Survival of *Phytophthora ramorum* following wildfires in the sudden oak death-impacted forests of the Big Sur region

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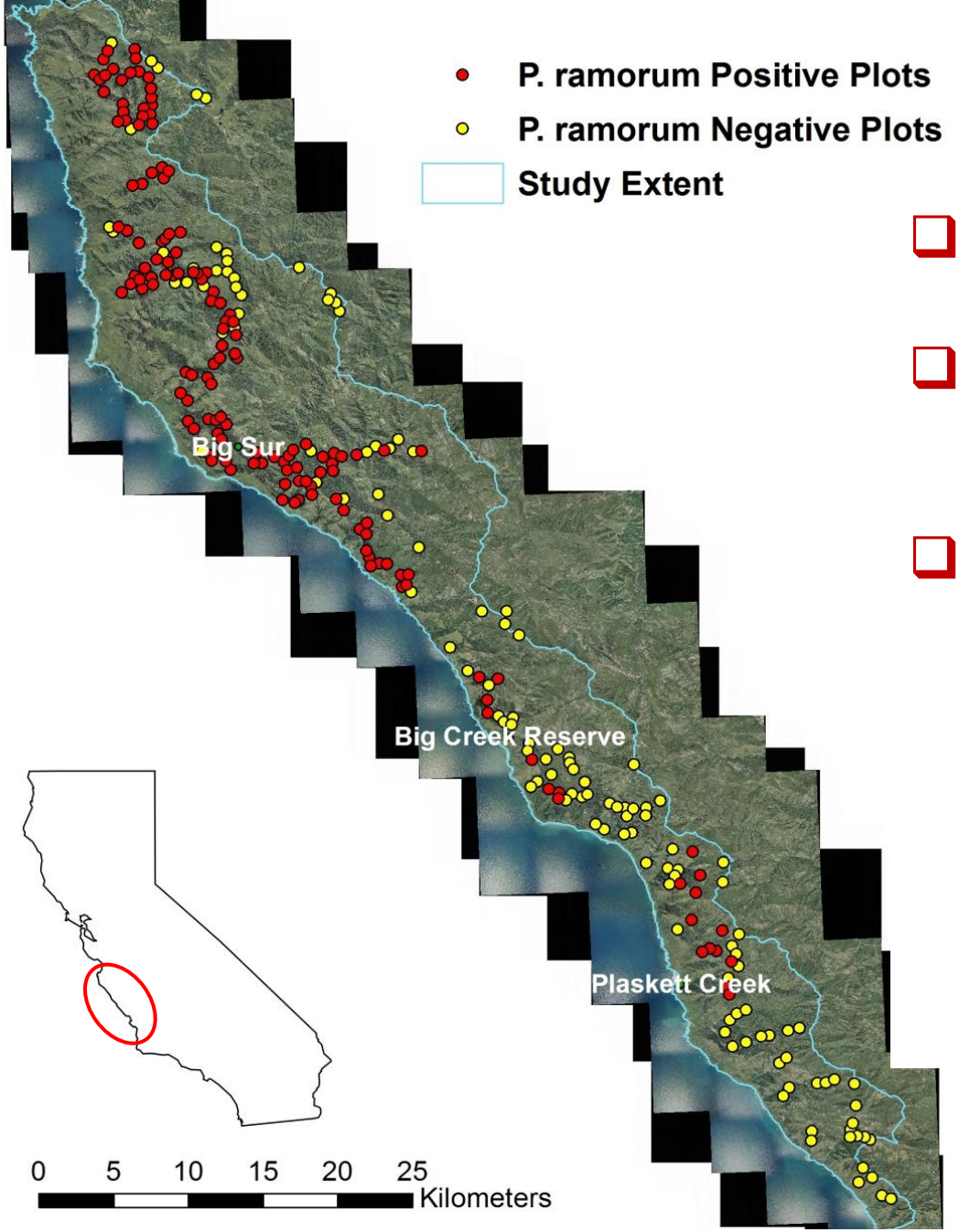
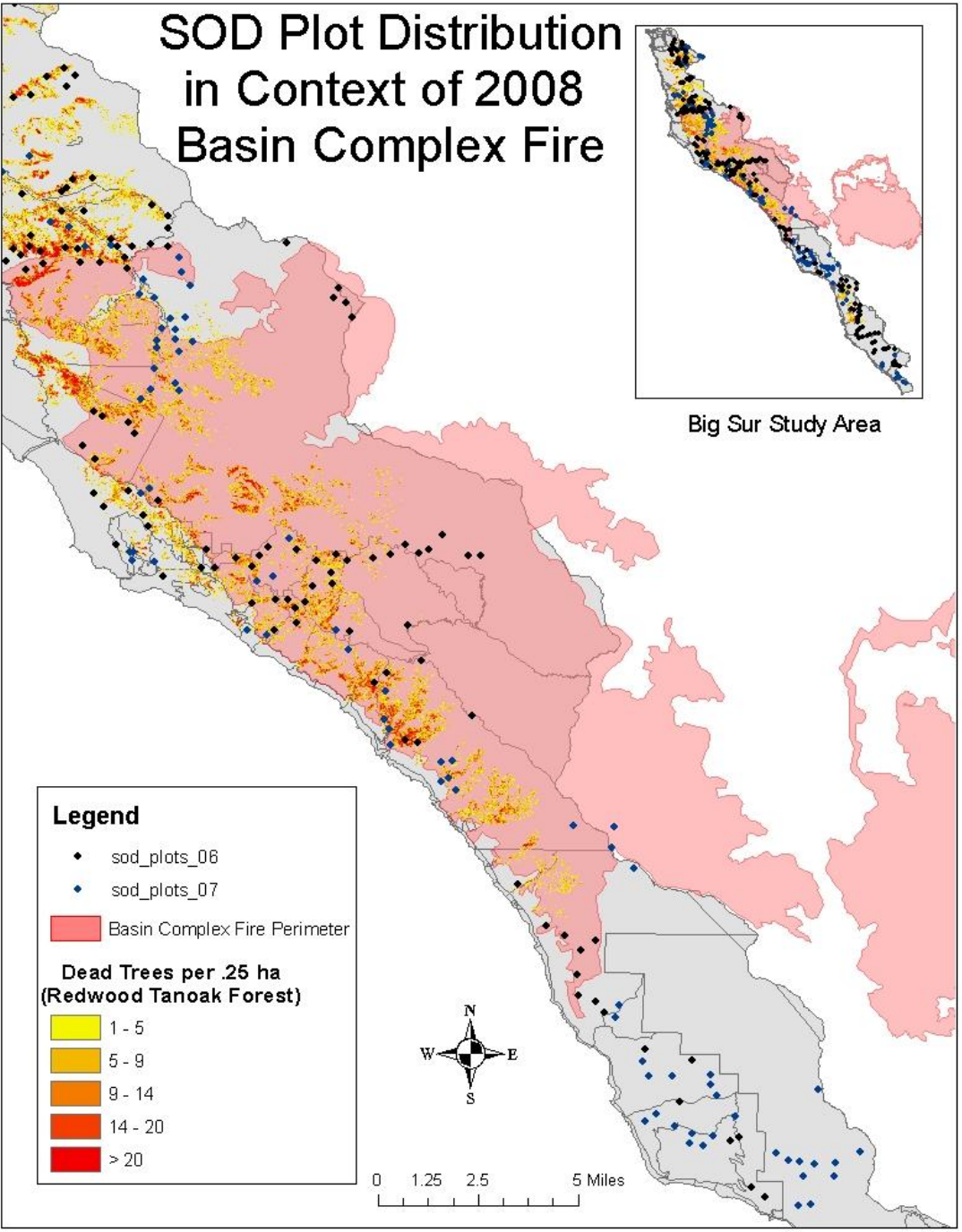
The study area

- Botanical and ecological diversity
- Infested early-on with *P. ramorum*
- Very high mortality levels due to sudden oak death

The plot network



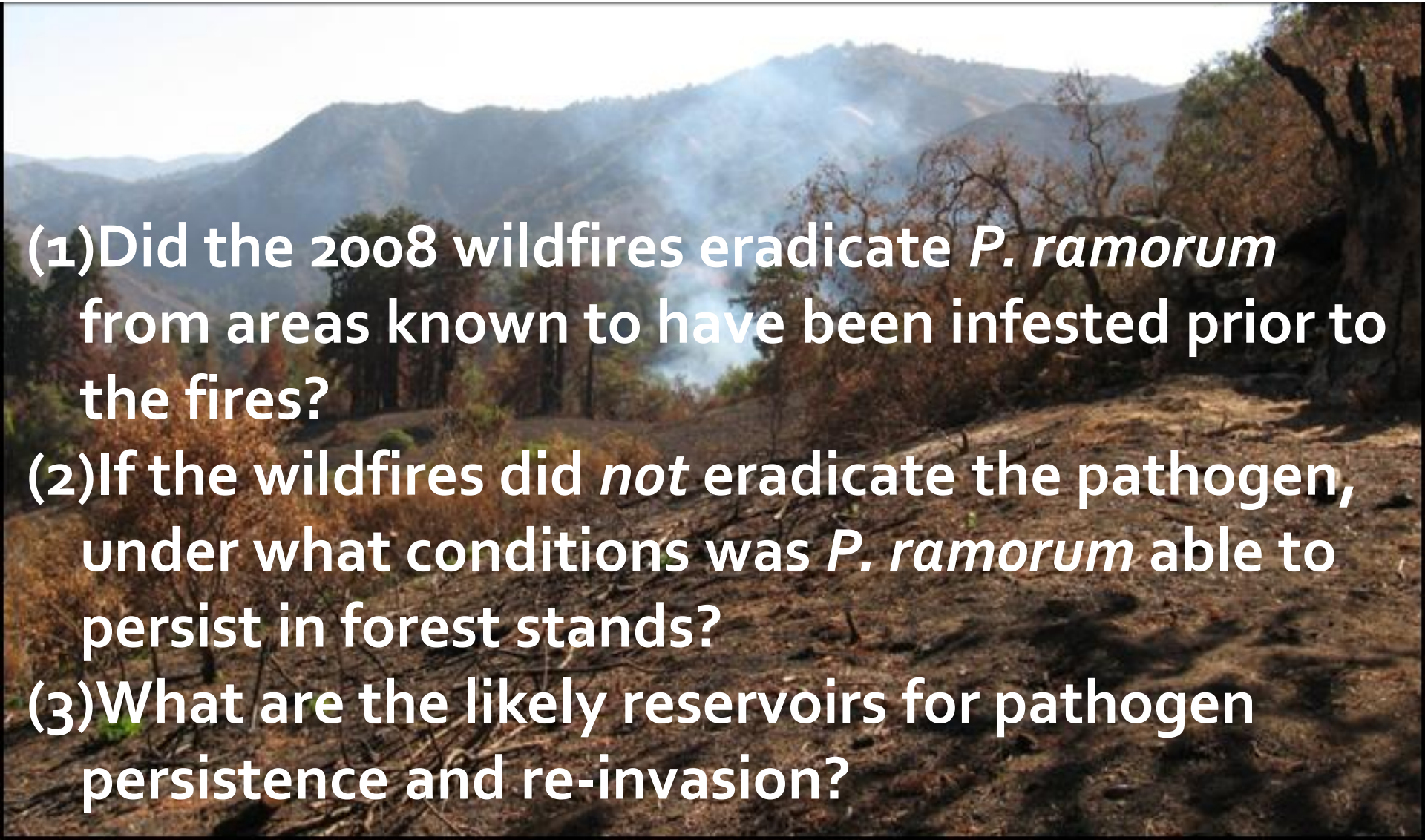
- 280 plots (each 500-m²) established in 2006 and 2007
- Stratified across watersheds, forest type, fire history, and SOD mortality
- Baseline data collected in plots upon establishment
  - All stems ≥1 cm dbh measured
  - *P. ramorum* symptoms and incidence in individual trees
  - Cylindrical volume of logs ≥ 20 cm
  - Other biological and physical characteristics of forest



Fires of 2008

- First major wildfires in forests infested with *P. ramorum*
- ~95,000 hectares burned in Basins-Indians Complex Fire
- ~6,400 hectares burned in the Chalk Fire
- 120 plots located within fire perimeters
- Completed burn severity measurements in ~60 burned plots during September-November 2008

Research Questions



(1)Did the 2008 wildfires eradicate *P. ramorum* from areas known to have been infested prior to the fires?

(2)If the wildfires did *not* eradicate the pathogen, under what conditions was *P. ramorum* able to persist in forest stands?

(3)What are the likely reservoirs for pathogen persistence and re-invasion?

Methods

Recovery results

***P. ramorum* recovery in burned plots was dis-proportionately low**

2009

9/45 (20%) burned plots

vs.

13/18 (72%) unburned plots

[χ^2=13.21, df=1, P< 0.001]

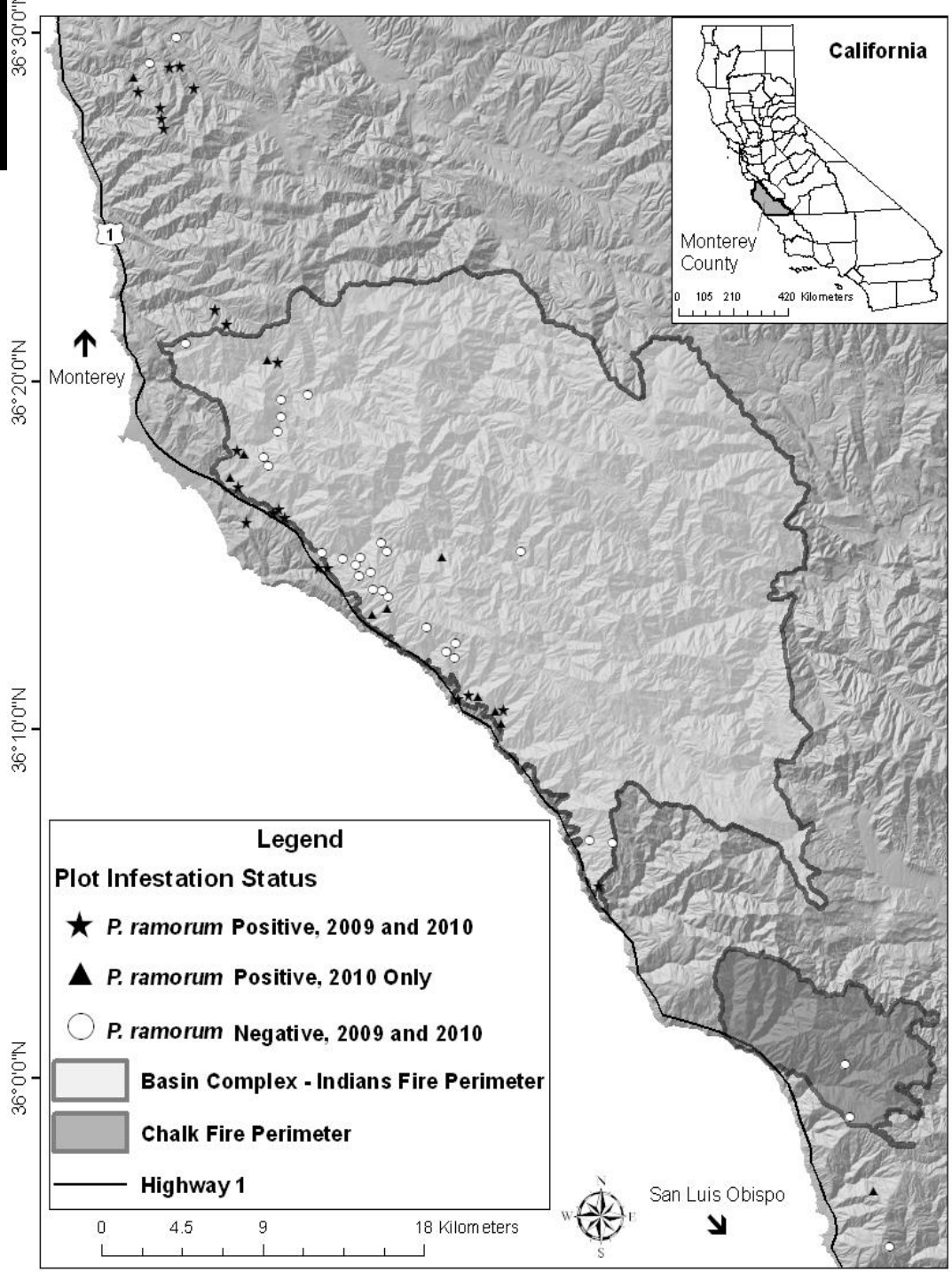
2010

18/45 (40%) burned plots

vs.

15/18 (83%) unburned plots

[χ^2=8.01, df=1, P< 0.01]



24 plot-level variables

- **BURN SEVERITY INDICES**
  - Composite (0-3)*
  - Dominant trees (0-3)*
  - Substrate (0-3)*
  - Proportion of dead bay basal area†
  - Proportion of dead tanoak basal area†

- **PRE-FIRE HOST DENSITY**

Bay laurel:
- Cover class (0-7)
- Live basal area (m^2/plot)
- Dead basal area (m^2/plot)
- Total (live + dead) basal area (m^2/plot)

Tanoak:
- Cover class (0-7)
- Live basal area (m^2/plot)
- Dead basal area (m^2/plot)
- Total (live + dead) basal area (m^2/plot)

- **POST-FIRE HOST DENSITY**
  - Live **bay** basal area (m^2/plot)
  - Live **tanoak** basal area (m^2/plot)

- **PRE-FIRE DISEASE LEVELS**
  - Number of symptomatic bays/plot
  - Number of symptomatic tanoaks/plot
  - Number of cankered trees/plot
  - Total log volume (m^3/plot)
  - Host log volume (m^3/plot)

- **LANDSCAPE FACTORS**
  - Slope (°)
  - Aspect (°)
  - Elevation (m)
  - Distance to nearest road (m)

*Key &Benson, 2006

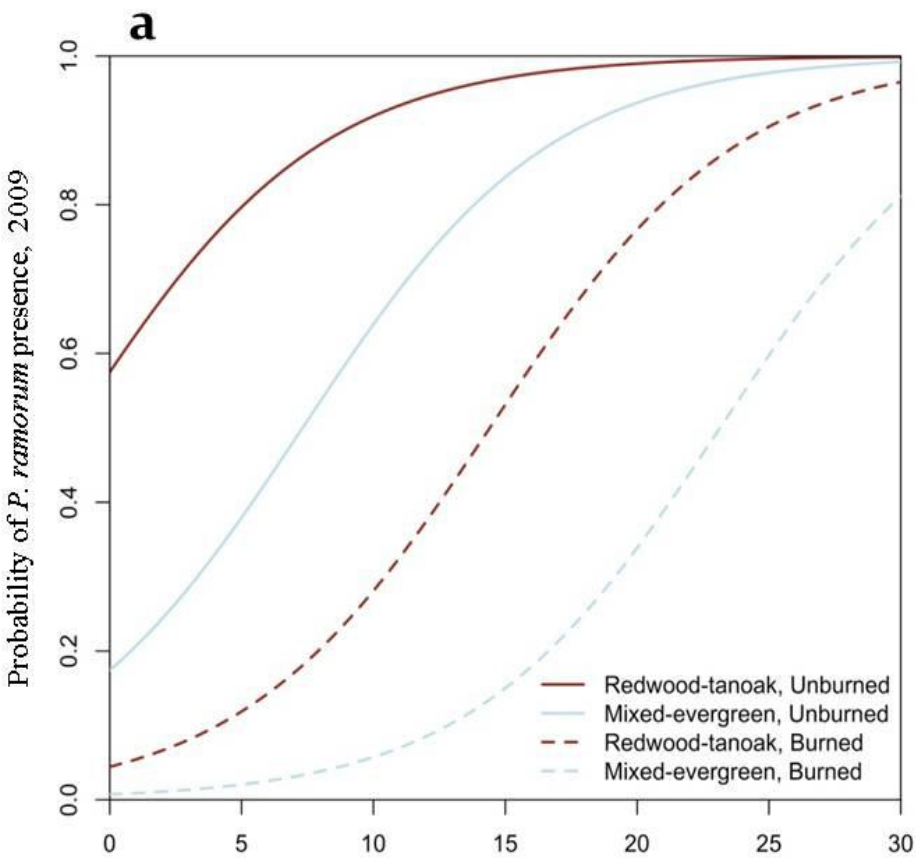
† based on cumulative mortality, 2006-2009

Multiple logistic regression model

	2009		2010	
Predictor variable[b]	**Odds ratio**	***P* -value**	**Odds ratio**	***P* -value**
Burn status: Unburned vs. Burned	29.117	0.009**	5.740	0.129
Forest type: RT[c] vs. ME[d]	6.418	0.134	11.682	0.038*
Pre-fire plot variables				
Total basal area, bay	2.006	0.627	6.670	0.094.
Total basal area, tanoak	3.156	0.128	1.164	0.817
No. of symptomatic bays	1.237	0.008**	1.079	0.200
No. of symptomatic tanoaks	1.056	0.267	1.016	0.708
Post-fire plot variables				
Prop. dead basal area, bay	0.053	0.133	0.019	0.006**
Prop. dead basal area, tanoak	0.276	0.436	0.972	0.981
AUC value	0.943		0.920	

Probability of *P. ramorum* presence…..

….in 2009 in response to varying numbers of pre-fire symptomatic bay laurels



No. of symptomatic bays prior to wildfire

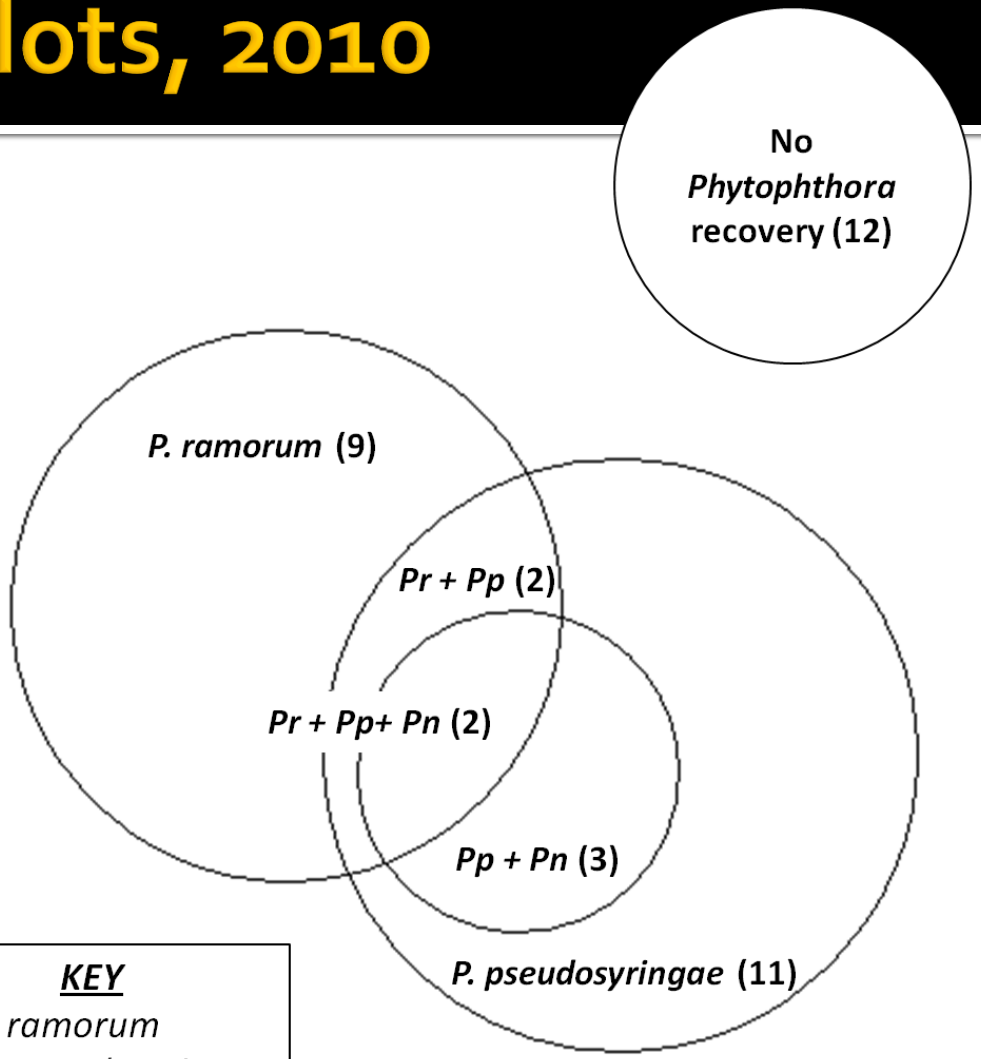
Recovery from hosts and tissue types

- In burned plots in 2009 and 2010, at least twice the recovery rate from bay laurel crown leaves compared to basal sprout leaves

- Opposite trend for bay laurel in unburned plots and for tanoak in all plots types

Co-occurrence of other *Phytophthora* species in burned plots, 2010

- No plots in which *P. pseudosyringae* or *P. nemorosa* were recovered known to contain these pathogens prior to fires
- *P. pseudosyringae* not recovered from any unburned plots
- Recovered predominantly from mixed evergreen plots (78% plots) and from bay laurel basal sprouts



KEY
Pr= P. ramorum
Pp= P. pseudosyringae
Pn= P. nemorosa

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- Los Padres National Forest
- Landels-Hill Big Creek Reserve
- Monterey Peninsula Regional Park District
- Numerous private landowners in the Big Sur region