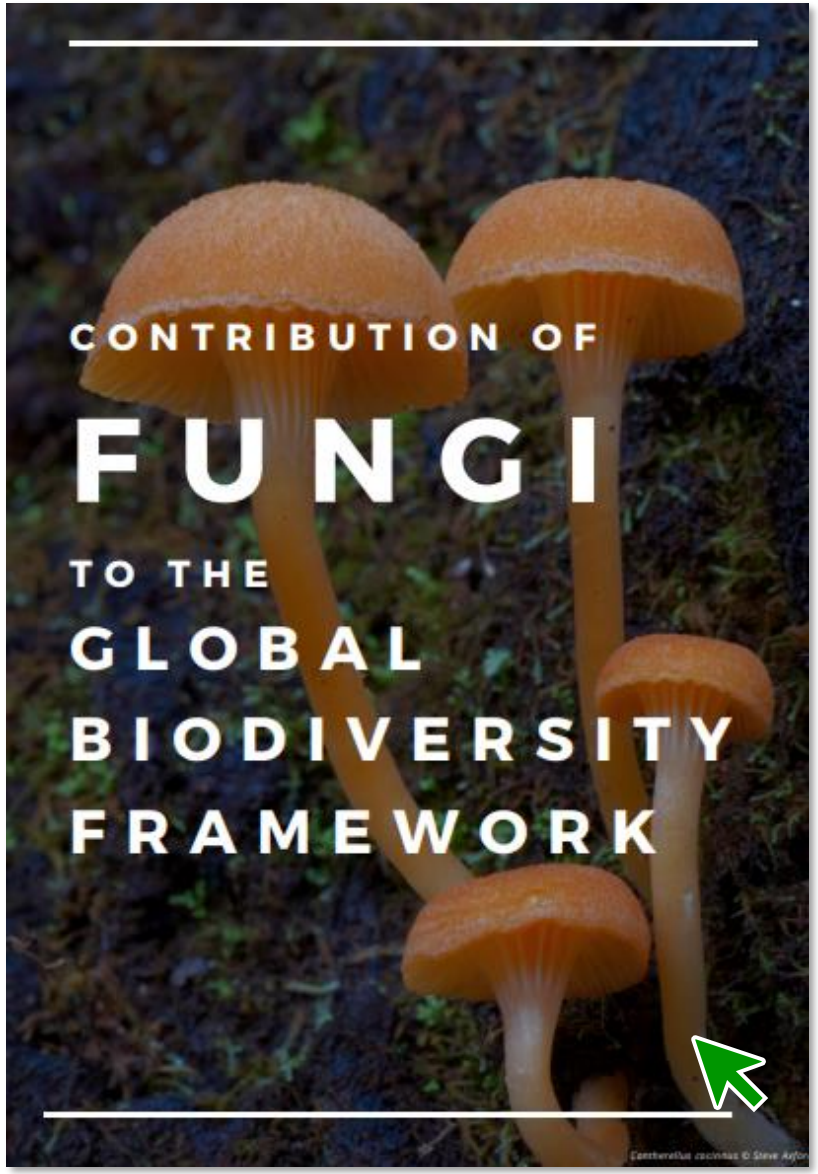
This webinar is brought to you by the SPP's Nature and Biodiversity chapter.

The Sustainable Procurement Pledge is an NGO with the mission to:

- ensure sustainable procurement becomes the default
- empower procurement professionals to drive sustainable change.

Our Nature and Biodiversity chapter aims to demystify nature and encourage procurement professionals globally to stand up for nature and take an active role in protecting and conserving it by buying better.

Fungi feature at COP 16



WHAT FUNGI AND WHY ARE THEY IMPORTANT

Emma Howcroft

Fungi are their own kingdom

- Fungi walls are made of chitin, same substance that forms insects and crustacea's exoskeletons
- Fungi store their food as glycogen, same as animals
- Fungi are heterotrophs, like animals, they gain their nutrients from other organisms
- Fungi's mycelium (their root structure) secret enzymes that dissolve their food so that it can be absorbed into their cells
- Fungi share electrical impulses through their mycelium, similar to the way our brain sends electrical impulses to coordinate behaviour, sensation, thoughts and emotions.

Caterpillar Fungus | Andrew Adamatzky

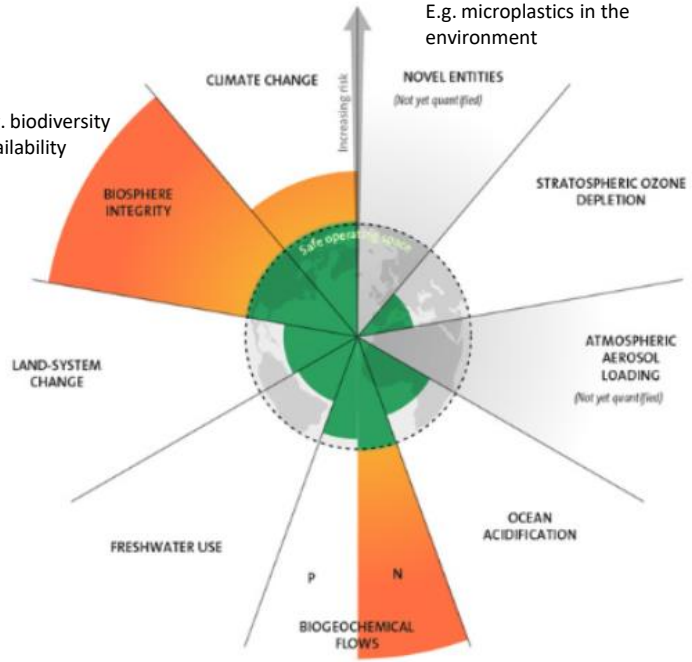
Types of fungi

- Saprotrophic: Recyclers
- Mycorrhizal: Symbiotes
- Endophytic: Hitch hikers
- Parasitic: Unwanted guests

HOW FUNGI CAN HELP US STAY WITHIN OUR PLANETARY BOUNDARIES

Our planetary boundaries are being exceeded

2009



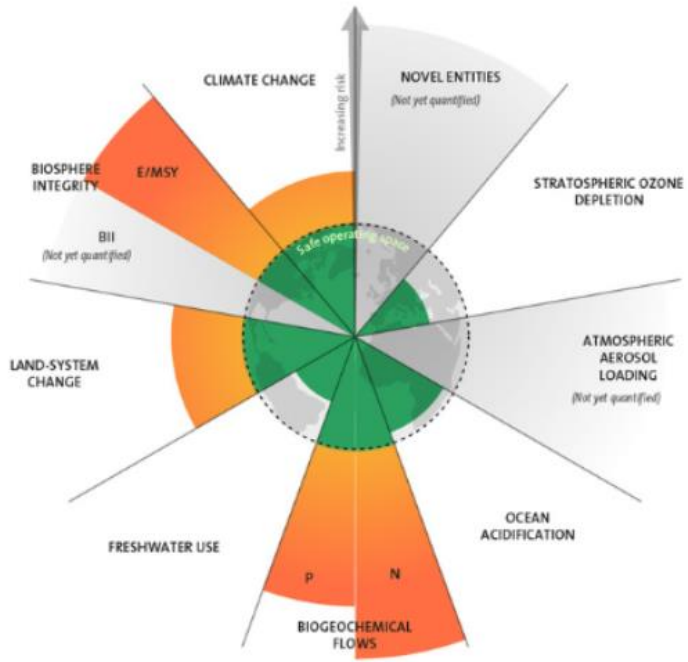
E.g. microplastics in the environment

E.g. biodiversity availability

E.g. the disruption of the natural nutrient cycles of key elements like nitrogen and phosphorus in the environment

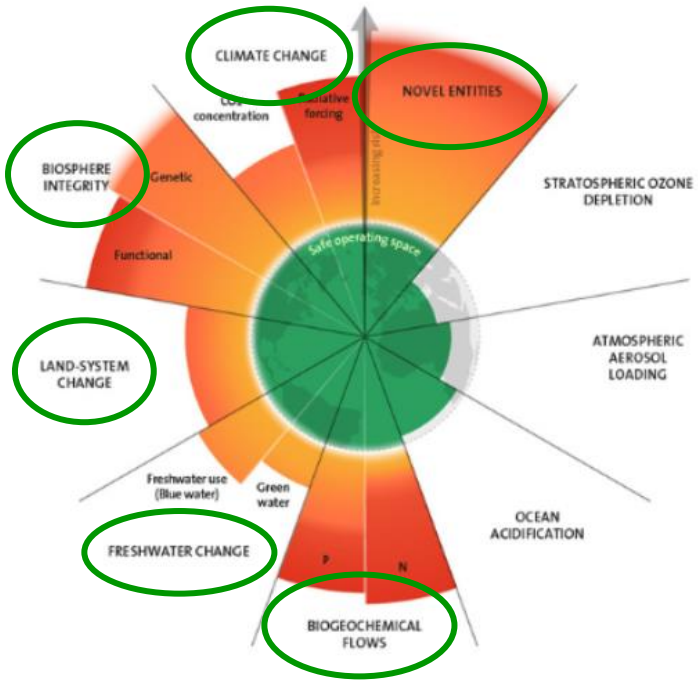
7 boundaries assessed,
3 crossed

2015



7 boundaries assessed,
4 crossed

2023



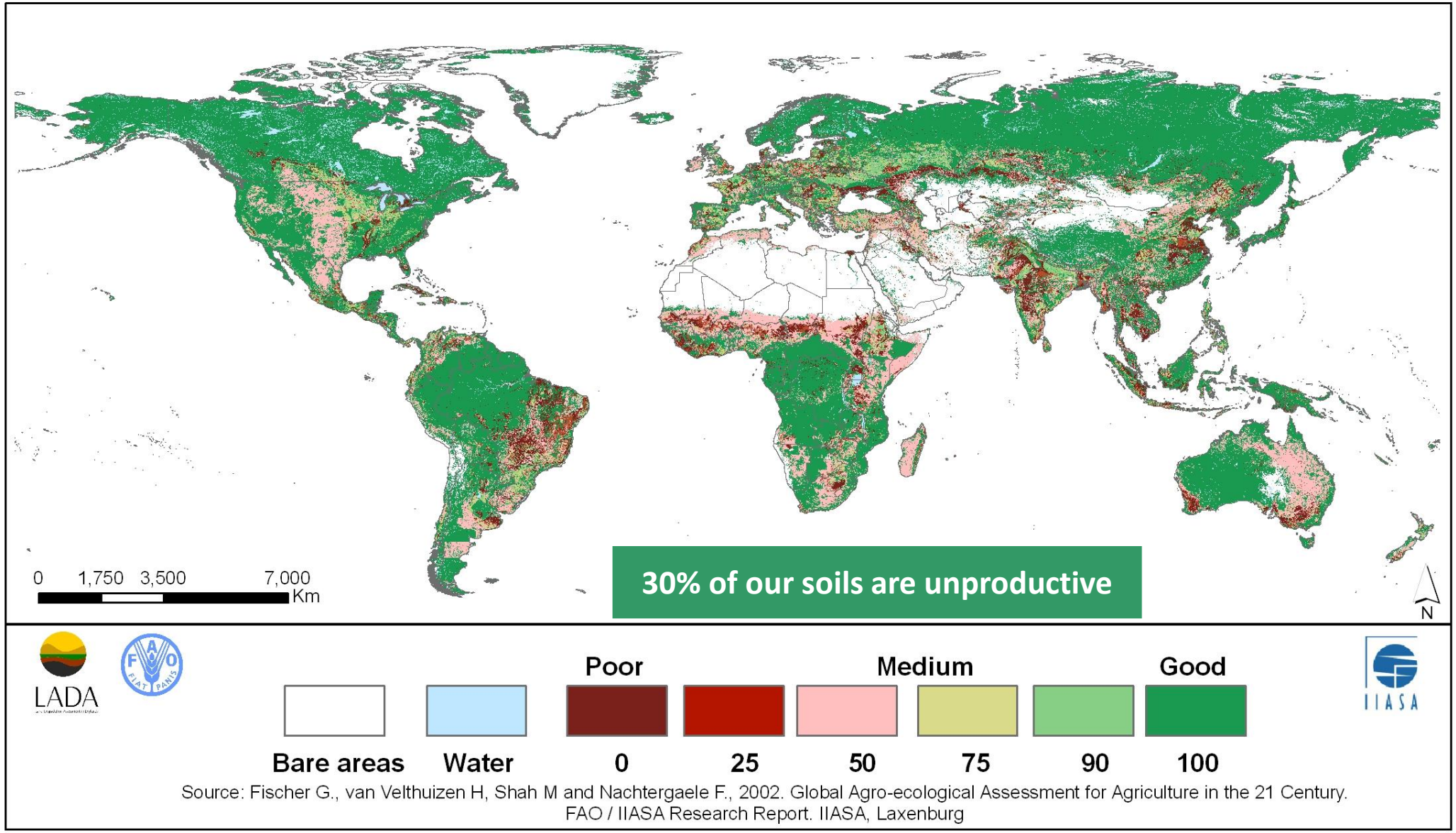
9 boundaries assessed,
6 crossed

Fungi can help us solve some of the challenges associated with our planetary boundaries

FUNGI AS A SOLUTION TO OUR AGRICULTURAL AND FOOD CHALLENGES

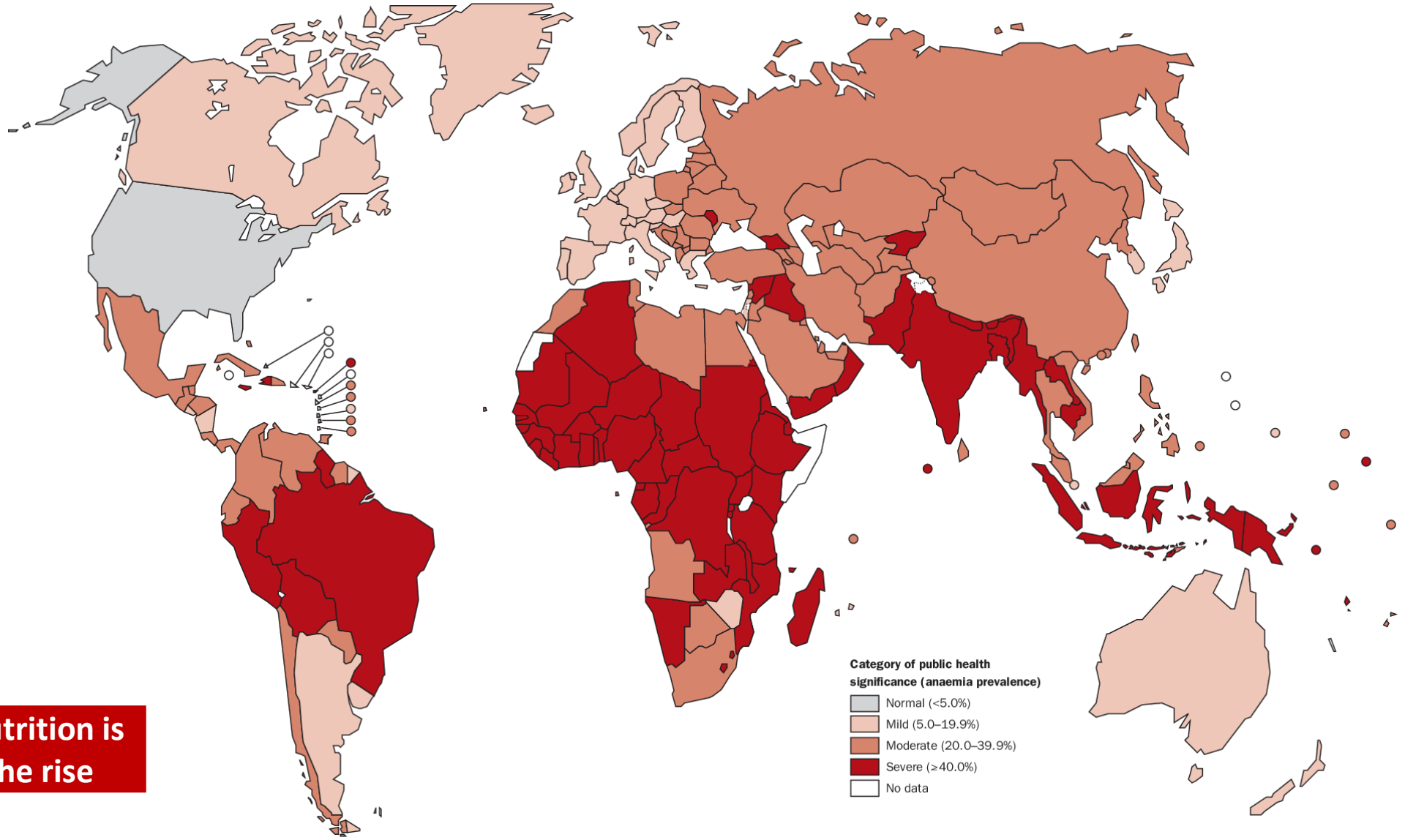
Emma Howcroft

We are facing unprecedented soil degradation



Yet we need to feed our population effectively

Rates of anaemia globally in pre-school children



Malnutrition is on the rise

Silva and Neto, 2020

1

We need a manner by which to improve our soil ecology and increase agricultural yields

2

We need a manner by which to feed our population while maintaining sufficient nutritional in-take levels

Plant nutrition pathways

There are 3 main plant nutrition pathways

Inefficient

Dynamic

Symbiotic

Chemical path
(Soluble nutrients)

Food web path
(Poop loop)

Mutualism path
(Partnerships)

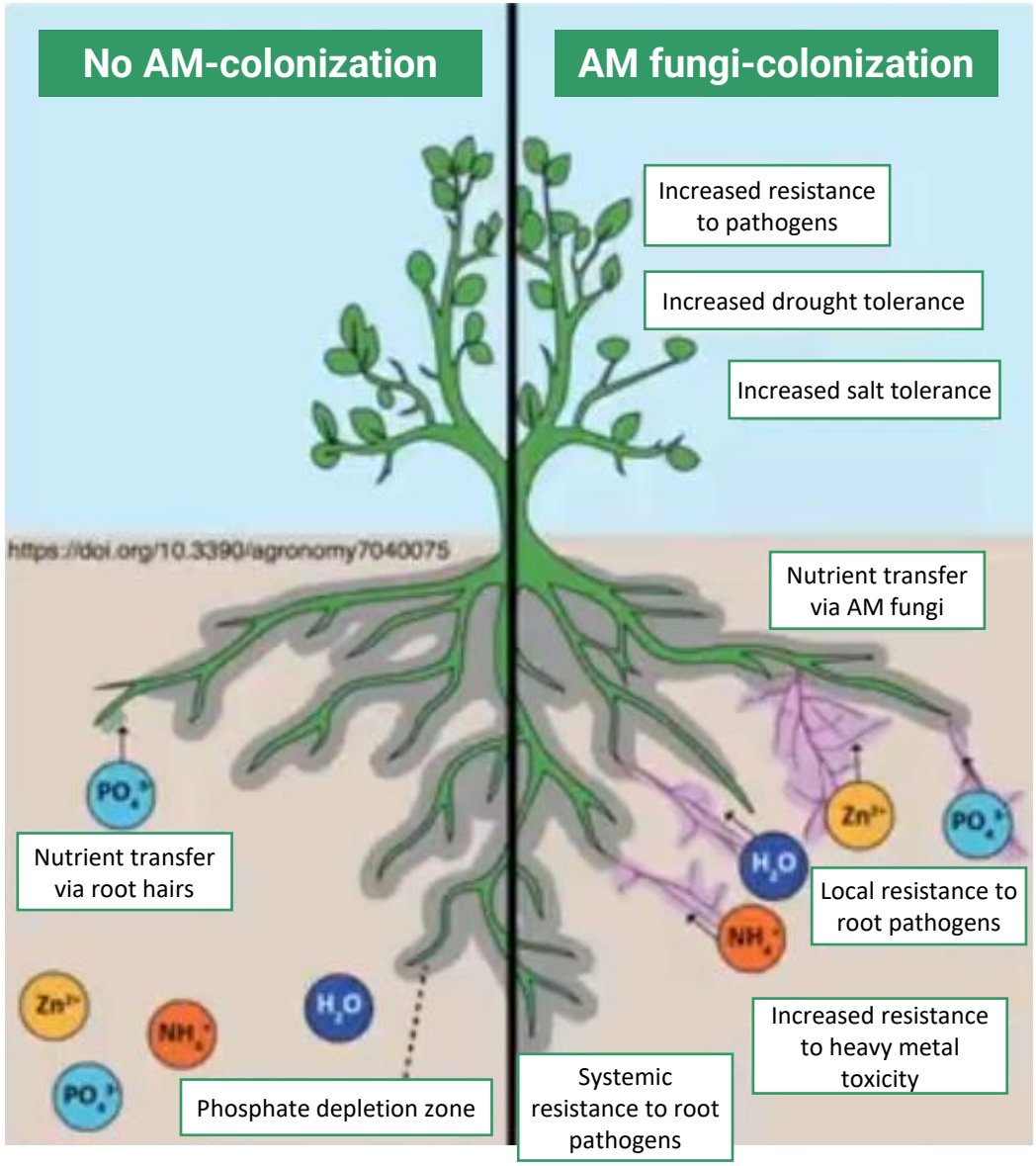
Agronomy

Regenerative

Agroecology

Dr Adam Cobb, 2022

Arbuscular mycorrhizal (AM) fungi



- Most crops and grasses partner with AM fungi
- AM fungi enhance nutrient and water uptake
- They increases the plants resistance
- They enhance soil structure
- Fungi represent 20% - 50% of the biomass in the soil

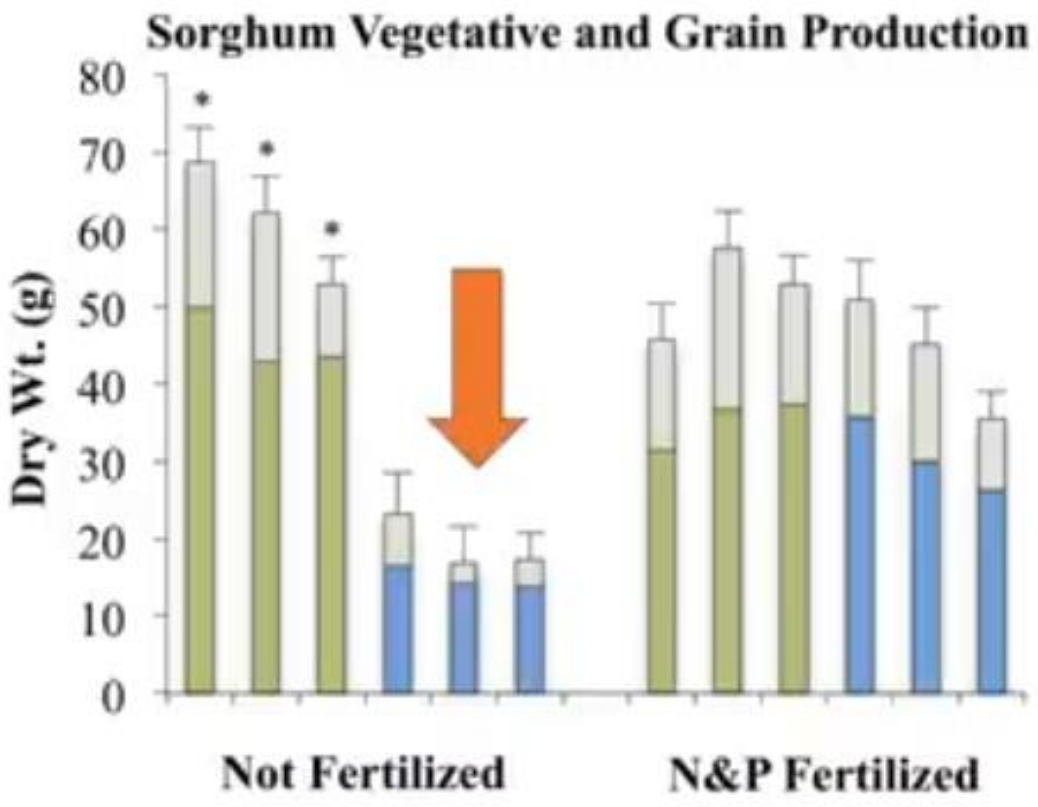
- Fungal networks can decrease leaching of nutrients in the soil by 50%
- They contribute up to 80% of a plant's phosphorus supply.

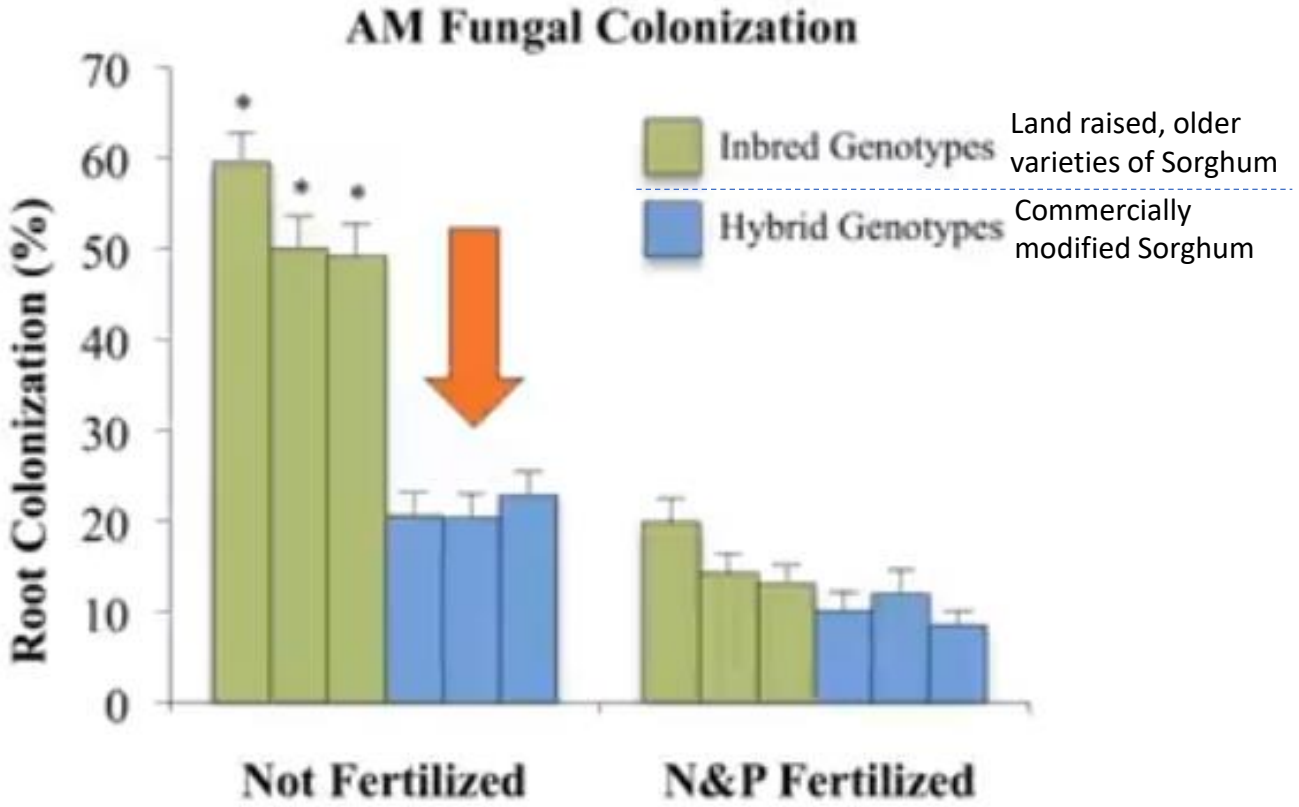
Rates of arbuscular mycorrhizal fungi are decreasing, which is exacerbating our ability to improve soil ecology and agricultural yields

Dr Adam Cobb, 2022. Forbes magazine.

What could be the cause of this reduction?

- Dr Adam Cobb's study in Zambia that there is a correlation between crop modification and commercial crops' ability to chemically communicate with their fungal partners.





Land raised, older varieties of Sorghum

Commercially modified Sorghum

N: Nitrogen
P: Phosphorus

Dr Adam Cobb

The solution

1. **Ensure mycorrhizal relationships are taken into account in selective crop breeding programmes.**
2. **Invest money in optimising mycorrhizal fungi's role as a biofertilizer and biocontrol agent.** *Focus on the cause of deforestation, not fixing the symptom!*

Examples of our biggest GMO corporations:

- **BASF**
- **Bayer**
- **DuPont**
- **Dow Chemical Company**
- **Monsanto**
- **Syngenta**





Good source of information

Toby Kiers @ Spun

1

We need a manner by which to improve our soil ecology and increase agricultural yields

2

We need a manner by which to feed our population while maintaining sufficient nutritional in-take levels

Mycoprotein as an alternative to meat

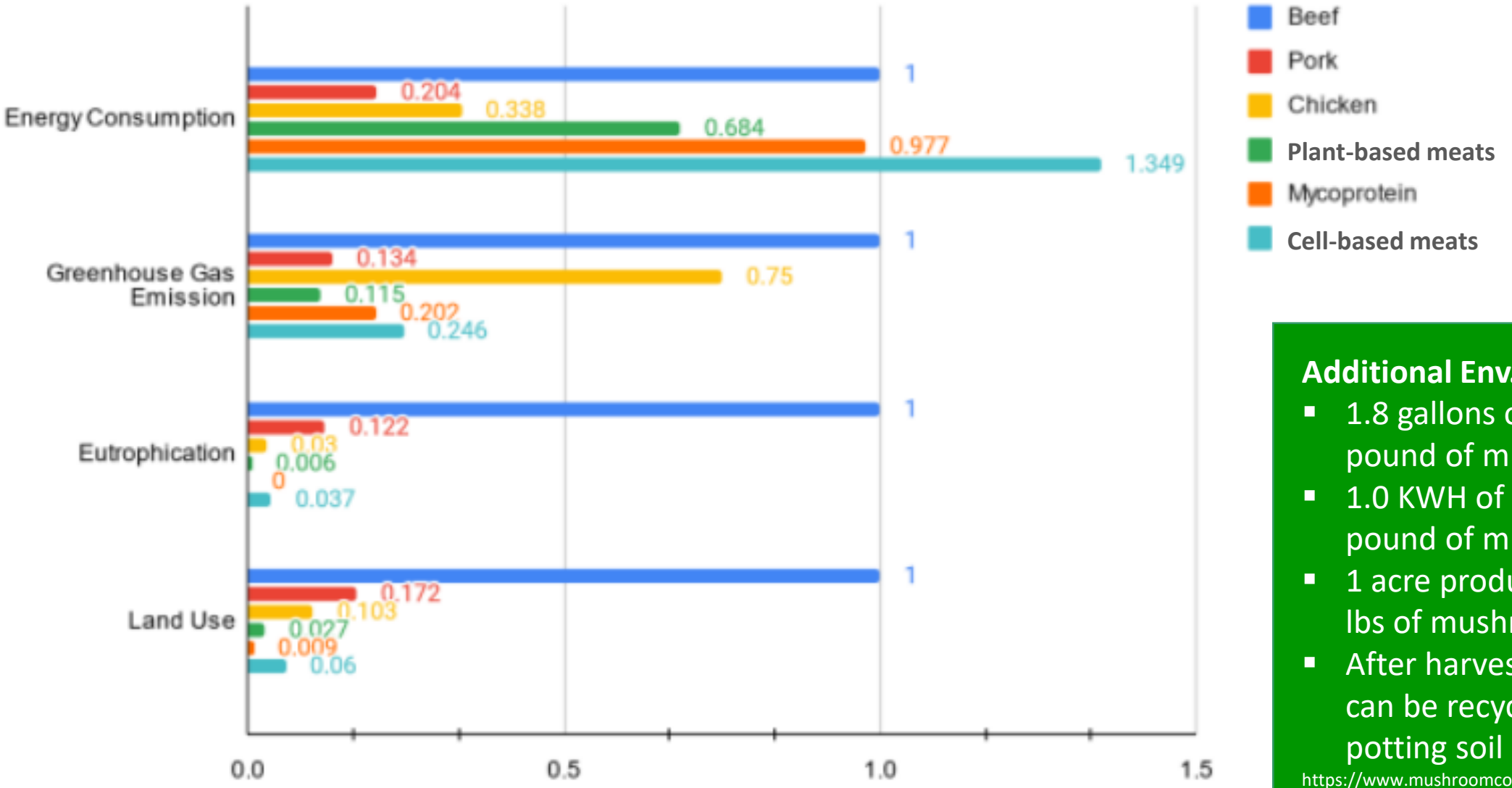
- Mycoprotein has a **much lower land use** and carbon footprint than meat: 0.00018 ha kg vs 0.0068 ha kg for beef.
- Mycoprotein has a **good balance of essential amino acids** compared with beef, although lower.
- Mycoprotein is a **good source of vitamin B9, vitamin D, zinc, selenium and antioxidants**.
- Mycoprotein and plant-based alternatives usually have **higher energy usage**, however, Quorn, for example, has one the least energy, land and water footprints.
- Mycoprotein can be **moulded to represent meat texture** which improves consumer acceptance.

Iron content (mg per 100g)	
Beef	2.47 mg
Lamb	1.78 mg
Arage-kikurage (dried)	10.4mg
Chanterelle mushrooms	3.5 mg
Cremini mushrooms	2.1 mg
Maitake mushrooms	1.5 mg
Oyster mushrooms	1.3 mg





Environmental impact of meat analogues



Smetana et al., 2015

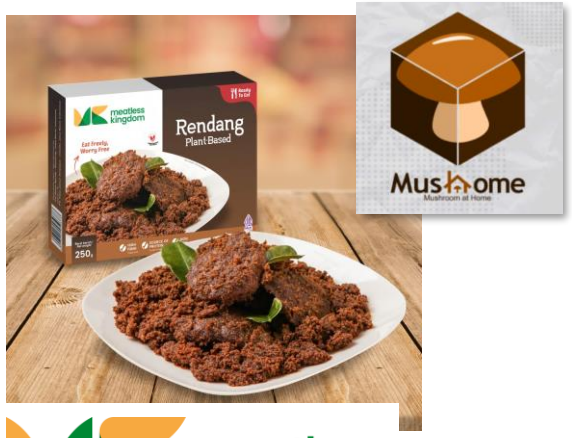
Additional Env. Stats.

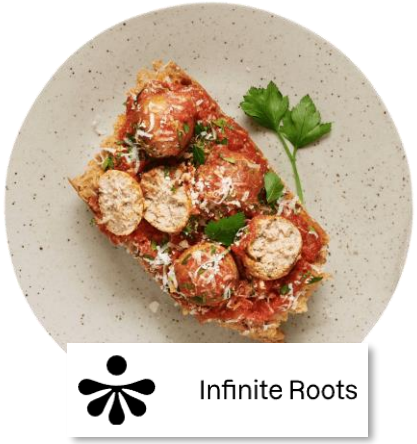
- 1.8 gallons of water per 1 pound of mushrooms
- 1.0 KWH of electricity per 1 pound of mushrooms
- 1 acre produces up to 1 million lbs of mushrooms annually
- After harvesting, mushrooms can be recycled back into the potting soil

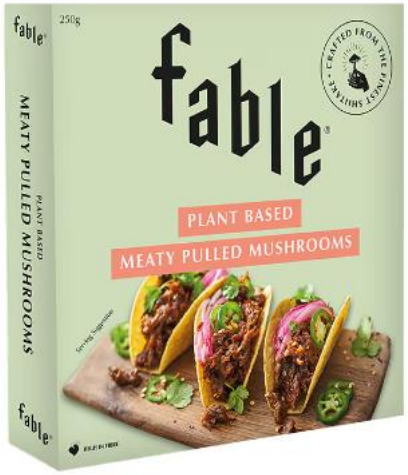
https://www.mushroomcouncil.com/wp-content/uploads/2017/12/Mushroom-Sustainability-Story-2017.pdf

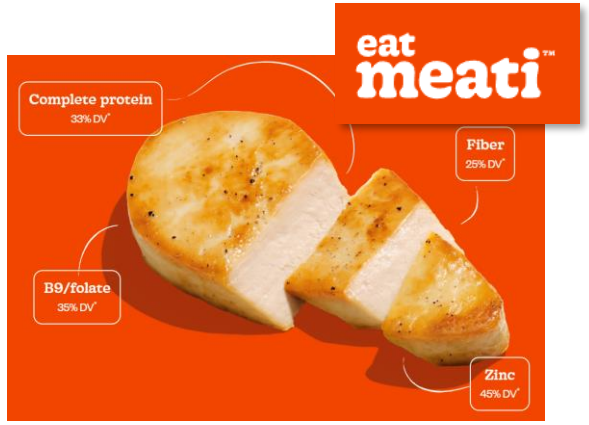
The solution

Food category managers should consider mushroom-based and mycoprotein options in the sourcing strategies…









Find food companies on the Fungi Protein Association website

Find food companies on the Myco-Stories website

Good source of information

Paul Shapiro @ the Better Meat Company

FUNGI AS A NATURE-BASED SOLUTION

Fungi act as huge carbon storers

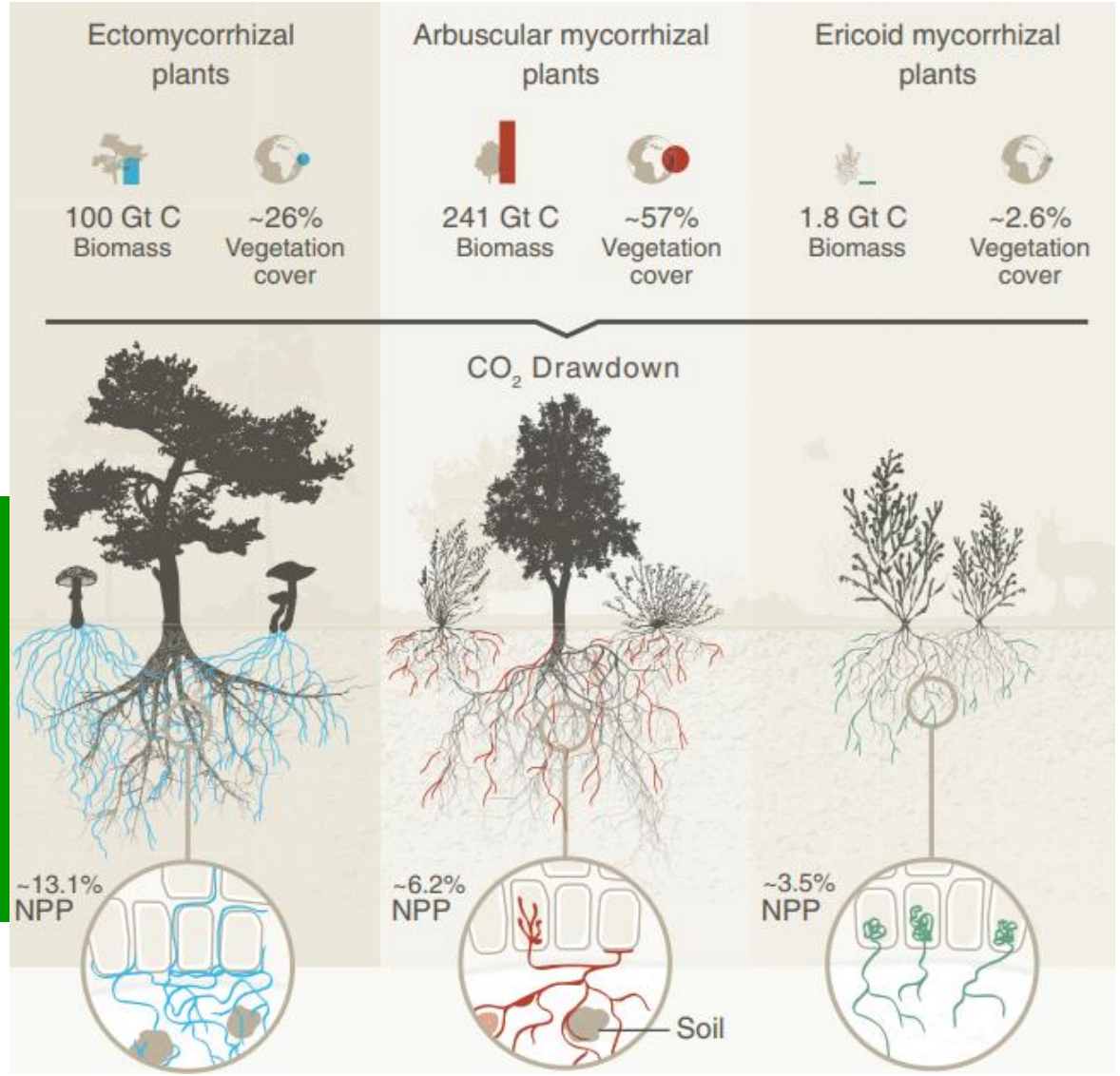
The paper estimates that global plant communities allocate:

- 9.07 Gt CO2e per year to ectomycorrhizal fungi, and
- 3.93 Gt CO2e per year to arbuscular mycorrhizal fungi, and
- 0.12 Gt CO2e per year to ericoid mycorrhizal fungi.

By this estimate 13.12 Gt of CO2e are allocated to the underground mycelium of mycorrhizal fungi per year, equating to 36% of current annual CO2 emissions from fossil fuels.

If we need solutions to store carbon, this finding is important!

Correction in video presentation: Ocean sequesters c30% of man-made carbon emissions annually

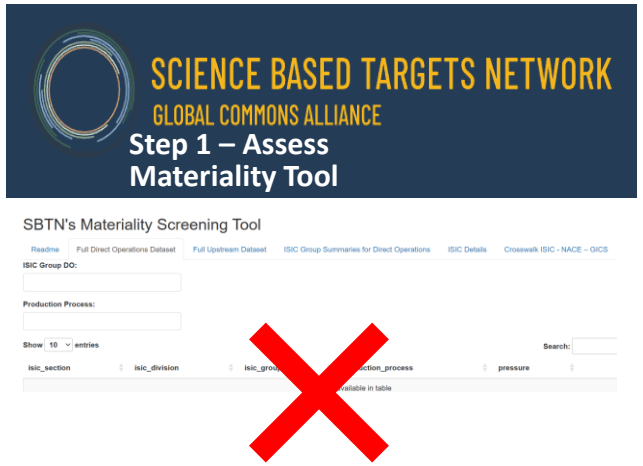


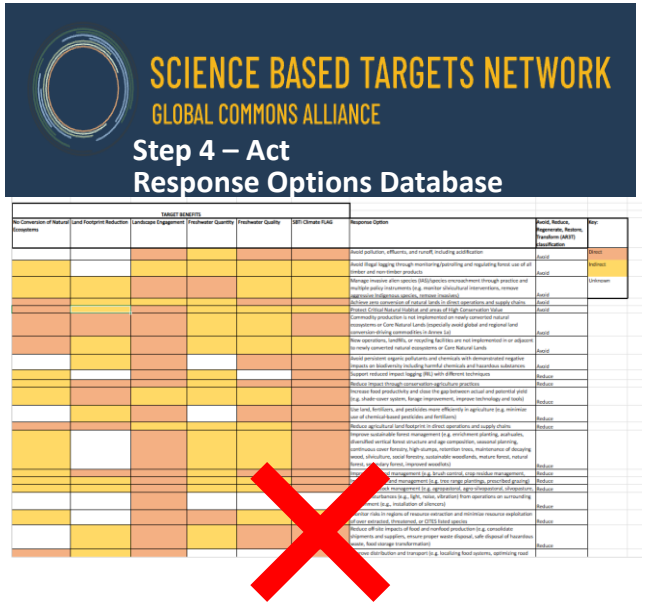
The estimated amount of carbon (photosynthate) allocated to different mycorrhiza is expressed as annual Net Primary Productivity (NPP).

The issue


“Fungi represent a meagre 0.2% of our global conservation priorities”. Fungi Foundation
Emma Howcroft

Where are fungi in our current nature-based frameworks?





Where are fungi in our articles on nature-based solutions?

Natural climate solutions

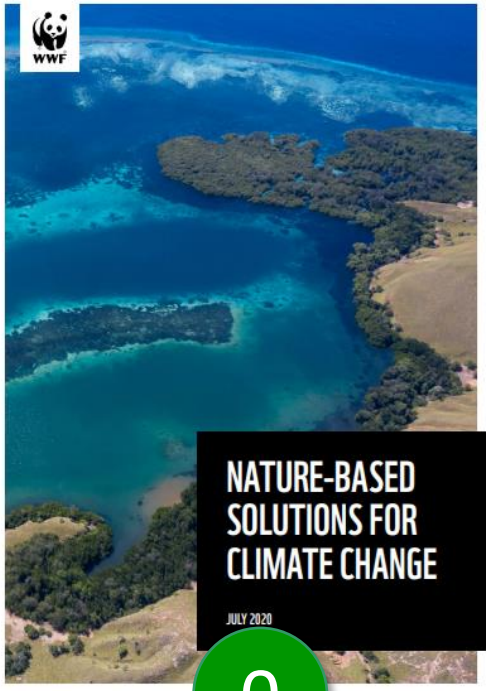
0

Natural climate solutions for the United States

0

Getting the message right on nature-based solutions to climate change

1



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The solution

- Ask for fungi to be included in nature-based frameworks and solutions

- Ask for case studies which involve fungi as an eco-service enhancers

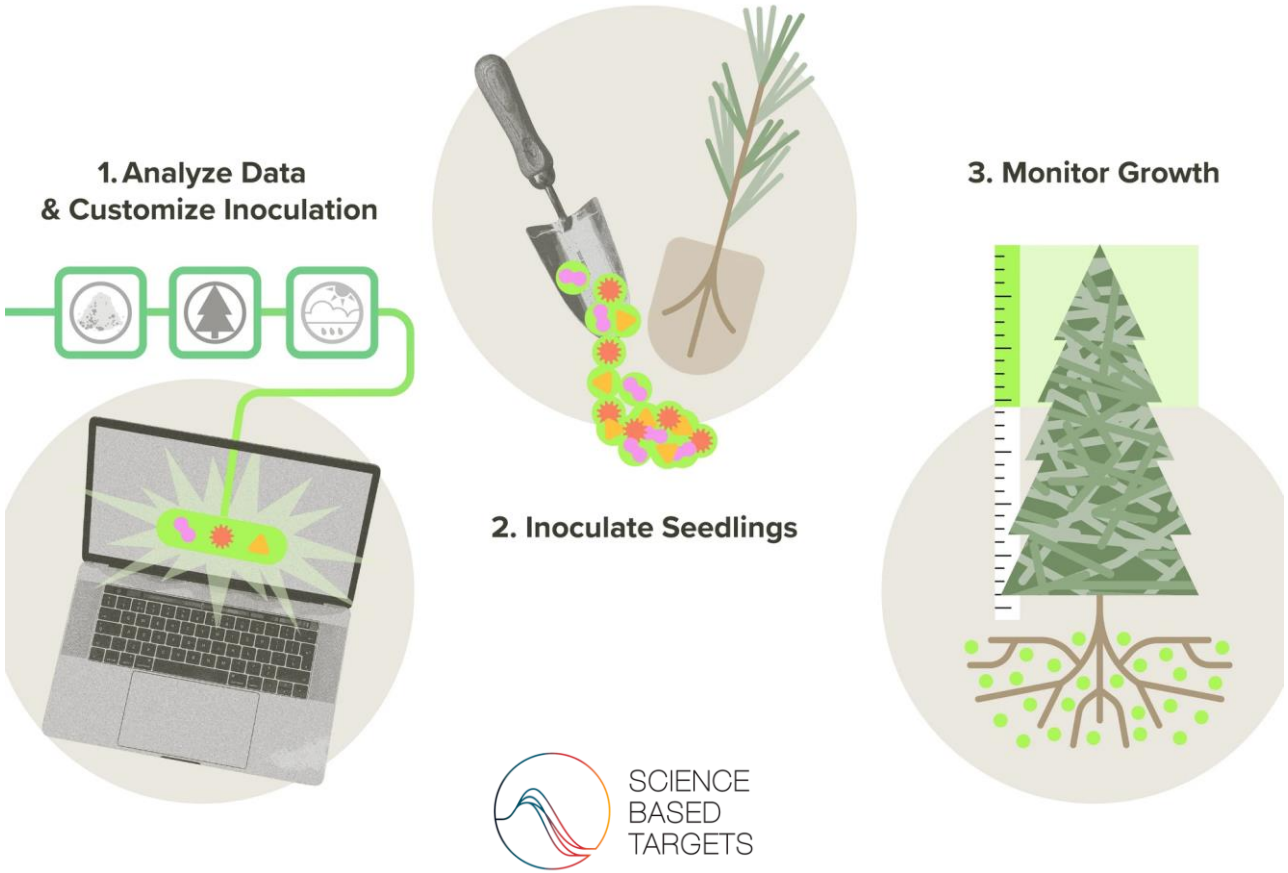
The solution

Go talk to the Fungi Foundation and Spun…

The solution

Consider fungi in your nature-based solutions…

Funga



SCIENCE BASED TARGETS

Funga surveys hundreds of forests to understand (1) which fungi live in the forest and (2) the growth and health of the forest. By doing so, we can identify forest fungal communities linked to forest health. We use this information to identify wild fungal communities that can both accelerate tree growth, and enhance fungal biodiversity across the forest landscape. Using the recommendations from this analysis, we inoculate tree seedlings with fungal communities at time of tree planting. Finally, we quantify how much **additional** carbon was removed as a result of forest microbiome restoration, compared to business as usual forestry activity. We sell these carbon dioxide removal outcomes to corporate partners working to build responsible net-zero strategies.

The solution

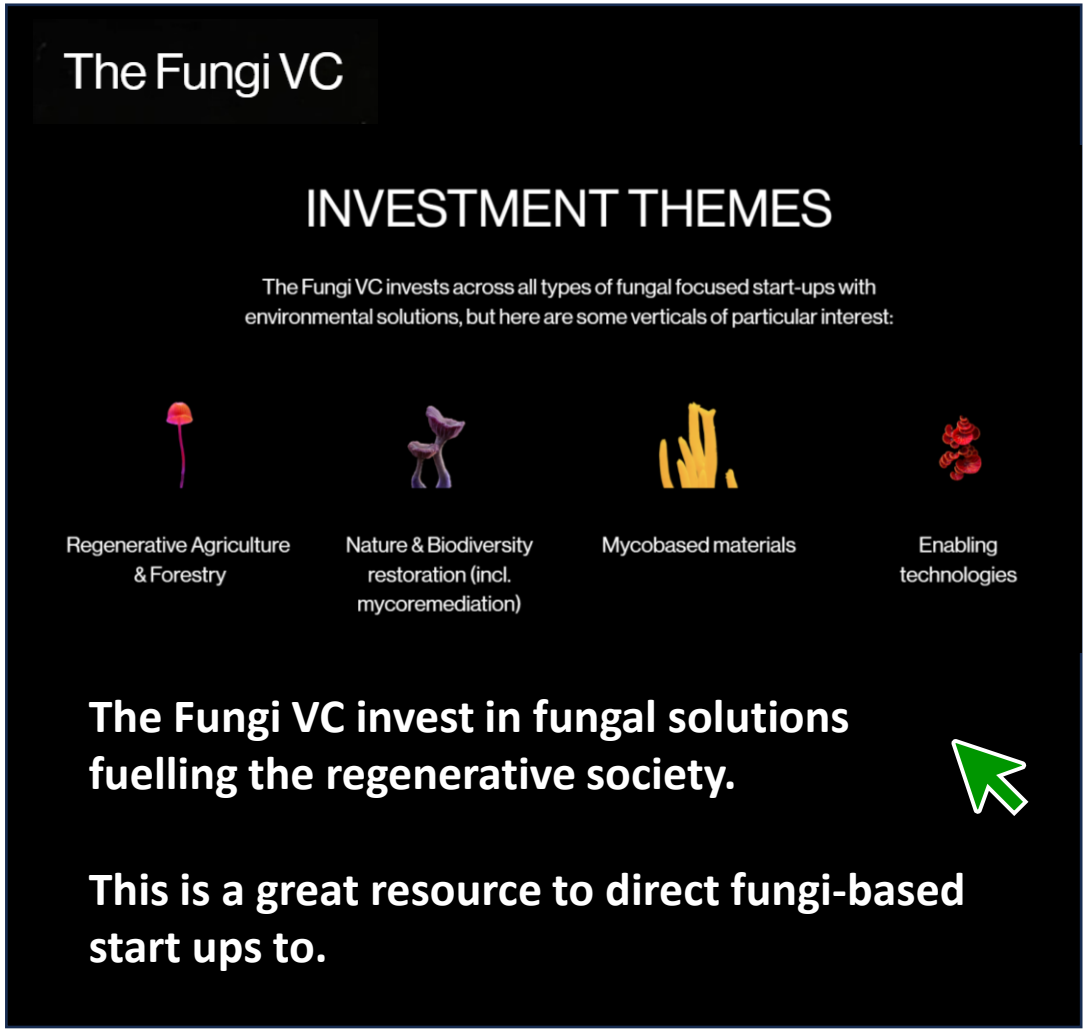
About to invest in a tree planting initiative? Consider adding Rhizocore to your team…

RHIZOCORE
TECHNOLOGIES

Rhizocore Technologies create locally-adapted mycorrhizal fungi pellets to enhance tree planting success. These fit effortlessly into the planting process, ensuring that new saplings flourish, build resilience to drought, and overcome the mortality rates so often seen across tree planting schemes.

The solution

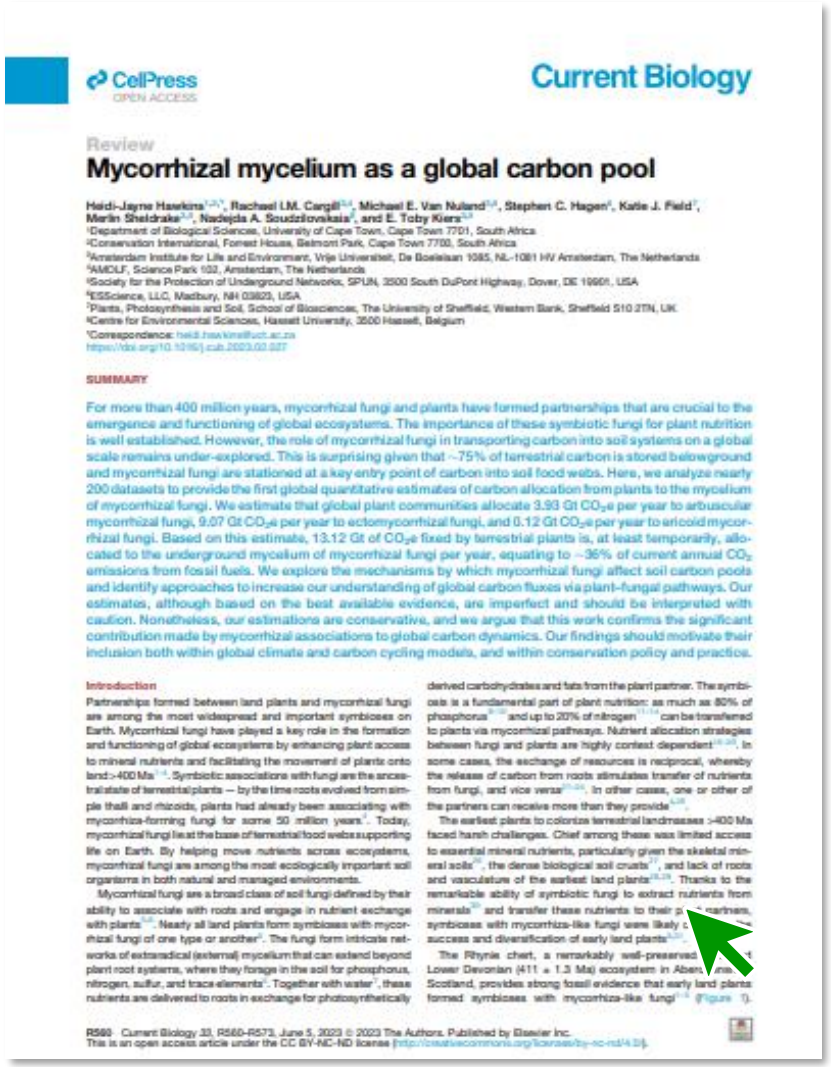
Think about investing in fungi-based companies or help fungi-based companies access funds.



Good source of information

Heidi-Jayne Hawkins, Rachael I.M. Cargill, Michael E. Van Nuland, Stephen C. Hagen, Katie J. Field, Merlin Sheldrake, Nadejda A. Soudzilovskaia and E. Toby Kiers

- Department of Biological Sciences, University of Cape Town, SA
- Conservation International, Cape Town, SA
- Amsterdam Institute for Life and Environment
- AMOLF, Amsterdam
- Society for the Protection of Underground Networks, USA
  ESScience, USA
- Plants, Photosynthesis and Soil, School of Biosciences, The University of Sheffield, UK
- Centre for Environmental Sciences, Hasselt University, Belgium



CellPress
OPEN ACCESS

Current Biology

Review

Mycorrhizal mycelium as a global carbon pool

Heidi-Jayne Hawkins[1,2,7], Rachael I.M. Cargill[3,4], Michael E. Van Nuland[5,6], Stephen C. Hagen[5], Katie J. Field[7], Merlin Sheldrake[8,9], Nadejda A. Soudzilovskaia[3], and E. Toby Kiers[3,6]
[1]Department of Biological Sciences, University of Cape Town, Cape Town 7701, South Africa
[2]Conservation International, Forest House, Belmont Park, Cape Town 7700, South Africa
[3]Amsterdam Institute for Life and Environment, Vrije Universiteit, De Boelelaan 1085, NL-1081 HV Amsterdam, The Netherlands
[4]AMOLF, Science Park 102, Amsterdam, The Netherlands
[5]Society for the Protection of Underground Networks, SPUN, 3500 South DuPont Highway, Dover, DE 19901, USA
[6]ESScience, LLC, Madbury, NH 03823, USA
[7]Plants, Photosynthesis and Soil, School of Biosciences, The University of Sheffield, Western Bank, Sheffield S10 2TN, UK
[8]Centre for Environmental Sciences, Hasselt University, 3500 Hasselt, Belgium
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https://doi.org/10.1016/j.cub.2023.02.027

SUMMARY

For more than 400 million years, mycorrhizal fungi and plants have formed partnerships that are crucial to the emergence and functioning of global ecosystems. The importance of these symbiotic fungi for plant nutrition is well established. However, the role of mycorrhizal fungi in transporting carbon into soil systems on a global scale remains under-explored. This is surprising given that ~75% of terrestrial carbon is stored belowground and mycorrhizal fungi are stationed at a key entry point of carbon into soil food webs. Here, we analyze nearly 200 datasets to provide the first global quantitative estimates of carbon allocation from plants to the mycelium of mycorrhizal fungi. We estimate that global plant communities allocate 3.93 Gt CO_2e per year to arbuscular mycorrhizal fungi, 9.07 Gt CO_2e per year to ectomycorrhizal fungi, and 0.12 Gt CO_2e per year to ericoid mycorrhizal fungi. Based on this estimate, 13.12 Gt of CO_2e fixed by terrestrial plants is, at least temporarily, allocated to the underground mycelium of mycorrhizal fungi per year, equating to ~36% of current annual CO_2 emissions from fossil fuels. We explore the mechanisms by which mycorrhizal fungi affect soil carbon pools and identify approaches to increase our understanding of global carbon fluxes via plant-fungal pathways. Our estimates, although based on the best available evidence, are imperfect and should be interpreted with caution. Nonetheless, our estimations are conservative, and we argue that this work confirms the significant contribution made by mycorrhizal associations to global carbon dynamics. Our findings should motivate their inclusion both within global climate and carbon cycling models, and within conservation policy and practice.

Introduction

Partnerships formed between land plants and mycorrhizal fungi are among the most widespread and important symbioses on Earth. Mycorrhizal fungi have played a key role in the formation and functioning of global ecosystems by enhancing plant access to mineral nutrients and facilitating the movement of plants onto land >400 Ma[1–4]. Symbiotic associations with fungi are the ancestral state of terrestrial plants — by the time roots evolved from simple thalli and rhizoids, plants had already been associating with mycorrhiza-forming fungi for some 50 million years[5]. Today, mycorrhizal fungi lie at the base of terrestrial food webs supporting life on Earth. By helping move nutrients across ecosystems, mycorrhizal fungi are among the most ecologically important soil organisms in both natural and managed environments.

Mycorrhizal fungi are a broad class of soil fungi defined by their ability to associate with roots and engage in nutrient exchange with plants[6–8]. Nearly all land plants form symbioses with mycorrhizal fungi of one type or another[9]. The fungi form intricate networks of extraradical (external) mycelium that can extend beyond plant root systems, where they forage in the soil for phosphorus, nitrogen, sulfur, and trace elements[7]. Together with water[7], these nutrients are delivered to roots in exchange for photosynthetically derived carbohydrates and fats from the plant partner. The symbiosis is a fundamental part of plant nutrition: as much as 80% of phosphorus[10–12] and up to 20% of nitrogen[11,13–15] can be transferred to plants via mycorrhizal pathways. Nutrient allocation strategies between fungi and plants are highly context dependent[16–20]. In some cases, the exchange of resources is reciprocal, whereby the release of carbon from roots stimulates transfer of nutrients from fungi, and vice versa[21–24]. In other cases, one or other of the partners can receive more than they provide[4,25].

The earliest plants to colonize terrestrial landmasses >400 Ma faced harsh challenges. Chief among these was limited access to essential mineral nutrients, particularly given the skeletal mineral soils[26], the dense biological soil crusts[27], and lack of roots and vasculature of the earliest land plants[28,29]. Thanks to the remarkable ability of symbiotic fungi to extract nutrients from minerals[30] and transfer these nutrients to their p… partners, symbioses with mycorrhiza-like fungi were likely c… success and diversification of early land plants[5,31].

The Rhynie chert, a remarkably well-preserved… Lower Devonian (411 ± 1.3 Ma) ecosystem in Aber… Scotland, provides strong fossil evidence that early land plants formed symbioses with mycorrhiza-like fungi[5,32] (Figure 1).

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Emma Howcroft

Good source of information

Colin Averill @Funga

FUNGI AS AN ALTERNATIVE MATERIAL

Emma Howcroft

Mycelium as an alternative to polystyrene packaging

- **Grown** to shape **in only 7 days**, no post-processing required
- Custom moulded at a **fraction of the cost** of foam packaging
- **Flame resistant**, due to inherent properties of mycelium
- **Naturally water resistant** (hydrophobic), making it suitable for thermal applications and shipping with ice packs that are subject to melting
- Biodegradable and **fully home-compostable**, returning nutrients back to the earth
- **An active soil amendment**, strengthens the growth of plants
- Its **shelf life is well over 10 years** if kept in correct conditions.

mycrobez

SMUSH

Mushroom Packaging
By Ecovative

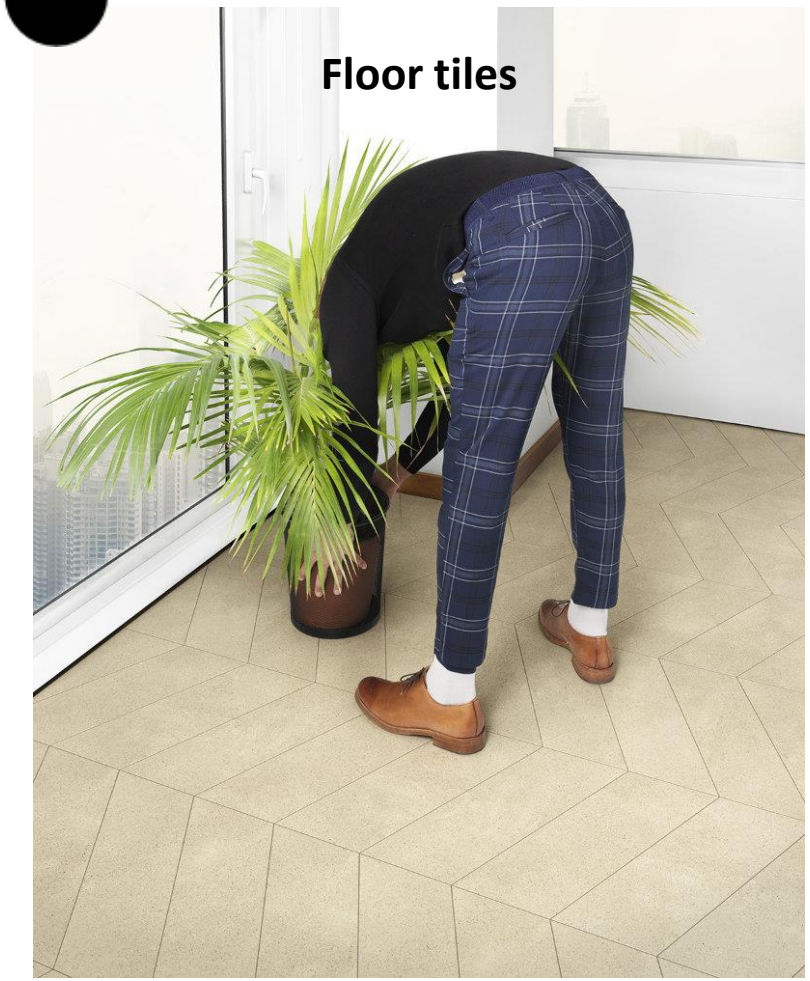
GROWN bio

MAGICAL MUSHROOM COMPANY®

Mushroom Packaging by Ecovative

Mycelium is a great alternative to floor tiles and sound proofing

mogu
RADICAL BY NATURE



Mycelium as an alternative to polyurethane (PUR), polyisocyanurate (PIR), or rock wool

Fairm

Fire resistant insulation panels

mykor

MykoFoam: acoustic and thermal mycelium insulation sheet

Mycelium an alternative to building materials

Mycelium an alternative to building materials

COMU Labs

Mycowood is an alternative to plywood which can be used for furniture and construction projects. Comu Labs also provides pop up factories (sold or leased) so you can grow your own Mycowood onsite.

Save up to 30% on lumber costs getting COMU microfactory

Container-sized production facility easily deployed next to your factory

Locally sourced

1 week to grow

Pressed into shape

Mycelium as an alternative to leather

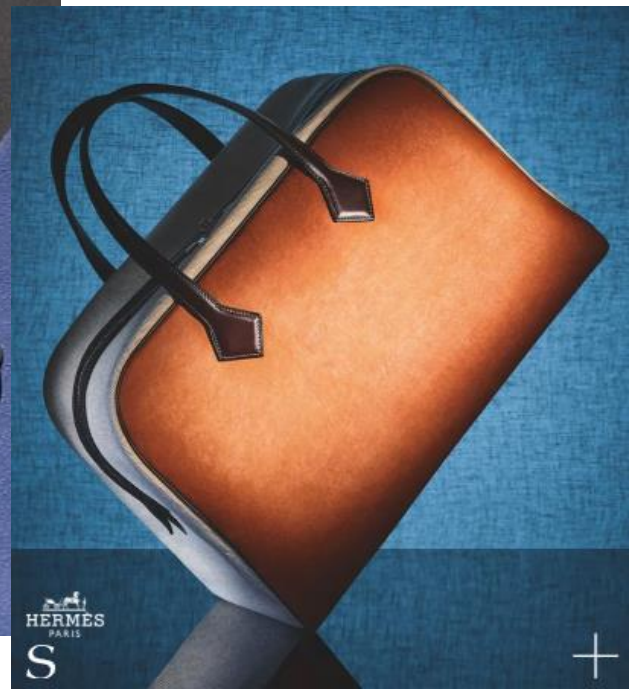
MYCL

clever rally

mylea™

MYCOWORKS

Cadillac: High-performance automotive interiors



Hermes: Designer leather

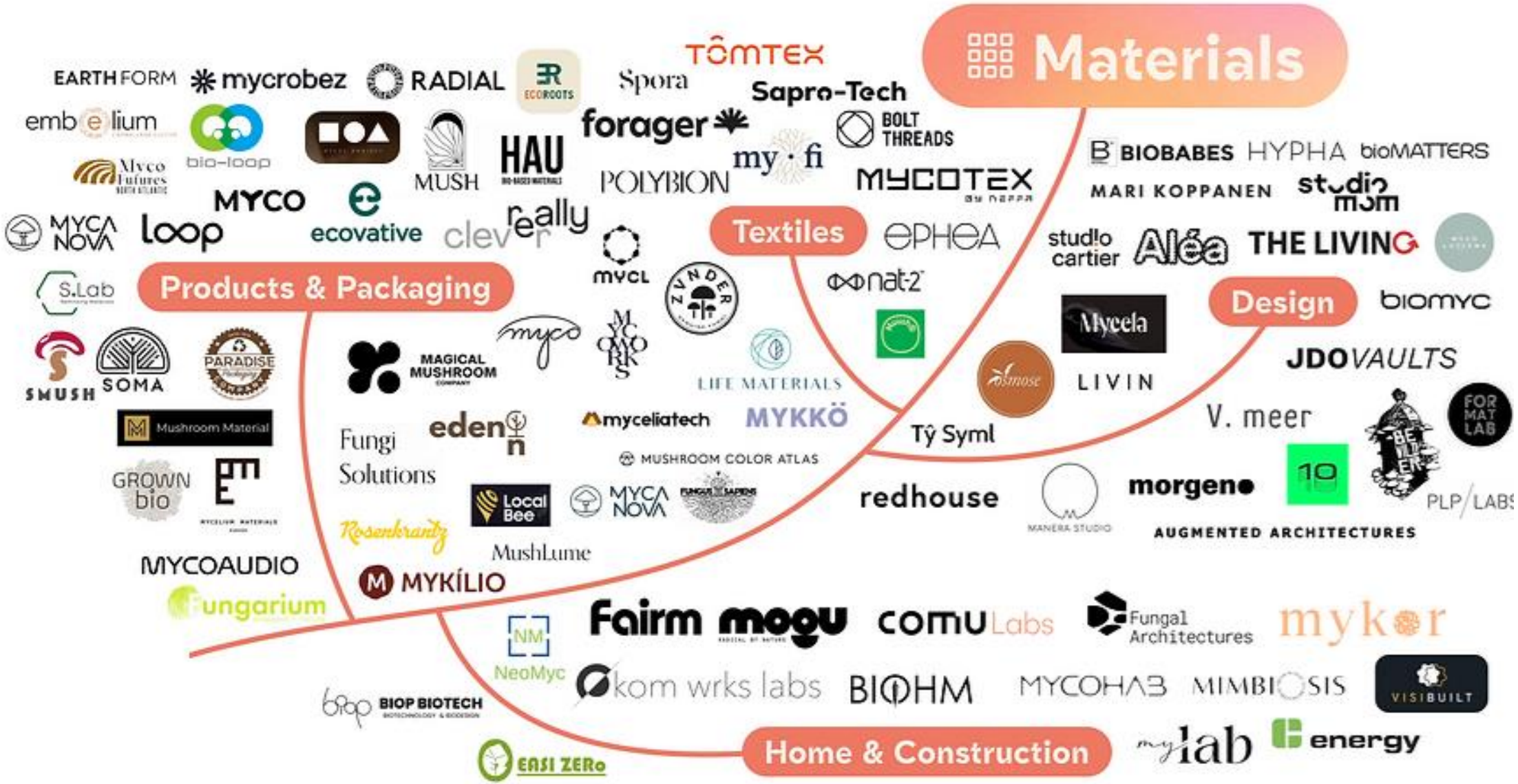
MYCA NOVA

Alternative leather products

Mycelium as an alternative to a wood coffin

Loop enrich nature by bringing human nutrients back into the cycle-of-life in the most natural way with a living mycelium-based coffin. This enables people to enrich the soil and allow new seedlings to thrive. From graveyard to forest.

Find materials companies on the Myco-Stories website



FUNGI AS A SOLUTION TO SOLVING POLLUTION

What is mycoremediation?

“Mycoremediation is the use of fungi to neutralise and degrade toxic constituents in nature”

Emma Howcroft

A few examples of mycoremediation

Removing E. coli from water. Oyster mushroom mycelia were used against E. coli-inoculated water made in a lab, as well as straight from the Chicago River, with a 99.25% and 99.74% respective rate of E. coli removal over a 96 hour period.

Filtering farm water runoff. Contaminated water run-off from farms is now being tackled by fungal filters- a mycelial network that both acts as a micro-filtration system while simultaneously releasing enzymes that degrade toxic contaminants.

Eliminating heavy metals and petroleum waste. The Pleurotus species (of which Oyster mushrooms are a member) holds incredible power to absorb heavy metals and other petroleum wastes in soil. Its mycelial networks degrades and transform the waste into less toxic compounds.

Real Mushrooms

Emma Howcroft

A few examples of mycoremediation

Remediating Diesel-Contaminated Fields. Paul Stamets, in collaboration with Battelle Laboratories, was able to demonstrate the soil remediating power of mycelium to create an entire thriving ecosystem from a previously diesel-contaminated field.

Eliminating bitumen mine waste. Kelcie Miller-Anderson (@ MycoRemedy) developed the MycoMat, a roll-out mat that is inoculated with oyster mushroom mycelium. It can then be rolled out onto tailings ponds or the surrounding soil. The fungi release powerful enzymes that make a meal of harmful hydrocarbons.

Removing plastic-related pollutants. Savannah Volkoff has identified fungal species that can decontaminate soil containing Polycyclic Aromatic Hydrocarbons, a byproduct of plastic production which can cause a slew of adverse health conditions in humans.

Real Mushrooms

Emma Howcroft

The solution

Engage with myco-researchers and mycoremediation companies to find suitable investment and research projects to lead and/or support.

Myco Farming

Myco Farming capture and degrade nutrients, like nitrogen and phosphorus, from agricultural runoff before they accumulate in our water bodies.

MYSOIL

The LIFE MySOIL project is developing technology to demonstrate the feasibility of mycoremediation to remediate all petroleum-derived organic pollutants from aged industrial contaminated soils.

novobiom

Bio-inspired waste treatment technologies.

TENCATE AQUAVIA

GeoClean aquatextile depollutes the runoff water of hydrocarbons and PAHs during their infiltration.

MycoMine®

MycoMine harnesses the power of mycelium for removal of environmental pollutions in water and soil — bioremediation. The match the relevant mycelium to the pollution substrate which needs addressing.

MYCOCYCLE

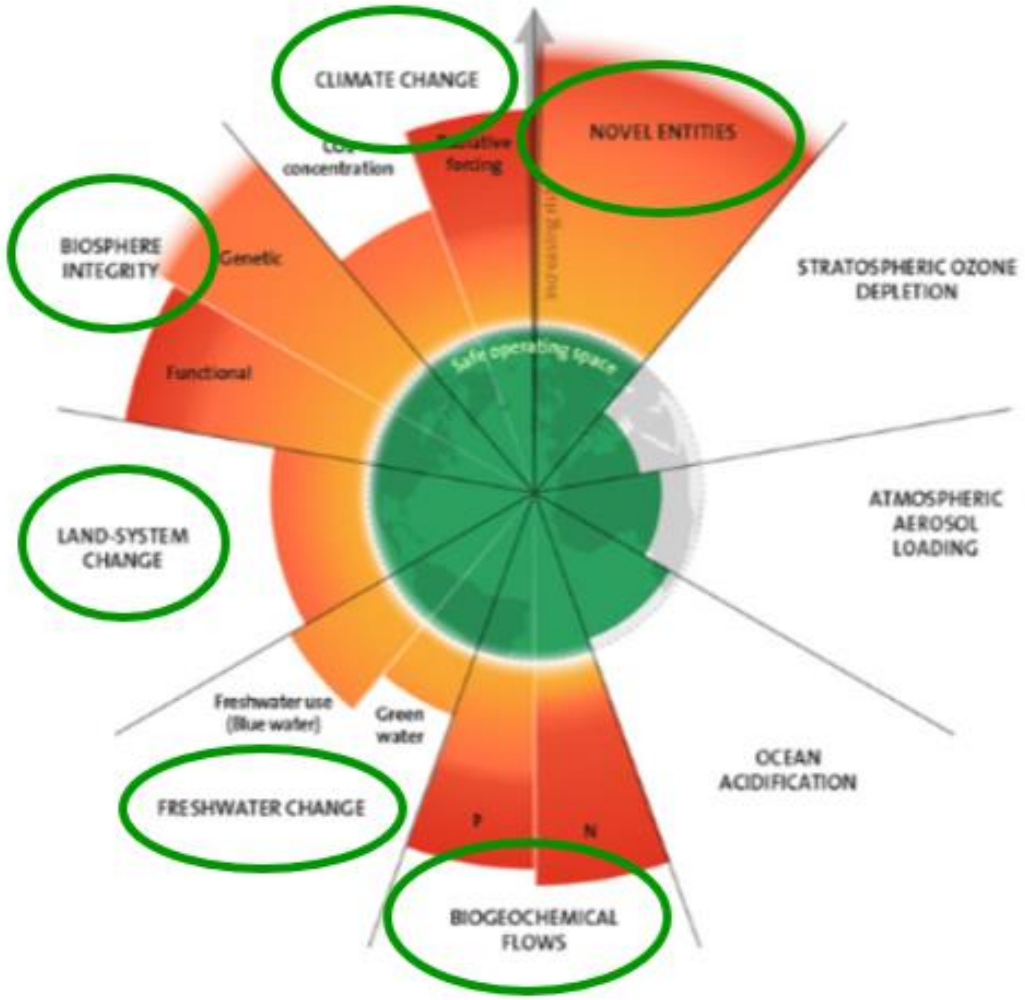
Mycocycle uses fungi to transform construction waste into low-carbon biobased materials for the built environment.

Good source of information

RECAP ON HOW FUNGI CAN HELP US STAY WITHIN OUR PLANETARY BOUNDARIES

Emma Howcroft

Fungi’s power to help us maintain our planetary boundaries



FUNGI AS SOLUTION TO OUR AGRICULTURAL AND FOOD CHALLENGES	Climate change, biosphere integrity, land system change, biogeochemical flows and freshwater change
FUNGI AS A NATURE-BASED SOLUTION	Climate change and biosphere integrity
FUNGI AS AN ALTERNATIVE MATERIAL	Climate change and land system change
FUNGI AS A SOLUTION TO SOLVING POLLUTION	Novel entities, climate change, biosphere integrity, freshwater change and biogeochemical flows

HOW TO BE FUNGI INCLUSIVE

Emma Howcroft

Be fungi inclusive

The Fungi Foundation is great place to start to get resources, support and guidance…

Sign the Fauna Flora Funga pledge

"I agree that fungi should be included in conservation frameworks and protected on an equal footing with animals and plants.“

CLICK HERE

Download the Guide for Organisations Adopting a Mycologically Inclusive Approach

CLICK HERE

Ask the Fungi Foundation for specific guidance

CONTACT: mlevi@ffungi.org

A FEW OTHER GOOD SOURCES OF INFORMATION

Emma Howcroft

Other resources

- How fungi will save the world | Kew
- Mushroom, Mycelium, Fungi Innovation | MycoStories
- 6 ways mushrooms can save the world | Paul Stamets | TED
- Antimicrobial properties of fungi | Paul Stamets | TED
- How trees talk to each other | Suzanne Simard | TED
- Entangled Life | Merlin Sheldrake | Amazon
- Are mushrooms the new plastic? | Eben Bayer | TED
- The Mycological Photographer | Explore the world of fungi, lichen and slime moulds

Emma Howcroft