Sudden Oak Death

Aka Ramorum Blight

California Oak Woodlands

- Cover 10% of California’s land area.
- Characterized by Mediterranean climate.
- Roughly 4 million acres.
- High levels of biodiversity (Swiecki and Bernhardt, 2001).
  - 300 vertebrate species
  - 1100 species of native vascular plants
  - 5000 species of arthropods
Disease Complex
Introduction

- Sudden Oak Death (SOD)
  - Affects 3 species of California oaks.
  - Caused by water mold *Phytophthora ramorum*.
  - Causes bark cankers eventually girdling trees, results in “sudden” mortality.

Photo: http://www.forestryimages.org/
Tree Species

- California black oak
  - *Quercus Kelloggii.*
  - Valuable hardwood lumber resource similar to northern red oak.
Tree Species

- California black oak
  - Mesophytic
    - Transitory between chaparral and upland, moist conifer habitat.
  - Site adaptations:
    - Mild temperatures: 31-82 degrees F.
    - Well drained soils.
    - 1,000-5,000 ft in elevation.

Photo: U.S. Forest Service
Tree Species

- **Coast live oak**
  - *Quercus Agrifolia*
  - Non commercial Species: Fuel wood only commercial use
  - Ecologically significant as a source of mast.
Tree Species

- **Coast live oak**
  - Dominant tree in low elevation oak woodlands and chaparral.
  - Evergreen, drought tolerant.
  - Extremely fire tolerant
    - Regenerates by sprouting following fire.
Tree Species

- **California tanoak**
  - *Lithocarpus densiflorus*.
  - Medium sized tree, co-occurs with redwood and douglas fir in coastal ranges.
  - Commercial uses: fuel and pulp.
  - Ecologically significant as a mast source.

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

Photo: Steven J. Baskauf, Ph.D, Vanderbilt University
Tree Species

- California tanoak
  - Site adaptations:
    - Humid climate: 40-100 inches of rainfall.
    - Moderate temperatures: 36-75 degrees F.
    - Deep, well drained soils
    - Best adapted to humid, moist slopes of coastal ranges.

Photo: U.S. Forest Service
Health Management Objectives

- Maintain SOD susceptible oak species as major components of the Californian oak woodland ecosystem.
  - Preserve California black oak as a commercial species.
  - Maintain abundance of coast live oak and tanoak within oak woodlands in order to preserve their ecological value.
Primary Stress

- *Phytophthora Ramorum.*

- Oomycete: “water mold”
  - Reproduces both sexually and asexually.

- Many susceptible host species.
  - Varying symptoms by host.

Photo: genome.jgi-psf.org/Physo1_1/pramorum.jpg
**P. ramorum** Lifecycle

**Sporangium** germinate, releasing zoospores.

Chlamydospores are produced by foliar infections. Chlamydospores are long-lived and durable, persisting in soil and water for long periods.

*P. ramorum* requires a film of water on leaf surfaces for zoospores to infect new hosts.
P. ramorum Lifecycle

- 2 mating types required for sexual reproduction.
- Second mating type has not been detected in U.S. forests.
  - Detected in U.S. nurseries.

Adapted from ‘The disease cycle of late blight caused by Phytophthora infestans’, G.N.Agrios, (with copyright permission Academic Press)
**P. ramorum Lifecycle**

- **Host Species:**
  - 40 genera identified as hosts (2005).
  - Most species are foliar hosts (produce inoculum).
  - Lithocarpus, Quercus species are “canker hosts”. Do not produce viable inoculum.

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<table>
<thead>
<tr>
<th>TABLE 1 Plant genera known to have species associated with <em>Phytophthora ramorum</em> in forests or nurseries$^1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abies</td>
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<tr>
<td>Acer$^*$</td>
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<td>Aesculus$^*$</td>
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<td>Arbutus$^*$</td>
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<td>Arctostaphylos$^*$</td>
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<td>Calluna</td>
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<td>Camellia</td>
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<td>Castanea</td>
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<td>Clintonia</td>
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<td>Corylus$^*$</td>
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<td>Drimys</td>
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<td>Dryopteris$^+$</td>
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<td>Fagus$^+$</td>
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<td>Fraxinus$^+$</td>
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<tr>
<td>Hamamelis</td>
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<td>Heteromeles$^*$</td>
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<tr>
<td>Kalmia</td>
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<tr>
<td>Laurus</td>
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<tr>
<td>Leucothoe</td>
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<tr>
<td>Lithocarpus$^#$</td>
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<td>Lonicera$^+$</td>
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</tbody>
</table>

$^1$Symbols: $^*$, found in California or Oregon forests; $^#$, canker host in North America; $^8$, canker host in Europe. Canker hosts refer to species in which infection by *P. ramorum* results in bleeding cankers on the main trunk of the tree; this is the symptom usually associated with sudden oak death. On all other hosts *P. ramorum* causes foliar or twig blight (based on 2, 10, 18, 63).
**P. ramorum Symptoms**

- **Foliar Host Species**
  - Source of viable inoculum.
  - Twig and leaf dieback main symptom.

**P. Ramorum infected Rhododendron**

Photo: Eric Chamberlain, USDA APHIS PPQ

**P. ramorum symptoms on California Bay Laurel**

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

**P. ramorum symptoms on douglas fir.**

Photo: Joseph O'Brien, USDA Forest Service, Bugwood.org
**P. ramorum Symptoms**

- **Canker Host Species**
  - *Lithocarpus denisflorus*
    - Most susceptible species.
      - All age classes vulnerable.
      - Mortality may occur within 1 year.
    - **Symptoms**
      - Dark, bleeding cankers on twigs and bark.
      - Foliar lesions.
      - Discolored vascular tissue.
      - Sheppard’s Crook

Photos: J.M Davidson et al. 2003
**P. ramorum Symptoms**

- **Canker Host Species**
  - *Quercus kelloggii, Q. agrifolia*
    - “Dead end” infection: no inoculum produced.
  - Symptoms
    - Bleeding bark cankers.
    - “Sudden” death: crown mortality.

*Photo: Garbelotto et al. 2001*
Disease Complex Development

- Predisposing Factors:
  - Non-native pathogen
  - Proximity of foliar host
  - Land use history
    - Cutover stands entering period of high competition
    - Lack of stand thinning events
Disease Complex Development

- **Predisposing Factors**
  - High amounts of early precipitation followed by drought.
  - Periods of cool, moist weather.
    - Production of inoculum.
    - Promotes new infections.

![1997 vs. Normal Monthly Rainfall](chart.png)
Disease Complex Development

- Inciting Factors
  - Infection by a *P. ramorum* spore.
Disease Complex Development

- Contributing Factors
  - Appear not to play role in primary stress lifecycle
    - *Hypoxylon thouarsianum*
    - Oak bark beetles
    - Ambrosia Beetles
Secondary Stress

- *Hypoxylon thouarsianum*
  - Sapwood decay fungus
  - Coal black fruiting bodies
  - Latent infections become opportunistic when host is stressed.

Photo: Garbelotto et al. 2001
Secondary Stress

- **Oak Bark Beetles**
  - *Pseudopityophthorus pubipennis, P. agrifoliae*

- **Signs & Symptoms**
  - Colonize outer sapwood.
  - Tunnels across grain.
  - Tan piles of frass.

Photo: Swiecki and Bernhardt 2006
Secondary Stress

- Ambrosia Beetles
  - *Monarthrum dentiger, M. scutellare*
- Signs & Symptoms
  - Galleries extending into sapwood.
  - White piles of frass.
- May contribute to stem failure.

Photo: Swiecki and Bernhardt 2006
Health Management Plan

- Pre-emptive:
  - Remove all foliar hosts with 10 meters of oaks.
  - Caution: thinning shock, residual stand damage.

Photo: http://bapd.org/hamilton-gulch-long-sequence.html
Health Management Plan

- **Pre-emptive:**
  - Use prescribed fire to eliminate susceptible species.
  - Maintain vigor on susceptible species

- **QUARANTINE:**
  - Infected nursery material.
  - Soil from infected areas.
    - Wash vehicle tires, shoes, etc.
  - Plant materials: firewood, foliage, etc.
Health Management Plan

- Monitoring and Surveying
  - Steam Monitoring.
    - Useful for detecting presence/absence within watershed.
  - Ground surveys.
  - Aerial surveys.
    - Can detect “patchy” outbreaks
  - Nursery monitoring.
    - Detect infected plant material


Photo: http://www.fs.fed.us/r6/nr/fid/health/2001highlights-or.shtml
Health Management Plan

- **Reactive Measures:**
  - Phosphite fungicides:
    - Bark application.
    - Primarily Preventative.
    - Mild therapeutic value.

![Photo: www.phytosphere.com/publications](image-url)
Health Management Plan

- Reactive Measures:
  - Remove and destroy all infected material.
  - Remove all foliar hosts within 10 meters of oak hosts.

Photo: Chris Evans, River to River CWMA, Bugwood.org
Conclusion

- Relatively new disease complex:
  - First identified in U.S. in mid 90’s.
  - Relatively unstudied.
- Novel forest pathogen.
  - Initially poorly studied and understood.
  - Today much of this uncertainty has been removed.

1993: *P. ramorum* isolated as a nursery pest in Germany on Rhododendrons.


2000: Plant Pathologist David Rizzo isolates *P. ramorum* as causal agent of SOD.

2000+: Bulk of Research Conducted on SOD.
Factors Affecting Perception of Risk

- Uncontrollable
- Involuntary
- Unfamiliar
- Poorly understood
- Uncertainty
- Exotic
- Synthetic
- Dread
- Catastrophic potential
- Affects future generations
- Related to children
- Delayed effects
- Irreversible
- Questionable benefits
- Unfair
- Identifiable victim
- Personal stake
- Untrustworthy source
- Linked to other risks
- High media attention

Conclusion

“Sudden” Oak Death

- Initiated by non-native pathogen.
- Exacerbated by atypical periods of cool moist weather.
- Spread primarily by foliar hosts.
- Monitoring of nursery shipments critical to preventing spread.
- Worldwide risk?
Further Spread?

Sources: DEFRA, 2004; Huberli et al., 2003; NAPFFAST, 2006; NatureServe, 2002; Orlikowski and Szukuta, 2002; Tooley et al., 2005; Vogtmann et al., 2001; Wayres et al., 2001
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