Ramorum Blight & Sudden Oak Death

Enhanced First Detector Training

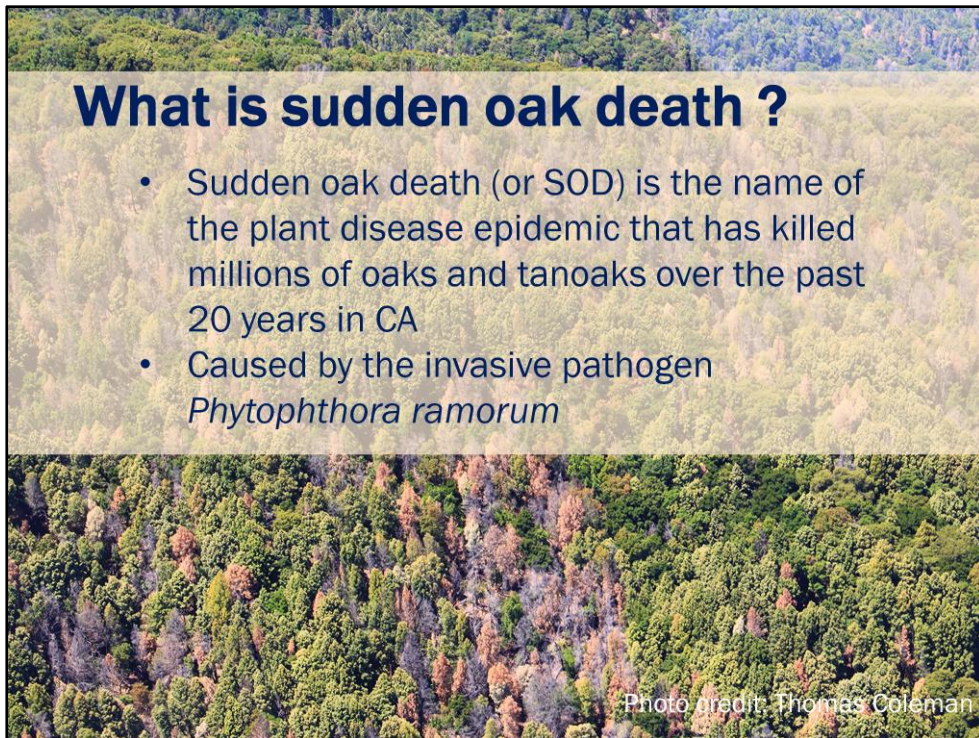Enhanced First Detector Training for New York State

Sudden oak death

- Potential impact
- Pathways
- Identification and life cycle
- Hosts
- Damage
- Scouting—signs and symptoms
- What to do if you suspect you find it

Photo credit: Thomas Coleman

Sudden Oak Death (SOD) is the name of the plant disease epidemic on the West Coast that has killed millions of oaks and tanoaks over the past 20 years.

The disease is caused by the plant pathogen *Phytophthora ramorum*

Here you can see a hillside in California dotted with many dead trees, killed by Sudden Oak Death

What is sudden oak death ?

- Sudden oak death (or SOD) is the name of the plant disease epidemic that has killed millions of oaks and tanoaks over the past 20 years in CA
- Caused by the invasive pathogen *Phytophthora ramorum*

Photo credit: Thomas Coleman

P. ramorum is considered **invasive** to North America because it is not native to this region and has negative ecological economic consequences. We don't actually know where *P. ramorum* came from but several factors point to it being a new arrival. Its rapid spread and lack of resistant hosts suggest it has not coevolved with plants native to this region. In addition, scientific research on the genetic structure of *P. ramorum* populations supports the fact that it is only recently established in this area.

References, introduced status of P. ramorum:
http://cisr.ucr.edu/sudden_oak_death.html

What is sudden oak death ?

Sudden oak death refers to the lethal trunk infection that *P. ramorum* causes on oaks and tanoaks—but *P. ramorum* can also cause many different disease symptoms on many different plants

Foliar lesions   **Trunk cankers**   **Shoot dieback**

www.suddenoakdeath.org

Photos: (left) www.suddenoakdeath.org, (middle and right) Joseph O'Brien, USDA Forest Service, Bugwood.org

Unlike some pathogens, which specialize on specific hosts, *P. ramorum* is a **generalist** and can infect many different hosts. But, the degree of damage it causes, or **virulence**, varies widely by host species.

On most host plants, *P. ramorum* only causes minimal foliar disease symptoms (called Ramorum blight). But its lethal effects on some dominant tree species (oaks and tanoaks) makes it a serious ecological and economic concern.

While Sudden Oak Death refers to infection on Coast Live Oak, Black Oak, Shreve's Oak, Canyon Live Oak and Tanoak, Ramorum Blight refers to infection on all other host species.

References, host and symptoms of *P. ramorum*:
http://www.suddenoakdeath.org/diagnosis-and-management/hosts-and-symptoms/
https://www.apsnet.org/edcenter/intropp/lessons/fungi/Oomycetes/Pages/SuddenOakDeath.aspx

Sudden oak death vs. Ramorum blight

Both are caused by the same pathogen, *Phytophthora ramorum,* which causes different diseases on different hosts

Sudden Oak Death
refers to infection on Coast Live Oak, Black Oak, Shreve's Oak, Canyon Live Oak and Tanoak

Ramorum Blight
refers to infection on all other host species (e.g. Rhododendron)

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Brief History of SOD

- In mid 1990s an unknown disease started killing oaks and tanoaks in California

- Trees were killed by cankers on their trunks which cut off water flow and girdled the trees

- Identified the cause: a new pathogen, *Phytophthora ramorum*, previously unknown

A brief historical context to Sudden Oak Death:

In the Mid 1990s, people observed an unusual number of dead and dying oaks and tanoaks in the California Bay Area. The browning tree canopies seemed to appear out of nowhere and were thus given the name Sudden Oak Death. At first people thought it was caused by beetles or environmental degradation, which later proved not to be the case.

These trees, were generally killed by cankers on their trunks and stems which cut off water supply and girdled the trees. Tree death appeared rapid, with very little time between first observable symptoms of trunk bleeding and complete tree death.

A new, previously unknown, pathogen was isolated from these cankers and found to be the cause of the disease- *Pytophthora ramorum*. The pathogen grows in the trees, clogging the vascular system and inhibiting the tree's ability to transport nutrients and water.

Drought years are cause especially high tree mortality because infected trees have a further compromised vascular system

References, history of SOD:
http://www.suddenoakdeath.org/about-sudden-oak-death/history-background/

Where is *P. ramorum* now?

- Naturalized in forests of CA coastal fog belt and up to southern Oregon

- Samples have tested positive from nurseries and waterways throughout the US

- In Europe, nurseries and forests are affected (causing widespread death in larch plantations in UK)

Since it's first identification, *P. ramorum* has killed millions of tanoaks and oaks, fundamentally changing redwood ecosystems (where tanoaks are the dominant understory tree) and oak chaparral.

Where is it now?
1) Naturalized in forests in CA fog belt and southern OR and in nurseries
2) In Europe, nurseries and forests
3) Samples have tested positive from nurseries throughout the US, including East Coast but not in forests yet

In North America, *P. ramorum* is now naturalized in landscape throughout the fog belt of CA. It has also spread through nurseries throughout North America. Several nursery species, especially rhododendron, are foliar hosts that may transmit the pathogen while exhibiting minimal symptoms, posing a risk to surrounding forest ecosystems.

In addition, *P. ramorum* has also been found in European nurseries and in the UK is killing off millions Japanese larch plantations
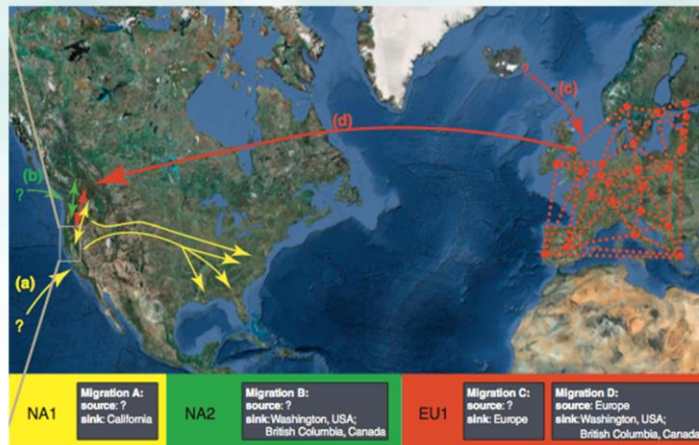
References, maps of *P. ramorum* distribution:
http://www.suddenoakdeath.org/library/maps/

Where is *P. ramorum* now?

- There are several major strains present in different parts of the world:

| NA1 | Migration A: source: ? sink: California | NA2 | Migration B: source: ? sink: Washington, USA; British Columbia, Canada | EU1 | Migration C: source: ? sink: Europe | | Migration D: source: Europe sink: Washington, USA; British Columbia, Canada |

TRENDS in Microbiology

There are currently thought to be 3 major strains of *P. ramorum*: NA1, NA2 and EU1. NA 1 and NA2 are mostly present in the United States while EU1 is mostly found in Europe.

P. ramorum also has 2 known mating types, and one of each is needed for sexual reproduction. Genetic work suggest that *P. ramorum* is not currently sexually reproducing in the wild however, the presence of both mating types in California makes this possible and it unclear how this would affect disease dynamics.

References, strains of *P. ramorum*:
- http://www.apsnet.org/edcenter/intropp/lessons/fungi/Oomycetes/Pages/SuddenOakDeath.aspx
- http://www.cell.com/trends/microbiology/abstract/S0966-842X(11)00227-7

Concern about SOD spreading

- Suitable *P. ramorum* habitat (precipitation, temperature, susceptible hosts), especially in Appalachian Mt. range
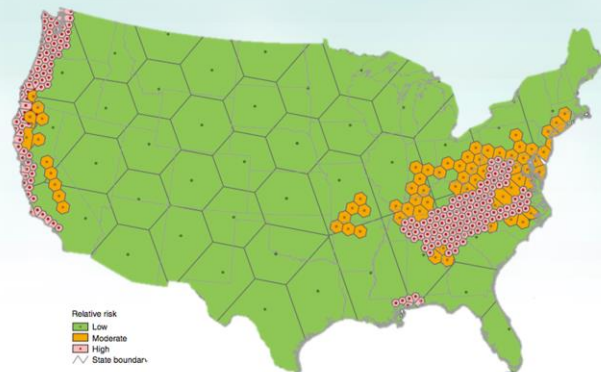
Koch and Smith,
FHM 2009
Technical Report

Relative risk
- Low
- Moderate
- High
- State boundary

Figure 7.1—2002 national sudden oak death (Phytophthora ramorum) risk map, designed to facilitate surveys in forested environments. State boundaries are included for reference.

There is concern that SOD will spread to Eastern forests.

There is ample suitable *P. ramorum* habitat (based on precipitation, temperature and susceptible hosts)
P. ramorum spreads easily and much of Appalachian Mt. range is considered a "high risk area"

Already, nurseries all over the US have tested positive (including NY, PA, NC) but so far hasn't broadly naturalized

We don't know what the changing climate will mean for SOD spread, but it could potentially expand into other areas with susceptible hosts

References, maps of *P. ramorum* distribution and risk:
http://www.suddenoakdeath.org/library/maps/
http://www.treesearch.fs.fed.us/pubs/43360

Potential Negative Impacts of SOD

- Changes in plant species composition

- Effect on maple syrup production in NE

- Loss of food sources for wildlife (acorns!)

- Changes in forest fire frequency and intensity

- Decreased water quality

- Impact to landowners and various industries

What are some of the potential impacts of *P. ramorum*/ SOD?

-Changes to affected ecosystems
-Changes to species composition (Susceptible and lethally affected hosts will die off. In addition, has the potential to affect other species. For example, redwoods in infected forests are more likely to die in a forest fire than those in an uninfected forest)
-Loss of food sources for wildlife (Tanoaks acorns, for example, are the major food source for small mammals in redwood ecosystems.)
-Change in fire frequency or intensity (More dead trees could increase fire risk and the fact that they are still standing when dead means they can provide a fuel ladder to spread fire into tree canopy and increase severity.)
-Decreased water quality (Due to an increase in exposed soil surfaces, especially following fire)
-Negative economic impact on land and homeowners as well as various industries (nursery)

The Pathogen: *Phytophthora ramorum*

Belongs to a group called oomycetes or "water molds"

- This group includes several well known, destructive, plant pathogens including the cause of the Irish Potato Famine
- In many ways, oomycetes are like fungi but some key differences
- Are actually more closely related to algae

Phytophthora ramorum, or P. ramorum, is the pathogen that causes Sudden Oak Death

It belongs to a group of organisms called **oomycetes** or water molds.
Although you may not have heard of oomycetes, this group includes several well known, very destructive plant pathogens, including the cause of the Irish potato blight
In many ways, oomycetes are similar to fungi but they have some key differences and are actually more closely related to algae

References, background on oomycetes:
http://www.apsnet.org/edcenter/intropp/PathogenGroups/Pages/IntroOomycetes.aspx
http://www.ucmp.berkeley.edu/chromista/oomycota.html

The Pathogen: *Phytophthora ramorum*

- Water molds are water loving!

- They require moist conditions to produce infectious spores

- Their spores can swim through water to find and infect susceptible hosts

P. ramorum growing out of infected leaf issue in a lab setting

Photo: Jeffrey W. Lotz, FDACS, Bugwood.org

Water molds are water-loving.
This means that *P. ramorum* requires very moist conditions to produce a type of **spore** (zoospores) which can swim through water to infect hosts

In addition, *P. ramorum* produces another type of spore, chlamydospores, which act as survival structures and stay dormant for years until favorable conditions

References, background on oomycetes:
http://www.apsnet.org/edcenter/intropp/PathogenGroups/Pages/IntroOomycetes.aspx
http://www.ucmp.berkeley.edu/chromista/oomycota.html

How does it spread?

P. ramorum spores can be spread through

- Water: wind-driven rain, fog drip, rivers, irrigation water
- Human activity: muddy tires and boots, moving infected plants around to new sites

P. ramorum spores may be spread through
-water (wind-driven rain, fog drip, rivers, irrigation water),
-plant material and
-human activity (muddy tires and boot, movement of soil)
-Nursery stock and moving infected plants to new sites

Spores land on host and under right conditions (wet and cool) will germinate and infect susceptible hosts

References, pathogen biology:
https://www.apsnet.org/edcenter/intropp/lessons/fungi/Oomycetes/Pages/SuddenOakDeath.aspx

How does it spread?

Foliar hosts are key to transmitting the pathogen

- CA epidemic thought to be driven by Bay Laurel (*Umbellularia californica*), an understory tree and foliar host

Foliar symptoms are less severe but produce lots of infectious spores

Lethal oak cankers do not produce spores and thus oaks are considered a dead end host

Epidemics have not (yet) occurred in Eastern forests, but infected nursery stock has been introduced from the West Coast

Foliar hosts are key to transmitting *P. ramorum* and causing Sudden Oak Death. In California, for example, the epidemic is driven by bay laurel, an understory tree and foliar host not lethally affected by *P. ramorum*. This is because lots of infectious spores are produced in these foliar lesions.

Oaks, on the other hand, are generally dead end hosts, despite being killed by *P. ramorum*, because these same infectious spores are not produced. However, because the pathogen is still viable in recently downed wood, there's a need to be cautious when moving wood between infected and uninfected sites. Take care to keep firewood away from oak and tanoak trees and in an area that will promote drying.

References, P. ramorum transmission:
http://www.suddenoakdeath.org/pdf/Bibliography/davidson2001a.pdf

Host plants

Infects a long (and growing) list of plants

Severity of disease and symptoms vary widely

Up to date list at:
http://www.aphis.usda.gov/plant_health/plant_pest_info/pram/

P. ramorum infects a long (and growing) list of plants
You can find an up to date list online

Host plants

- For many hosts, disease symptoms are minimal and infection is non-lethal

- Few hosts are killed by *P. ramorum* (but very significant for those it does kill, like some oak and tanoak species)

- Non-lethal infections are key to pathogen transmission

Keep in mind that while many plants are susceptible, most only experience mild symptoms unless heavily infected and only a few are lethally affected.

References, *P. ramorum* hosts:
http://www.suddenoakdeath.org/diagnosis-and-management/hosts-and-symptoms/

Identification

2 basic types of disease symptoms, depending on host: Foliar lesions and shoot dieback

From www.suddenoakdeath.org's extensive images of symptoms

P. ramorum infection causes a wide variety of symptoms depending on the host plant

2 basic disease types we will talk about in detail:1) foliar lesions and shoot dieback and 2) cankers

Identification

2 basic types of disease symptoms, depending on host: Trunk cankers (below) or leaf/shoot symptoms

From www.suddenoakdeath.org 's extensive images of symptoms

With bole and trunk cankers, you may only see a few drops of sap oozing from the stem or trunk. However, if you were to cut into the tree you would see a larger lesion, in oaks generally dark red or brown in color.

Cankers may look like stained bark after a period of rain or dry weather.

There may be multiple cankers present

Ooze is not foul smelling and comes out of undamaged bark.

Often, secondary infections are also present, such as hypoxylon, as well as bark and ambrosia beetles.

There are many diseases that share these symptoms, so remember that lab testing is necessary to determine if *P. ramorum* is the cause.

Identification

Inspect closely: Rhododendrons

Photos: Joseph O'Brien, USDA Forest Service, Bugwood.org

It's very important to inspect nursery plants closely for symptoms of *P. ramorum* infection. Sometimes, symptoms of infection will be mild and not obvious, but infections can kill these plants and have the potential to spread from nursery stock into natural plant communities in susceptible areas.

Two particularly important nursery ornamentals to keep an eye on are Rhododendron and Camellia (with symptoms shown here)

The nursery plants Viburnum, Pieris and Kalmia are also key potential hosts.

Infested leaves have a water-soaked appearance and diffuse black margins at the edge of the leaf spots. In general, cracked leaves and crip margins are not characteristic symptoms of ramorum blight.

When purchasing a plant from a nursery, it is a good idea to put the plant in "quarantine" for about 8 weeks. Hold the plant away from the landscape and other plants and be sure no symptoms are expressed. While this isn't a guarantee that *P. ramorum* isn't present, it is an added layer of protection.

References, Rhododendron symptoms:
http://www.suddenoakdeath.org/wp-content/uploads/2010/03/Rhody-Symptom-Card.pdf

References, Camellia symptoms:
http://www.suddenoakdeath.org/wp-content/uploads/2010/03/Camellia-Symptom-Card.pdf

Identification

Inspect closely: Viburnums

Photos from www.suddenoakdeath.org 's extensive symptoms images

References, Viburnum symptoms:
http://www.suddenoakdeath.org/wp-content/uploads/2010/03/Viburnum-Symptom-Card.pdf

Identification

Inspect closely: Andromeda (*Pieris*)

Photos from www.suddenoakdeath.org 's extensive symptoms images

References, Pieris symptoms:
http://www.suddenoakdeath.org/wp-content/uploads/2010/03/Pieris-Symptom-Card.pdf

References, Kalmia and other host symptoms:
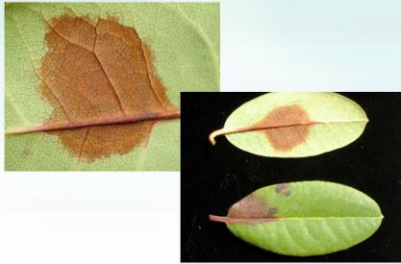http://www.suddenoakdeath.org/wp-content/uploads/2010/03/UK-Host-Symptom-Card.pdf

Diagnosis:

Lots of look-alikes!

- Rhododendron foliar lesions:

P. ramorum positive   *P. ramorum* negative

Photos from www.suddenoakdeath.org 's extensive symptoms images

Unfortunately, there are many *P. ramorum* look-alikes which cause similar disease symptoms.

Because of this lab testing is always necessary to know for sure if *P. ramorum* is present.

Diagnosis:

Lots of look-alikes!

- Camellia foliar lesions:

P. ramorum positive

P. ramorum negative

Photos from www.suddenoakdeath.org 's extensive symptoms images

Diagnosis:

- Even for the experts, visual symptom are not enough

- To be sure, send samples in for laboratory testing

- Send your sample to the Cornell University Plant Disease Diagnostic Clinic at:

- http://plantclinic.cornell.edu

Even for *P. ramorum* experts, visual symptoms can be misleading and are insufficient to diagnose infection.

Because of this it is very important that, if you see symptoms, you send samples into a laboratory for genetic testing

You can find a diagnostic lab online at:

What you can do, in areas with sudden oak death...

No cure for infected trees

Preventative measures can be taken but only decrease risk:

- Phosphonate treatment of healthy oaks and tanoaks
- Selective removal of bay laurel and other key hosts

Plan ahead and plant resistant species

In areas with Sudden Oak Death, management options are very limited

Despite what some sales-people will try to convince you, there is no known cure for infected trees

There are some preventative measures you can take that decrease tree risk:
-Phosphonate treatment of healthy oaks and tanoaks found within an infectious perimeter of a few miles around a known infection
-Selective removal and pruning of bay laurels and other hosts key to pathogen transmission (But, keep in mind that this wont guarantee the pathogen won't still arrive and leave you without both oaks and bays. Spores have been known to travel for miles during severe weather conditions. Because of this, a mass removal of Bay trees in not recommended)

But keep in mind, these only reduce tree risk are not guaranteed solutions and can be costly.

When removing infected plant material, chip small amounts on site and spread in a thin layer (to promote rapid drying) but away from oak and tanoak trunks. Larger pieces can be cut into firewood and used on site, but don't move to minimize the risk of spreading the pathogen to a new area.

What you can do, in areas without sudden oak death...
Help prevent its spread!

- Don't move in plants or soil from areas with *P. ramorum*
- Inspect nursery plants carefully
- Follow good sanitation practices
- Send symptomatic plant material to diagnostic lab for testing

Because there are so few management options, it is very important that we try to reduce the spread of *P. ramorum* to new area

Don't move in plants or soil or mulch from areas with *P. ramorum*
Inspect nursery plants carefully
Follow good sanitary practices, especially when traveling between areas with and without *P. ramorum*
Send symptomatic plant material to diagnostic labs for testing

What you can do- get involved!

Scout for the disease and send in suspicious samples

Learn more about Sudden oak death and Ramorum blight:

- California Oak Mortality Task Force: www.suddenoakdeath.org
- Up to date host list and regulations from the USDA: www.aphis.usda.gov/plant_health/plant_pest_info/pram

Participate in citizen science projects sampling and looking for *P. ramorum*

More resources

California Oak Mortality Task Force: www.suddenoakdeath.org has great information an a large list of other resources

Up to date host list and regulations from the USDA: www.aphis.usda.gov/plant_health/plant_pest_info/pram

Interactive map of SOD spread: www.oakmapper.org

Research sites with scientific information:

- Garbelotto Lab, UC Berkeley www.cnr.berkeley.edu/garbelotto/english/index
- Rizzo Lab, UC Davis http://ucanr.edu/sites/rizzolab/

Great video explanation from KQED: http://science.kqed.org/quest/video/plant-plague-sudden-oak-death/

Credits

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