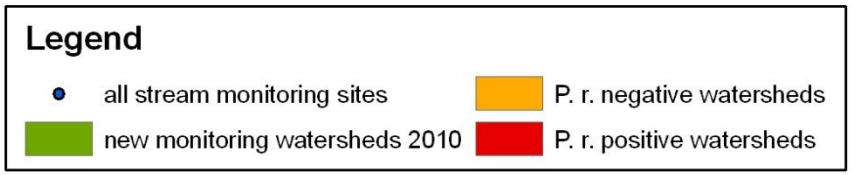
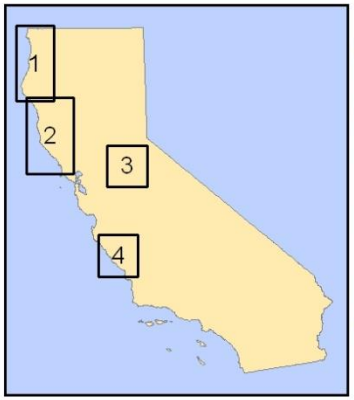
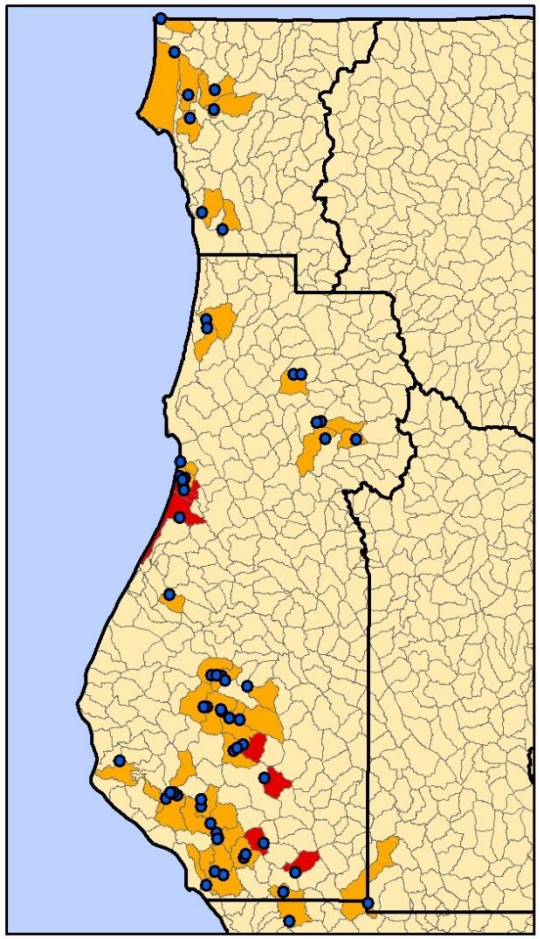
Phytophthora in streams

Stream Monitoring Detection of *Phytophthora ramorum* 2004-2009

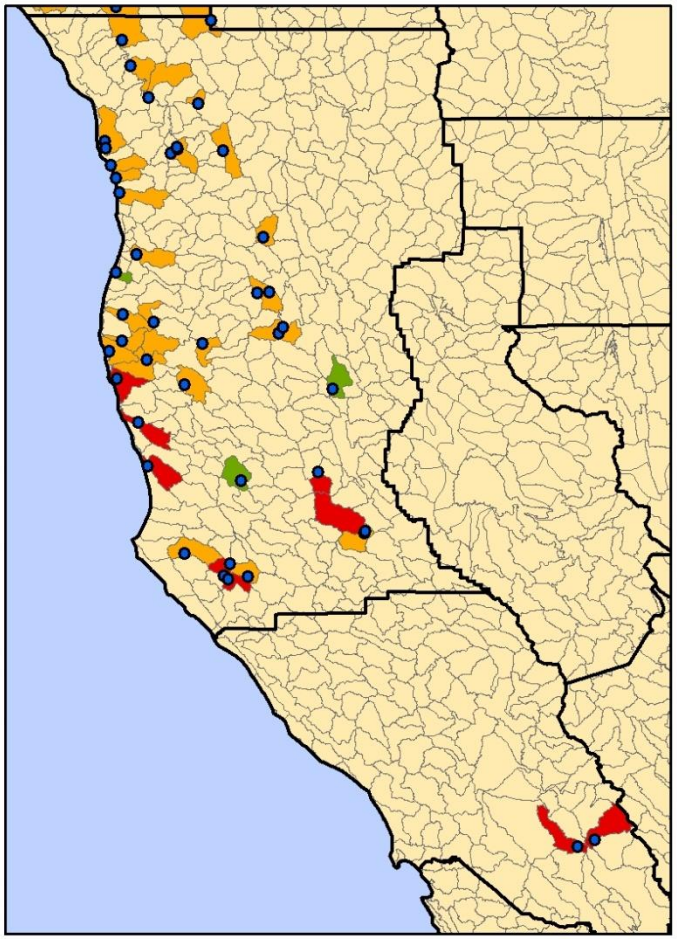




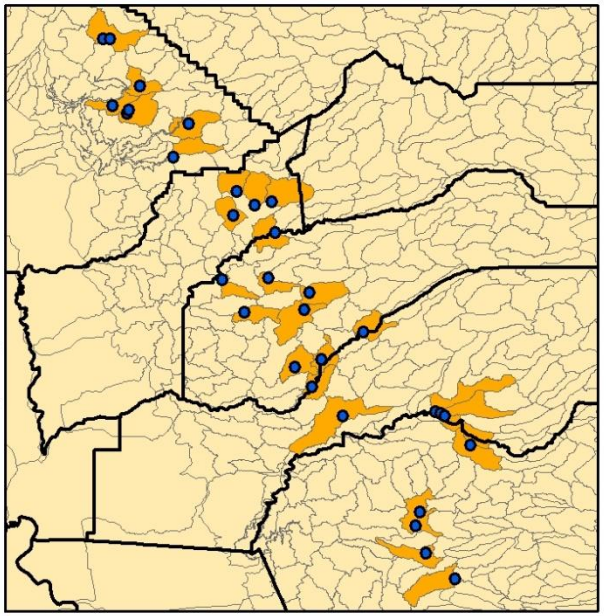
1. Del Norte & Humboldt Co.



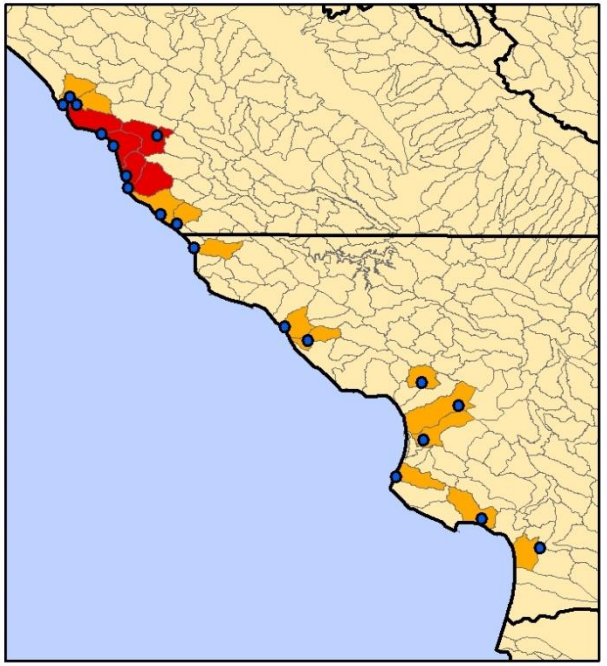
2. Mendocino & Sonoma Co.



3. Northern Sierra Nevada



4. South Monterey & San Luis Obispo Co.



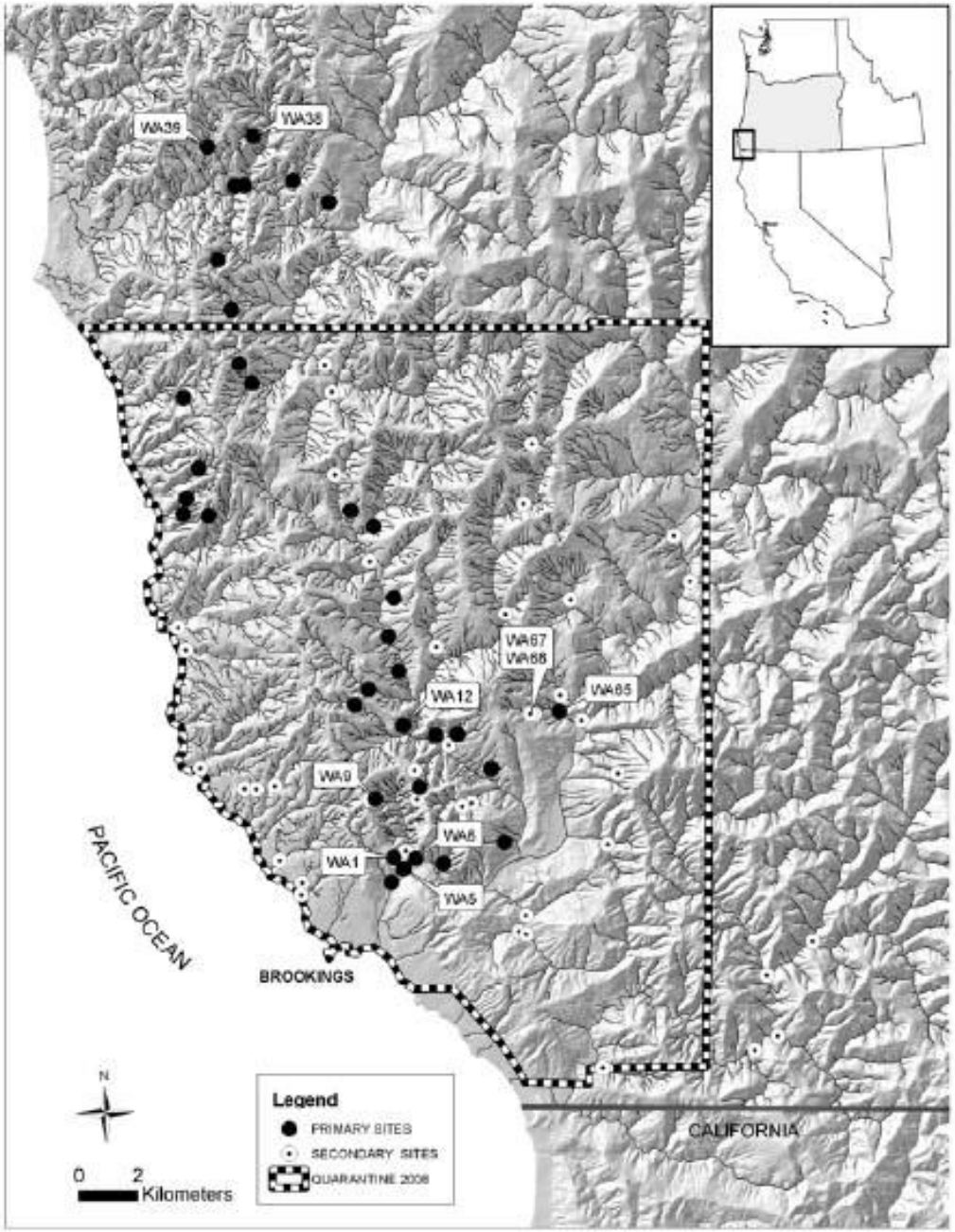
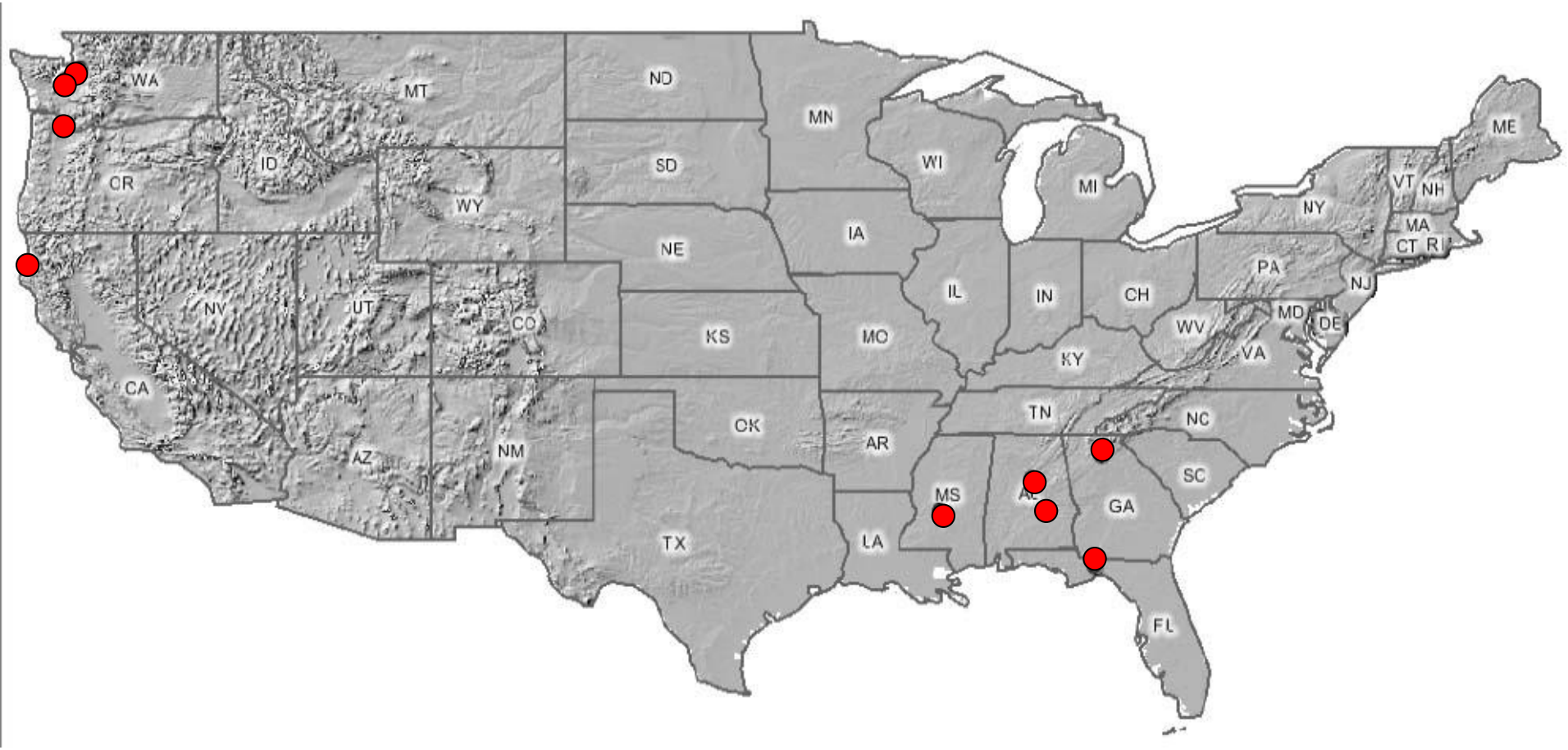


Fig. 1. *Phytophthora ramorum* stream monitoring sites in southwest Oregon. Primary sites include 32 monitored continuously from 2004 to 2008 and three others highlighted in the text (WA 38, WA 39, and WA 65). Thirty-six secondary sites were monitored for various lengths of time during this period.

Sutton et al. 2009



Locations where *Phytophthora ramorum* has been detected in waterways associated with nurseries. (Chastagner et al., 2010)

http://www.biology.ed.ac.uk/research/groups/jdeacon/microbes/zoospore.htm


Phytophthora lateralis
Image: E. Hansen

Phytophthora alni

Image: T. Jung

Phytophthora in streams

What are we looking for?

- **Known pathogens (e.g., *P. ramorum*)**
- **Unknown organisms (i.e., potential pathogens)**
- **Biodiversity studies to set baselines**

Phytophthora in streams

- **Biodiversity**

- **Ecology**

Stream Surveys in Oregon and Alaska Forests

- ***P. gonapodyides***
- ***P. megasperma***
- ***P. cactorum***
- ***P. siskiyouensis***
- ***P. plurivora***
- ***P. pini***
- ***P. nemorosa***
- ***P. pseudosyringae***
- ***P. cambivora***
- ***P. syringae***
- ***P. europaea***
- ***P. ramorum***
- **Six undescribed Phytophthoras**
- ***Halophytophthora***

(Reeser et al., in press)

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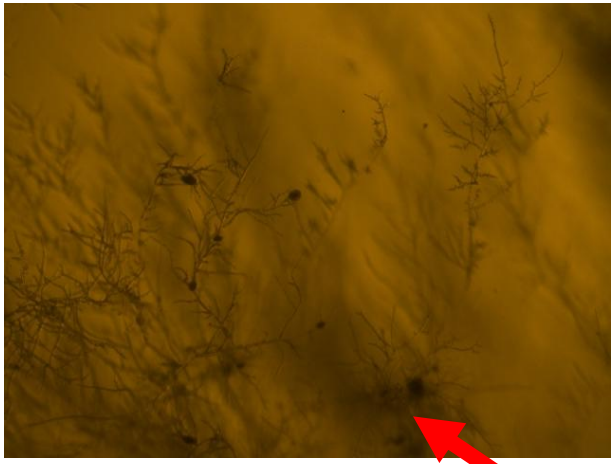
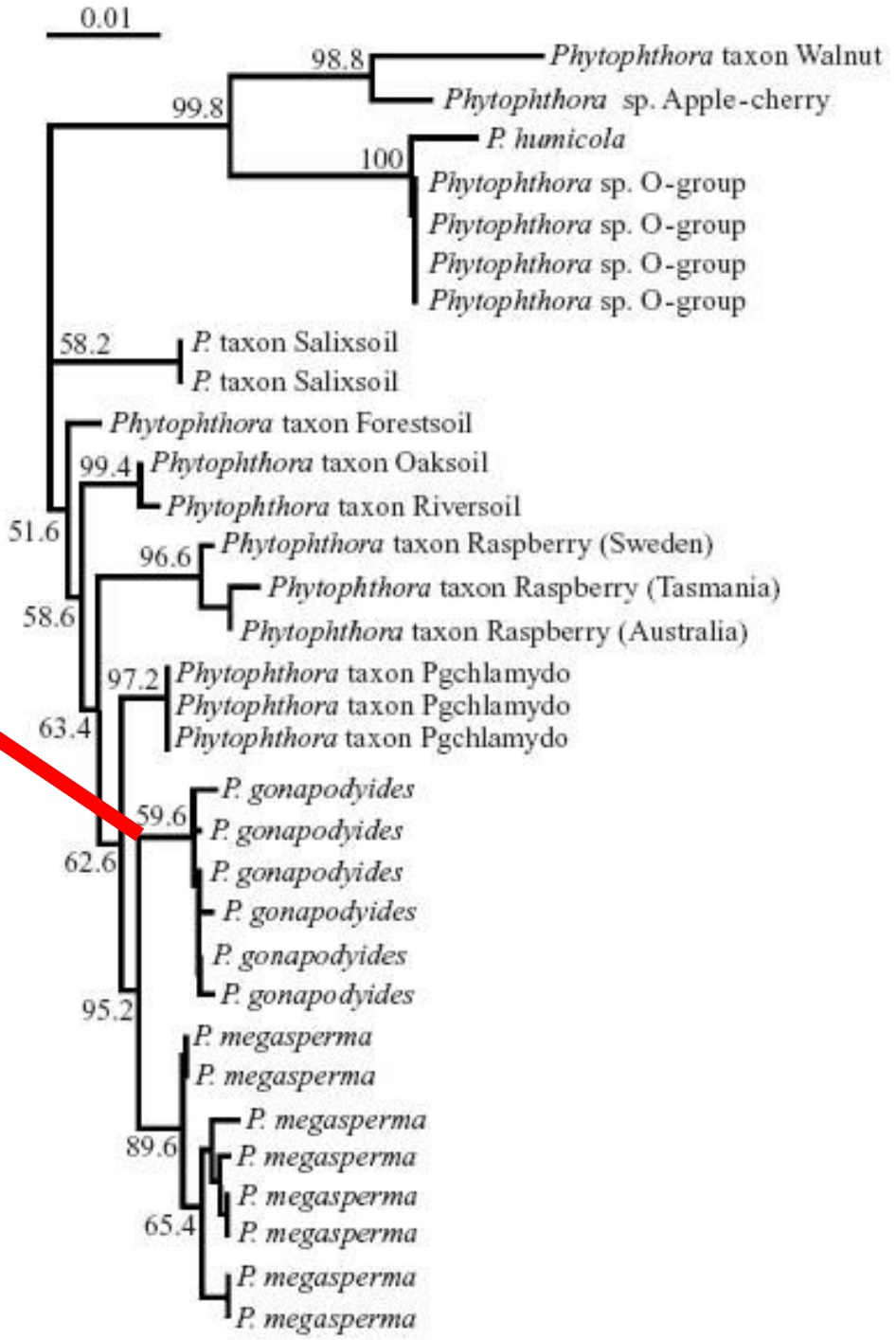
Clade 6





(Brasier et al., 2003)

Stream Surveys of Eastern US Forests

- ***P. gonapodyides***
- ***P. cinnamomi***
- ***P. cambivora***
- ***P. citricola***
- ***P. pseudosyringae***
- ***P. citrophthora***
- ***P. heveae***
- **seven undescribed Phytophthoras**

(Hwang et al., 2009, 2010)

Phytophthora species / taxa Post 2000

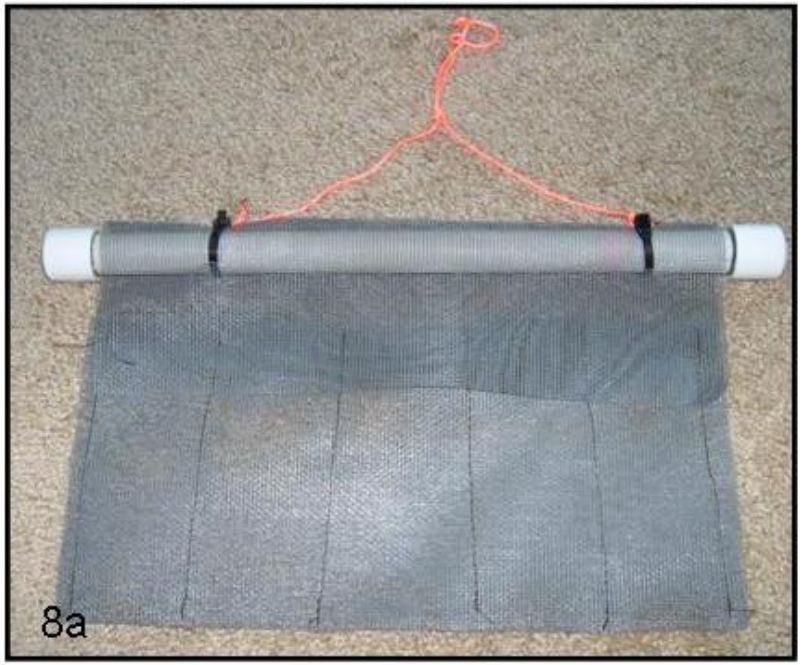
Associated with research on nursery trees, forests and natural ecosystems

P. alni (x 3)	*P. kernoviae*	*P. frigida*	*P.* taxon *salixsoil*
P. andina	*P. nemorosa*	*P. austrocedrae*	*P.* tax. *pgchlamydo*
P. asparagi	*P. niederhauserii*	*P. lagoariana*	*P.* taxon *riversoil*
P. bisheria	*P. pistaciae*	*P. cuyabensis*	*P.* taxon *oaksoil*
P. brassicae	*P. polonica*	*P. cact x hedr*	*P. parvasperma*
P. captiosa	*P. pseudosyringae*	*P. foliorum*	*P .hungarica*
P. europaea	*P. psychrophila*	*P. sulawesiensis*	*P. sylvatica*
P. fallax	*P. ramorum*	*P. siskiyouensis*	*P. carica*
P. gallica	*P. sansomea*	*P. uliginosa*	*P. quercetorum*
P. glovera	*P.* taxon Banksia		*P.* tax. meadii-like
P. hedraiandra	*P.* taxon. chicory		*P.* taxon Acer
P. inundata	*P. cact x nic*		*P.* taxon Agathis
P. ipomoeae	*P. tropicalis*		*P.* taxon orphan
P. kelmania	*P. alticola*		30+/50 = 60+%

Source: C. Brasier

Detection of *Phytophthora* in Streams

- **Sampling method**
- **Timing of sampling**
  - **Daily**
  - **Season**
- **Location**
  - **Habitat**
  - **Stream type, size**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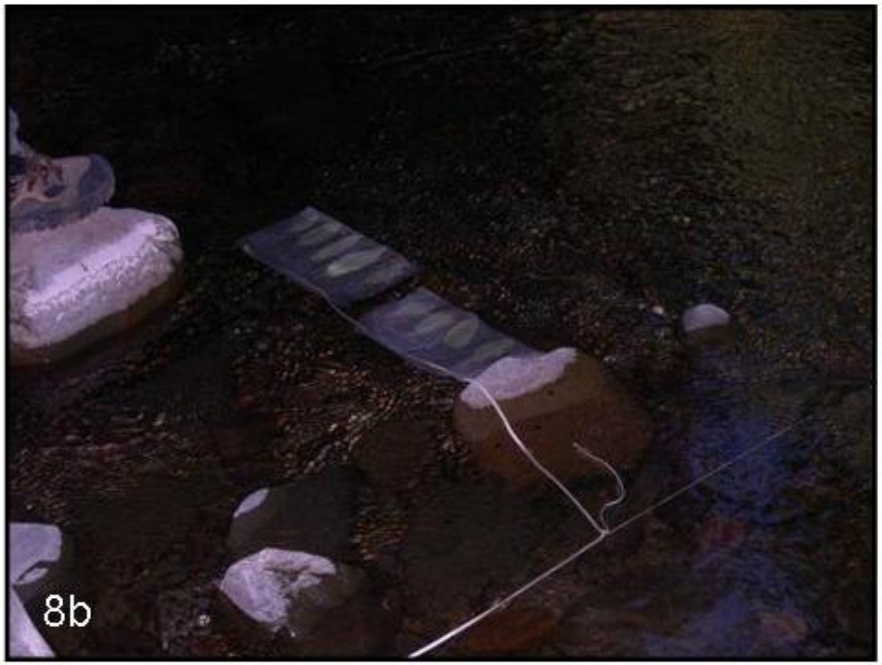
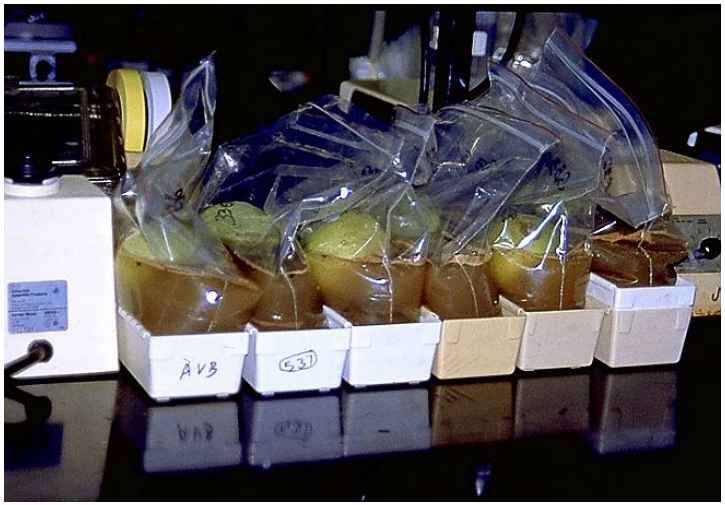

8b

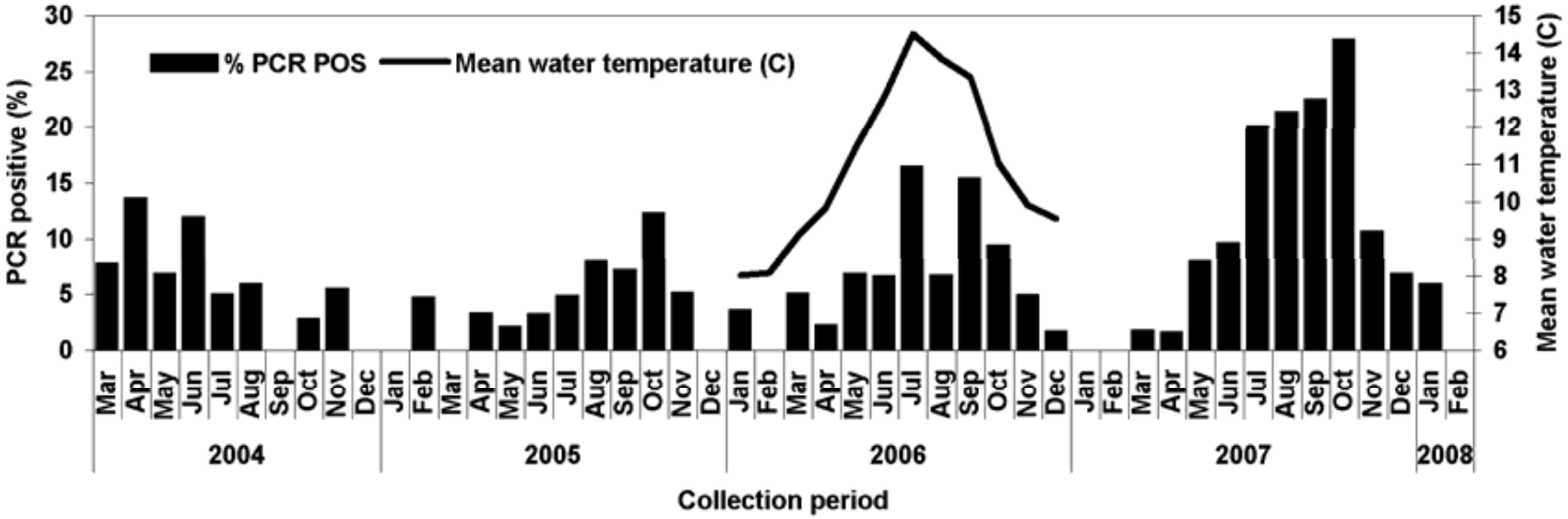

1
2
3
4
5

Filtering *Phytophthora* from Streams



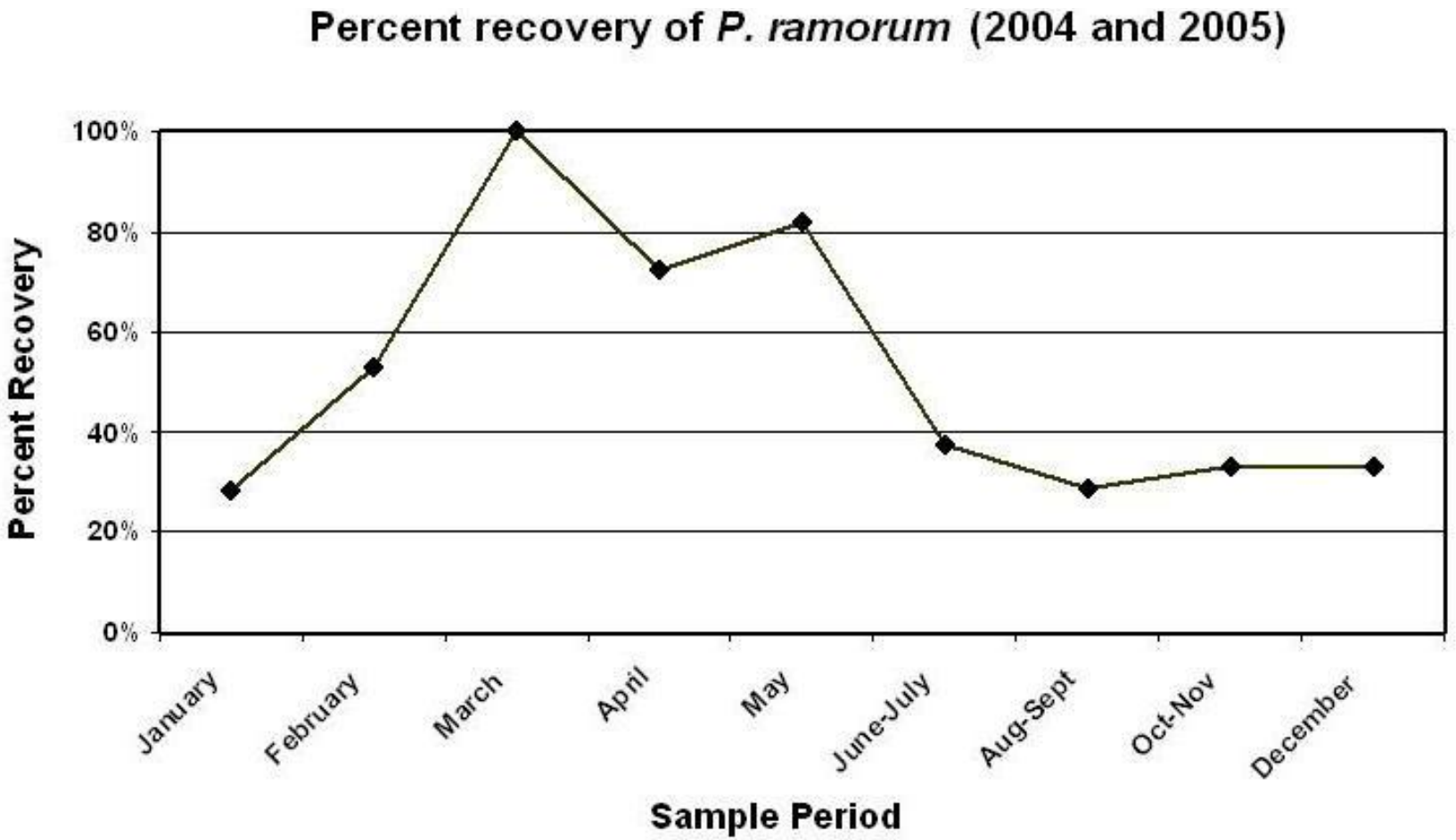
Pear baiting

Recovery of *Phytophthora ramorum* Oregon streams



Sutton et al., 2009

Recovery of *Phytophthora ramorum* California streams



Phytophthora in streams

- **Biodiversity**

- **Ecology**

Phytophthora in streams: Ecology

…very little is known about the active phase of aquatic phycomycetes.

M. W. Dick, The Ecology of Aquatic Phycomycetes, 1976

Phytophthora in streams: Ecology

Studies of largely unexplored non-agricultural ecosystems….are likely to reveal large numbers of 'new' undescribed oomycete species with yet unknown functions, capabilities, or host ranges. (Nechwatal et al., 2008)

***Phytophthora* species are generally regarded as 'water moulds', but their aquatic ecology is largely unknown. (Ghimire et al., 2009)**

Previous work suggested that *Phytophthora* species are relatively abundant in natural streams in healthy forests, but the species present are poorly characterized and their ecology is essentially unknown. (Resser et al., in press)

A search of science-based solutions to this crop health issue reveals a surprising lack of information on the aquatic ecology of *Phytophthora* species. (Kong et al, 2009)

Phytophthora in streams: Ecology

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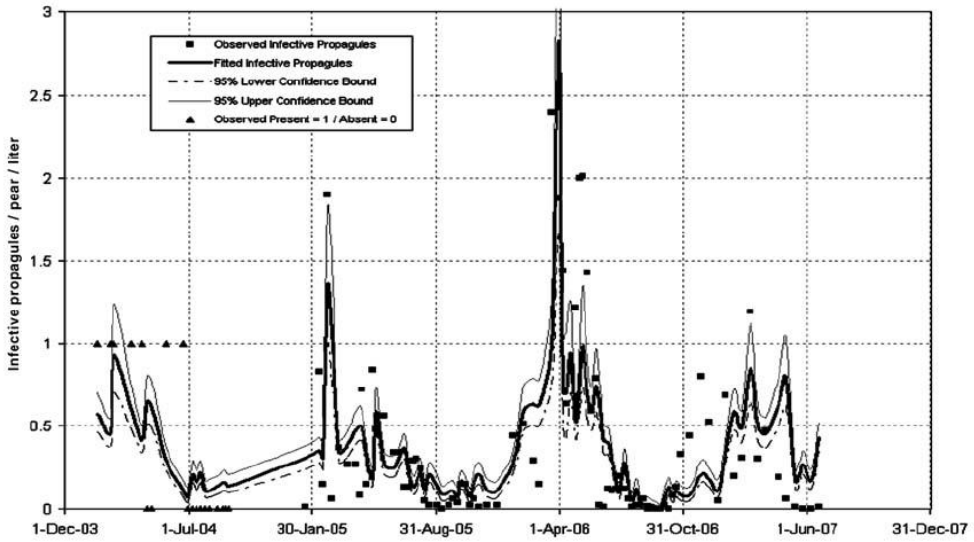
What are these Phytophthoras doing in streams?

- Where do they come from?
- When are they active?
- Where do they get their nutrients in the stream?
- How do they colonize baits?
- How do they contribute to microbial communities in streams?

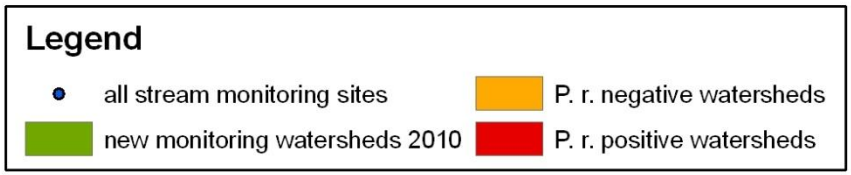
Ecological types

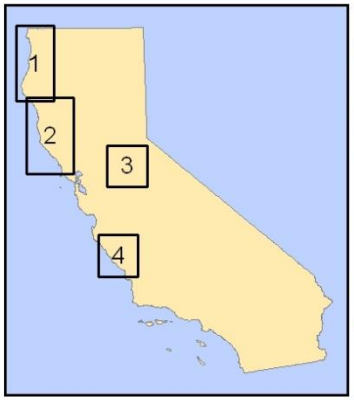
- **Facultative pathogens - resident**
- **Foliar pathogens – accidental?**
- **Root pathogens – accidental?**

Reeser et al., in press


Observed Infective Propagules
Fitted Infective Propagules
95% Lower Confidence Bound
95% Upper Confidence Bound
Observed Present = 1 / Absent = 0
Infective propagules / pear / liter
3
2.5
2
1.5
1
0.5
0
1-Dec-03
1-Jul-04
30-Jan-05
31-Aug-05
1-Apr-06
31-Oct-06
1-Jun-07
31-Dec-07

Stream Monitoring Detection of *Phytophthora ramorum* 2004-2009





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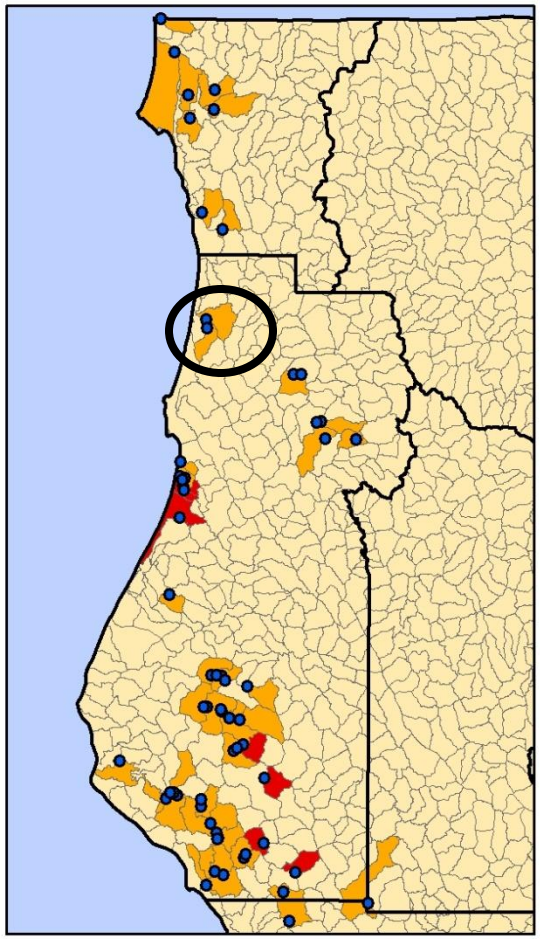

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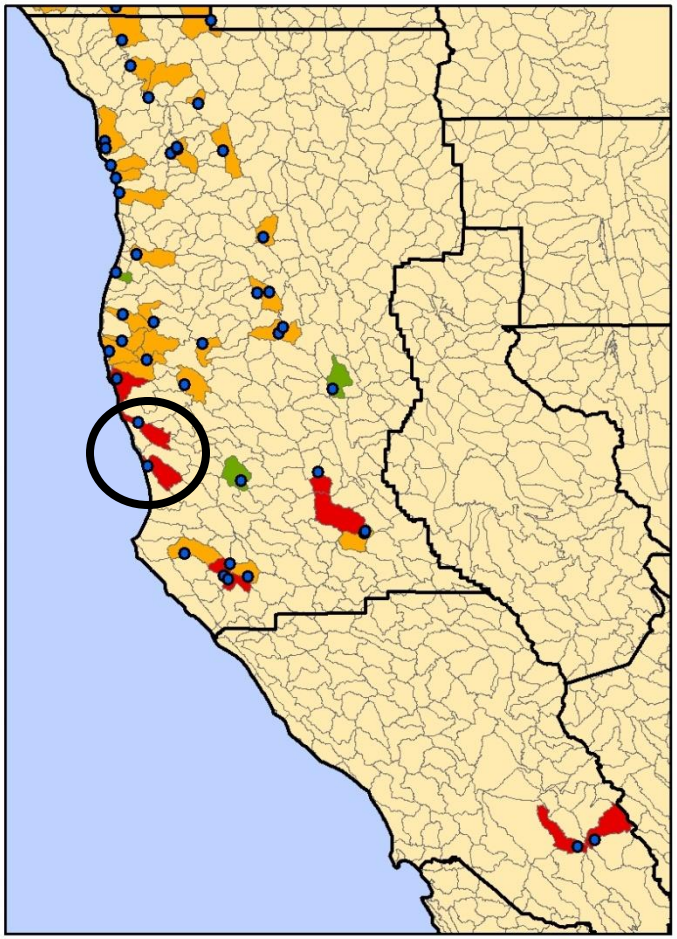

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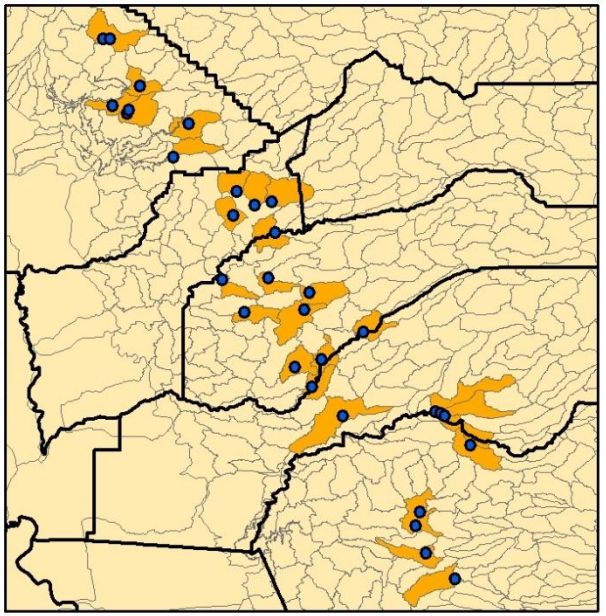

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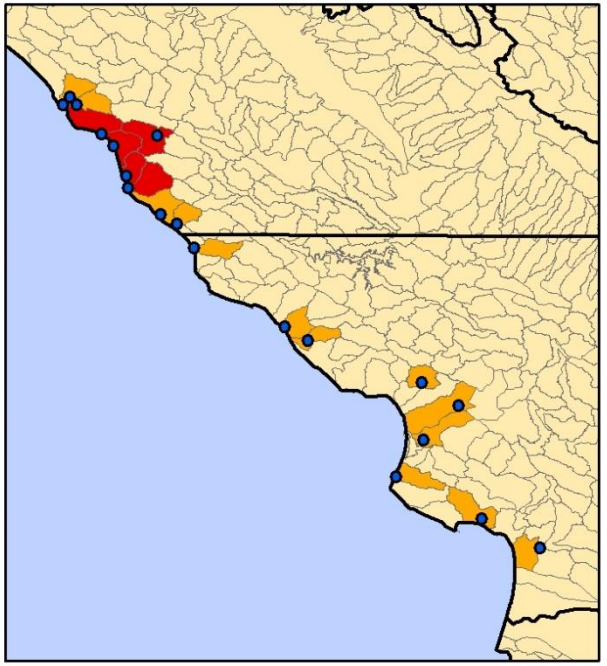
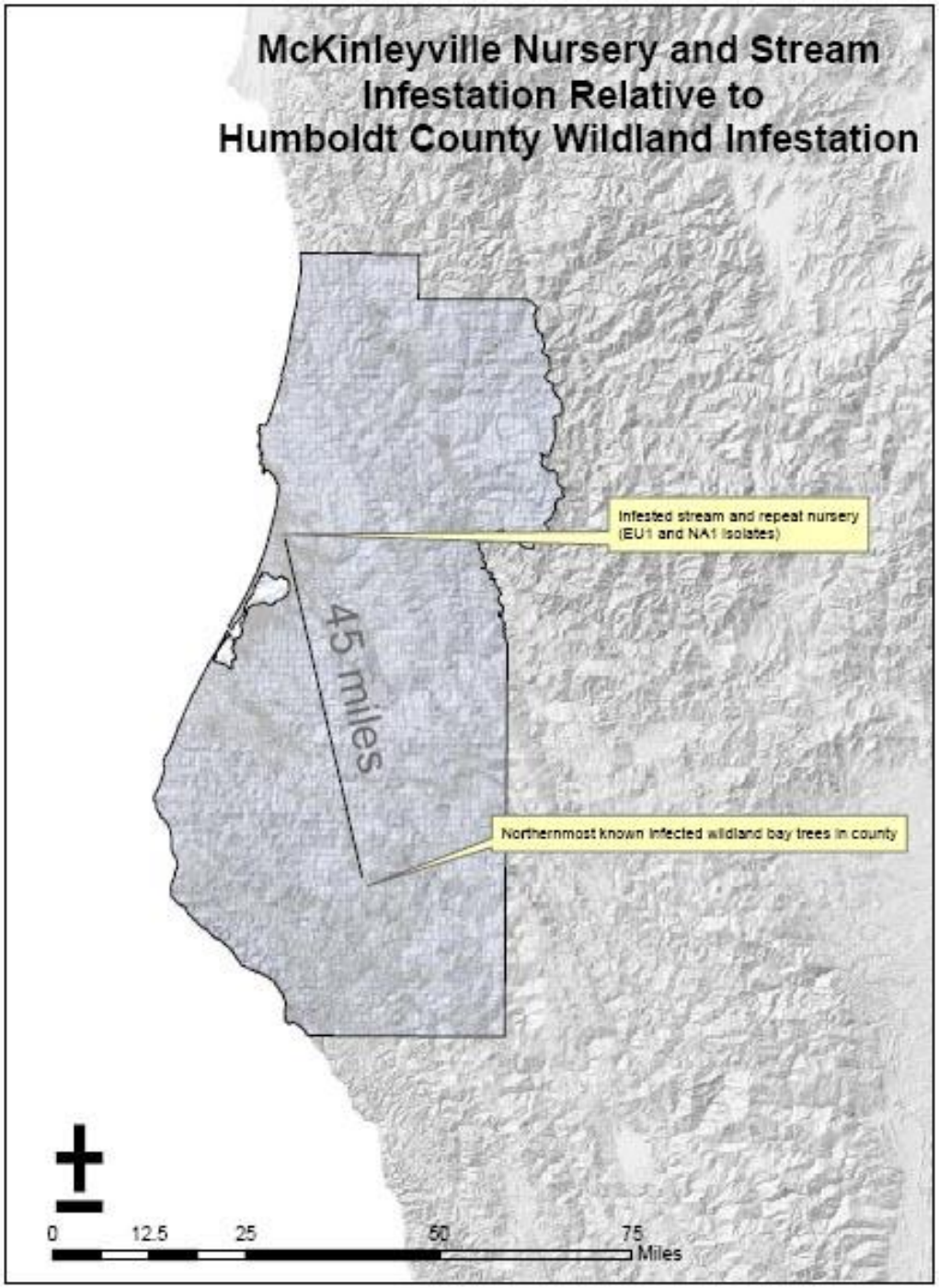
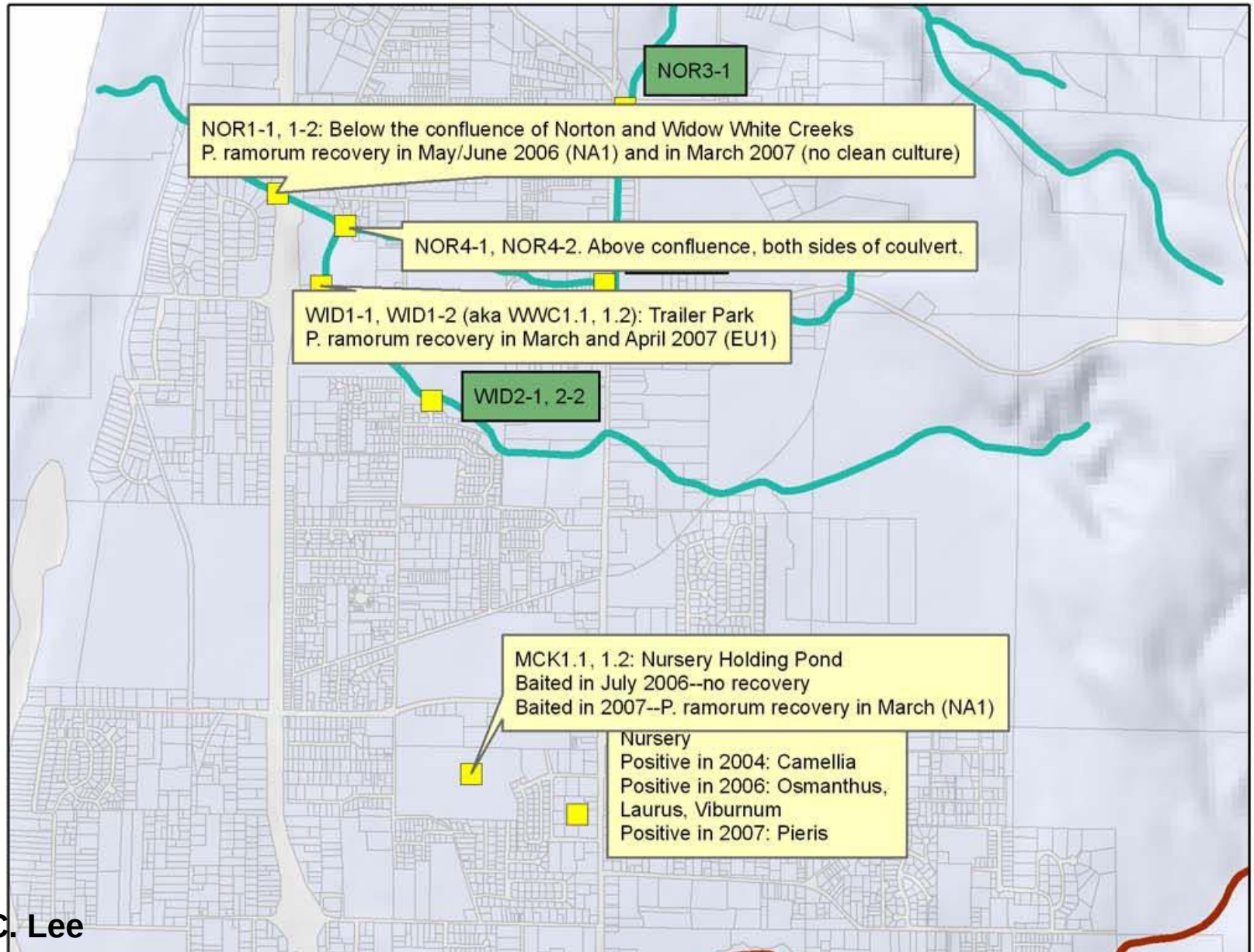



McKinleyville Nursery and Stream Infestation Relative to Humboldt County Wildland Infestation
Infested stream and repeat nursery (EU1 and NA1 isolates)
45 miles
Northernmost known infected wildland bay trees in county
0
12.5
25
50
75
Miles

Source: C. Lee

McKinleyville Water Sampling Points 2006-08



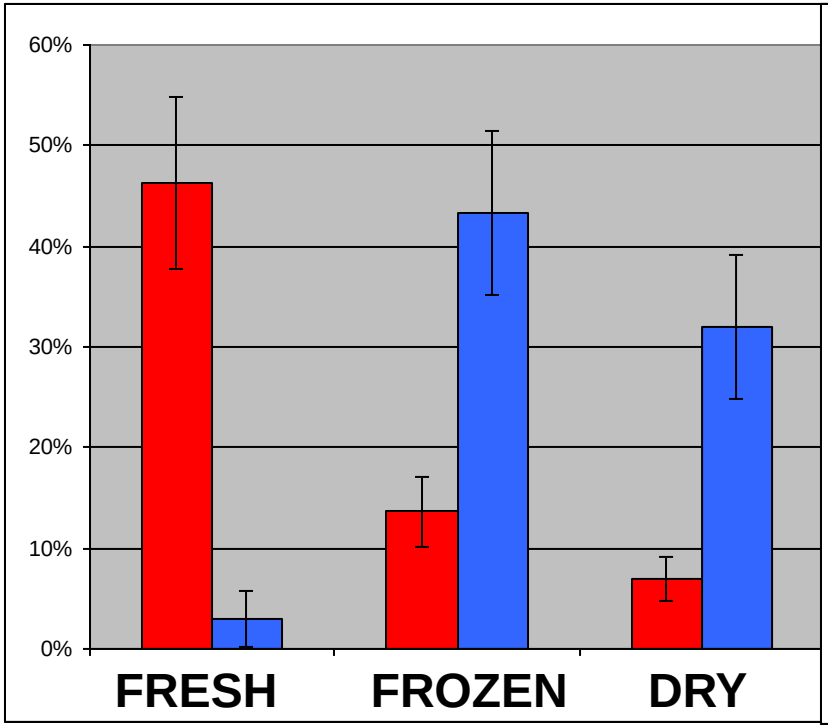
Source: C. Lee

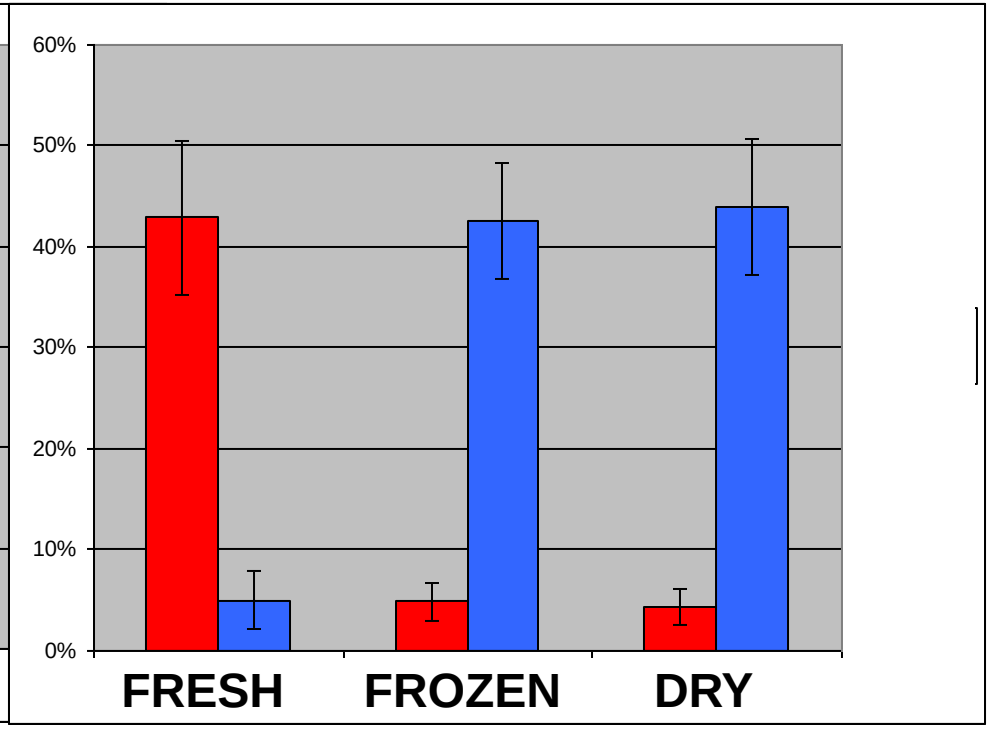
Source: C. Lee


Source: C. Lee


Source: C. Lee

In vitro experiments:





Experiment 1

sporangia inoculum

Experiment 2

zoospore cyst inoculum

P. ramorum ***P. gonapodyides***

Experiments in stream

Pr	**0%**	**0%**	**74%**
Other	66%	64%	63%

Cattail (*Typha* sp.)

Cattail
(*Typha* sp.)

Duckweed
(*Lemna minor*)

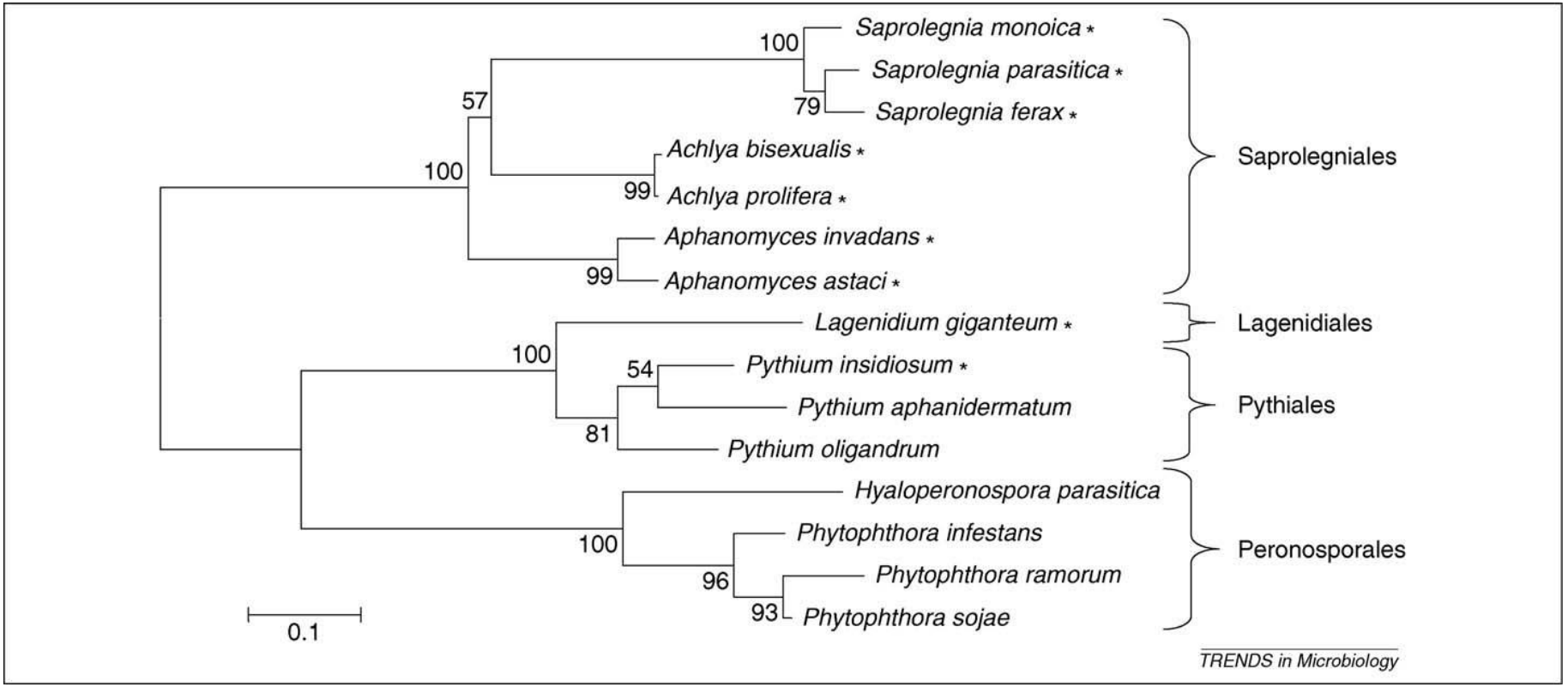
Monkey flower
(*Mimulus* sp.)

Red alder
(*Alnus rubra*)

Ecology of Phytophthora in Streams

- **Temperature**
- **Flow rates**
- **pH**
- **Carbon supply**
- **Nutrient levels**
- **Microbial community**

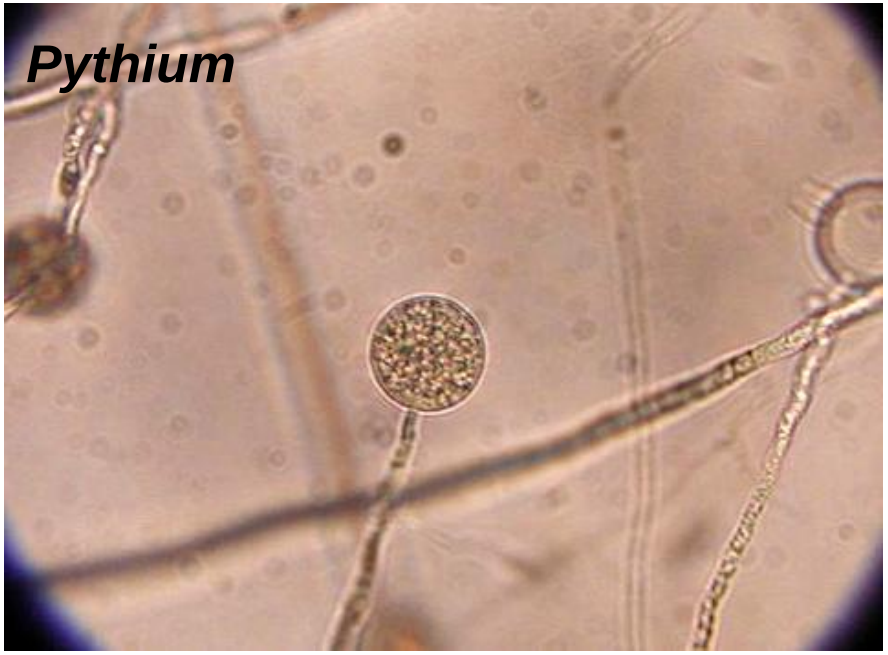
Animal and plant pathogenic oomycetes



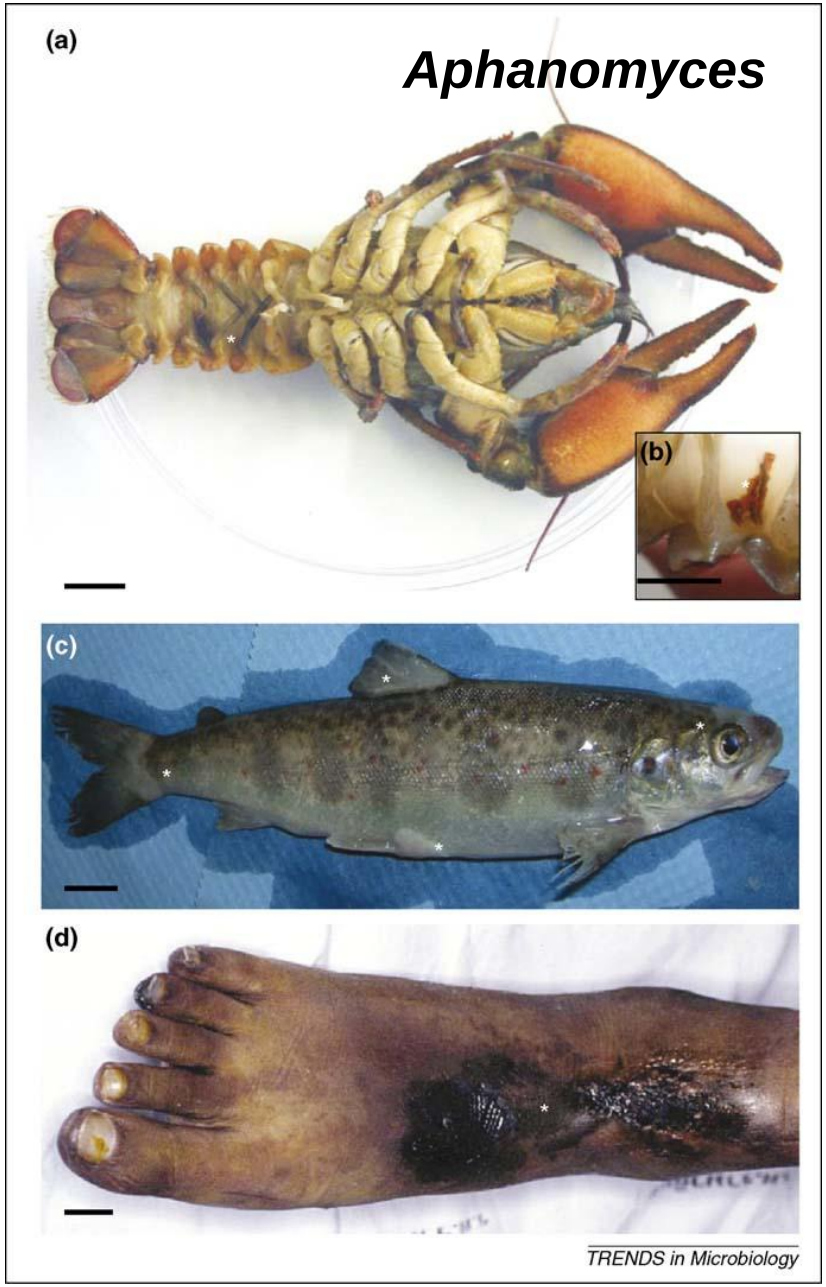
Phillips et al. 2008

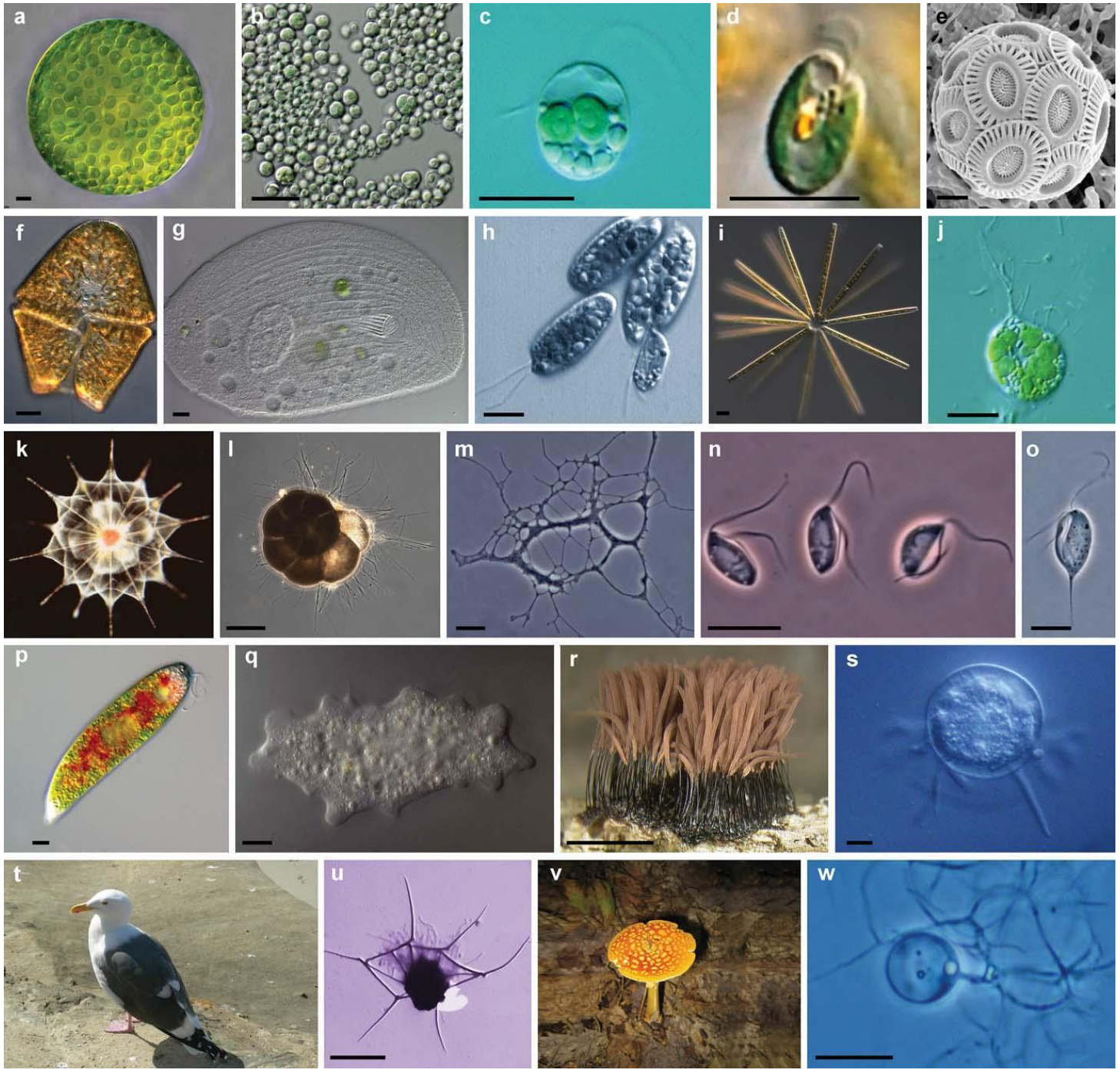
Saprolegnia

Pythium



Aphanomyces

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Microbes in streams

What is missing from our understanding of microbial composition and distribution is knowledge of the functional links connecting measures of which groups are present, their inherent metabolic capacity, actual expression of that capacity, and consumption or release of biomolecules in the environment.

S. Findlay, 2010. Stream microbial ecology. J. N. Am. Benthol. Soc. 29:170-181.