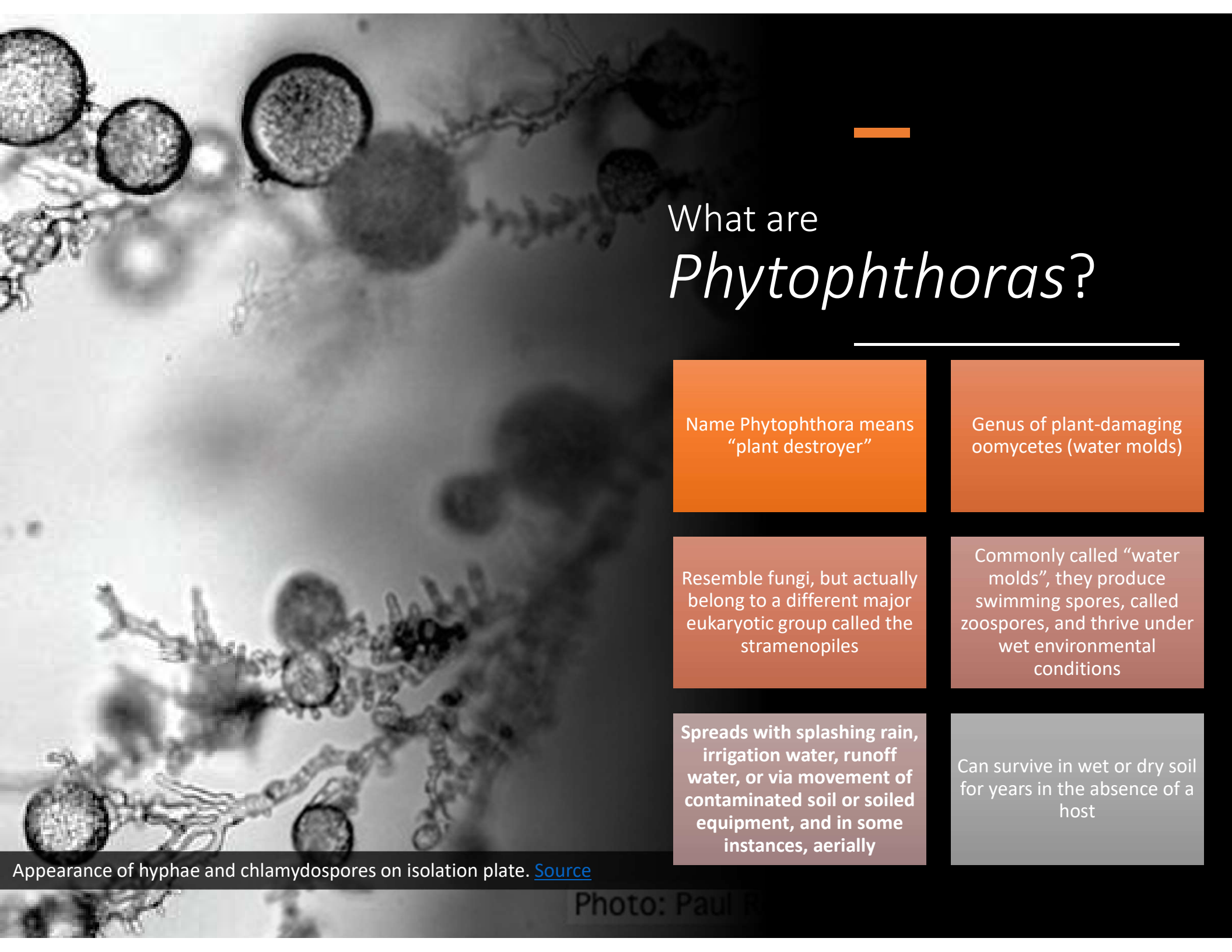




Best Management Practices to Minimize the Spread of *Phytophthora* species

- What are *Phytophthoras*?
- How did *Phytophthoras* get here?
 - Species of Concern in the Bay Area
 - *Phytophthora* Spread and Disease Cycle
- How do they relate to land management?
 - Effects on Ecosystem
 - Fire and *Phytophthoras*
 - High-Risk Activities and Areas
 - Tree Work
- *Phytophthora* BMPs

A black and white microscopic image showing the structure of Phytophthora. It features several large, circular, thick-walled chlamydospores and a network of thin, branching hyphae. The background is dark, making the lighter-colored fungal structures stand out.

What are *Phytophthoras*?

Name Phytophthora means
“plant destroyer”

Genus of plant-damaging
oomycetes (water molds)

Resemble fungi, but actually
belong to a different major
eukaryotic group called the
stramenopiles

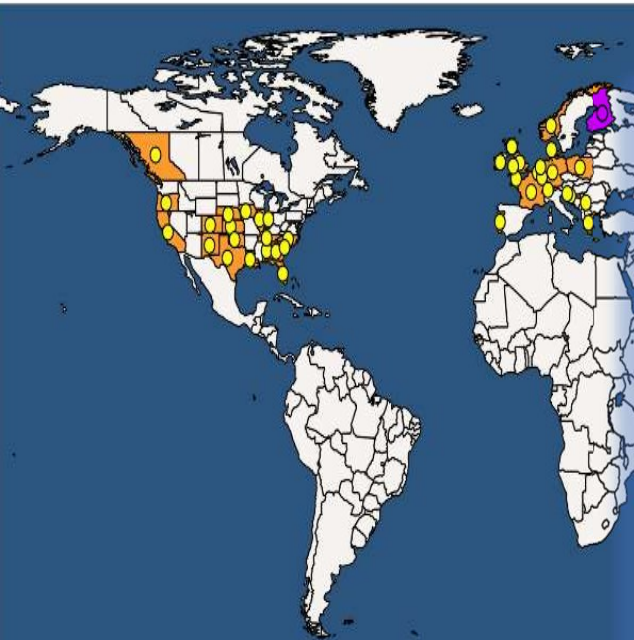
Commonly called “water
molds”, they produce
swimming spores, called
zoospores, and thrive under
wet environmental
conditions

Spreads with splashing rain,
irrigation water, runoff
water, or via movement of
contaminated soil or soiled
equipment, and in some
instances, aerially

Can survive in wet or dry soil
for years in the absence of a
host

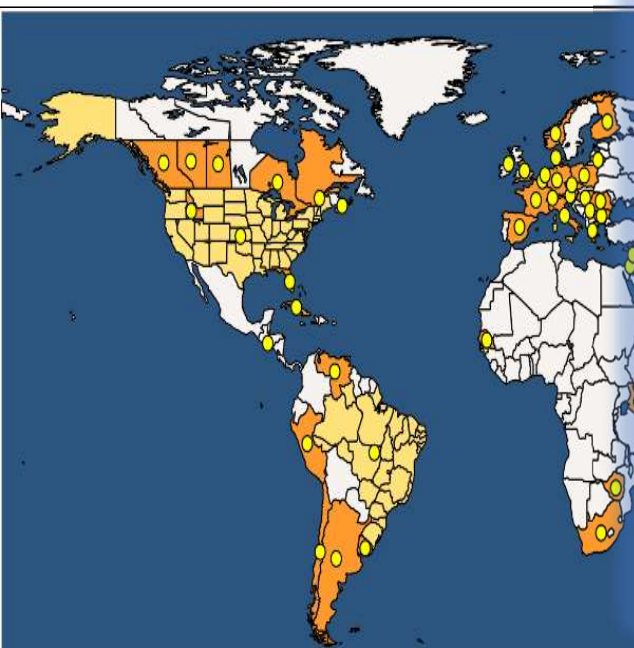
Appearance of hyphae and chlamydospores on isolation plate. [Source](#)

Photo: Paul R.



Phytophthora ramorum (PHYTRA)

● Present ● Transient

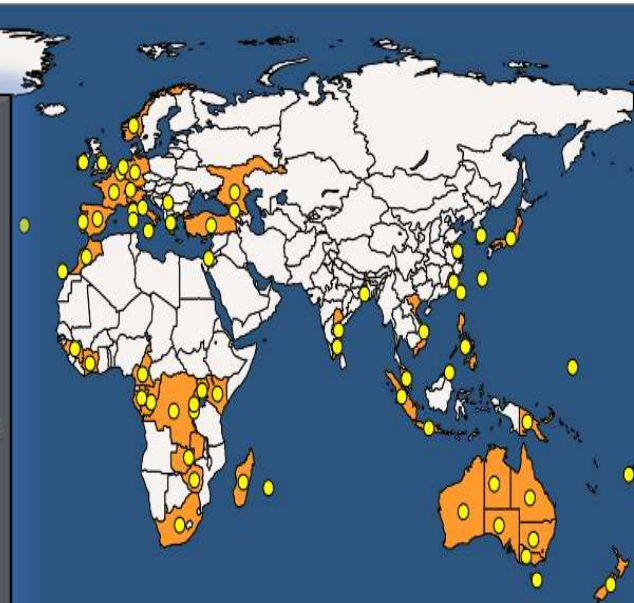


Phytophthora cactorum (PHYTCC)

● Present ● Transient

The spread of *Phytophthora* species throughout ecosystems and the world has been accelerated in recent decades by human activities such as the nursery trade, imports of contaminated soil, and contaminated vehicles, and tools.

The most infamous *Phytophthora* is *Phytophthora infestans*, which was the cause of the Irish potato famine in the 1840s, and led to the deaths of over 1 million people. Renewed focus on *Phytophthora* has occurred in recent years due to Sudden Oak Death (*Phytophthora ramorum*) causing significant impacts in California and Oregon.



Phytophthora cinnamomi (PHYTCN)

● Present ● Transient



Phytophthora tentaculata (PHYTTA)

● Present

Selected *Phytophthora* Species of Concern



P. cinnamomi impacts on madrone on Old Cañada Road on the Peninsula

- ***P. ramorum* (SOD)**
 - Estimated to have killed more than 10 million oak trees during the last 2 decades
- ***P. cinnamomi***
 - Widespread, can kill a broad range of trees and other plants
- ***P. cactorum***
 - Infects a variety of native trees and shrubs, may be present in nursery stock
- ***P. tentaculata***
 - Still relatively limited in its distribution but impacting sensitive environments



2008



2012

From 2003 to 2012, this forest saw mortality of ~20% of the coast live oaks and 50% of the tanoak trees due to *P. ramorum*. Even small losses of canopy cover can have disproportionately large impacts if they affect critical areas or involve unique resources (i.e., the loss of acorns affects wildlife habitat value, dead or dying trees can lead to increased wildfire risk).



2013



2016

Spread of *Phytophthora* Species

There are more than 100 *Phytophthora* species
and 1000's of documented host species

Methods of Human Transfer Include:

Movement of container
plants and plantings

Movement of organic
material import – mulch,
soil, dirty aggregate base

Movement of
dirty/muddy PPE, shoes,
and tools

Movement of mud on
tire tracks
(cars/trucks/equipment)

Muddy livestock moved
in wet season

Raw water movement

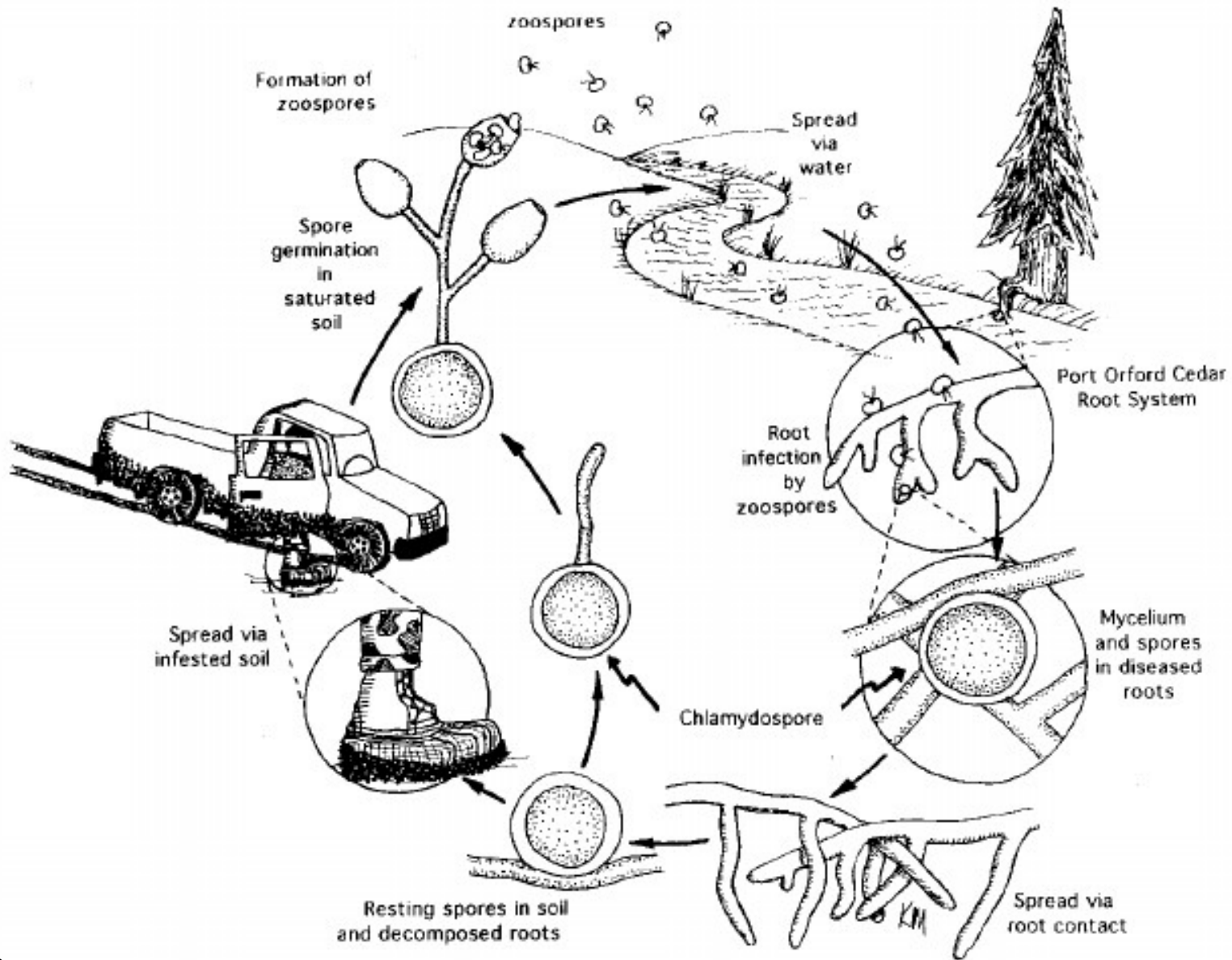
Methods of Natural Dispersal:

Seasonal or perennial
water flow and surface
water flow from
contaminated areas

Surface water flow that
moves infected plant
fragments

Root-to-root spread
between and along
host roots in soil

Most of these *Phytophthora* species are spread via infested soil. Wet conditions tend to increase movement and eliminating an infestation is close to impossible



Disease Cycle

for Human-Aided Natural Dispersal

Aerial Spread in SOD (*P. ramorum*)

Foliar Hosts Examples

- California Bay
- Douglas Fir
- Madrone
- Big-leaf Maple

Bark Canker Hosts Examples

- Coast Live Oak
- Black Oak
- Tanoak
- Golden chinquapin

There are more than 75 documented host species

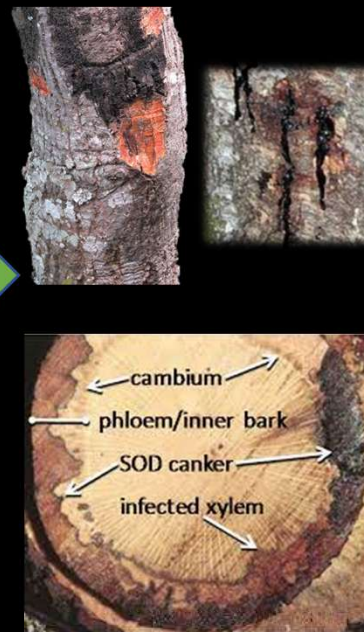
Dispersal



Leaf Infection



Bark Canker Formation



Death



Mortality is highest where foliar hosts co-occur with susceptible bark canker species



Protecting Ecosystems: Why?

- **Introduced pathogens harm ecosystems by:**
 - Reducing biodiversity and genetic diversity
 - Reducing food availability for dependent fauna
 - Increasing economic costs associated with maintenance and plant deaths
 - Being difficult to eradicate once established in the soil
 - Potentially becoming more widespread with climate change and increased human activity
 - Reducing water quality

Phytophthora and Fire Risk

Diseased and dying trees increase fuel loads.

Initial tree death can elevate the risk of crown fire ignition, while latter stages can increase surface fuel loading.



Increased wildfire severity leading to unexpected increases in mortality of non-susceptible tree species, changes in nutrient cycling, and dramatically altered stand structure.



Consequences for post-fire regeneration and future ecosystem function.



High Risk Activities



- Entering infested areas during wet conditions.
- Collecting or transporting host plant material from an infested or quarantined area.
- Driving or working in areas of wet soil and mud.
 - Always keep vehicles on paved and graveled surfaces when conditions are wet
- Traveling between areas of known infestations to areas without known infestations, especially during the wet season
 - If you do enter an infested area during wet conditions, check yourself, vehicle and equipment for accumulations of mud, soil, organic material, and detached plant leaves.
 - If you live in an area infested with *Phytophthora ramorum*, chances are some of your belongings may be contaminated by the pathogen. Do not re-wear these items to work without thorough inspection and sanitation
 - See more details at <https://www.suddenoakdeath.org/sanitation-and-reducing-spread/>



Tree Work and Sudden Oak Death

https://www.suddenoakdeath.org/wp-content/uploads/2018/06/Phytosphere.GGNPC_.BMPS_.Trails.Construction.Soil_.Import.31Jan2018.pdf

https://www.suddenoakdeath.org/wp-content/uploads/2021/07/arborist-06-08-with-2014-map.sf_.07.09.21.pdf

Before working:

- Worker training and preparation
- Cleaning and sanitation required BEFORE entering a job site

While working:

- Minimize pruning on oaks
- Minimize disturbed area footprint
- Work in disease-free areas before working in known infested areas

After working:

- Clean or disinfect materials and other items BEFORE removing them from job site
- Follow BMPs for proper disposal of cut and removed vegetation

Best Management Practices for **Preventing Phytophthora Introduction**



No movement of
contaminated materials
INTO a work site;



No spread of
contaminated materials
WITHIN a site; and



No movement of
contaminated materials
TO OTHER sites

Yes, but...



If the pathogen already is present in the ecosystem, why does it matter if we spread it where it already exists?

Trees die naturally all the time anyway from other diseases or stresses, why is *Phytophthora* so different?



Why do we have to clean the equipment between job sites on the same watershed?



Why would we implement specs that are so much more drastic than our neighboring landowners?



...because,



Phytophthora is not present everywhere, and decon procedures prevent the spread of other pathogens as well



Phytophthora is an aggressive pathogen that can infect and kill otherwise healthy trees



Phytophthora can survive in both wet and dry conditions, and once it's present in the ecosystem, it's almost impossible to remove



We want to set a high standard for responsible natural resource management as it is part of our stewardship policy





How does this relate to my work?



- You are a potential vector!
 - Do not accelerate spread with your activities
 - Do not introduce a new species to a new area (increased stress, increased chance of a virulent hybrid being created)
- Anything that moves soil and debris around can spread and introduce the disease

Phytophthora BMPs: General

Remove all plant material and soil from boots and clothing when moving between watersheds and between discrete areas within a watershed.

Be aware of Phytophthora symptoms on plants, including stunted growth, nutrient deficiency-like symptoms, smaller than normal leaves, wilting, and dead roots.

Prevent the introduction of non-native species by power washing and inspecting construction equipment and vehicles prior to arrival onsite to ensure that it is free of plant material.

All mulch, soil imports, imported organic material, and erosion control measures should be heat treated and other construction materials must be certified “weed free”.

Phytophthora BMPs: General

All mineral material (rip rap, gravel, aggregate base, etc.) imports should be from virgin (non-recycled) sources, free of soil, and free of weed seeds. Imports should be inspected and rejected if they don't meet these criteria.

Power washing and steam cleaning should be done systematically to ensure that all surfaces are decontaminated.

Nursery stock is generally prohibited. Following consecutive years of negative testing and demonstrated good performance, nursery stock may be brought in following the guidelines for holding stock outlined in Guidelines to Minimize Phytophthora Pathogens for Holding (non-production) Nurseries at Restoration Sites.

Follow the Guidelines to Minimize Phytophthora Contamination in Restoration Projects for all planting projects (Working Group for Phytophthoras in Native Habitats 2018). Visit Phytophthora-free areas before contaminated areas. If lands are untested for contamination, assume that they are contaminated and take appropriate precautions.

Work from upstream areas to downstream areas in high-risk areas based on pathogen risk analysis maps.

Whenever possible, schedule activities when invasive species are not in seed when working in an area with invasive plants.

Phytophthora BMPs: Vehicles and Tools

Unless there is an overriding reason for off-road activity, vehicles should stay on established roads, especially during wet periods. Overriding reasons include: emergencies to protect human life and property, allowing for two-way traffic on narrow roads, etc.

Avoid driving on muddy unpaved roads when feasible. Consider a different work schedule or alternate mode of transportation if the soil is wet enough to stick to vehicle tires and undercarriage.

If driving on wet unpaved roads is necessary, then plan your routes to minimize distances travelled.

Driving off-road into areas known to be infected by plant pathogens is prohibited.

Phytophthora BMPs: Vehicles and Tools

Dust and dry soil should be brushed or washed off of vehicles and personnel routinely.

Any activities performed off road should be conducted during dry conditions whenever possible to minimize soil disturbance.

Limit the number of vehicles at a work site. Establish contained staging areas to park unused vehicles.

Tools should be clean or new before beginning work. Store tools in a clean and dry location.

If exposed to a known contaminated area, decontaminate upon departure.

Strategically plan movement between discrete drainages, grazing parcels, or properties before entering a site.

Keep vehicles as clean of soil as possible. Do not move soil between watersheds with vehicle travel.

Phytophthora BMPs: People

Avoid travel from pathogen-infected areas to non-infected areas, especially during wet periods and plan your travel route based on the information in the attached pathogen risk analysis

Consider wearing easy to clean boots that have limited holding places for invasive plant seeds and soil (i.e. no mesh, laces, Velcro, etc.).

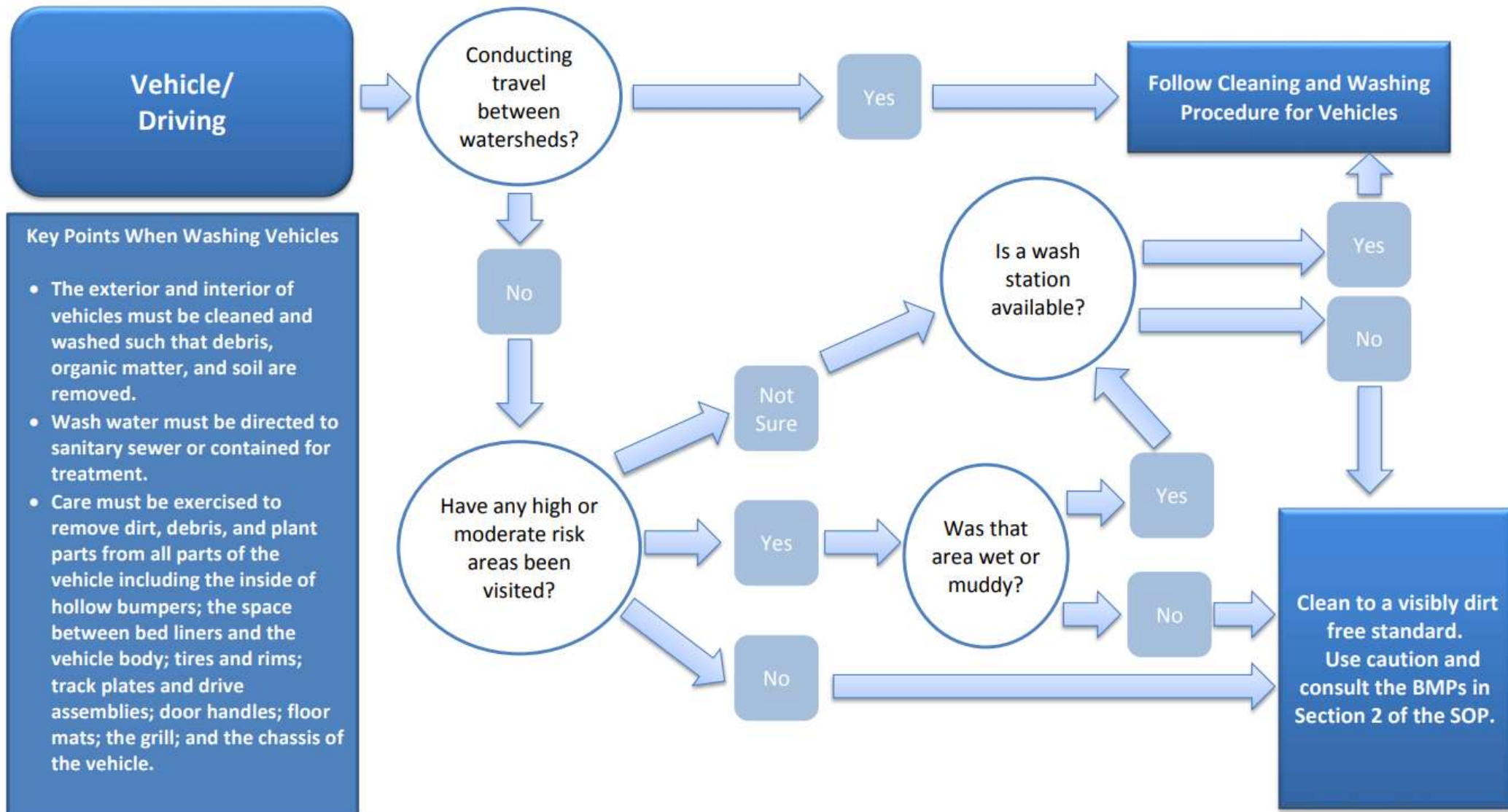
Clean invasive plant seeds and soil off gaiters, boots, and clothing between watershed areas and decontaminate footwear with alcohol after removing soil.

If possible, avoid passing through invasive plants while in flower or with seeds.

Clean and decontaminate footwear between sites

Decontamination Procedures

Vehicle Flowchart - Decontamination Procedures for Non-Aquatic Areas



Take Home Messages



- Start Clean, Stay Clean
- Prevention is the best measure
- Do not accelerate spread
- When in doubt, disinfect
- Follow and read all BMPs

Helpful Links and Documents

- **BMPs for Sudden Oak Death:** <https://www.suddenoakdeath.org/diagnosis-and-management/best-management-practices/>
- **BMPs for Trail work, Construction, soil import:** https://www.suddenoakdeath.org/wp-content/uploads/2018/06/Phytosphere.GGNPC_.BMPS_.Trails.Construction.Soil_.Import.31Jan2018.pdf
- **Cleaning and Sanitation:** <https://www.suddenoakdeath.org/sanitation-and-reducing-spread/>
- **Protocol for Arborists:** https://www.suddenoakdeath.org/wp-content/uploads/2021/07/arborist-06-08-with-2014-map.sf_.07.09.21.pdf
- **Protocol for Landscapers/Gardeners:** <https://www.suddenoakdeath.org/wp-content/uploads/2014/12/landscaper-1-08-with-new-2014-map.pdf>
- **SOD Host Species:** <https://www.aphis.usda.gov/aphis/resources/pests-diseases/hungry-pests/the-threat/sudden-oak-death>