Phytophthora ramorum
Research Update

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Highlights of recent research on *P. ramorum*

- Landscape level mapping and modeling
- Effects on plant communities/adaptive management
- Epidemiology: Spread from plant to plant
- Epidemiology: Spread within plants
- Soil ecology and root infection
- Persistence in the absence of a host
- Population genetics
Landscape level mapping and modeling

- *P. ramorum* has killed many more trees than we thought
Assessment of Oak Mortality and Host Distribution in Big Sur, CA
Ross Meentemeyer, UNC Charlotte

• Examine the spatial distribution of forest types
• Assess distribution of SOD mortality in each forest type
• Estimate the number & abundance of dead trees
• Use results in adaptive management planning
• Use mortality distribution for epidemiological modeling
Project Components

1) Established plots
2) Mapped forest types
3) Mapped tree mortality
4) Validation/Estimation
Findings

- McWay Cove sub-watershed is composed of
  - 2,136 ha Mixed evergreen
  - 1,577 ha Redwood/Tanoak
  - 4,864 ha Non-forest

- Estimate of Oak Mortality
  - 59,680 dead trees
  - 61% Tanoak
  - 39% Coast live oak & black oak
Adaptive management of SOD-infested areas
Dave Rizzo, UC-Davis

- Establish a network of ecological monitoring plots
- Evaluate impacts of SOD on ecosystem composition and dynamics
- Develop a SOD management plan that complements other landscape management goals
- Test the efficacy of management actions
- Develop an outreach program that involves local communities
Epidemiology: spread from plant to plant

- In the forest: most new infections arise within 100 m of infected trees. A small number of new infections arise from inoculum up to 5000 m away.
Approximate Location of Sudden Oak Death Patches December 2001

Regulated Area
Approximate Location of Sudden Oak Death Patches December 2004

Regulated Area
Dispersal Gradient

Distance from Previous Infection (m)

Number of New Infections

25 m = 15%
100 m = 51%
200 m = 70%
300 m = 88%
Lateral Spread

Everett Hansen, Oregon State Univ.

- Clustered distribution
- Long “tail”
- Greater than expected dispersal distances?

Suggests:
- contagious spread,
- discrete sources,
- no “background” of pre-existing infections,
- two distinct mechanisms of dispersal?

AN EXOTIC, INVASIVE, PATHOGEN
Epidemiology: spread from plant to plant

- In a nursery setting: Most new infections arise within 1 m of infected plants. Sprinkler irrigation with contaminated water, or contaminated potting media can also result in plant infections.
Infected Plants Observed within Plant Block

2004-2005 Season  1/24/2005

Central Inoculated plant
10 inoculated leaves

#  Number of infected leaves in all 5 replicated blocks
Infection Observed with Stream Water and Sprinkler Irrigation

Experimental factors tested

1. City Water/ Drip
2. City Water/ Sprinkler
3. Stream Water/ Drip
4. Stream Water / Sprinkler

4/22/2005 only

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<th>BLOCK</th>
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# of necrotic lesions on multiple plants
Leaves touching soil become infected

2003-2004 Season
Epidemiology: Spread within plants

- *P. ramorum* can infect roots
- Root infections can lead to stem and leaf infections
- *P. ramorum* spreads in the vascular system of many hosts
Infection after approximately one month of plants inoculated with a root drench of sporangia of *P. ramorum*

Nina Shishkoff USDA-ARS, Ft. Detrick, MD

<table>
<thead>
<tr>
<th>Plant species&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Common name or cultivar</th>
<th>No. plants inoculated</th>
<th>% plants infected</th>
<th>% washed roots infected</th>
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<tbody>
<tr>
<td><em>Acer macrophyllum</em></td>
<td>Bigleaf maple</td>
<td>12</td>
<td>16.6%</td>
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<sup>a</sup>=All species listed are known to be foliar hosts of *P. ramorum* except *Buxus*. 
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![Image](https://via.placeholder.com/150)
• *P. ramorum* can infect the roots of foliar hosts
• Can inhabit the rhizosphere of the roots of nonhost plants
• Persists in dead roots at least 340 days
• Chlamydospores can persist in potting mix > 650 days
• Roots can be infected by chlamydospores in potting mix or by propagules from leaf litter
Rhododendron stem lesion initiated from a root infection – zoospore inoculum
*P. ramorum* infects sapwood of tanoak

**Microscopy**

**Culture**

**PCR**
Soil ecology and persistence in the absence of a host

- *P. ramorum* has a soil phase!
Seasonal Distribution of Inoculum in Soil

Elizabeth Fichtner and Dave Rizzo, UC-Davis

Frequency of recovery

Bay  Tanoak  Redwood

Winter 2004  Winter 2005  Winter ‘06
Recovery of *P. ramorum* from infected leaf tissue

Location*time P ≤ 0.0001

- **soil**
- **interface**
- **surface**

Time (weeks)

% recovery

- 4/27/04
- 5/11/04
- 6/22/04
- 10/20/04
Stream baiting and stream sampling
Everett Hansen, Oregon State Univ.
Steve Jeffers, Clemson Univ.
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Recovery of *P. ramorum* downstream from an infested nursery

Jennifer Falacy
Washington State Dept. of Agriculture
Stream baiting/sampling is a useful monitoring tool

*P. ramorum* is persistent in streams in previously infested areas
  - ? Where is it coming from?
  - ? Is it epidemiologically important?

*Phytophthora* species are diverse and abundant in forest streams, all year round
  - ? What does it all mean?
Population genetics

- 2 mating types (A1, A2)
- 3 genotypes (EU, US, WA)
- Primarily clonal population
- Use of microsatellites in epidemiological studies
Microsatellites to distinguish individuals in clonal populations

Matteo Garbelotto, UC-Berkeley
Simone Prospero, OSU and many others

• Simple sequence repeats (SSR) codominant markers
• High variability
• Detect potential outcrossing
• An epidemiological tool to trace the source and spread of the pathogen