

Phytophthora in wildlands, native plant nurseries, and management:

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Photos by: Laura Sims

Phytophthora tentaculata in California since at least 2012



Photo by: S. Rooney-Latham



Photo: Phytosphere research

Phytophthora overview

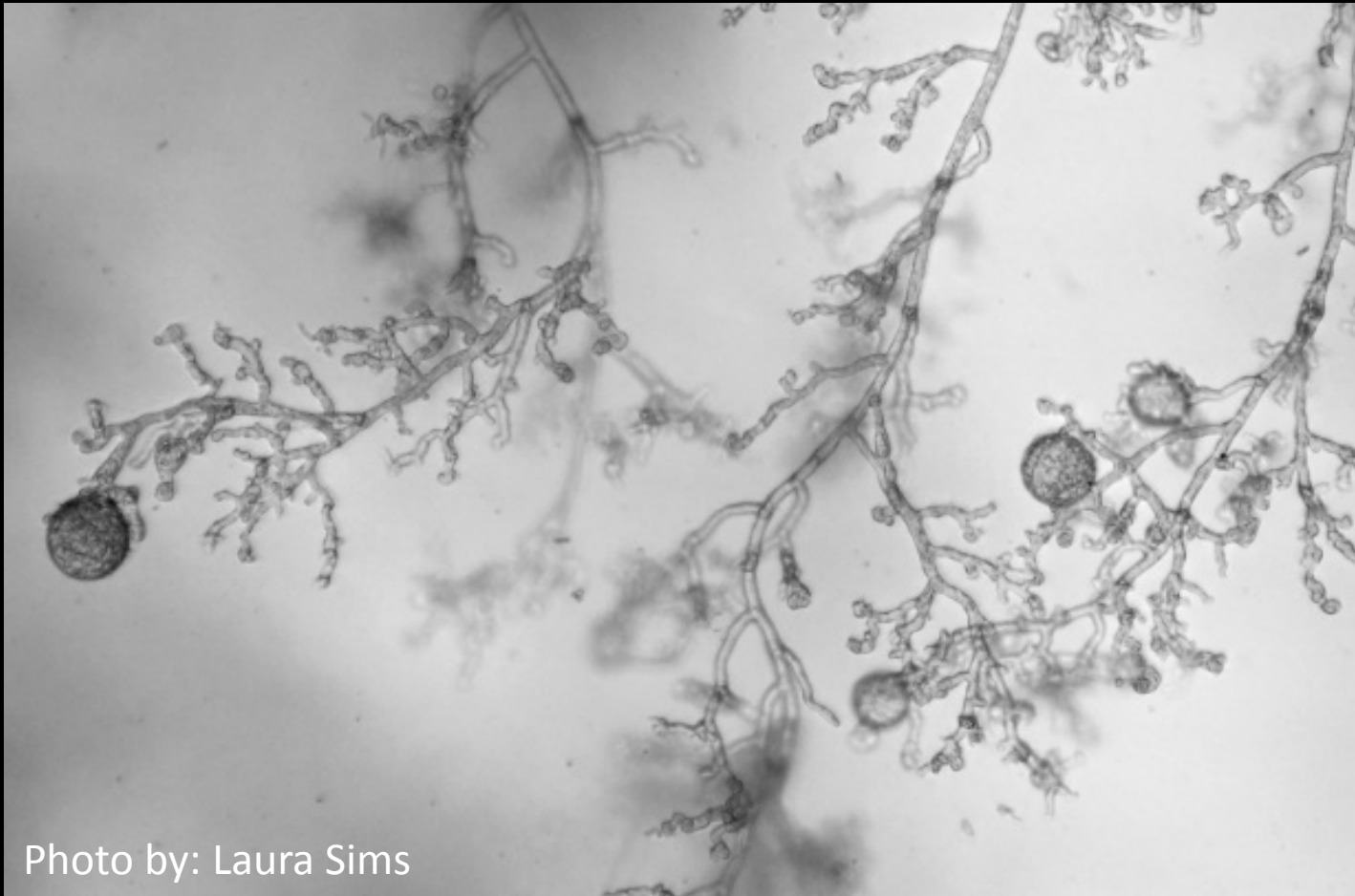
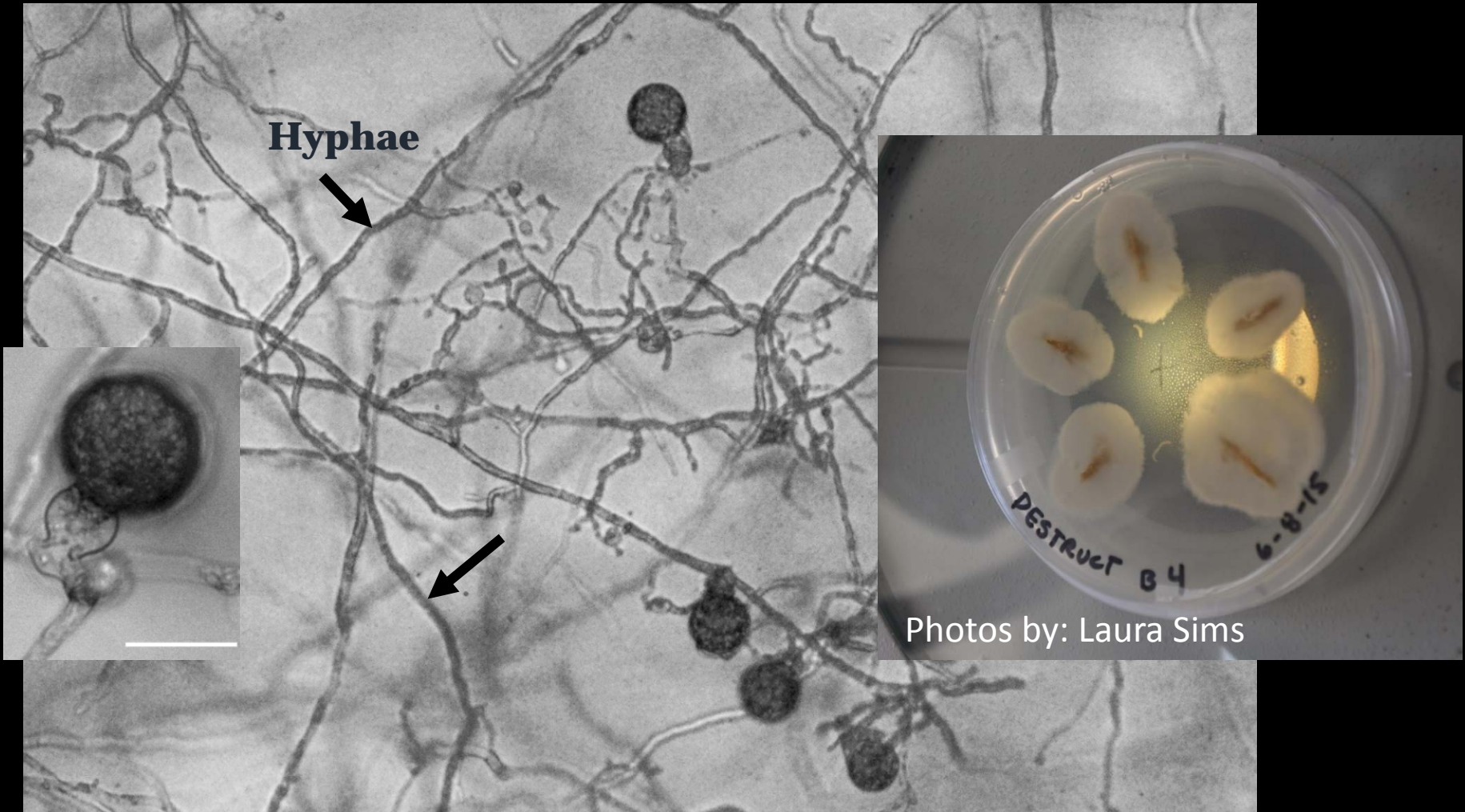


Photo by: Laura Sims

What does *Phytophthora* look like?

Microscopic fungal-like organism that produces spores and hyphae (unrelated to true Fungi)



Phytophthora spore types and sporangia

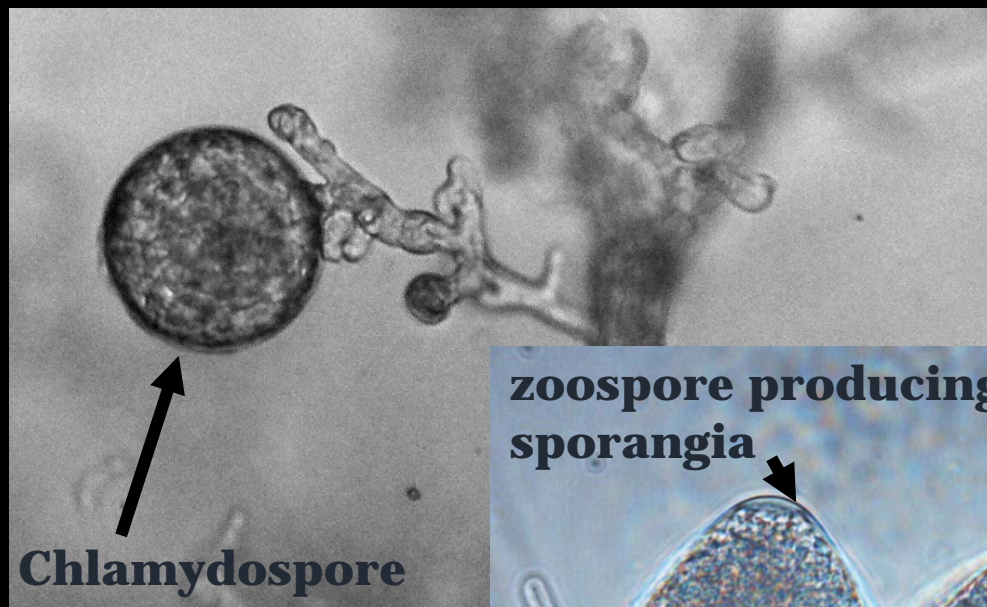
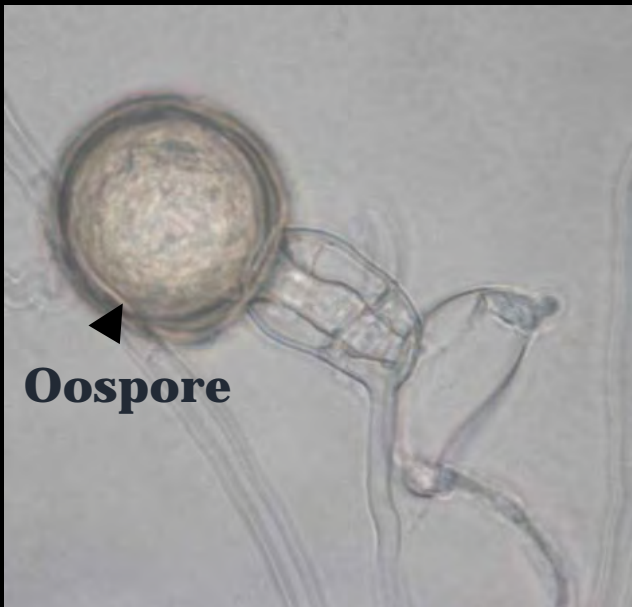


image:Judelson 2005

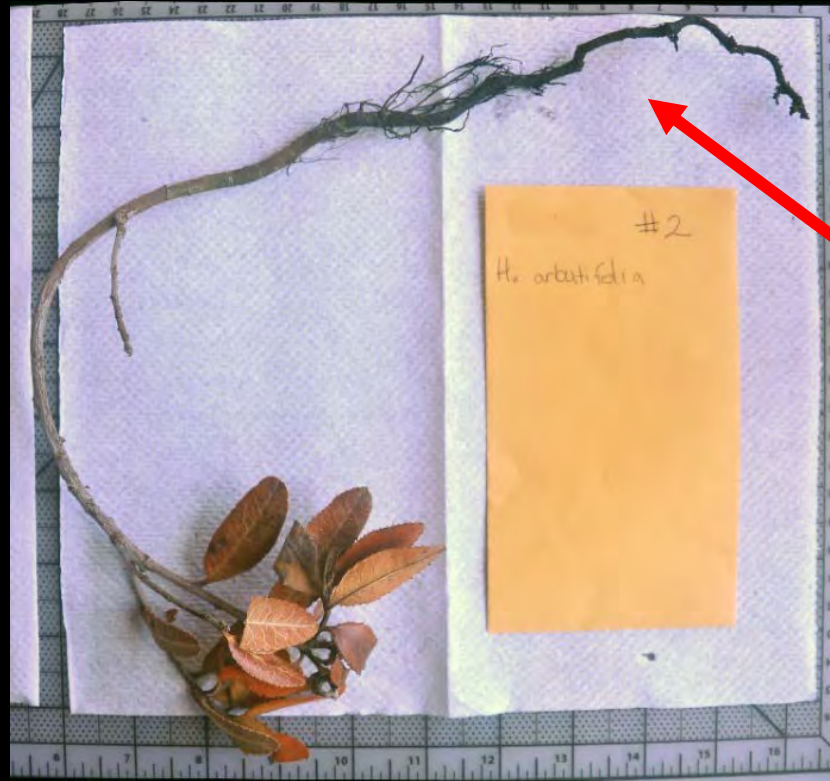


Photos except zoospore by: Laura Sims

Phytophthora interruption to plant root function

-When roots are damaged from disease causing agent one or more of these functions is interrupted:

- Anchorage
- Absorption
- Storage
- Conduction



Non-functional root system resulting in disease and ultimately death

Photo by: Laura Sims

Drought tolerant native plant may work off of reserves long after roots used for absorption are gone

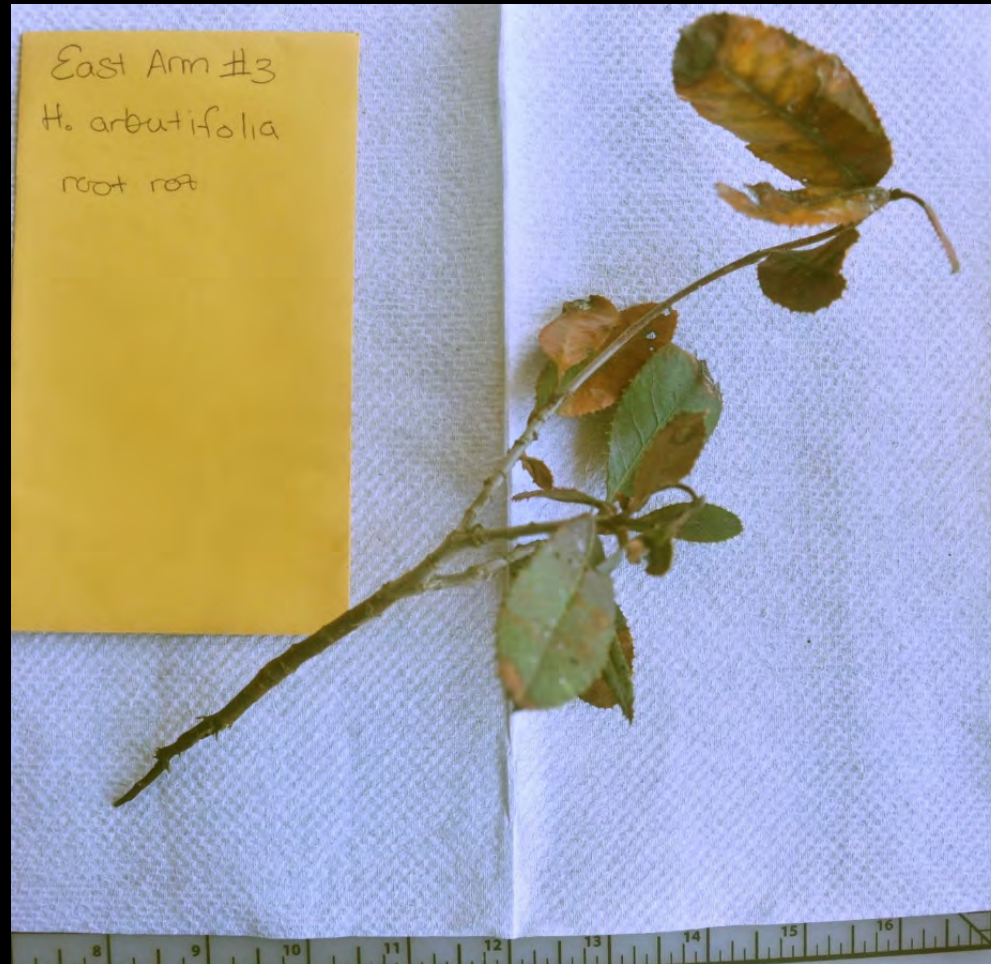


Photo by: Laura Sims

Many of the worst infectious agents in wildlands around the world are believed to have started from nursery stock several cause **Phytophthora diseases (green text)**

- Chestnut blight-introduced on ornamental nursery stock in the 1890's
- White pine blister rust-introduced on white pine nursery stock 1900's
- **Jarrah dieback / Phytophthora dieback-introduced to WA and Victoria probably on nursery stock 1920's**
- **Phytophthora disease of alder-introduced via restoration planting of alder along streams in the 1990's in Europe**
- **Sudden oak death- introduced to California forests through multiple introduction on disease plant stock, likely rhododendron in the 1980's**

Other important Phytophthora diseases in US wildlands of unknown origin

- Chestnut root disease-sometime in the 1800's killed chestnut in its more southernly reaches prior to the chestnut blight which occurred in the more northern areas
- Little leaf disease on pines in the southeast
- Sand pine root disease in Florida
- Port-Orford Cedar Root disease-introduced to the Pacific Northwest before the 1920's
- Root and crown rot of manzanita in California
- Alder disease in Oregon



Photo: acf.org

Phytophthora diseases are one of the most important problems faced by restoration nursery & landscape managers due to problems resulting in both urban and wildland areas



Photos by: Laura Sims

Poor nursery conditions



Photo: Jennifer Parke



Photo: Laura Sims

infection with poor irrigation and cultural controls

Ceanothus thyrisflorus infested with: *Phytophthora cactorum*,
P. hedraiandra, and *P. multivora* in the nursery



Photos by: Laura Sims

Plants from native plant nurseries that are infested and then introduced to wildlands have already lead to restoration failure, introduction to wildlands in California



Photo by: Joe Ortiz

root disease

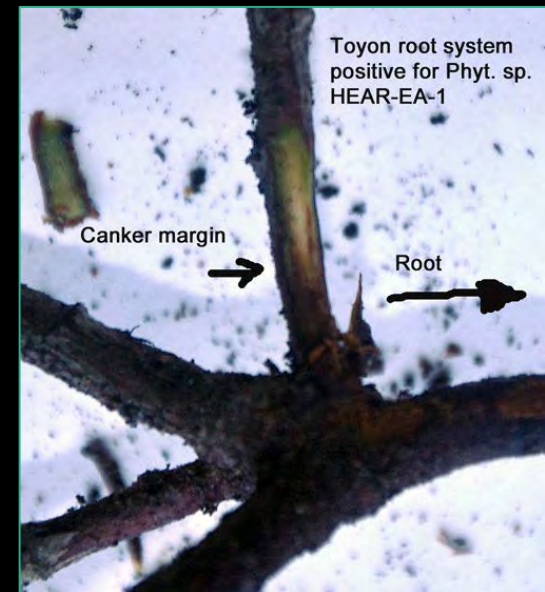


Photo by: Laura Sims

Potential pathways of invasion into California wildlands





Photo by: Lew Stringer



Photos by: Lew Stringer . Displaying dieback of *Ceanothus thyrsiflorus*, associated with *Phytophthora cryptogea*, isolated in the field from plants with these types of symptoms

Frangula californica dieback associated with multiple *Phytophthora* species: *P. multivora*, *P. crassamura*, *P. cactorum* and *P. cryptogea*- clade



Photos by: Laura Sims

Current List of Host X *Phytophthora* from native plant nurseries

19 *Phytophthora* taxa including hybrids

Confirmed from 16 different hosts or substrated

Host or substrate	Phytophthora species				
	1	2	3	4	5
<i>Acer circinatum</i>	<i>Phytophthora cactorum</i>	<i>P. multivora</i>	<i>P. occultans</i>		
<i>Aesculus californica</i>	<i>P. cryptogea</i> -group	<i>P. multivora</i>	close to <i>P. niederhauserii</i>		
<i>Arctostaphylos uva-ursi</i>	<i>P. pini/citricola</i> clade	<i>P. pseudocryptogea</i>	<i>P. "taxon raspberry"</i>		
<i>Ceanothus thyrsiflorus</i>	<i>P. multivora</i>	close to <i>P. niederhauserii</i>			
<i>Cornus sericia</i>	<i>P. crassamura</i>				
<i>Diplacus aurantiacus</i>	<i>P. crassamura</i>	<i>P. "taxon kelmania"</i>	<i>P. "taxon kelmania-close"</i>	<i>P. cryptogea/pseudocryptogea</i> clade	<i>P. pseudocryptogea</i>
<i>Eriogonum latifolium</i>	<i>P. megasperma</i> -like				
<i>Frangula californica</i>	<i>P. cryptogea</i> -group	<i>P. cactorum</i>	<i>P. pini/citricola</i> clade	<i>P. multivora</i>	
<i>Heteromeles arbutifolia</i>	<i>P. x cactorum</i>	<i>P. cactorum</i>	<i>P. niederhauserii</i>	<i>P. nicotianae</i> -close	
<i>Juncus effusus</i>	<i>P. crassamura</i>				
<i>Lonicera hispidula</i>	<i>P. cactorum</i>				
<i>Morella californica</i>	<i>P. cactorum</i>				
Nursery bed	<i>P. hedriaindra</i>	<i>P. multivora</i>			
Nursery irrigation water	<i>P. gonapodyides</i>	<i>P. cryptogea</i> -group	<i>P. gregata</i>		
<i>Quercus arbutifolia</i>	<i>P. cactorum</i>				
<i>Salix lasiolepis</i>	<i>P. cactorum</i>	<i>P. x cactorum</i>			

Preliminary findings one nursery- 47 *Phytophthora* species isolates from 50 symptomatic plants and 44% of plants were infected/infested

California Native Plant Nursery *Phytophthora* totals from one very infested nursery

Isolate totals: 47 *Phytophthora* species isolates

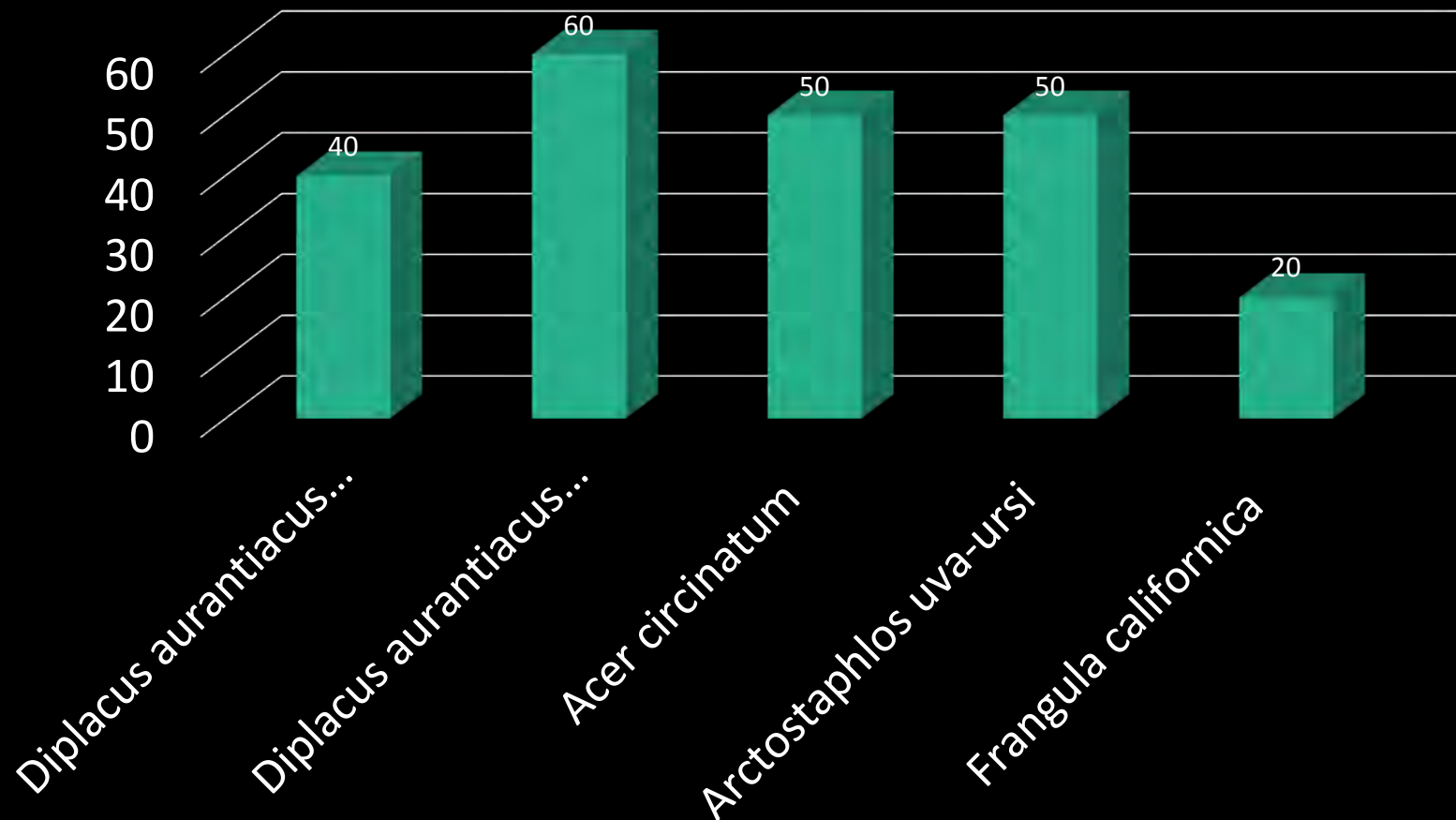
Taxa totals: 10 identified taxa based on consensus ITS

ITS clade totals: 1 clade 1 isolate from 1 sample, 1
taxa; 13 Clade 2 isolates from 6 samples, 3 taxa; 4

ITS Clade	<i>Phytophthora</i> species (taxon)	host ₁	host ₂	# of isolates	# of plants n=10
1	<i>Phytophthora cactorum</i>	<i>Acer circinatum</i>	-	1	1
2	<i>P. multivora</i>	<i>Acer circinatum</i>	<i>Frangula californica</i>	9	3
2	<i>P. occultans</i>	<i>Acer circinatum</i>	-	3	3
2	<i>P. pini/citricola</i> clade	<i>Arctostaphylos uva-ursi</i>	-	1	1
6	<i>P. crassamura</i>	<i>Diplacus aurantiacus</i>	-	1	1
6	<i>P. "taxon raspberry"</i>	<i>Arctostaphylos uva-ursi</i>	-	3	3
8	<i>P. cryptogea/pseudocryptogea</i> clade	<i>Diplacus aurantiacus</i> "trish" type	-	18	5
8	<i>P. "taxon kelmaniana"</i>	<i>Diplacus aurantiacus</i>	-	5	1
8	<i>P. "taxon kelmaniana-close"</i>	<i>Diplacus aurantiacus</i>	-	2	1
8	<i>P. pseudocryptogea</i>	<i>Diplacus aurantiacus</i> "trish" type	<i>Arctostaphylos uva-ursi</i>	2	2
8	Unidentified clade 8 species	<i>Diplacus aurantiacus</i>		2	2

Very infested native plant nursery

Percentage of plants that tested positive for Phytophthora in a single California native plant nursery



Not all restoration nurseries are that bad-

Non commercial restoration nursery evaluation:

Phytophthora Incidence before and after BMPs

% positives Y1, Y2 for each Nursery

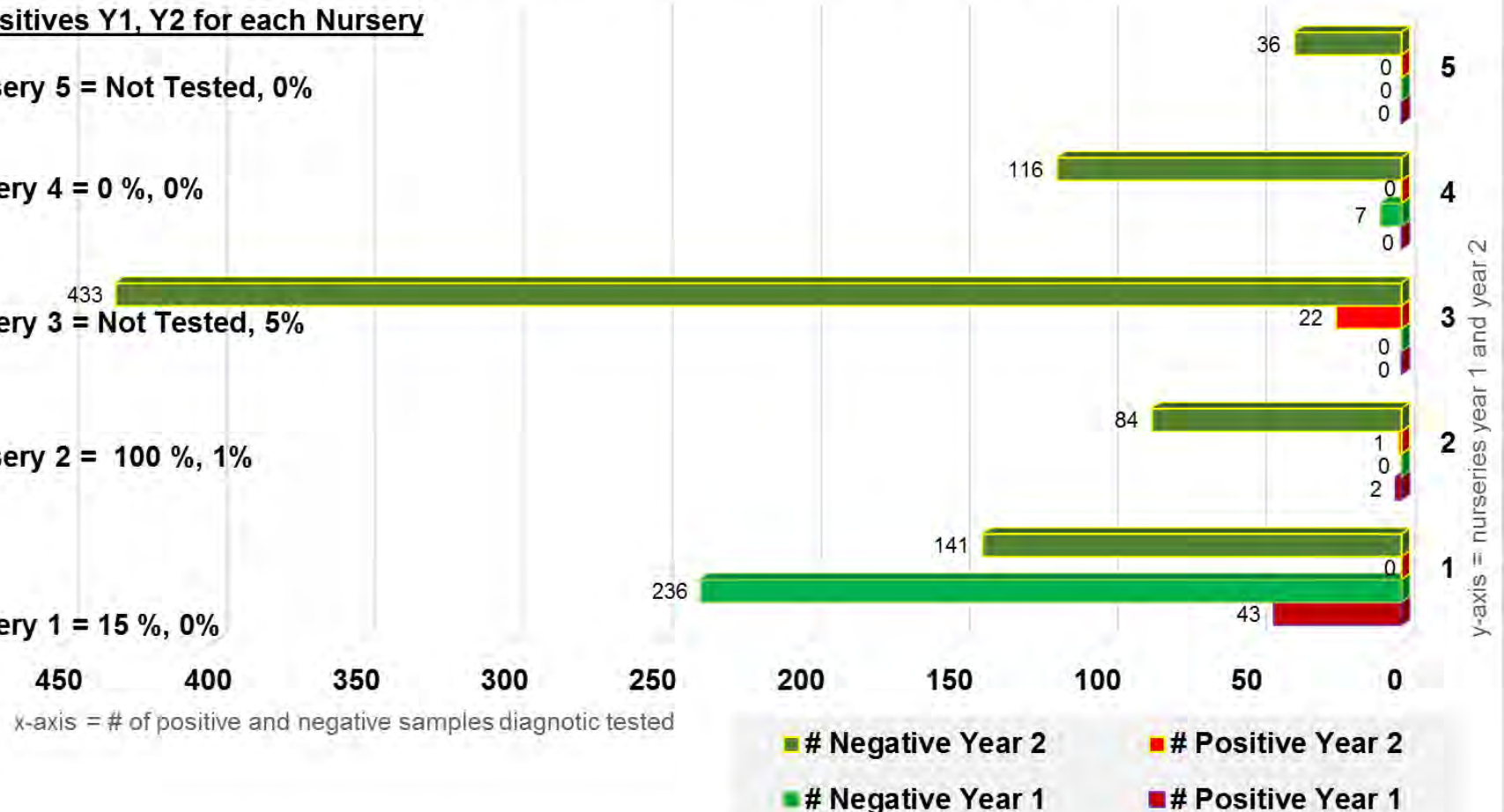
Nursery 5 = Not Tested, 0%

Nursery 4 = 0 %, 0%

Nursery 3 = Not Tested, 5%

Nursery 2 = 100 %, 1%

Nursery 1 = 15 %, 0%



Nursery changes made

Train staff, interns, and volunteers

Water

- Use a municipal water source

- Group plants by water needs, not by project

- Eliminate drainage problems

Sanitation

- Disinfect growing areas between crops

- Use only new or clean and disinfected pots

- Disinfect boots and equipment before entering growing structures

- Remove and compost discarded debris

- Control weeds

Propagate by seed, or disinfect cuttings

Use pasteurized potting mix

Trained staff monitor each crop for disease symptoms

Test select crops

Dispose of all infected crops

Keep records

Phytophthora incidence before and after BMP in 5 noncommercial restoration nurseries

% <i>Phytophthora</i> Incidence Overall		n (total samples)	
Before	After	Before	After
15.63	2.76	288	833



Five-fold decrease in % *Phytophthora* incidence in the 1st year following BMPs, even with a tripling of sampling effort. Year 2, thus far *Phytophthora* undetected

Take Home Message: BMPs result in a large decrease in *Phytophthoras* in nurseries

Some factors that affect spread

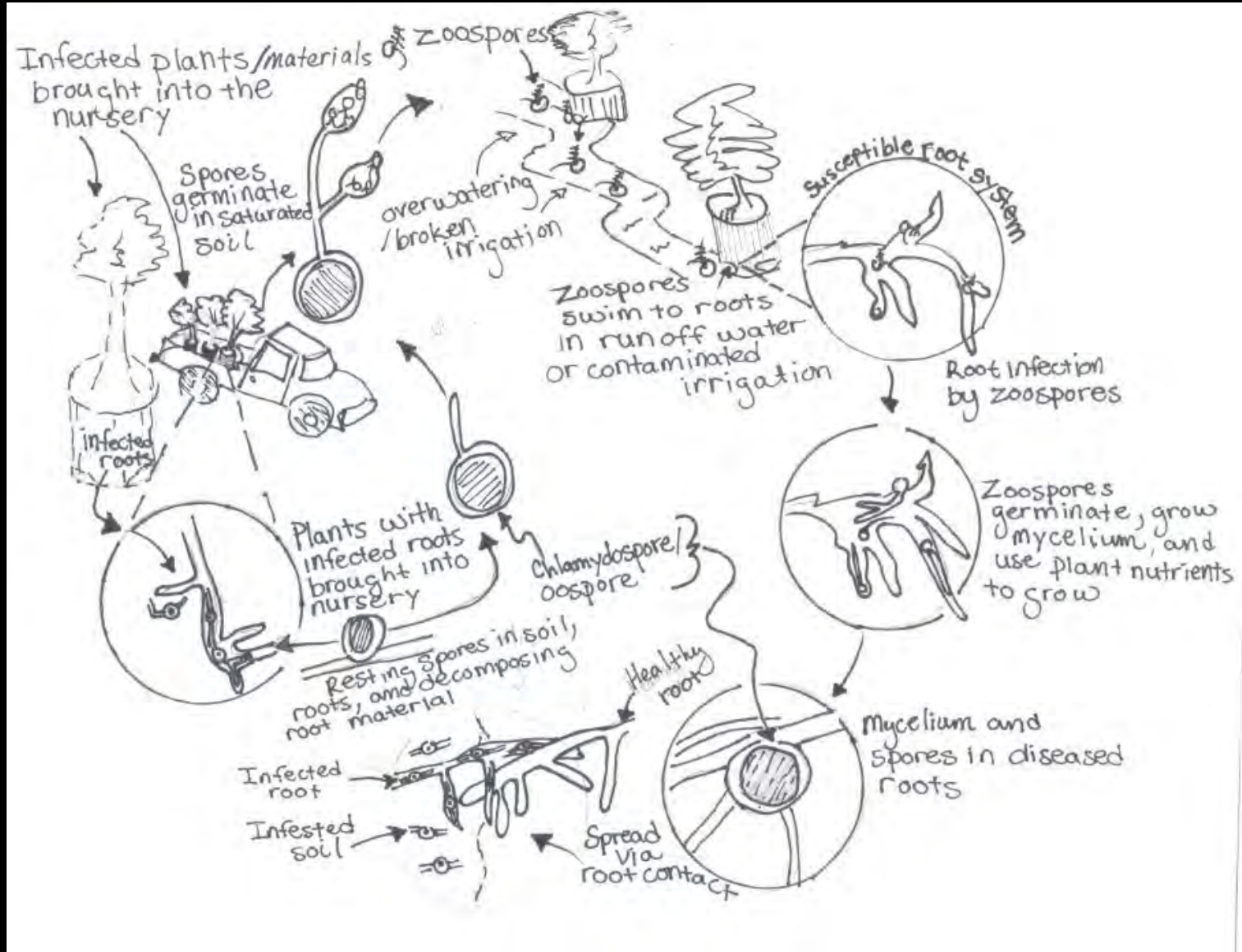
- Multiple or single host in same ecosystem (or nursery system)
- Correct environmental conditions to support movement
- Multiple of single pathogens involved
- Host susceptibility level
- Pathogen virulence
- Amount of inoculum
- How spores move



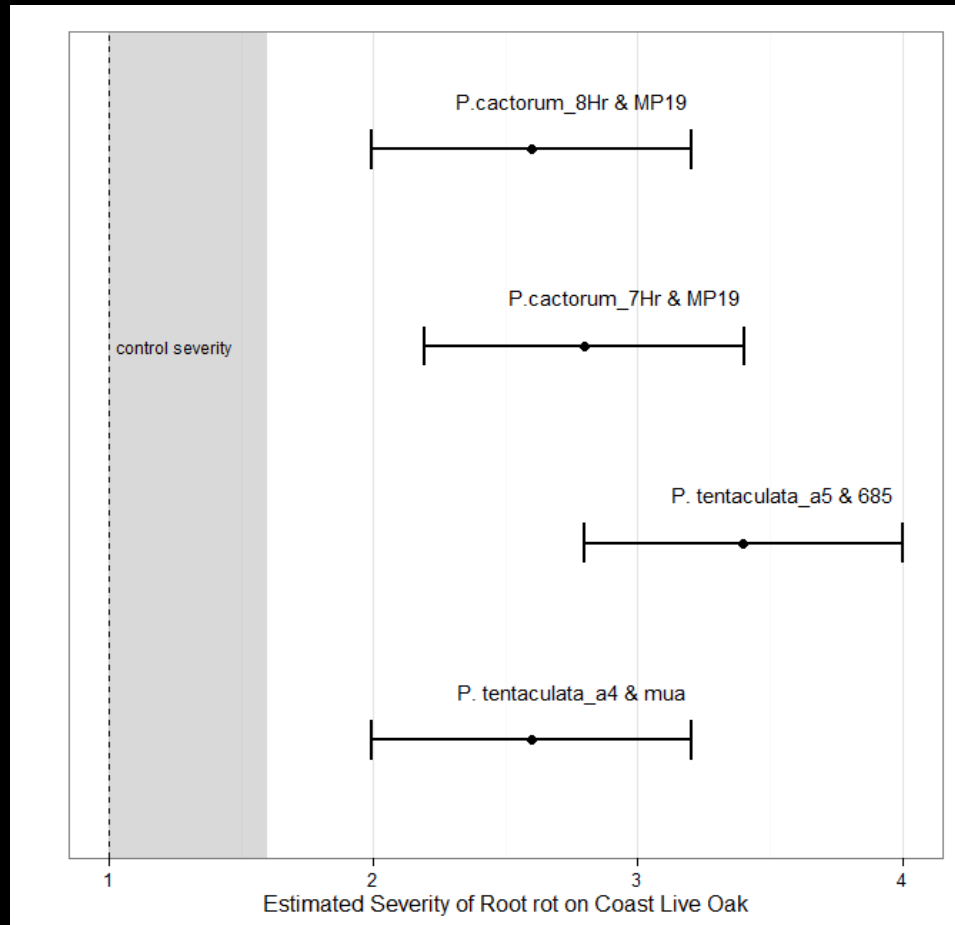
Photo:Chastagner & Benson, The Christmas Tree: Traditions,
Production, and Diseases

Root infecting *Phytophthora* can move with
irrigation runoff

Draft lifecycle of root rotting *Phytophthoras* in native plant nurseries



Greenhouse pathogenicity trials suggest after moving from one plant species to another could cause disease in new host



Important- Host jumps can lead to expression of new disease types.
For example-Root to Stem or Stem to Root diseases

Having multiple species on a host can lead to forming hybrids- we have already found putative hybrids of *P. x cactorum*. Hybrids can cause new and/or worse disease than parents.

Example one of the worlds worst pathogens is a hybrids - *P. x alni*



Photo credit: Thomas Cech

Management- Prevention Is The Key to Control

- Prevent disease...Start clean stay clean
- Plant with seeds or clean cuttings from healthy plants
- Use good quality soil (pasteurized or from deep source)
- Use high quality certified compost
- Use clean containers (new or washed and sanitized)
- Sanitation to maintain clean areas for production is really important
- Know the health status of planting and collection sites



Pay attention to what is brought into the nursery. Be alert for disease symptoms on buy-ins. Make sure materials brought in are high quality. Test for pathogens, hold for several weeks prior to introduction into the nursery.



Photos by: Christa Conforti

Use quality propagation material and keep propagation areas as clean as possible. Is propagation material infested?



Photo by: Laura Sims

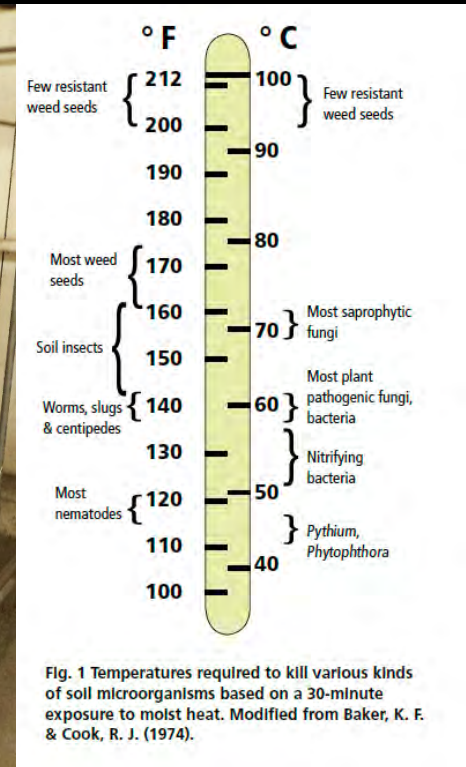


Photo: Christa Conforti

Don't use dirty containers or reuse soil/ potting materials without treatment

Do-

- Soil Pasteurization
- Clean and sanitize containers



Photos by: Lew Stringer

Do not place containers on bare soil, clean up
plant debris

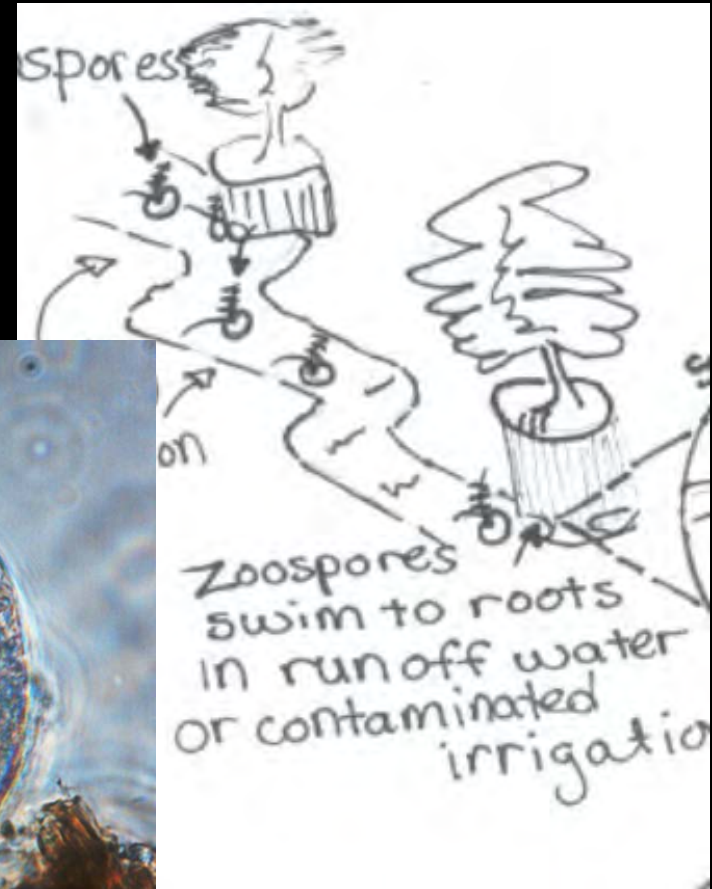


Photo by: J. Parke

Ensure good drainage, make sure irrigation runoff does not provide a pathway from contaminated materials to clean materials



Photo by: Laura Sims



Use only clean water for irrigation

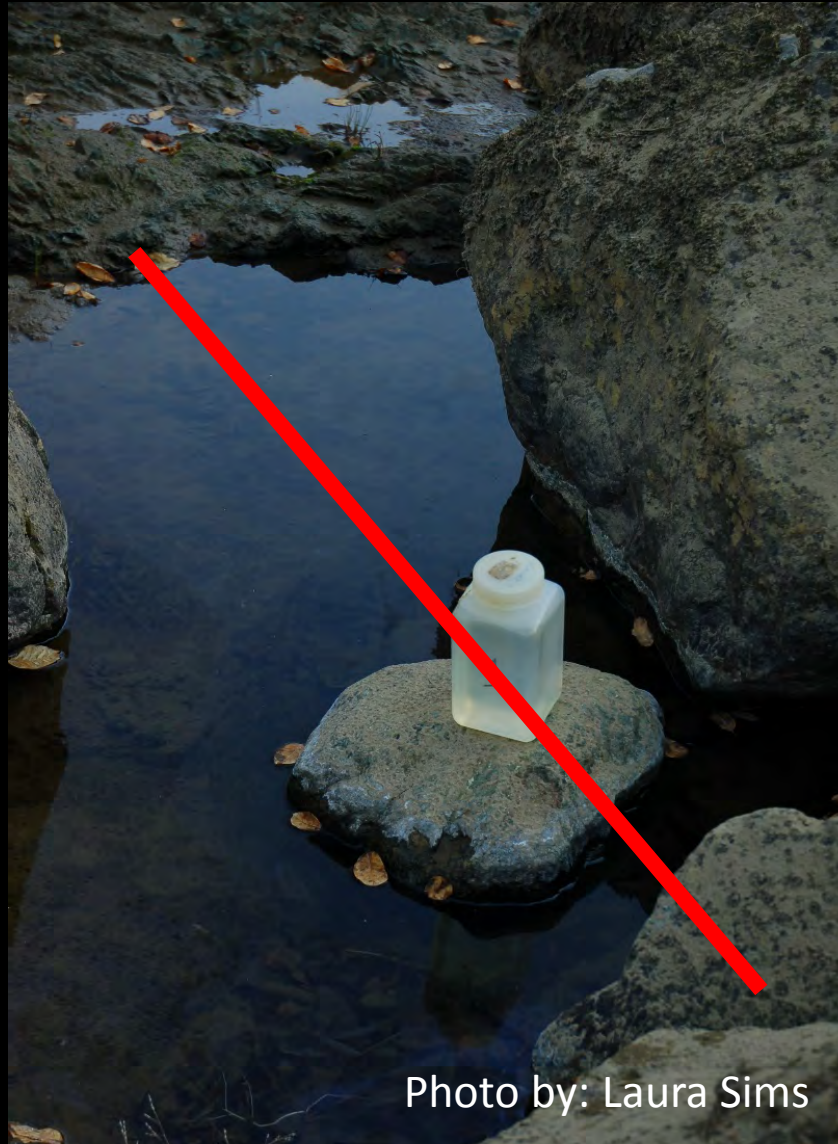


Photo by: Laura Sims

Don't keep or use sick plants

Do be on the look out for plant disease symptoms



Photos by: Laura Sims

Frangula californica
plants infected with
Phytophthora multivora

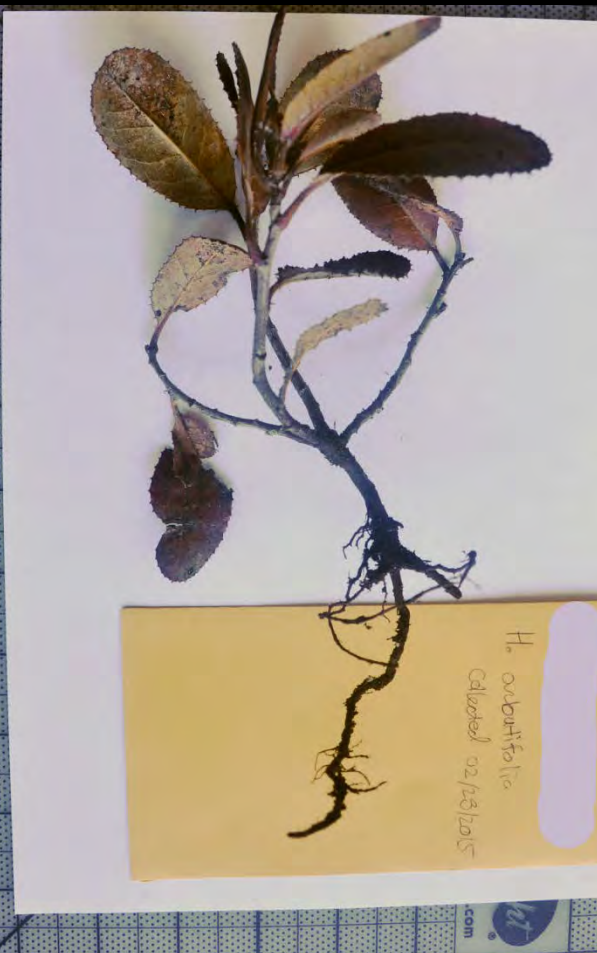
No obvious symptoms yet

Obvious *Phytophthora* root rot



Photo by: Laura Sims

After planting, be alert for disease symptom



Photos by: Laura Sims

Keep it clean-Clean tools, boots, trucks and sanitize benches and working areas between crops to begin the clean cycle again



Photo courtesy of Matteo Garbelotto

Nurseries Integrated approach sanitation, water management, monitoring, and nonhost selection

- Start clean: sanitize benches, pasteurize soil (and other planting media components) use new containers, and use healthy plant propagules - leads to healthy plants for landscapes
- Irrigate properly: group plants on benches based on their watering needs –water appropriately using tensiometers
- Monitor: scout plants for symptoms weekly
- Host selection: select plant species that are not hosts for pathogens in your nursery

Land managers working with plants from native plant nurseries need clean material

Prevention:

- Purchase clean materials, keep tools, clothing and vehicles sanitary
- Have sites tested prior to planting—if *Phytophthora* is already present avoid host species

Cultural control:

- Good drainage, proper planting, plant stock in good condition, planted in ecologically appropriate location
- Don't water tree trunks or irrigate so there is excessive splash

Chemical control (where viable option):

- Aliette, Alude, Fosphite, Mefenoxam or Subdue may be effective if not phytotoxic to the plants
- Fungicides combined with cultural controls work better than either alone
- Fungicides may not be a viable option in most wildland applications-why prevention is key

Thank you!

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