Little Things that Make a Difference: Endophytes in Forestry

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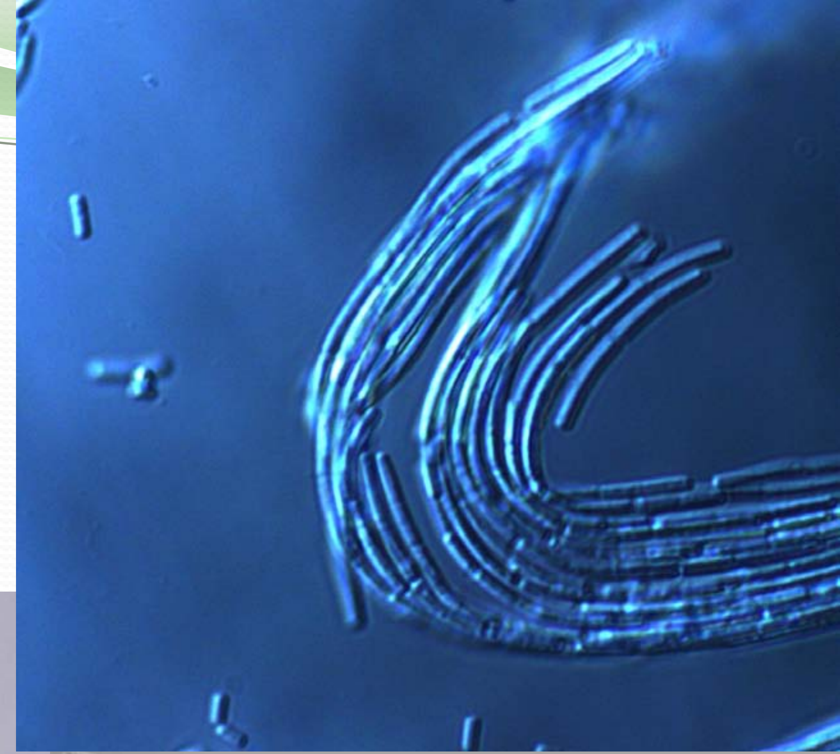
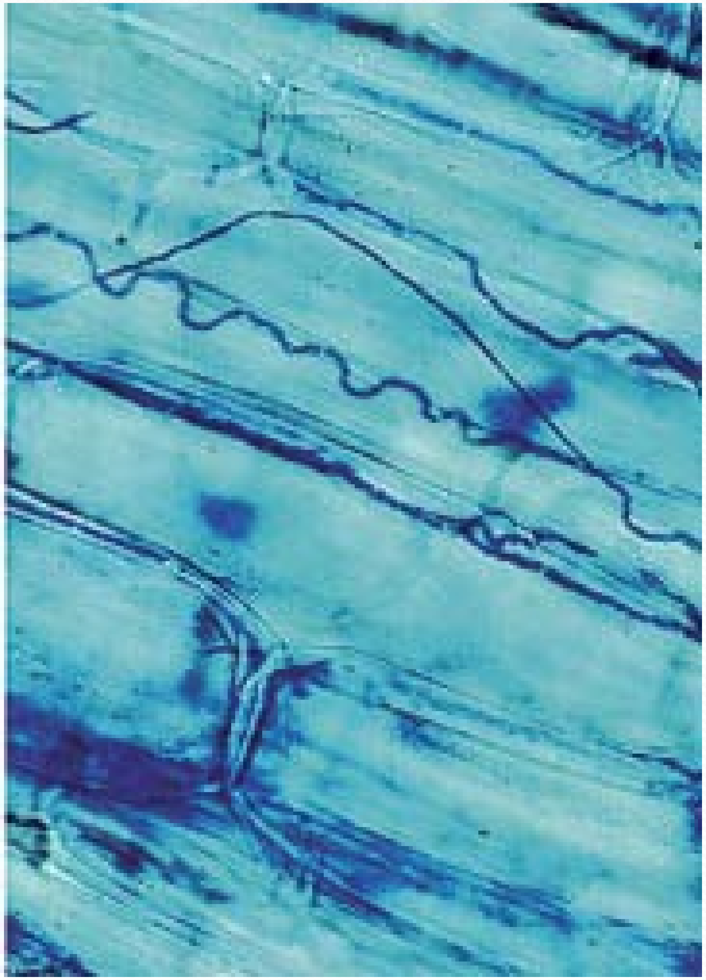
How we define an endophyte

Organisms that live in plant tissues without causing apparent harm to the host (Petrini, 1991)

- Fungi
- Bacteria
- Nematodes



Endophyte ecology

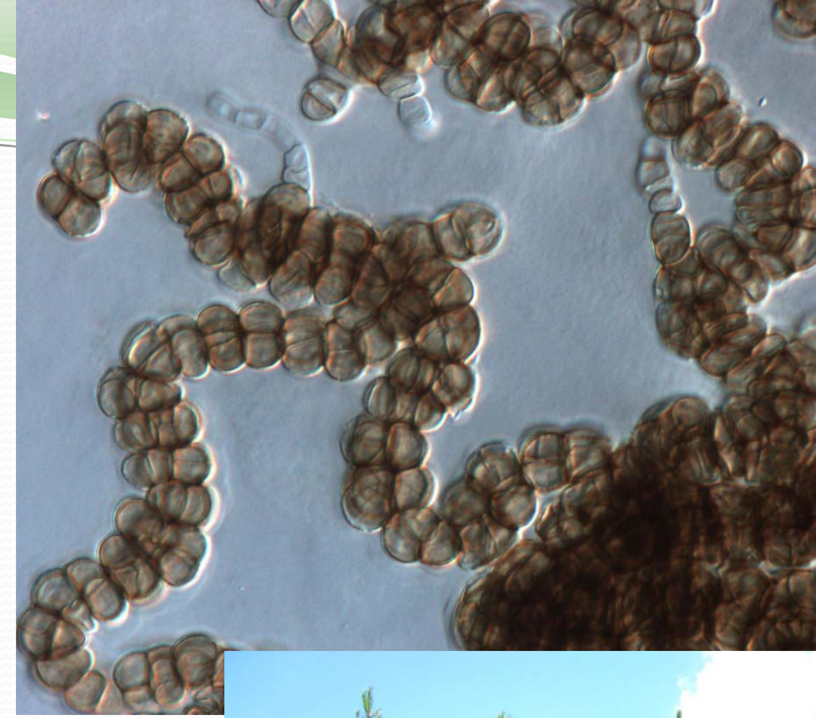


- Endophytes are found in all plants
- They are found in large numbers
  - A single pine needle may contain 3 to 10 organisms that can be cultured
  - As many may be “unculturable”

Endophyte ecology

- They spread by soil, wind, water, seed, and other endophytes

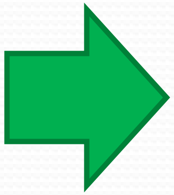
- Endophytes form dynamic communities in the host that affect host fitness—but **may be host specific**

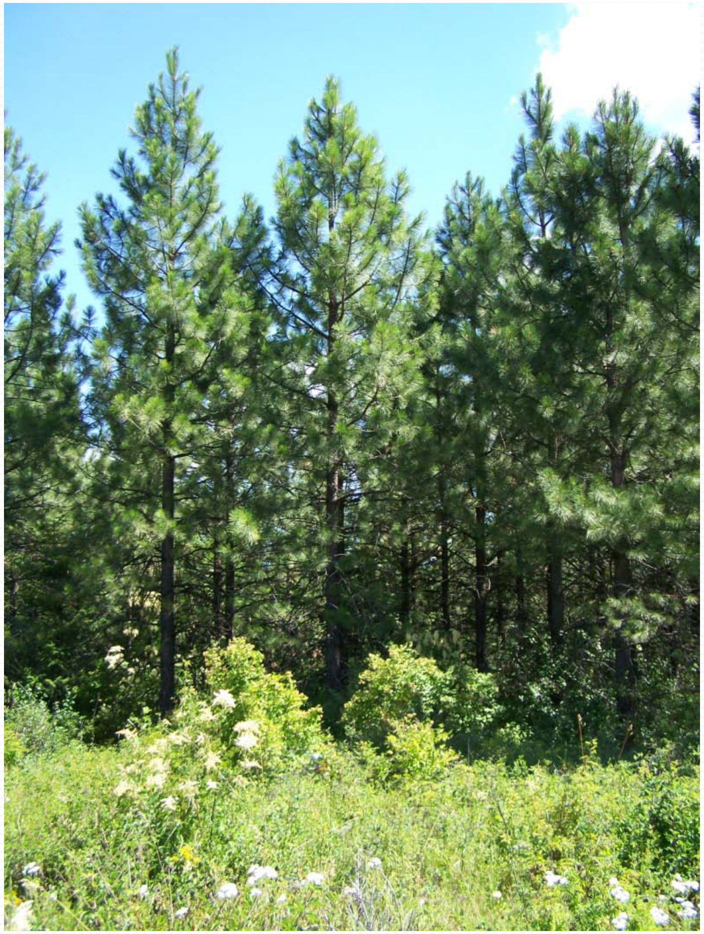


Mutualistic benefits

- Insect resistance
- Disease resistance
- Thermotolerance
- Drought tolerance
- Improved nutrient uptake
- Better growth and survival

Can Endophytes Improve Forest Health?





Fundamental objectives

- Identify endophytes endophytes can contribute to out-planting success, growth and disease and insect resistance in PNW forestry
- Develop a better understanding of endophyte interactions in forest ecology through controlled assays and establishment of out plantings for long-term monitoring

Collections from the UIEF

- Ten trees per species
  - 100 needles
  - 20 cm root tissue per tree
- Total recovery: ~7000 endophytes!
- Morchella elata—black morel
- Greenhouse/nursery isolates

Needles

Roots

Endophytes in forest trees

Diseases in forest trees

- White pine blister rust
- Root diseases
  - Armillaria root rot—*Armillaria* sp.
  - Laminated root rot—*Phellinus weirii*
  - Schweinitzii root and butt rot—*Phaeolus schweinitzii*

- Nursery root diseases
  - *Fusarium* sp.
  - *Cylindorcarpon* sp.
  - *Phytophthora*

Implications for root diseases

- Nursery diseases and the predisposing factor phenomenon (Manion, 1991)
  - Species of *Fusarium* and *Cylindrocarpon* are common in forest nurseries and may colonize asymptomatic seedlings (James, 1985)
  - *Cylindrocarpon* infection is significantly lower in natural regeneration (Axelrood, 1998)

There goes the neighborhood—endophyte succession

- Exclusionary principles
- Successional infection processes
- Replacement
- Implications in managed forests
  - Natural regeneration
  - Out planting

Implications for root diseases

- Can seedling *Fusarium* infection predispose plantings to disease and insect attack and reduce fitness?

- Can inoculation with endophytes reduce seedling infection by *Fusarium* and improve out plantings long term?

Fusarium root rot in conifer seedlings

- 360 Ponderosa seedlings
- 16 treatments
- Endophyte treatments reduced mortality and symptoms in seedlings

Sterile DI Control

Morchella elata

Why Morel?!?

- *Morchella* sp. found as an endophyte in cheatgrass (*Bromus tectorum*) (Baynes et al., 2011)
- *Morchella* increased biomass and fecundity of cheatgrass (Baynes et al., 2011)
- *Morchella elata* (black morel) increased coleoptile elongation and growth in *Zea mays* (Yu and Newcombe, unpublished)
- Morel forms mycorrhizal associtations with pines (Dahlstrom et al., 2000)

- Inoculation with *Morchella elata* increased thermotolerance of seed of *Bromus tectorum* (Baynes et al., 2011)

Heat, fire, and drought

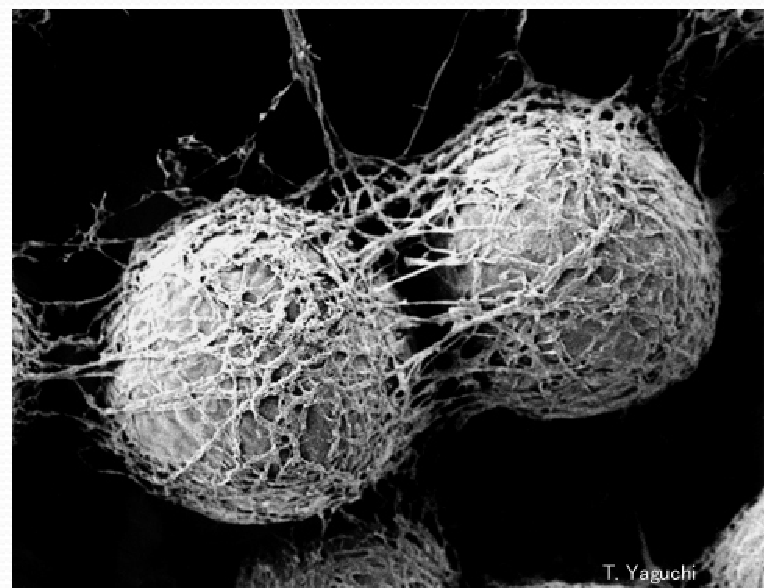
- Is there ecological significance in relationship of thermotolerant, fire adapted and drought-tolerant endophytes and forest hosts?

Root endophytes of interest

- Thermotolerant genera isolated from root tissues
  - Eupenicillium
  - Talaromyces
  - Byssochlamys
  - Penicillium
  - Paecilomyces

Eupenicillium sp.

- Tolerate extreme conditions
  - pH (2.6 to 8.3)
  - High salts—100 µM NaCl
  - 2°C to 40°C—known to survive pastuerization temperatures
  - Drought



Nutritional implications

- *Eupenicillium* sp. and phosphate solubiliztion
- Endophytes may improve nitrogen uptake similar to mycorrhizae (Jumpponen et al, 1998)
- Endophytes may contribute to nitrogen use efficiency (Alberton et al., 2010)
- Better nutrient uptake and assimilation
  - Better growth and health
  - Greater stress resistance

Reforestation and forest health

Reforestation and forest health

On-going research

- Establishment of outplantings inoculated with endophytes for long-term monitoring
- Finding disease and stress tolerance assays with implications for endophyte selection in forestry

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