ENDOPHYTIC FUNGI IN GOOD AND BAD PLANTS

George Newcombe, Professor

College of Natural Resources

Center for Research on Invasive Species and Small Populations

University of Idaho

Context for the use of endophytes to manage good and bad plants:

Biotic homogenization

Enemy (pathogen) release

Introduced plants

GOOD PLANTS (CROPS, ORNAMENTALS)

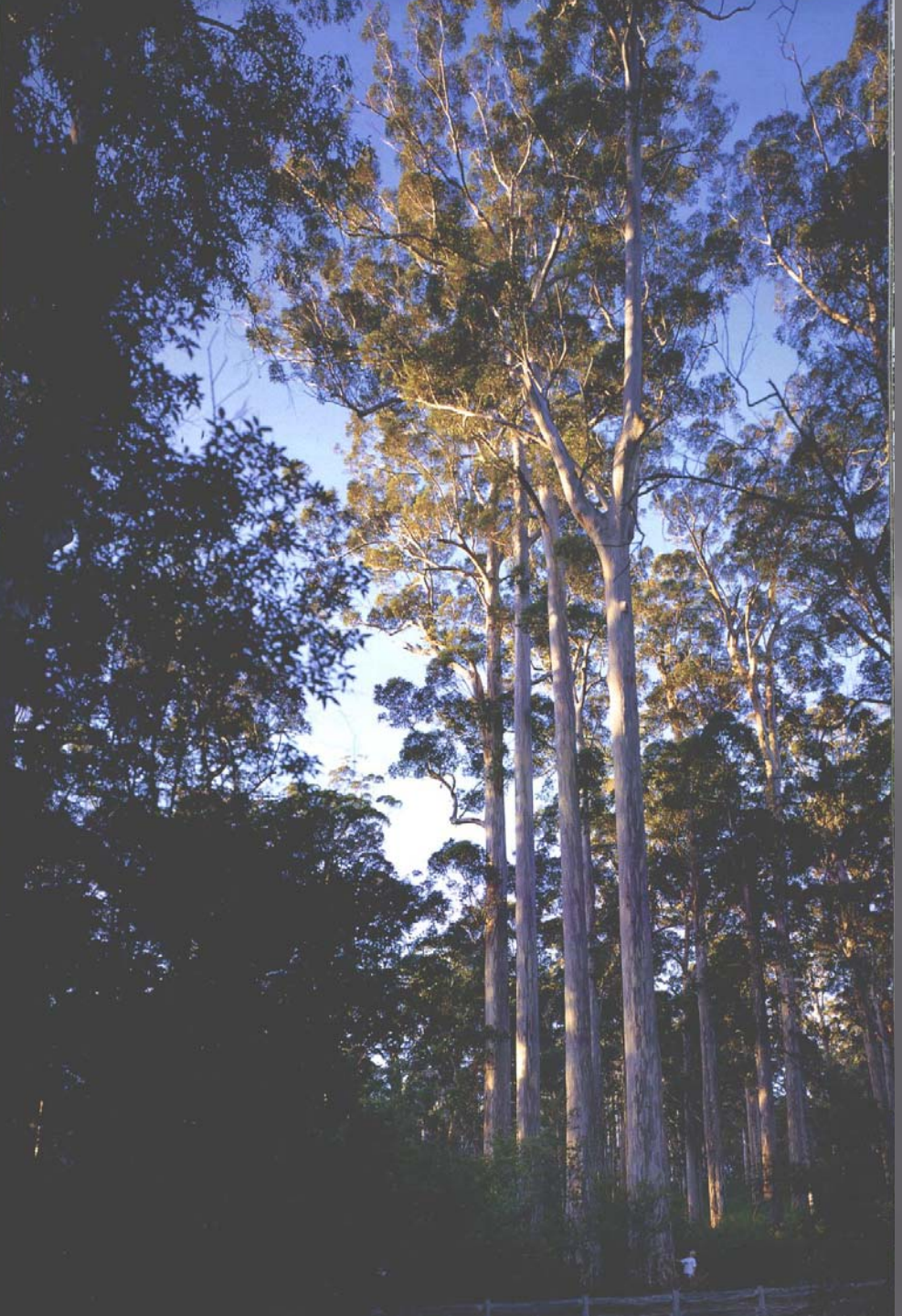
- Benefit from enemy, or pathogen, release

BAD PLANTS (WEEDS, INVADERS)

- Benefit from enemy, or pathogen, release

Even native and endemic plants can be in a state of pathogen release…

Enemy release can be natural. Example: *Brighamia* is a rust-free genus endemic to Hawaii that evolved from rust-hosting Asian *Lobelia*.



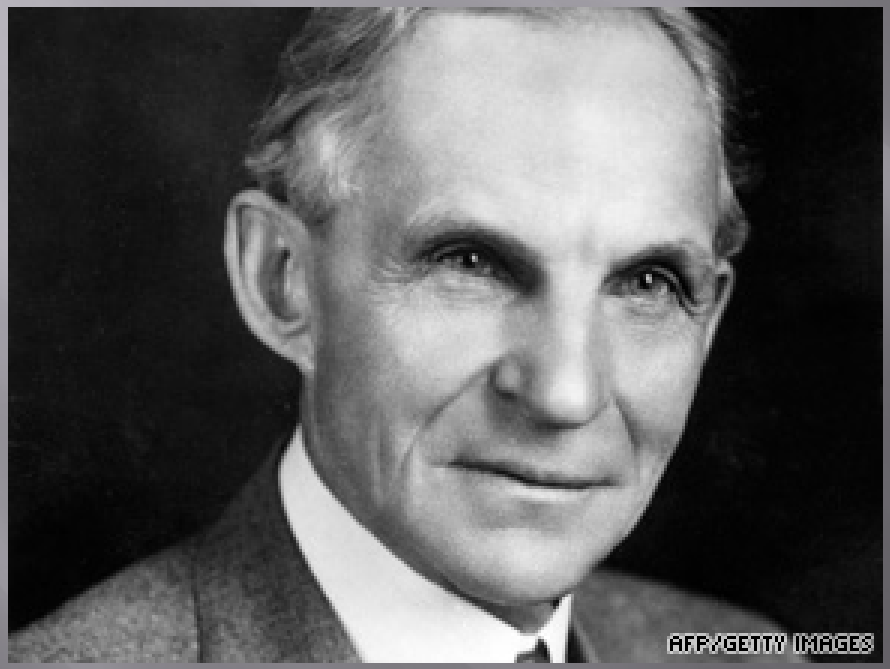
The ‘Four Aces’ in Western Australia: *Eucalyptus diversicolor* [karri locally]. Up to 300 ft. tall. Photo from ‘Remarkable Trees of the World’.

Eucalypts are virtually endemic to Australia and the most planted hardwood trees in the world. Following their discovery in the late eighteenth century, they were introduced into India (*c*. 1790), France (*c*. 1804), Chile (1823), Brazil (1825), South Africa (1828), and Portugal (1829).

"A phenotypically outstanding *Eucalyptus grandis*×*E. camaldulensis* F1 hybrid in a family trial in Guangxi Dongmen Forest Farm, China. At 10 years the diameter at breast height of this tree was 32 cm compared with the adjacent tree in the foreground that measured only 11.3 cm. Such individuals are damaged at the base to cause coppice shoots that are multiplied by tissue culture to provide sufficient stock plants for production of hardwood cuttings for clonal tests."

Pathogen release that changed history:

Rubber from *Hevea brasiliensis* and its pathogen, *Microcyclus ulei*.



Henry Ford in 1942

The most tragic end to enemy release was in Ireland. From about 1590 when potatoes were introduced until September 1845, *Phytophthora infestans* was not present in Ireland.

Silvics of N. America: "Monterey pine *(Pinus radiata) is* the most widely planted pine in the world. Rapid growth and desirable lumber and pulp qualities cause it to be the leading introduced species in Australia, New Zealand, and Spain, and a major species in plantations of Argentina, Chile, Uruguay, Kenya, and the Republic of South Africa. In these countries, Monterey pine is a mainstay of the forest economy, serving internal markets, generating valuable foreign exchange reserves as an export, and reducing cutting pressure on native forests."

.

Silvics of North America: Native stands of Monterey pine are found in three distinct areas of central-coastal California in San Mateo, Santa Cruz, Monterey, and San Luis Obispo Counties.

Scots broom,

P. nigra cv. *italica*

Pinus radiata

All 3 plants are native to the northern hemisphere, and they are thriving in the Andes in Argentina

Resin streaming from multiple cankers on the main stem of *Pinus radiata* caused by *Fusarium circinatum*.

Gordon: In 1986, the disease was discovered in California as a cause of extensive damage and mortality to planted *Pinus radiata* (common names: Monterey pine and radiata pine). Soon thereafter, pitch canker was reported in both native forests and plantations in Mexico, in pine seedling nurseries in South Africa, and among planted pines in Japan. More recently, pitch canker has been documented as a cause of seedling mortality in Chile and Spain. NOT YET PRESENT in New Zealand, where quarantines are strict.

As biotic homogenization increases…

pathogen release decreases.

In time, the honeymoon will be over, with opposite effects on good and bad plants.

Some examples of recent enemy reunions from my own diagnostic work…

Worapong, J., J. Sun, and G. Newcombe. 2009. First report of *Myrothecium roridum* from a gymnosperm. *North American Fungi* 4(6):1-6. doi: 10.2509/naf2009.004.006 Published November 5, 2009.

Abstract. Although *Myrothecium roridum* has been reported as a pathogen and an endophyte with a wide host range among angiosperms, it has never before been reported from a gymnosperm host. Reports of this fungus are also much more common in Asia than in North America where *M. roridum* is infrequently found on introduced plants in the warmer, southernmost parts of the United States. Thus, it was surprising on three levels to isolate endophytic *M. roridum* from a North American native gymnosperm, *Pinus albicaulis*, at high elevation in Crater Lake National Park (CLNP) in Oregon.

New records for pathogenic fungi on weedy or non-indigenous plants

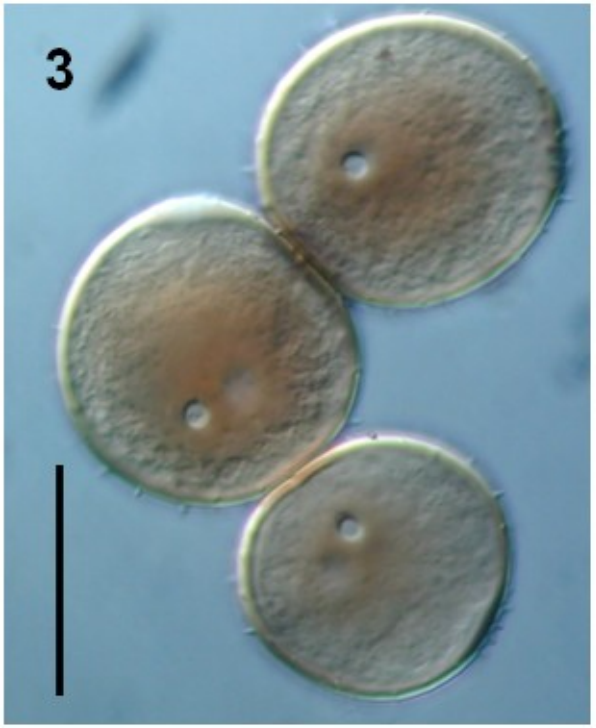
George Newcombe[1], Rhonda Gaylord[2], Joseph P. Yenish[3], Joy Mastrogiuseppe[4], and Frank M. Dugan[5]

[1]College of Natural Resources and Center for Research on Invasive Species and Small Populations, University of Idaho, Moscow, Idaho 83844-1133,
[2]George Fischer Agricultural Sciences Library,
[3]Department of Crop and Soil Sciences,
[4]Ownbey Herbarium, and
[5]USDA-ARS Plant Germplasm Introduction and Testing Research Unit, Washington State University, Pullman, Washington 99164.

North American Fungi 4 (8): 1-12. doi: 10.2509/naf2009.004.008. To be published online next week.


1


2


3


4


5


6

So, as biotic homogenization increases…

pathogen release decreases.

What will we do to protect good plants?

What will we do about the bad plants that are not in a state of pathogen release currently?

Endophytic fungi are defined as fungi that can be isolated from healthy plants.

All healthy plants harbor endophytes.

Endophytes can be mutualists. On the other hand, endophytes can be latent pathogens.

The Swiss needle cast fungus, pictured here, is a pathogen that also has an endophytic phase.

Endophytes: As enemies of bad plants

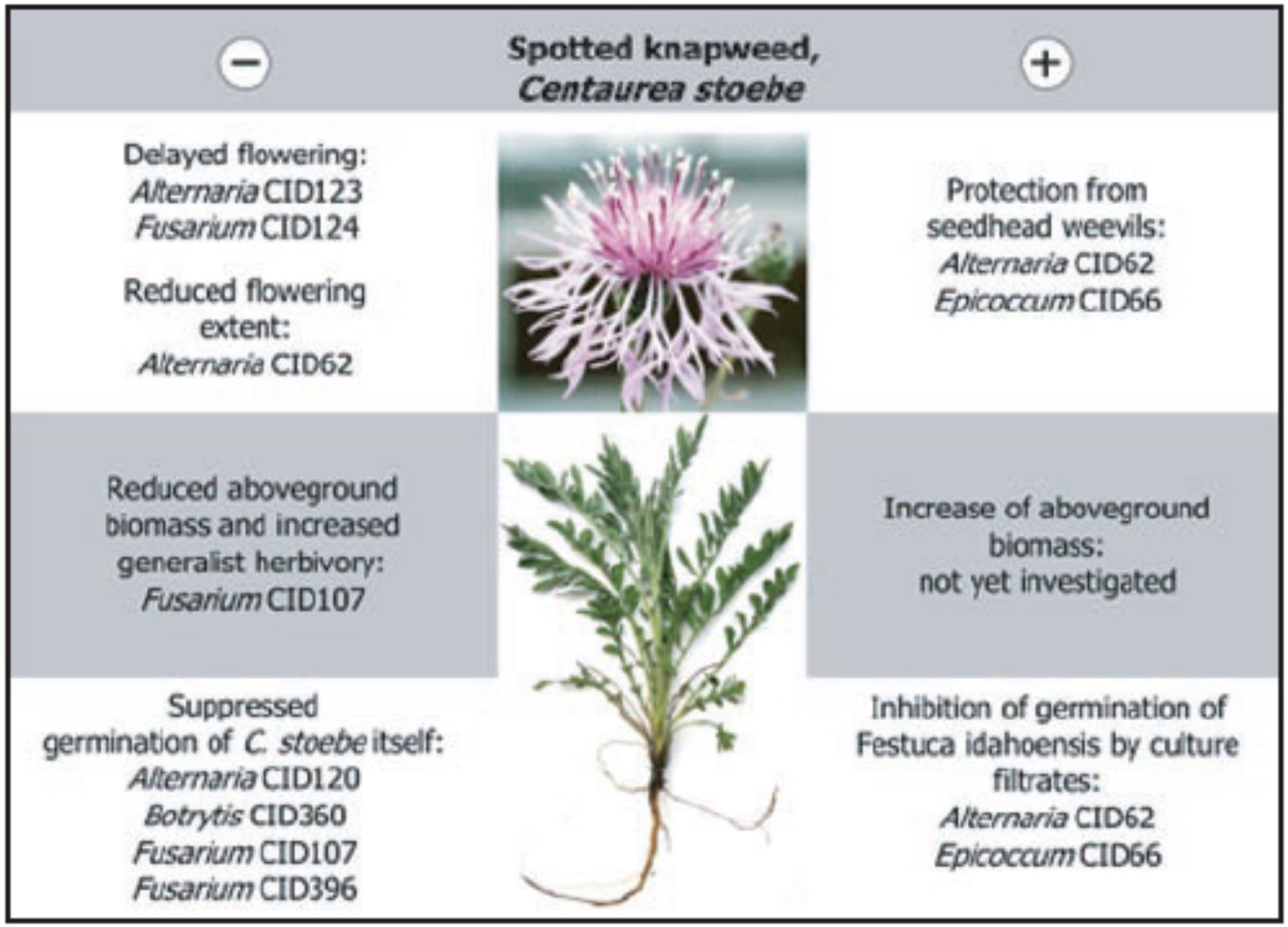
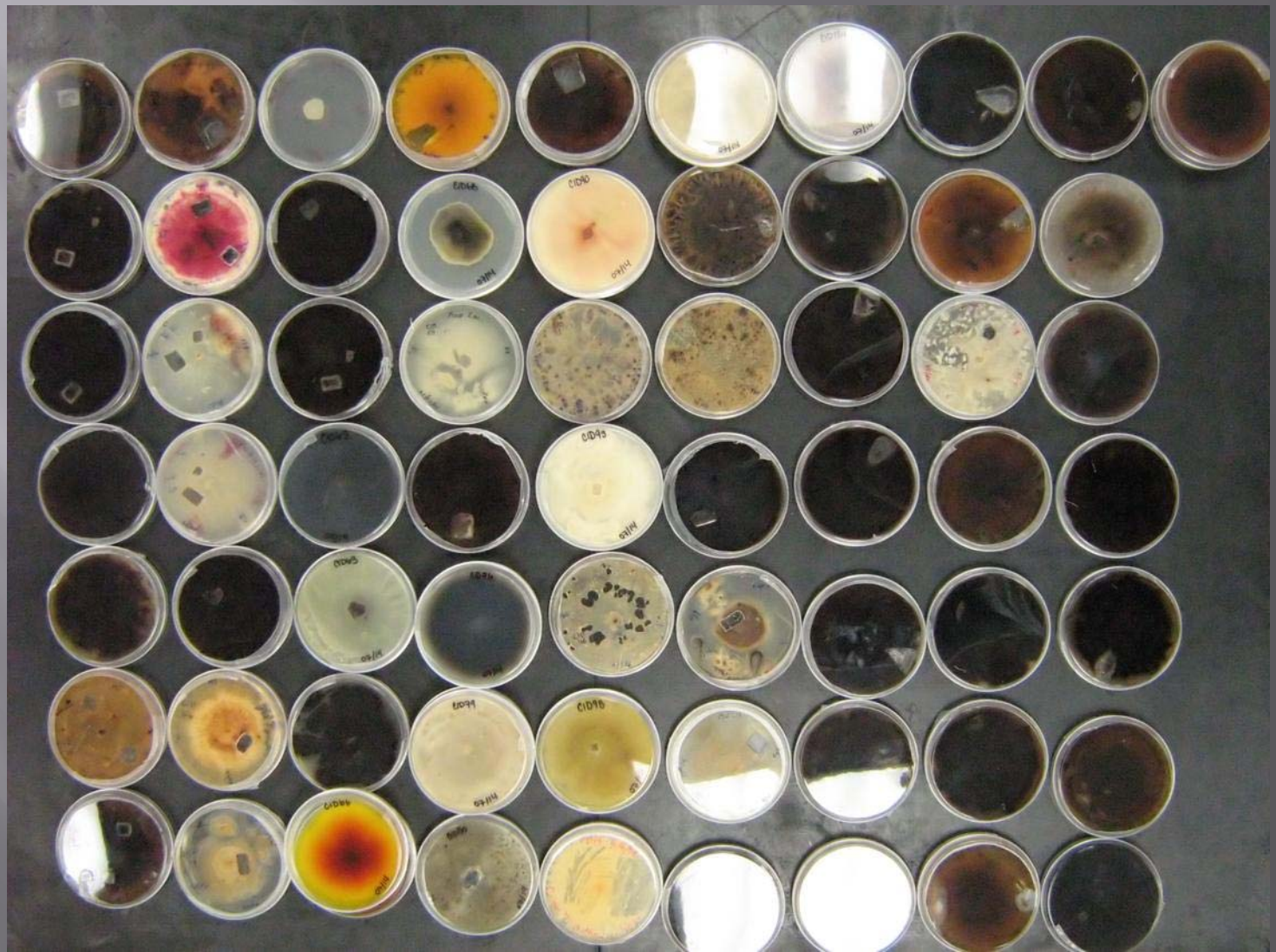
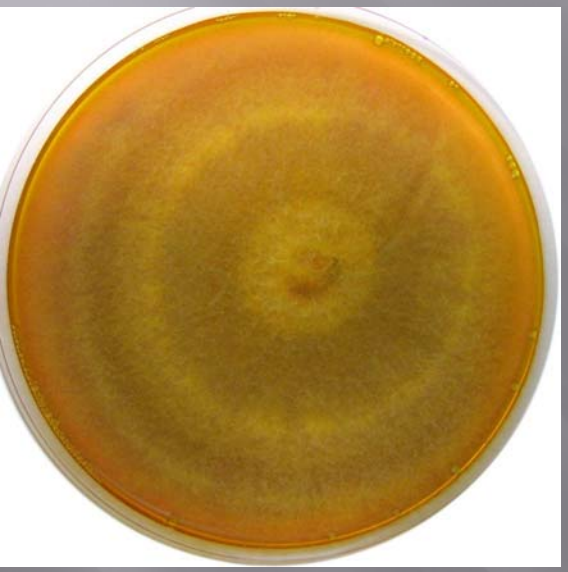


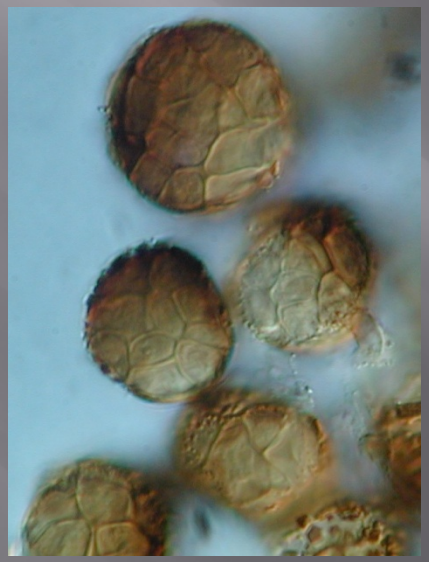
Figure 2. Growth, flowering and biotic interactions of *C. stoebe*, all significantly influenced by specific endophytes. Endophyte genera are followed by CID numbers that are keyed to GenBank accession numbers and to isolation frequencies in the native and invaded ranges of *C. stoebe*.[1]

Knapweed endophyte diversity, seen here, is typical. It may be possible to select endophytes for specific functions.



ITS and Alt A1 sequences



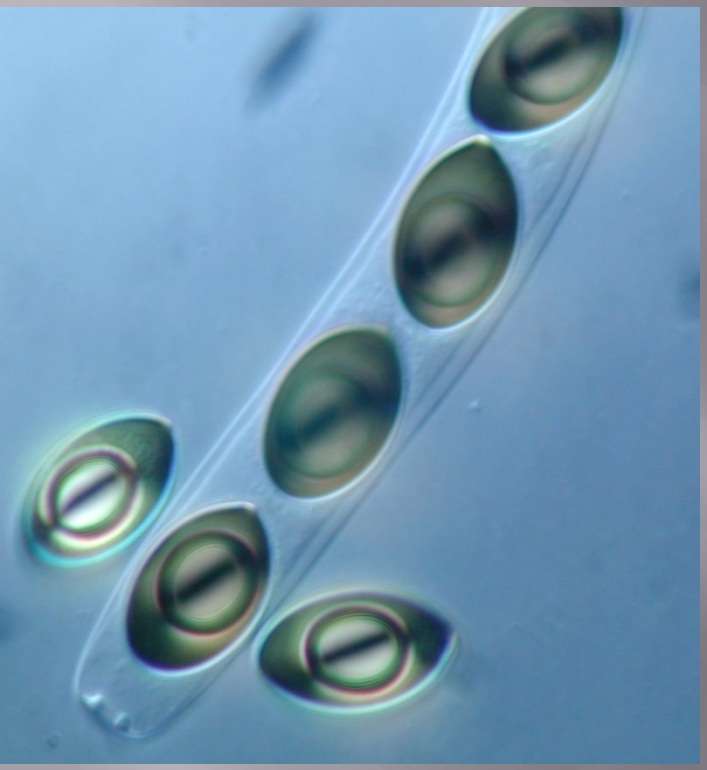


ITS and Alt A1 sequences

Cultures Micromorphology Sequences

How we distinguish one endophyte from another.

What will we do about the bad plants that are not in a state of pathogen release currently?



We have discovered endophytic dung fungi in cheatgrass that reduce the fecundity of this invader.

Fecundity was reduced even in a cheatgrass population that otherwise responded favorably to endophytes.

"We" includes: Melissa Baynes [PhD student at the UI], Rosemary Pendleton [FS - Albuquerque] and Linley Dixon [USDA Systematic Mycology and Microbiology Lab – Beltsville]

Endophytes as mutualists in good plants:

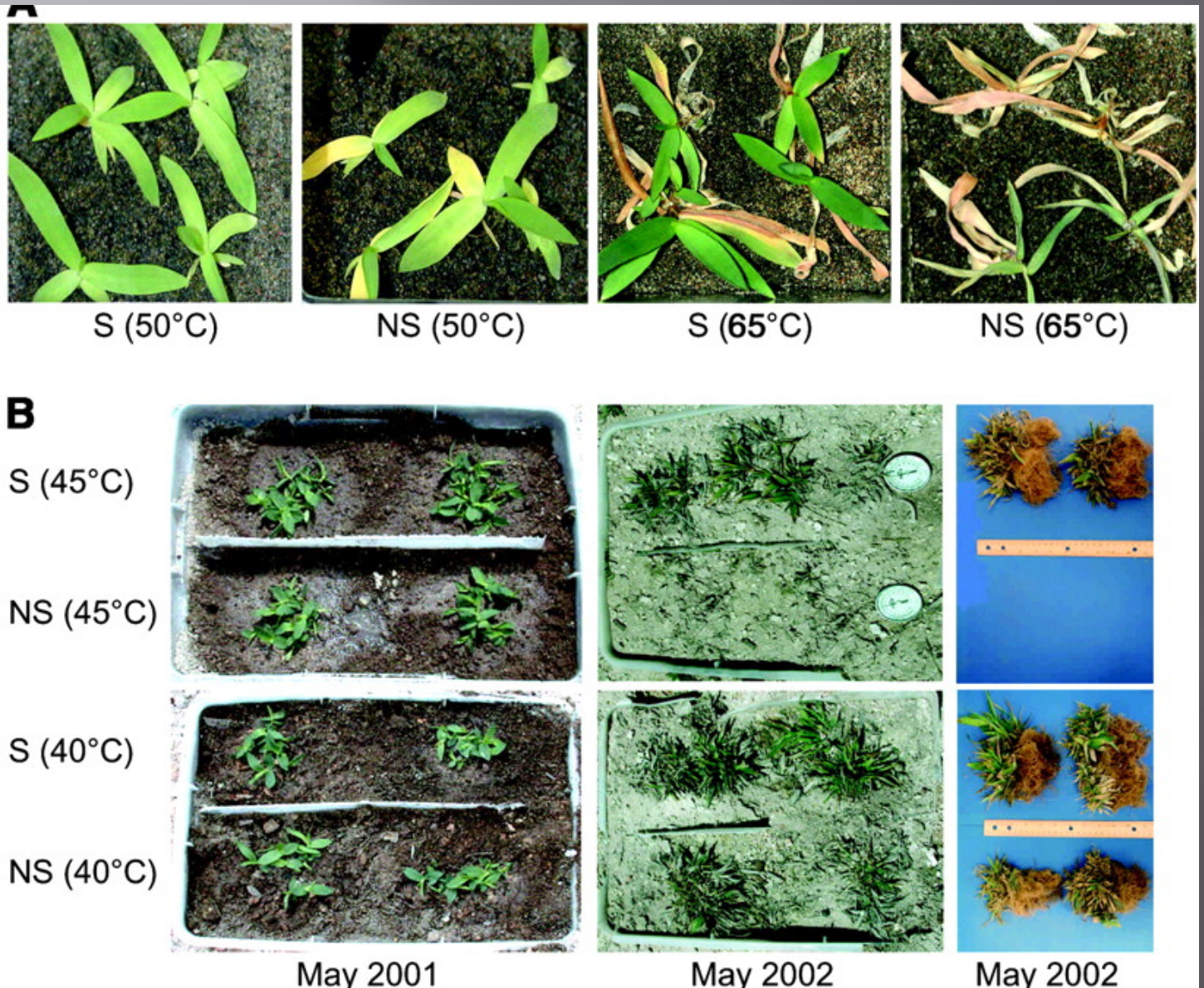
The most outstanding example is that of *Dichanthelium lanuginosum* plants from geothermal soils in Lassen Volcanic and Yellowstone National Parks. These soils have annual temperature fluctuations ranging from about 20° to 50°C.

How do these plants survive those hot soils?

Redman et al. at the University of Washington figured it out here:

Redman, Regina et al. 2002. Thermotolerance generated by plant/fungal symbiosis. Science 298: 1581.

Endophytes as mutualists: S=with endophyte or symbiont; NS=no endophyte or symbiont



A positive, commercial use of endophytes in forestry:

Needles of white spruce inoculated with rugulosin-producing endophytes contain rugulosin. Rugulosin reduces the growth of spruce budworm larvae (*Choristoneura fumiferana*) – Miller, J.D. et al. 2002. Mycological Research 106: 471-479.

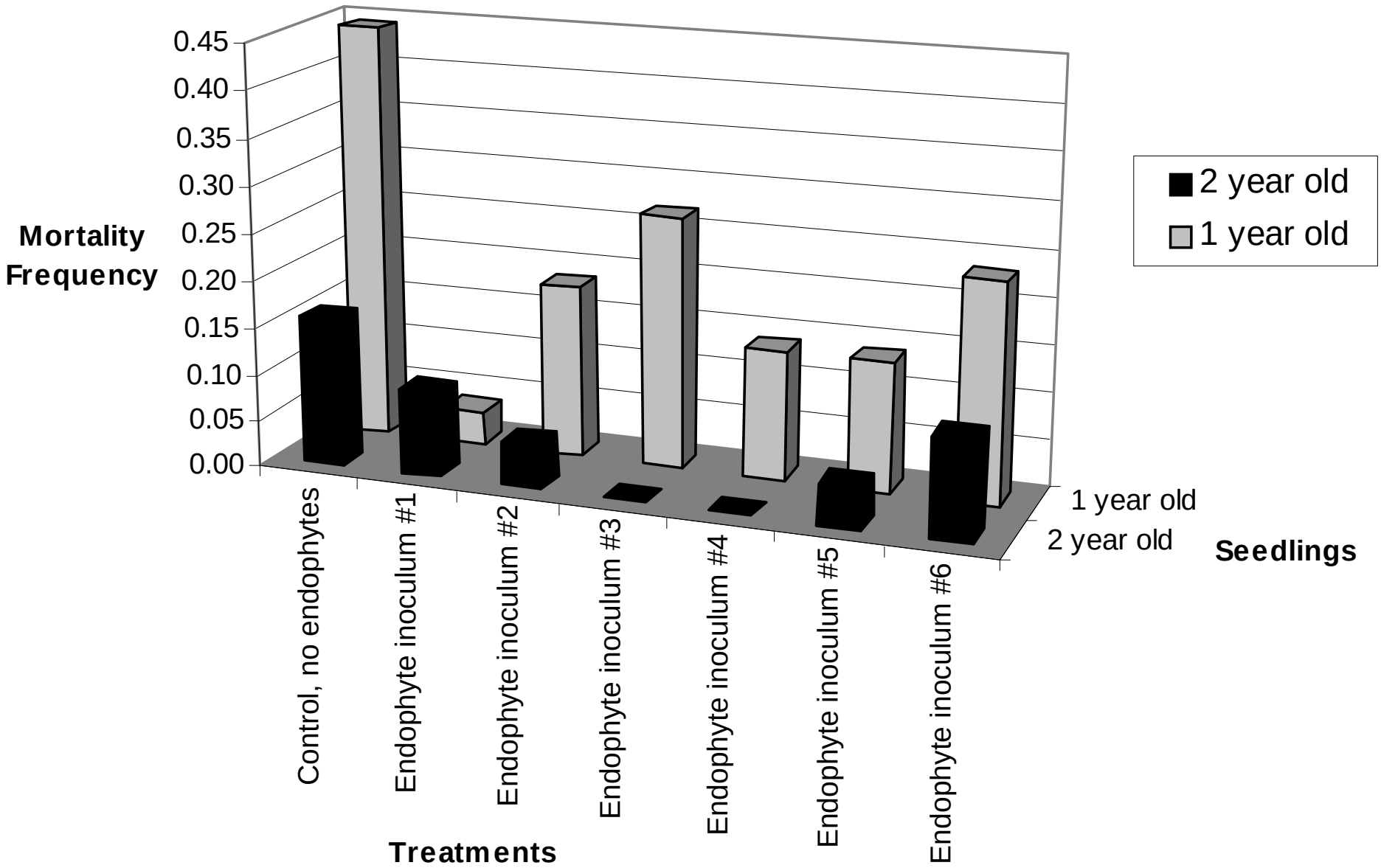
This discovery has gone commercial. Millions of spruce seedlings grown by J.D. Irving of Canada are now inoculated with these endophytes. They call their product "endophyte-enhanced white spruce" on their web site: http://www.jdirving.com/environment.aspx?id=304&ekmensel=8_submenu_16_link_3

Could needle endophytes prevent or reduce the effects of blister rust?

The answer was YES:

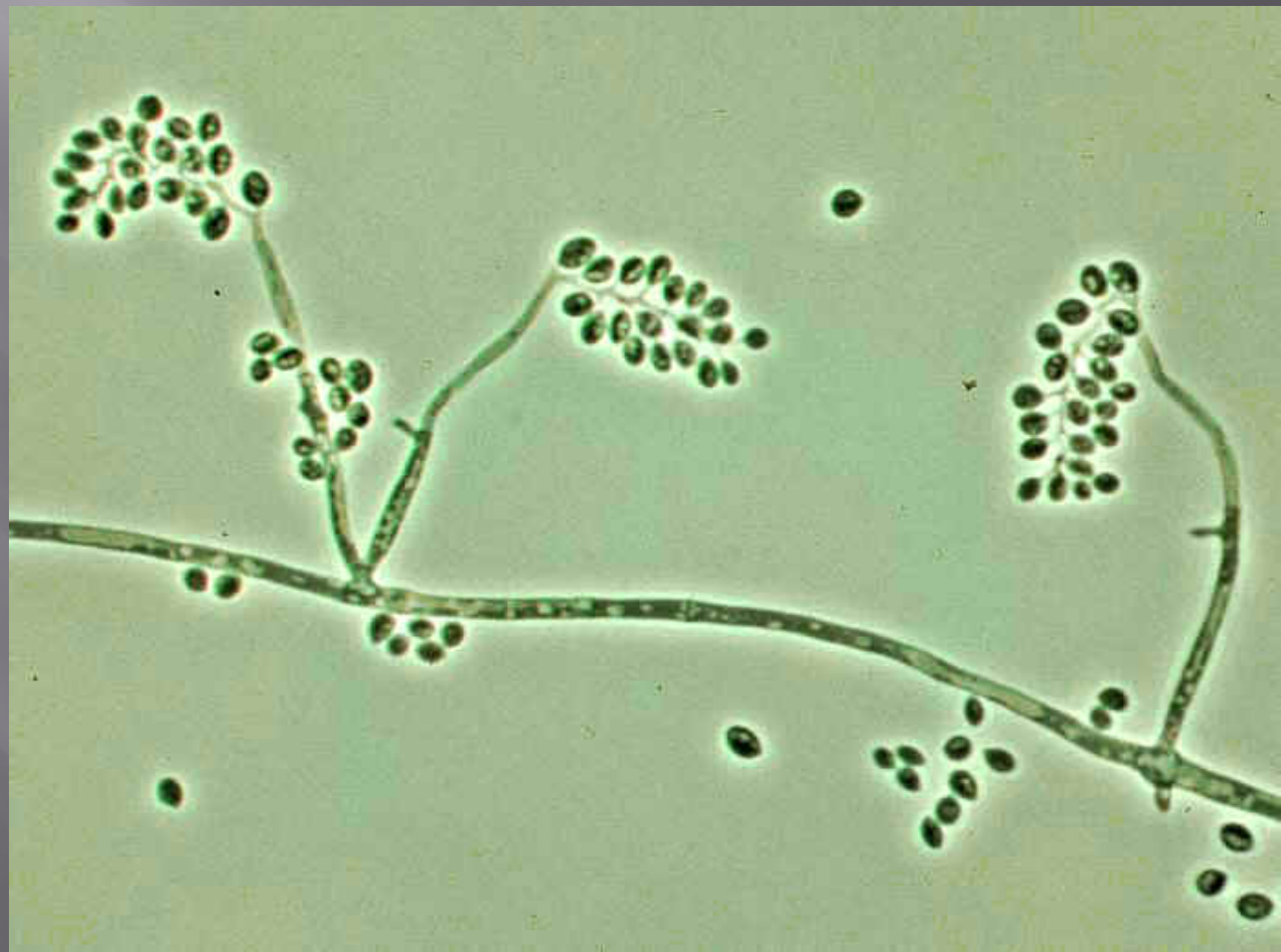
Ganley, Beccy, Sniezko, Richard, and Newcombe, George. 2008. Endophyte-mediated resistance against white pine blister rust. Forest Ecology and Management 255: 2751-2760.

Figure 1. Endophyte-mediated resistance in western white pine against white pine blister rust



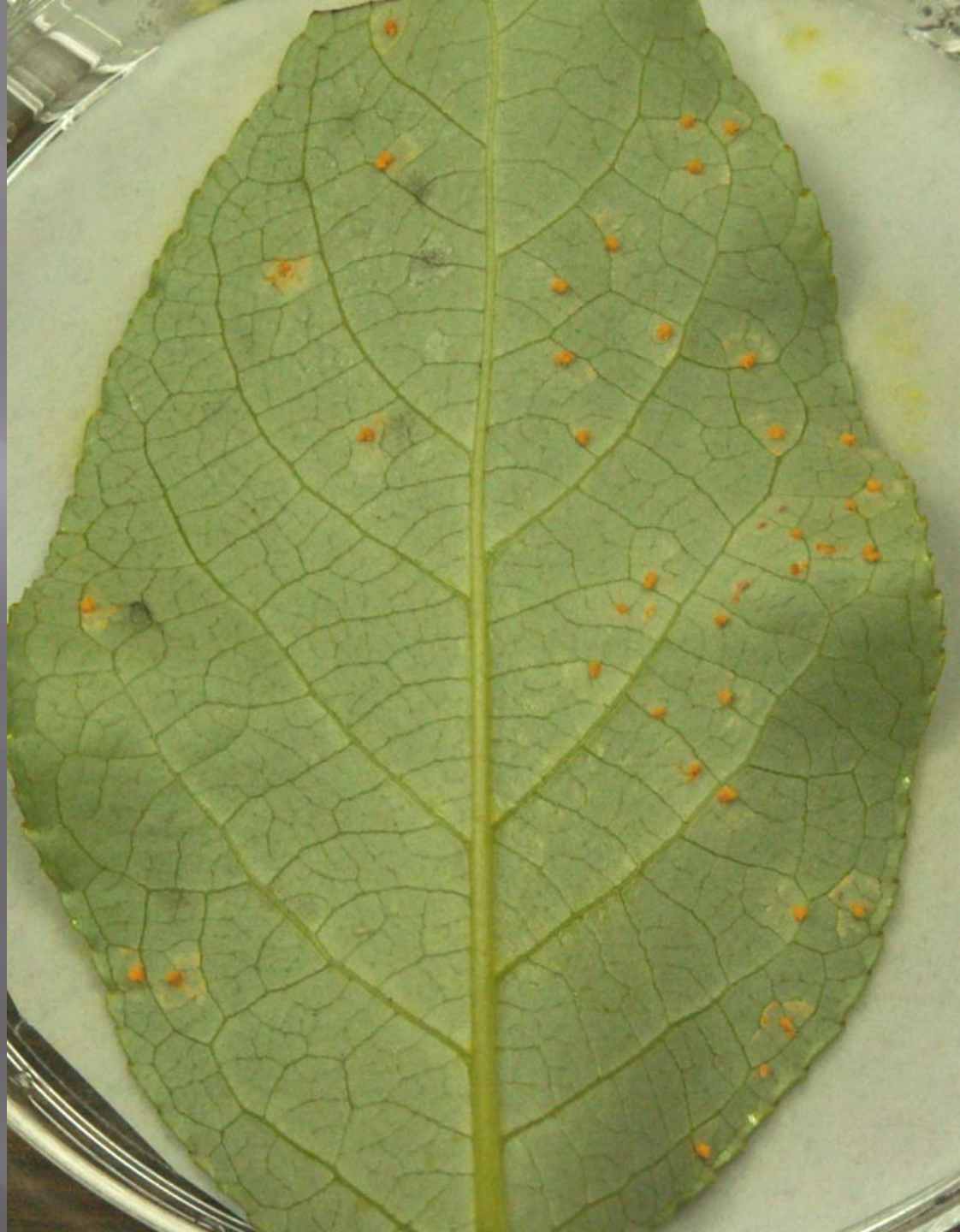
One of the endophytes in western white pine is *Beauveria bassiana,* a known entomopathogen, or pathogen of insects.

If this endophyte were inoculated into white pine seedlings, they could easily be more resistant to insect attacks.



Outlet for this research: whitebark pine restoration project at Crater Lake National Park

Left side inoculated with *Ulocladium* plus rust, versus right side with rust only.



Acknowledgements: Beccy Ganley, Alexey Shipunov, Anil Raghavendra, Melissa Baynes, UI CRISSP colleagues, USDA FS, Crater Lake National Park, Boise Cascade Corp., Greenwood Resources.