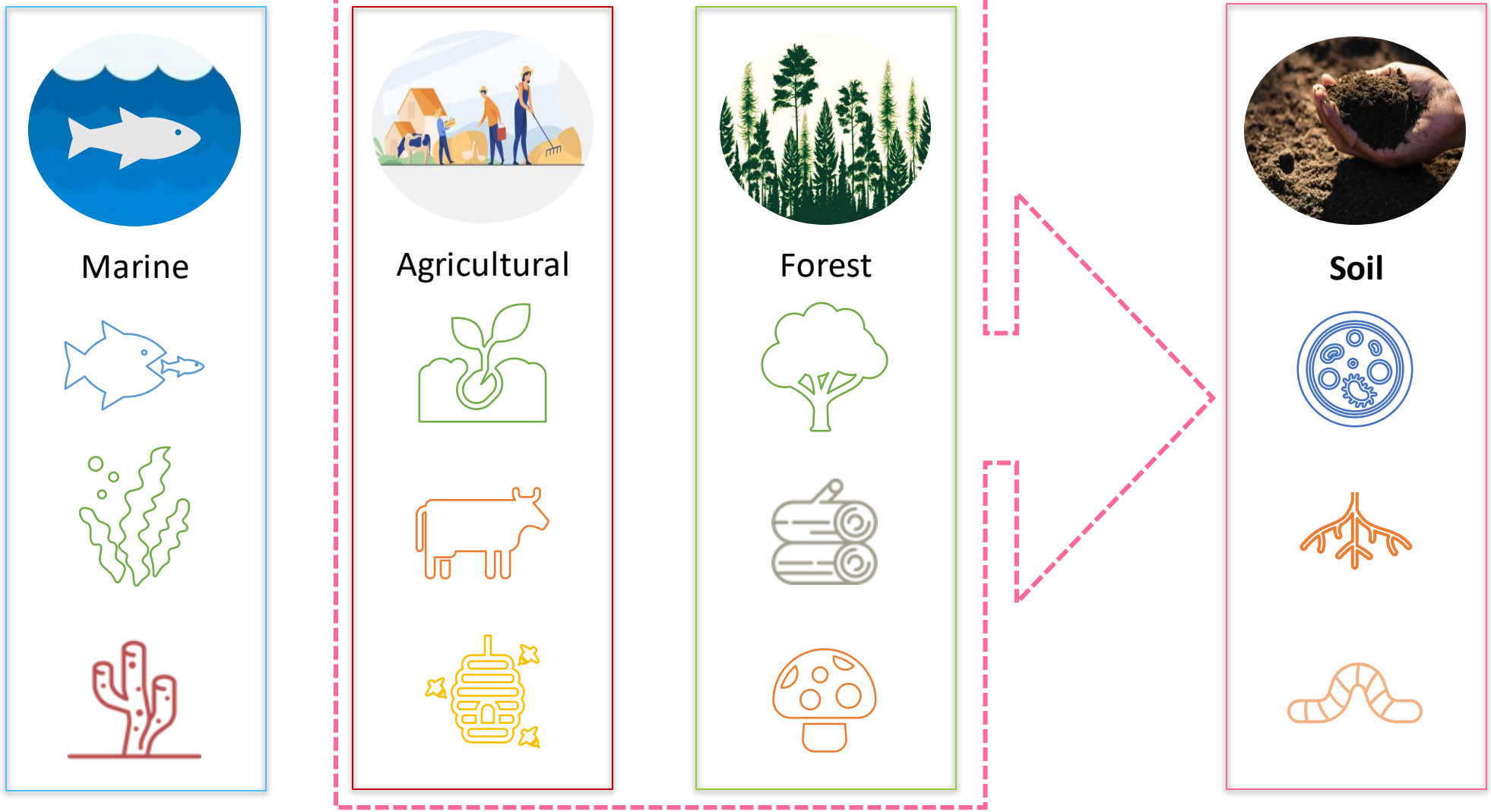
Fungi - a nature-based solution

Biofertilizers And Precision Agriculture

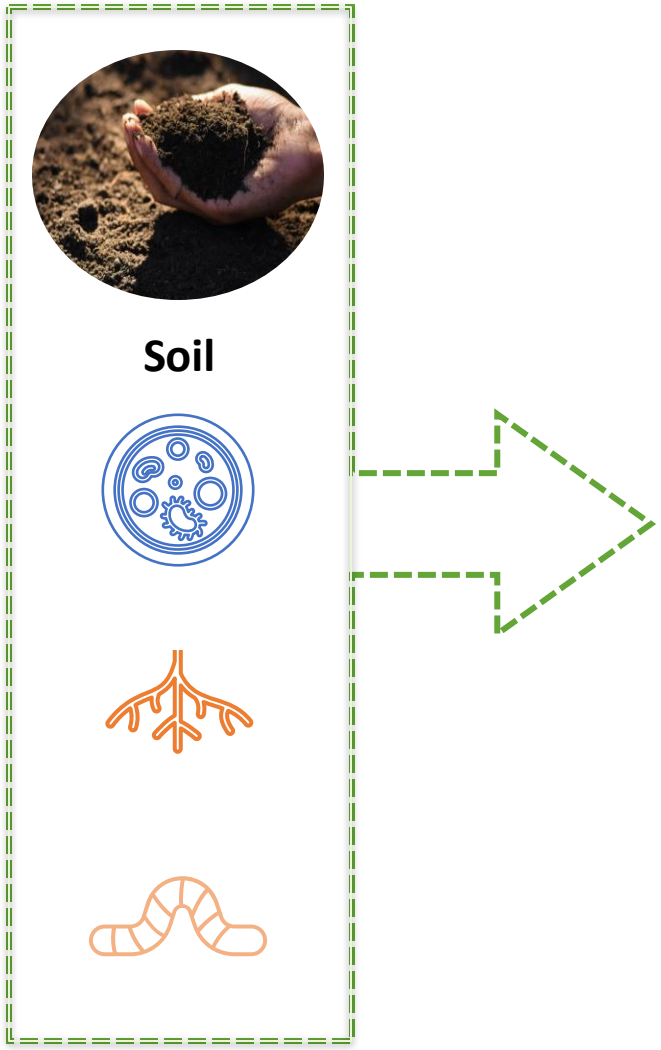
Inês Ferreira

23 June 2023

Fungi as endogenous resources



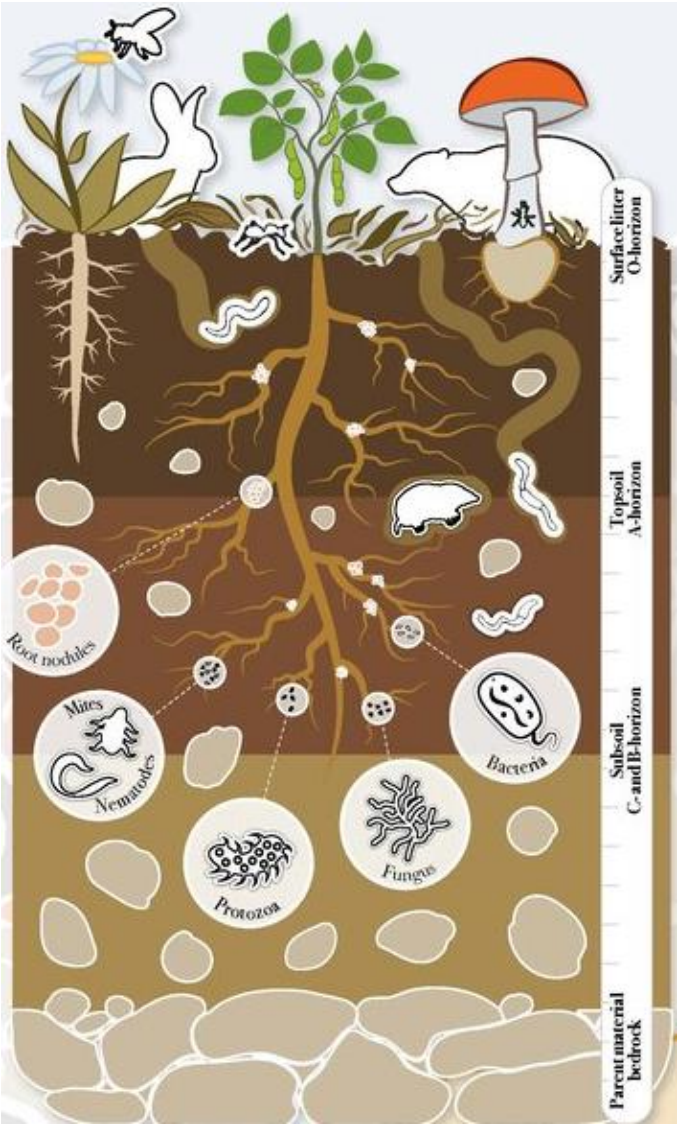
Fungi as endogenous resources



Plants nurture a whole world of creatures in the soil, that in return feed and protect the plants.

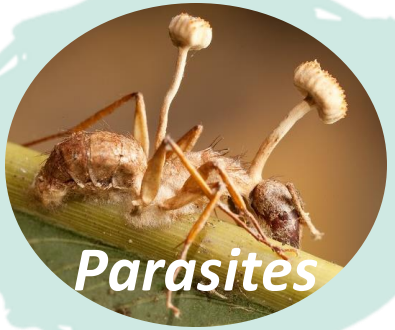
This diverse community of living organisms keeps the soil healthy and fertile.

This vast world constitutes soil biodiversity and determines the main biogeochemical processes that make life possible on Earth.



Fungi - What are they?

Mushrooms are the **fruitbodies** of some fungi.

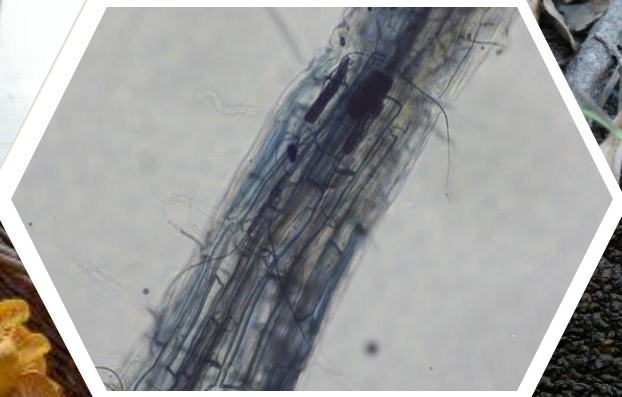


Endogenous resources

Desert Truffles

Wild Saprophytic Mushrooms

Endomycorrhiza



Cultivated mushrooms

Wild Mycorrhizal Mushrooms

Mycelium

Ectomycorrhiza

MUSHROOMS

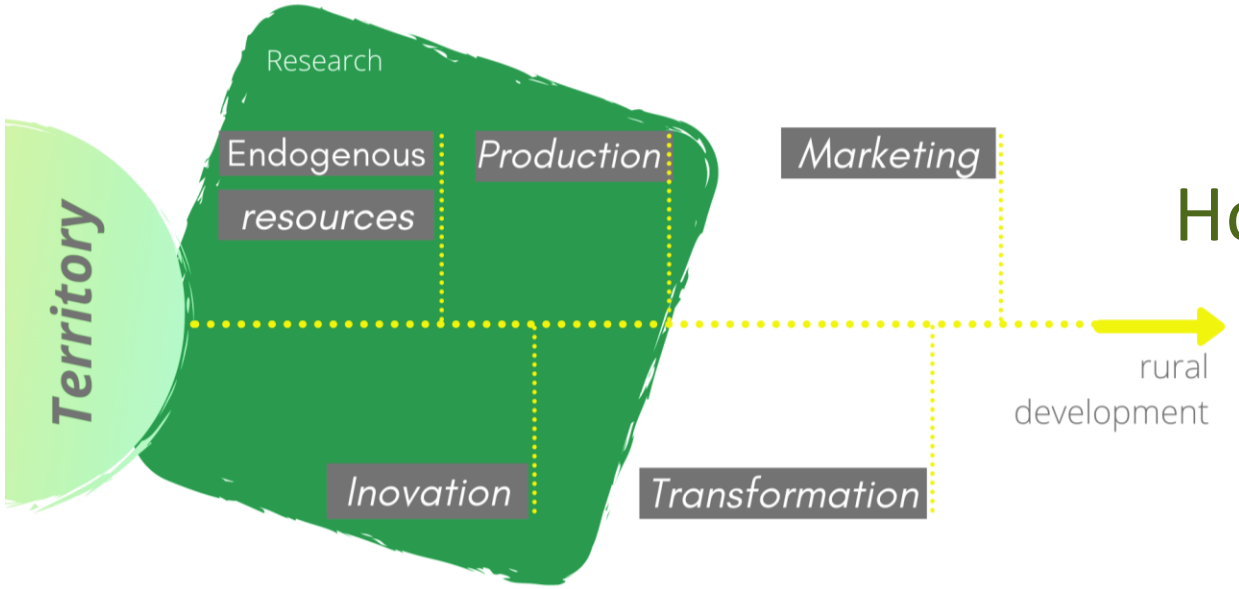
Relevance in the current scenario

It is necessary to find new sustainable forms of food production and innovate in green chemistry

Rural development

Biodiversity

Green biotech



How?

Traditional commercial exploitation

WILD MUSHROOMS

Seasonal product

Mainstream activities

Mycotourism

Wild Mushroom harvest

CULTIVATED MUSHROOMS

Continuous production

Mainstream activities

Production in Small scale

Production in Large Scale

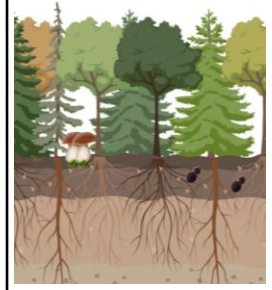
Ectomycorrhizal species authorised for trade in EU countries, commercialised product and market prices

ECM species	N° of EU countries[a]	Commercialized product t/year[b]	Commercialized product Period	Market prices €/kg[b]	Market prices Period	Country	References
Boletus edulis	14	25,000	2014	12	2017	Spain	Bonet et al. (2020); Baars (2017)
		400	1978–2016	7.7	1978–2016	Finland	Tahvanainen et al. (2019)
Cantharellus cibarius	14	2,500	2007	20	2003	Spain	Bonet et al. (2020); de Román and Boa (2004)
		12.6	1978–2016	13.8	1978–2016	Finland	Tahvanainen et al. (2019)
Hydnum repandum	12	700	n.a	9.9	2002	Spain	Bonet et al. (2020); de Román and Boa (2004)
Lactarius deliciosus	14	6,800	1990–1998	13	2002	Spain	Bonet et al. (2020); de Román and Bo, (2004)
		100	1978–2016	4.0	1978–2016	Finland	Tahvanainen et al. (2019)
Terfezia claveryi	2	670	2001–2015	60	n.a.	Spain	Andrino et al. (2019); Oliach et al. (2020)
Tuber aestivum	8	30	2016	50	n.a	Spain	Oliach et al. (2020)
Tuber brumale	6	0.5	2015	120	n.a	Spain	Oliach et al. (2020)
Tuber melanosporum	9	47	2013–2017	550	2016–2017	Spain	Oliach et al. (2020)

Abbreviations: €/kg, Euros per kilogramme; n.a., data not available; t/year, tonnes per year.
[a]Data from Peintner et al. (2013).
[b]Maximum values registered.

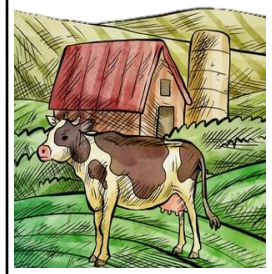
New Applications

Applications:
Production of wild mushrooms, **improvement of biomass production and abiotic stress mitigation**



Forest

Applications:
Production of animal feed



Livestock

Applications:
In Biofertilizers (AM Fungi) and **phytohormones promoting plant growth and enhanced crops**

Crops

Integrated forestry, agriculture and live stock systems

SUBSTRATE

FEED

FERTILIZERS

Industrial level production systems

Fermentation products

Applications:
For food, beverage, medicine, biorefineries and other biotech applications

Solid-state Fermentation

Applications:
In packaging, furniture and composite materials for technological applications

Mushroom Production

Applications:
Introduction of novel species for food, medicine and biocompounds extraction

Ectomycorrhizal Fungi

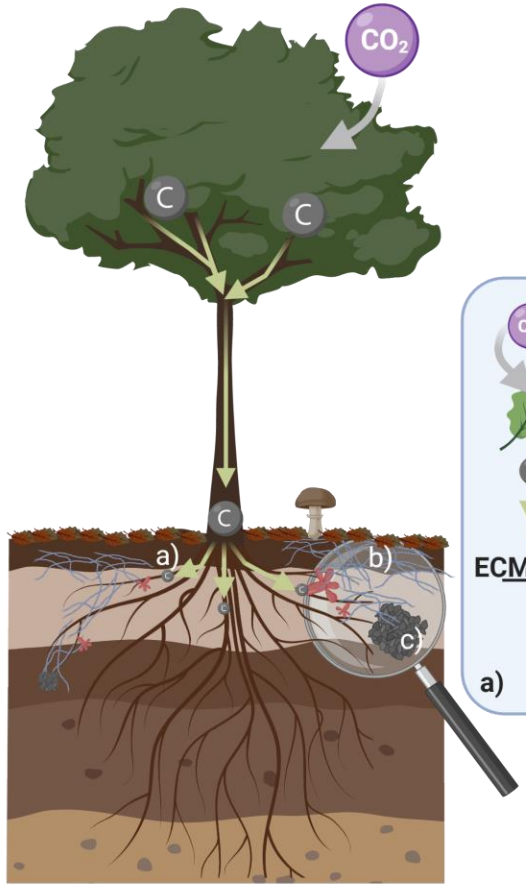
Forestry

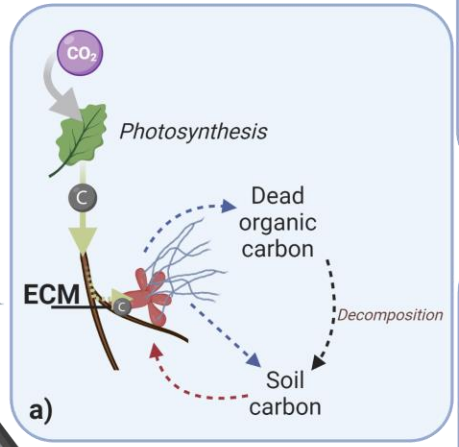
Applications:

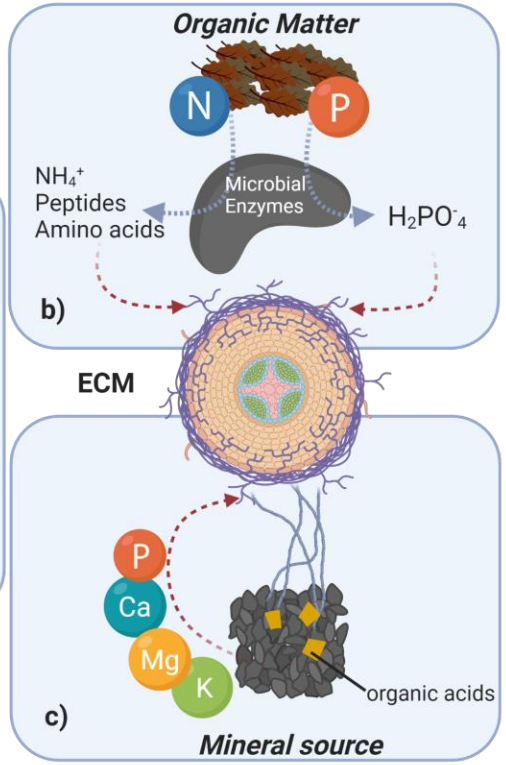
- Production of ***wild mushrooms***
- Improvement of ***biomass*** production
- ***Abiotic stress mitigation***

Ectomycorrhizal structures

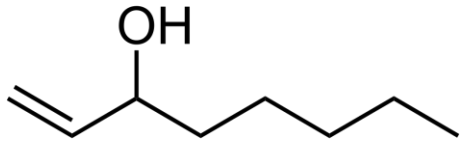
Janowski et al. 2019







Ectomycorrhizal Fungi volatiles



1-octen-3-ol

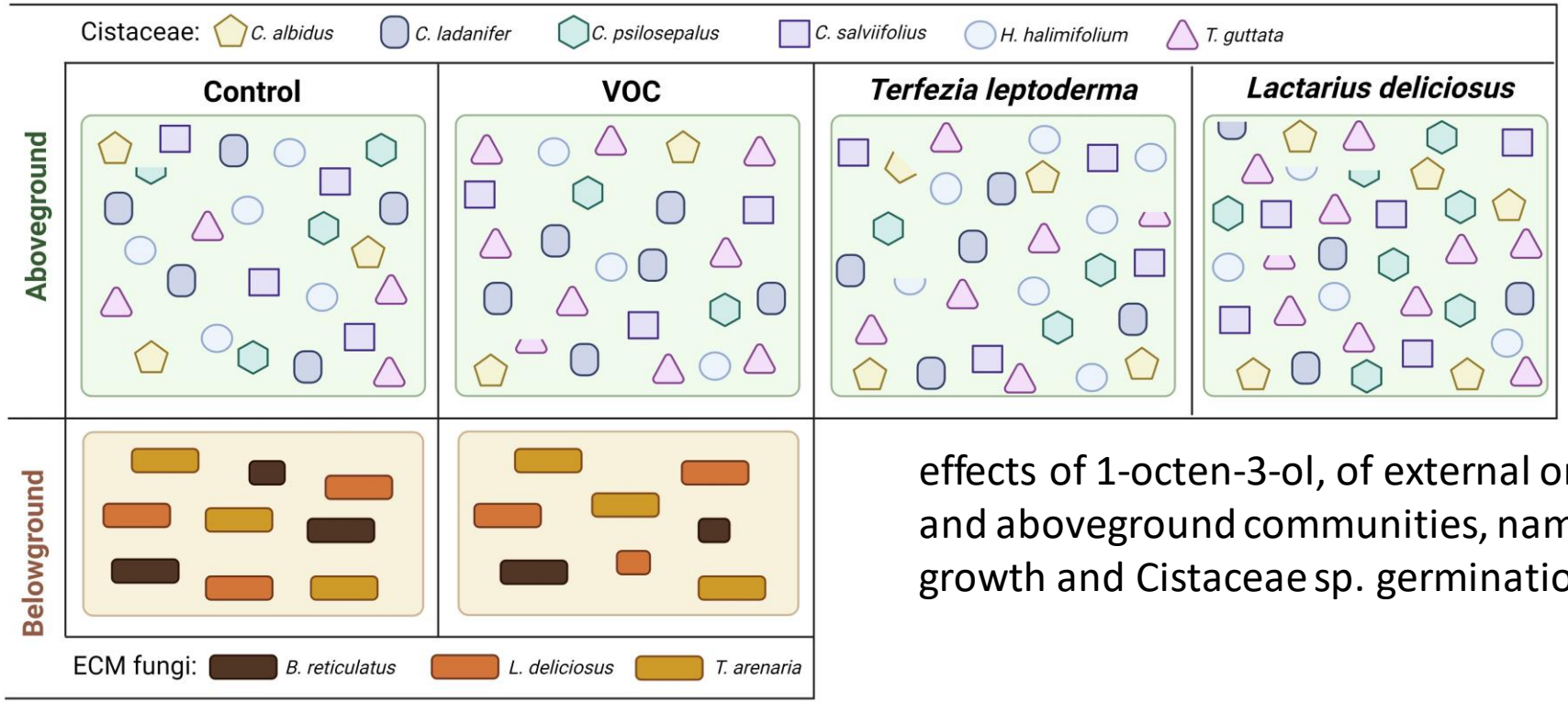
Mushroom alcohol

Journal of *Fungi* MDPI

Article

The Potential of Ectomycorrhizal Fungi to Modulate below and Aboveground Communities May Be Mediated by 1-Octen-3-ol

Inês Ferreira, Teresa Dias * and Cristina Cruz



effects of 1-octen-3-ol, of external or biogenic origin, on below and aboveground communities, namely on the ECM mycelial growth and Cistaceae sp. germination.

Forestry

From lab to nursery

ECM fungi inoculum

ECM sporocarp

Sporocarp powder

Pure culture

Spores inoculum

Solid mycelium

Liquid mycelium

Plant inoculation

Plants *in vivo*

Plants *in vitro*

From nursery to field

Mycorrhiza establishment

Aclimatization

Mycorrhiza evaluation

Field establishment

Forest management

≠ ECM species
≠ Hosts
≠ Ecosystems

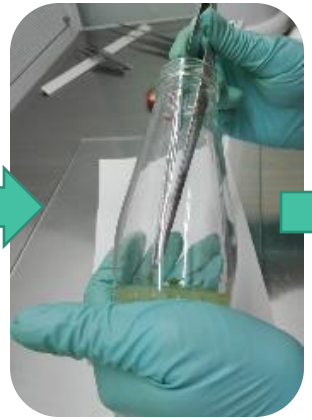
≠ management guidelines and practices

Climate
Plant hosts
ECM species
Density and canopy
Clearing, cutting and thinning
Site characteristics and landscape
Plantation or natural regeneration

Mycosilviculture

NURSERY PRODUCTION

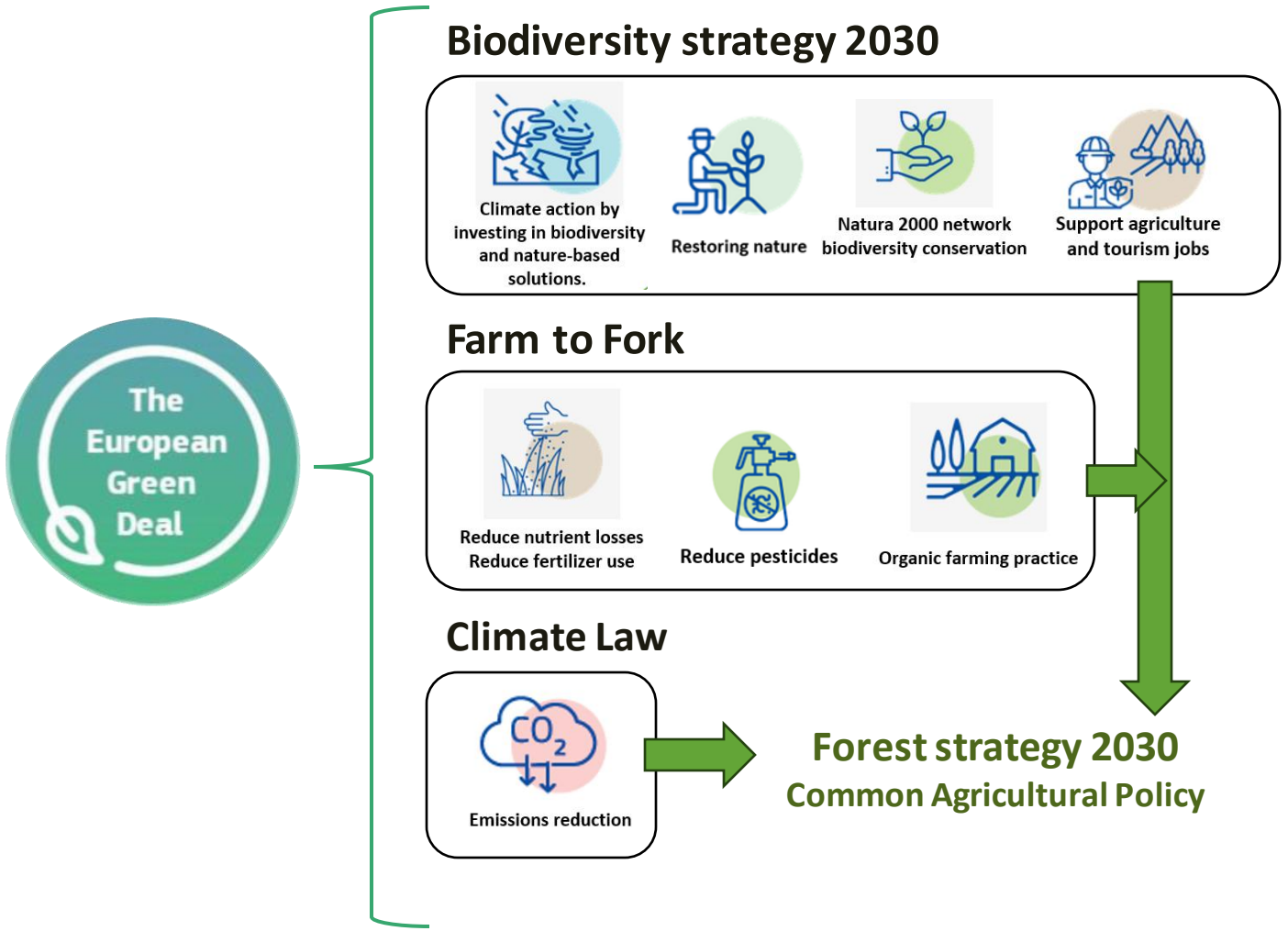
GREENCLON PLANTAS



Tuber melanosporum

Lactarius deliciosus

Ectomycorrhizal Fungi and European Green Deal



ECM Fungi contributions

Biodiversity

Soil quality

CO_2 Sequestration

Nutrient cycle

Plant health

Biocompounds

Food resources

Nutritional proprieties

Micotourism

Cultural values

Bioeconomy

Rural Development

Biofertilizers and precision agriculture

New EU Forest Strategy 2030

Forest resilience to climate changes

Increase carbon sequestration in soils and forests

Restoration of degraded ecosystems

Ectomycorrhizal Fungi

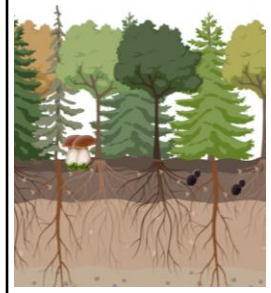
Promoting the bioeconomy and simultaneously preserving biodiversity

Supporting sustainable food production

New target to restore and expand EU carbon sinks by 2030:

New Applications

Applications:
Production of wild mushrooms, **improvement of biomass production and abiotic stress mitigation**



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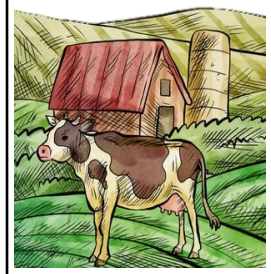

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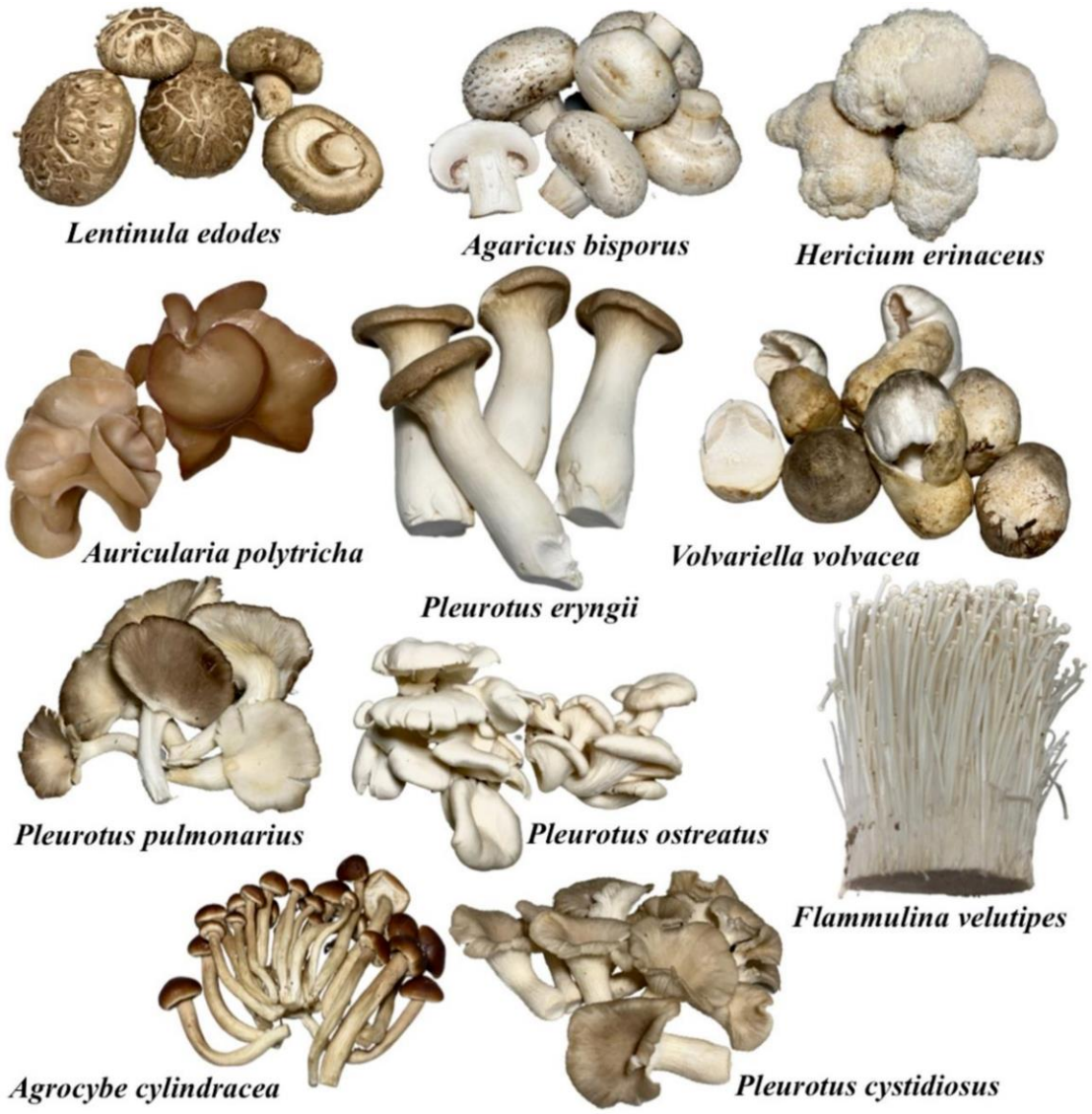
Mushroom Production

Applications:

- Introduction of ***novel species*** for food or other applications
- **Biocompounds** extraction from by-products

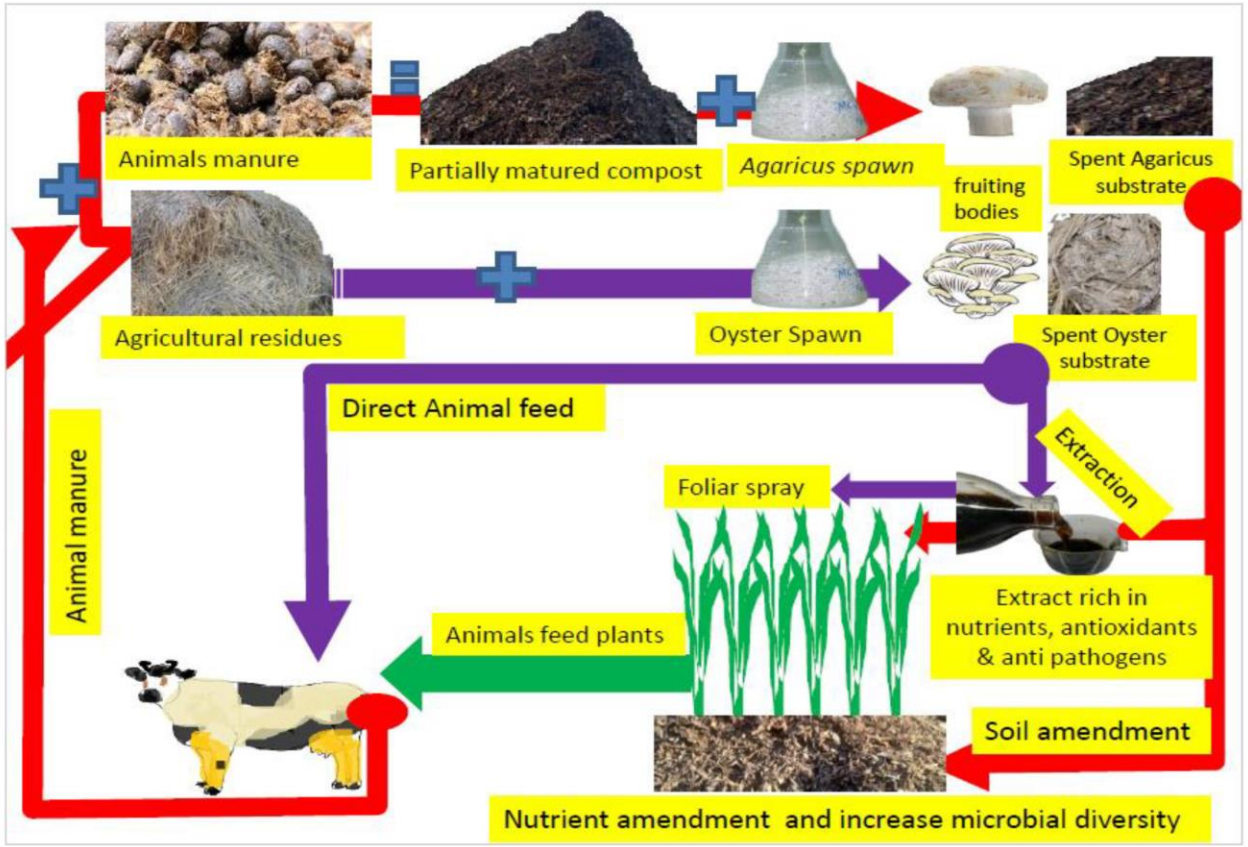
25 species cultivated worldwide



Applications:

- Biofertilizers (AM Fungi)
- Spent Mushroom substrate as plant substrate
- Mushroom metabolites

Organic pots made of residual substrate from *Ganoderma lucidum* cultivation



Elsakhawy et al. 2022

Conclusion

- Ectomycorrhizal and Saprophytic fungi → **BIOECONOMY**
  - **Contribute to CIRCULAR ECONOMY**

- CAP (Common Agricultural Policy) and the 2030 Forest Strategy
  - *Social, environmental and economic sustainability in agriculture and forestry*
  - *Promote bioeconomy in rural areas.*

- Fungi → Nature-based solutions for Europe's sustainable development
  - European Green Deal and integrate them into the strategies:
    - *Farm to Fork, Biodiversity Strategy 2030, Climate Law, CAP*

- **New cultivation methodologies**
  - *Mitigating impacts* and species adaptation *to climate change*
    - Achieve **carbon neutrality**

More than 10,000 known species worldwide!

… a (in)finite resource?

Thank you

Biofertilizers and Precision Agriculture

Inês Ferreira

23 June 2023