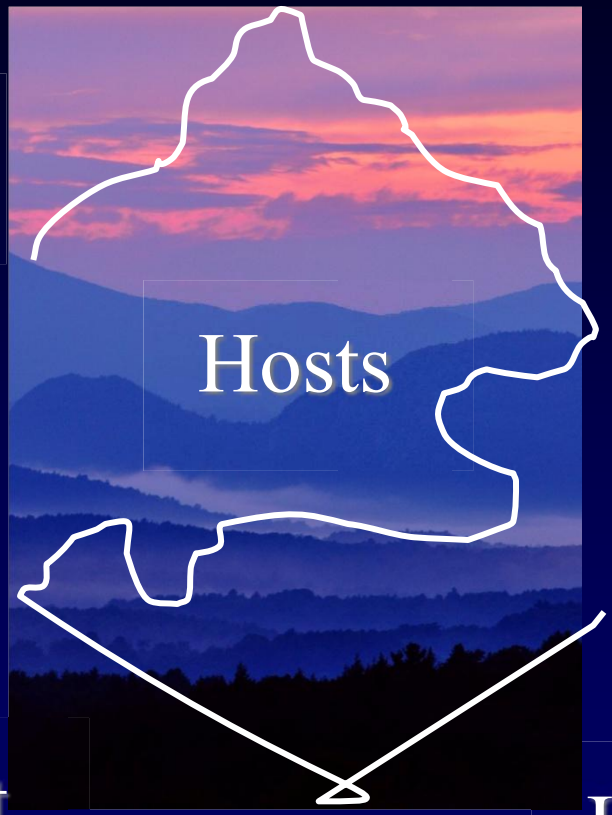
Sudden Oak Death: an integrated approach to management

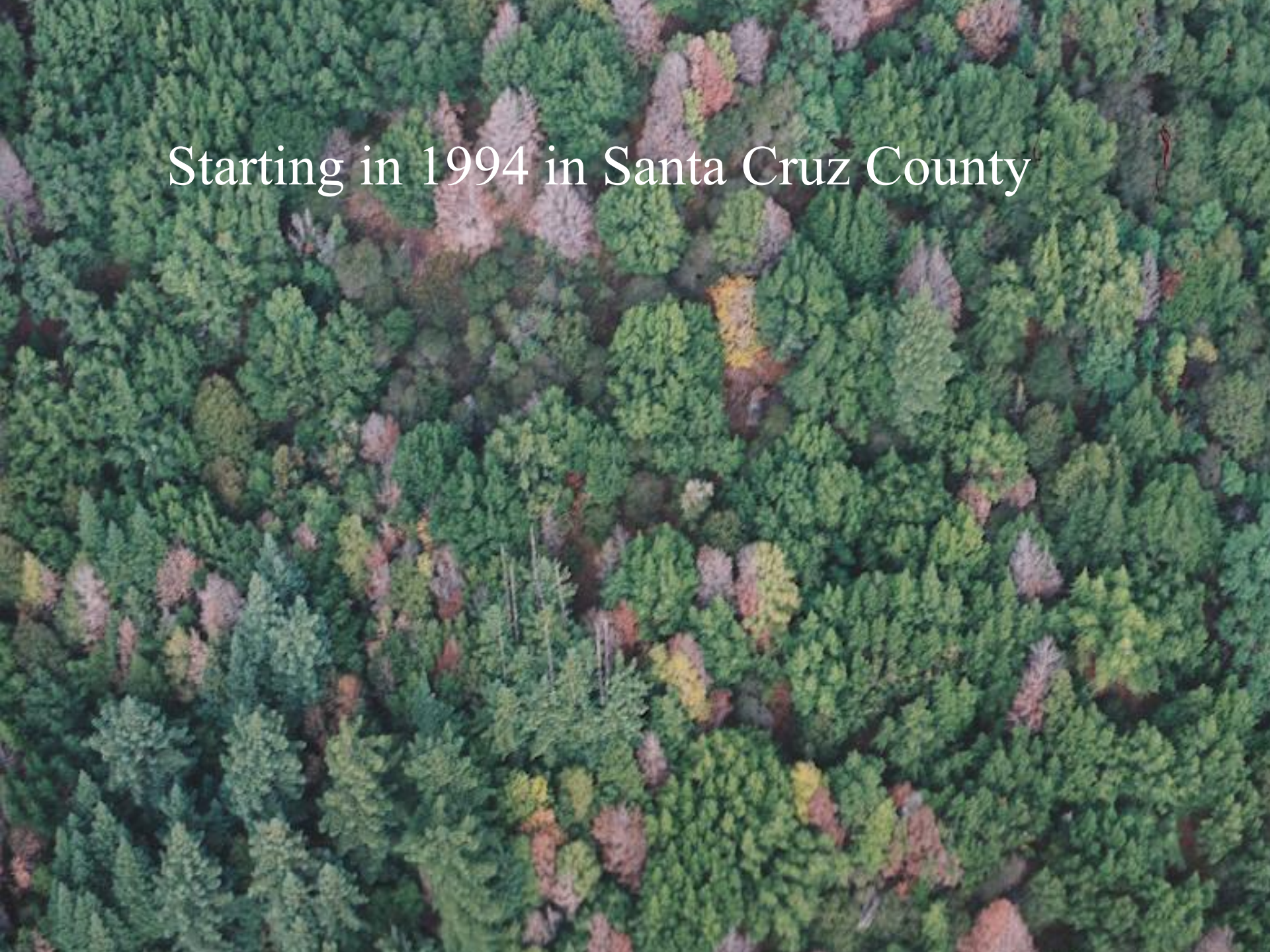
Pathogen



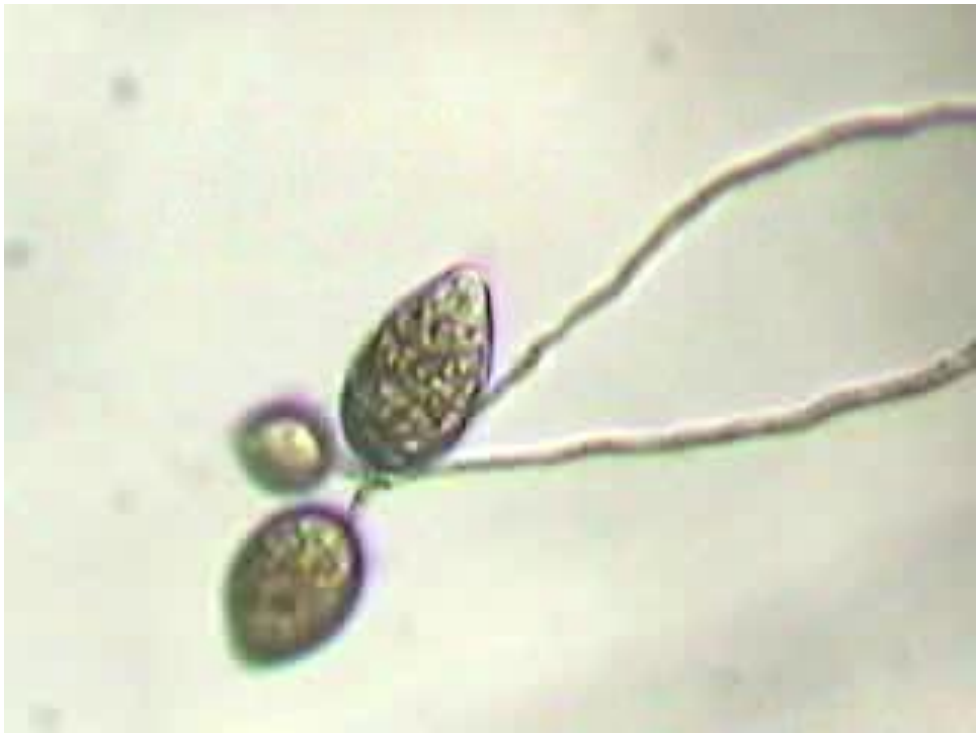
Man

Environment

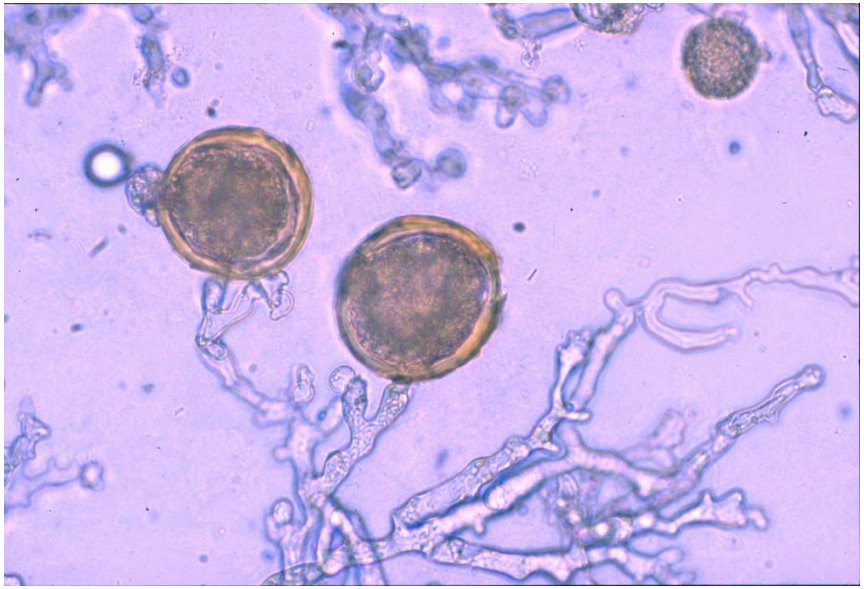
Interactions


Starting in 1994 in Santa Cruz County

Phytophthora ramorum

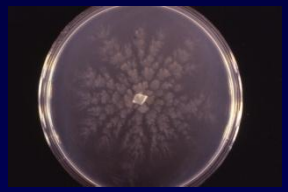


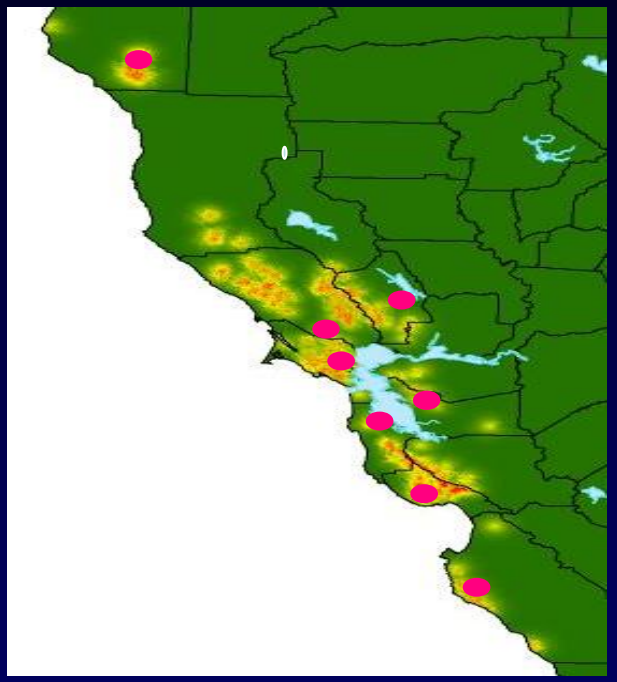
Sporangia



Chlamydospores

P. ramorum introduced at least 8 times in CA (Mascheretti et al. 2009). Multiple introductions and not ability to move far explain distribution of disease





Because pathogen is exotic, native flora has limited resistance to its attack and regular tree health maintenance simply will not suffice

Because of complexity of SOD, and of limited resources

- Management needs to be based on knowledge of biology, epidemiology, and ecology, including timing issues

- Try to get the most effect with the least effort, potentially managing for SOD and other issues simultaneously

Bay/Oak association

Bay

Yearly

Coast Live Oak (no sporulation)

Canker margin in phloem

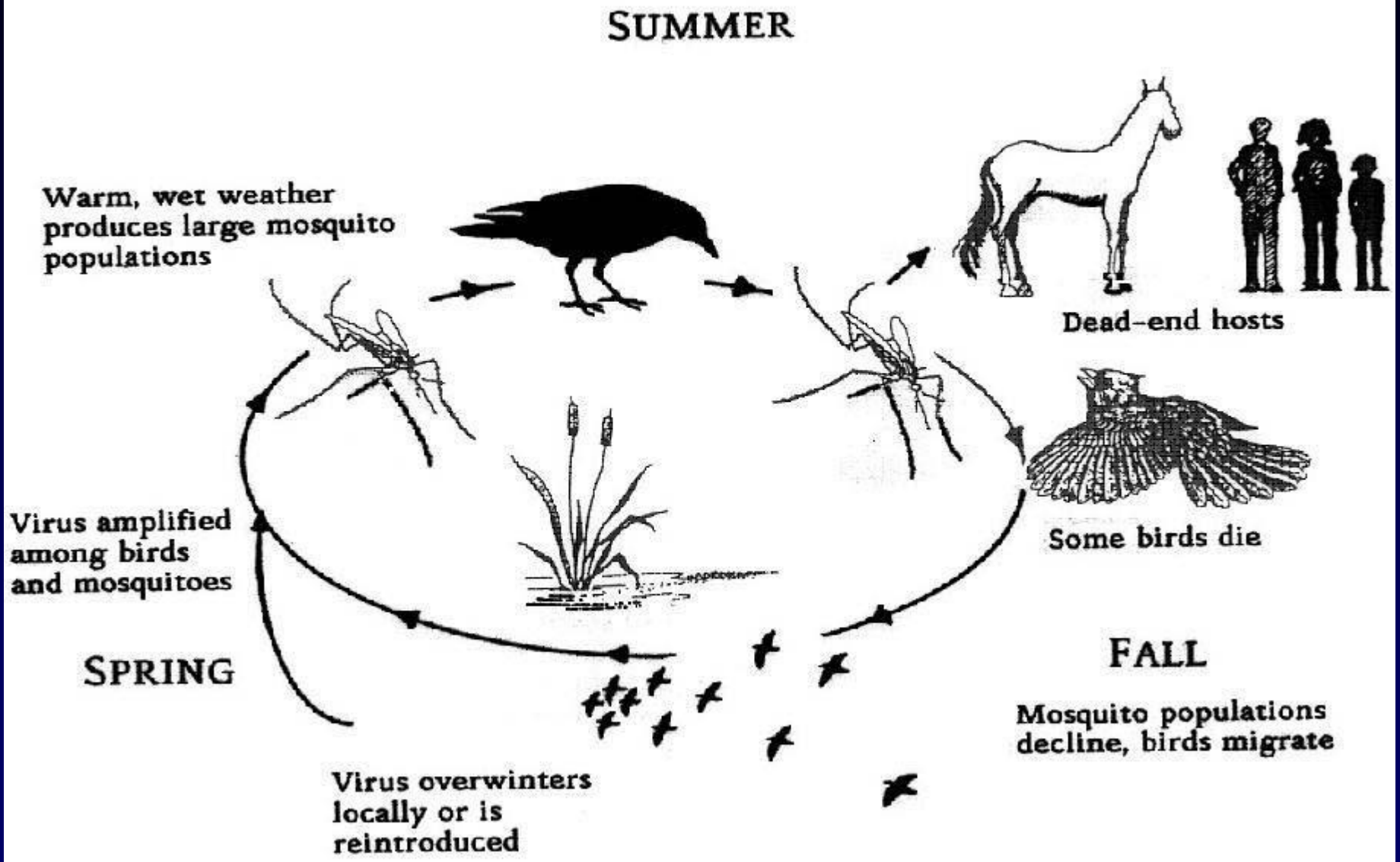
Sporangia

Wave years

Bleeding canker

Soil

Life Cycle of the West Nile Virus



- Sporangia and chlamydospores will end up in soil
- In organic layer survival shorter than in mineral soil
- Strains in soil different than those on plants
- Pathogen was cultured from soil on shoes in the spring
- Soil infestation in a forest soil will not survive one year if rainfall below average

Soil may be epidemiologically irrelevant in infested forests but it may cause an outbreak if moved to uninfested sites

Oaks

Coast live oak

Quercus agrifolia

Black oak

Q. kellogii

Shreve's oak

Q. parvula var. *shrevei*

Canyon Live oak

Tanoak

Notholithocarpus densiflorus

Hypoxylon (Anulohypoxylon) fruitbodies on the main stem are a sign that a tree is functionally dead

Only health compromised trees attract bark and ambrosia beetles: frass (sawdust) on the trunk is a sign of insect colonization

Tanoak vs. Oak mortality

- Tanoak – Big Sur
  - 70%
- Marin – predicted
  - 15 years for 90%

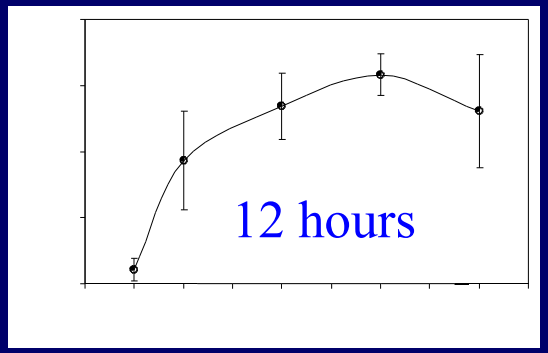
- Oak- Big Sur
  - 40%
- Marin – predicted
  - 35 years for 90%

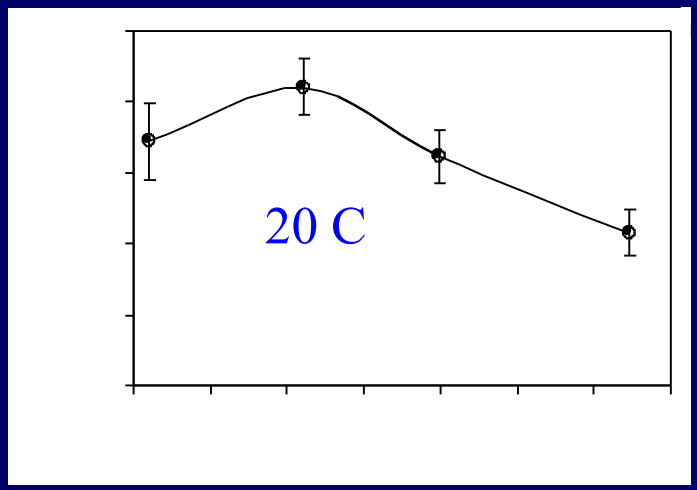
Primary cause of death is girdling of phloem, vessel blocking and secondary organisms accelerate the process

Girdling occurs much faster than visible symptoms on crown. Girdled trees can survive apparently "green" 4 years + after being girdled

Girdled trees can fail even if "green" because of activity of secondary organisms

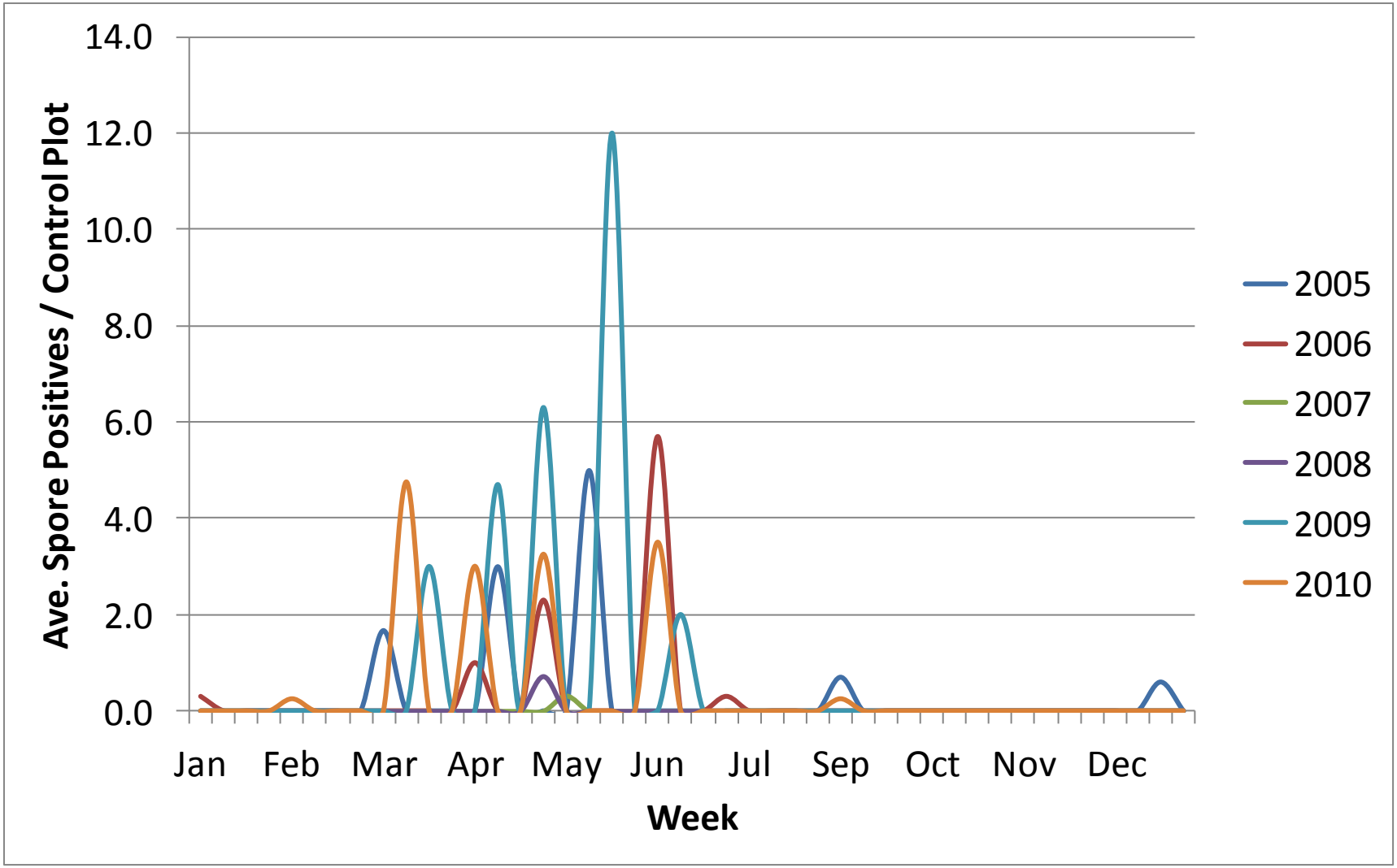
While insecticides may temporarily prolong the life of treated trees, beetle attacks are a good indicator of "hazard" trees





By inoculating with zoospores and without wounding, the ideal conditions for infection were figured out: these conditions are present in California especially when there are rainy late Springs: these conditions do not happen every year

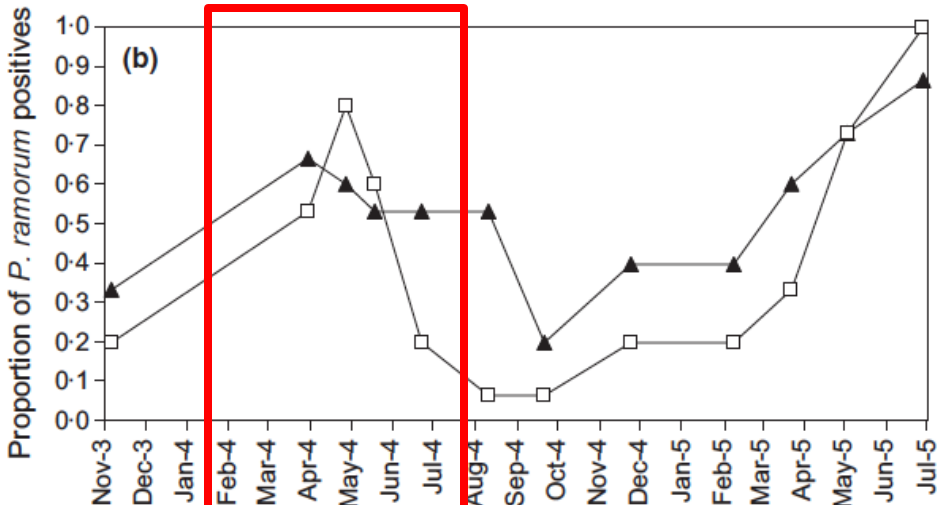
SOD spore catches in water: mid-April to mid-June is consistent



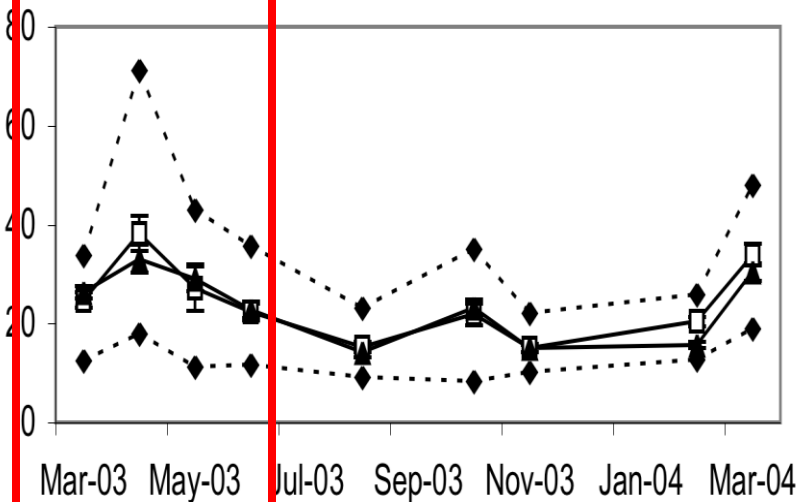
Synchrony pathogen-host:

Host susceptibility

Susceptibility of bay laurels
(lesion size in nature)



Susceptibility of oaks
(lesion size in lab)



Pathogen

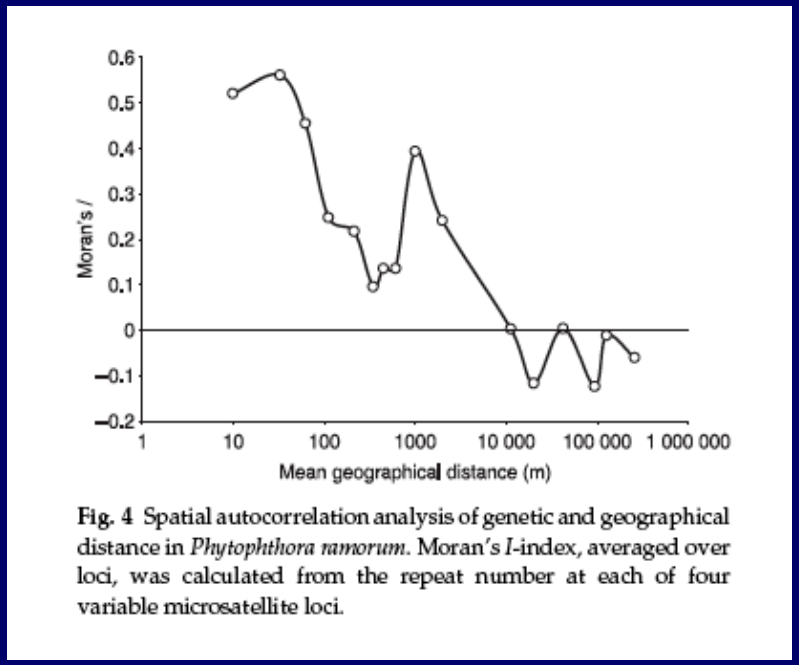


Fig. 4 Spatial autocorrelation analysis of genetic and geographical distance in *Phytophthora ramorum*. Moran's *I*-index, averaged over loci, was calculated from the repeat number at each of four variable microsatellite loci.

When multiple rain events occur sporangia are produced on leaves of infectious hosts such as bay laurel and tanoak and can be airborne

mostly up to 100 m but when winds are strong up to 2 miles

New infections occur almost exclusively during the rainy season in or near sites previously infested

Limit tree-care and forestry work during wet season

If necessary to work in wet season, schedule to work in uninfested sites before working in infested sites

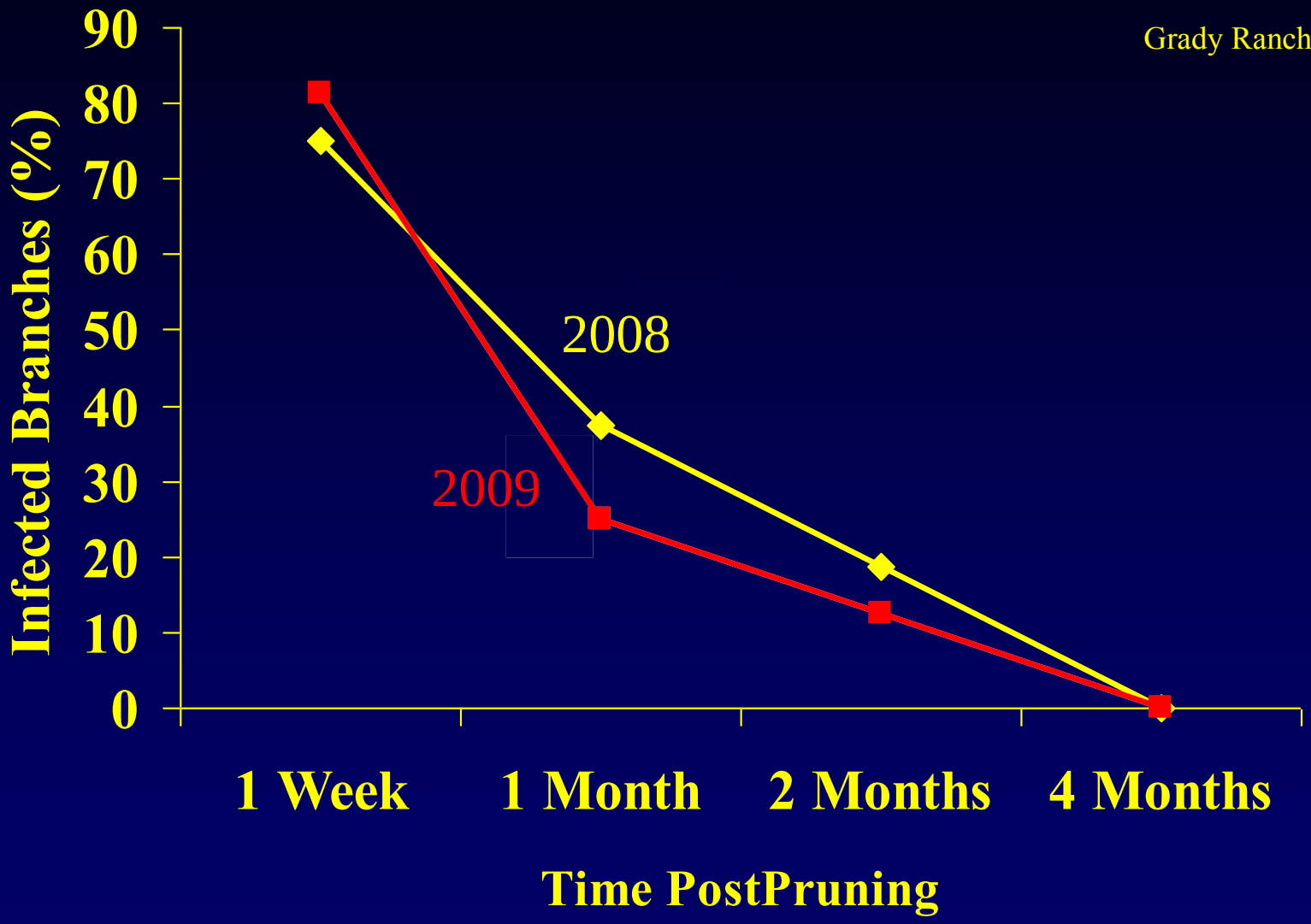
P. ramorum has a short spread range, knowing its fine scale distribution is essential

Transmission of SOD through pruning:

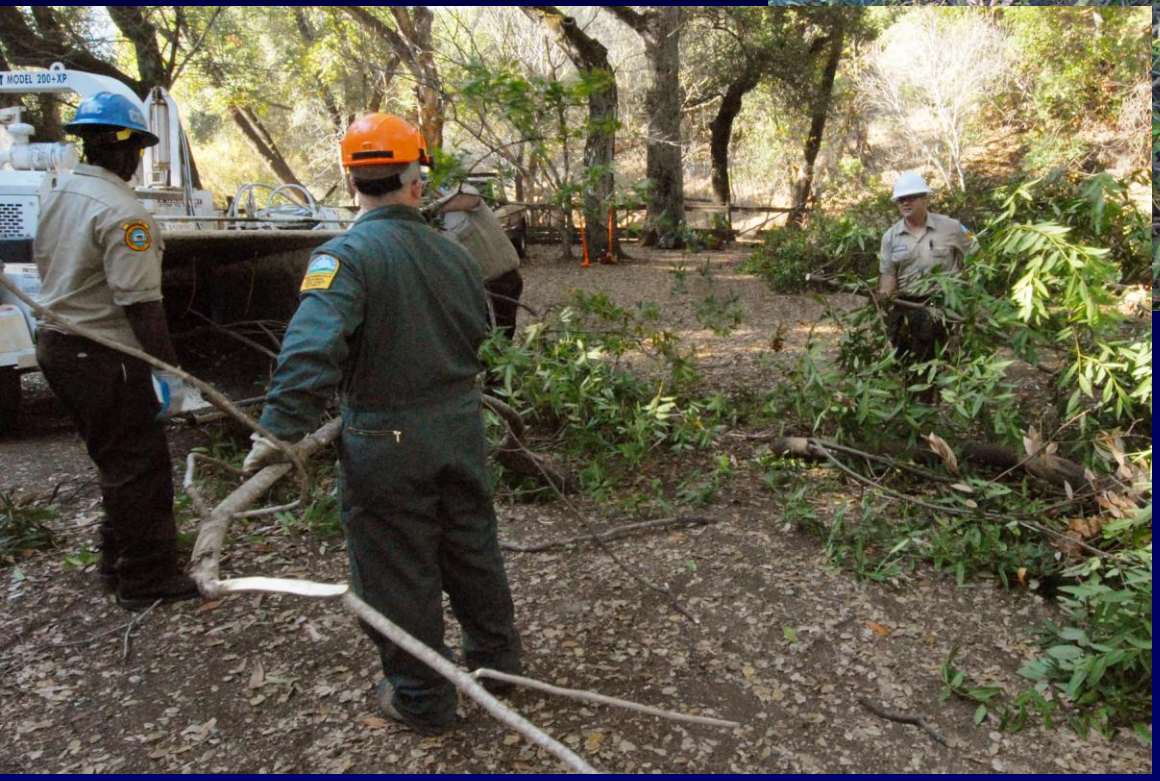
- Can tree pruning introduce SOD infection?
- Is the timing of cutting a factor?

Skywalker / Grady Ranch Site

Transmission of SOD Through Branch Pruning



Bay Laurel Removal for SOD Control

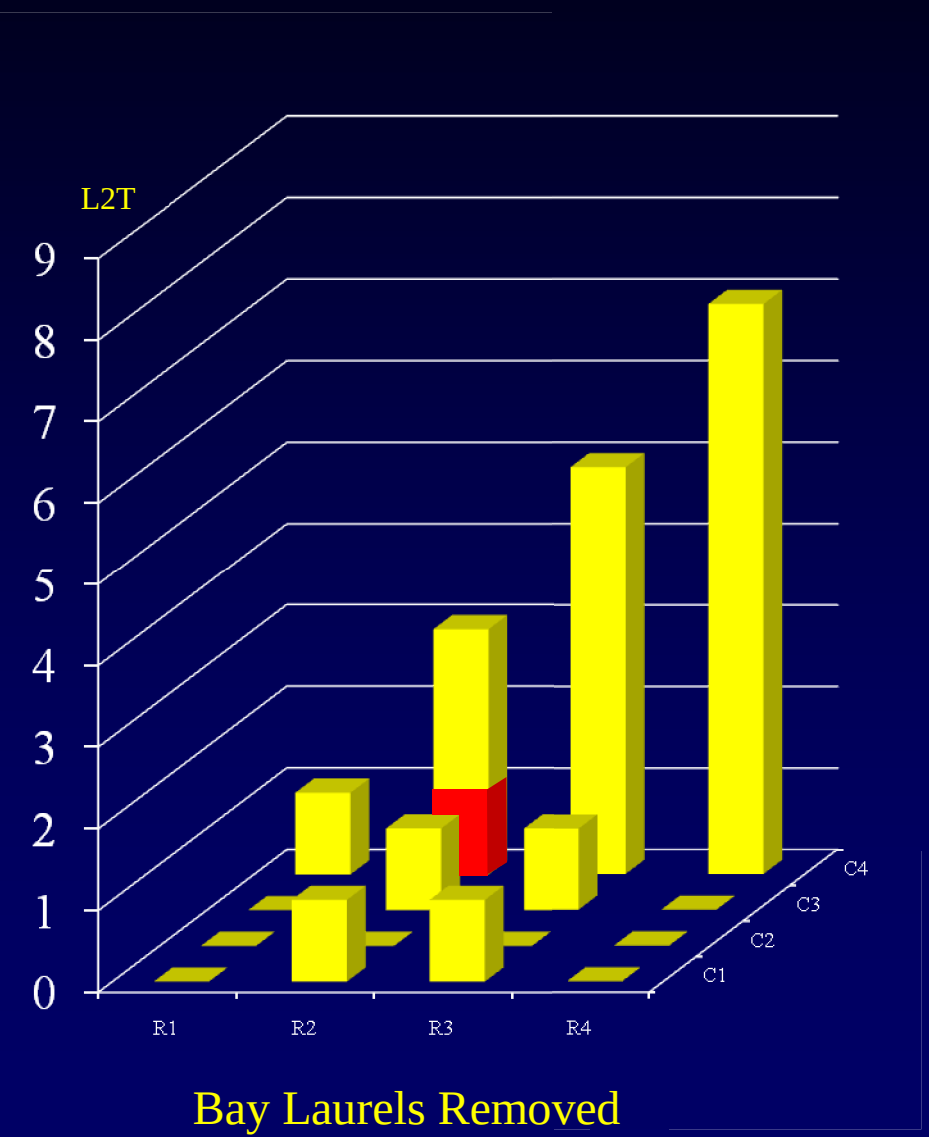


SOD Spore Monitoring at SDSF

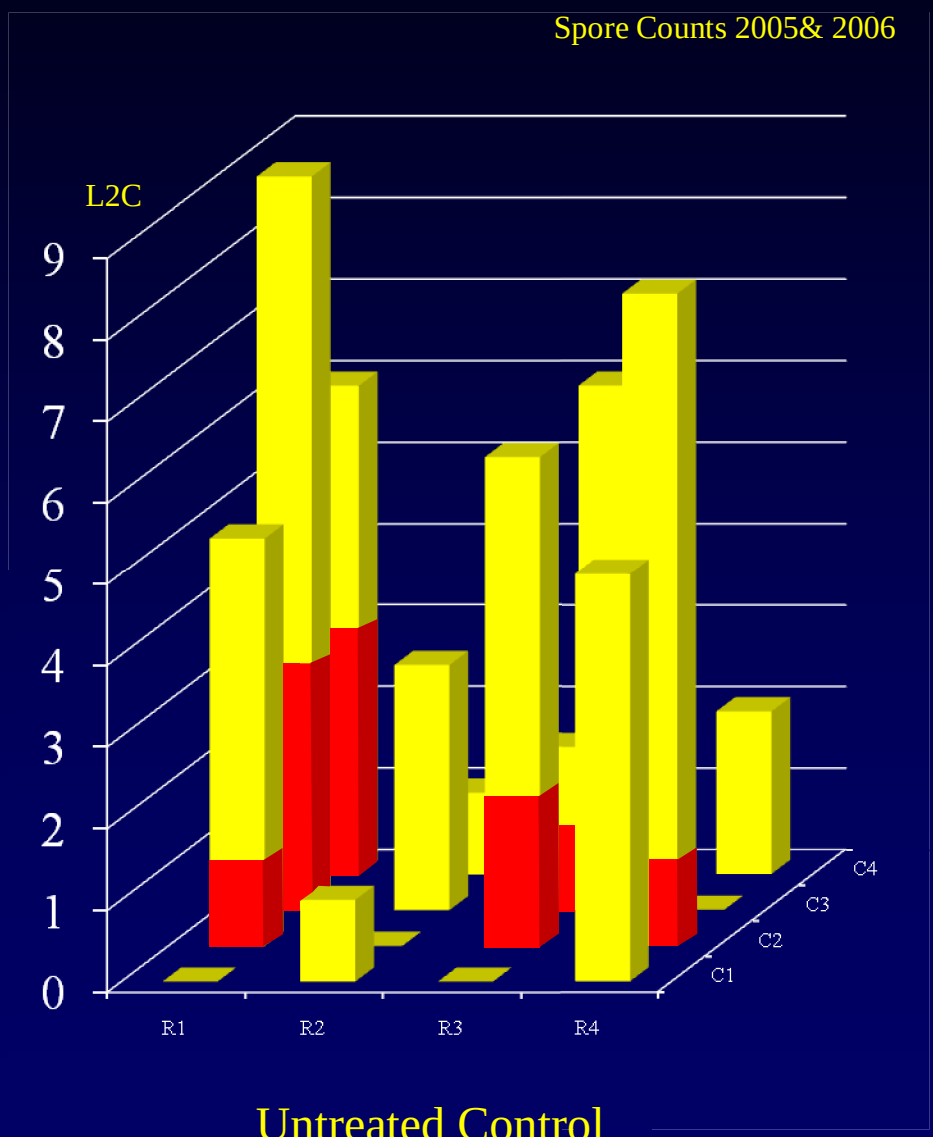
8 Experimental Field Sites
16 Buckets / Site
5 Leaves / Bucket
= 640 leaves sampled every 3 weeks February through June for 6 years

Effect of Bay Removal on SOD Spore Counts

Combined *P. ramorum* Spore Counts 2005& 2006



Bay Laurels Removed



Untreated Control

Is reduction in spore loads caused by removal of bays in the 10-20 m range sufficient to prevent infection of oaks?

ONLY HIGH INOCULUM (RED) CAUSED OAK INFECTION

Conclusions:

1- Bay removal at moderate distance from oaks appears to sufficiently reduce inoculum level to prevent infection, even if it does not eliminate it
Removal of bays 10 m around oaks recommended.
For large specimens we recommend 20 m

Oak-centric

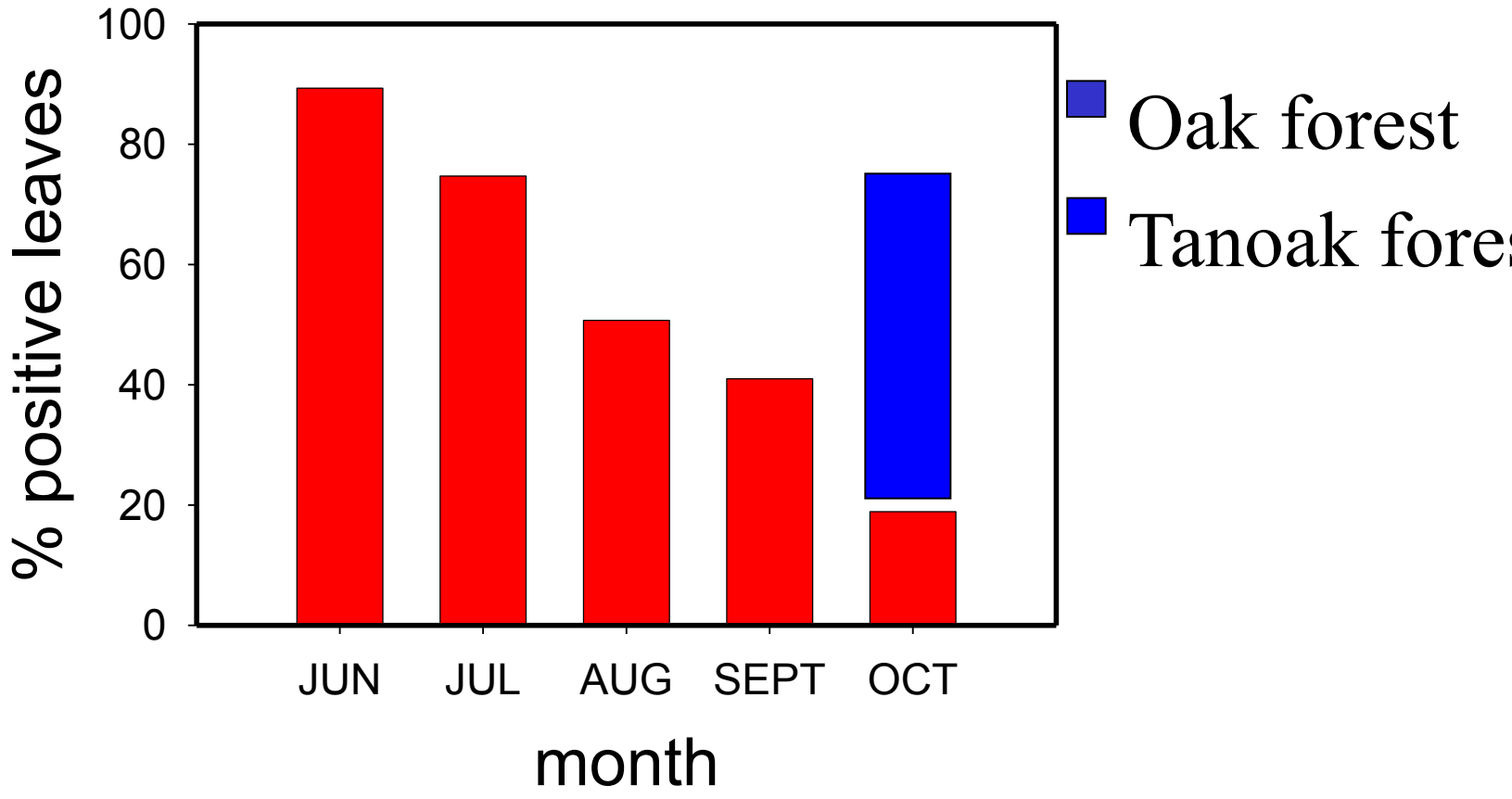
2- Bay removal at the stand level will reduce inoculum. Floristically more diversified forests show lower disease incidence.

Stand-wide

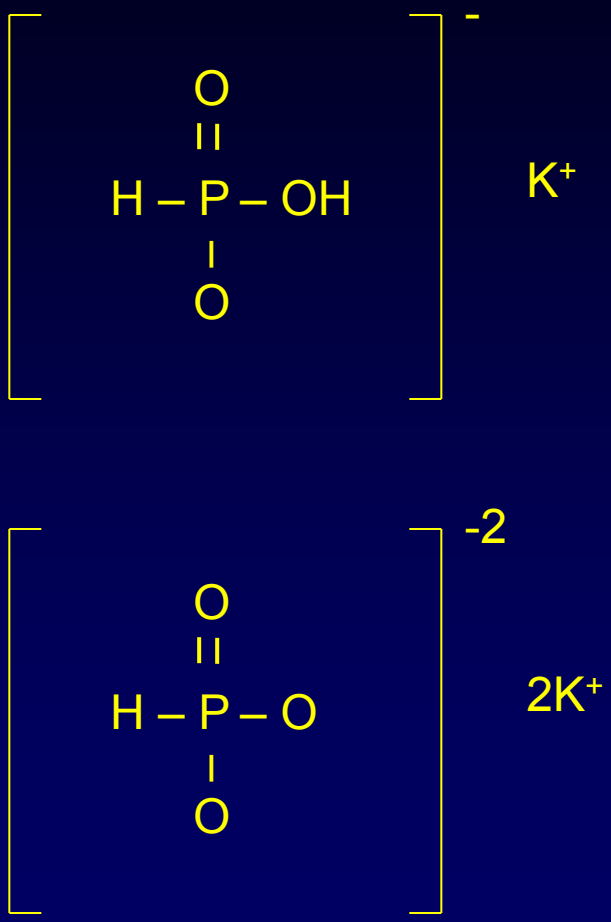
3- *P. ramorum* survives on bay leaves, but not everywhere. We have recently shown that only some sites allow survival during droughts. Elimination of bays in these sites will be very effective

Ecology

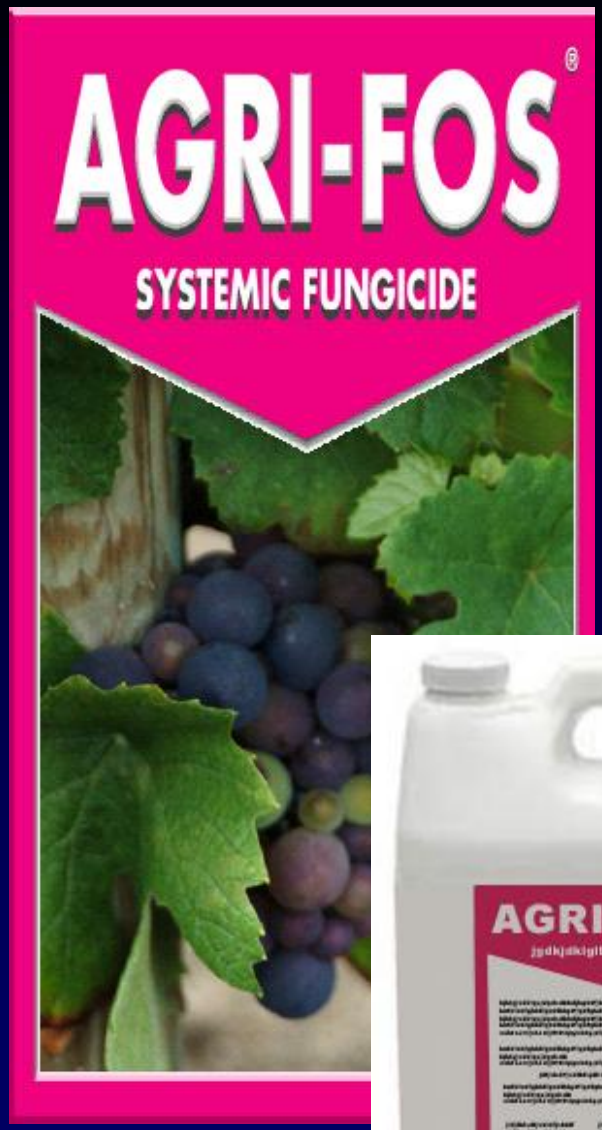
Recovery of *P. ramorum* from attached bay leaves



Phosphonate (aka Phosphite) Chemical Treatments

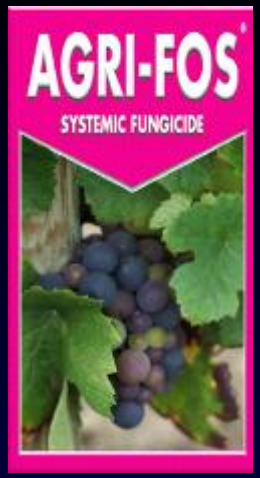


- Water soluble. Systemically absorbed and translocated by the xylem and phloem
- Inhibits fungal growth and activates the plant's own defensive response
- Preventative treatments are more effective than curative


AGRI-FOS®
SYSTEMIC FUNGICIDE


AGRI-FOS


Injection Treatment



Plant Pathology (2008) Doi: 10.1111/j.1365-3059.2008.01894.x

Efficacy of phosphonic acid, metalaxyl-M and copper hydroxide against *Phytophthora ramorum in vitro* and *in planta*

M. Garbelotto*, T.Y.

Department of Environmental Si

Arboriculture & Urban Forestry 33(5): September 2007 309

ISA

Arboriculture & Urban Forestry 2007. 33(5):309–317.

ARBORICULTURE & URBAN FORESTRY

Phosphite Injections and Bark Application of Phosphite + Pentrabark™ Control Sudden Oak Death in Coast Live Oak

M. Garbelotto, D.J. Schmidt, and T.Y. Hamik

Preventive treatment that strengthens response of oaks: we developed an alternative to injection

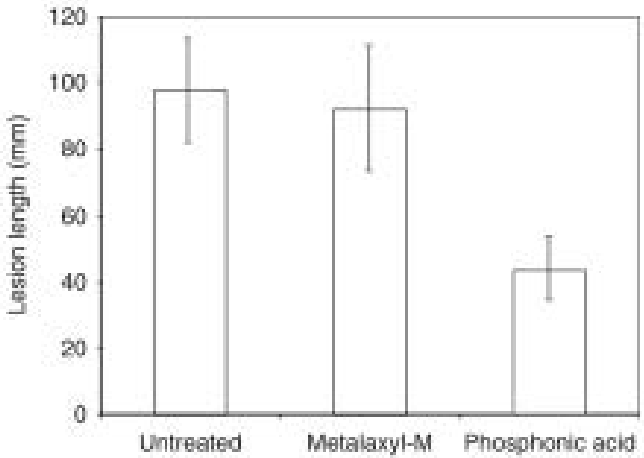


Figure 2 Lesion length (with bars showing standard deviation) caused by three *Phytophthora ramorum* isolates inoculated underbark in the phloem of potted coast live oak saplings, either untreated, treated with metalaxyl-M drench, or by phosphonic acid injection. Each treatment was performed on 15 saplings one week before inoculation; the experiment was terminated 6 weeks after inoculation.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BARK PENETRATING SURFACTANT
PENTRA-BARK
CAUTION
Quest


Topical Treatment

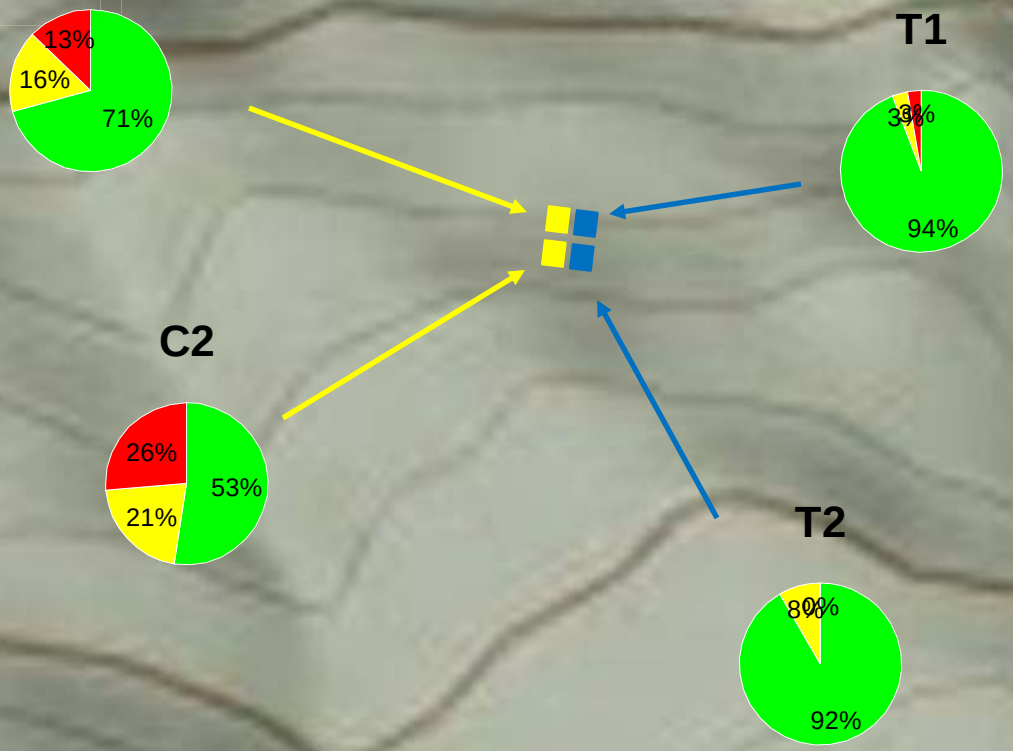
Long Term Treatment of Tanoaks SOD Spore Survey 2009

- 32 Field Plots
- 6 Sites in 3 Counties
- 672 Tanoaks > 8cm DBH

Long Term AF Treatment of Tanoaks

Treated 75 % healthy
Controls 56% healthy
32 plots in 16 pairs
P=0.0002

Year 3



Soquel Site A

Soquel Demonstration State Forest

11/2009

Bicycles for Cargo Transport

Conclusions on treatments

- Treat with phosphites before infection occurs (infected bays but oaks healthy/ entire tanoak cluster healthy)
- Treat once a year but in Fall to give time for plant to respond. If first treatment in Spring, repeat in Fall the first year. Do not treat in summer or December-January as trees do not respond well
- Injection holes will seal in three years, do not inject in spring as drill holes could facilitate infection

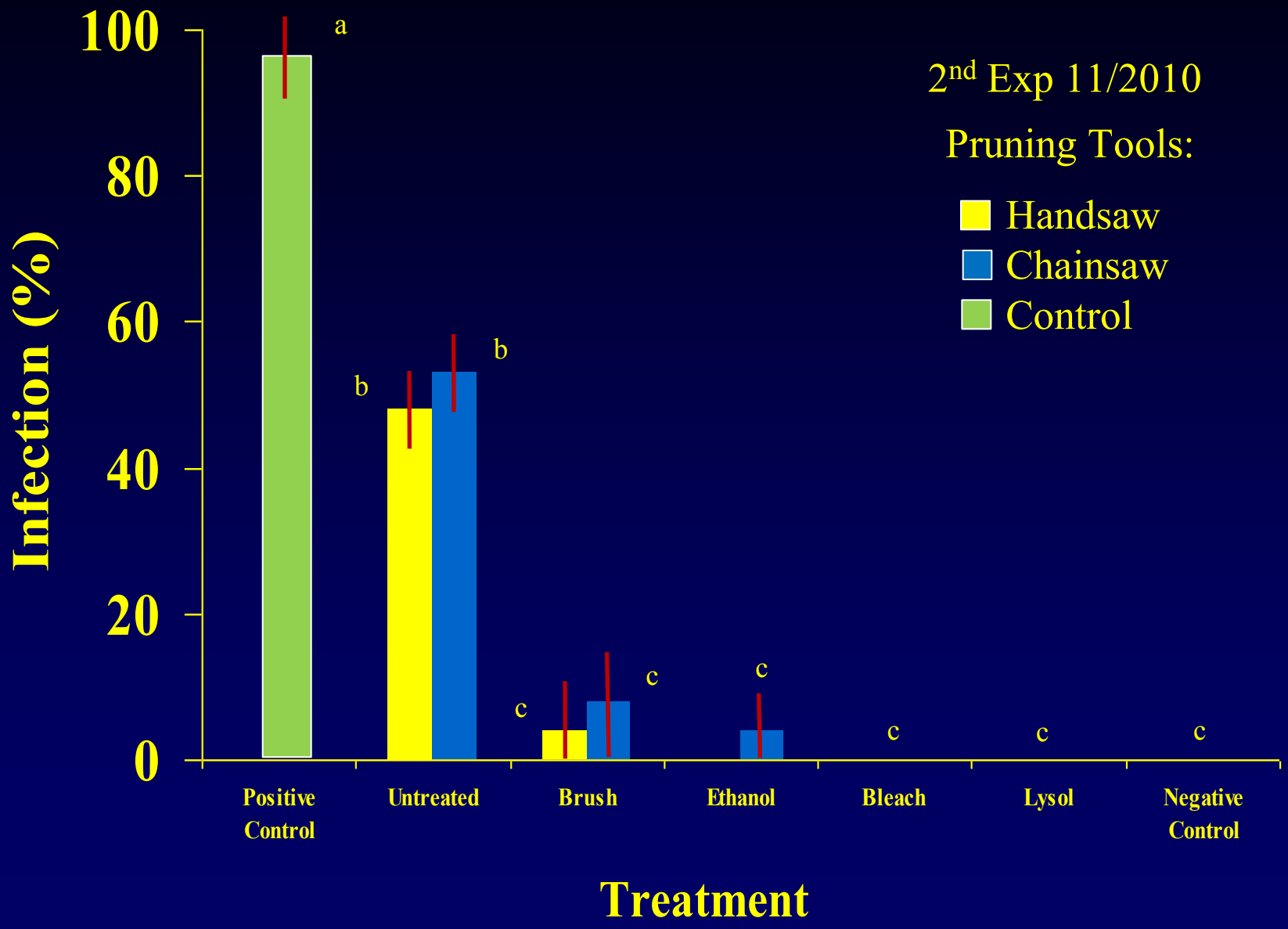
Four Treatments:

- Wire Brush
- 70% Ethanol + Brush
- 5% Bleach (Na Hypochlorite) + Brush
- 6.25% Lysol (ADBAC) + Brush

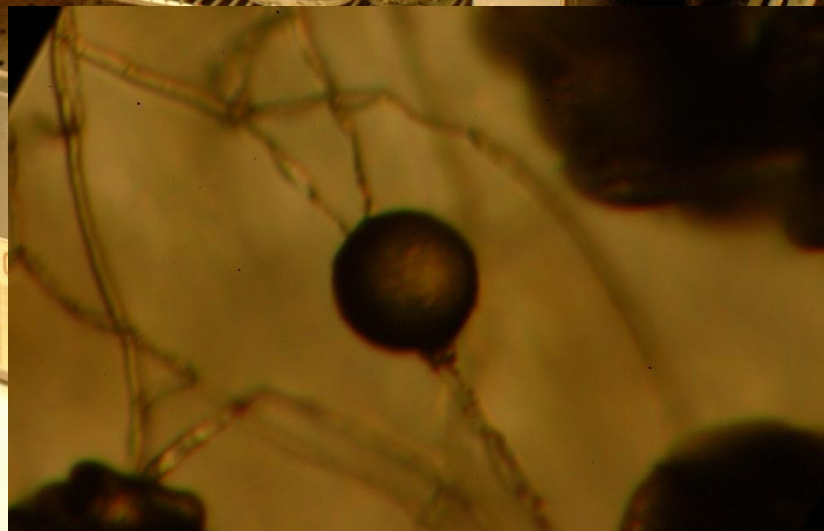
Cleaning Tools

Infected Tool Surface

Transmission of SOD Through Pruning Tools



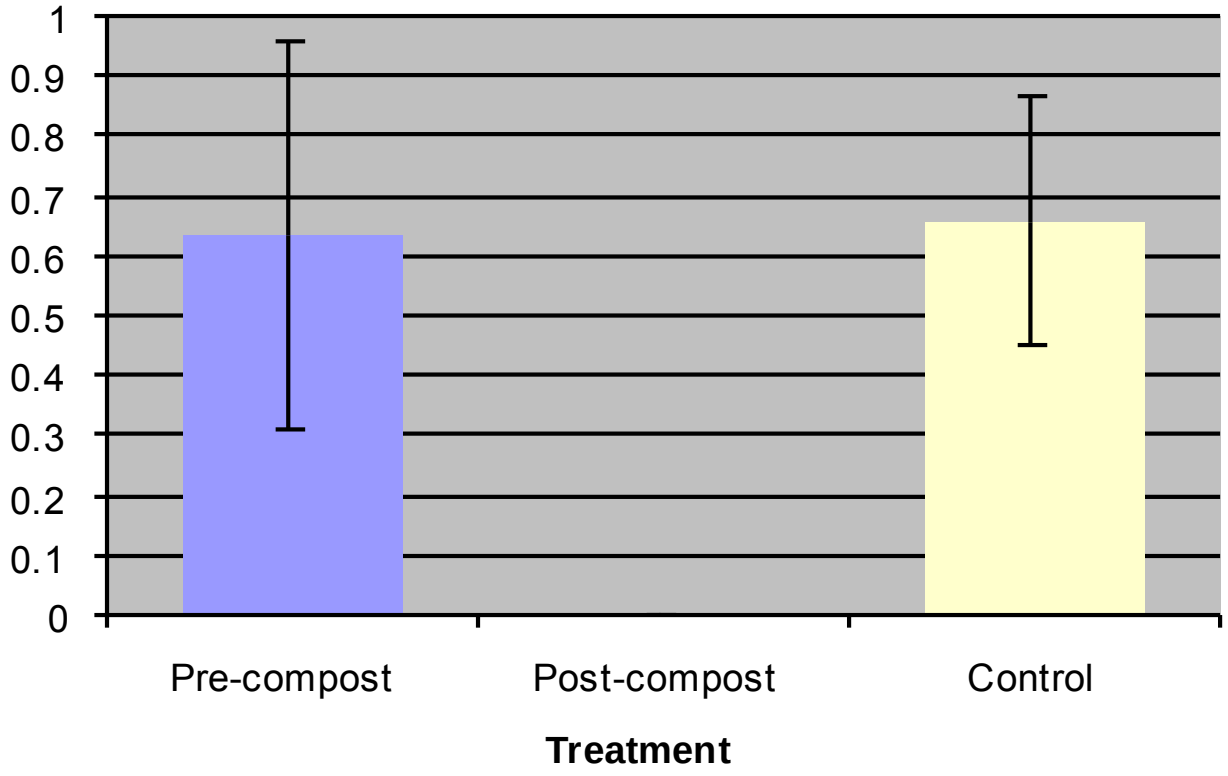
Heat Treatment on Natural Substrates



Heat Treatment on Natural Substrates

- **Pre-treatment - baseline (isolation success, direct plating)**
  - **Wood Chips = 96% (n=87)**
  - **Stems = 44% (n=48)**
  - **Bay Leaves = 100% (n=50)**
- **1 week of heat (55 deg C)**
  - **Wood Chips = 0% (n=87)**
  - **Stems = 0% (n=48)**
  - **Bay Leaves = 30% (n=50)** ←
- **2 weeks of heat (55 deg C)**
  - **Wood Chips = 0% (n=87)**
  - **Stems = 0% (n=48)**
  - **Bay Leaves = 0% (n=50)**
- **Controls**
  - **Wood Chips = 90% (n=87)**
  - **Stems = n/a (n=48)**
  - **Bay Leaves = 100% (n=50)**

Effects of Composting (Forced Air) on the Survival of *P. ramorum*



Effect of substrate

- Sporulation does not occur on wood with bark
- Sporulation may occur on debarked wood if wet
- Sporulation not seen on wood chips
- Sporulation (sporangia) on some plant species
- Resting spores on a more restricted list
  - From easy to hard for sanitation purposes
    Wood chips
    Wood logs
    Leaves without chlamydospores
    Leaves with chlamydospores

Conclusions

Green waste more infectious than wood and soil

Drying infected material is best strategy to sanitize: small chips best, thin layers best, exposure to sunlight best, dry on site before removing if possible

For sanitation of equipment, tools, and vehicles: if it looks clean it is not infectious

The search for the Holy Grail of resistance:

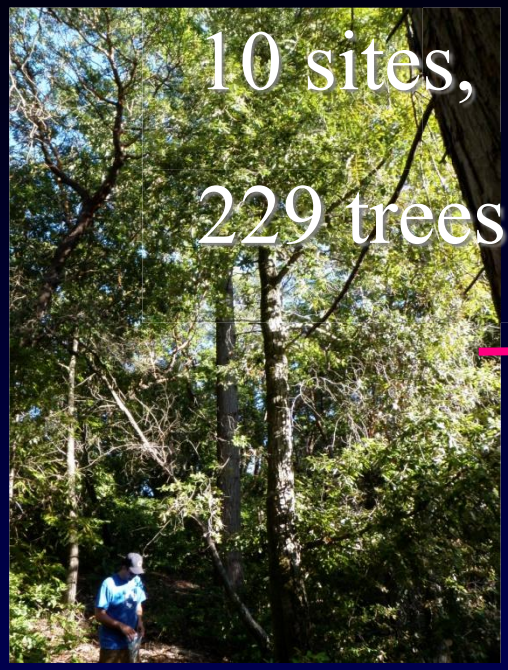
There are significant differences in susceptibility among individuals within all species tested

Constitutive chemistry and/or phenology invoked to explain differences that are both inheritable (i.e. genetic)and determined by the environment

Resistance proper not found yet, but decreased susceptibility and/or tolerance may be extremely useful and more durable

The search for the Holy Grail of resistance:

Ongoing screening for resistance in tanoak includes common garden tests both in lab and nature. With phenotypic traits studied by family (half sibs) including lesion size, survival in absence and presence of SOD and morphology


10 sites,
229 trees

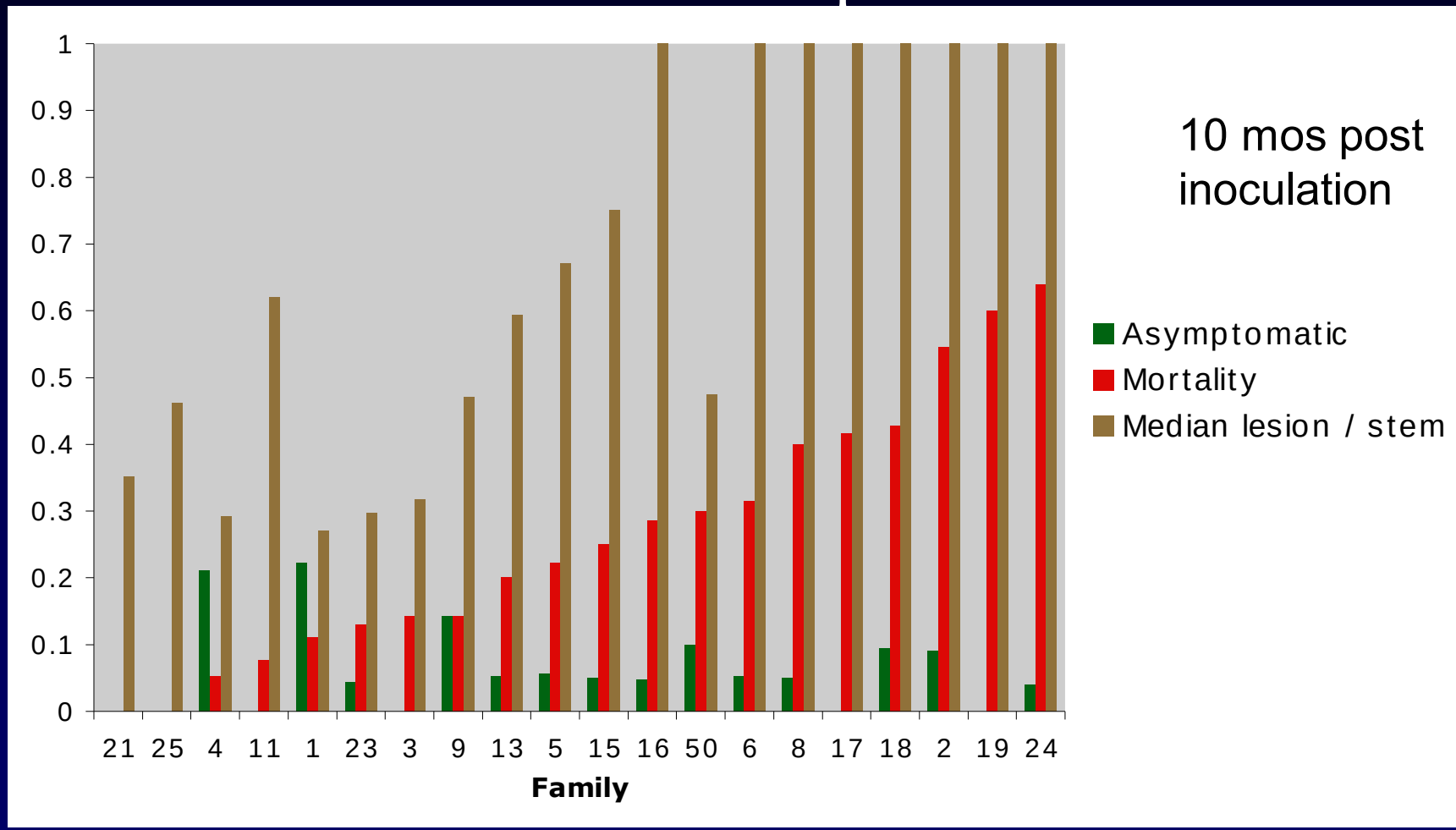

13,000


BL-5-221

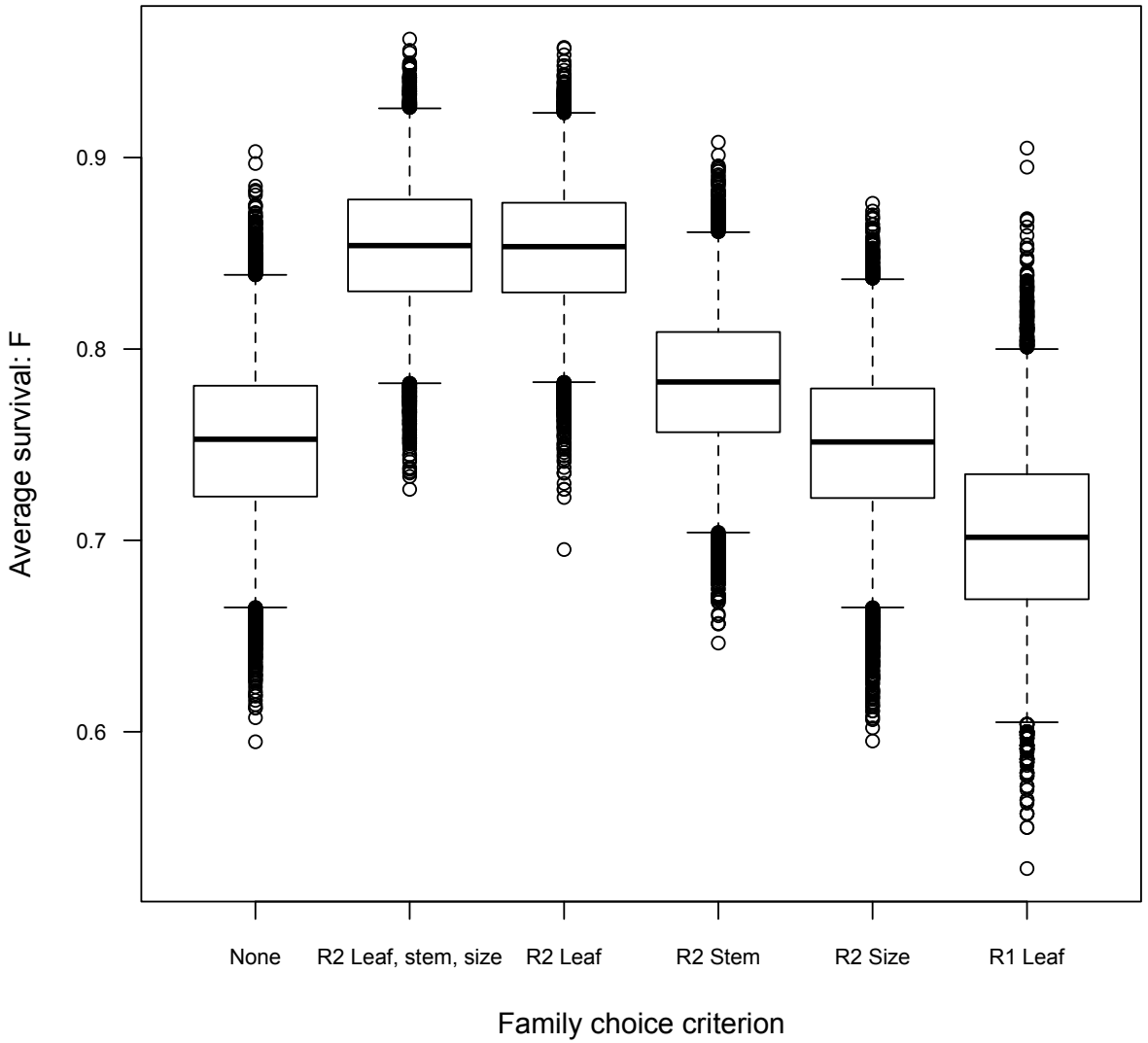

BL13.236


800

Common garden seedling tip assays of families indicates role of genetic variation within host species



Predicted survival of seedlings with and without selection based on resistance to *P. ramorum*



Why should we care about variation in susceptibility?

1- Less susceptible oaks/tanoaks in habitats less conducive to *P. ramorum*= survival

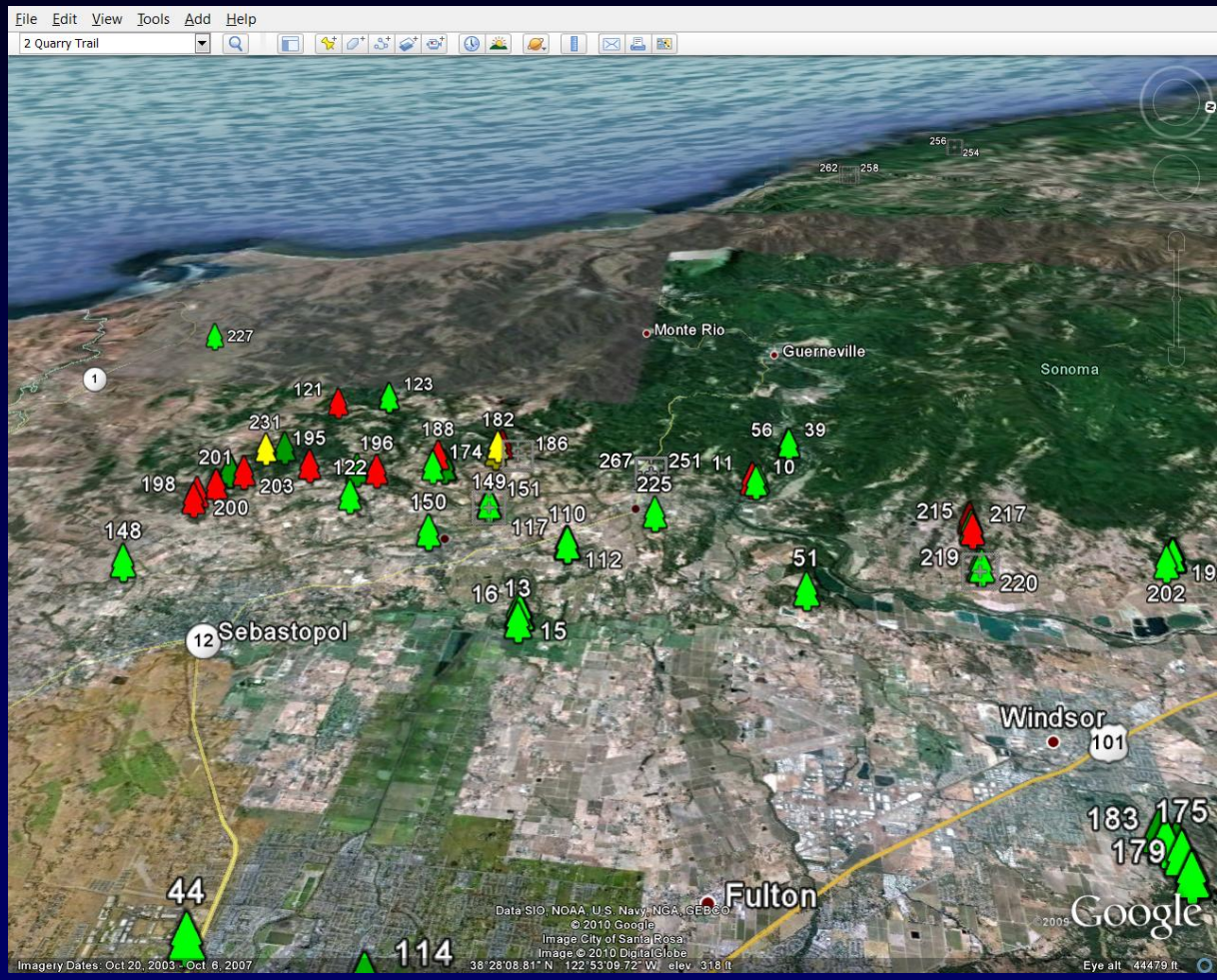
2- High susceptibility of bays can be used to predict sites with the highest risk of SOD outbreaks

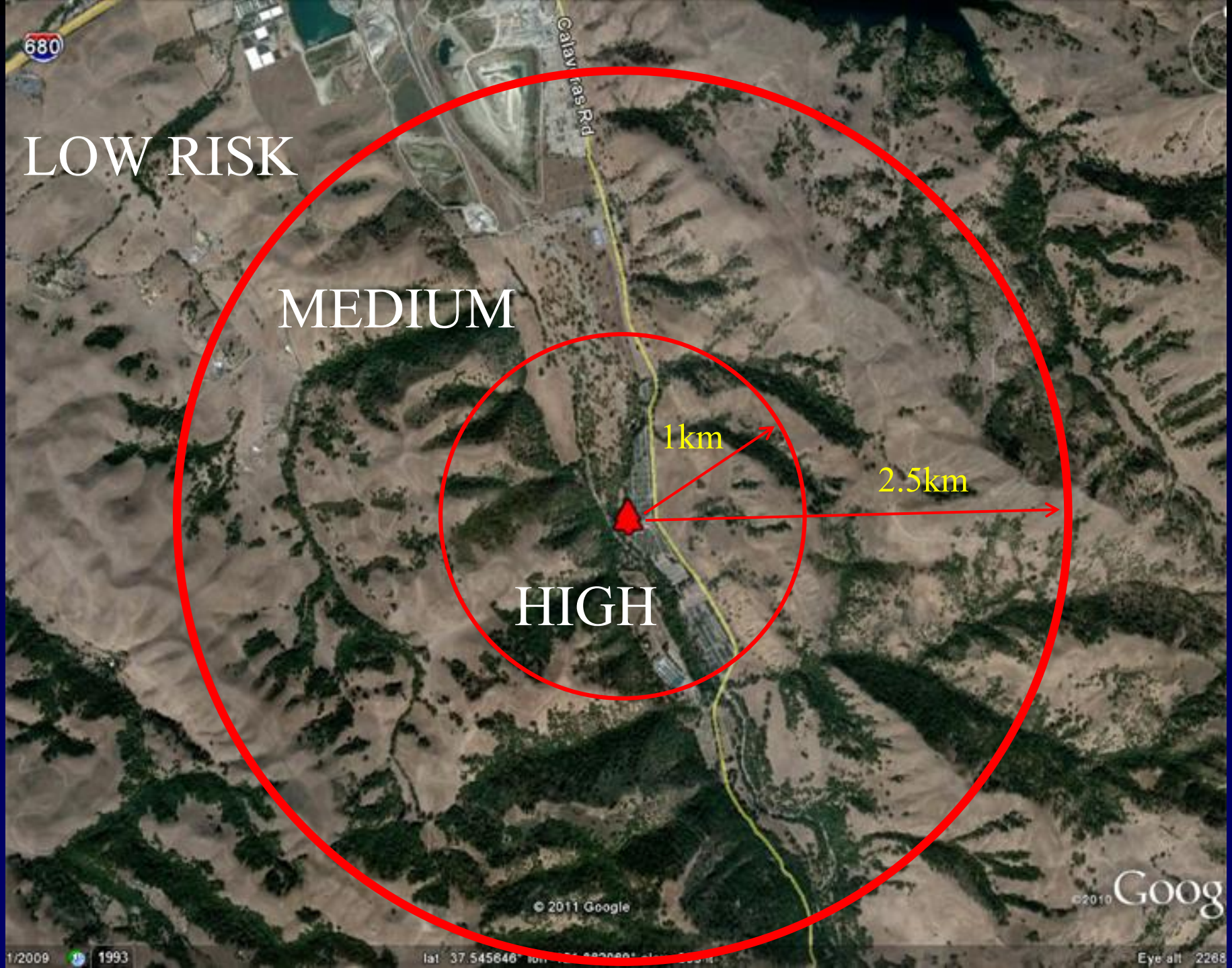
3- We have shown that reforestation efforts using families that show low susceptibility in the lab and good growth are going to be significantly more successful

SOD Blitzes and SODMAP (June 2012)
www.matteolab.org

<u>16 Collection Locations</u>

- 10000 samples
- 2000 trees sampled and mapped
- 50000 acres surveyed
- Over 450 people participated
- Results posted on web
- Tens of thousands of hits




LOW RISK
MEDIUM
HIGH
1km
2.5km
680
Calaveras Rd
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SOD SQUAD