

WHAT'S KILLING MY TREES?

What we will talk about

- ▣ Tree diseases and other problems, and how to recognise them
- ▣ Sudden oak death
- ▣ Madrone blight



Plants get sick too!

▣ Abiotic

- Weather
 - Drought
 - Freezing
- Management practices
 - Chemicals
 - Mechanical damage
- Soil conditions
- Water
- Nutrients

Symptoms tend to involve the whole plant

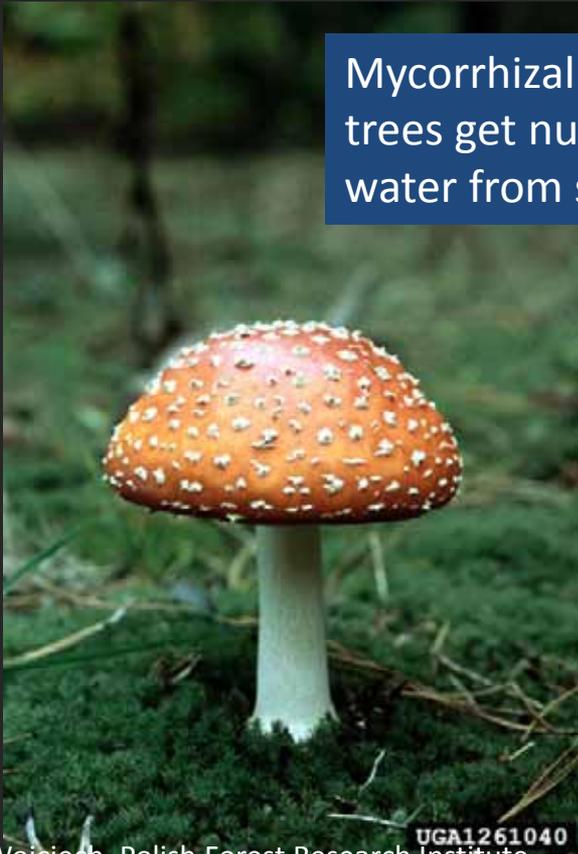
▣ Biotic

- Insects
- Mollusks
- Vertebrates
- Diseases
 - Viruses
 - Fungi
 - Bacteria
 - Nematodes
 - Oomycetes
 - Others

Symptoms tend to only involve certain plant parts

Many plant diseases are caused by fungi, but not all fungi are bad

Mycorrhizal fungi help
trees get nutrients and
water from soils



UGA1261040

Gil Wojciech, Polish Forest Research Institute,
www.forestryimages.org



UGA3036077

Robert L. Anderson, USDA Forest
Service, www.forestryimages.org

Some molds, like *Trichoderma*, protect plants
from disease organisms

What is “normal”?

- ▣ Know what plant you have
- ▣ Recognize what a healthy plant looks like
- ▣ Compare problem plants and healthy plants
- ▣ What part of the plant is affected?



Unusual tanoak (*Lithocarpus densiflorus*)

Photo: Kathy Riley, WSU



Nutrient deficiency on *Quercus*

Petr Kapitola, State Phytosanitary Administration



Normal leaf coloration on *Coleus*

Photo by and (c)2006 Derek Ramsey ([Ram-Man](#)). Location credit to the Chanticleer Garden.

Symptoms

- ▣ The same symptoms can have different causes
- ▣ Plants can have more than one problem



Sooty mold often accompanies a whitefly or aphid infestation

5393369

Root disease

- ▣ Root and butt rots
 - Basidiomycete fungi
 - Decay, physical failure
- ▣ Cortical root disease
 - *Phytophthora*
- ▣ Vascular wilts
 - Ascomycete fungi

Root disease on the landscape - Aerial photograph of root disease patches. Ringworm pattern in an otherwise uniform canopy.



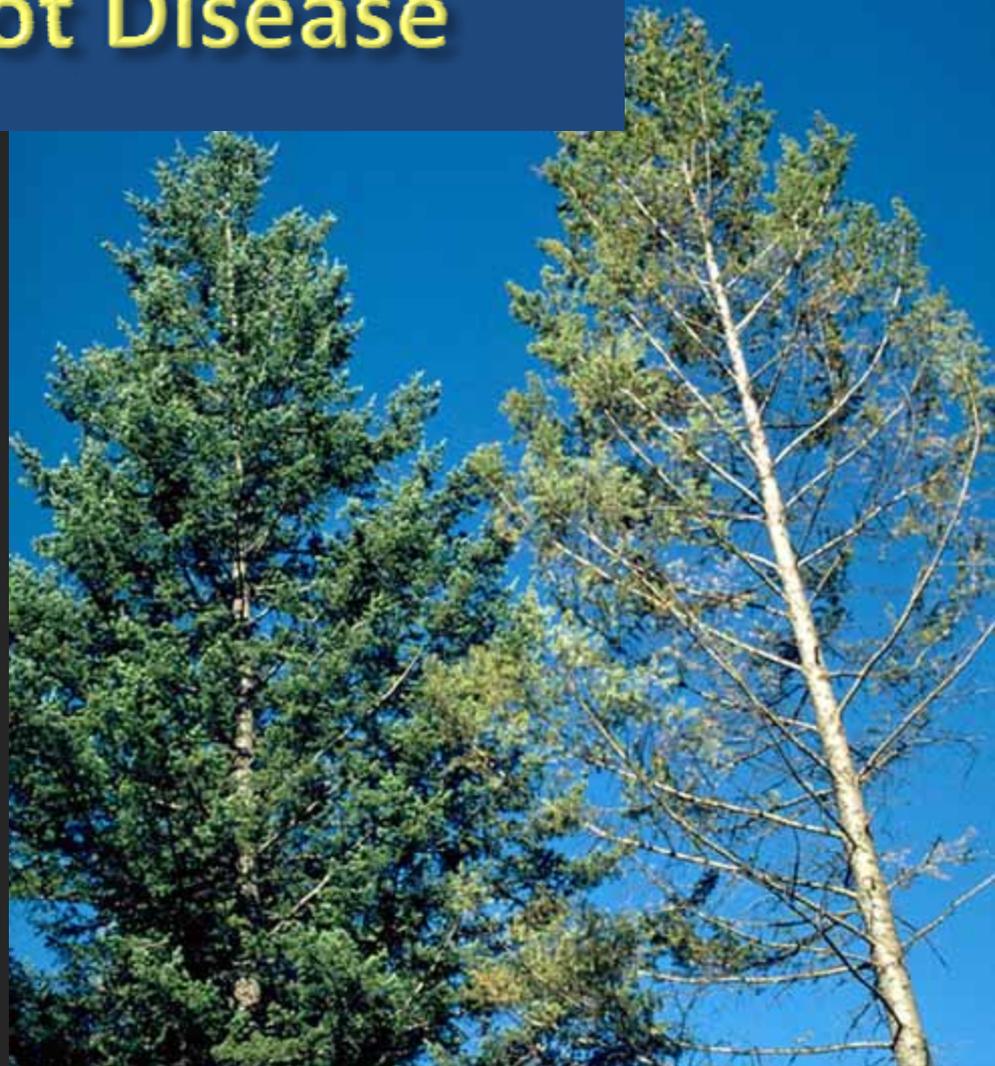
Symptoms of Root Disease

Conifers

- ▣ Reduced growth, flattening of crown
- ▣ Stress cone crop

Hardwoods

- ▣ Thin foliage, small leaves
- ▣ Wilting
- ▣ Branch dieback



Crown symptoms of root disease (right) are most evident when compared to a healthy crown (left).

Susan K. Hagle, USDA Forest Service, www.forestryimages.org

Other root problems

Soil compaction from pavement



Flooding

Root rots

- ▣ Armillaria
- ▣ Annosus root and butt rot
- ▣ Laminated root rot



Armillaria mycelial fan under bark at base of tree

Minnesota Department of Natural Resources Archive, Minnesota Department of Natural Resources UGA4294008

www.forestryimages.org

Annosus root rot; windthrow



UGA1502052

USDA Forest Service - Region 8 Archive,
USDA Forest Service,
www.forestryimages.org

Phytophthora root diseases

- ▣ Port Orford Cedar root rot (*P. lateralis*)
- ▣ *Phytophthora* root rot of ornamentals
 - Several species of *Phytophthora*
 - Many woody ornamental hosts



Andrej Kunca, National Forest Centre - Slovakia, www.forestryimages.org 06A1371017

Necrosis on the roots and root collar, brown stain under bark

Phytophthora root disease

- ▣ Flooding
- ▣ Poor drainage
- ▣ At bottom of slope



Andrew J. Boone, South Carolina Forestry Commission, Bugwood.org
UGA0010134



Pat Moore, WSU

Some of these raspberries are resistant to
Phytophthora rubi

Stem and branch diseases

- ▣ Vascular wilts
- ▣ Cankers
- ▣ Wetwood
- ▣ Shoot blight
- ▣ Wood decay
- ▣ Rusts



Canker and branch dieback on Pacific madrone

Vascular wilts

- ▣ Dutch elm disease
- ▣ Verticillium wilt of maple
- ▣ Blackstain root disease

Maple trunk section with outer tissue cut away to reveal characteristic olive green color of Verticillium-infected xylem.



Advanced crown symptoms of Dutch elm disease

JGA1398053

Cankers

- ▣ Localized necrosis of the bark and cambium on stems, branches or twigs caused by fungi.
- ▣ Often centered around a wound or branch stub
- ▣ Other symptoms – sunscald, wound reactions, frost damage



Cankers on Pacific madrone stem

Phytophthora canker

- ▣ Bleeding
- ▣ No callus margin
- ▣ Brown staining under bark

P. ramorum – Sudden Oak Death

P. lateralalis – Port Orford cedar

P. cambivora – many hosts

P. cinnamomi – *Eucalyptus* and others



Abiotic canker symptoms



Sunscald is seen on the south side of thin barked trees



Poor quality landscape tree with a frost crack.



Hail damage on twigs

Mechanical damage



Parking lot damage



Mechanical damage from
frisbee golf



This tree has a chestnut
blight canker that formed
after the name was
carved in the trunk.

Joseph O'Brien, USDA Forest
Service, www.forestryimages.org

Canker rots



Tree failure from decay caused by Hypoxylon canker



Bacterial Wetwood

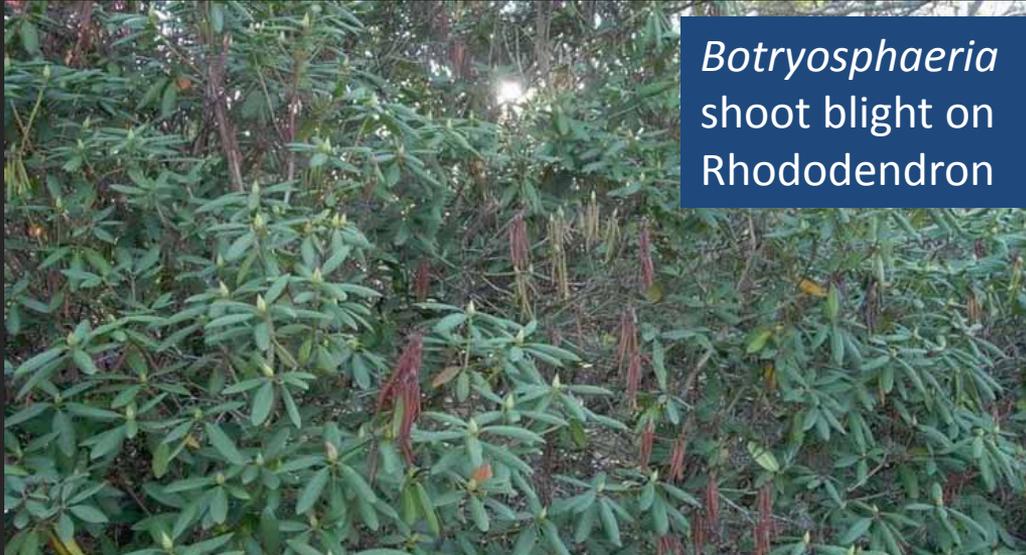
Occupies the **heartwood** of some tree species

- conifers: firs and hemlocks primarily
 - hardwoods: elms, poplars, birches, oaks
- ▣ Appears to represent a mutualistic relationship where the bacteria create conditions that help defend the tree from decay fungi.



Bacterial wetwood and slime flux on elm tree at UW arboretum, Seattle, WA

Shoot blight



Botryosphaeria
shoot blight on
Rhododendron

Elizabeth Bush, Virginia
Polytechnic Institute and
State University,
www.forestryimages.org



“Shepherd’s crook” on
poplar caused by
Venturia populina

Manfred Mielke, USDA Forest Service,
www.forestryimages.org



Tip dieback on juniper caused
by *Phomopsis juniperivora*

USDA Forest Service Archive, USDA Forest
Service, www.forestryimages.org

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Wood decay

A tree can live for years with heart rot



Edward L. Barnard, Florida
Department of Agriculture and
Consumer Services, Bugwood.org

UGA4822032

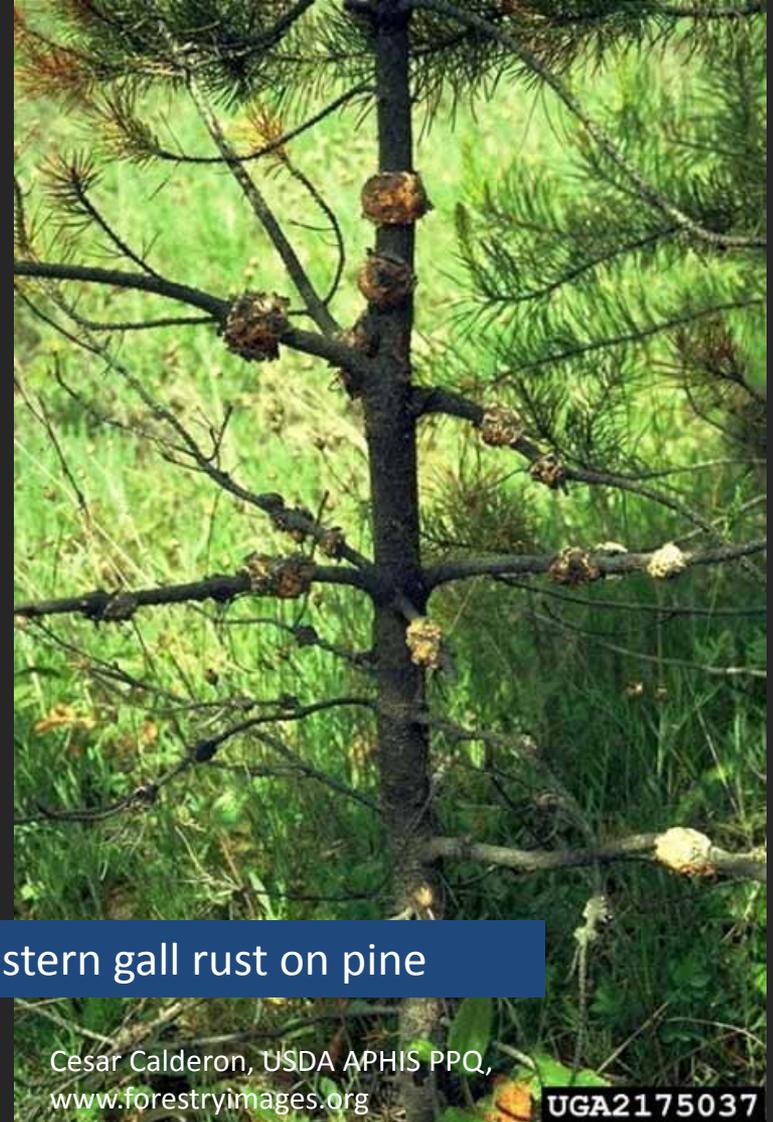


Joseph O'Brien, USDA Forest Service, www.forestryimages.org

UGA5055083

Rusts

- ▣ They are often host specific, but many tree rusts just go to a genus or part of one.
- ▣ They may use only one host during their life cycle or may alternate between two unrelated hosts in completing life cycle
- ▣ Most rusts have up to 5 spore stages.



Western gall rust on pine

Cesar Calderon, USDA APHIS PPQ,
www.forestryimages.org

UGA2175037

Foliar diseases

Hardwoods

- ▣ Anthracnose
- ▣ Leaf spots
- ▣ Sooty mold
- ▣ Powdery mildew
- ▣ Blister blights
- ▣ Rusts

Conifers

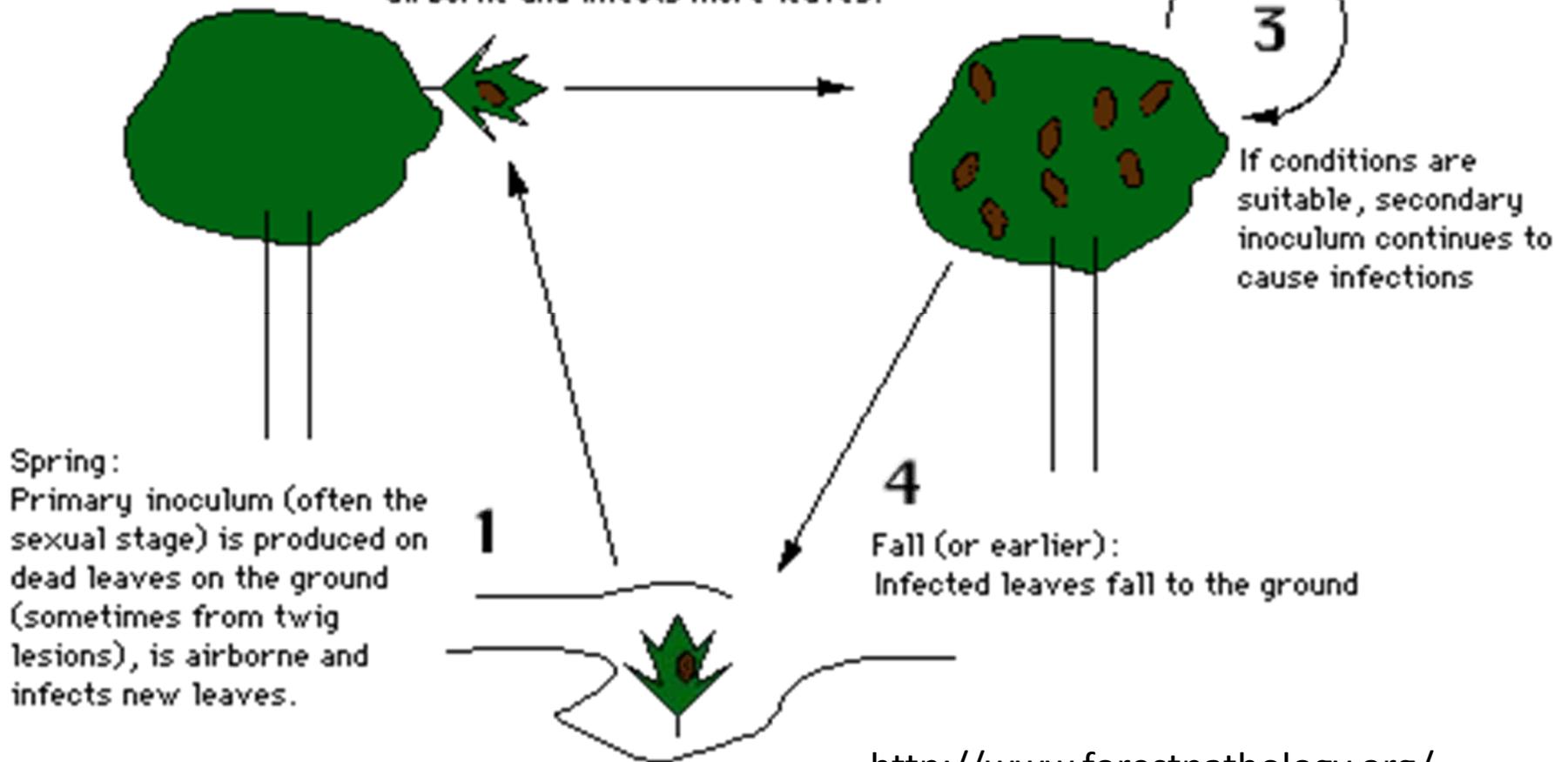
- ▣ Needle cast
- ▣ Needle blight
- ▣ Needle rusts

Abiotic

- Nutrient deficiency
- Air pollution damage
- Drought

Disease cycle

- 2 Late spring, summer :
Secondary inoculum (often asexual) is produced on infected leaves on the tree. It is water-splashed or airborne and infects more leaves.



Anthracnose

- ▣ Causes small twig cankers
- ▣ Leaf spots or blights in spring
- ▣ Worse in wet weather



Theodor D. Leininger, USDA Forest Service,
www.forestryimages.org

Sycamore anthracnose

Leaf spots

Many fungal diseases can be identified by their fruiting bodies, such as Tar spot on maple caused by the fungus *Rhytisma punctatum*



Andrej Kunca, National Forest Centre - Slovakia, www.forestryimages.org

UGA1415148



Leaf blotches caused by elm leaf beetle may look like a disease – but look for the insects on foliage



Whitney Cranshaw, Colorado State University, Bugwood.org

UGA5302087

UGA5038065

Powdery mildews

- ▣ Host-specific, obligate parasites
- ▣ Superficial
- ▣ Carry water with them so not as dependent on wet conditions



Lilac leaves showing signs of infection with powdery mildew (*Microsphaera syringae*).

Blister blights

- ▣ Caused by *Taphrina* spp.
- ▣ Obligate parasites

Oak leaf blister caused by *Taphrina caerulescens*



Joseph O'Brien, USDA Forest Service, www.forestryimages.org



Cheryl Moorehead, individual, www.forestryimages.org

Galls on foliage can be caused by mites. Maple bladdergall mite looks very similar.

Foliar diseases of conifers

- ▣ More serious than on hardwoods because they cannot refoliate
- ▣ More severe in artificial, managed situations

Lophodermium needle cast on sand pine (*Pinus clausa*)



Photo: Edward L. Barnard, Florida Department of Agriculture and Consumer Services

UGA4823057

Abiotic foliar “diseases”

- ▣ Usually affect whole tree
- ▣ No fruiting bodies

- ▣ Fungal diseases
 - Need water
 - In lower part of canopy
 - Fruiting bodies can be seen



Nutrient deficiency damage on
Beech (*Fagus sylvatica*)

Nutrient deficiency



Petr Kapitola, State Phytosanitary Administration,
www.forestryimages.org

Nitrogen deficiency often causes chlorosis,
or yellowing foliage



Division of Plant Industry Archive, Florida Department of Agriculture
and Consumer Services, www.forestryimages.org

Air pollution



Robert L. Anderson, USDA Forest Service, www.forestryimages.org
UGA0355005



Robert L. Anderson, USDA Forest Service, www.forestryimages.org

UGA0364093

Ozone produced by vehicle exhaust, is the most damaging to plants

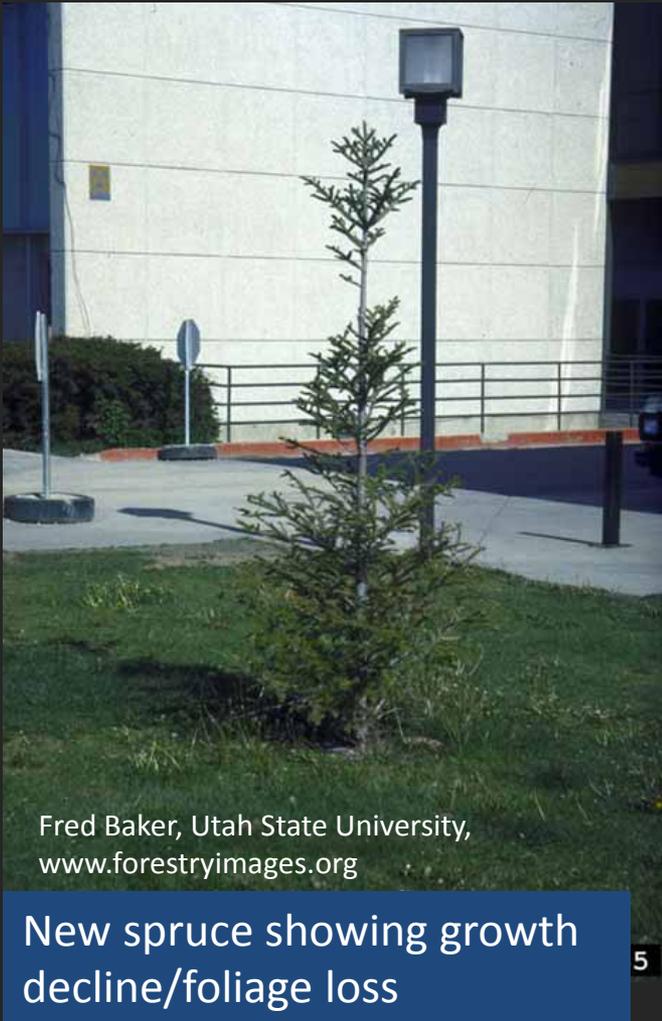
Sun scorch



Petr Kapitola, State Phytosanitary Administration, Bugwood.org



What's killing this tree?



Fred Baker, Utah State University,
www.forestryimages.org

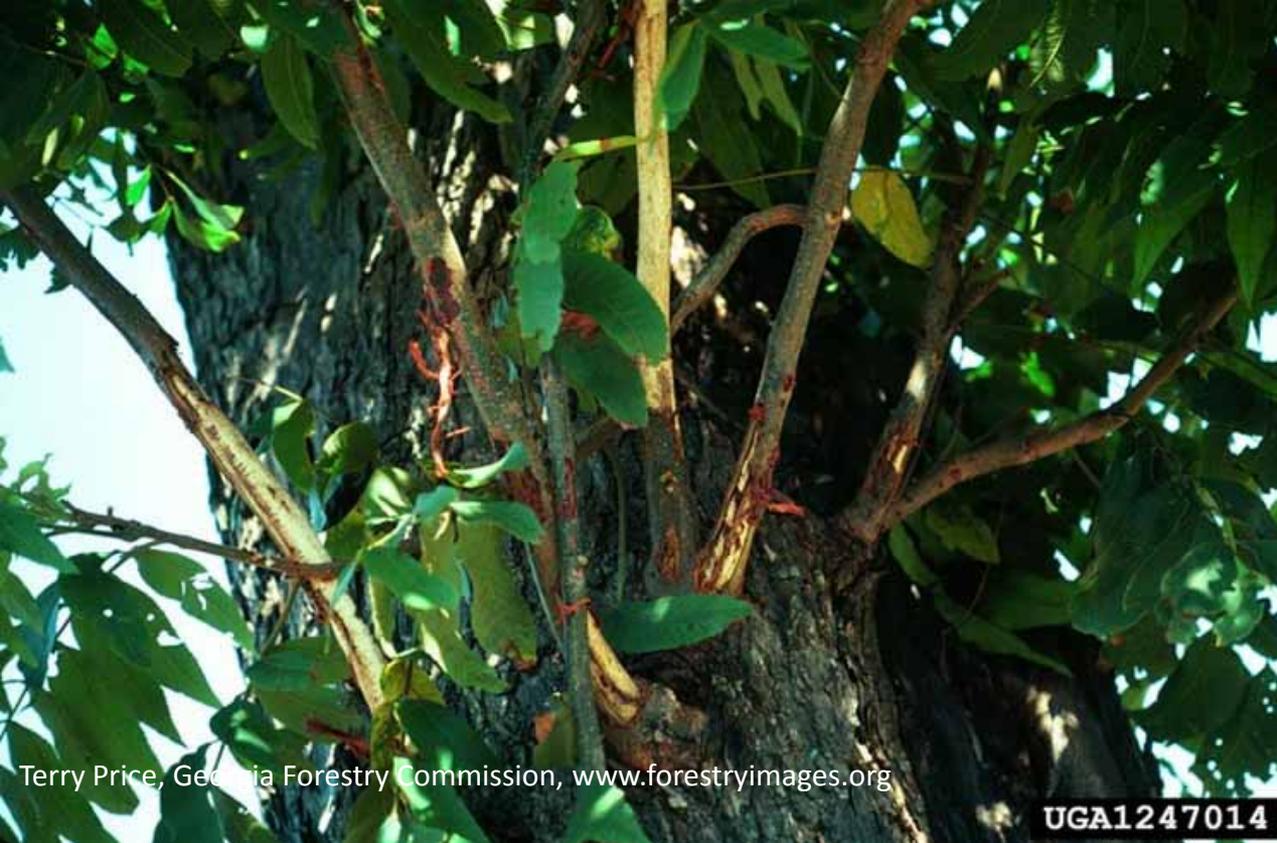
New spruce showing growth
decline/foliage loss

5



William M. Brown Jr., www.forestryimages.org

5356896



Chewing damage from squirrels

Terry Price, Georgia Forestry Commission, www.forestryimages.org

UGA1247014

Dryer lint blew onto this tree and looks like fungal damage.



Mary Ann Hansen, Virginia Polytechnic Institute and State University

5337054

Disease management

- ▣ The most effective management technique is prevention
- ▣ Cultural
- ▣ Chemical and biological controls



Removal of elm killed by Dutch Elm disease

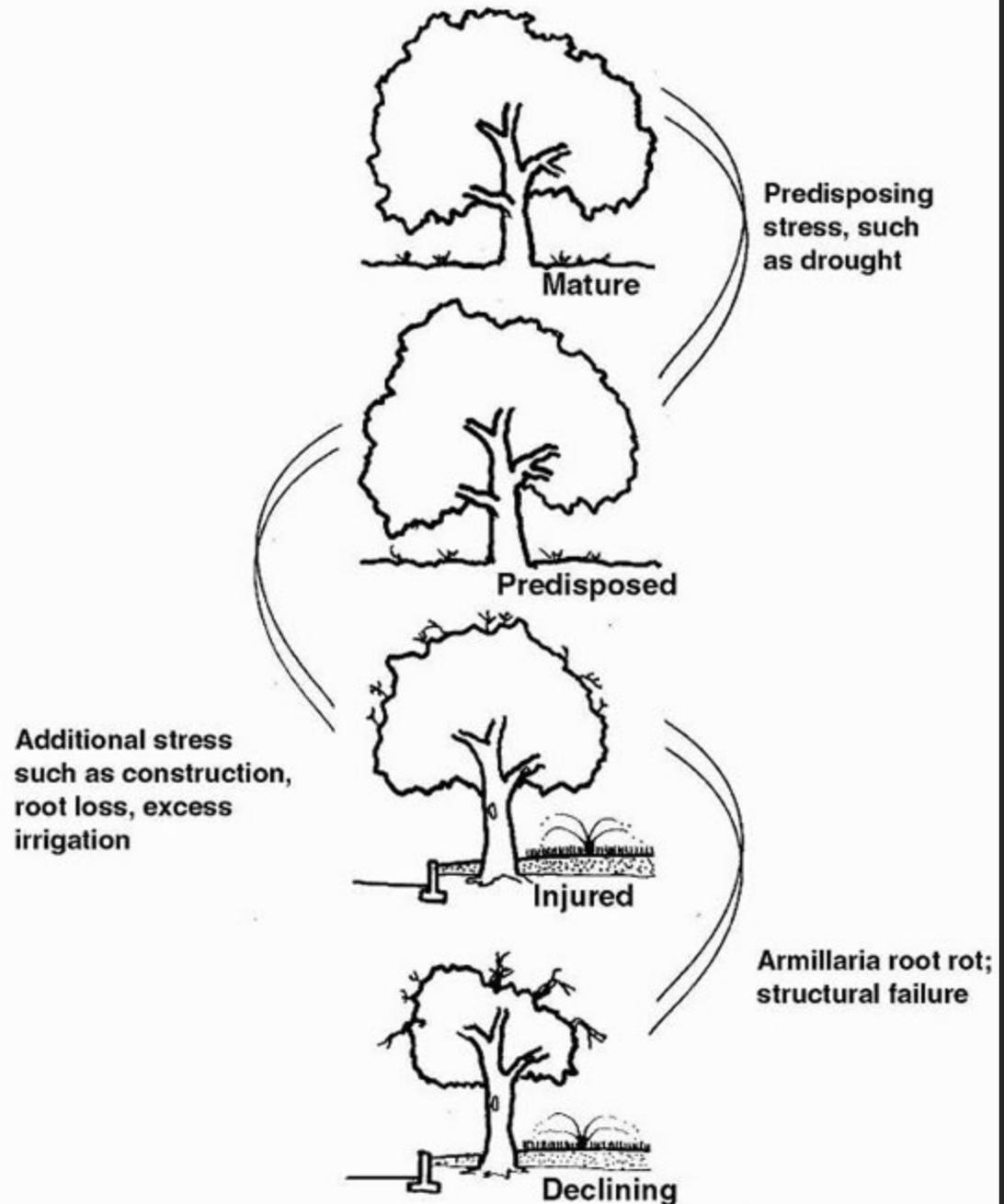
Water Management

Phytophthora breeds in standing water



Plants that tip over into puddles containing inoculum (zoospores) become infected within 10 seconds!

Drought stress
predisposes plants
to attack by
opportunistic
fungi

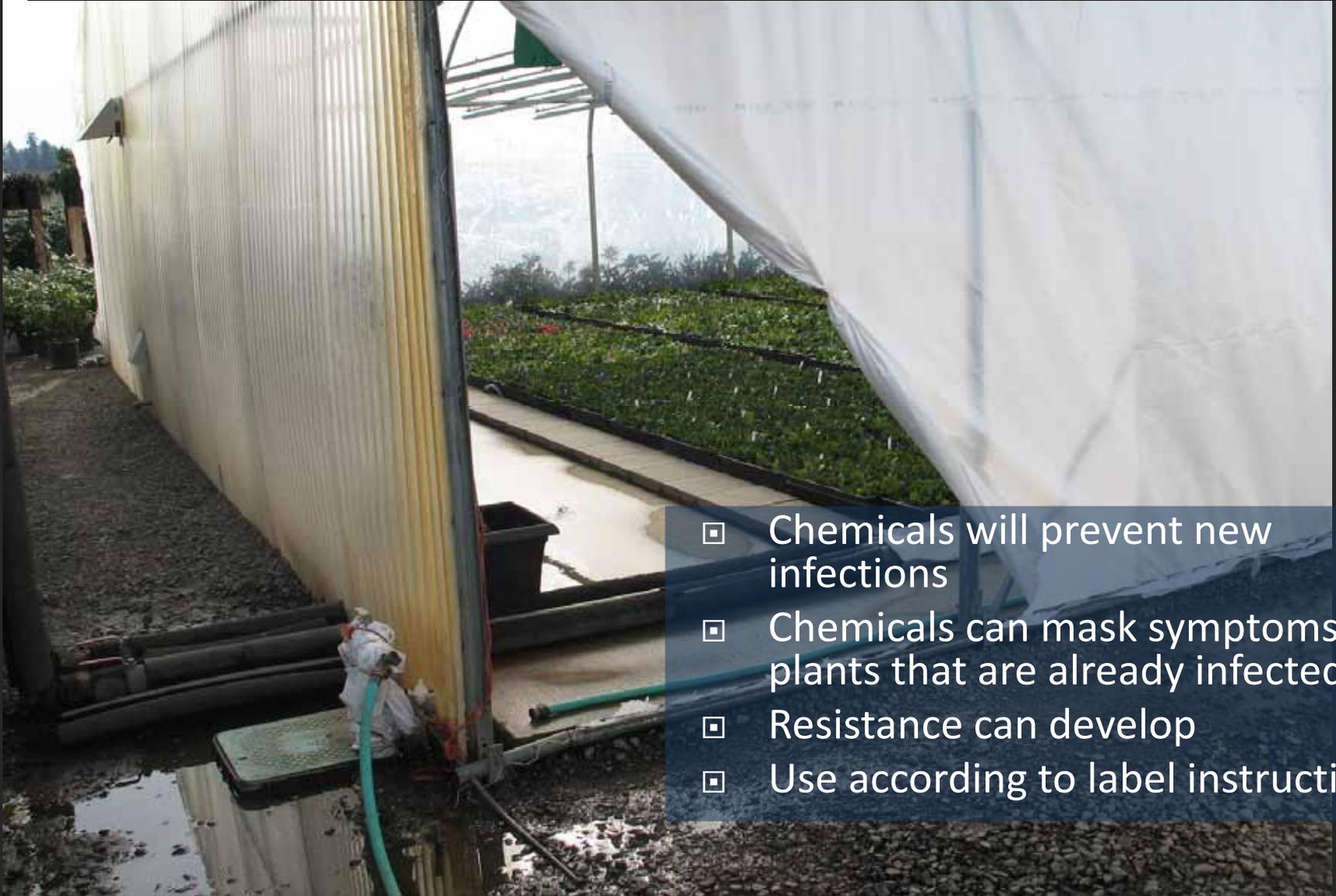


Sanitation

- ▣ Remove fallen leaves – they are a source of inoculum for new infections
- ▣ Use clean pots
- ▣ Weeds can harbor pathogens, remove them



Fungicides – use with caution



- ❑ Chemicals will prevent new infections
- ❑ Chemicals can mask symptoms in plants that are already infected
- ❑ Resistance can develop
- ❑ Use according to label instructions

Biological controls

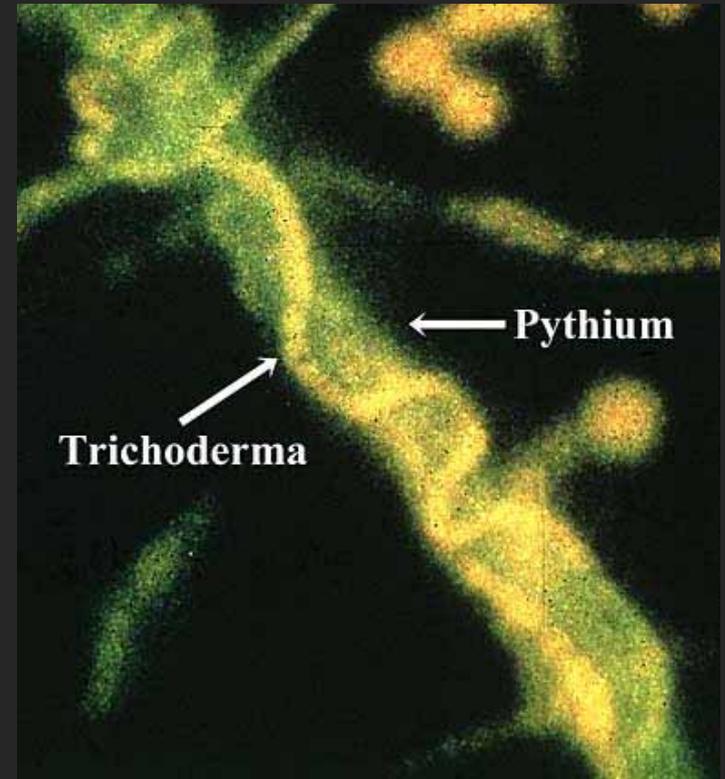
Most effective when applied to
soils or potting mix

Some commercially available biocontrol
agents:

Bacteria – *Bacillus subtilis*, *B. cereus*

Fungi – *Trichoderma spp.*

Streptomyces spp.



Organic soil treatments

- ▣ Mulches, composts, bark chips
- ▣ Contain antagonistic bacteria and fungi
- ▣ Chemicals
- ▣ Cellulolytic enzymes



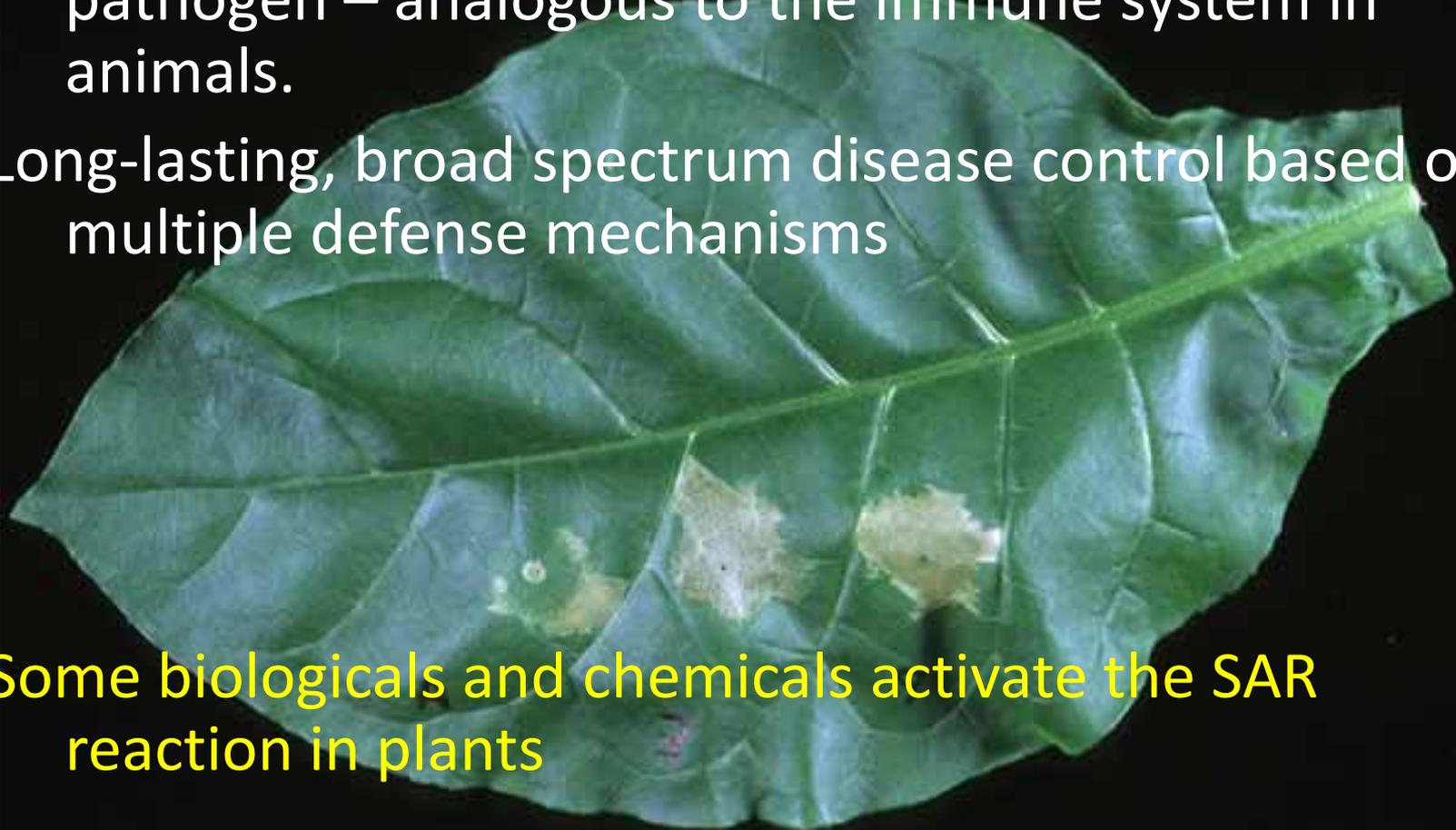
Photo: Wilson's Garden Center, Utica, OH

Systemic Acquired Resistance

A 'whole plant' resistance response to infection by a pathogen – analogous to the immune system in animals.

Long-lasting, broad spectrum disease control based on multiple defense mechanisms

Some biologicals and chemicals activate the SAR reaction in plants



Any questions about tree diseases?

SUDDEN OAK DEATH



Invasive plant diseases

- ▣ Chestnut blight
(*Cryphonectria parasitica*)
on American chestnut
- ▣ White pine blister rust
(*Cronartium ribicola*) on
Western white pine
- ▣ Dutch elm disease
(*Ophiostoma ulmi*) on
American elm
- ▣ **Sudden oak death**
(*Phytophthora ramorum*)
on tanoak

These are capable of eliminating certain host species from an ecosystem



Chestnut blight caused by the fungus *Cryphonectria parasitica*

Phytophthora – the plant destroyer



P. infestans – responsible for the Irish potato famine in 1845

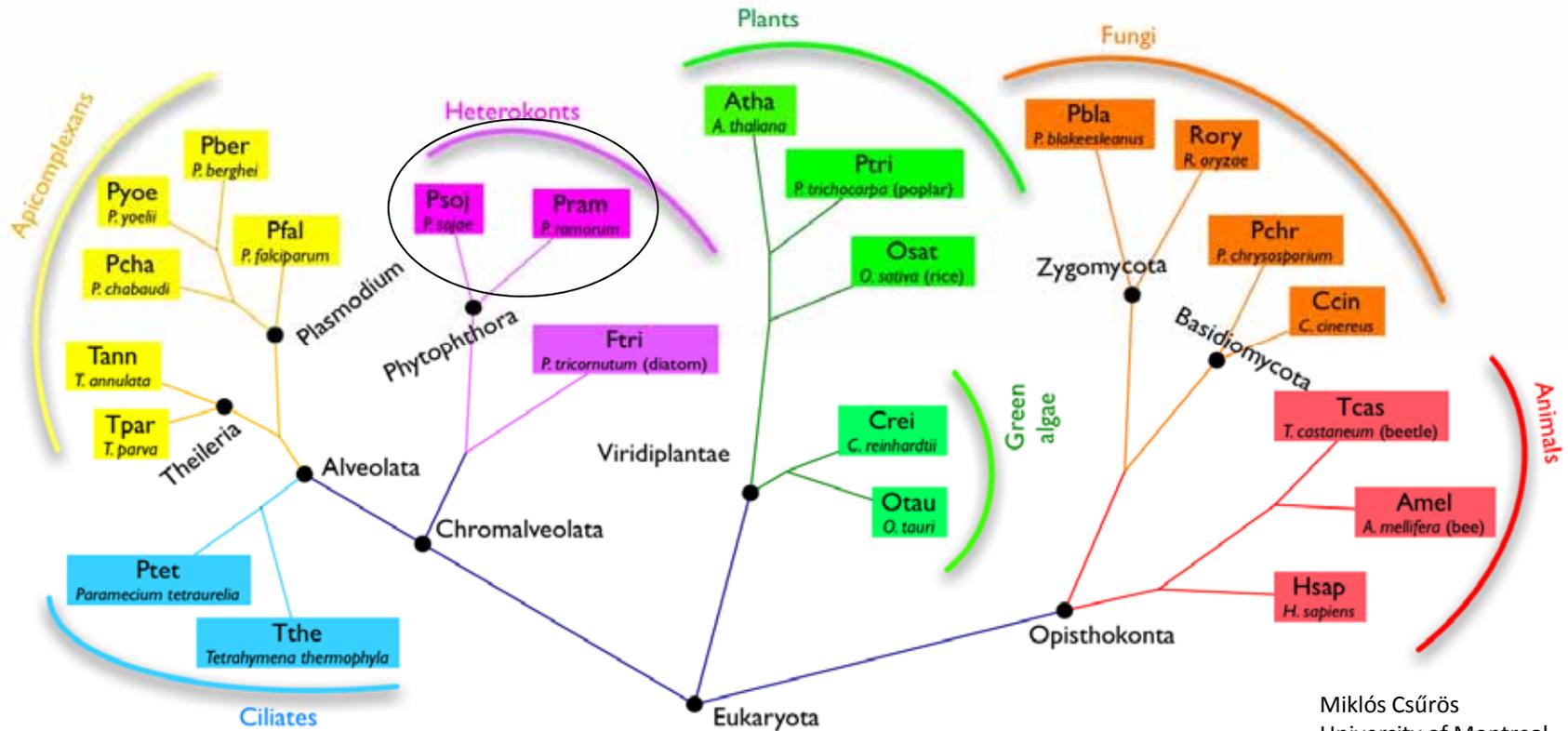
P. sojae - soybean stem and root rot

Several *Phytophthora* spp. cause disease on cacao

P. cinnamomi – causes damage to forest ecosystems worldwide

P. ramorum – causes Sudden Oak Death (SOD)

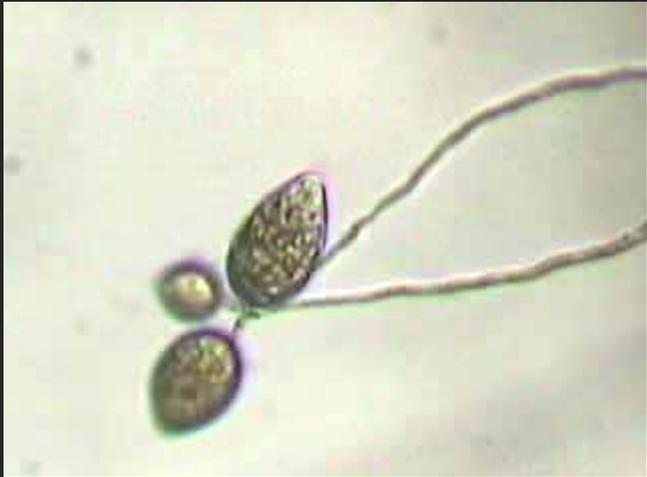
Phytophthora is not a fungus



Miklós Csűrös
University of Montreal

- ❑ Oomycetes were once considered to be fungi
- ❑ Fungi and Oomycetes have similar growth forms – convergent evolution
- ❑ Control agents for fungi may not work for Oomycetes and vice-versa

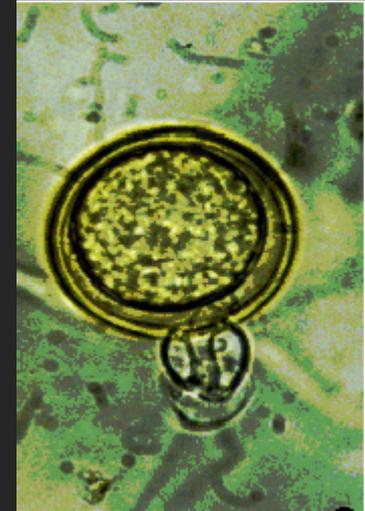
Phytophthora spore stages



Sporangia containing swimming zoospores



Chlamydospores



Oospores (*P. infestans*)

Phytophthora is microscopic and species can be identified by spore stages and/or DNA sequencing

P. ramorum genetics

- ▣ Two mating types – A1 and A2
- ▣ Three clonal lineages – NA1, NA2, EU1

NA1 and NA2

All A2

EU1

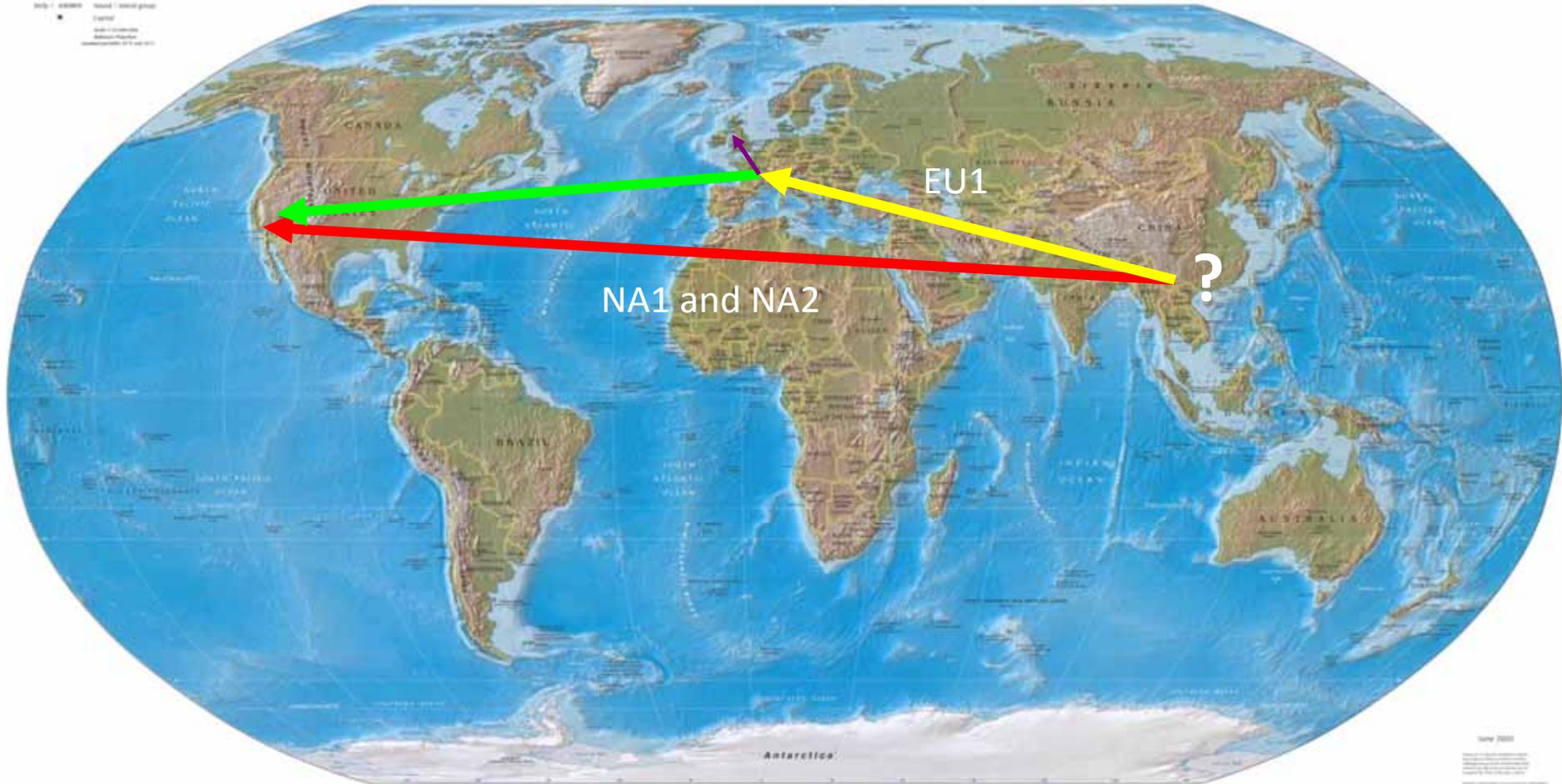
Mostly A1,
with a few A2

No evidence of breeding between EU and US populations has been observed, although it has been done in the lab.

P. ramorum origins

Physical Map of the World, June 2003

INDEPENDENT STATES
DEPENDENCIES OR AREAS OF SPECIAL INTEREST
CANTONS
UNINCORPORATED TERRITORIES
UNRECOGNIZED STATES



Sudden Oak Death in forests

California and SW Oregon

- On tanoak, black oaks, and coast live oak

Not present in WA forests

UK – SW England, Wales, Northern Ireland

- On Japanese larch
- Also on chestnut, birch, beech, oak, Douglas-fir, and western hemlock



Symptoms on trees

- ▣ Bleeding cankers
- ▣ Cankers can girdle the tree and kill it
- ▣ Host species in Fagaceae: oaks, beech, tanoak
- ▣ Other *Phytophthora* spp can cause the same symptoms

P. cambivora on Beech



P. ramorum on Oak

Foliar hosts carry the disease

- ▣ California bay laurel (*Umbellularia californica*)
- ▣ *Rhododendron ponticum*

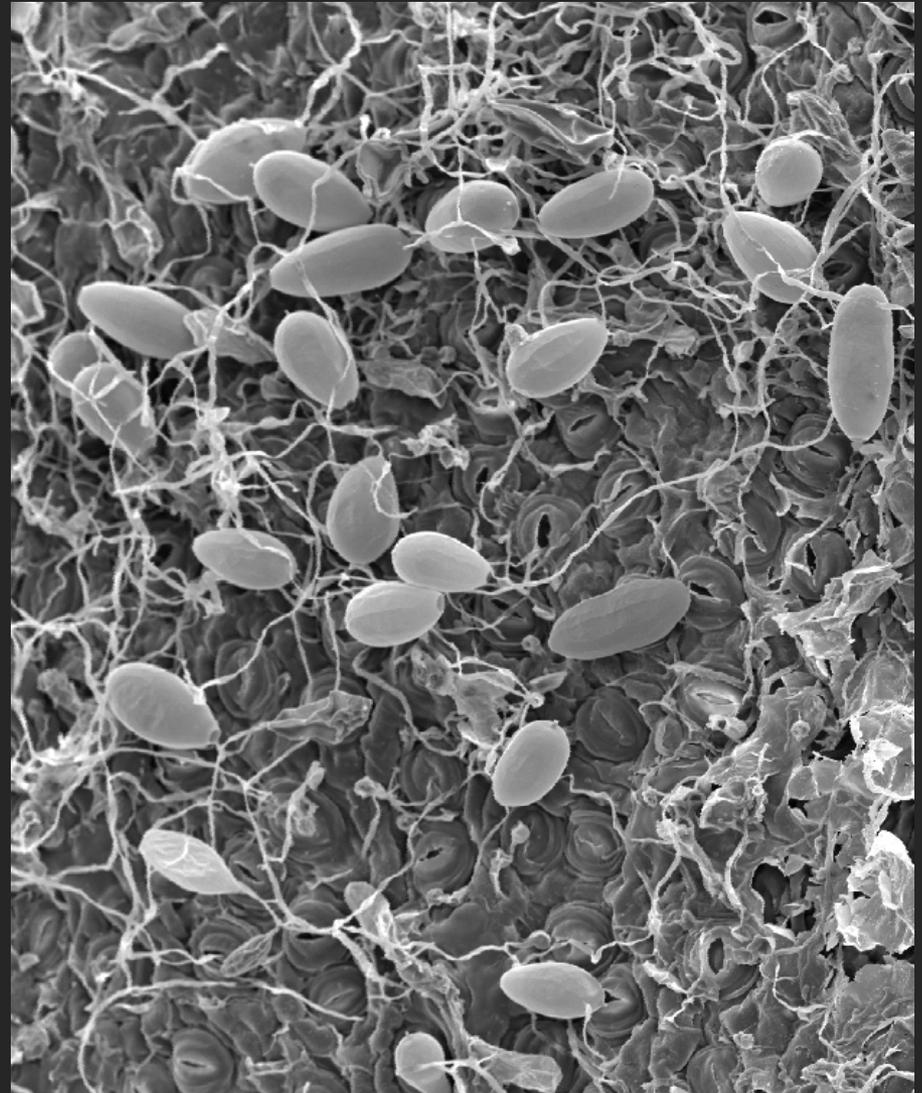


Foliar hosts

Epidemiologically important hosts produce large numbers of sporangia



Rhododendron 'Purple Splendour'



SEM Photo by K. McKeever, WSU

Chlamydospores in infected foliage are another source of Pr inoculum





High risk areas for Sudden Oak Death with suitable climate and native plants are shown in bright red.

Tankersley, Boyce, Dunn, Christopher, Henderson, Min, Viegals, David, Riccardi, Greg, Allenstein, Pam, AND Kappe, Dietrich. "PlantCollections - A Community Solution" *First Monday* [Online], Volume 13 Number 8 (13 August 2008)

P. ramorum in WA nurseries

45 nurseries in western WA
have been Pr+ between
2004-2010

8 have gone out of business



Plants infected with *P. ramorum* must be
burned or buried for disposal.

How does SOD impact WA's economy?

Ornamental nurseries who ship interstate

All these commodities represent a large proportion of WA trade

Forest products: Douglas fir and western hemlock logs (more than 12 bn \$US in 2010)

Non-timber forest products: greenery, transplants, floral products

Christmas trees



Interstate shipping from west coast nurseries

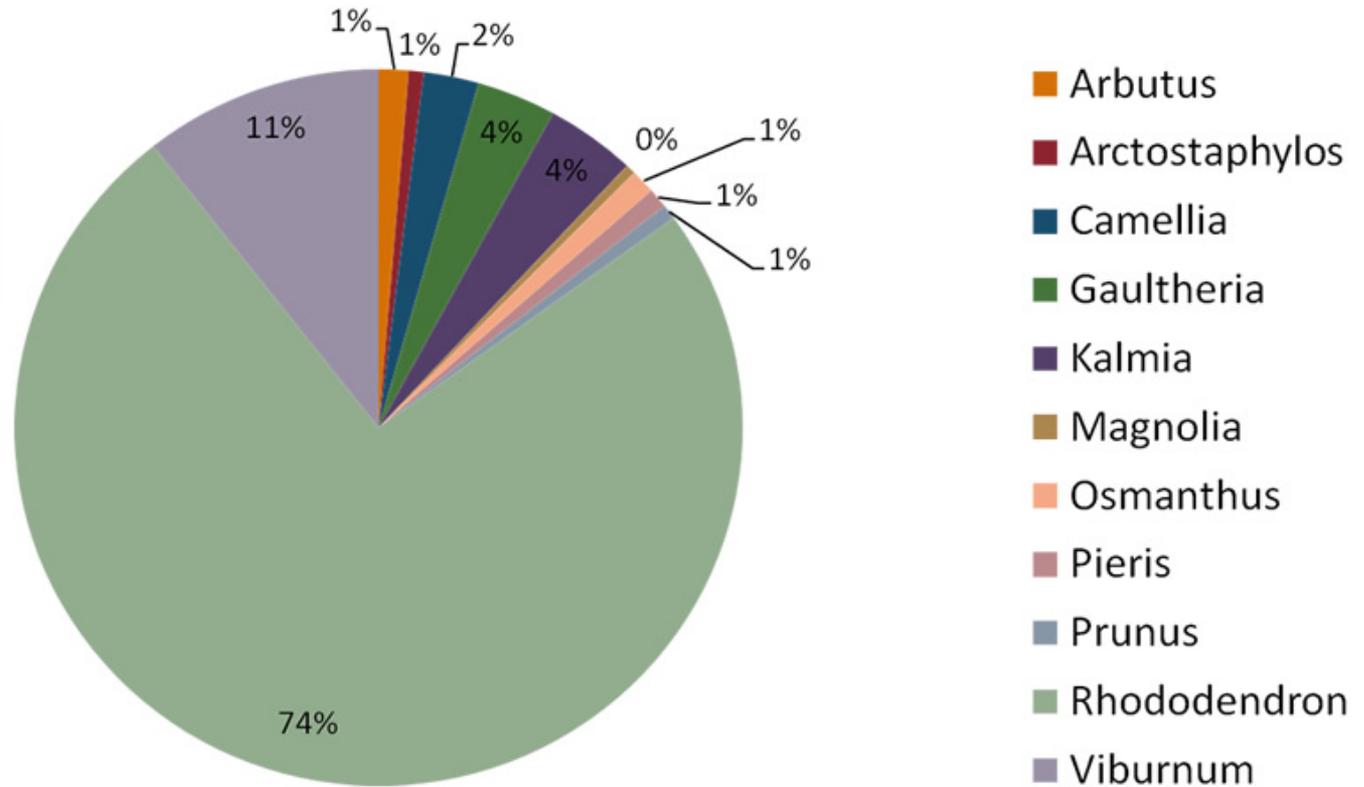
- ▣ Washington – 282
- ▣ Oregon – 1800
- ▣ California - 1562



2009 data from WSDA

Host material

Most Pr detections in WA nurseries are on Rhododendrons



2004-2010

Data from WSDA

Monitoring for *P. ramorum*

WSDA monitors Pr+ nursery sites and perimeters year round

DNR monitors selected waterways during late winter-early summer as part of USFS national *P. ramorum* survey

WSU volunteers monitor additional sites near nurseries that had been Pr+ in the past and not currently being monitored by WSDA or DNR



- ▣ *P. ramorum* inoculum increased in CA forest streams after rainfall
- ▣ Pr not found to infect aquatic and streamside vegetation in CA



Infected tanoaks in
California forest

UGA1427090

WA vegetation surveys

	Years Pr+	Result
Rosedale Stream	2006-2010	negative
Wollochet Creek	2009-2010	Salal near ditch
Sammamish River	2008-2010	negative

Is *P. ramorum* a threat to WA forests?

- ▣ *Pr* is often found in waterways near nurseries that have had positive soil and/or water
- ▣ *Pr* may persist on leaf litter in soil and water
- ▣ Most riparian plant species and many invasives are resistant to obvious *Pr* infection, but may be infected asymptotically

QUESTIONS ABOUT SOD

MADRONE LEAF BLIGHT



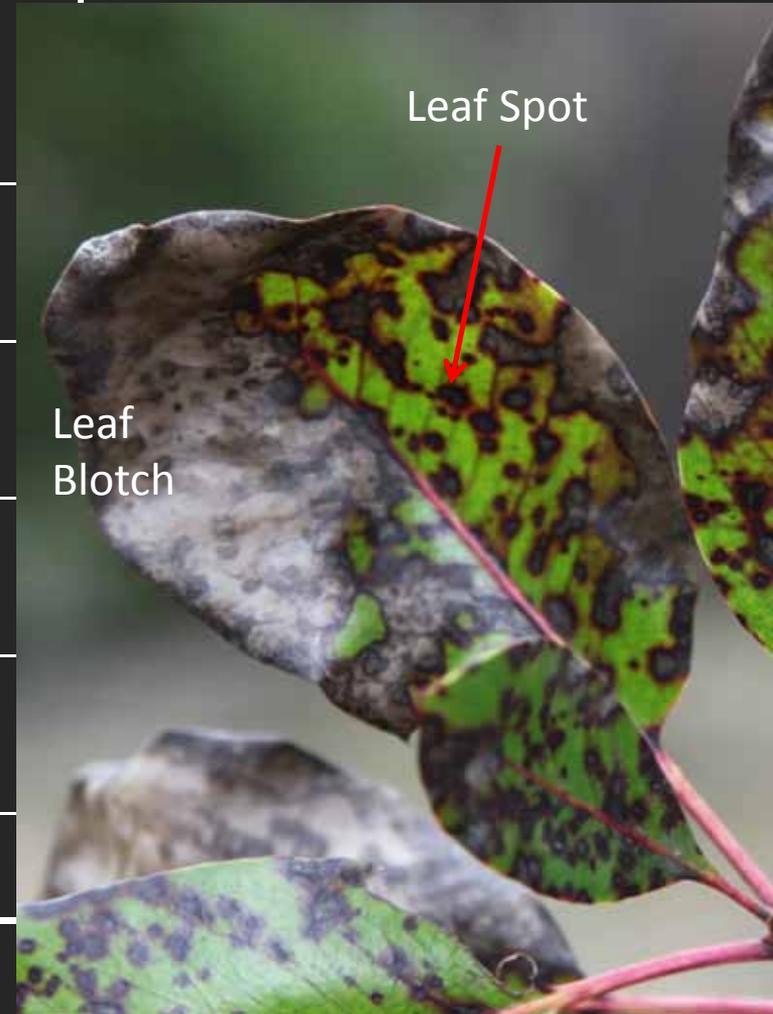
May 2009

Leaf blight on madrones



Isolation frequency of *Phacidiopycnis washingtonensis* May 2009

All samples (224)	41% (91)
<i>Arbutus menziesii</i> , both symptoms, mature foliage (162)	32% (62)
Leaf spot (91)	29% (26)
Leaf blotch (91)	54% (49)
<i>A. menziesii</i> , new foliage (10)	70% (7)
<i>A. unedo</i> (32)	28% (9)



Phacidopycnis washingtonensis

- ▣ A post-harvest rot in apple, also causes twig dieback
- ▣ Grows at low temperatures and is inhibited at temperatures above 25 °C



Xiao, C.L. , Rogers, J.D., Kim, Y.K., and Liu, Q.
2005. *Phacidopycnis washingtonensis* – a new
species associated with pome fruits from
Washington State. *Mycologia* 97 (2): 464 - 473

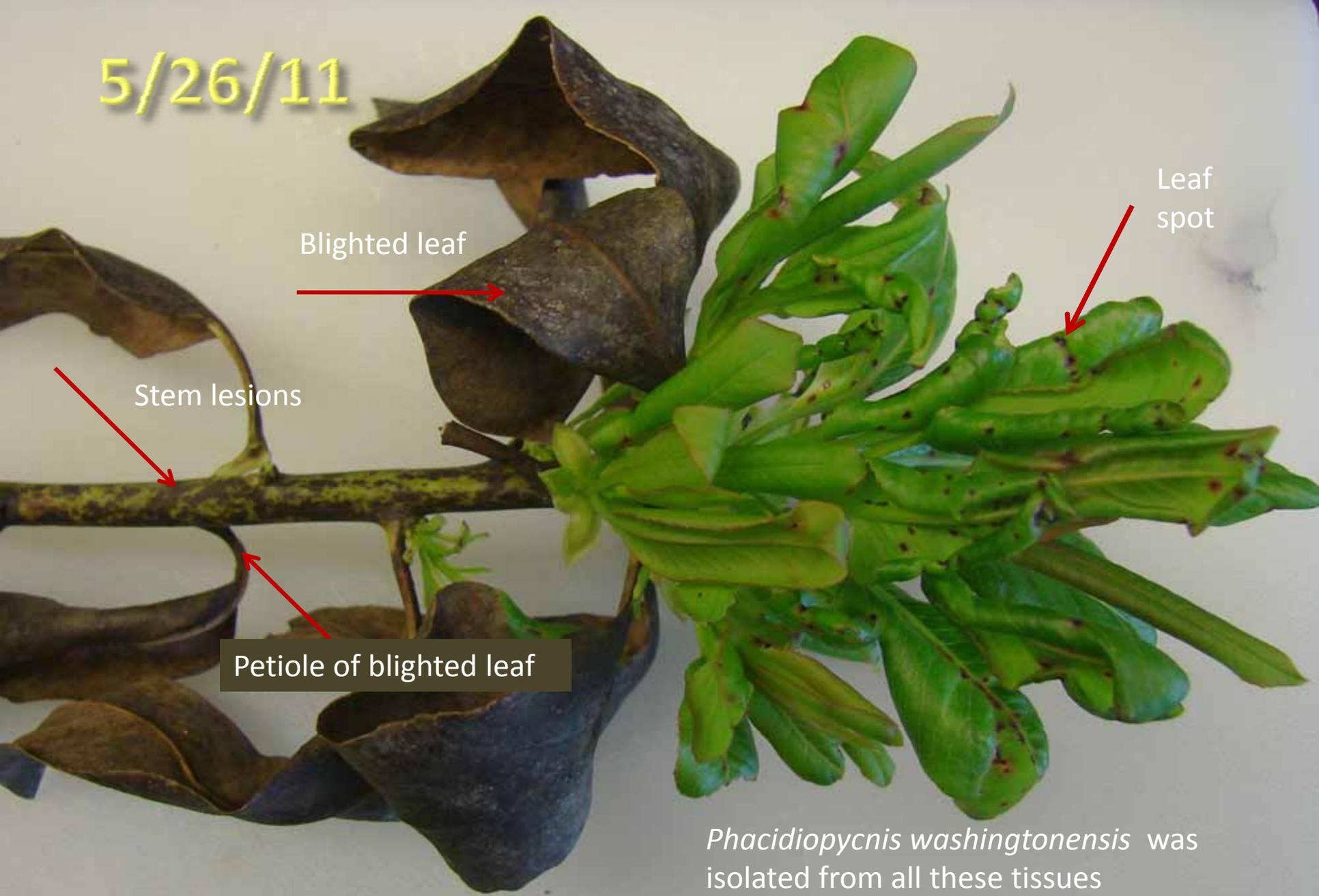


May 2011



Oregon
March 2011

5/26/11



Blighted leaf

Leaf spot

Stem lesions

Petiole of blighted leaf

Phacidiopycnis washingtonensis was isolated from all these tissues

Madrone blight survey 2011

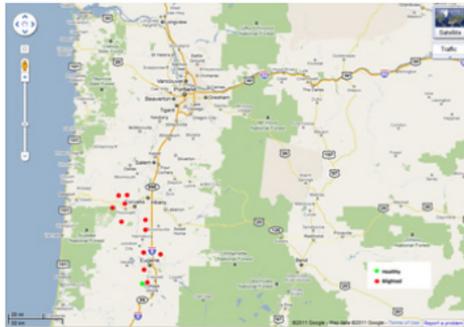
Pacific Madrone Research

Ornamental Plant Pathology

- Home
- General Information
- Madrone Seed Collection
- Diseases of Pacific Madrone**
- Propagation
- Research Results
- Support the Project
- Contact Info

[Pacific Madrone](#) > [Diseases](#) > [Foliar Diseases](#) > [2011 Leaf Blight](#)

Northwest Oregon



May 10, 2011

"We have severe blight around the south Willamette Valley. These pictures were taken 3 miles southwest of Creswell, and even on a south slope most trees have lost all but one layer of leaves. I did notice a few individual trees less affected, so perhaps there is a range of resistance?"

May 2, 2011

"We are seeing this quite common in the Willamette Valley and south along the I 5 corridor and up side valleys. Quite common all around Corvallis and eastern foothills of the Coast Range.

The trees south toward Roseburg etc are really hammered and up through Glide on the Umpqua River."



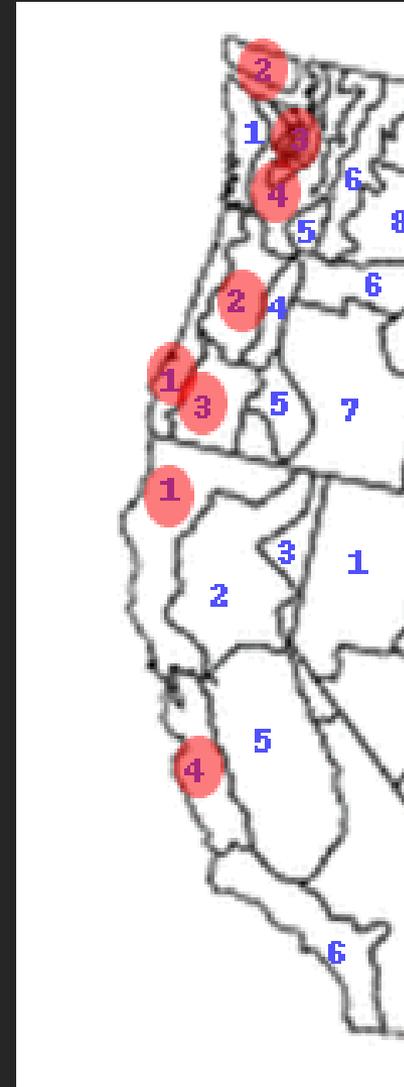
Flowering madrone shoot with blighted leaves



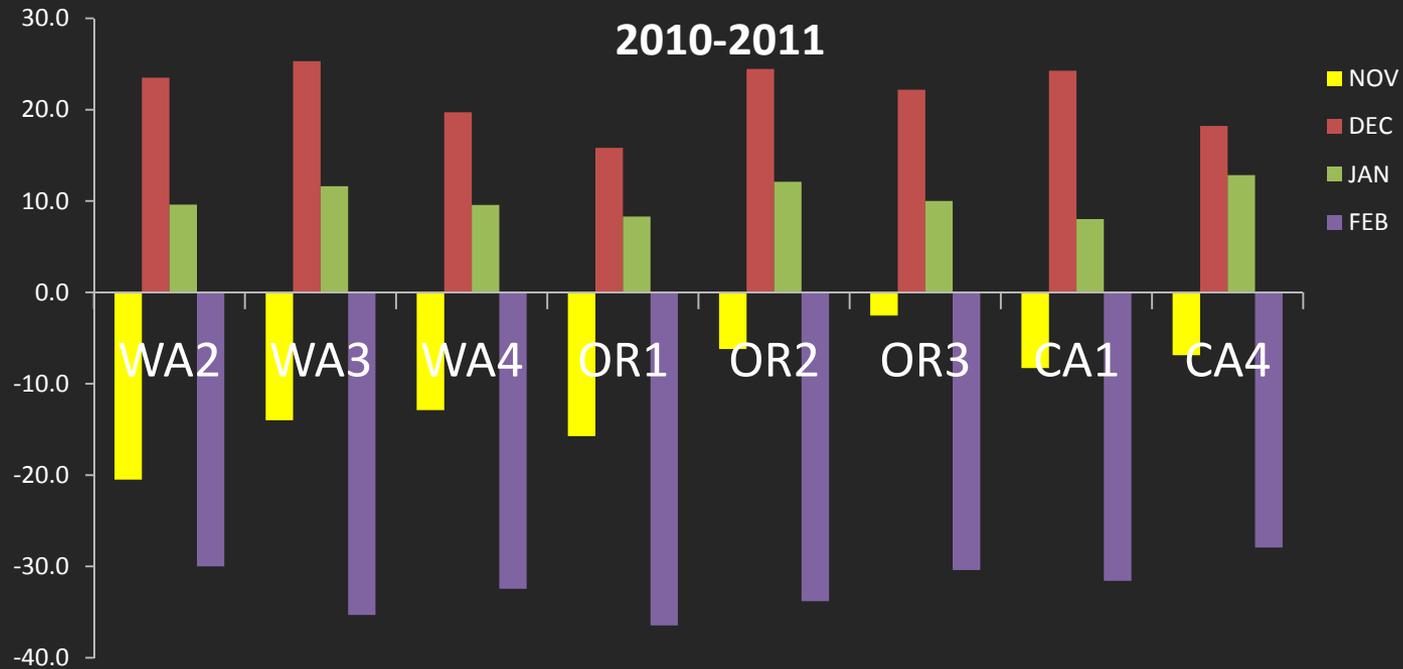
New buds emerging on blighted shoots

Climate zones

- ▣ **WA2** North East Olympics, San Juan Islands
- ▣ **WA3** Puget Sound Lowlands
- ▣ **WA4** East Olympics, Cascade Foothills
- ▣ **OR1** Coastal Area
- ▣ **OR2** Willamette Valley
- ▣ **OR3** Southwestern Valleys
- ▣ **CA1** North Coast Drainage
- ▣ **CA4** Central Coast Drainage



Winter temperatures

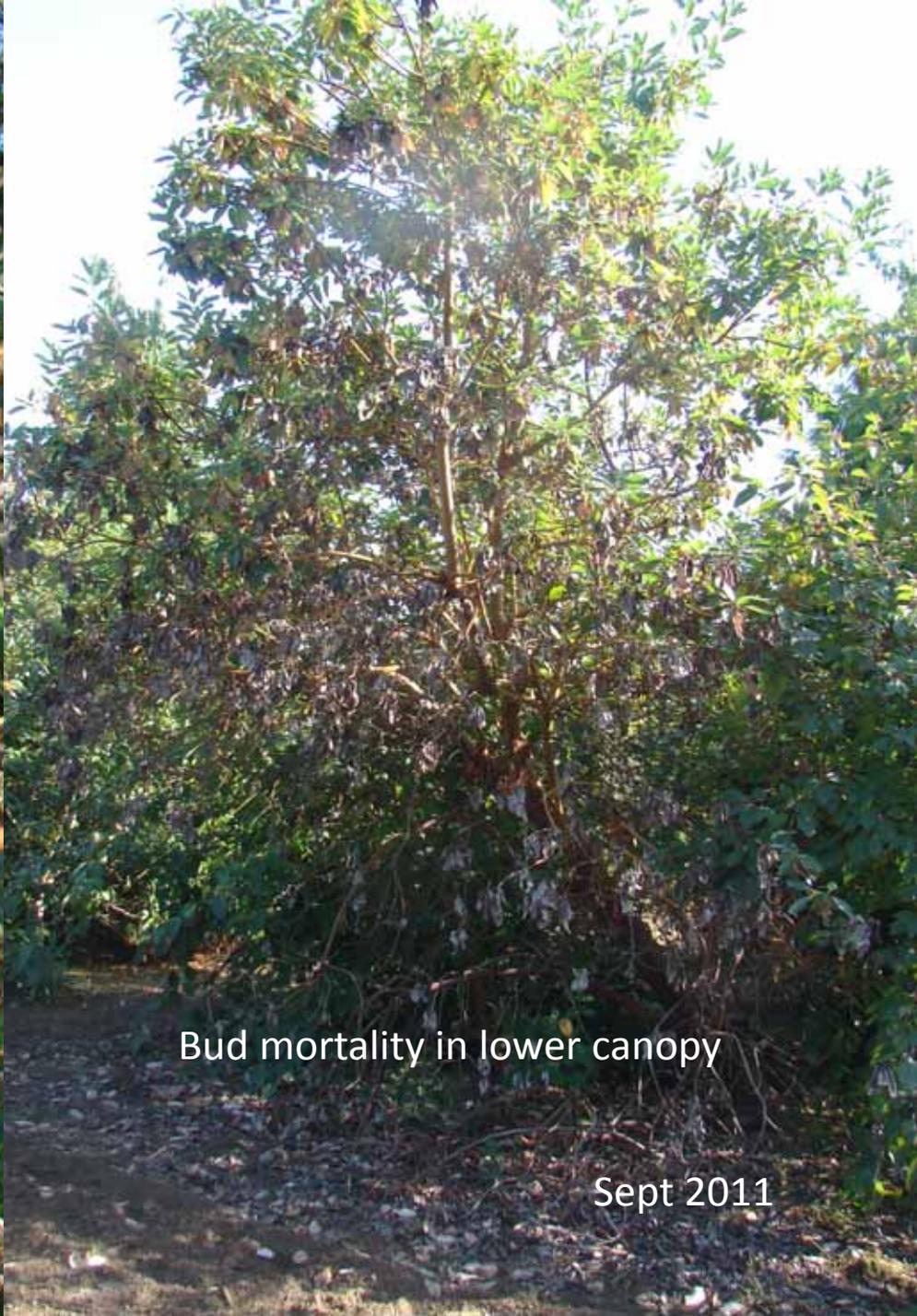


Departures from normal, tenths of degrees F

La Nina weather pattern produces cold, wet weather in PNW

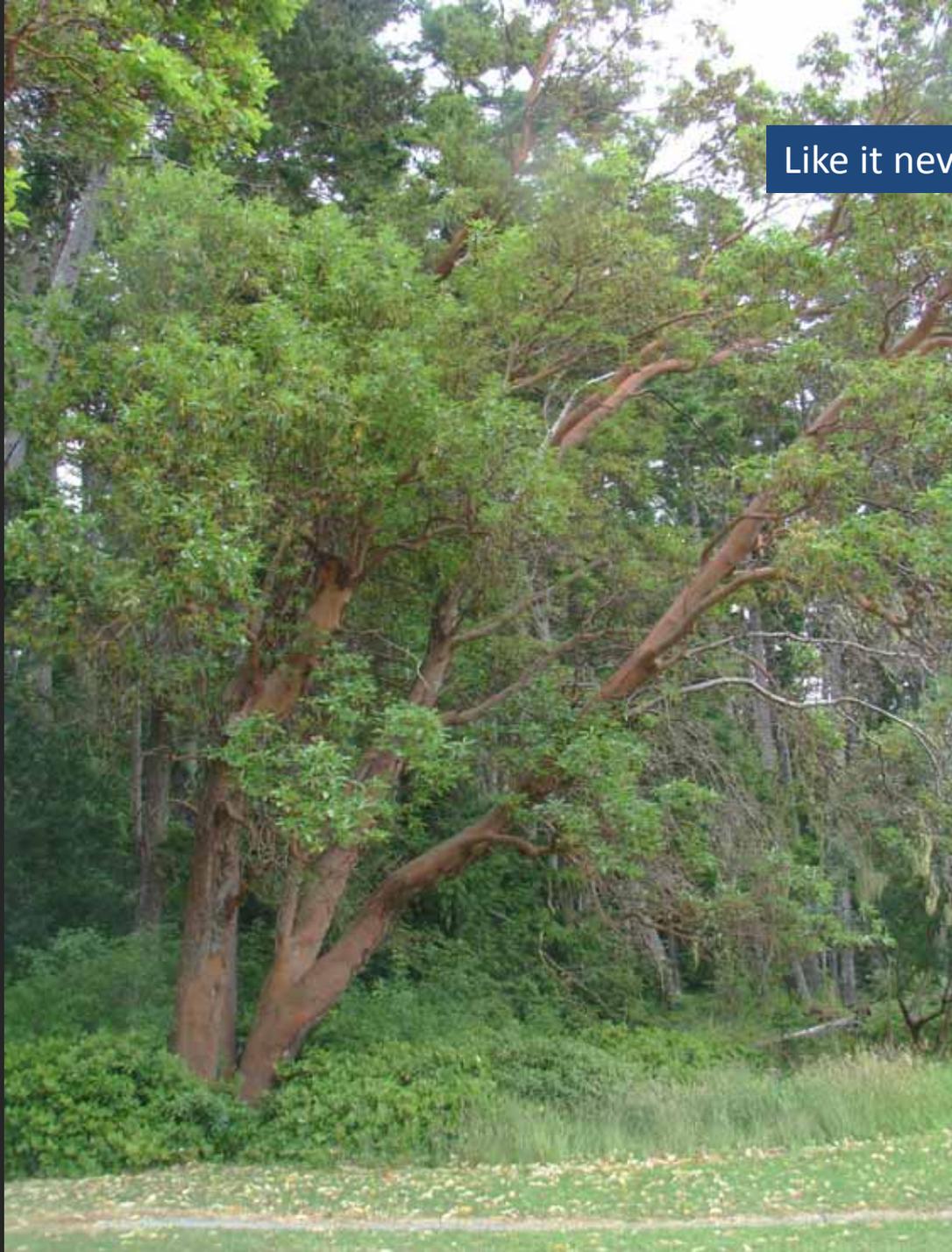
Cold – symptom expression

Wet – new infections



Bud mortality in lower canopy

Sept 2011



Like it never happened!

East Sooke Park,
Vancouver Island, BC
July 2011

For more information

Forest and Shade Tree Pathology online course

<http://www.forestpathology.org/>

Tom Volk's Fungi

<http://tomvolkfungi.net/>

WSU Sudden Oak Death Program

<http://www.puyallup.wsu.edu/ppo/sod/>

WSU Pacific Madrone Research

<http://www.puyallup.wsu.edu/ppo/madrone/>

Thanks for listening



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