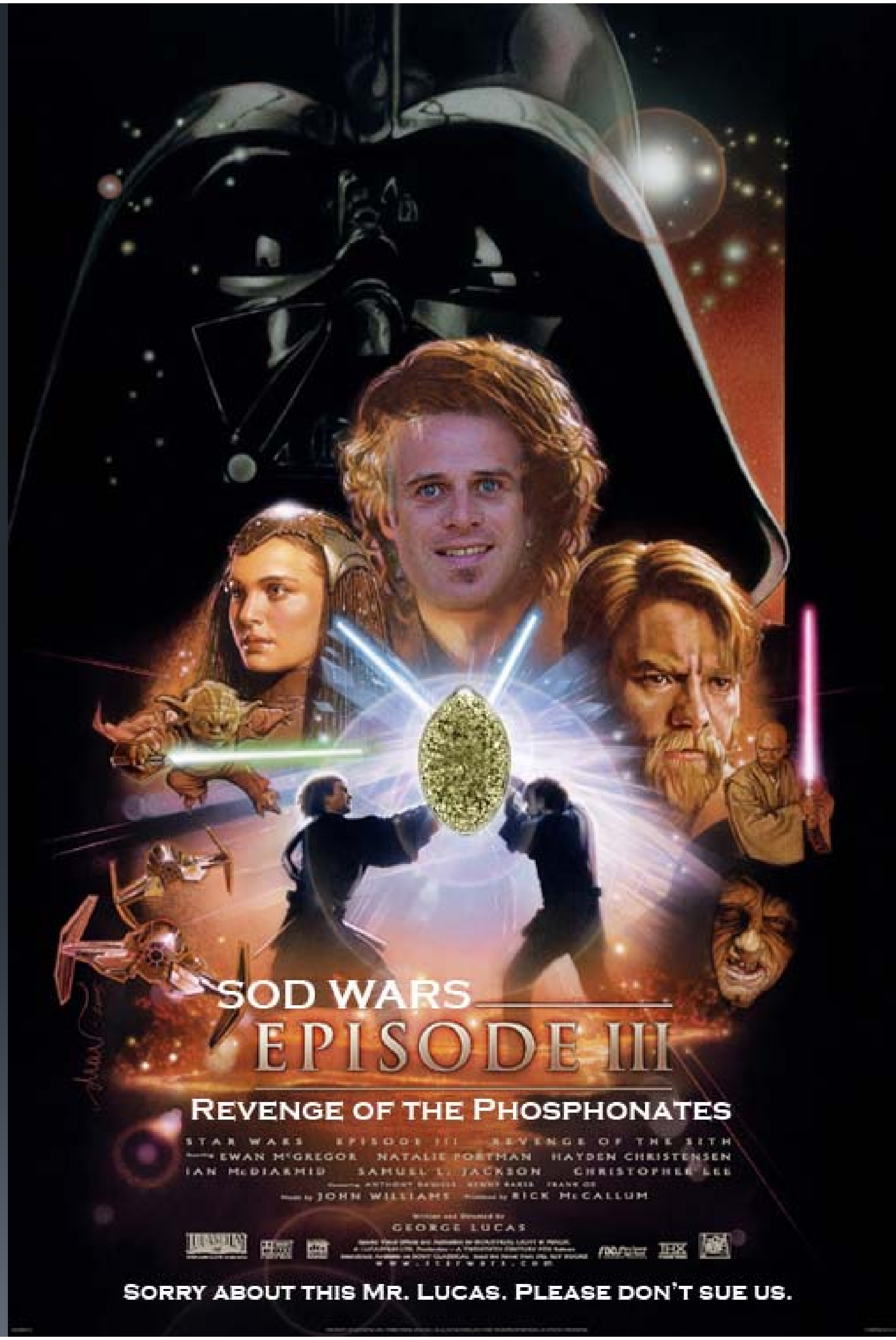
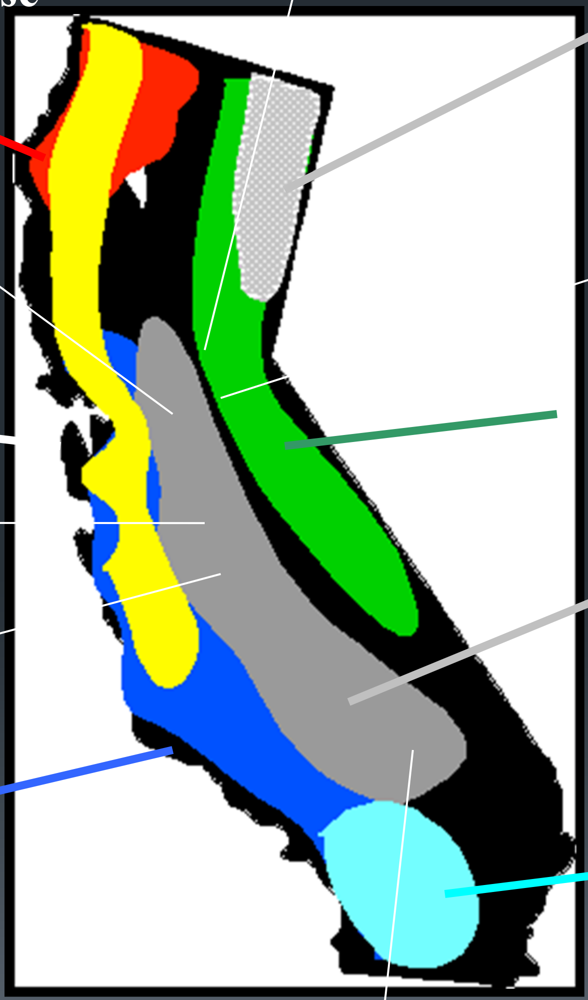


SOD WARS
EPISODE III
REVENGE OF THE PHOSPHONATES
STAR WARS EPISODE III REVENGE OF THE SITH
EWAN McGREGOR NATALIE PORTMAN HAYDEN CHRISTENSEN
IAN McDIARMID SAMUEL L. JACKSON CHRISTOPHER LEE
JOHN WILLIAMS RICK McCALLUM
GEORGE LUCAS
SORRY ABOUT THIS MR. LUCAS. PLEASE DON'T SUE US.

California invaded: 1849 A.D.

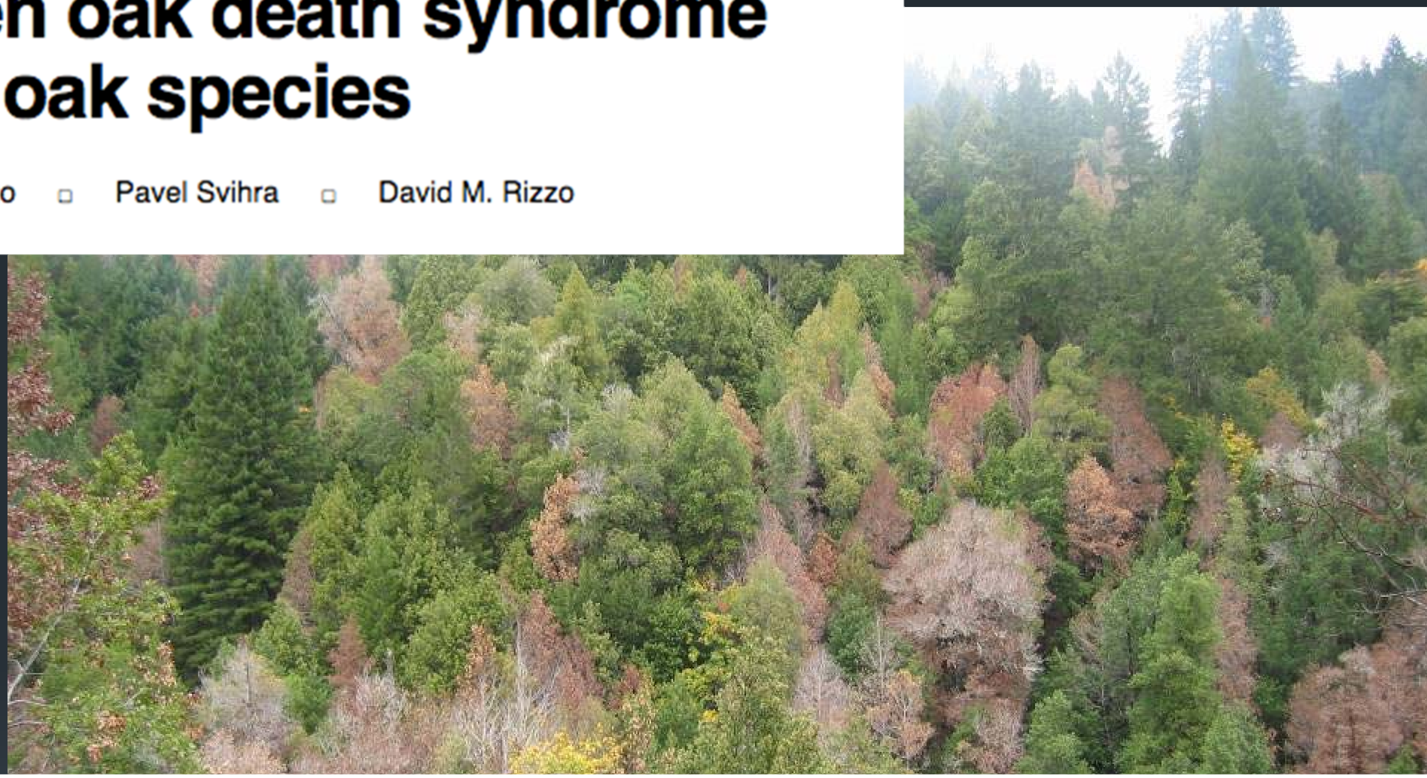


2000 AD

New pests and plant diseases

Sudden oak death syndrome fells 3 oak species

Matteo Garbelotto ▫ Pavel Svihra ▫ David M. Rizzo



Phytophthora ramorum as the Cause of Extensive Mortality of *Quercus* spp. and *Lithocarpus densiflorus* in California

2001

D. M. Rizzo, Department of Plant Pathology, University of California, Davis 95616; **M. Garbelotto,** Department of Environmental Science, Policy and Management, Ecosystem Science Division, University of California, Berkeley 94720; **J. M. Davidson** and **G. W. Slaughter,** Department of Plant Pathology, University of California, Davis; and **S. T. Koike,** University of California Cooperative Extension, 1432 Abbott Street, Salinas, CA 93901

Why do we care about Sudden Oak Death?

- Over 50 million trees already lost

- Ecological effects:

--forests look different
--wildlife impacts

- Social effects:

--hazard trees
--fire risk
--economic costs
--emotional impacts

- Ongoing threat:

--30% of susceptible forest affected so far

Ecological Impacts

- There are about 110 species of birds which breed in California's oak woodlands. Another 60 or so species use oak woodlands outside the breeding season.
- 105 mammal species.
- 58 amphibians and reptiles.
- An estimated 5,000 species of insects.
- An unknown number of microbes.
- Wide variety of other trees, shrubs and flowering plants which co-exist with oak woodlands.

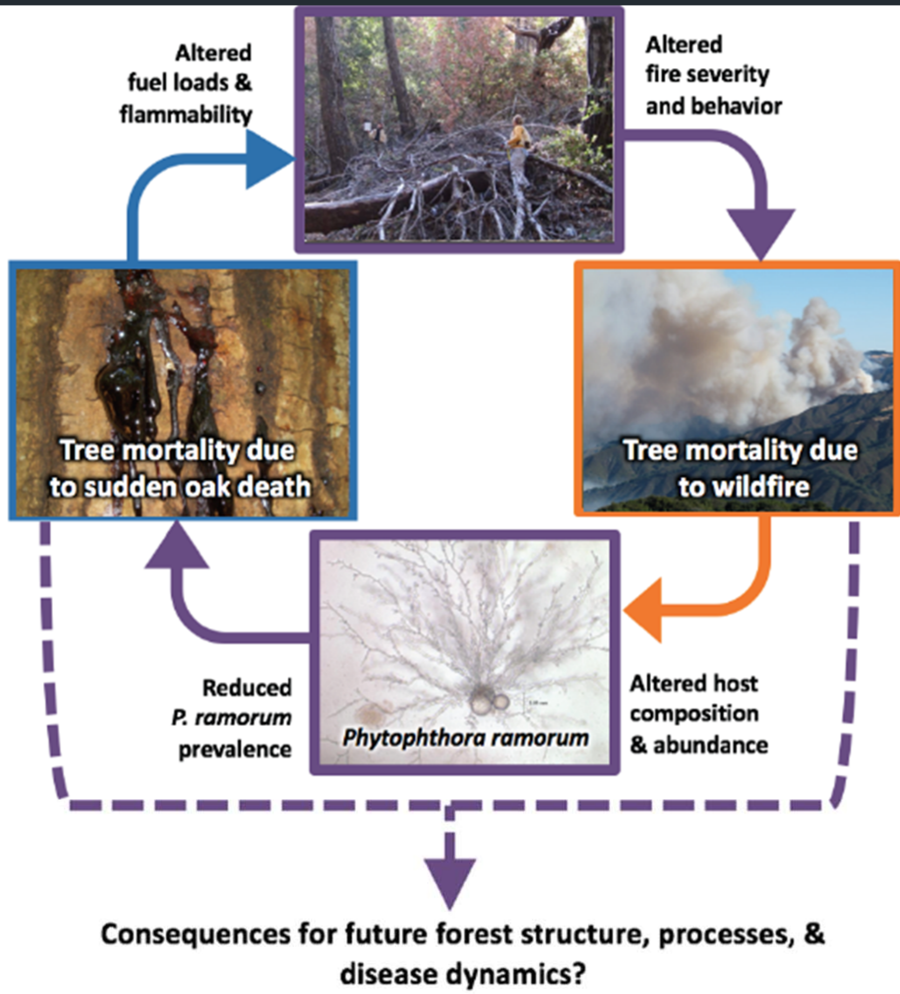


Figure 1. Conceptual diagram of potential interactions between sudden oak death and wildfire. Solid lines indicate direct effects of either disturbance on forest characteristics; dashed arrows indicate the interactive effects of both disturbances for forest and disease dynamics. Photos courtesy of the Rizzo lab at UC Davis.

SOD affects the amount of aerial crown and downed dead wood fuels

- 2 to 4 times higher standing dead trees in Big Sur
- 10-100 times higher coarse woody debris in redwood tanoak forests
- 6 times dead CLO stems in Bay Area with fuels between 2 and 20 times higher
- In Douglas fir tanoak forest fuel increased over 2 times and depth was four times that of healthy forests

Temporal and Composition effect on fire

- SOD infected tanoak canopy has only 5-10% moisture content vs. 80%

- In the short term pre SOD flammability is low, during SOD it becomes high, however post SOD flammability may go lower than pre-SOD because of elimination of tanoaks (Varner et al 2017)

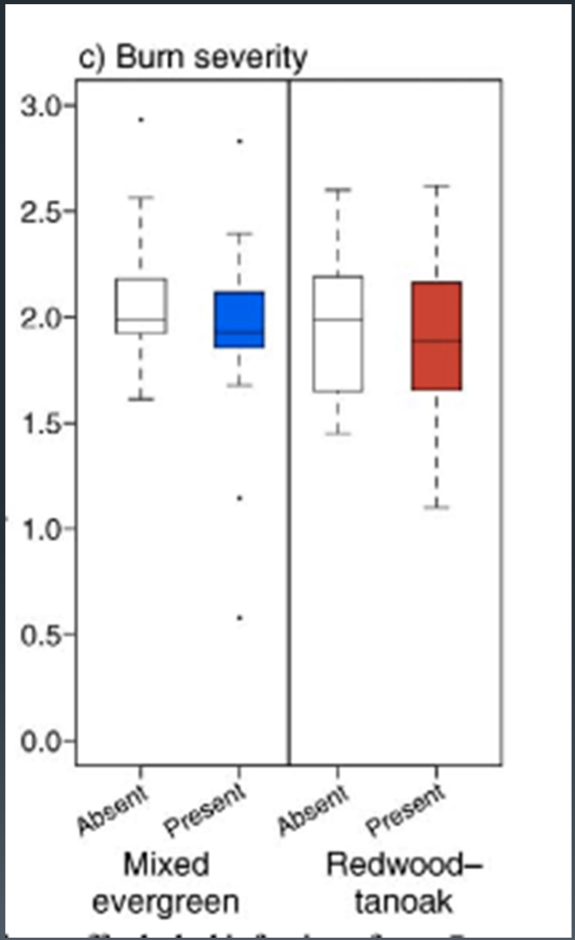
So how does SOD change fire behavior during a SOD outbreak (mid to later SOD stage)

- In simulated models for Douglas-fir tanoak forests, flame length tripled, spread rates increased sevenfold and fireline intensity was 13 times higher (Forrestel et al 2015)

- Immediate outcome: change of response from manned crews to mechanical (Valachovic et al 2011)

- During the Basin Complex fires: SOD increased frequency of hotspots that could not be controlled by crews and that increased long distance dispersal of fire and generated variability in burn rates

However overall burn intensity was not affected by SOD



M
e

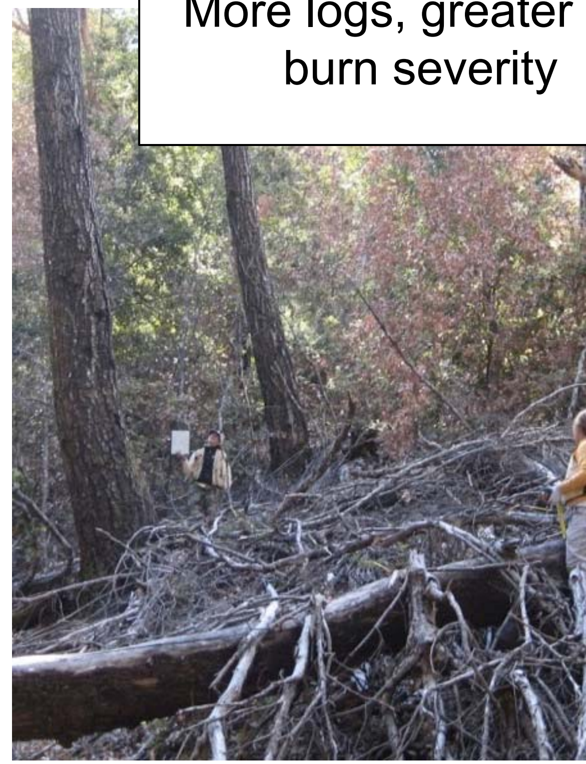



Fuels vary with disease stage

Early… **…Late**

More crown fires, scorching, torching

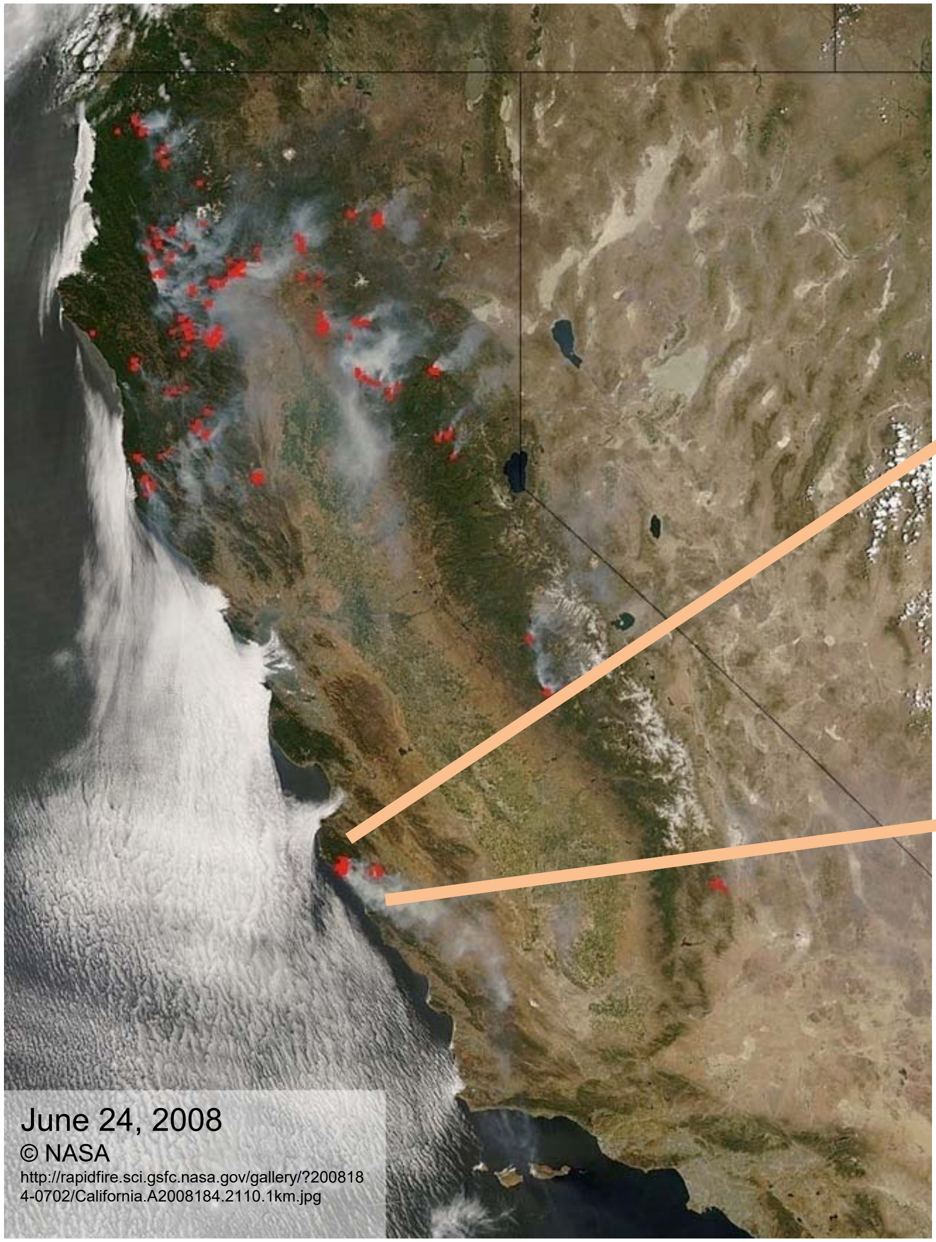
More logs, greater soil burn severity

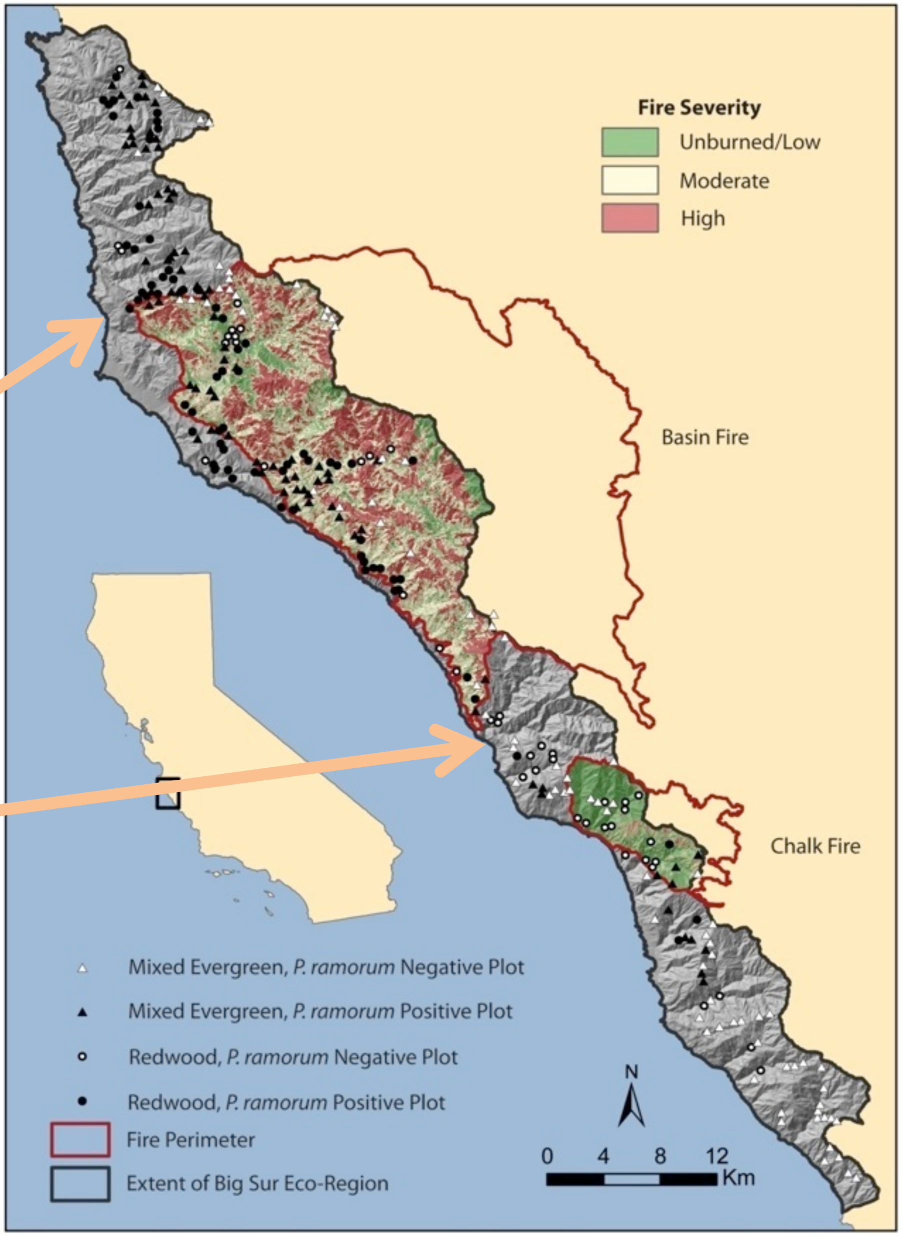


Surface, ladder and aerial fuels
Various stages of fragmentation and decay

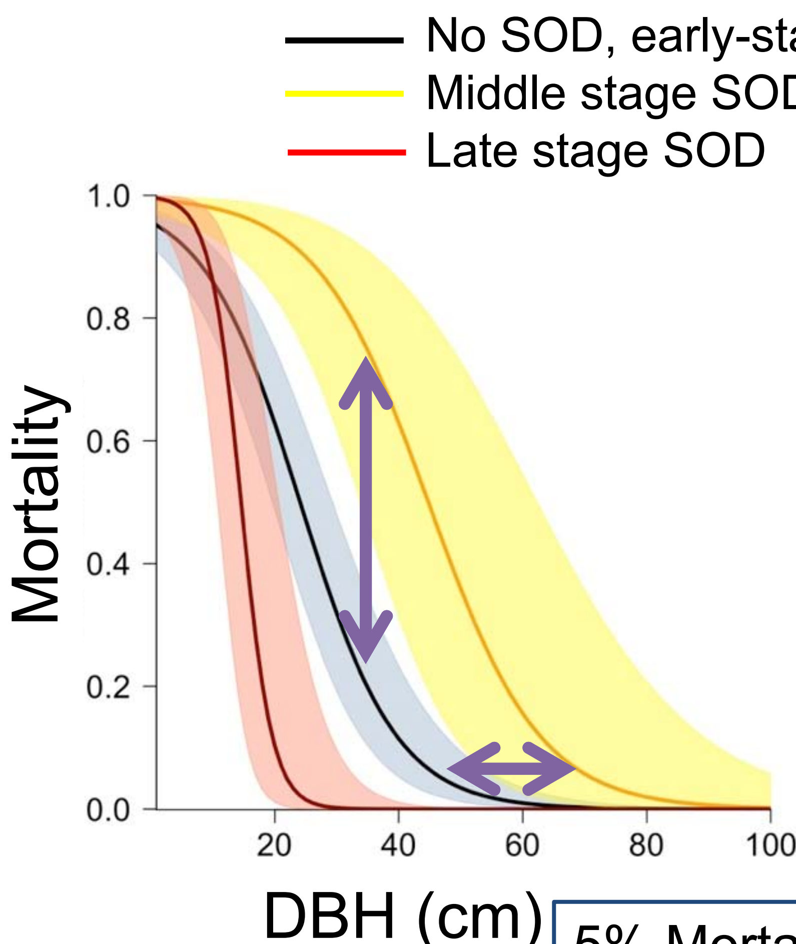
Kuljian & Varner 2010 *Forest Ecol & Mgmt;* Valachovic et al. 2011 *Forest Ecol & Mgmt;* Metz et al. 2011 *Ecological Applications;* Metz et al. 2013 *Ecology*

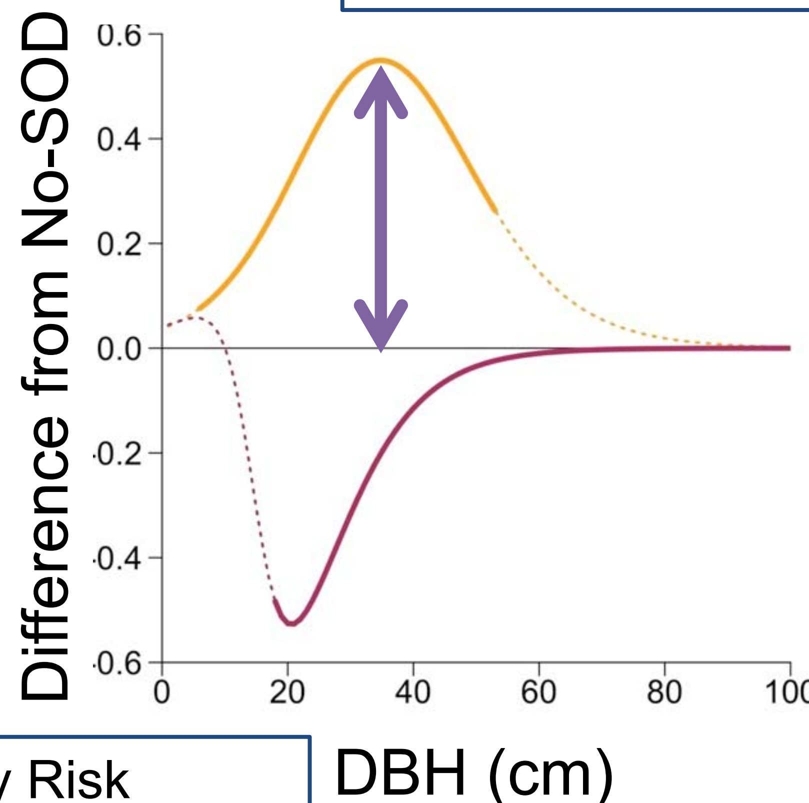
Wildfires in Big Sur, CA (2008)





Disease stage affects redwood risk

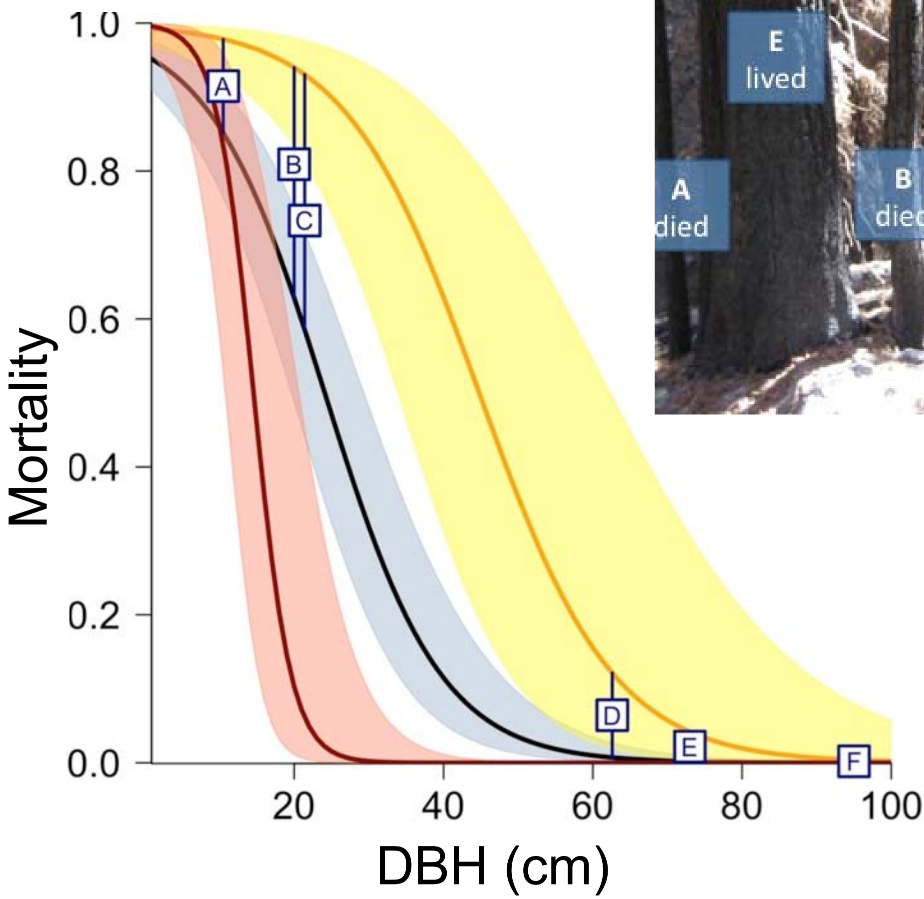




<u>Mortality of 35 cm trees</u>
Without SOD = 20%
With SOD = 75%

<u>5% Mortality Risk</u>
Without SOD, ≥ 48 cm
With SOD, ≥ 72cm

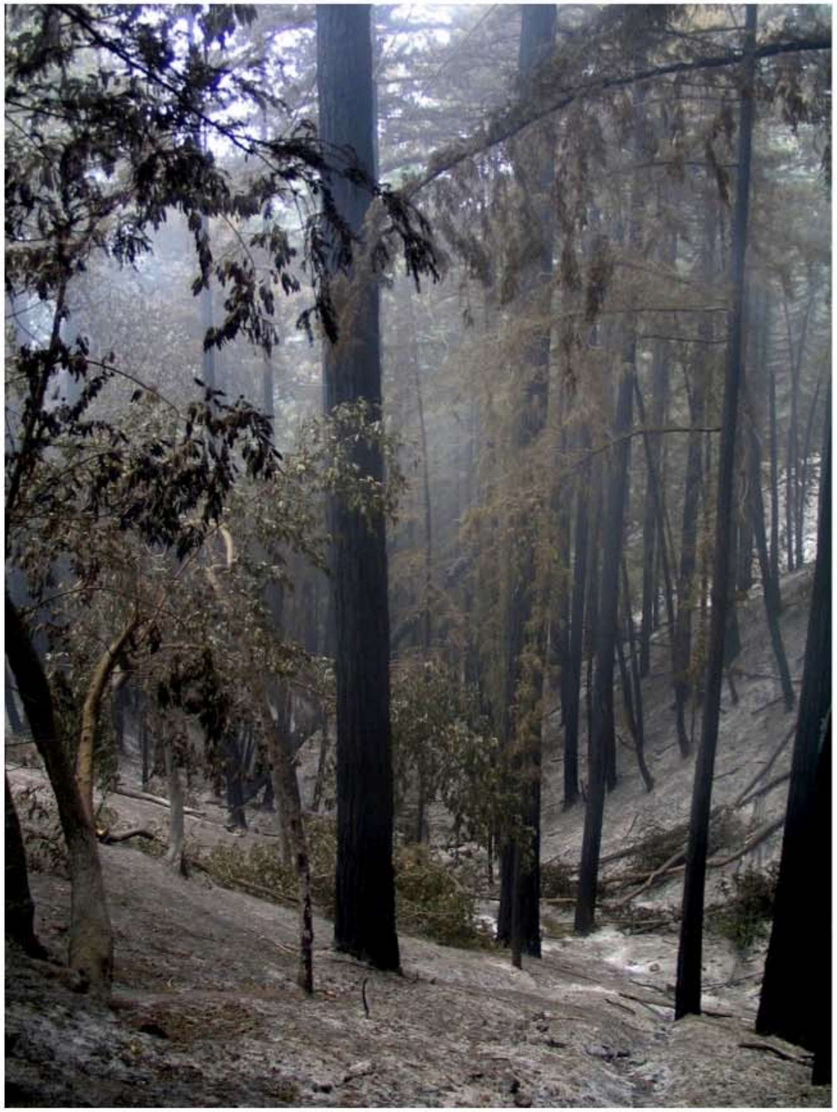
Metz et al. 2013. Ecology



No SOD, early-stage SOD
Middle stage SOD
Late stage SOD

Metz et al. 2013. Ecology

Dead tanoaks carried flames upwards



What about effect of fire on SOD?

- Reduction in abundance of *P. ramorum* is short lived and within 5 years , 81% of plots that originally had the pathogen were positive again

- Re-infestation source from refugia due to fire heterogeneity and to sprouting providing a favorable substrate for infection by *P. ramorum*

- *CAN WE USE MANAGEMENT APPROACHES TO DEAL WITH BOTH SOD AND OTHER ISSUES, IN PARTICULAR WILDFIRE?*

Valacovich et al 2017, Forest Phytophthoras

What about effect of fire on SOD?

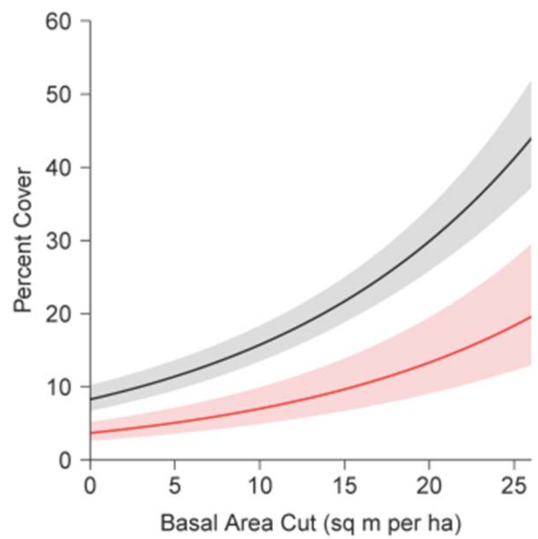


Figure 3. Model of cover of tanoak stump sprouts at Jay Smith in 2016 versus basal area of tanoak cut in 2006 without fire (black line) or with fire (red line). Shading represents 95% confidence of prediction; R^2 = 0.52.

Prescribed burns did reduce extend of sprouting

What about effect of fire on SOD?

Table 2. Comparison of duff and litter depth depths and fuel bed heights among treatments.

Site-treatment	Duff Depth (cm)		Litter Depth (cm)		Fuel Bed Height (cm)	
Jay Smith	Mean (SEM)	Plot Range	Mean (SEM)	Plot Range	Mean (SEM)	Plot Range
Cut only	4.91 (0.78) b	2.67-8.42	3.29 (0.56) ab	2.24-6.91	9.96 (1.19)	3.17-12.82
Cut & fire	0.98 (0.29) a	0.19-2.62	1.54 (0.26) a	0.72-2.59	12.97 (2.08)	4.58-20.50
No treatment	6.33 (2.16) b	4.34-9.37	4.24 (0.98) b	1.89-6.34	15.64 (2.57)	11.07-22.63
Salmon Creek						
Herbicide	2.81 (0.56)	0.17-4.02	2.88 (0.78)	0.77-4.63	16.97 (4.32)	8.43-30.20
No treatment	3.74 (1.03)	1.98-5.57	3.04 (0.41)	2.31-3.71	8.76 (2.48)	6.09-13.72

Prescribed burns and cutting reduced litter and duff

HOWEVER

Some Douglas fir mortality was caused by the treatments with an increase both in pathogen and insect attacks.

What about the effect of thinning on fuels and on SOD?

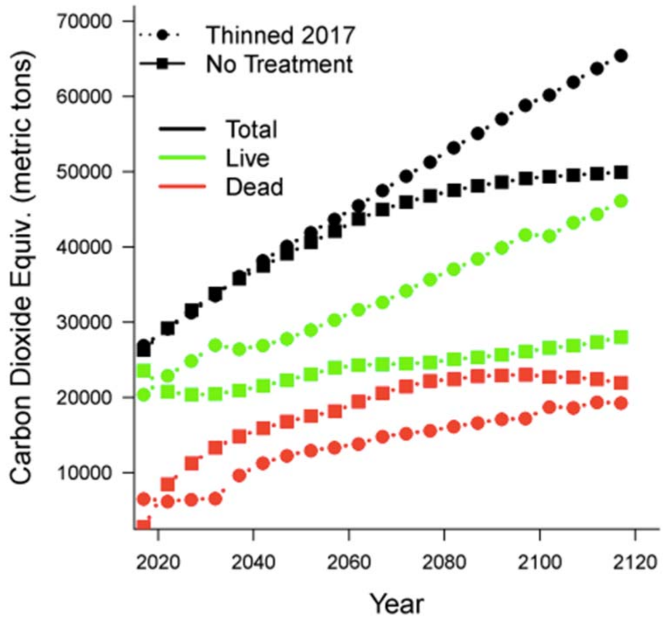


Figure 6. Stand stored carbon dioxide equivalents forecast under bay removed/tanoak thinned and untreated scenarios for 100 years of growth. Results correspond to (b) untreated and (c) thinned scenarios in Figure 7.

What about the effect of thinning on fuels and on SOD?

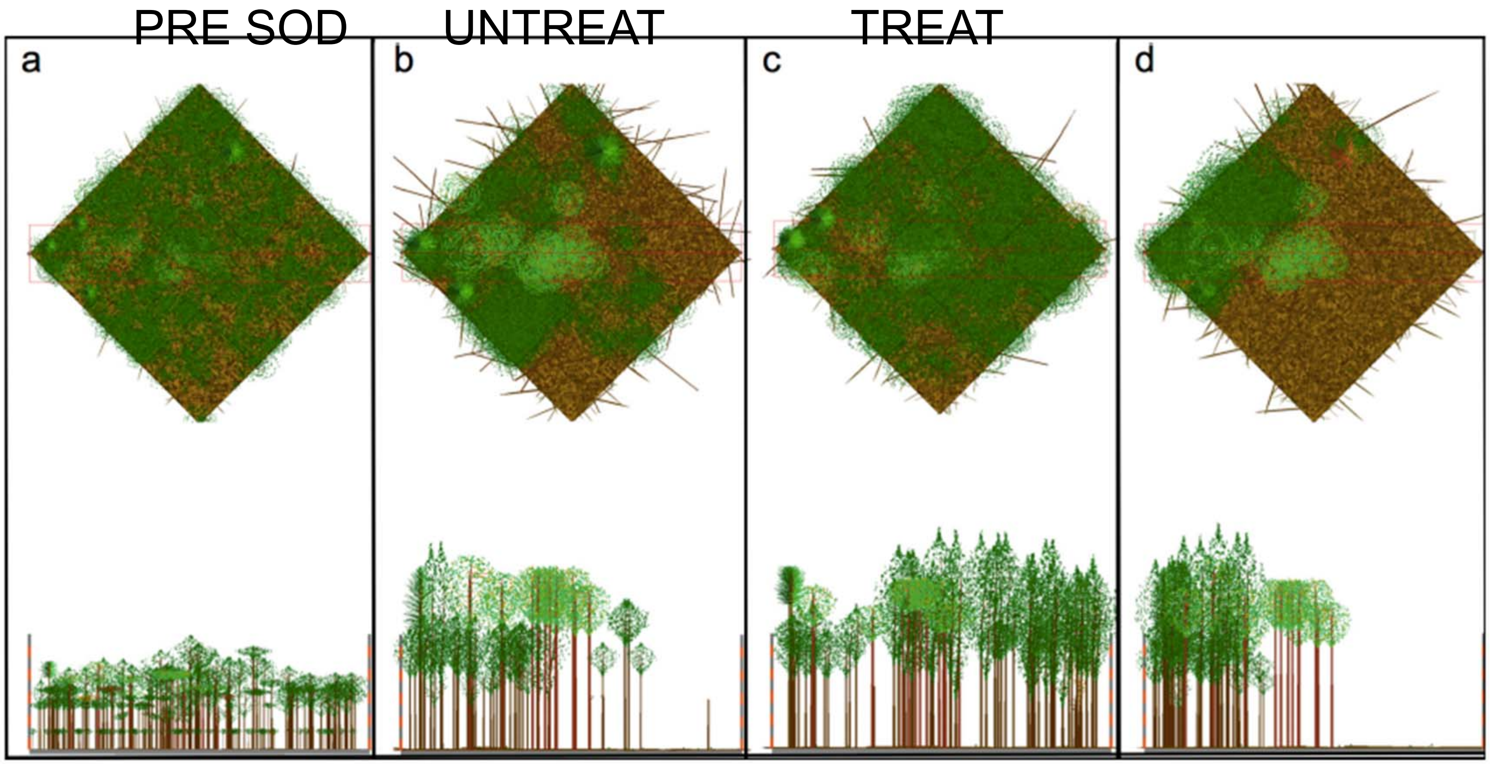


Figure 7. Stand representations from FVS stand visualization system for the (a) pre-treatment condition stand in 2017 and (b-d) growth simulated under three disease mortality scenarios until year 2117, from above (top) and in profile (bottom). In (b) the stand is untreated, and large trees are killed first by *P. ramorum*; in (c) bay laurel is removed from the stand and tanoak is thinned in 2017, with large trees killed first by *P. ramorum*; and in (d) disease dynamics are modeled with an additional 10% of the stand stems comprised by bay laurel and the stand goes untreated, but mortality is uniform across tree sizes at model initiation.

Tree/limb failures responsible for fire causation

1. Tree or limb failure on power lines the major reason for fires at the WUI

2. Whole tree failures are caused by health or stability issues; health issues can be related to the presence of tree diseases or pest attacks, while stability issues can be caused by wood decay agents or by disturbances in the environment (previous fires, grading, disturbances)

3. Limb failures can also be associated with health or decay factors or can be caused by yet unknown factors (sudden limb drop). Normally limb failures associated with specific weather patterns

4. There are many **site and tree factors** associated with failures

5. **GOOD EVIDENCE THAT SOD INFECTED TREES FAIL EVEN BEFORE THEY ARE CLEARLY DEAD**

How do companies survey for hazard trees to be in compliance with their mandate?

1. What kind of data are collected (site and tree data)

1. How often

1. How many trees are surveyed

1. Record keeping, data transfer and data analysis are key elements

PG&E

Site Data Collection

Survey ID
Survey Date
Region
Measurement System
Plot Code Letter
Plot Code Number
Plot type
Circular Dimensions - Lat/Long at Center of Circle
Circular Dimensions - Radius
Square Dimensions - Lat/Long at Center of Square
Square Dimensions - Length of Square Side
Rectangular Dimensions - Length
Rectangular Dimensions - Width
Rectangular Dimensions - Lat/Long midway of 1st Short Side
Rectangular Dimensions - Lat/Long midway of 2nd Short Side
Transect Size - Lat/Long at Beginning of Transect
Transect Size - Lat/Long at End of Transect
Slope
Aspect
Improvements
Canopy Cover
Tree Density (per Ha)
Canopy Species Composition
Species Percentages
Dominant Shrubs in Under-story
Human population density
Emergency response time
Summer temperature
Summer and Fall winds at least 10 mph
Development and land use
Fuel type
Fuel continuity
Fuel moisture content
Electrical company assets
Electrical line
Number of customers

PG&E (in red UCB added relevant metrics)

Tree Data Collection

Important upgrades in Red

Tree - Tree ID
Tree - Time of inspection start
Tree - Tree age
Tree - Lat/Long of Tree
Tree - Species
Tree - Number of Stems
Tree - DBH of Largest Stem (cm)
Tree - DBH of 2nd Largest Stem (cm)
Tree - DBH of 3rd Largest Stem (cm)
Tree - Height (m)
Tree - Select improvements that would be in jeopardy if the tree falls.
Tree - Distance between tree and nearest improvement(s)
Tree - Path of failure between tree and nearest improvement
Tree - Angle in degrees of tree lean
Tree - Direction of lean, with respect to nearest improvement/facility
Tree - Where would weight push tree with respect to nearest improvement/facility?
Tree - Roads
Tree - Canopy Width (m)
Tree - Canopy Length (m)
Tree - Canopy to Stem Ratio
Tree - Height of First Branch Scaffold (m)
Tree - Crown Transparency
Tree -Tree canopy sail

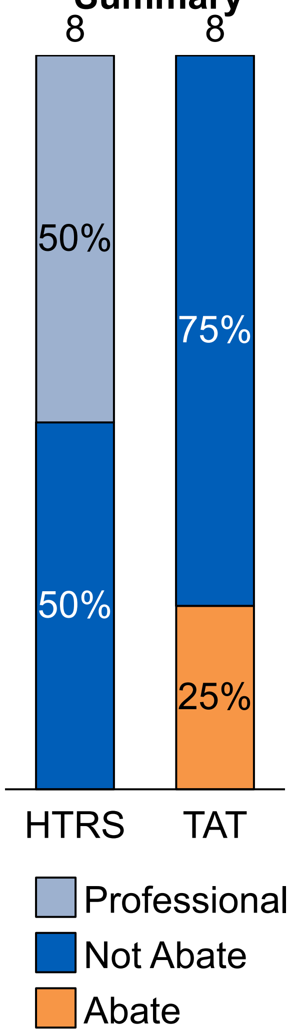
Tree - Percentage of Branches with Diseased Foliage
Tree - If mushroom on roots or lower part of bole, what color was it?
Tree - If mushroom on roots or lower part of bole, was it a mushroom or a shelf?
Tree - If mushroom on roots or lower part of bole; was it by itself or were there multiple ones?
Mushrooms, self fungus, or fruiting bodies present on:
Tree - Overall disease level
Tree - Overall insect attack on stem/major branches
Tree - Percentage of circumference with defects
Tree - Percentage of stem with defects
Tree - If stem defect is on butt or lower 1/3 of stem collect sample and put sample ID# here:
Tree - Tree condition (overall OR part most likely to fail)
Tree - Whole tree or partial failure likely
Tree - Estimate number of other trees of the same species in similar or worse condition?
Tree - Codominance, branch splitting with included bark
Tree - Wind exposure
Tree - Winter storm severity
Tree - Structures present below conductor
Tree - Time of year species likely to fail
Tree - Species Failure Potential
Tree - Soil support

The picture can't be displayed.

TAT Sample field testing

PRELIMINARY – FOR DISCUSSION

Results Summary



Field Testing Tree Scores, n = 8

HTRS Assessment

Tree Score	0 (Very Low)	1 (Low)	2 (Mod)	3 (High)	4 (Very High)
7 (Very High)					
6 (High)					
5 (High)					
4 (Mod)					
3 (Mod)			E		
1, 2 (Low)		B2, C	A2, A, D		
0 (Very Low)			C2, B		

Impact Score

TAT Assessment

Tree Health Score	1 (Low)	2 (Mod)	3 (High)	4 (Very High)
5	A			
4				
3				E
2			A2	
1 (Very low)	C2, C, B	B2		D

Tree Environment Score

Auto abate from major wounds on trunk

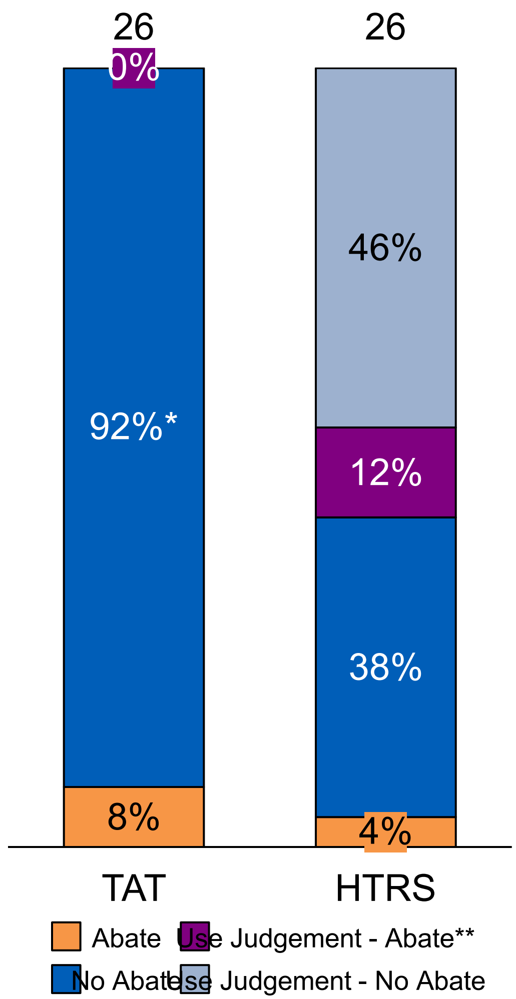
Poor canopy health, codominance, highest tendency to cause ignitions,

- **HTRS tool has multiple borderline trees** which will rely heavily on individual, subjective decisions
- **HTRS does not directly recommend abatement** of hazard tress based on this sample
- **TAT tool has no borderline trees** as it provides a clear abatement recommendation
- **All abatement decisions are clear;** TAT more likely to abate hazard trees based on this sample

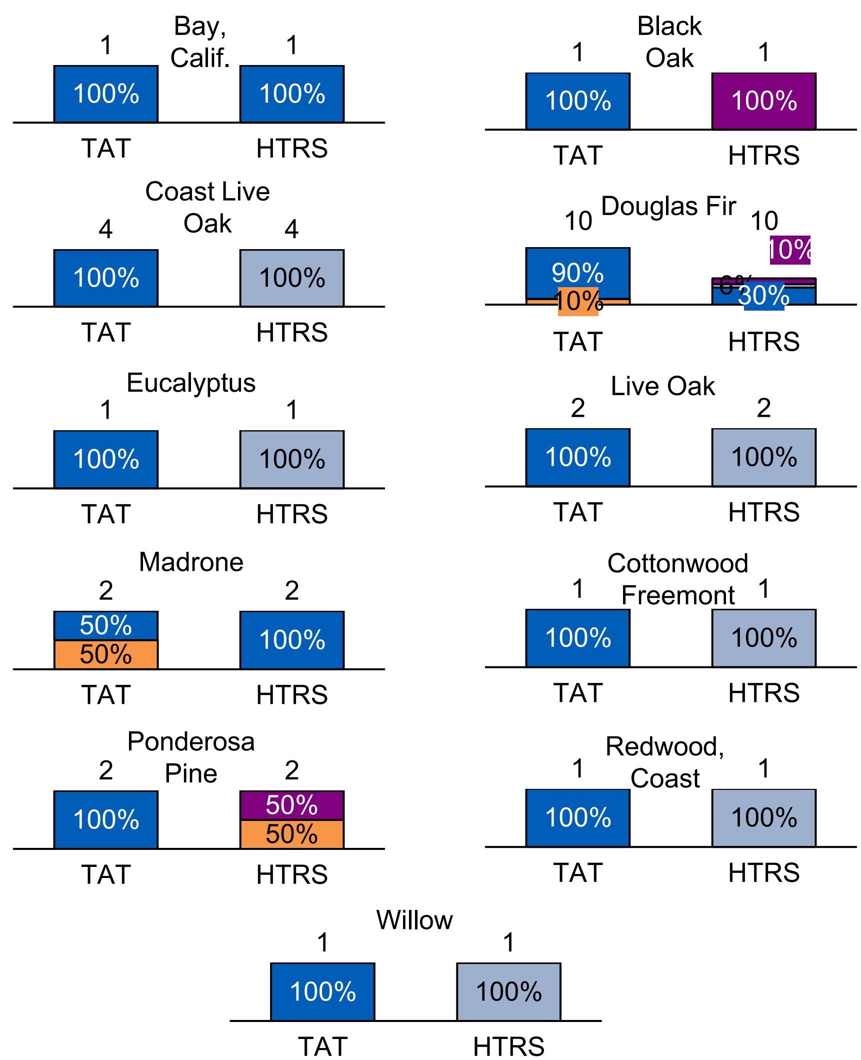
PRELIMINARY

TAT vs. HTRS preliminary field testing results

(PG&E North Coast Region)



Results Comparison by Species



Note: Use Judgement" is only used in HTRS
* "STOP" TAT result included in "no abate"
** Use Judgement – Abate indicates tree that was marked for removal

PG&E Tree - Work flow
UCB proposal real time analysis

Mobile App data collection

Survey ID	Tree - Direction of lean, with respect to nearest improvement/facility	Tree - Where would weight push tree with respect to nearest improvement/facility?	Tree - Rc
26140	3 - moderate into	2 - moderately toward it	1 - Re: st
26141	3 - moderate into	2 - moderately toward it	1 - Re: st
26142	3 - moderate into	2 - moderately toward it	1 - Re: st
26143	3 - moderate into	2 - moderately toward it	1 - Re: st
26144	3 - moderate into	2 - moderately toward it	1 - Re: st
26145	3 - moderate into	2 - moderately toward it	1 - Re: st
26146	3 - moderate into	2 - moderately toward it	1 - Re: st
26147	3 - moderate into	2 - moderately toward it	1 - Re: st
26148	3 - moderate into	2 - moderately toward it	1 - Re: st
26149	3 - moderate into	2 - moderately toward it	1 - Re: st
26150	3 - moderate into	2 - moderately toward it	1 - Re: st
26151	3 - moderate into	2 - moderately toward it	1 - Re: st

Data download

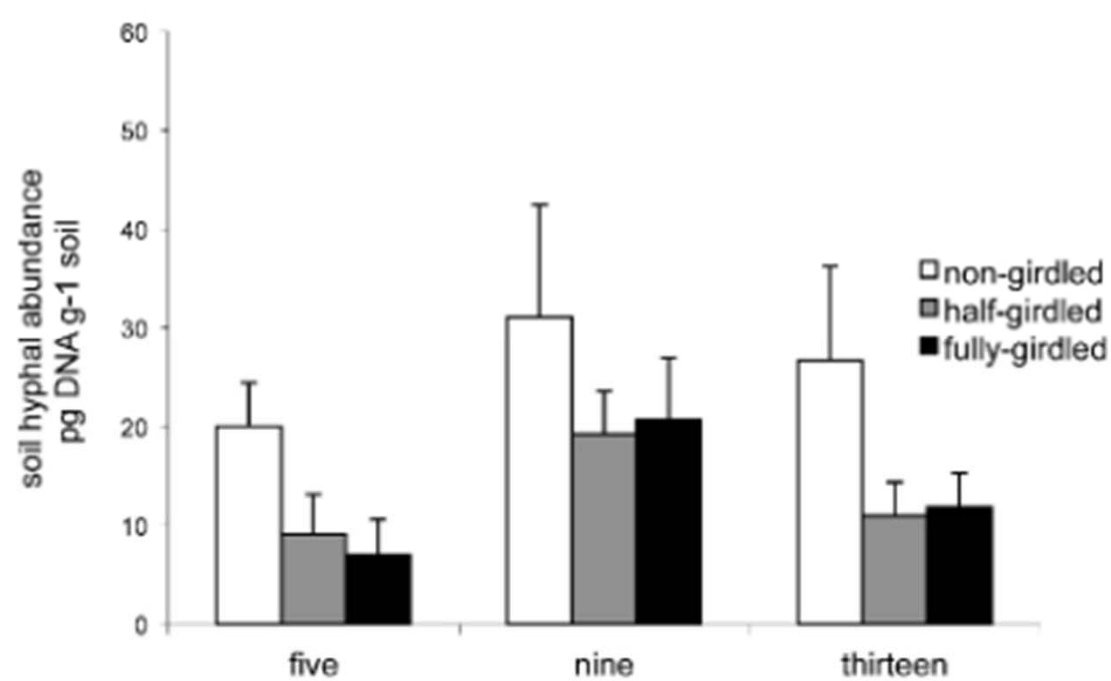
Survey ID #	HTRS Assessment Scoring Matrix	Risk
44610	100	
44611	90	
44612	90	
44613	80	
44614	80	
44615	80	
44616	70	
44617	70	
44618	70	
44619	60	
44620	60	
44621	60	
44622	60	
44623	60	
44624	60	
44625	50	
44626	50	
44627	50	
44628	50	
44629	50	
44630	50	
44631	40	
44632	40	
44633	40	
44634	40	
44635	40	
44636	40	
44637	40	
44638	30	
44639	30	
44640	30	
44641	30	

Tree hazard assessment

Implications of Tanoak Decline in Forests Impacted By *Phytophthora ramorum*: Girdling Decreases the Soil Hyphal Abundance of Ectomycorrhizal Fungi Associated With *Notholithocarpus densiflorus*

Author(s): Sarah E. Bergemann , Nicholas C. Kordesch , William VanSant-Glass and Matteo Garbelotto Timothy A. Metz
Source: Madroño, 60(2):95-106. 2013.
Published By: California Botanical Society

Long term effects on nutrient cycles



California (8th economic world power) one of the hotspots of trade and travel

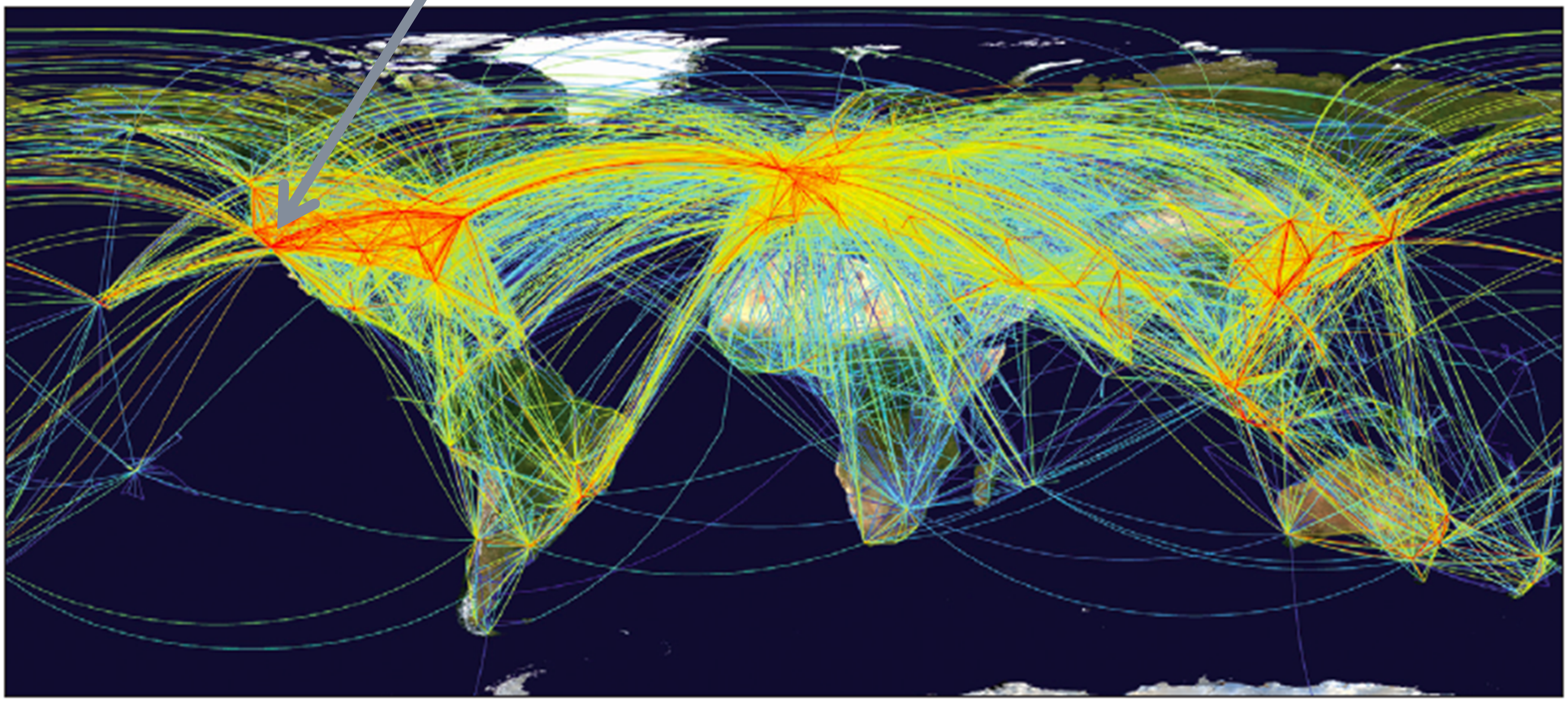
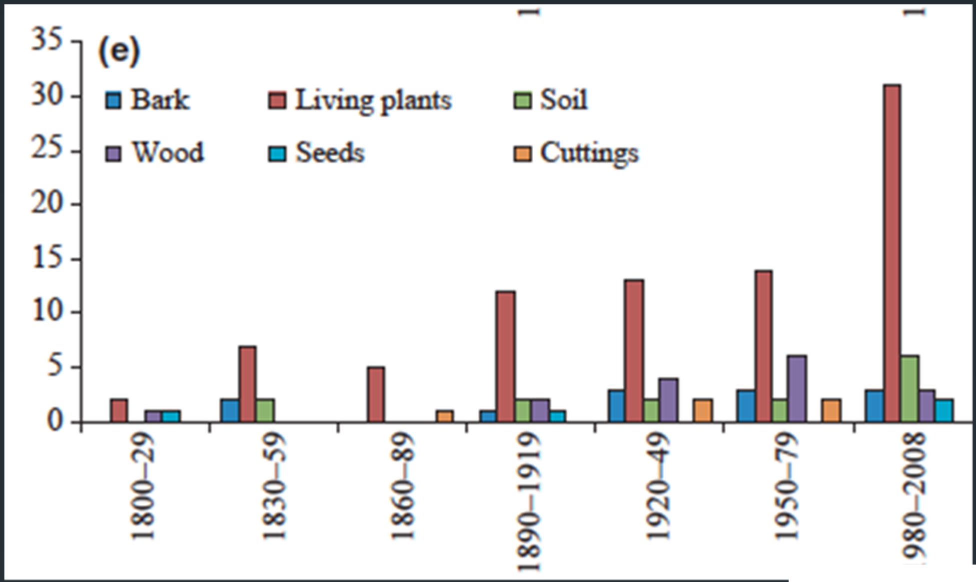
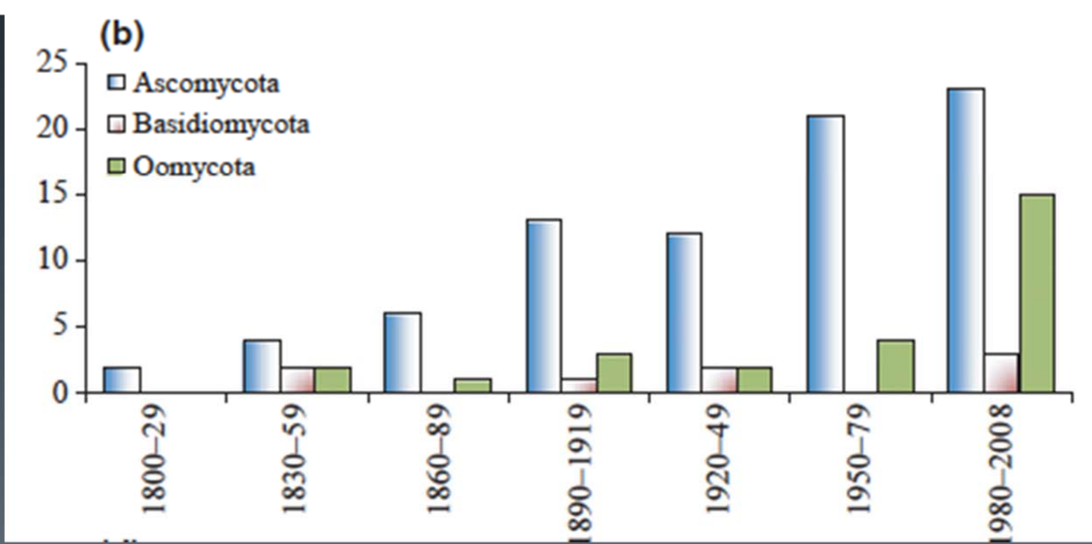


Figure 2: The global aviation network

SUBSTRATE/PATHWAY of introduction (Santini et al. 2013)



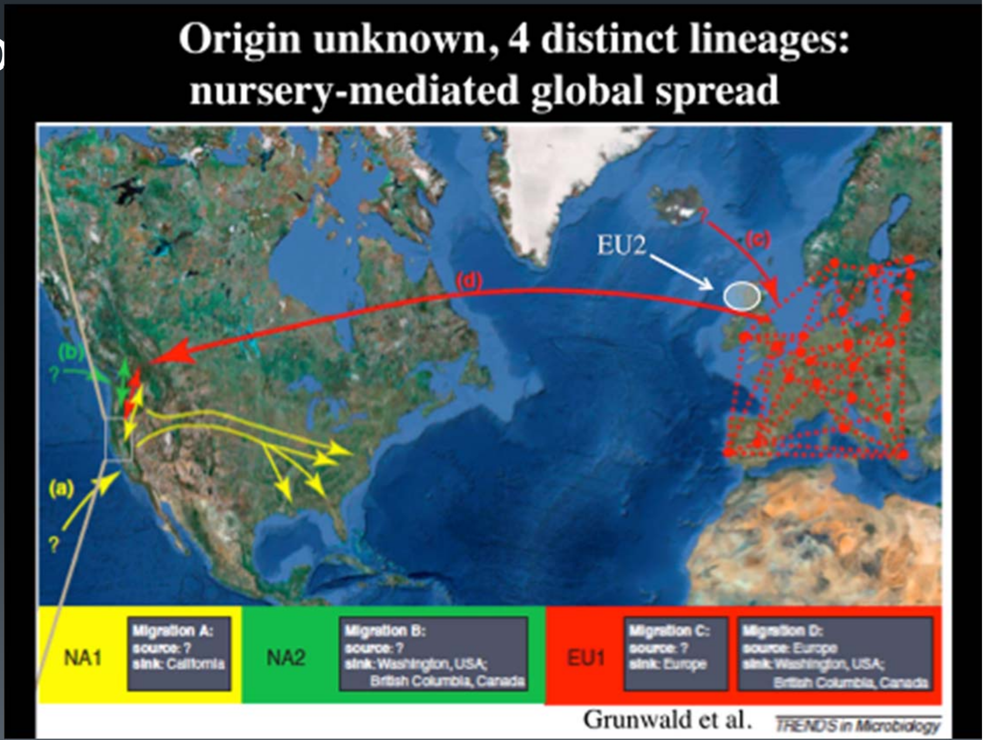


Soilborne, waterborne *Phytopthora* species

- Clear association with water: along streams, in areas that are temporarily flooded
- Ability to rest in soil with resting structures such as chlamydospores, oospores, but also encysted zoospores

Phytophthora ramorum

- 4 different subspecies (lineages)
- Origin likely to be SouthEast Asia
- Ornamental trade, worldwide
- Hundreds of host species
- Different diseases: from mild to lethal depending on host



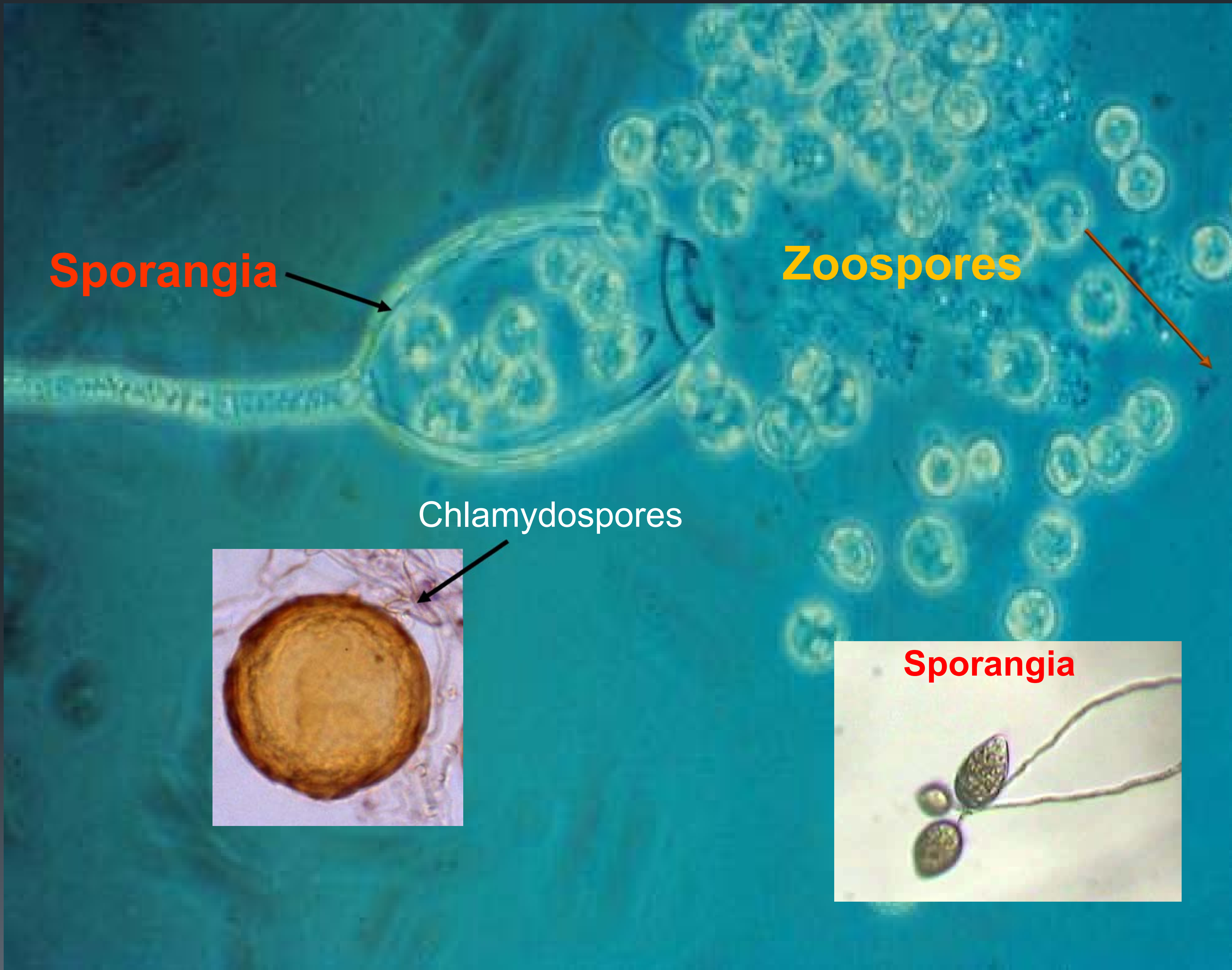
Aerial species

- First discovered for temperate forests: characterized by deciduous sporangia

- Splash dispersed: sporangia do not dry

- True aerial will naturally infect aerial parts without need for root infections or transmission by tools

- Ability to rest in soil with resting structures is not lost!!, but epidemiological relevance not clear in nature


Sporangia
Zoospores
Chlamydospores
Sporangia

Ecology and Epidemiology

e-Xtra*

Population Dynamics of Aerial and Terrestrial Populations of *Phytophthora ramorum* in a California Forest Under Different Climatic Conditions

C. A. Eyre, M. Kozanitas, and M. Garbelotto

Forest Pathology and Mycology Laboratory, Department of Environmental Science, Policy and Management, 5
California, Berkeley 94720.
Accepted for publication 20 May 2013.

Ecology and Epidemiology

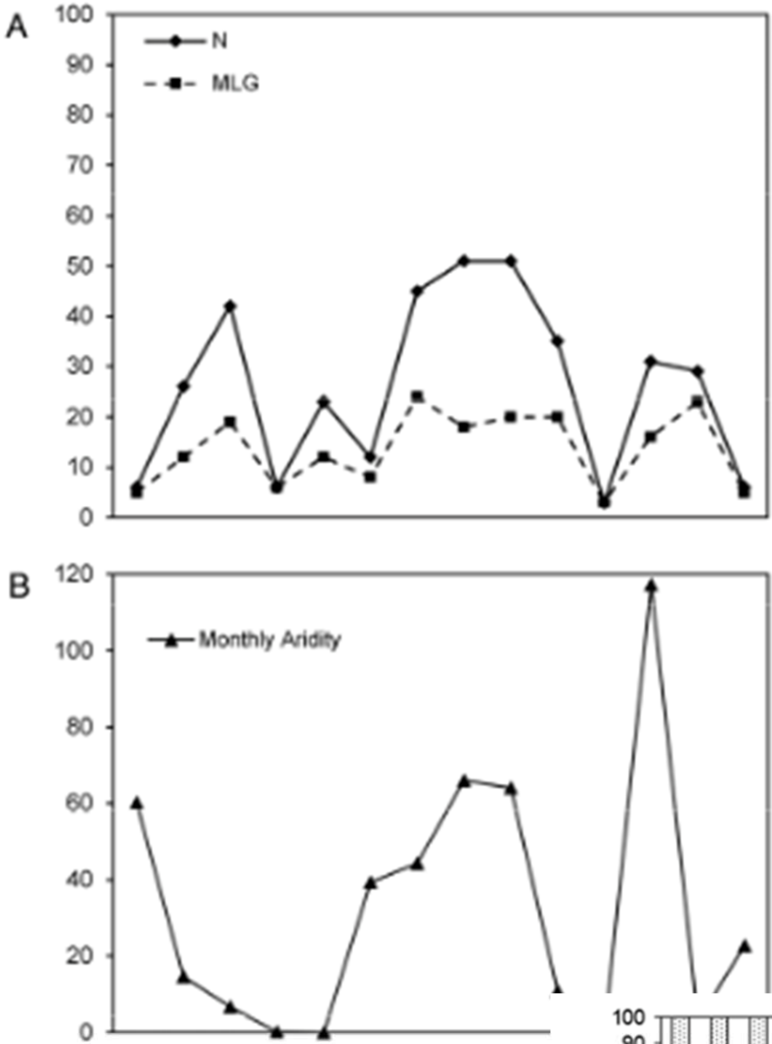
e-Xtra*

Detection, Diversity, and Population Dynamics of Waterborne *Phytophthora ramorum* Populations

C. A. Eyre and M. Garbelotto

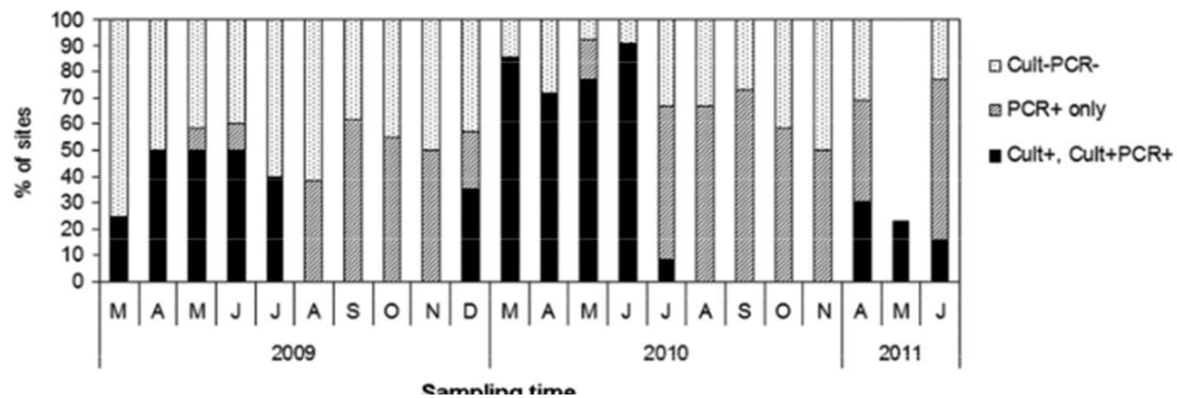
Forest Pathology and Mycology Laboratory, Department of Environmental Science, Policy and Management, University of California Berkeley, 54 Mulford Hall, Berkeley 94720.
Accepted for publication 2 July 2014.

- Soil and water populations derived from aerial populations
- Soil genotypes change yearly, while aerial genotypes are persistent
- Dispersal range changes with weather but only for aerial populations
- Most genotypes are generated on leaves (some in water) but different selection results in different genotypic composition in leaves, soil and water



- Isolation success from Water

- Aridity



Symptoms on Foliar Hosts

- Infections limited to leaves and twigs; *not fatal*

Rhododendron

California bay

Tanoak

RESEARCH ARTICLE

Non-oak native plants are main hosts for sudden oak death pathogen in California

Matteo Garbelotto
Jennifer M. Davidson
Kelly Ivors
Patricia E. Maloney
Daniel Hüberli
Steven T. Koike
David M. Rizzo

2003 AD

Aerial stem cankers on oak spp. and tanoaks: deadly but not infectious, e.g. stem lesions do not produce significant number of spores

Girdling aerial 'cankers' removed from roots

Tanoak

(*Notholithocarpus densiflorus*)

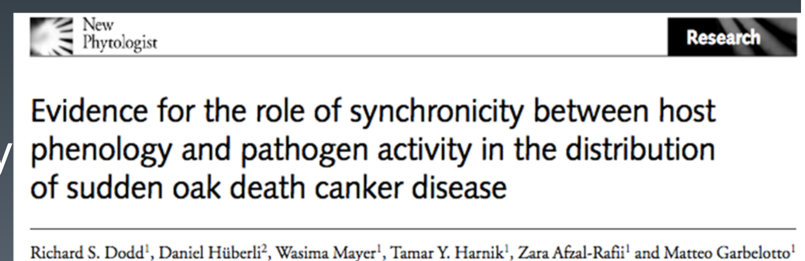
- Most important host
- Small branches, twigs, & leaves
- Leads to more infection

P. ramorum introduced at least 12 times in CA (Croucher et al. 2013). Multiple introductions and not ability to move far explain distribution of disease

Pathogen is exotic:

1 -native flora has limited resistance, but additionally

2- synchronicity between sporulation and host susceptibility (perfect ecological match)



New Phytologist — Research

Evidence for the role of synchronicity between host phenology and pathogen activity in the distribution of sudden oak death canker disease

Richard S. Dodd[1], Daniel Hüberli[2], Wasima Mayer[1], Tamar Y. Harnik[1], Zara Afzal-Rafii[1] and Matteo Garbelotto[1]

NURSERY POPULATION

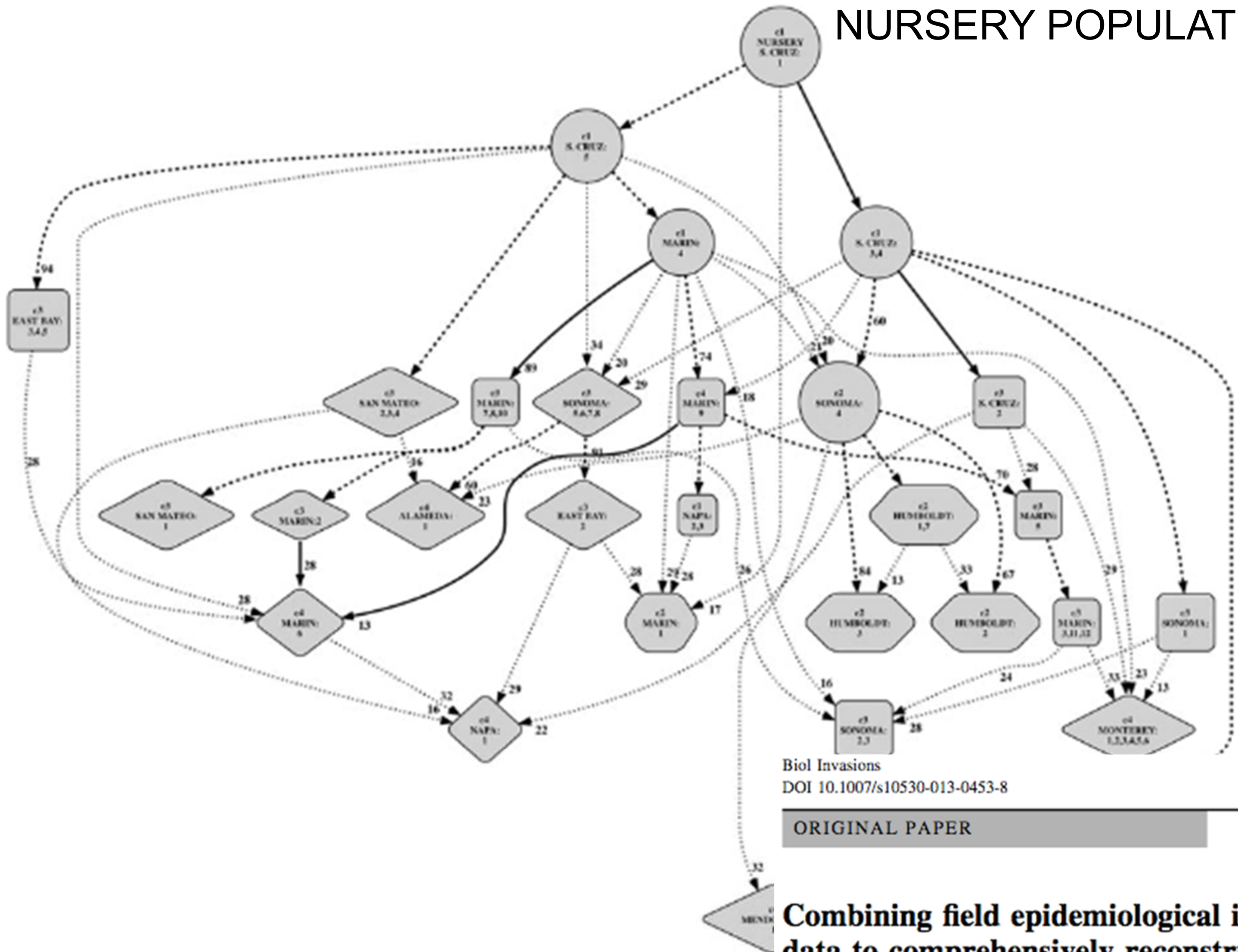


Fig. 5 MIGRATE-N model-choice based reconstruction of the possible colonization routes of *P. ramorum* during the Californian SOD epidemic. Population names are indicated at nodes along with genetic cluster ("clade") membership. *Nodes shapes* correspond approximately to time since infestation: *circle* 20+ years; *square* 15–20 years; *diamond* 10–15 years;

hexagon ≪1
populations
bold-dashed
50 % of the
Numbers ne
migration rou

Biol Invasions
DOI 10.1007/s10530-013-0453-8

ORIGINAL PAPER

Combining field epidemiological information and genetic data to comprehensively reconstruct the invasion history and the microevolution of the sudden oak death agent *Phytophthora ramorum* (Stramenopila: Oomycetes) in California

Peter J. P. Croucher · Silvia Mascheretti · Matteo Garbelotto

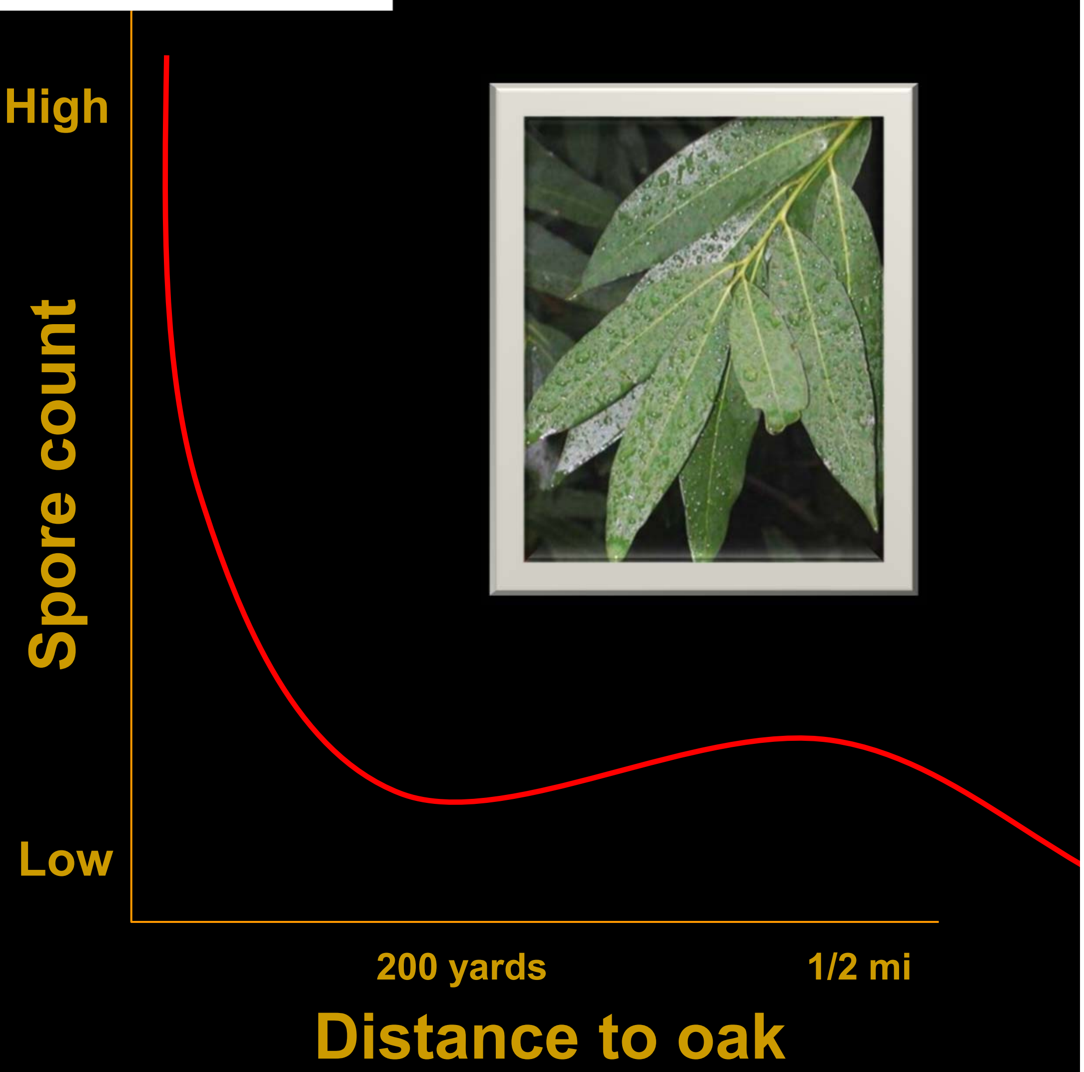
Molecular Ecology (2008) doi: 10.1111/j.1365-294X.2008.03773.x

Reconstruction of the Sudden Oak Death epidemic in California through microsatellite analysis of the pathogen *Phytophthora ramorum*

S. MASCHERETTI,* P. J. P. CROUCHER,* A. VETTRAINO,† S. PROSPERO‡ and M. GARBELOTTO*
*Department of Environmental Science, Policy and Management, 137 Mulford Hall, University of California, Berkeley, CA 94720-3114, USA, †Department of Plant Protection, University of Tuscia, I-01100 Viterbo, Italy, ‡INRA, UMR 1202 Biodiversité Gènes et communités, Equipe de pathologie Forestiere, BP 81, 33883 Villenave d'Omon Cedex, France

2008 AD

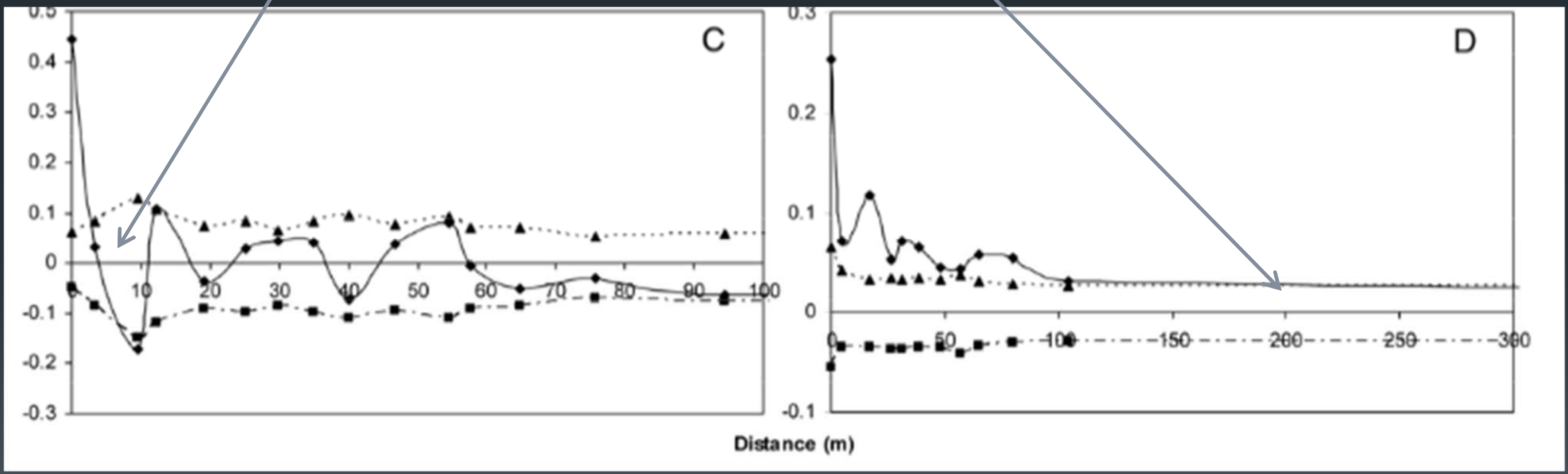
Distance Spread from Foliar Hosts



Dispersal range is different in wet vs. dry years

DRY

WET

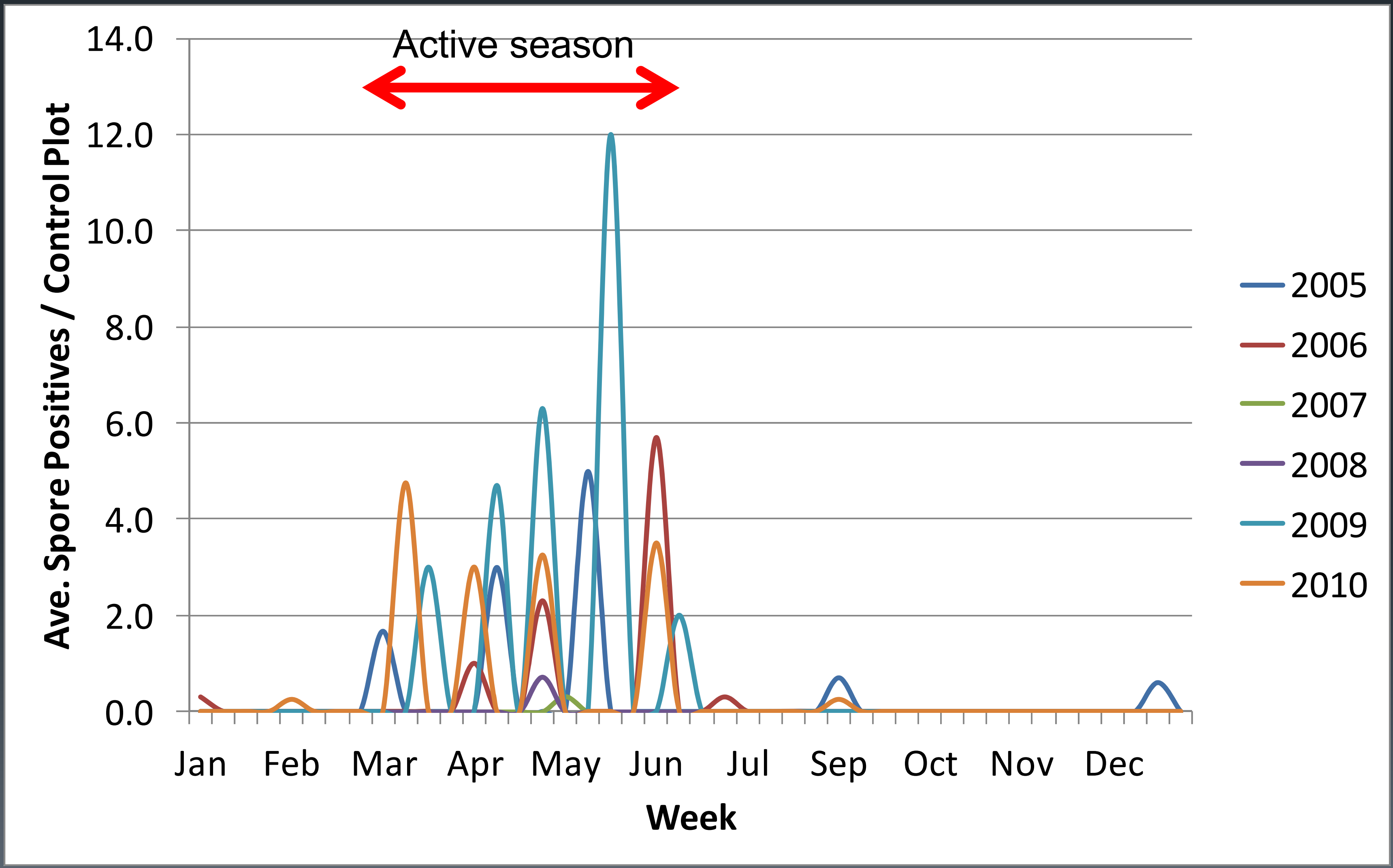


A few meters

Up to 200 meters

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

Average Temperatures in Plots



12 hours

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

Plant Pathology (2011) Doi: 10.1111/j.1365-3059.2011.02535.x

Intraspecific variation in host susceptibility and climatic factors mediate epidemics of sudden oak death in western US forests

D. Hüberli[ab*†], K. J. Hayden[a], M. Calver[b] and M. Garbelotto[a]

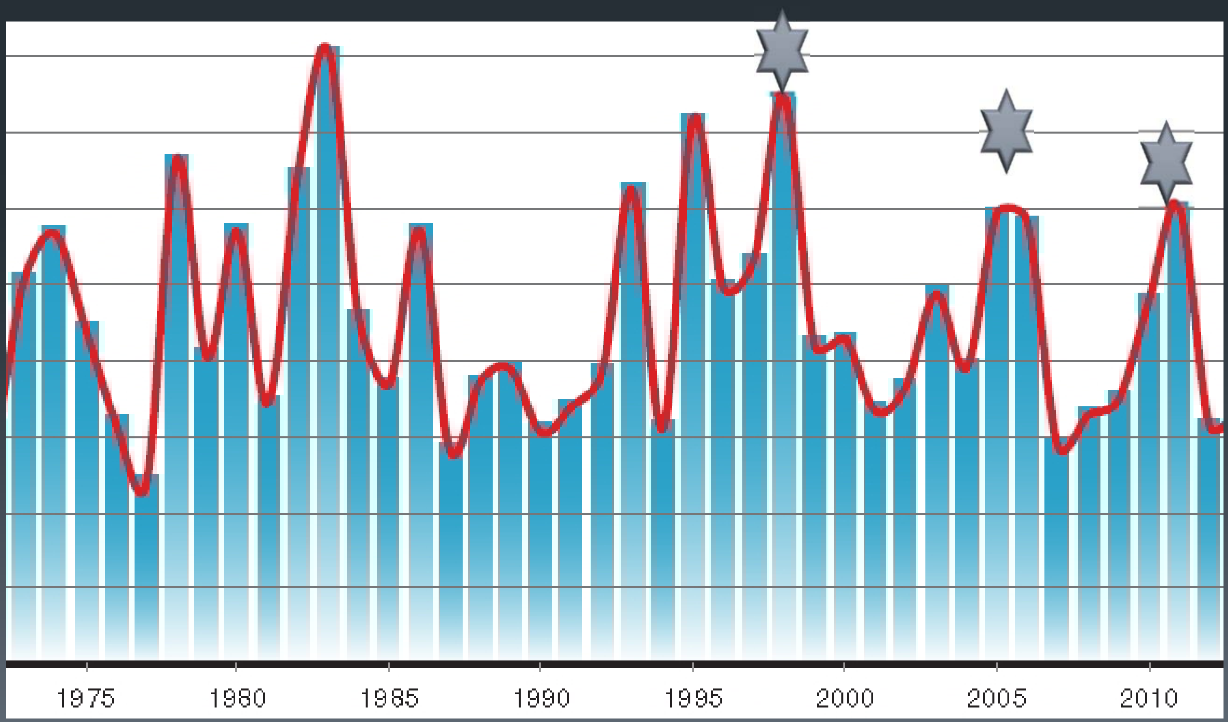
[a]Department of Environmental Science, Policy and Management, 137 Mulford Hall, University of California, Berkeley, CA 94720, USA; and [b]Centre for Phytophthora Science and Management, School of Biological Sciences and Biotechnology, Murdoch University, Murdoch, WA 6150, Australia

20 C

Oak infection:

1- High rainfall in short period (400 mm of rain),
2- Six weeks incubation,
3- One-two weeks of warmer weather
4- Proximity to bay laurels (closer than 60 feet)

RESULT IN HIGH INOCULUM LEVELS NECESSARY FOR OAK INfECTION

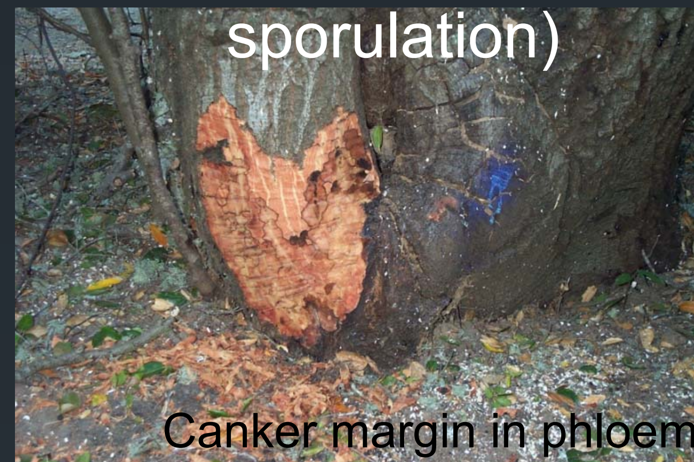


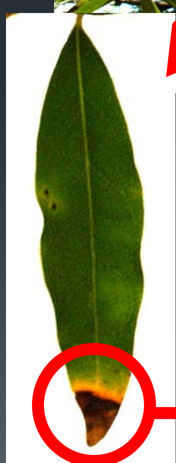
Bay/Oak association

Bay

Yearly

Coast Live Oak (no sporulation)



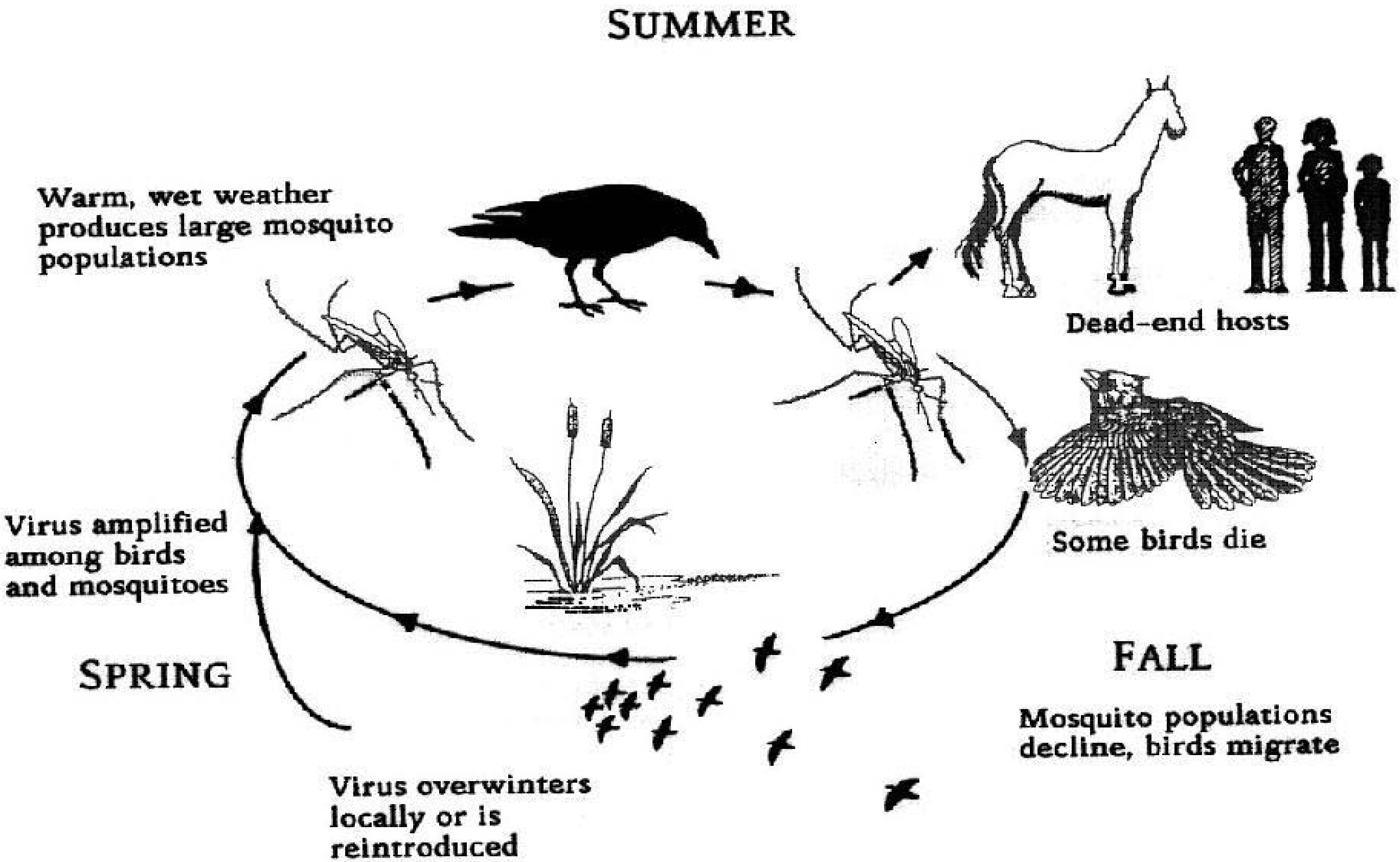


Wave years

Sporangia

Soil

Life Cycle of the West Nile Virus



Populations of *P. ramorum* can be differentiated in at least 2 ways:

- Aerial (plant) vs. soil vs. water communities
- Transmissive vs. dead-end hosts

For. Path.

doi: 10.1111/j.1439-0329.2011.00715.x

Phytophthora ramorum is a generalist plant pathogen with differences in virulence between isolates from infectious and dead-end hosts

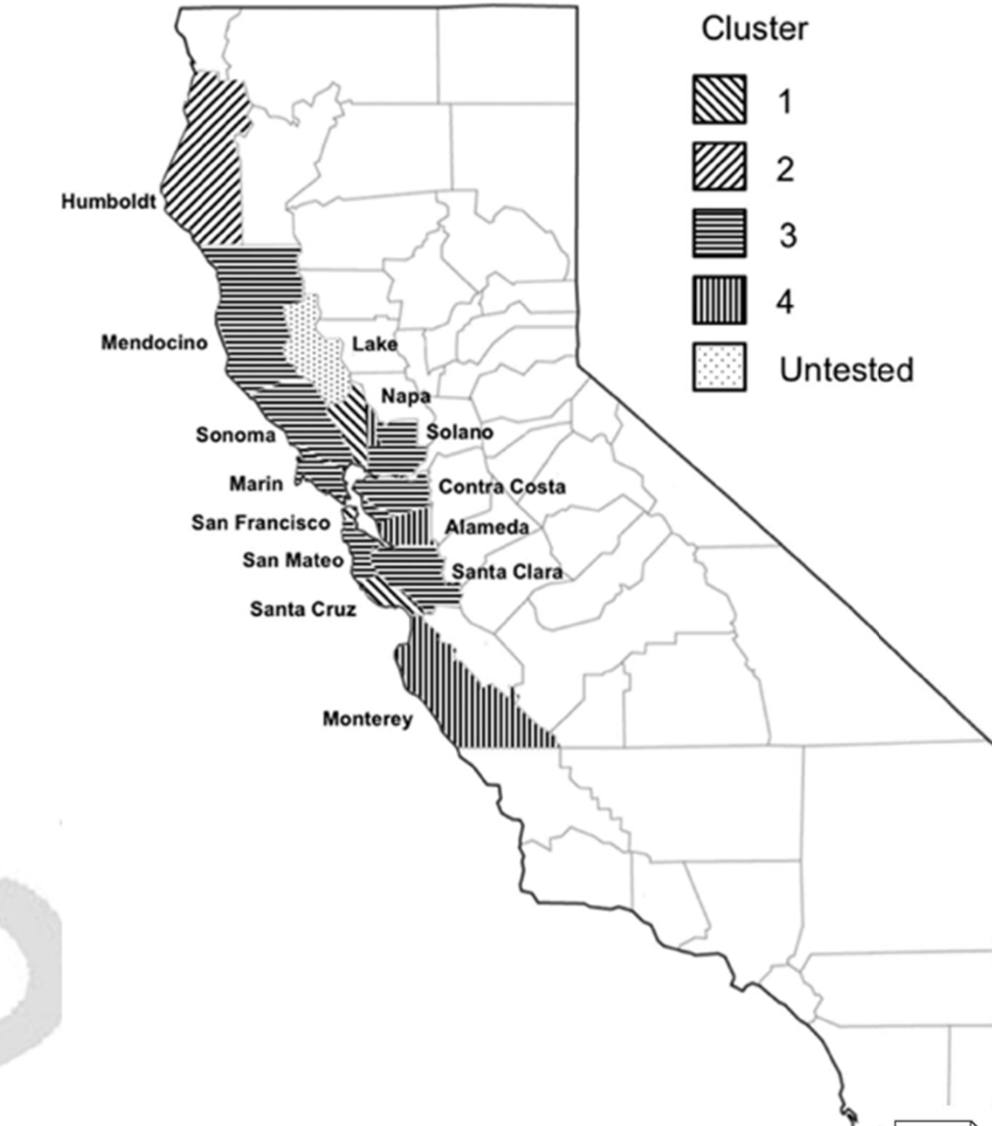
By D. Hüberli* and M. Garbelotto[1]

OPEN ACCESS Freely available online

PLoS one

Phenotypic Diversification Is Associated with Host-Induced Transposon Derepression in the Sudden Oak Death Pathogen _Phytophthora ramorum_

Takao Kasuga[1], Melina Kozanitas[2], Mai Bui[1], Daniel Hüberli[2¤], David M. Rizzo[3], Matteo Garbelotto[2*]



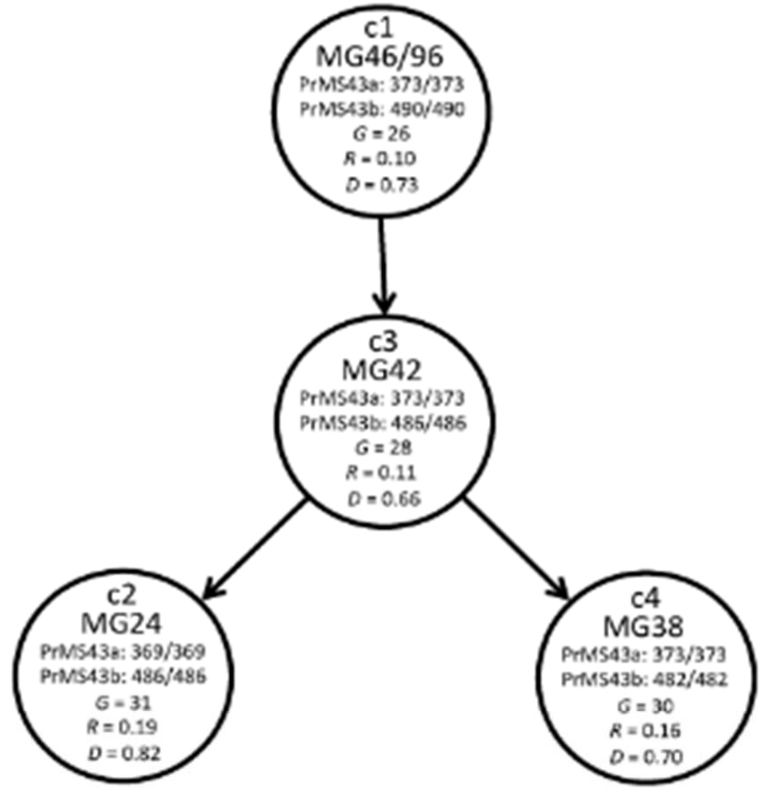


Fig. 3 Minimal representation of mutational shifts between the four common and putatively founding multi-locus genotypes (MGs) (MG46/96, MG42, MG24, MG38) that define each of the four genetic clusters or "clades" (c*1*–c*4*). The key changes (bp) at the two microsatellite loci PrMS43a and PrMS43b are indicated. *G* Number of MGs in cluster, *R* clonal genotype diversity, *D* genetic diversity $(1-\Sigma g_i^2)$, *g* is the frequency of MG *i*. (MG96 was merged with MG46 as they are identical except for missing/null alleles at MS18)

Cluster 1 of genotypes first to be introduced but not the most widespread,,suggesting new genotypes may be more fit

EC
Journals.ASM.org
MINIREVIEW

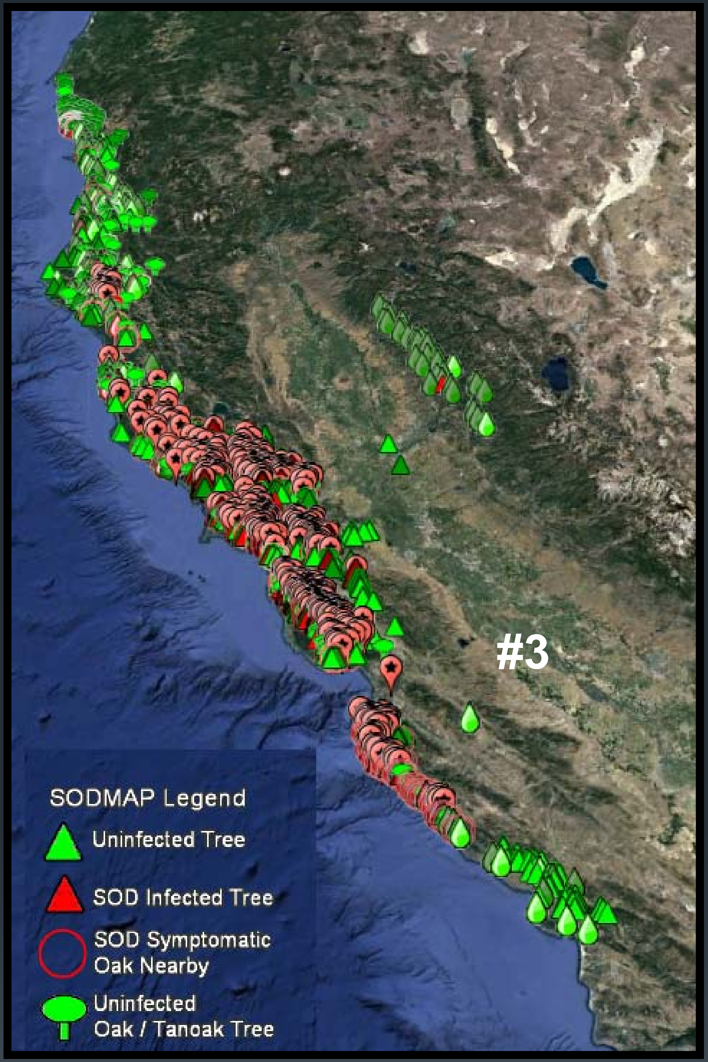
Sudden Oak Death: Interactions of the Exotic Oomycete *Phytophthora ramorum* with Naïve North American Hosts

Matteo Garbelotto and Katherine J. Hayden
Department of Environmental Science, Policy and Management, University of California, Berkeley, California, USA

NATURAL SPREAD 5 m to 5 km per year through splash dispersal and turbulent air flow.

On average 200-600 m foliar to foliar.

Foliar to oaks 10-20 m



--Has host spp
--Confirmed in 15 in CA
--(rt. map) + & - Samples

Statewide Status

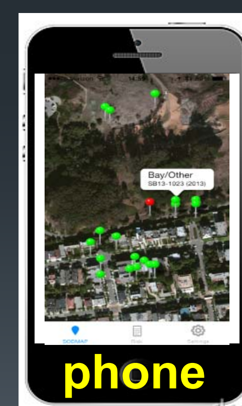
SODmap.org

“SOD Blitz” (citizen science)

UC Berkeley & CA NPS host informational meetings.

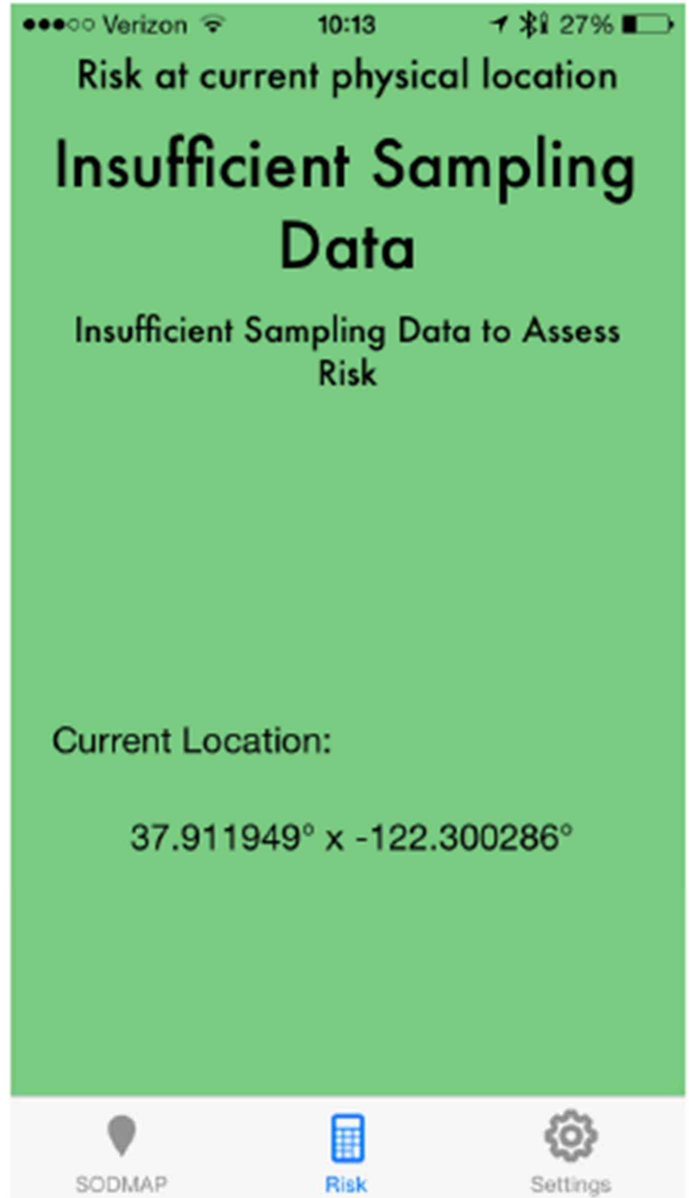
Do the SOD Blitz survey to track SOD in your community!

sodblitz.org

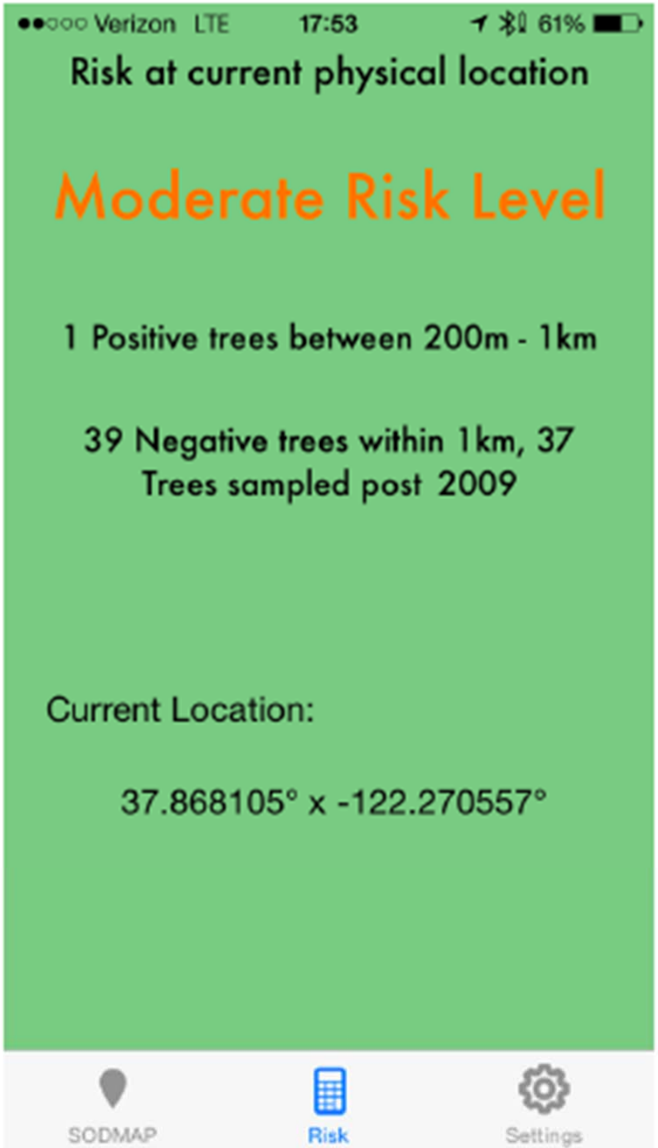


Download SODmap Mobile app (iPhone and Android)

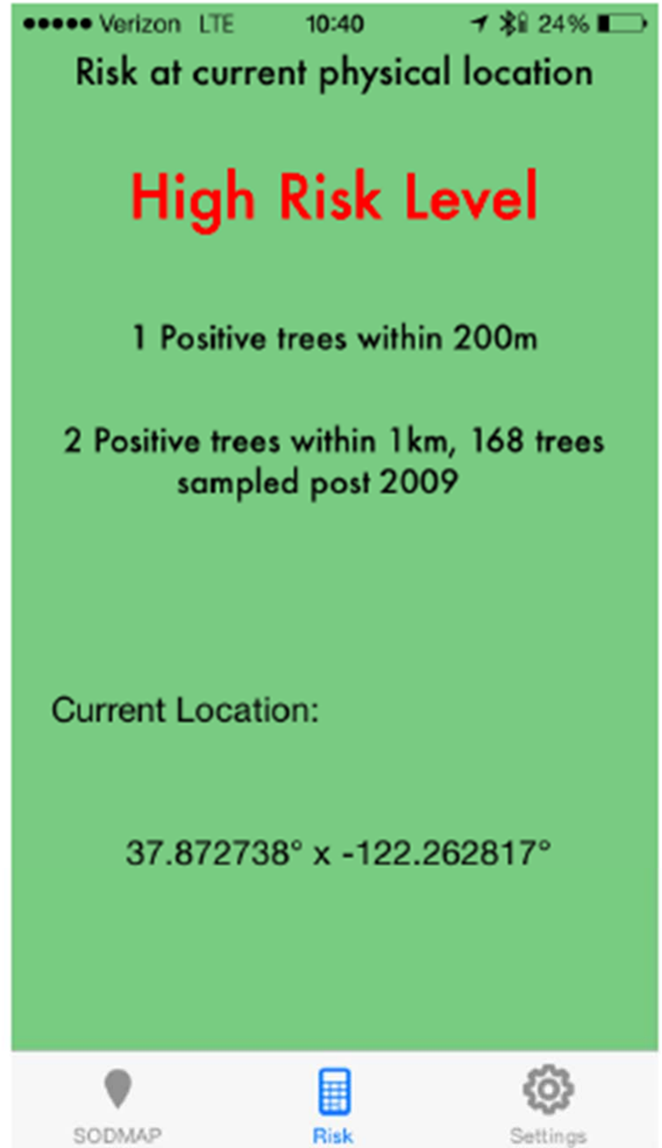
Tap on risk icon



Risk where you are physically standing



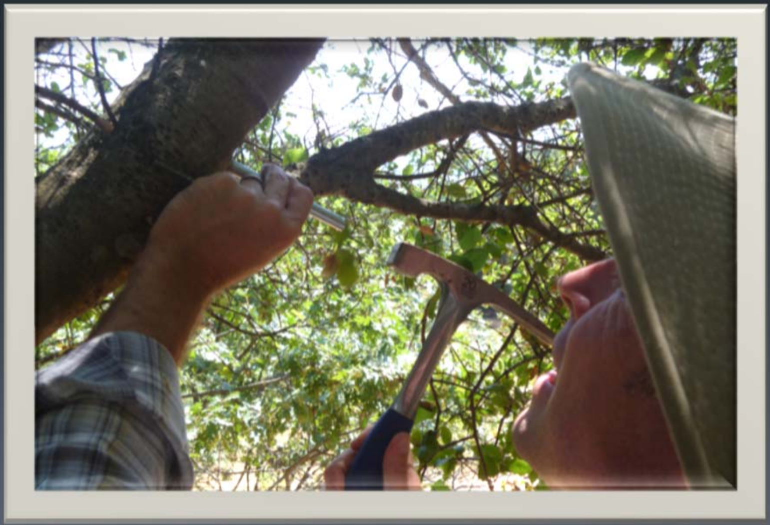
May want to do something



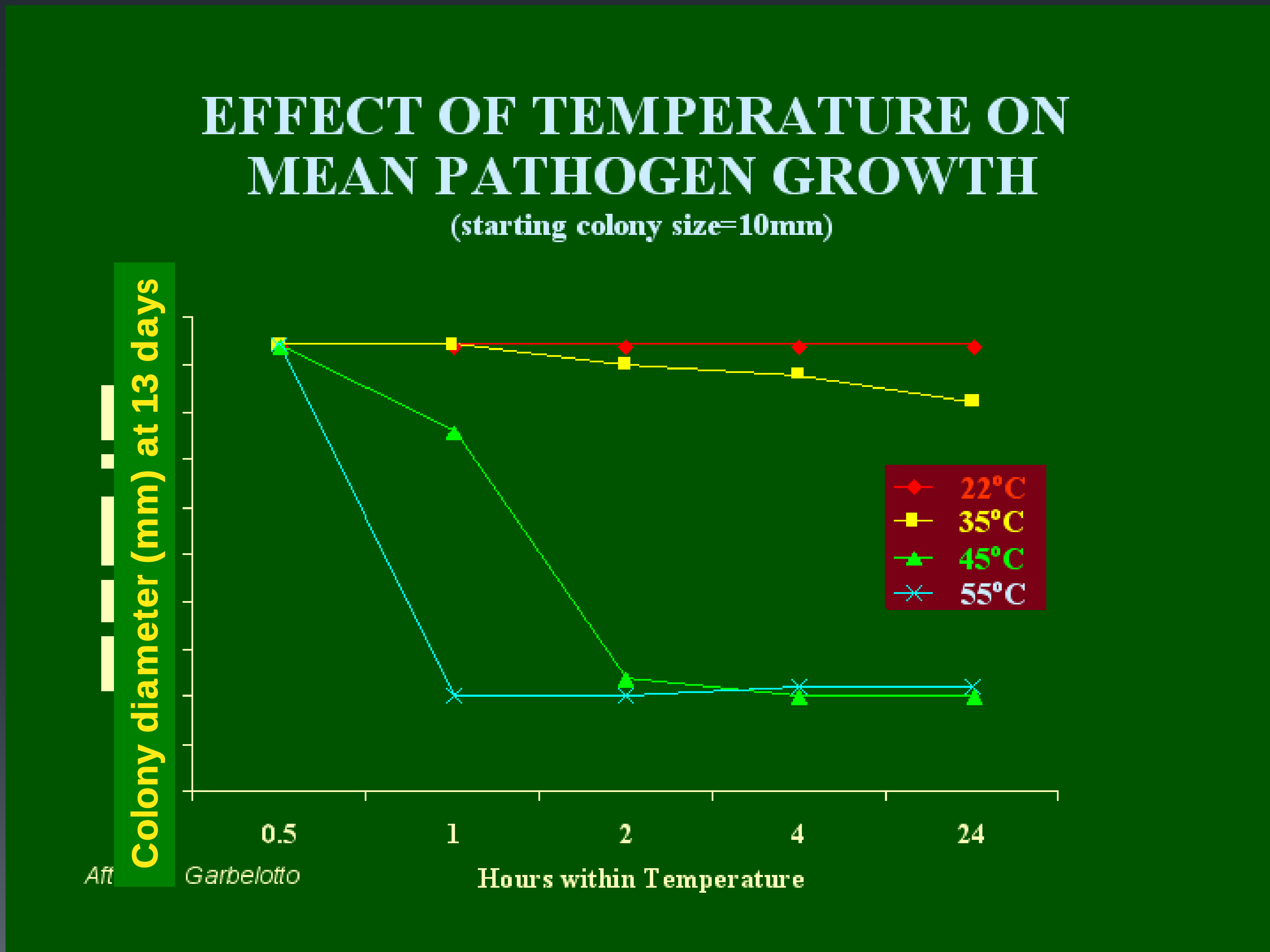
Urgent to do something if you have Oaks and bays growing together

Treatment options:
(Disproven or Unproven)

- **Insecticides**: don't address underlying *P. ramorum* infections.
- "**Alternative**" **treatments**: soil amendments, fertilization, compost teas, etc. are not effective.
- **Excisions**: no effect



Proven : Heat based sanitation:
Heat, Less Heat + Vacuum, Composting



Heat treatment results (at 55 C)

- **Pre-treatment - baseline (isolation success)**

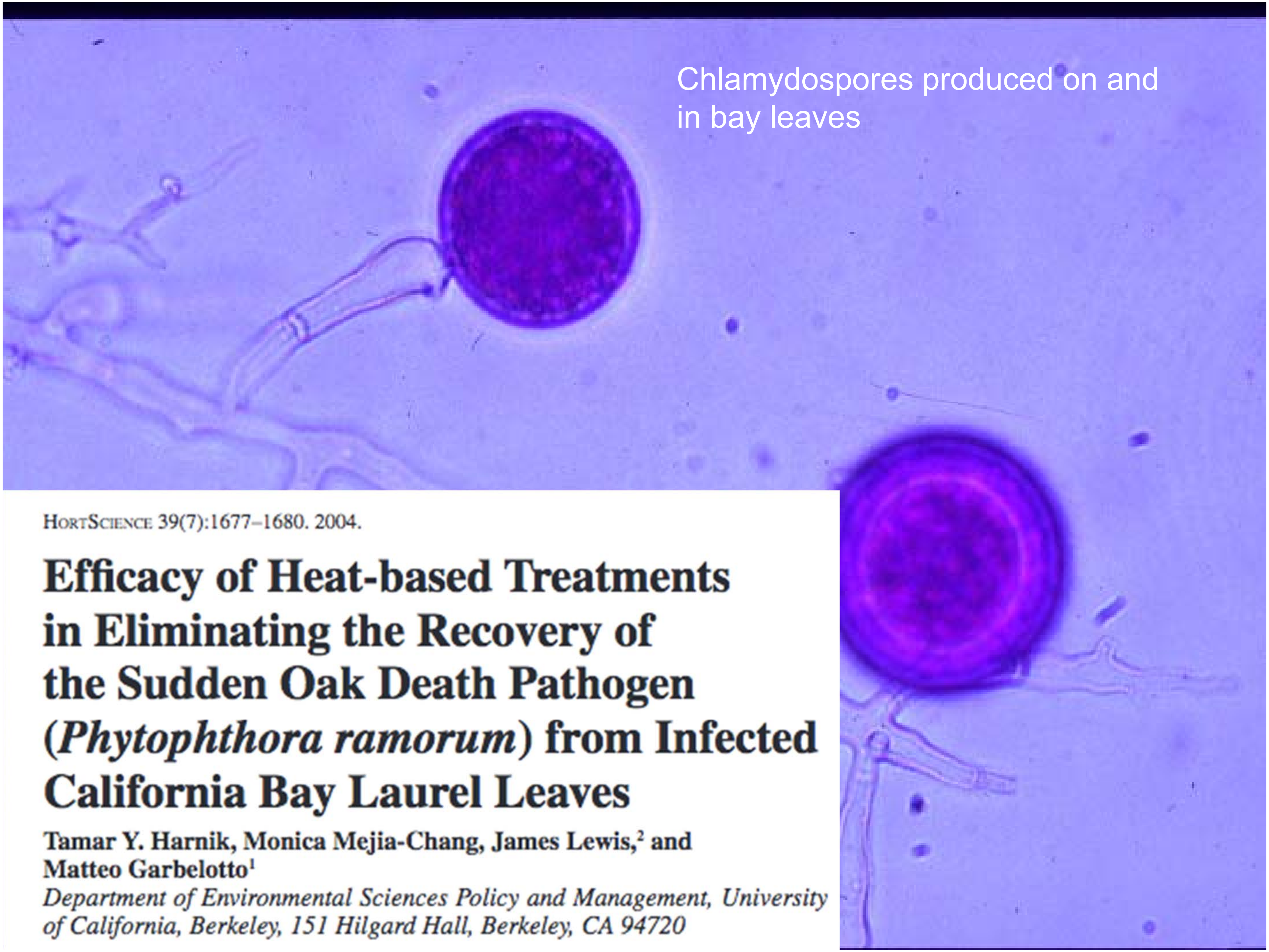
Wood Chips =	96%	(n=87)
Wood Logs =	44%	(n=48)
Bay Leaves =	100%	(n=50)

- **1 week of heat**

Wood Chips =	0%	(n=87)	
Wood Logs =	0%	(n=48)	
Bay Leaves =	30%	(n=50)	WHY?

- **2 weeks of heat**

Wood Chips =	0%	(n=87)
Wood Logs =	0%	(n=48)
Bay Leaves =	0%	(n=50)



HortScience 39(7):1677–1680. 2004.

Efficacy of Heat-based Treatments in Eliminating the Recovery of the Sudden Oak Death Pathogen (*Phytophthora ramorum*) from Infected California Bay Laurel Leaves

Tamar Y. Harnik, Monica Mejia-Chang, James Lewis,[2] and Matteo Garbelotto[1]
Department of Environmental Sciences Policy and Management, University of California, Berkeley, 151 Hilgard Hall, Berkeley, CA 94720

Sanitation

Green waste more infectious than wood and soil

Composting works: fine grain can be sanitized more easily than coarse material

Journal of Applied Microbiology ISSN 1364-5072

ORIGINAL ARTICLE

Composting is an effective treatment option for sanitization of *Phytophthora ramorum*-infected plant material

S. Swain[1], T. Harnik[1], M. Mejia-Chang[1], K. Hayden[1], W. Bakx[2], J. Creque[3] and M. Garbelotto[1]

1 Department of Environmental Science, Policy, and Management, University of California, Berkeley, CA, USA
2 Sonoma Compost, Sonoma, CA, USA
3 McEvoy Ranch, Marin, CA, USA

Research Article

***Phytophthora ramorum* can survive introduction into finished compost**

by Steven Swain *and* Matteo Garbelotto

Chemical treatment

- **Phosphonate**
  - Injection
  - Surface application
- **Application**
  - Specimen trees
  - Every other year in the fall (2x the first year)
  - Prophylactic, no cure!

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 S

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. Harnik

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

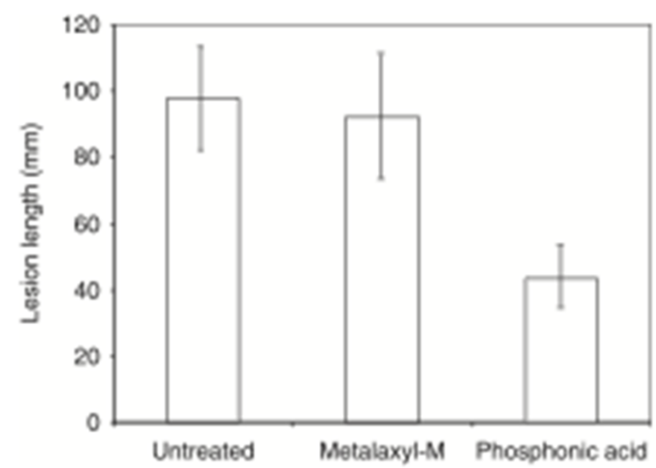


Figure 2 Lesion length (with bars showing standard deviation) caused by three *Phytophthora ramorum* isolates inoculated underbark in the phloem of potted coast live oak saplings, either untreated, treated with metalaxyl-M drench, or by phosphonic acid injection. Each treatment was performed on 15 saplings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


AGRI-FOS®
SYSTEMIC FUNGICIDE
AGRI-FOS


Injection Treatment

Topical Treatment

Injected Phosphonate Efficacy

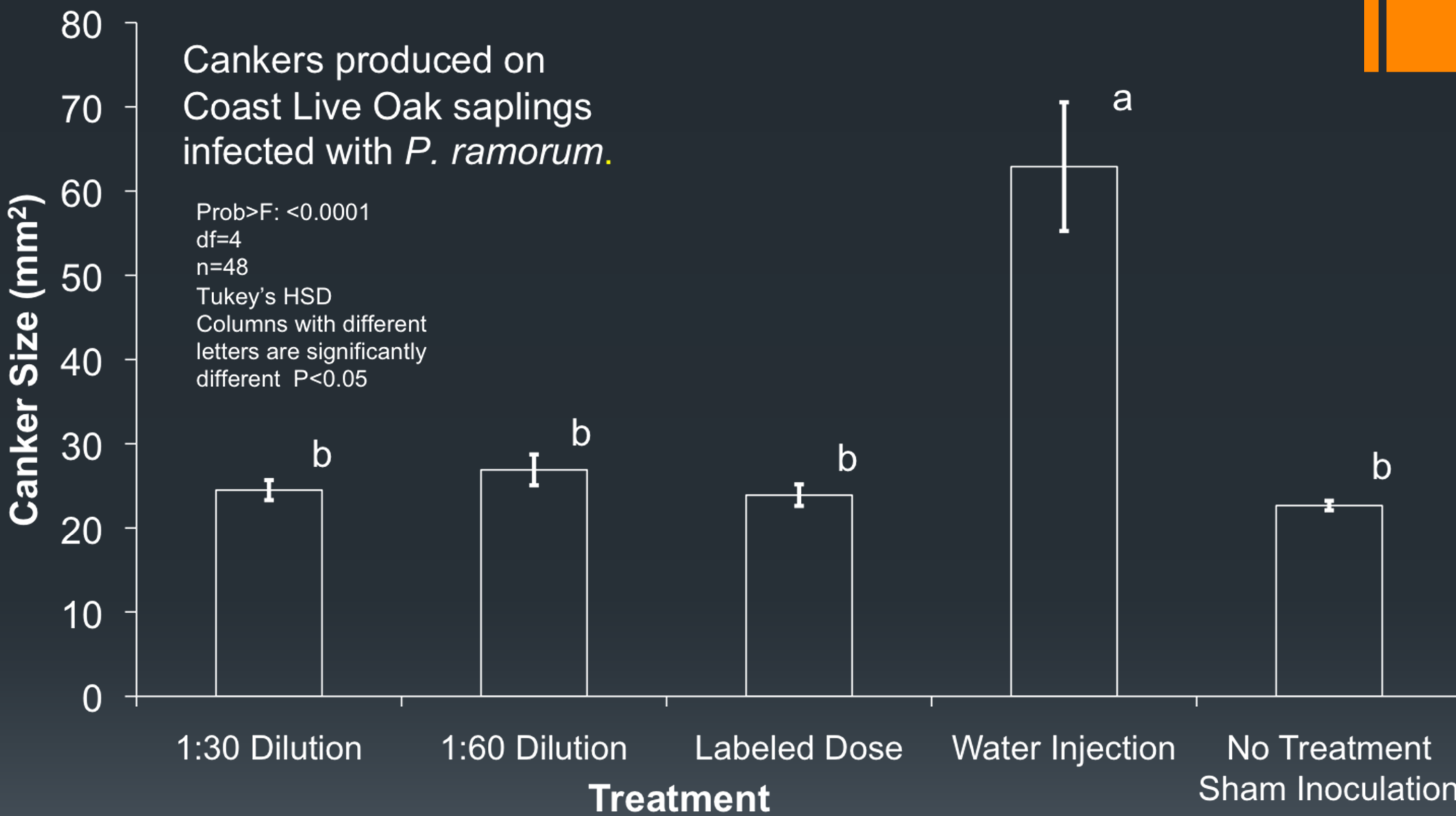


Figure 1. Efficacy of labeled dose vs updated dilution ratios. Smaller lesions = higher efficacy.

Phosphonate Damage to Wood

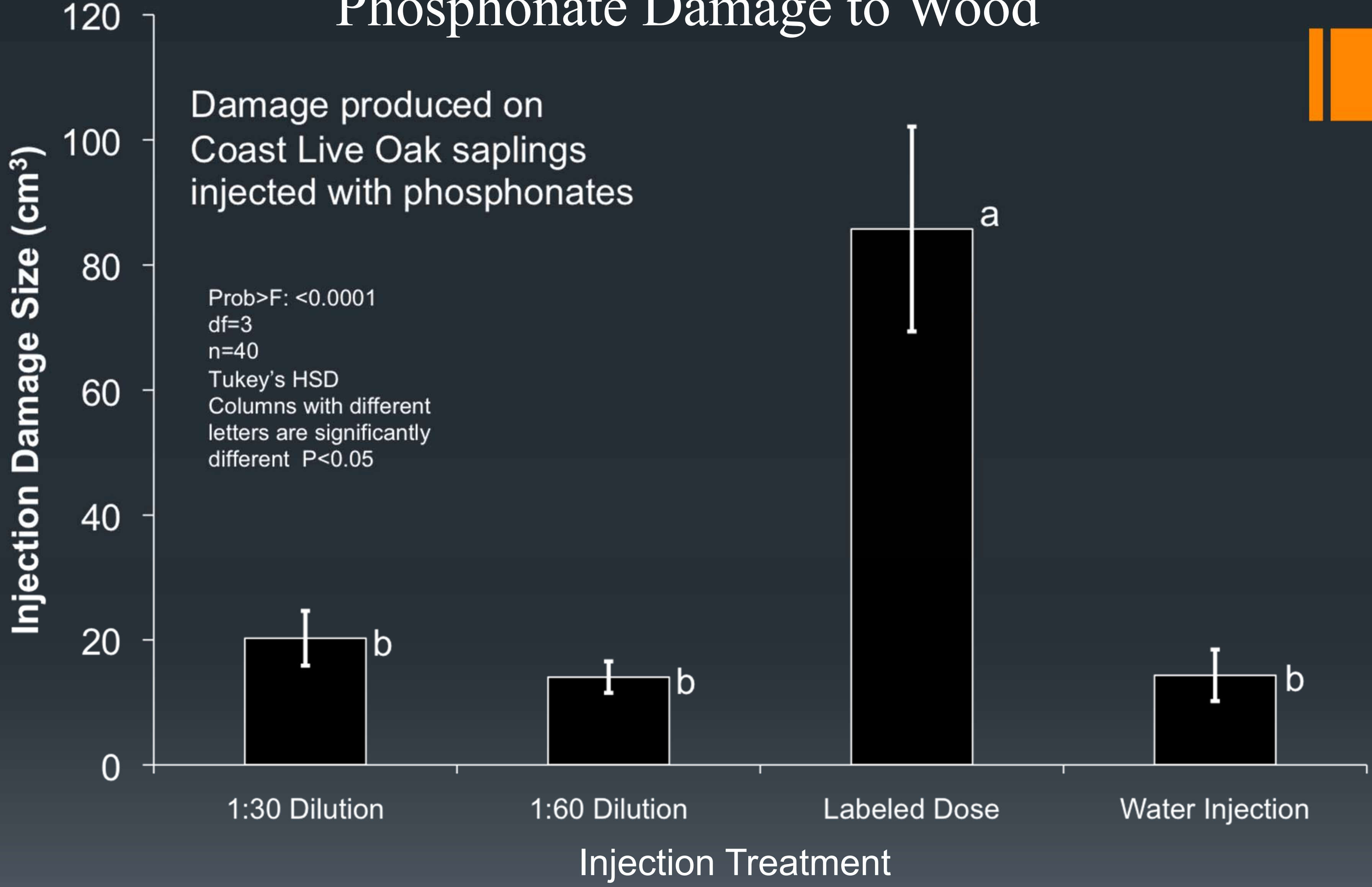
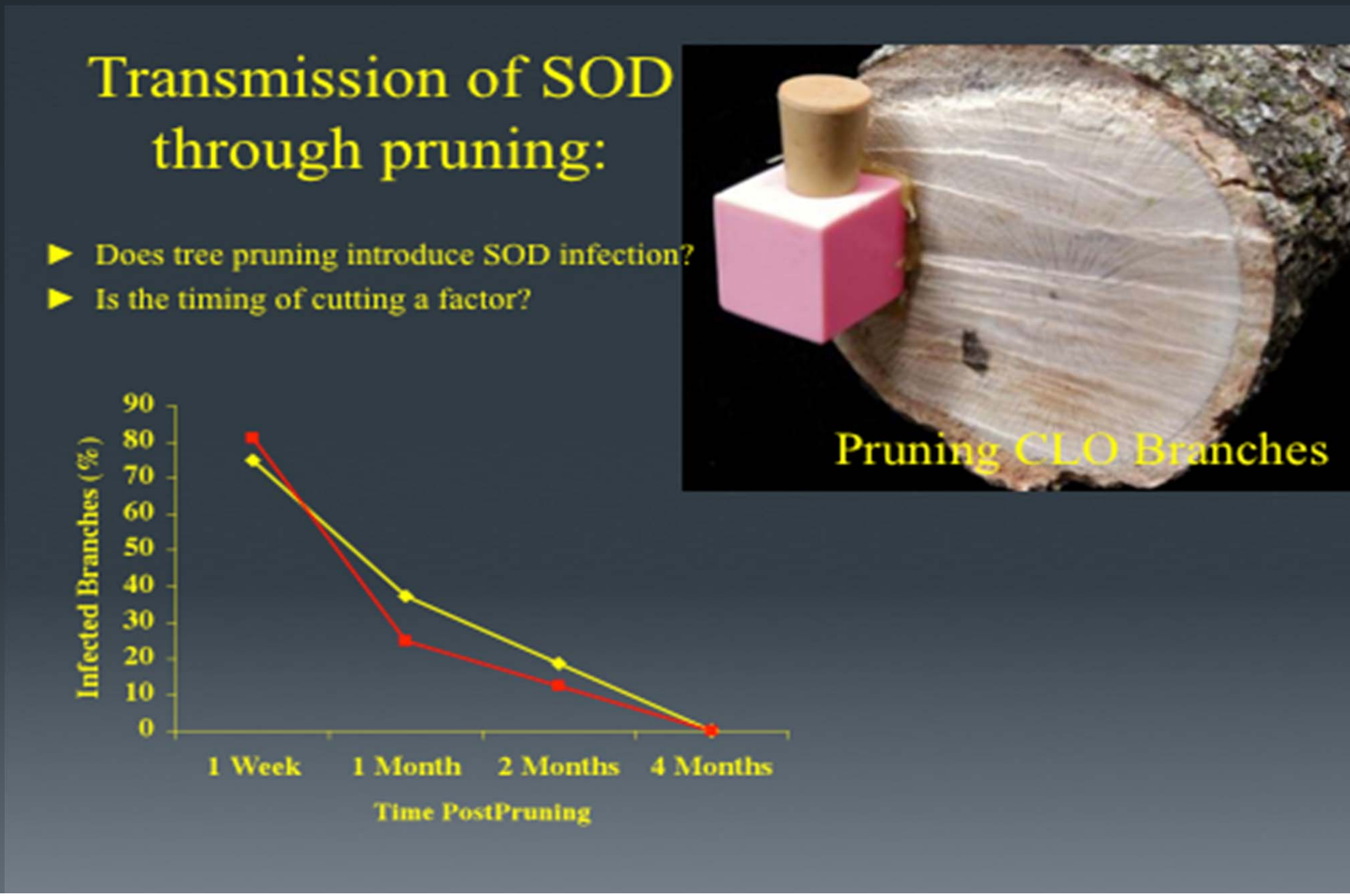


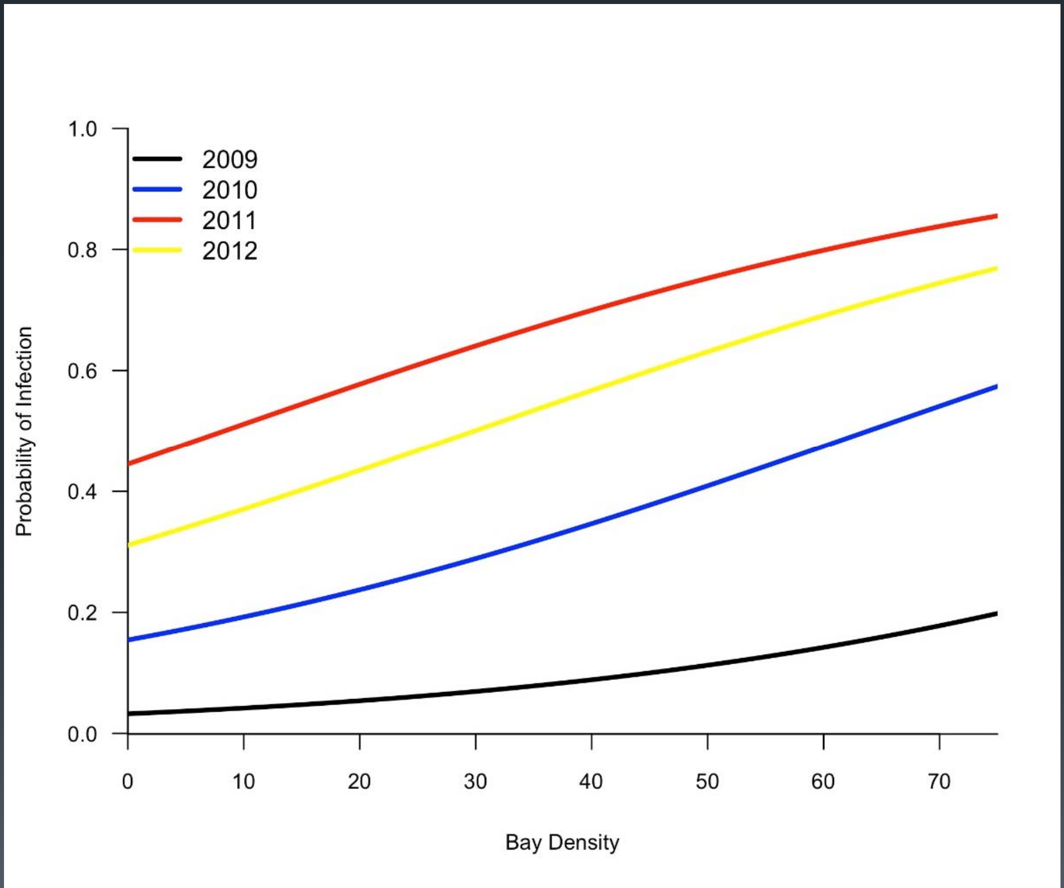
Figure 2. Injection damage caused by labeled dose vs updated dilution ratios. Note that updated dosage damage is indistinguishable from damage caused by only injecting water.

Cultural treatments

(i.e., Foliar host removal or timing of pruning



Stand level bay removal will reduce intensity of outbreak



Probability of bay infection with varying bay density

Wholesale Bay Laurel Removal

- Potentially costly
- Intensive and Invasive
- Multi-year follow up

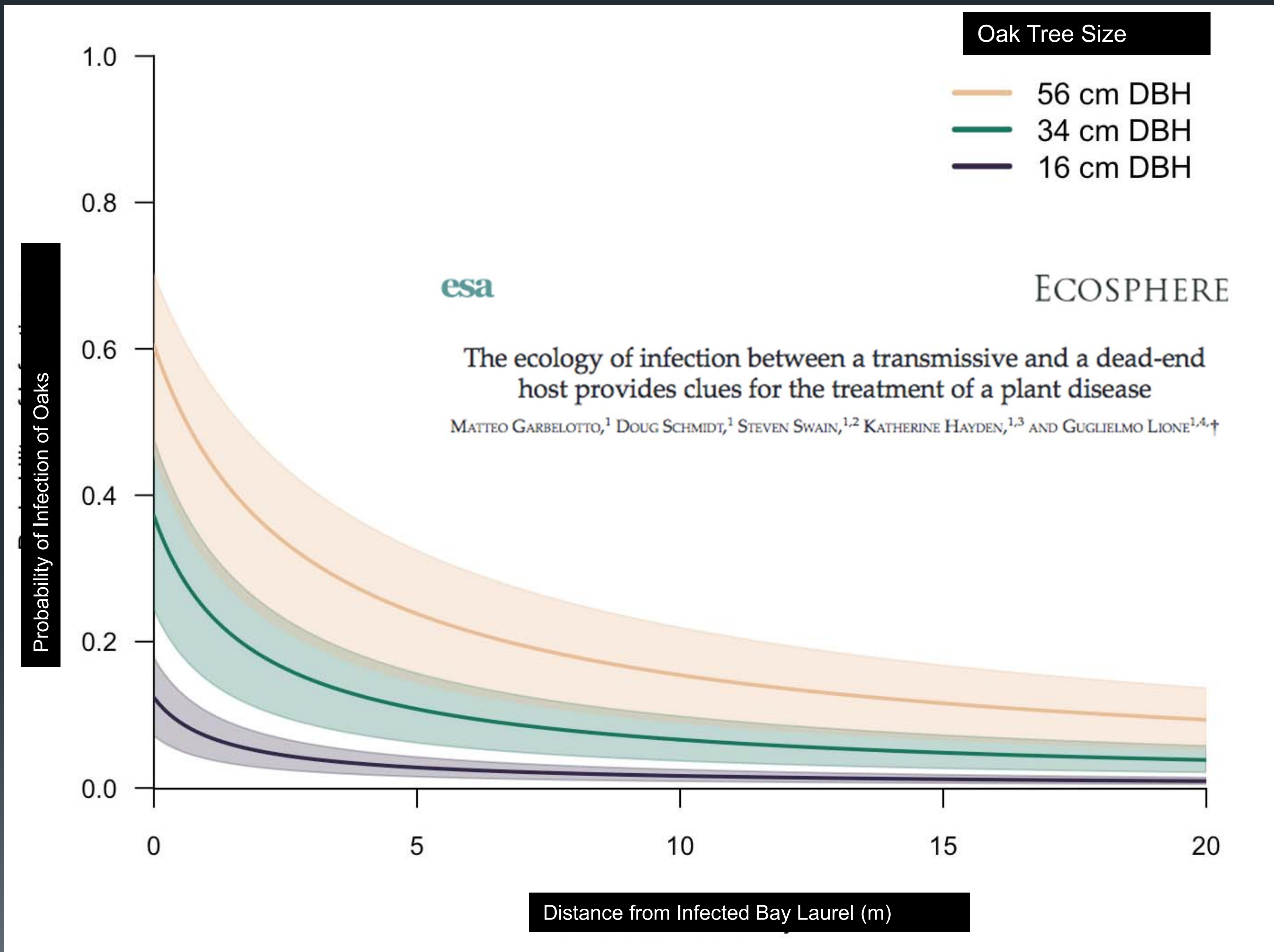
Selective Bay Laurel Removal

Two Major Criterion in Selective Approach

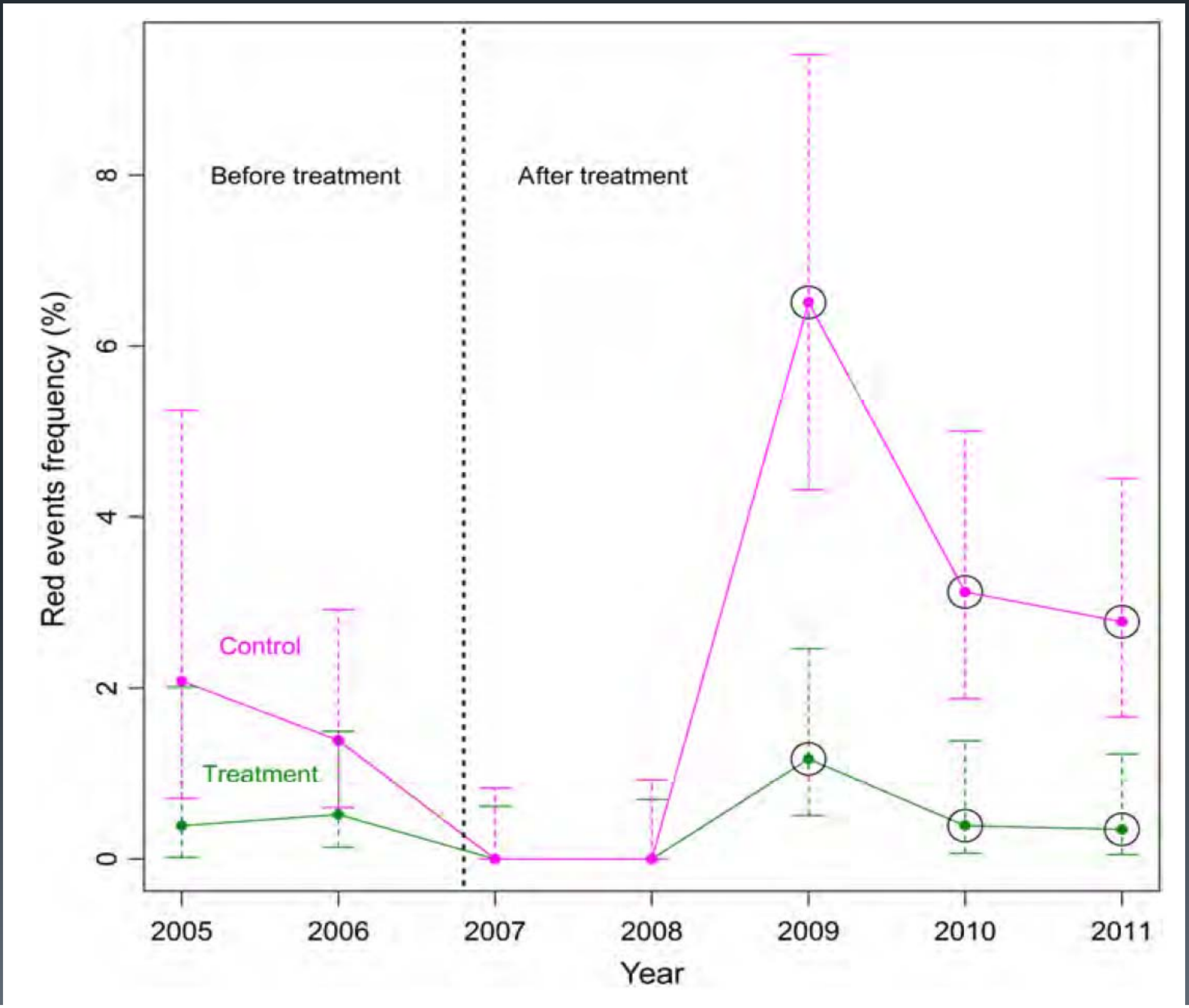
Spatial – Based on their proximity to oaks

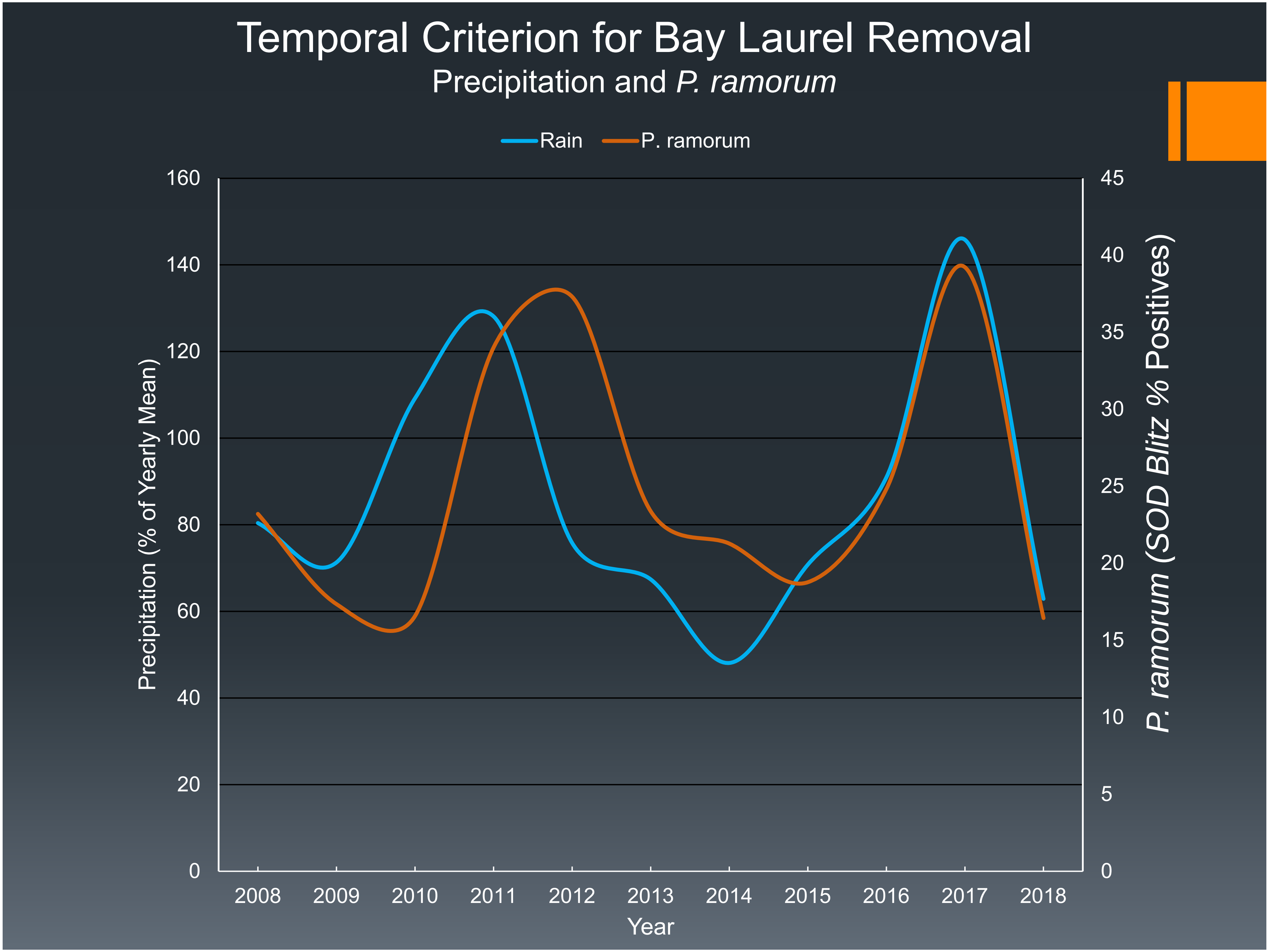
Temporal – Removal of bay laurels that remain infected during drought and that serve as a reservoir of inoculum for following outbreaks

Selective Bay Laurel Removal



Bay removal around oaks: we tested the efficacy of removal 10 m around oaks in a 7 year-long study





Temporal Criterion for Bay Laurel Removal
Precipitation and *P. ramorum*
Rain
P. ramorum
Precipitation (% of Yearly Mean)
160
140
120
100
80
60
40
20
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Year
P. ramorum (*SOD Blitz* % Positives)
45
40
35
30
25
20
15
10
5
0

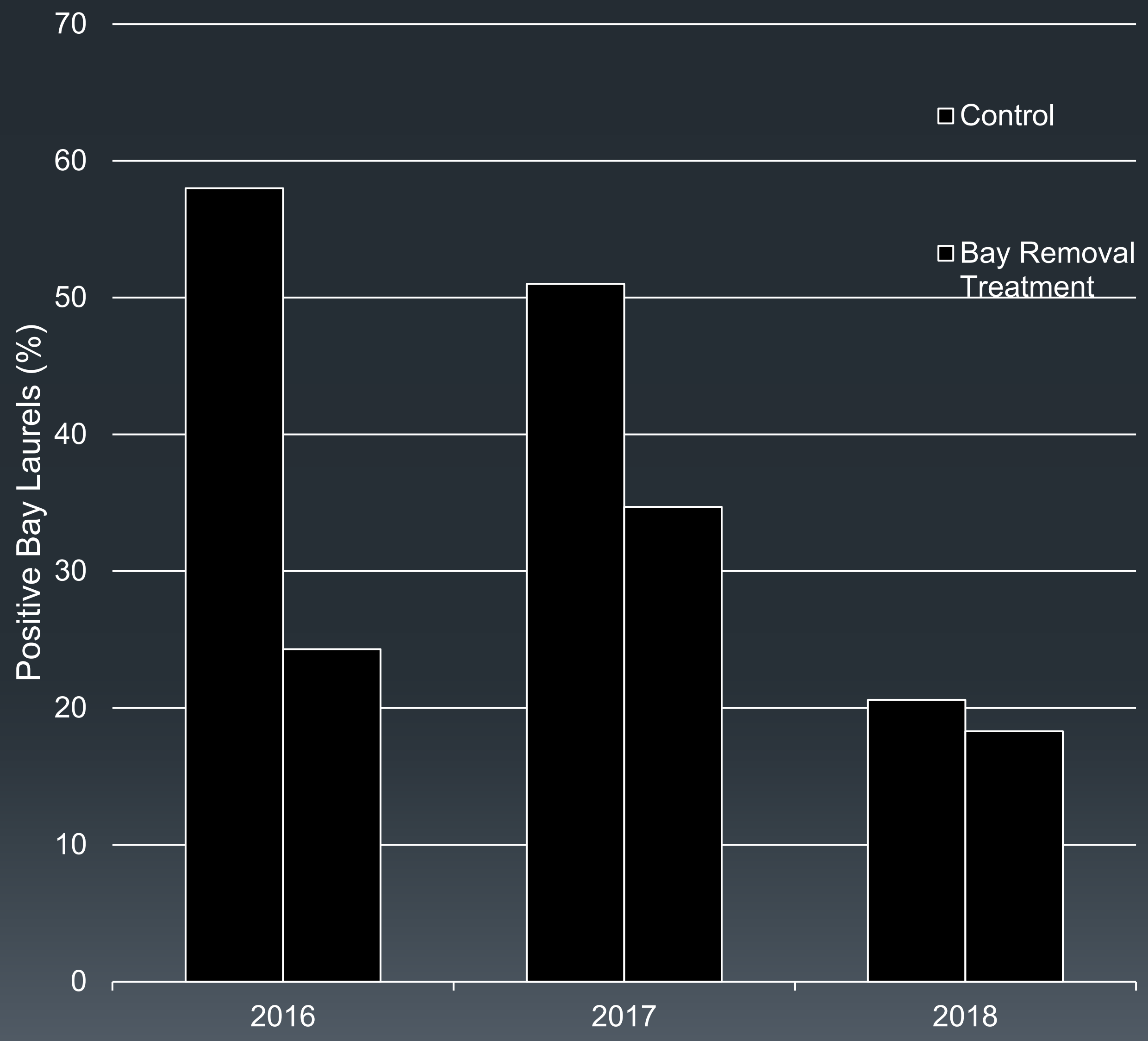
Temporal Criterion for Bay Laurel Removal

SODMap Comparison

Rainy
2 years

After
2 years
of drought

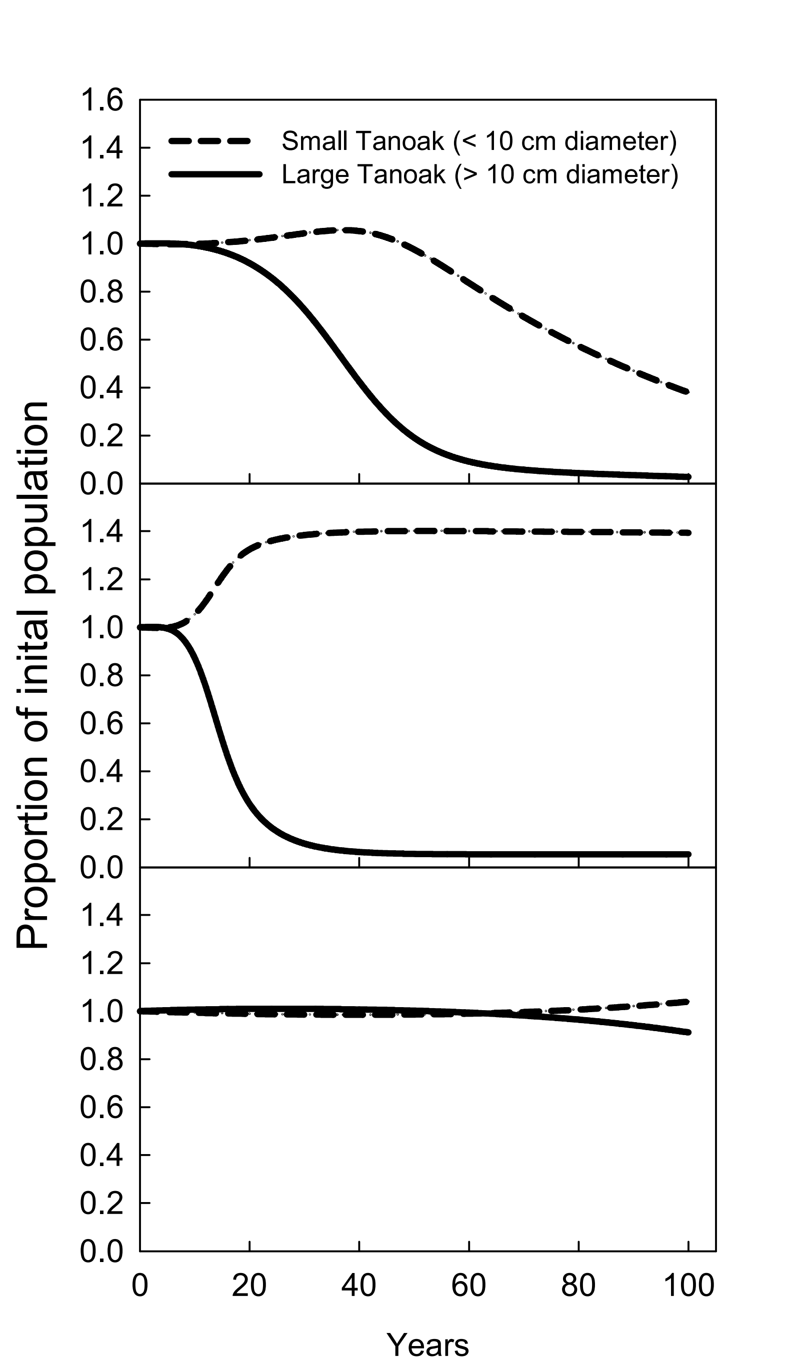
SFPUC Management - Bay Thinning in 2015



Conclusions

- California bay laurel is an important species in California but is also the primary vector for the spread of SOD and infection of oaks by *P. ramorum*
- Non-selective wholesale removal of bays is predicted to result in a generalized decrease of disease incidence but:
  1. costly, 2. intensive, 3. doesn't protect specific oaks
- Selective removal of bays 10m around oaks, significantly reduces local inoculum density and consequent oak infection
- Selective removal of bays that act as inoculum reservoirs during drought reduces intensity of future SOD outbreaks
- We don't advocate complete removal of bay laurels or very large bays, bays in strictly riparian habitats, or on steep slopes

Humboldt County, CA



Effect of tanoak density

Disease in stands with bay laurel *and* tanoak results in severe loss of tanoak

In tanoak only stands the disease removes large trees but increases small tanoak stems that develop on dead trees

However, tanoak can persist at low densities (< 44 trees ha $^{-1}$) when no bay laurel is present

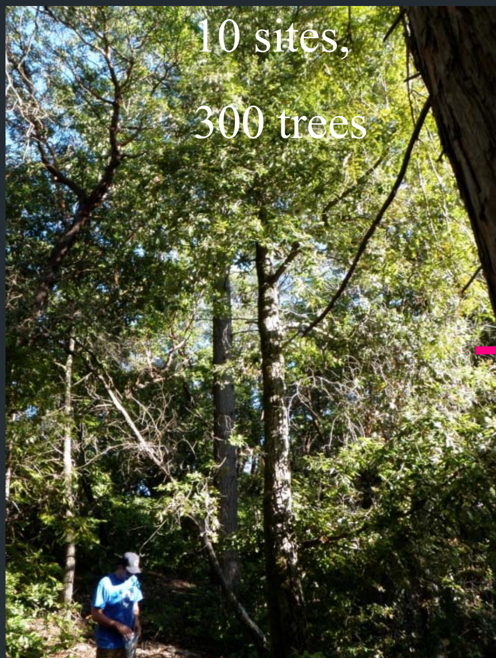
The search for the Holy Grail of resistance:

There are significant differences in susceptibility among individuals and populations

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


10 sites,
300 trees

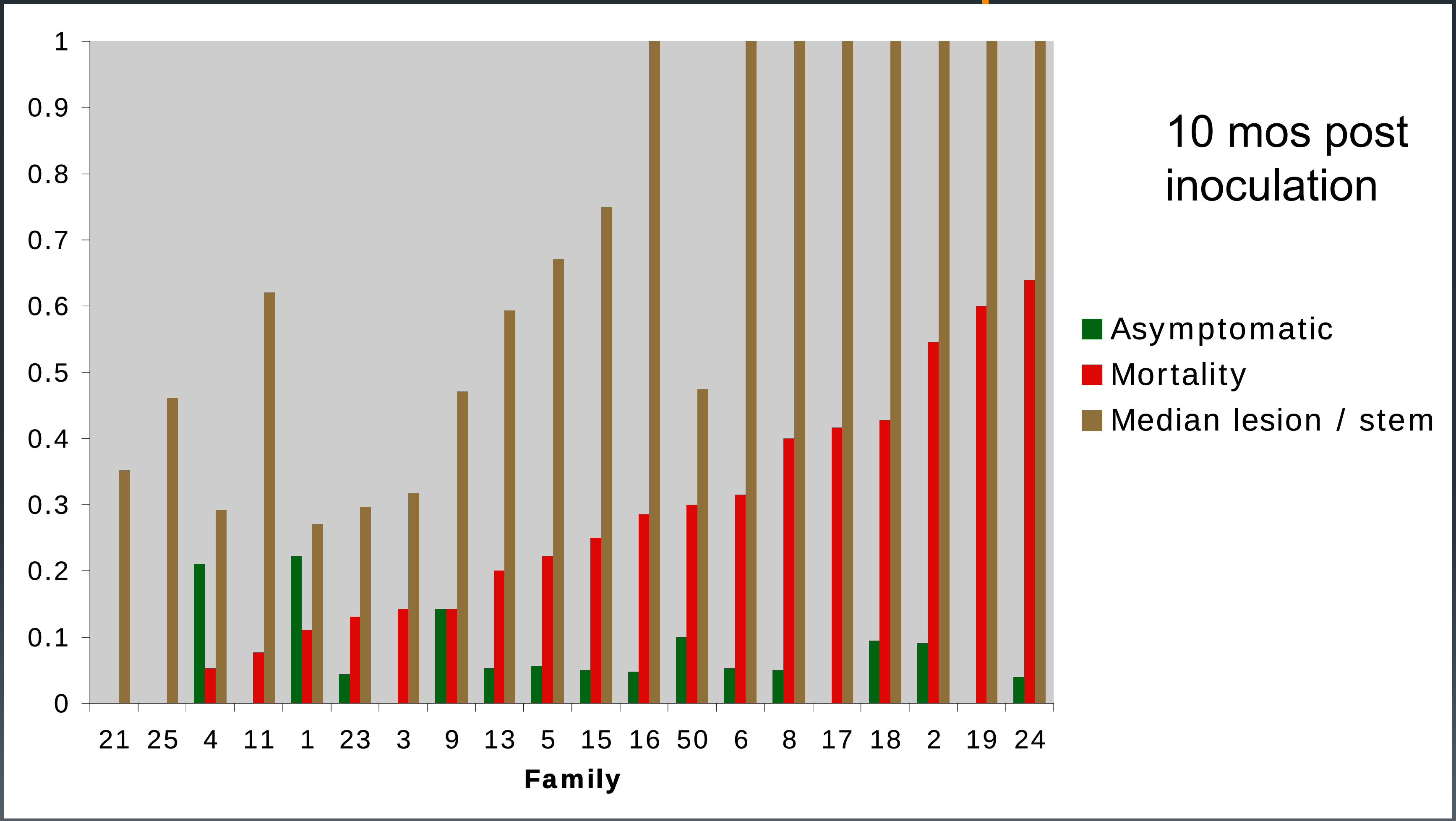

20,000


BL-5-227

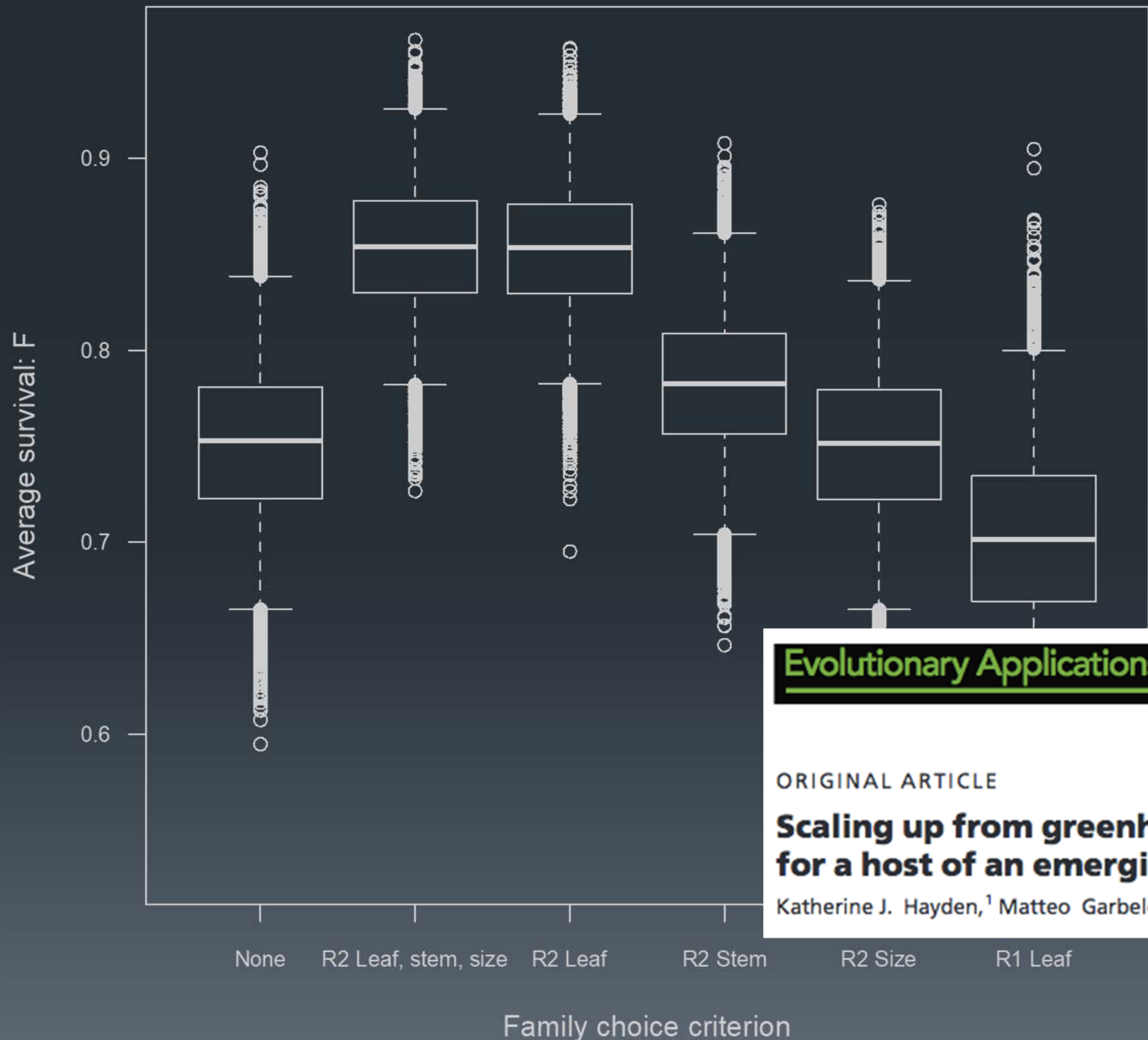

800


BL-13-236

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



Survival highest in families picked as more resistant based on lab assays



Evolutionary Applications
Open Access
Evolutionary Applications ISSN 1752-4571
ORIGINAL ARTICLE

Scaling up from greenhouse resistance to fitness in the field for a host of an emerging forest disease

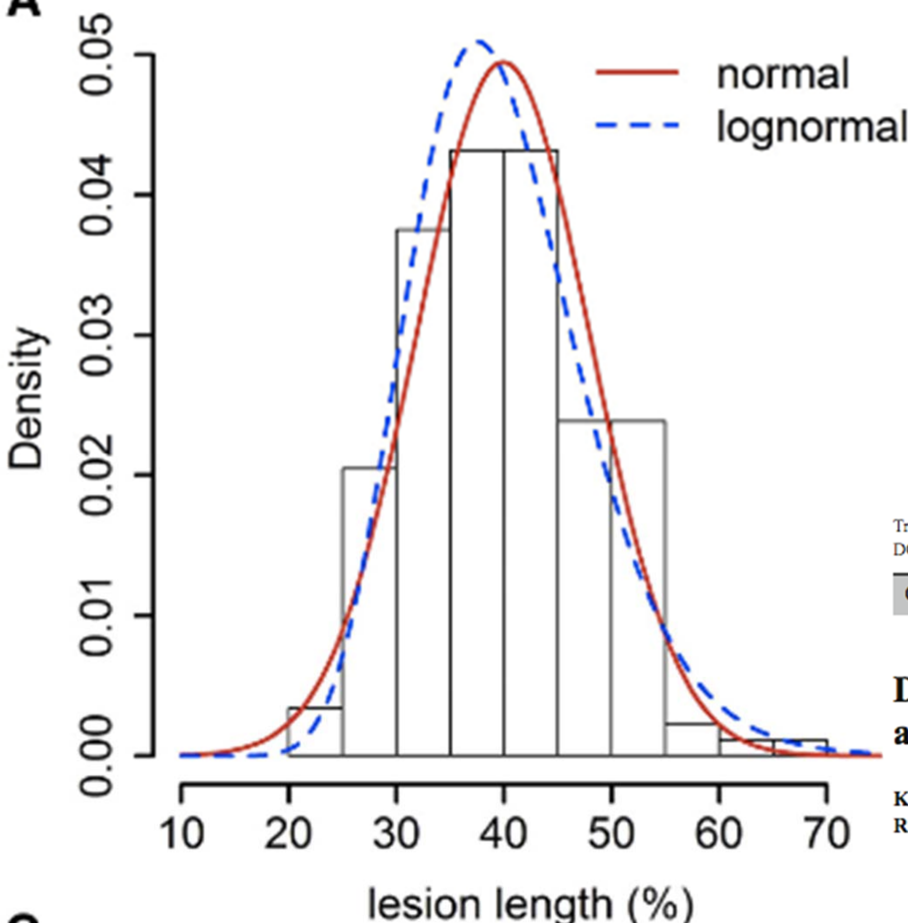
Katherine J. Hayden,[1] Matteo Garbelotto,[1] Richard Dodd[1] and Jessica W. Wright[2]

Ecology and Epidemiology

Promise and Pitfalls of Endemic Resistance for Cultural Resources Threatened by *Phytophthora ramorum*

Richard C. Cobb,[1,†] Noam Ross,[2] Katherine J. Hayden,[3,4] Catherine A. Eyre,[4] Richard S. Dodd,[4]
Susan J. Frankel,[5] Matteo Garbelotto,[4] and David M. Rizzo[6]

A



C

Normal distribution of disease tolerance but identification of tolerant families not trivial because not associated to tree morphology or neutral genetic markers

Tree Genetics & Genomes (2014) 10:489–502
DOI 10.1007/s11295-014-0698-0

ORIGINAL PAPER

Dual RNA-seq of the plant pathogen *Phytophthora ramorum* and its tanoak host

Katherine J. Hayden · Matteo Garbelotto · Brian J. Knaus ·
Richard C. Cronn · Hardeep Rai · Jessica W. Wright

Can we predict future disease spread? Which variables matter the most?

RESEARCH COMMUNICATIONS RESEARCH COMMUNICATIONS

Citizen science helps predict risk of emerging infectious disease

Ross K Meentemeyer[1,2*], Monica A Dorning[2], John B Vogler[2], Douglas Schmidt[3], and Matteo Garbelotto[3,4]

Temp. the most Important variable followed by precipitation, host density, and disease incidence

Predictive accuracy (PA) based on generalized linear logistic regressions

Model	Sample size	Equation	Predictive accuracy
2008	879(+) 689(-)	$6.19882 + 0.16551 * FOI_{2007} + 0.01188 * HOST_{dens} + 0.00737 * PRECIP$	0.61
2008-2009	983(+) 1145(-)	$5.1664 + 0.05235 * FOI_{2008} + 0.01488 * HOST_{dens} + 0.01671 * PRECIP$	0.67
2008-2010	1093(+) 1551(-)	$4.56107 + 0.03154 * FOI_{2009} + 0.01830 * HOST_{dens} + 0.01491 * PRECIP$	0.72
2008-2011	1640(+) 2562(-)	$0.06359 + 0.02408 * FOI_{2010} + 0.01728 * HOST_{dens} + 0.01741 * PRECIP - 0.25731 * T_{max}$	0.71
2008-2012	2261(+) 3600(-)	$0.03347 + 0.01418 * FOI_{2011} + 0.01897 * HOST_{dens} + 0.01242 * PRECIP - 0.21431 * T_{max} - 0.00019 * POP_{dens}$	n/a

PA Increase from 0.61 to 0.71

Currently the best performing predictive model for SOD !!

forests

MDPI

Article

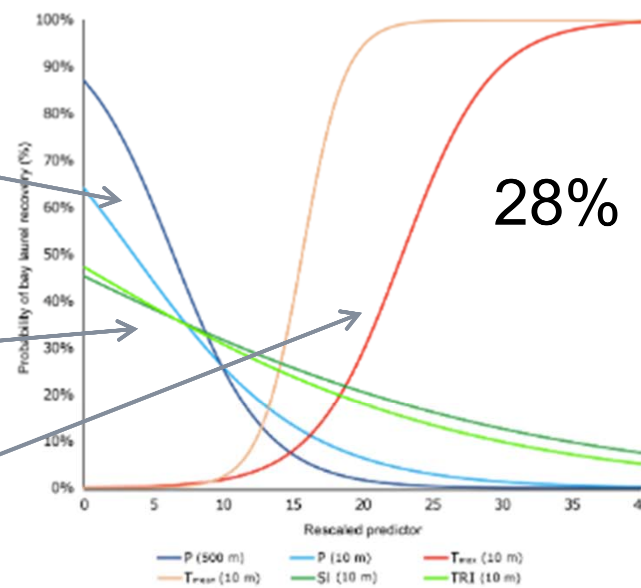
Environmental Factors Driving the Recovery of Bay Laurels from *Phytophthora ramorum* Infections: An Application of Numerical Ecology to Citizen Science

Guglielmo Lione [1,2], Paolo Gonthier [1] and Matteo Garbelotto [2,*]

precipitation

slope

temperature

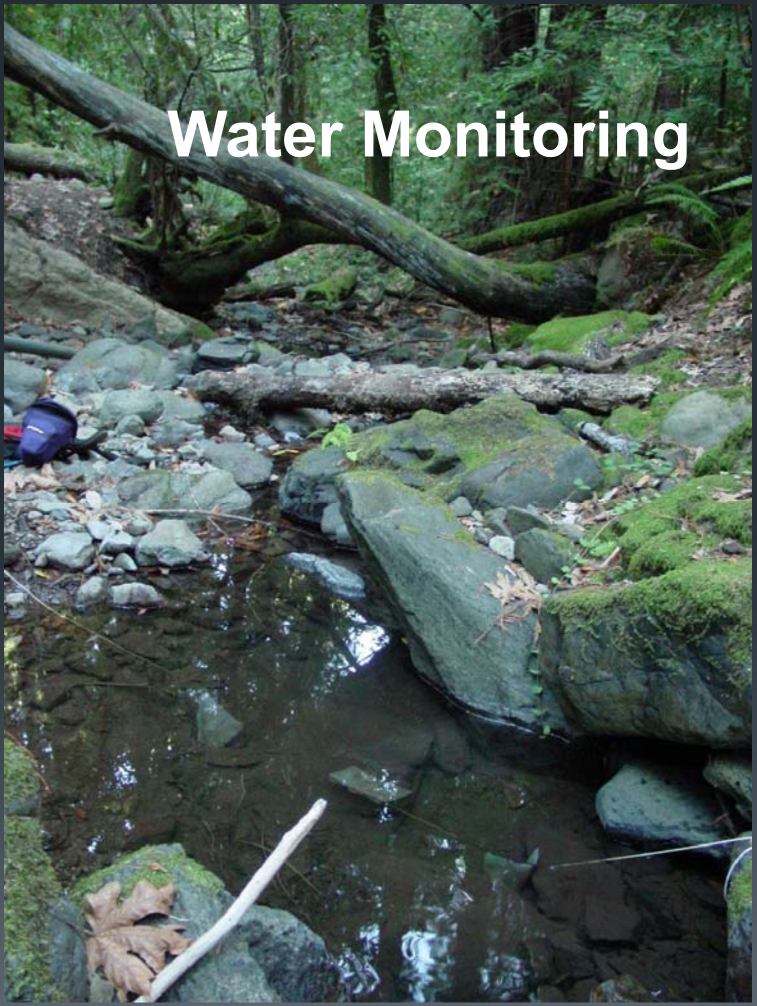


28% recovery!

Figure 6. Graphs of the logistic equations modelling the probability of bay laurel recovery based on the single significant predictors detected in scenario-500 m (500 m) and scenario-10 m (10 m). The abscissa (rescaled predictor) represents each factor eventually rescaled so that one unit equals: 100 mm for precipitations (P), 1 °C for temperatures (T), 1% for slope (Sl) and 10 points of terrain ruggedness index (TRI). For more details about factors acronyms, see the main text.

Prevention is key!

Early Detection



RESEARCH ARTICLE

Three new *Phytophthora* detection methods, including training dogs to sniff out the pathogen, prove reliable

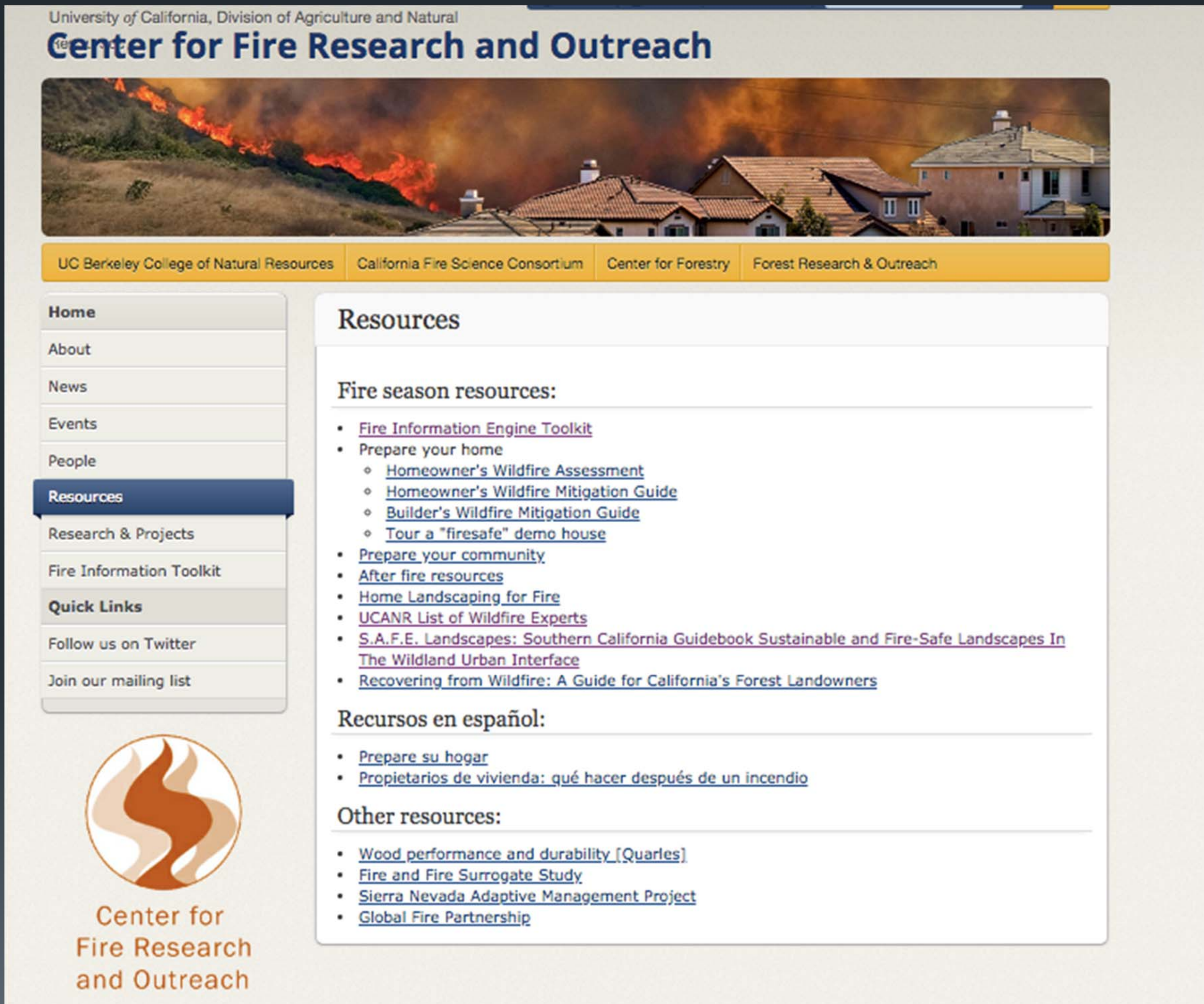
A scent detection dog identified *Phytophthora* in media with a 100% accuracy; two other simple and cost-effective methods detected the pathogen with great confidence directly from plants.

by Tedmund J. Swiecki, Matt Quinn, Laura Sims, Elizabeth Bernhardt, Lauralea Oliver, Tina Popenuck and Matteo Garbelotto

Dog training

P. ramorum
P. cinnamomi
P. nemorosa
P. cactorum

water, soil, infected plants


University of California, Division of Agriculture and Natural
Center for Fire Research and Outreach
UC Berkeley College of Natural Resources
California Fire Science Consortium
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Center for Fire Research and Outreach
Resources
Fire season resources:
Fire Information Engine Toolkit
Prepare your home
Homeowner's Wildfire Assessment
Homeowner's Wildfire Mitigation Guide
Builder's Wildfire Mitigation Guide
Tour a "firesafe" demo house
Prepare your community
After fire resources
Home Landscaping for Fire
UCANR List of Wildfire Experts
S.A.F.E. Landscapes: Southern California Guidebook Sustainable and Fire-Safe Landscapes In The Wildland Urban Interface
Recovering from Wildfire: A Guide for California's Forest Landowners
Recursos en español:
Prepare su hogar
Propietarios de vivienda: qué hacer después de un incendio
Other resources:
Wood performance and durability [Quarles]
Fire and Fire Surrogate Study
Sierra Nevada Adaptive Management Project
Global Fire Partnership

Defensible space

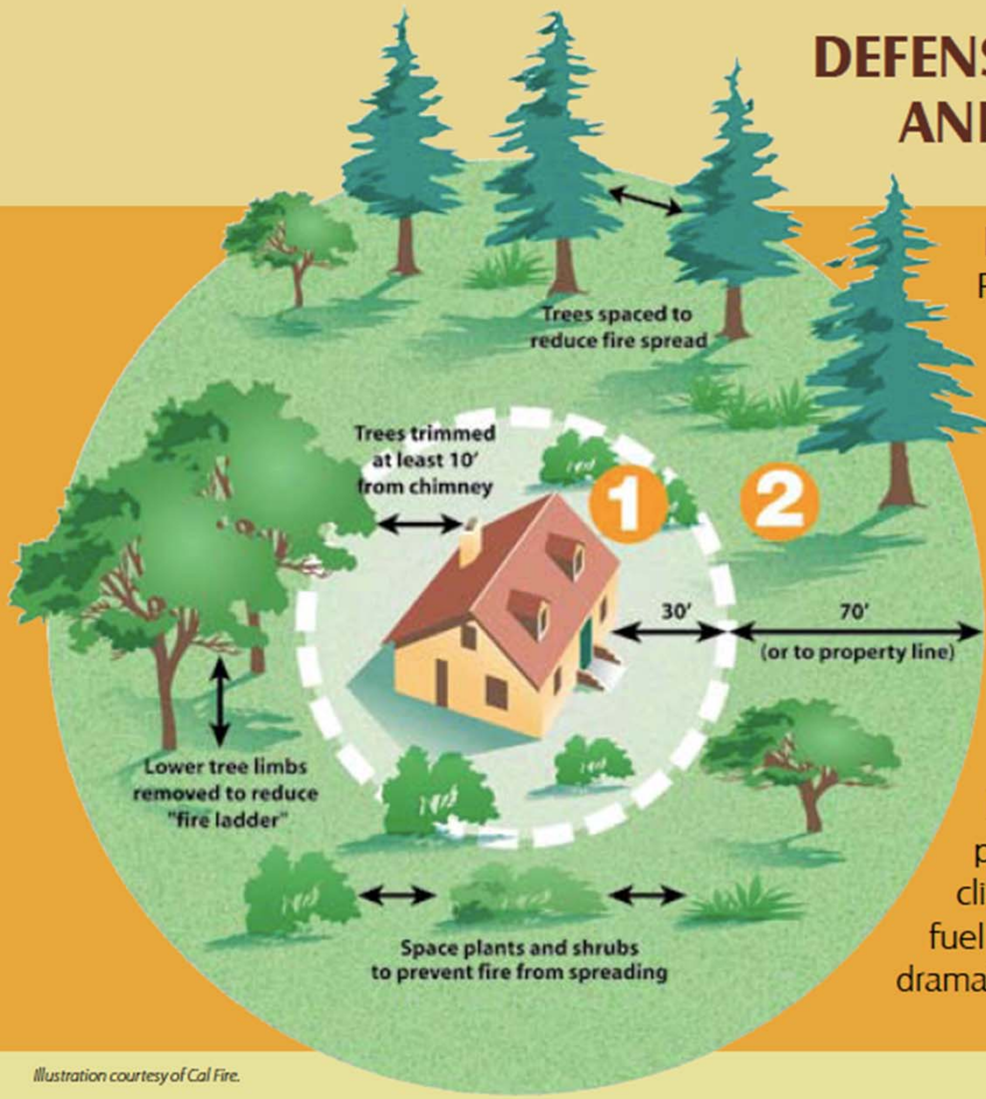
- Fire Resilient Landscaping: use appropriate species, flammability and plant architecture, avoid invasive, plant taking into consideration location and possible ladder role the vegetation may play

- Proper Vegetation Management

- Fire Resilient building: : Fire safe homes through appropriate design and materials

From the “SAFE landscapes brochure”

DEFENSIBLE SPACE AND FIRE-SAFE LANDSCAPES



DEFENSIBLE SPACE

Providing a “defensible space” can reduce the risk of structural damage caused by wildfire. This space, at least 100 feet wide in California, is the area surrounding a structure where plants are maintained in a way that decreases the fire hazard and provides an opportunity for firefighters to safely defend your home. Vegetation that does not ignite easily should be planted in the defensible space. Landscape plants protect soils from erosion and provide aesthetic and ecological benefits. Trees and shrubs are acceptable as long as they are widely spaced and do not provide a continuous path of fuel for a fire to climb from the ground to a tree crown or roof (a fuel ladder). Proper landscape maintenance can dramatically improve the fire safety of a yard.

Illustration courtesy of Cal Fire.

Fire safe home: materials

1. Fire rating (A to C)
2. Energy Efficiency
3. Green Technology and Sustainability
4. Health and Safety
5. Company safety records, recognition, and diversity

Why Now and Why California?

In the US, California is fertile ground for the rapid adoption and growth of mineral wool board insulation used to wrap the exterior walls of homes and buildings before certain sidings or claddings are applied. This is due to:

1. **growing free market choices** related to building and consumer products and their environmental attributes;
2. **a steady progression of climate and environmental law and policy** impacting buildings;
3. **past and expected enhancements to energy and other codes** applicable to commercial, multifamily and single-family homes -- with a focus on the building envelope; and
4. **the tragic devastation resulting from multiple wild fires** that have leveled entire communities and uprooted citizens and businesses.

Provide details on what is on the market with a more global outlook