MYCORRHIZAS

Bob Edmonds
Professor, Forest Soil Ecology and Forest Pathology

CFR 522
Winter 2011

References

Bothe, H., K. Turnau, and M. Regvar. 2010. The potential role of arbuscular mycorrhizal fungi in protecting endangered plants and habitats. Mycorrhiza 20:445-457.

Gianinazzi, S., A. Gollottee, M-N. Binet, D. van Tuinen, D. Redecker, and D. Wipf. 2010. Agroecology: the key role of arbuscular mycorrhizas in ecosystem services. Mycorrhizas 20:519-530

Smith, S.E. and D.J. Read. 2008. Mycorrhizal symbiosis. 3rd ed. Academic Press, New York.

Tedersoo, L., T.W. May and M.E. Smith. 2010. Ectomycorrhizal lifestyle in fungi: global diversity, distribution, and evolution of phylogenetic linkages. Mycorrhiza 20:217-263.

Web site – Steve Trudell

http://www.mykoweb.com/articles/index.html#apm1_4

THE BELOWGROUND ECOSYSTEM – Hard to study

Lecture Topics

1. Types and roles of mycorrhizas

2. Ectomycorrhizal diversity

3. Roles of arbuscular mycorrhizas in ecosystem service and protecting endangered plants and habitats

4. Practical uses of mycorrhizas

1. Types of mycorrhizas

MYCORRHIZA

Greek – Root + Fungus

(fine root/fungal muutalistic symbiotic association)

Mycorrhizas are old –
been around 460 million years

Types of Mycorrhizas

- Ectomycorrhizas (ECM)
- Arbuscular (AM)
- Ectendomycorrhizas
- Ericoid
- Arbutoid
- Monotropoid
- Orchid

Fungal Phyla

- Basidiomycota – mushrooms, puffballs,etc
- Ascomycota – truffles
- Glomeromycota

Thousands of species of ectomycorrhizal fungi (Basidiomycota and Ascomycota– on relatively few plant species) – 2000 spp. of fungi on Douglas-fir roots

Relatively few species of arbuscular fungi (AM) (Glomeromycota) – on most plant species

Most plant species are mycorrhizal (86%)

Non mycorrhizal plants – aquatic, mustard family, many early successional plants

- plant provides sugars to fungus
- fungus provides nutrients and water to plants and protects plants against pathogens, water stress, heavy metals

Types of mycorrhizas and plant families

- Ectomycorrhizas – Pineacea, Betulaceae, Fagaceae, Nothofagaceae, Myrtaceae, Dipterocarpaceae
- Arbuscular– most plant families
- Ericaceous – Ericaceae – Erica to Vaccinium
- Ectoendo – Pinaceae
- Arbutoid – Ericacaea - *Arbutus*, *Arctostaphylos* and *Pyrola*
- Orchid – Orchidaceae
- Monotropoid - Monotropaceae

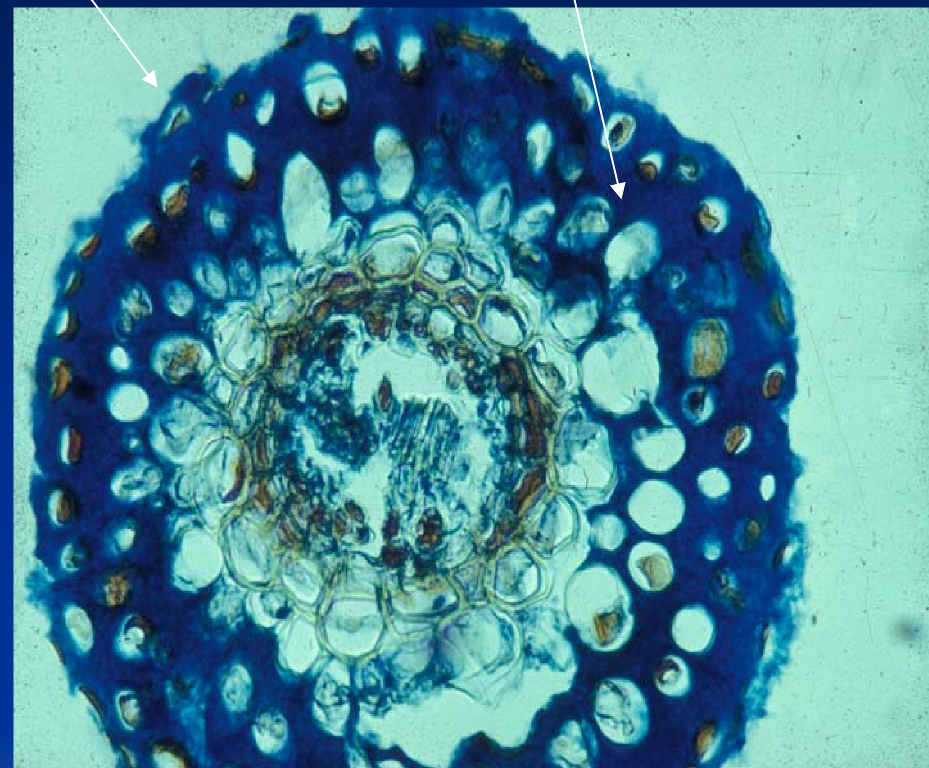
ECTOMYCORRHIZA (EcM)

Hyphae (with crosswalls –septate) do not penetrate plant cell walls

Two ectomycorrhizal fungi forming mantle on same fine root

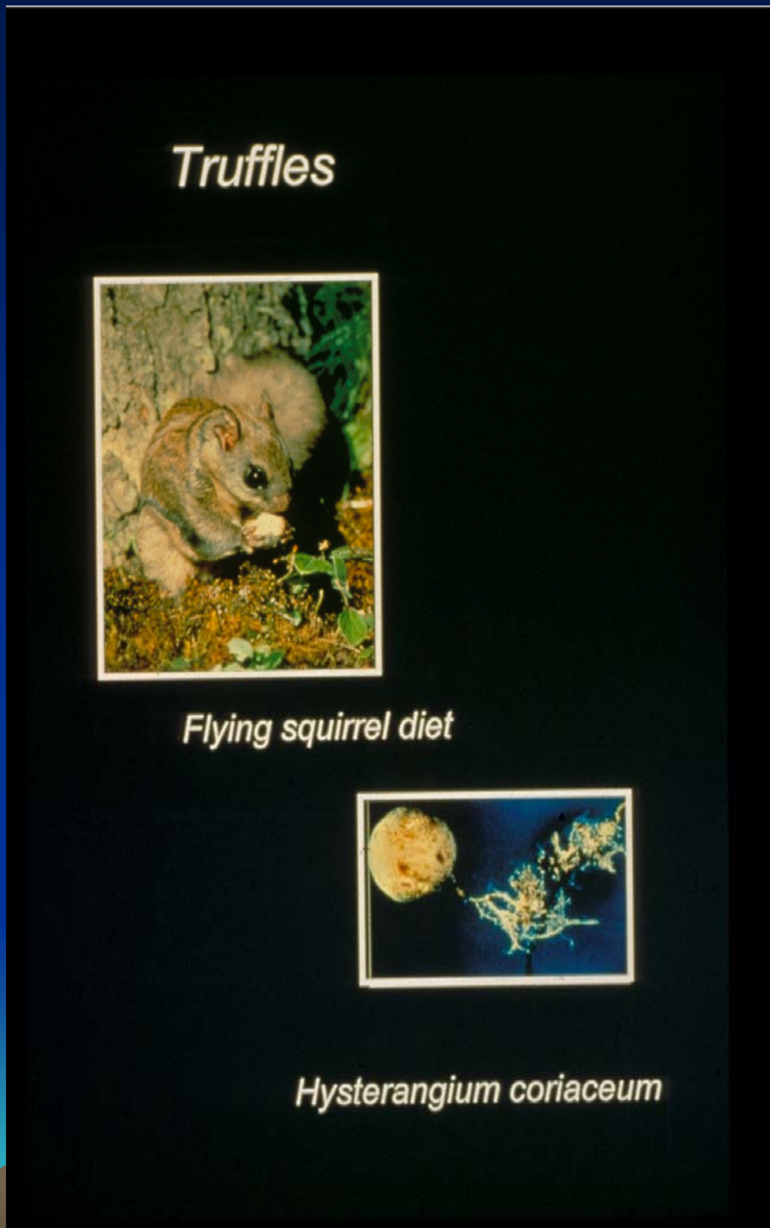
Mantle

Hartig net



Cross section of Douglas-fir fine Root showing ectomycorrhizal mantle and Hartig net

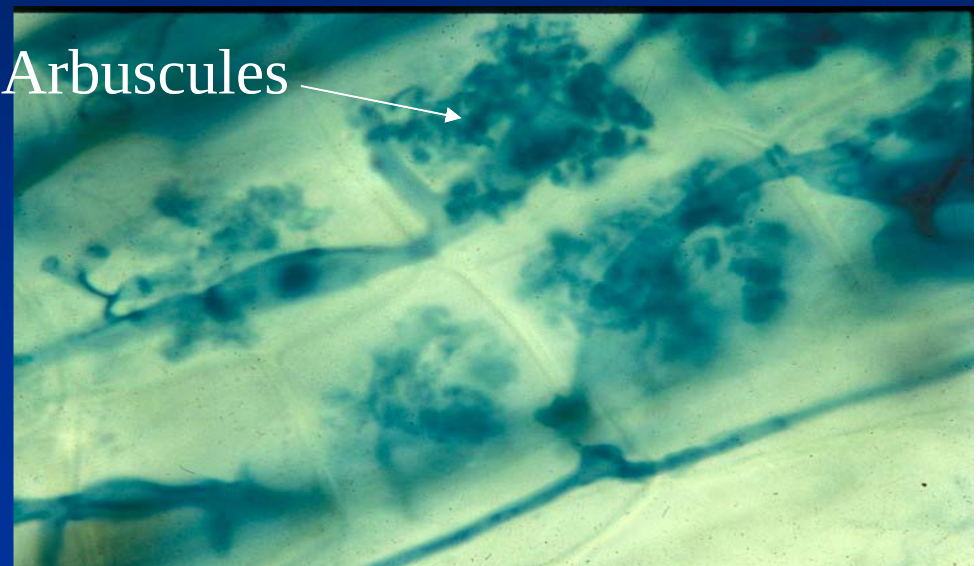
Mostly reproduce by sexual spores



Belowground ectomycorrhizal fungi – spores spread by small mammals eating fruiting bodies (truffles)

Arbuscular mycorrhiza (AM)
(Vesicular arbuscular mycorrhizas)
No mantle, no Hartig net
Reproduce asexually - spores

Arbuscules



Hyphae (without crosswalls) penetrate cell wall, but not cell membrane

Large spores

Vesicles

How do mycorrhizal fungi find and colonize roots?

- Probably through mechanisms similar to nodulation of N fixing plants – recognition of chemical signals.

2. ROLES OF MYCORRHIZAS

a. Benefits to plants

Increase plant nutrient supply by increasing root surface and acquiring nutrient forms (organic) normally available.

Protection from parasitic fungi and nematodes

Improving water relations and phytohormones

b. Other roles in ecosystems

Soil hyphae may prevent nutrient losses from the system, especially at times when roots are inactive.

Hyphae are conduits that may transport carbon from plant roots to other soil organisms involved in nutrient cycling processes .

Provide food for mammals and invertebrates

c. Values to people

ECM fungi are economically and nutritionally important as human food resources. These mushrooms have also have been used as medicines and natural dyes. Fungi have aesthetic values and are an important part of the as culture, folklore and appreciation of nature by many people

Fungal diversity is a bio-indicator of environmental quality.

Fungi which have adapted to local soil conditions are required for agriculture, horticulture and forestry. (can’t grow N. hemisphere plantation conifers in S. hemisphere without their native mycorrhizal fungi)

Carbon and mycorrhizas

Relationships between net primary production (NPP) and mycorrhizas

In high elevation Pacific silver fir ecosystems mycorrhizal fungi contribute roughly 1% of the total ecosystem biomass. In mature stands mycorrhizal fungi contribute ~15% of NPP and mycorrhizal fungi plus conifer roots contribute 75% of NPP. Most of the C fixed in photosynthesis goes belowground.

In these forests trees really need help getting nutrients

Transfer of carbon from one tree species to another (birch to Douglas-fir) via a common mycorrhizal fungal network -
an argument for biodiversity in managed forest ecosystems

(Simard et al.)

Mycorrhizal mat in the Olympic rain forest
-yellow fungus is Piloderma

2. Diversity of Ectomycorrhizal Fungi

Basidiomycetes

Suillus sp.

Typical ectomycorrhizal fruiting bodies (sporocarps) – mushrooms (Basidiomycota)

Ectomycorrhizal lifestyle

- Only 6000 out of estimated 220,000 – 420,000 plant species
- Only 20,000-25,000 out of estimated 1,500,000 fungal species
- Oldest EcM root fossils 50 Million years
- Majority evolved from humus and wood saprotrophic fungi without reversals
- Three main lineages

  Holarctic – largest

  Austral

  Panglobal

Ectomycorrhizal roots
Morphotypes

Morphotypes

Amy Honan

Mycorrhizas and Plant Succession

Mycorrhizal fungi change with stand age in Pacific Northwest Douglas-fir/hemlock forests

Laccaria laccata

Cantherellus formosus

Russula xerampelina

Young forests

Mature and old-growth forests

Photos – Canadian Forest Service

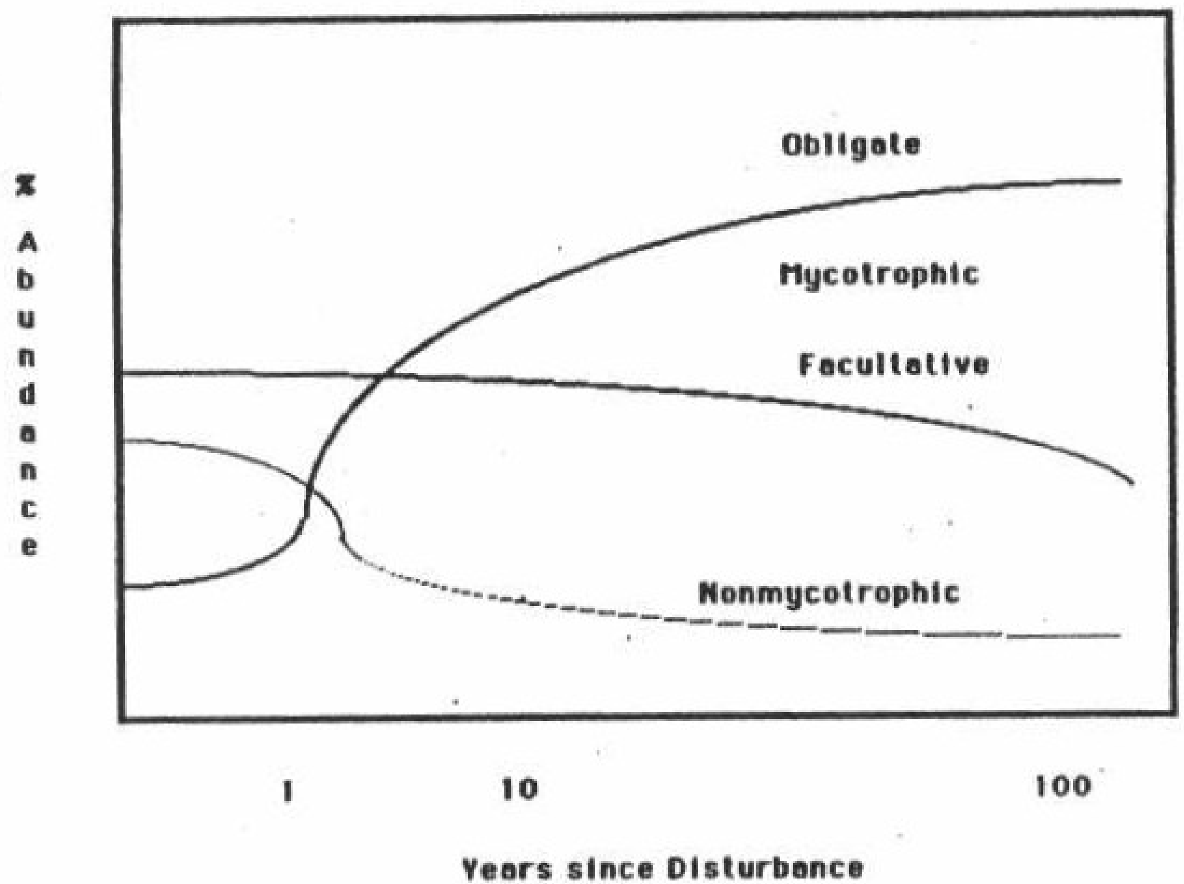
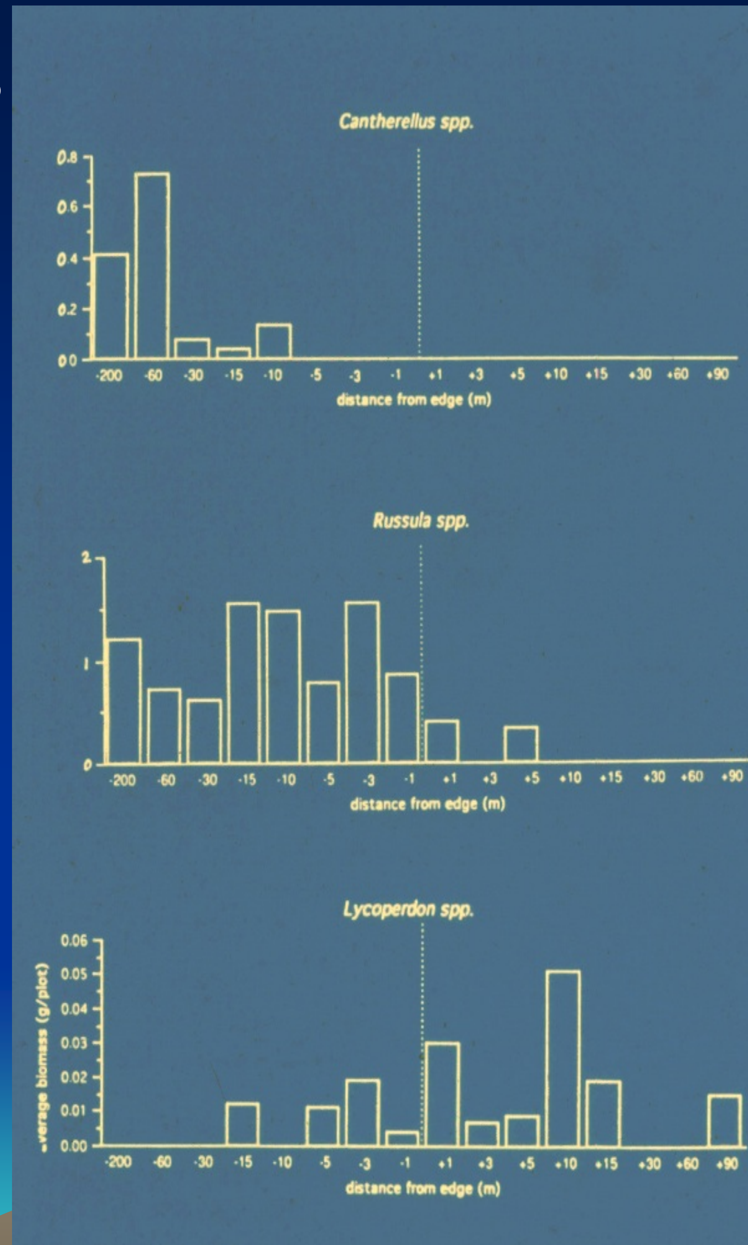


Figure 7.1. A model of succession derived from Janos (1980) using the mycorrhizal categories proposed by Stahl (1900).

Molina

Effects of forest edges
-Grace Sparks



Tools for studying mycorrhizal fungi

a. Molecular

PCR

Sequencing- ITS - rRNA gene

b. Stable isotopes of C and N

Green tree retention forestry – Cedar River Watershed

Erica Cline

Green tree retention

- Seedlings near (2-6 m) residual Douglas-fir trees had more mycorrhizas (4.1 taxa per seedlings and 42 total taxa) than seedlings far (16-30 m) from trees (3.5 taxa per seedling and 33 total taxa) – PCR/RFLP – ITS rRNA gene

Stable isotopes

- ^{13}C
- ^{15}N

Stable isotopes of C and N
Steve Trudell

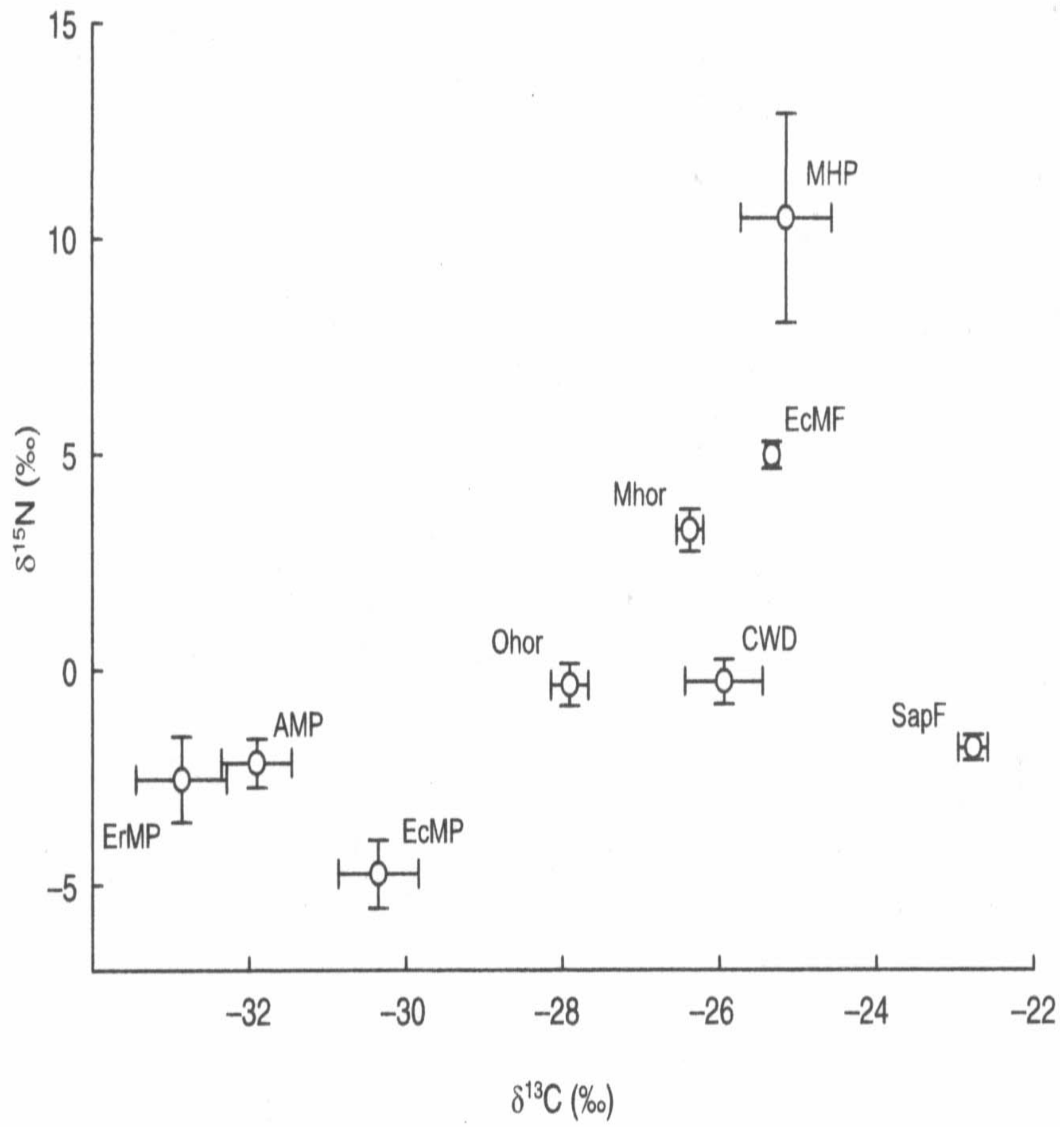


Fig. 1 Nitrogen and carbon stable isotope values for nine ecosystem pools from two areas – upper Hoh River Valley (Hoh) and lower Deer Park Road (DP) – Olympic National Park, Washington, USA. Data points represent means, error bars 95% CI. Sample types and *n* for each pool are given in Table 3. AMP, arbuscular mycorrhizal plants; CWD, coarse woody debris; EcMF, ectomycorrhizal fungi; EcMP, ectomycorrhizal plants; ErMP, ericoid mycorrhizal plants; Mhor, upper mineral soil; MHP, myco-heterotrophic plants; Ohor, soil O-horizon; SapF, saprotrophic fungi.

3. Roles of arbuscular mycorrhizas in ecosystem services and protecting endangered plants and habitats

- AM fungi increase soil stability – glomalin
- AM fungi reduce the need for phosphate fertilizer inputs – reduce expense
- AM fungi increase crop plant tolerance against abiotic stresses – drought, salinity, heavy metals
- AM fungi protect plants against biotic stresses - pathogens
- AM enhance plant quality for human health – Zn, secondary metabolities
- Many invasive species upset mycorrhizal associations of endangered plants
- Modified habitats – excess N deposition, mine spoils, reduce mycorrhizal associations
- AM fungi determine plant community structure in endangered habitats

4. Practical uses of mycorrhizas

- Mine spoil reclamation
- Establishing northern hemisphere trees in the southern hemisphere
- Improving growth of agricultural plants
- Protecting against fine root diseases - nurseries


Without mycorrhizal application
WITH mycorrhizal application

Holden Copper mine restoration – Lake Chelan, WA

- Aspen tends to colonize mine spoils because of natural mycorrhizal fungi that tolerate low pH, heavy metals, drought, low nutrients

Aspen mycorrhizas on smelter impacted sites

Anaconda Cu smelter, MT

30 species of native mycorrhizal fungi grew on these sites
Laccaria proxima, Tricholoma flavovirens, T. populinum, Scleroderma cepa, Paxillus vernalis

Trail lead smelter, BC

Cathy Cripps Montana State University

Pisolithus tinctorius

Commercially available mycorrhizal fungi

Plant Success

<u>Contains :</u>

Propagules/g	Mycorrhizal fungus
	Ectomycorrhizal
12,510	Pisolithus tinctorius
317	Rhizopogon rubescens
317	Rhizopogon fulvigleba
317	Rhizopogon villosulus
317	Rhizopogon subcarelescenz
	Arbuscular mycorrhizal
246	Glomus intraradices
246	Glomus aggregatum
246	Glomus mosseae

Fungi Perfect Mycogrow

Non-myc Myc

- **Contains concentrated spore mass of the following:**
- **Endomycorrhizal fungi** *Glomus intraradices, Glomus mosseae, Glomus aggregatum, Glomus etunicatum*
- **Ectomycorrhizal fungi** *Rhizopogon villosullus, Rhizopogon luteolus, Rhizopogon amylopogon, Rhizopogon fulvigleba, Pisolithus tinctorius, Scleroderma cepa, Scleroderma citrinum*

GreenGro™ Ultra-Fine Mycorrhizae
Breathe Life Into Your Soil.™
Green Gro
ULTRA-FINE
Mycorrhizae
breathe life into your soil
Water Soluble Micronized Inoculants
Premium Ingredients:
Norwegian Kelp Extract
Rare Earth Humates
endomycorrhizae
Beneficial Bacteria
Green Gro™
Product Information:
Increases:
Growth Potential
Fruiting & Flowering
Nutrient Storage and Uptake
Decreases:
Drought Stress
Water & Fertilizer Needs
Pest Damage
Promotes:
Extensive Root Systems
Sustainable Agriculture
Uses:
Indoor & Outdoor
Hydroponic
Greenhouse
PO Box 976
Windsor Ca 95492
(866) 884-6803
www.thegreengro.com
sales@thegreengro.com


EARTH JUICE
Rooter's
Mycorrhizae
Hydroponics & Soil
HydroOrganics


Killer Roots for Killer Plants
Great White
Premium Mycorrhizae
Beneficial Bacteria & Trichoderma
Net Weight
4 oz. / 113.4 grams


HydroOrganics
products
farm garden hydroponics
ROOTER'S
MYCORRHIZAE
Super Pack
endo/ecto mycorrhizae blend
Mycorrhizae Exp Date:
06-2010
Net wt 1 lb / 454 gms