Mycorrhizae, Gesundheit

- Definition
- Mycorrhizal types
- What do they look like?
- What do they do?
- Ecological Significance
- Mycorrhizal Research

Definition of Mycorrhizae

Myco = fungus

rhiza = root

<u>Mycorrhizae</u> = symbiosis between fungi and plant roots

Mycorrhizal Types

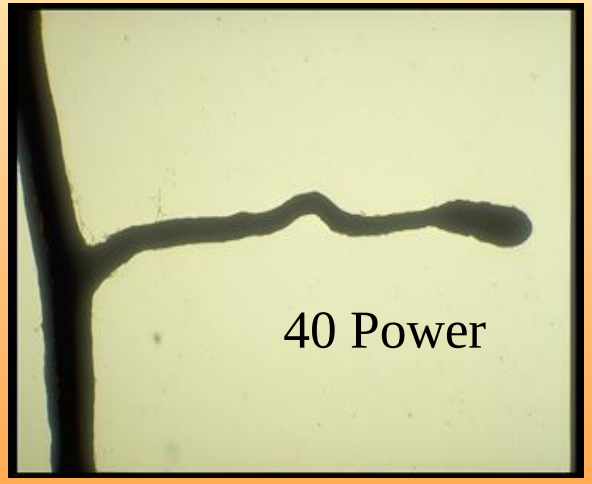
1. Ectomycorrhizae
2. Endomycorrhizae or Vesicular Arbuscular Mycorrhizae (VAM)
3. Ectendomycorrhizae or Ericoid
4. Orchid Mycorrhizae (parasitic)

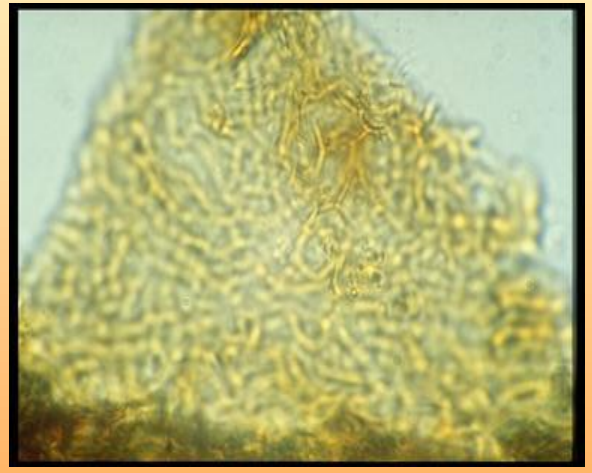
What do they look like?

•<u>Ectomycorrhizal Families:</u> Pinaceae, Fagaceae, Betulaceae, Salicaceae

–Mantle made of hyphae

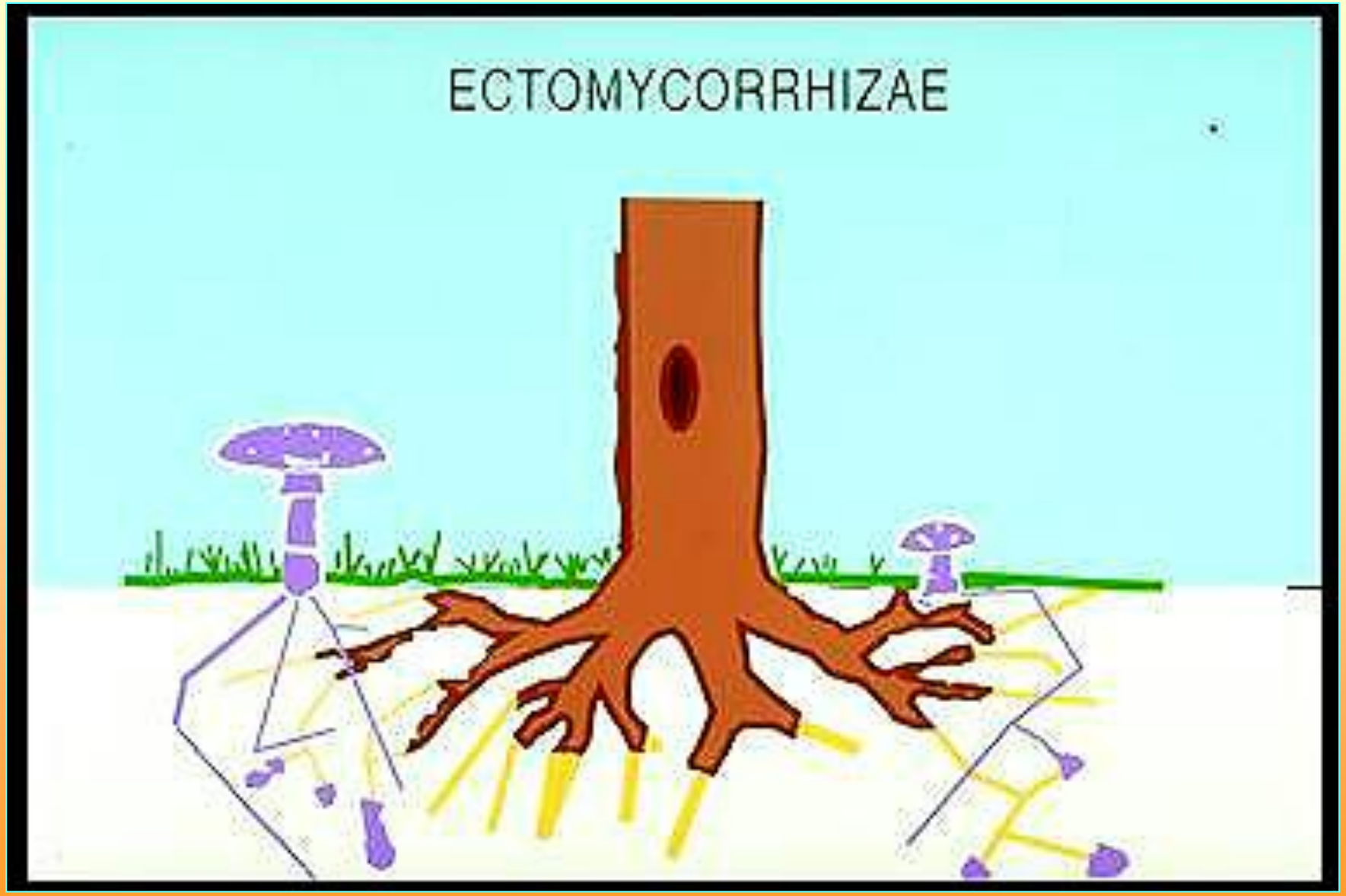
•Hartig net





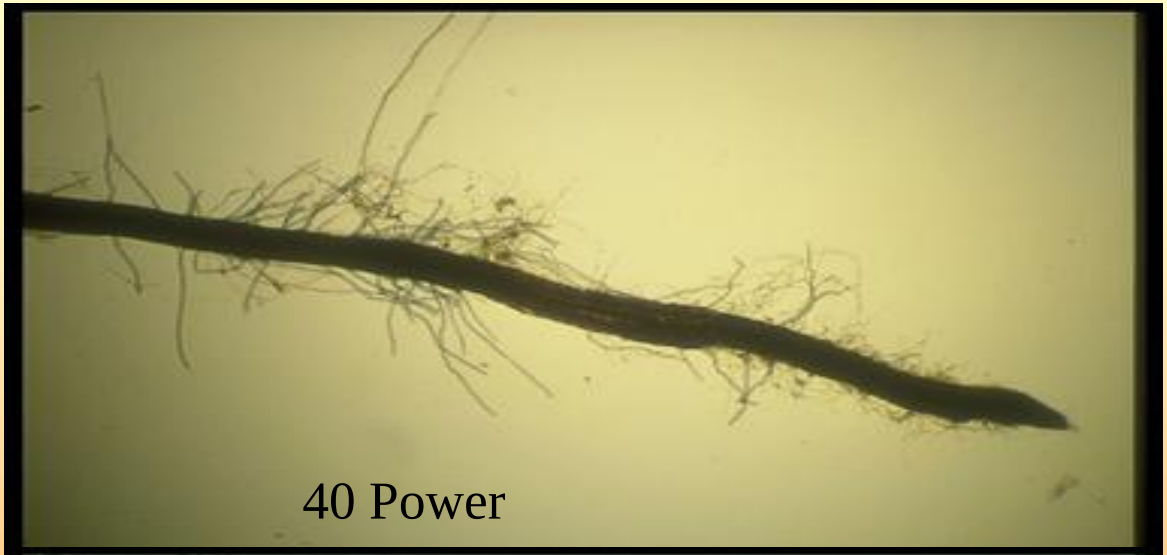
–Septate hyphae: D. Ascomycota and D. Basidiomycota (clamp connections)

*Photos from Masters Thesis UAF



*Cartoon from Masters Thesis UAF

What do they NOT look like?

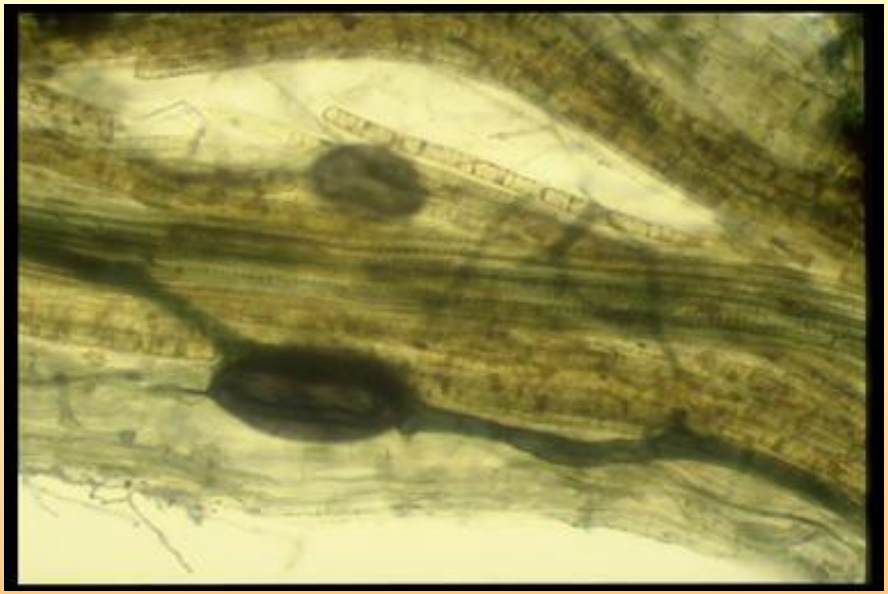


Uninfected salicaceous fine roots

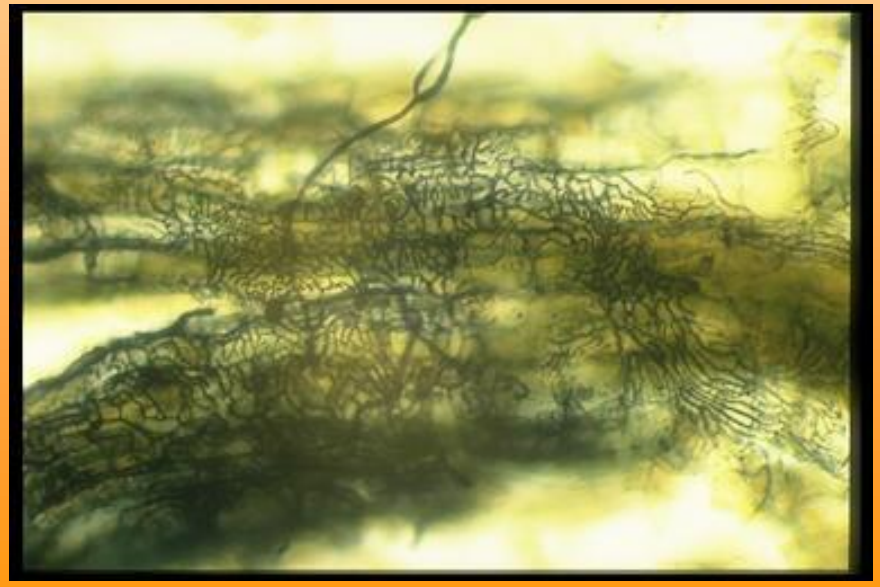
*Photos from Masters Thesis UAF

What do they look like?

- <u>Endomycorrhizae</u>
  - –Vesicles



  - –Arbuscules
  - –Non-septate hyphae
    - D. Zygomycota



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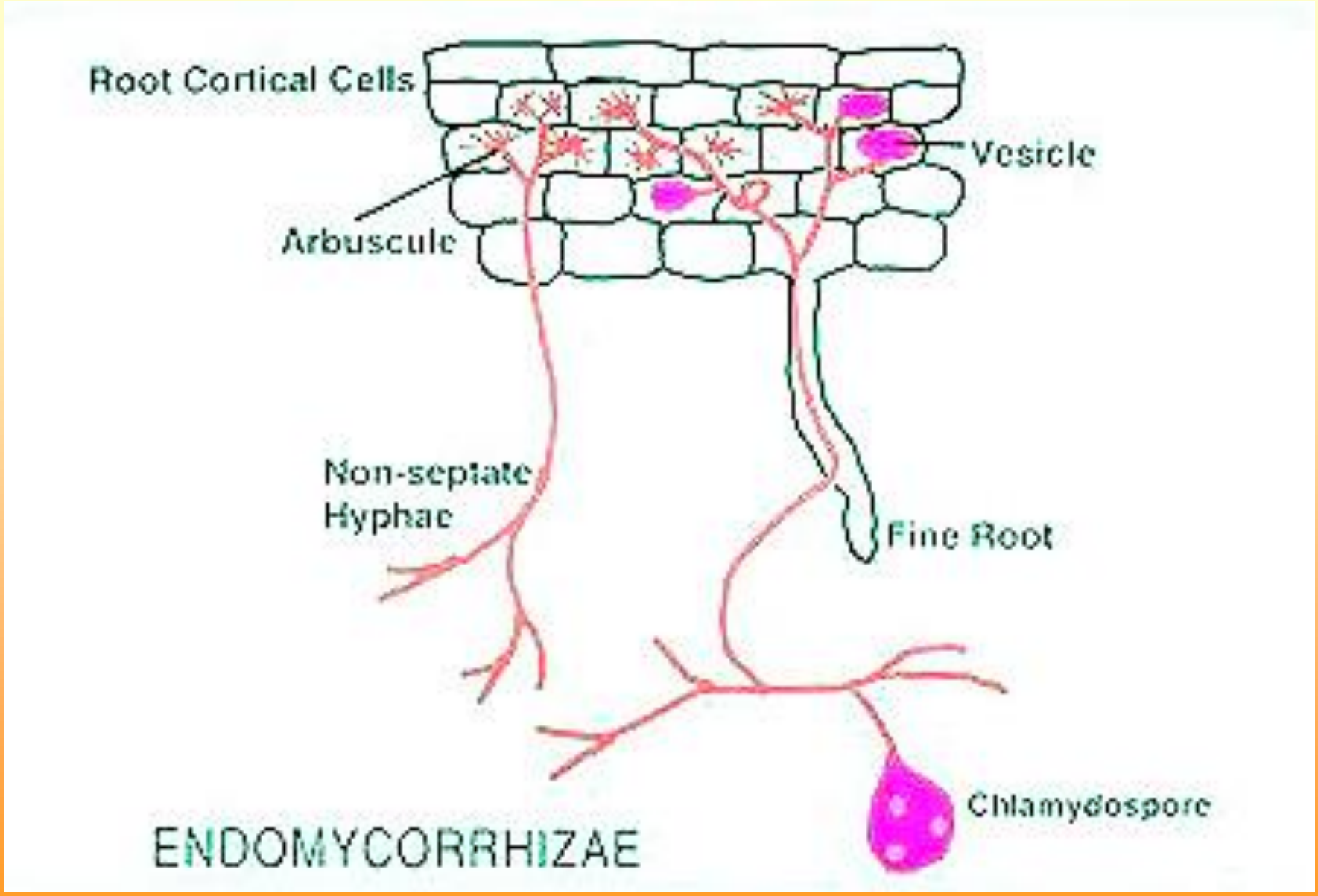


*Cartoon from Masters Thesis UAF

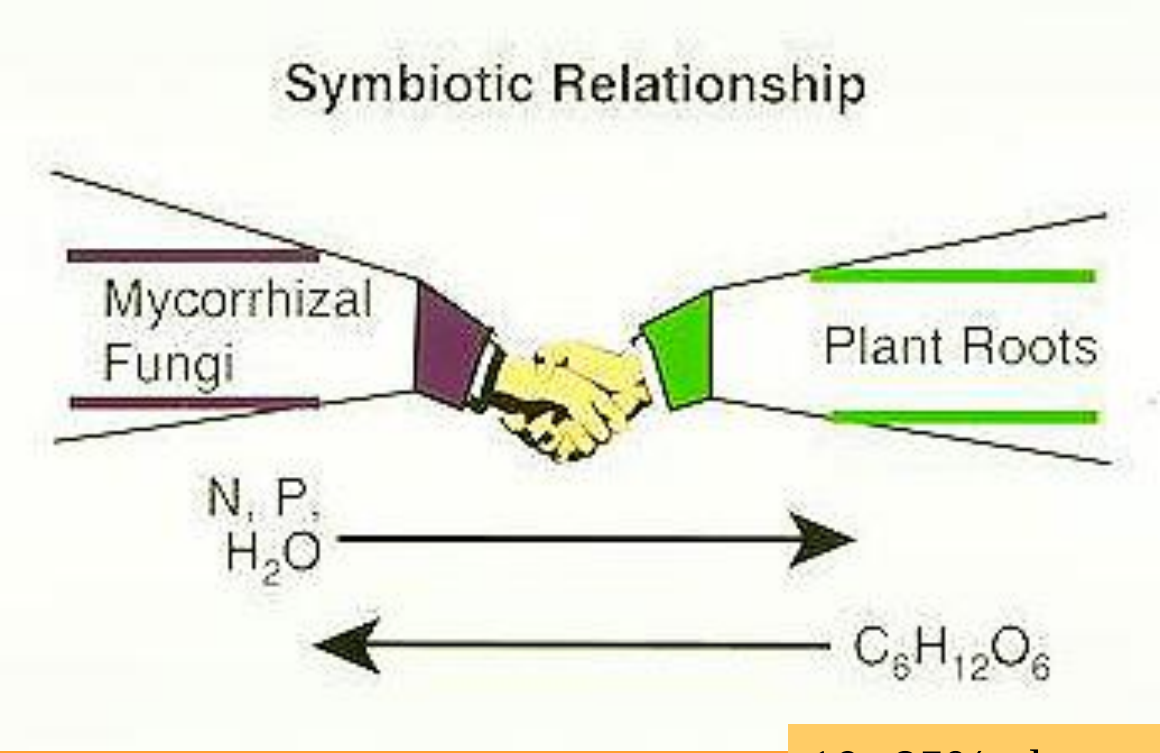
How Do Mycorrhizae Function?

- Fungal hyphae release enzymes (chitinase, peroxidase, cellulase, protease) which allows them to digest and penetrate substrates.
- Secretion of enzymes breaks down tough organic substrates that can then be absorbed and used by the fungus and/or host plant as energy and nutrient sources for growth and reproduction.

(Laursen 1985)

Function of Mycorrhizae: Benefits to Plants

•Hyphae increase surface area of roots for increased absorption of soil nutrients: Nitrogen, Phosphorus

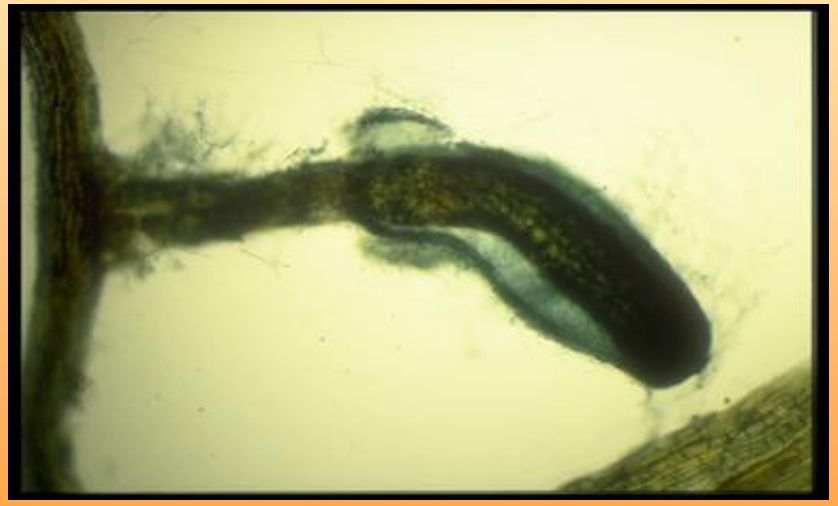


10 -85% photosynthates made (Finlay and Söderström 1992)

Function of Mycorrhizae: Benefits to Plants

•Increase water uptake and aid drought resistance to plants

•Resistance to some root pathogens due to thick hyphal mantle



•Increase plant tolerance to soil temperature extremes, pH extremes, toxic heavy metals, and transplant shock

Function of Mycorrhizae: Benefits to World Agriculture

- Aid in plant establishment on nutrient poor soils (mining reclamation and revegetation projects)
- Increase plant size in short time period (forestry)
- Reduce fertilizer requirements
- Cut down production costs
- Decrease fertilizer contamination of the environment

Ecological Significance

- Plants of different families or genera can share the same mycorrhizal connection.
  - Cheating potentials
- Tripartite associations: ectomycorrhizae, endomycorrhyzae, AND nitrogen fixing nodules on the same root (Forest Soils Lab, Corvallis)
- Holistic ecology: linking Northern Spotted Owl to Old Growth Forests to their flying squirrel prey who feed on the mushrooms from the mycorrhizae that form specifically on Old Growth tree roots. Take one out of the link, and the other three in the system fail: owl, squirrel, mycorrhizae, tree

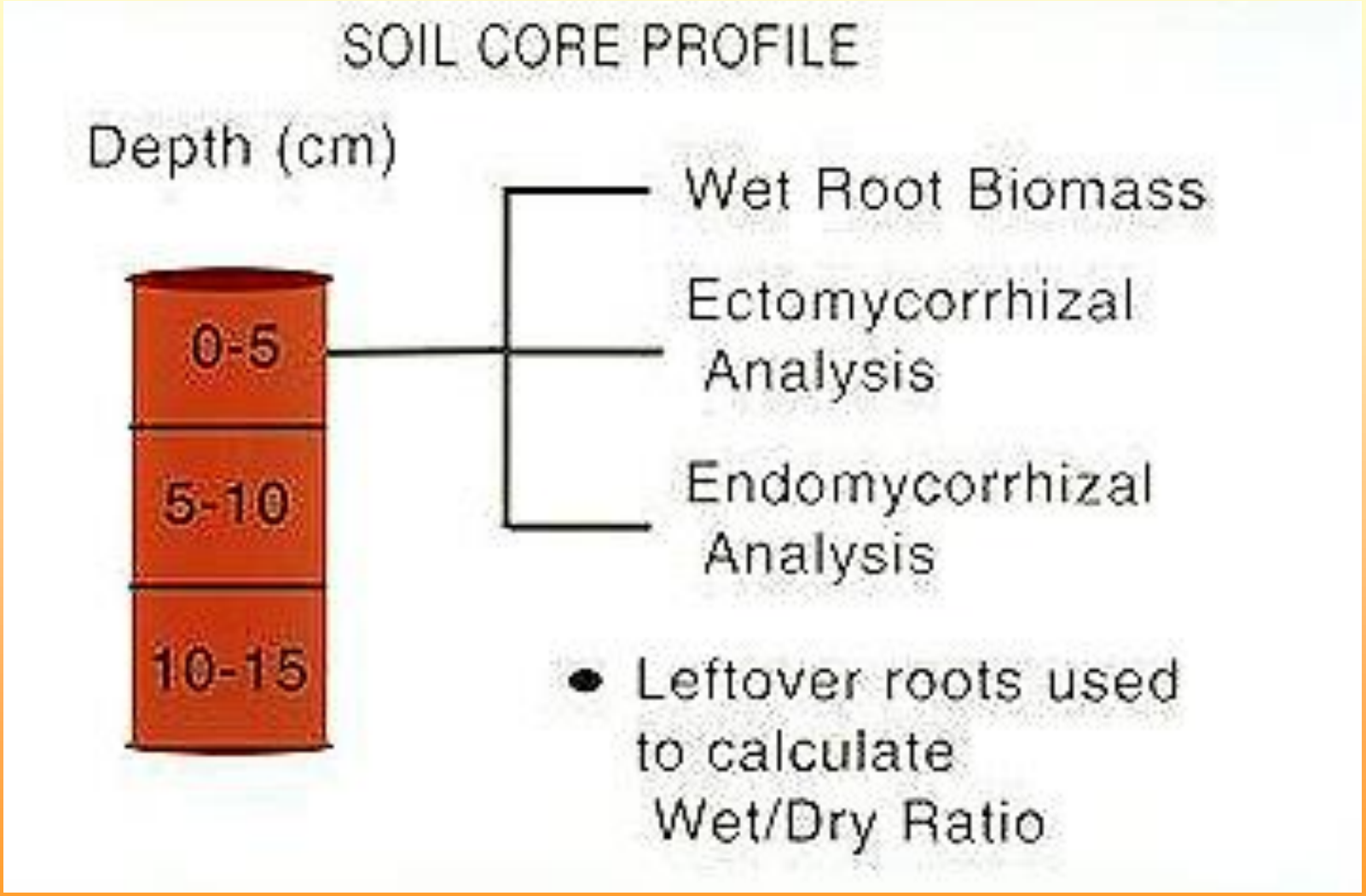
Mycorrhizal Research at University of Alaska, Fairbanks

Testing Gehring and Whitham's hypothesis (1991) that herbivory reduces aboveground photosynthetic tissue which in turn reduces the sugars available for maintaining mycorrhizae.

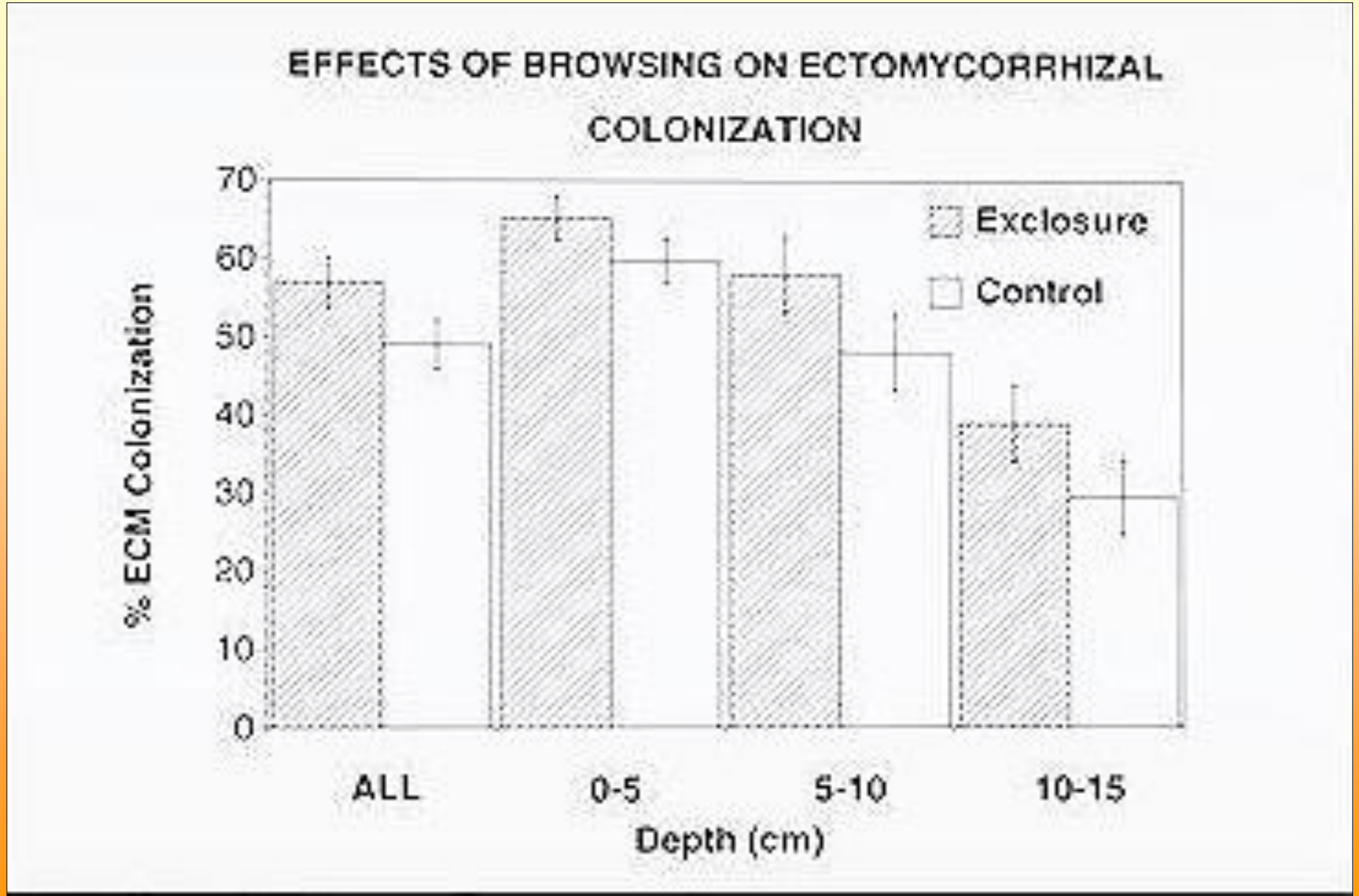
Hypotheses

- *Does browsing affect*
  - The total dry Salicaceous (Cottonwoods: willow, poplar, aspen) fine root mass
  - The quantity of ectomycorrhizae on Salicaceous fine roots
- *Does the depth affect*
  - The total dry Salicaceous fine root mass
  - The quantity of ectomycorrhizae on Salicaceous fine roots
- *Does the combination of browsing and depth affect*
  - The total dry Salicaceous fine root mass
  - The quantity of ectomycorrhizae on Salicaceous fine roots

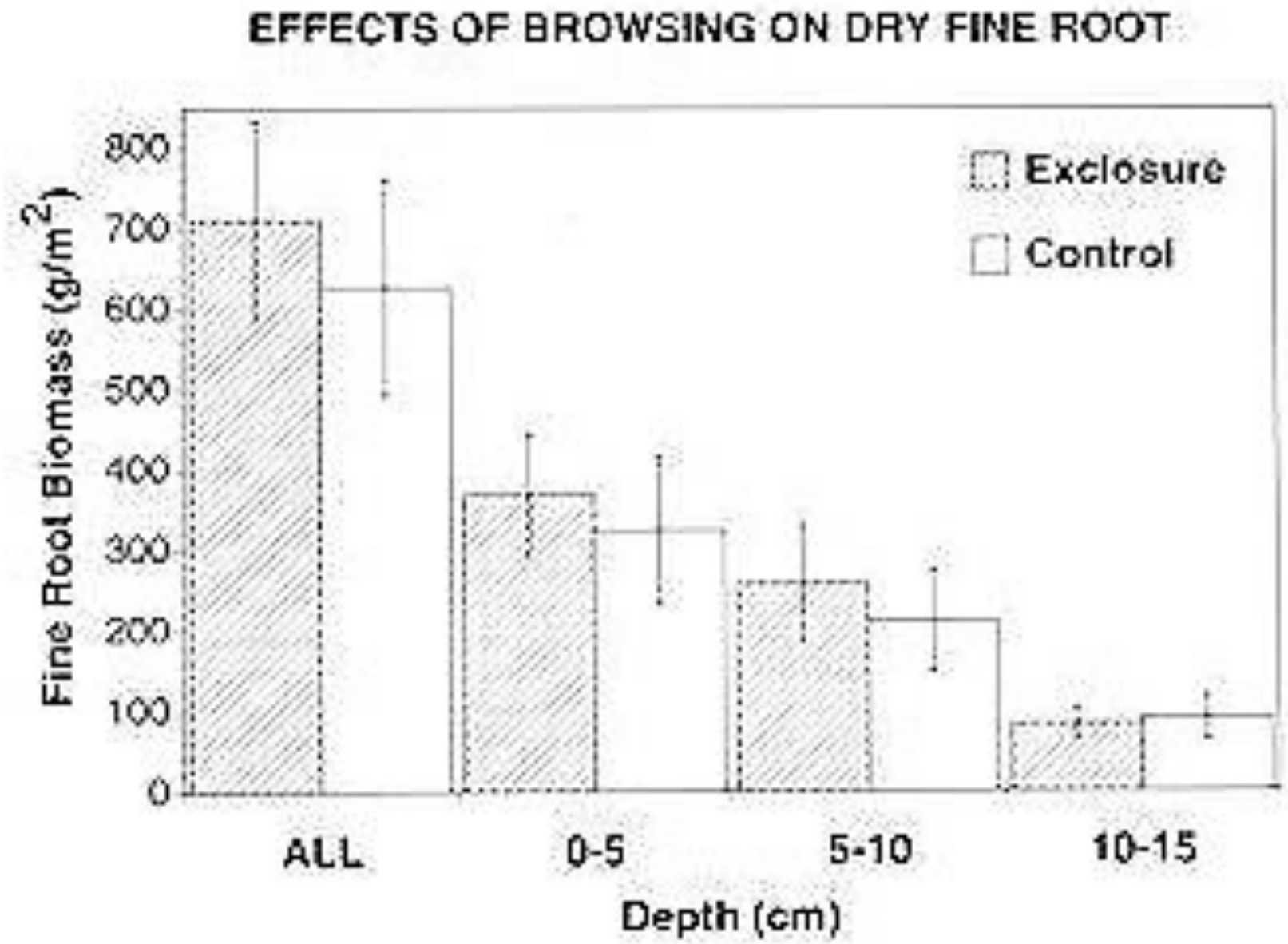
Data Gathering



Results


EFFECTS OF BROWSING ON ECTOMYCORRHIZAL COLONIZATION
% ECM Colonization
70
60
50
40
30
20
10
0
Exclosure
Control
ALL
0-5
5-10
10-15
Depth (cm)

Results


EFFECTS OF BROWSING ON DRY FINE ROOT
Exclosure
Control
Fine Root Biomass (g/m2)
800
700
600
500
400
300
200
100
0
ALL
0-5
5-10
10-15
Depth (cm)

Results

Browsing Effects on Ectomycorrhizal Colonization

Source of Variation	*df*	*F*	*P*
Point Bars	6	5.68	0.0005
Exclosure (E)	1	11.3	0.0021
Depth in Soil (D)	2	33.1	0.0001
E x D	2	0.26	0.7731
Error	30		

ANOVA of browsing effects on ectomycorrhizal infection (%) and fine root biomass (g/m^2)

Mean % Browsing BNZ LTER Floodplain (Kielland 1996)

1988-89 60%

1989-90 60%

1990-91 50%

1991-92 25% (Deep snow)

Browsing Effects on Fine Root Biomass

Source of Variation	*df*	*F*	*P*
Point Bars	6	3.87	0.0056
Exclosure (E)	1	0.55	0.4635
Depth in Soil (D)	2	13.2	0.0001
E x D	2	0.17	0.8480
Error	30		

Discussion

- Ectomycorrhizal infection of fine roots of willow and balsam poplar growing outside exclosures was reduced by about 16% in comparison to ectomycorrhizal infection of willow and balsam poplar that had been protected from browsing by moose and snowshoe hare for the previous 4 winters.

- 16% reduction in ectomycorrhizae compares favorably to the results of Gehring and Whitham (1995) following simulated herbivory on pinyon pines growing in infertile cinder soil and fertile sandy loam soil.

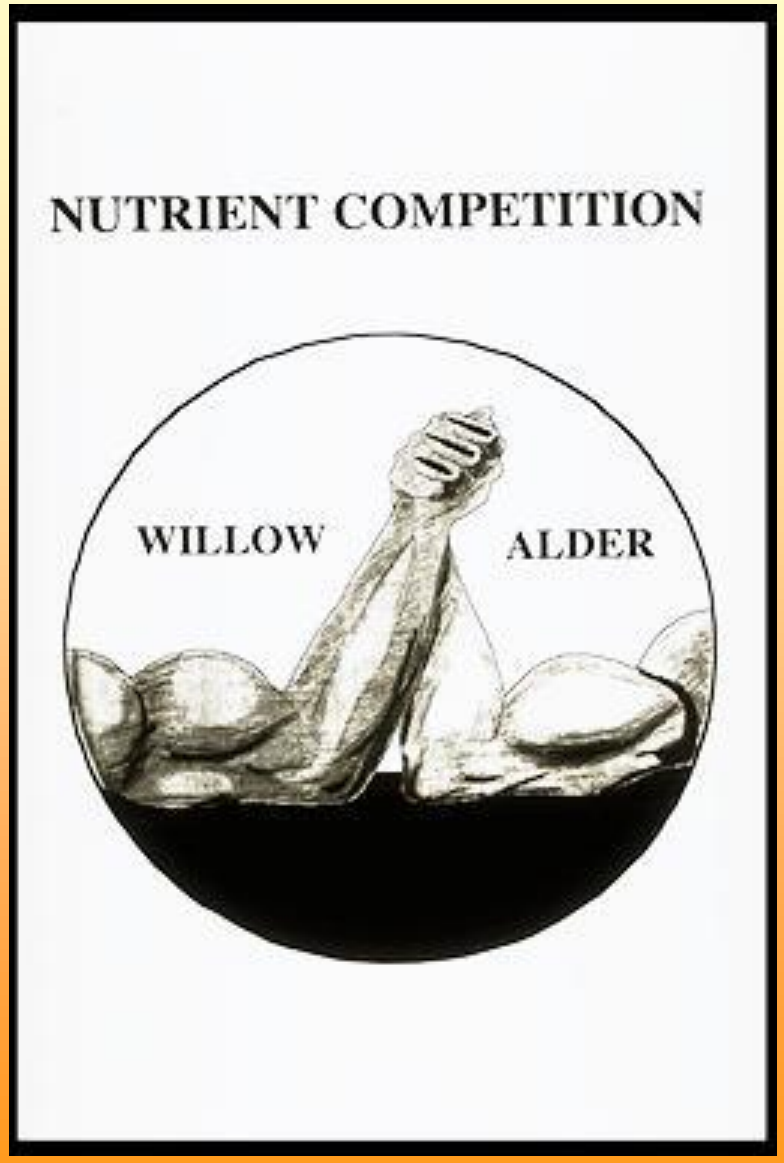
- Bryant (1987) demonstrated that pruning of shoots in one winter reduced the soluble carbohydrate concentration of current-year shoots in the next winter.

Discussion

- Thus, browsing by moose and snowshoe hare could reduce the supply of soluble carbohydrate to roots, thereby reducing the supply of carbohydrate available to ectomycorrhizae, and as a consequence, reduce ectomycorrhizal infection of salicaceous fine root.
- Successful infection of fine roots by ectomycorrhizae is very important to the competitive ability of woody plants (Allen and Allen 1990), and especially woody plants growing in nutrient deficient soils (Allen 1991), such as the recently deposited glacial silt that formed our sites on the floodplain of the Tanana River (Van Cleve et al. 1991)

Discussion

By reducing ectomycorrhizal infection of willow and balsam poplar fine roots, winter browsing by snowshoe hare and moose are likely to reduce the ability of these species to compete for nutrients with thinleaf alder (*Alnus tenuifolia*), a species that is mycorrhizal and rarely browsed by snowshoe hare and moose (Wolff and Zasada 1979; McAvinchy 1991).



Discussion

- This shift from willow to alder is an extremely important event in ecosystem development because the nitrogen fixed by alder in the alder stage of primary succession provides most of the nitrogen annually accumulated by the Tanana River Floodplain ecosystem (Klingensmith and Van Cleve 1993; Van Cleve et al. 1993)
- Thus the willow stage of succession will be brief with browsing, and the alder stage will take over, giving less food to sustain moose and snowshoe hare. (implications for hunting)