Revisiting our understanding of Pierce's disease epidemiology in the North Coast

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Pierce's Disease
Control Program

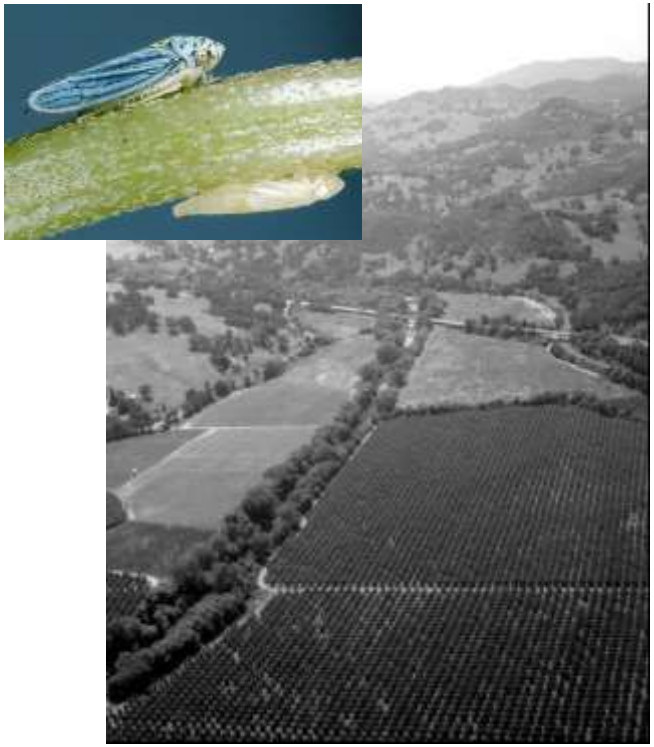
A. Conventional view of PD epidemiology
   - the vector
   - disease epidemiology
   - implications for PD management

B. Ongoing research
   - BGSS abundance and infectivity
   - Pierce's disease prevalence
   - plant community composition
   - other "minor" vectors
   - climate as a potential "trigger"

Blue-green sharpshooter (*Graphocephala atropunctata*)

BGSS only/most important vector in North Coast vineyards

Reproduces on select plants in riparian habitat and to limited degree in other habitats



- *Rubus* spp., periwinkle, elderberry, *Vitis* spp., mugwort, mulefat are key reproductive hosts

- Uses other plants to varying degrees

Blue-green sharpshooter (*Graphocephala atropunctata*)

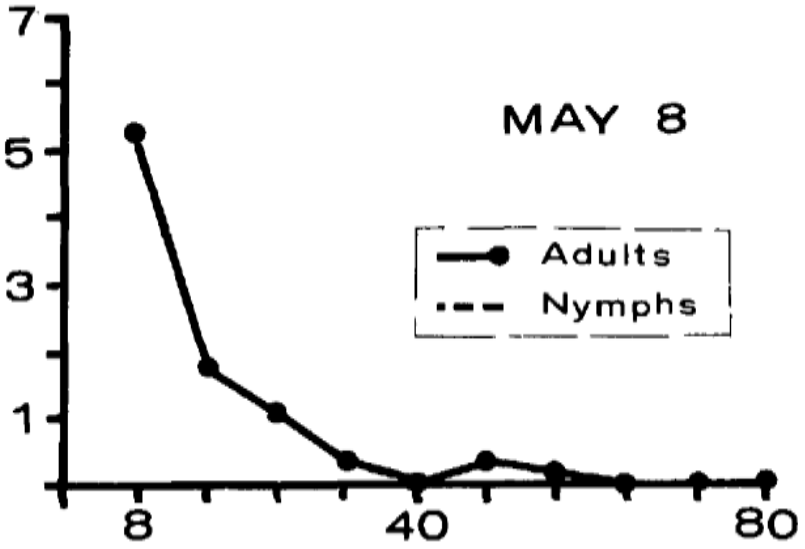
BGSS only/most important vector in North Coast vineyards

Reproduces on select plants in riparian habitats and to limited degree in other habitat

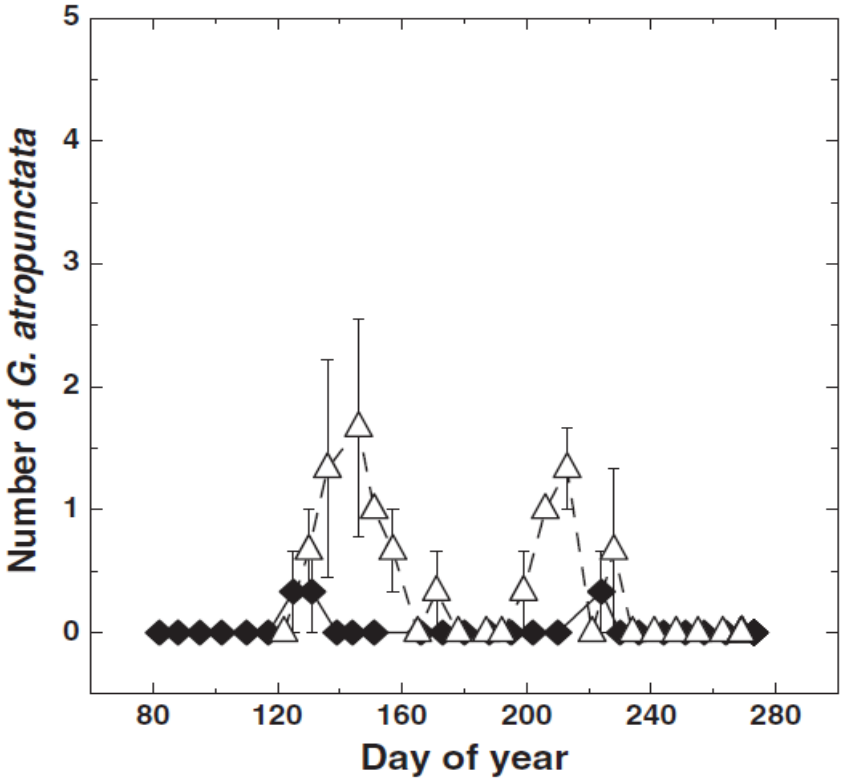
Acquires *Xf* in reproductive habitat (?); infectious for life; long-lived

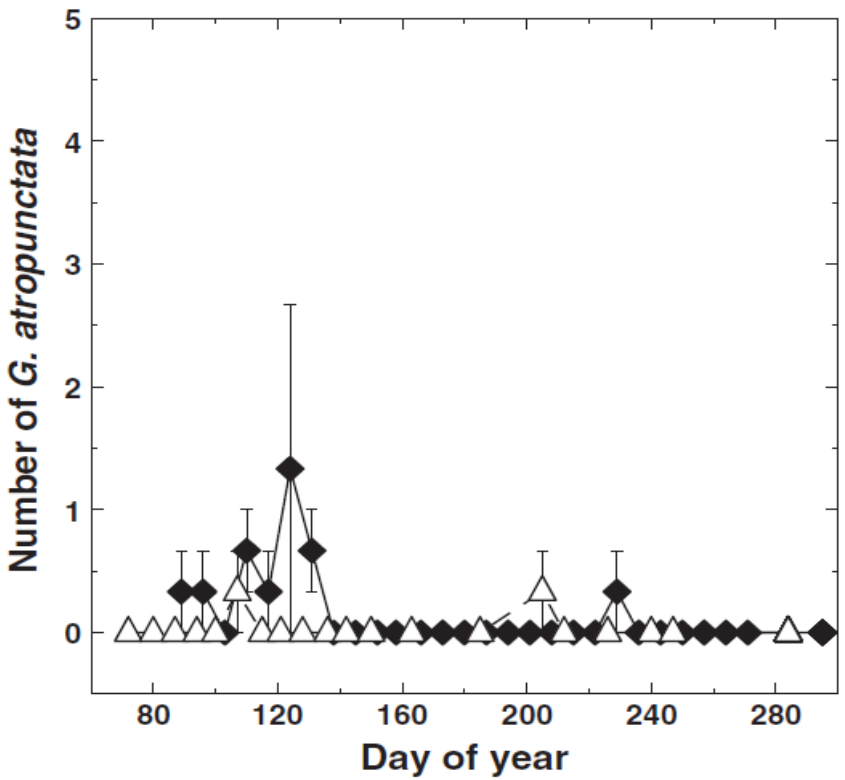
Very efficient at transmitting *Xylella fastidiosa*

Does not move far into vineyards (< 75 m)



Blue-green sharpshooter (*Graphocephala atropunctata*)





Does not move far into vineyards (< 75 m)

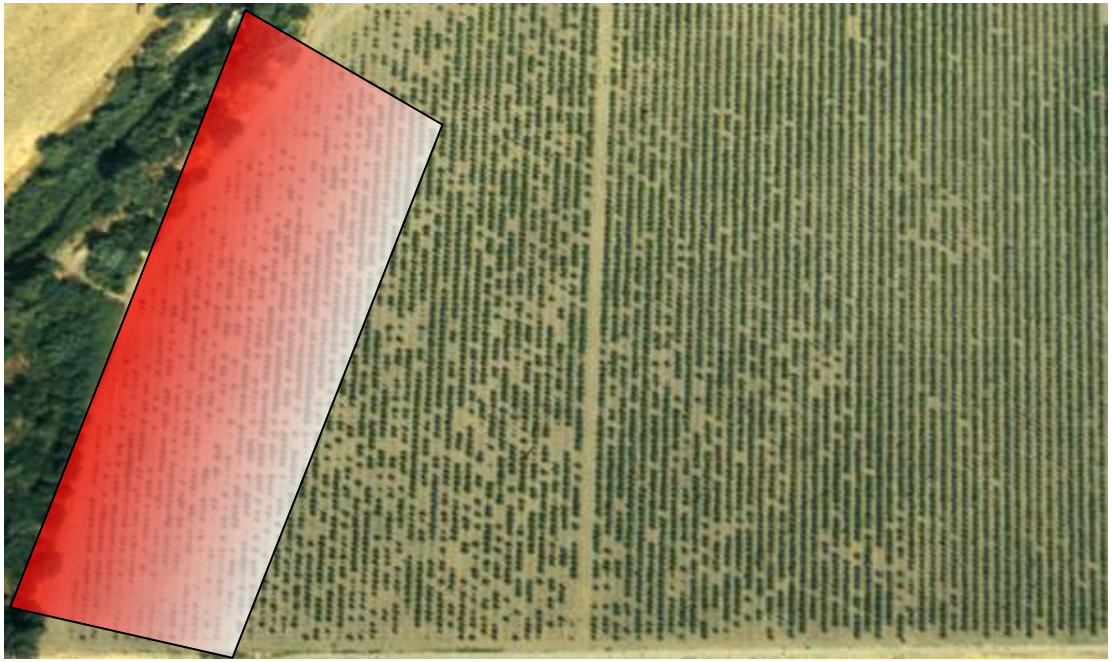
Single generation; overwinters in reproductive habitat; reproduces in Spring; active in vineyards in Spring and mid-Summer

Pierce's disease epidemiology

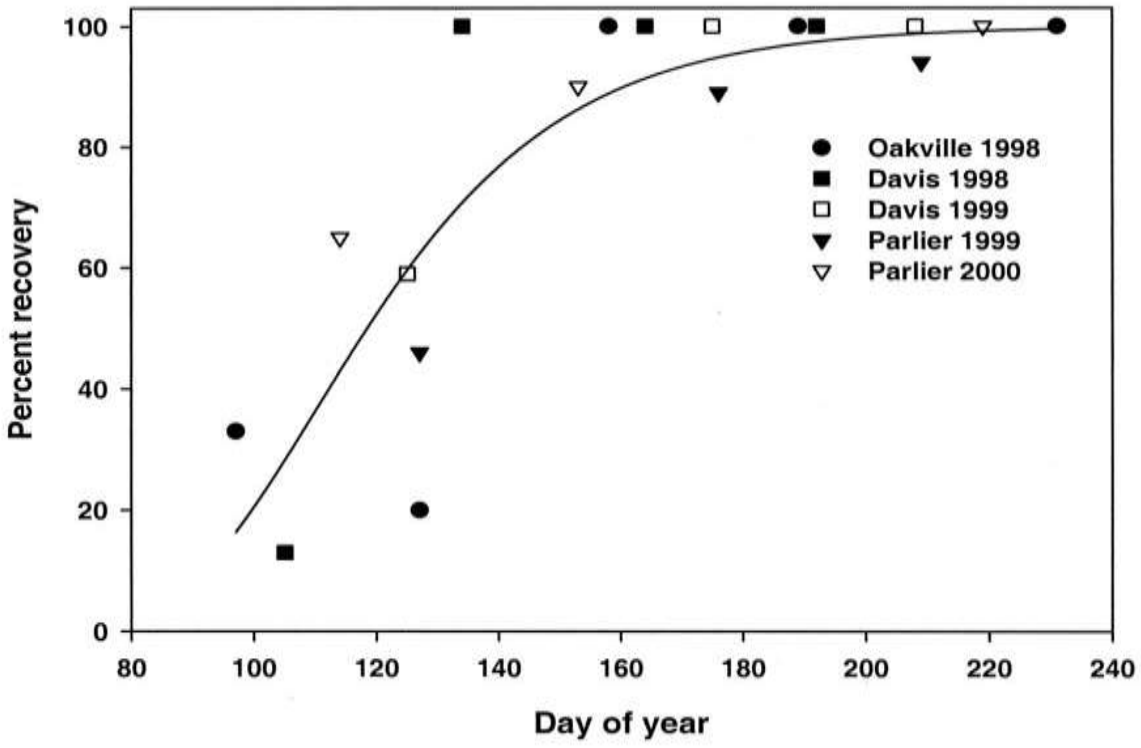
Low prevalence at non-riparian sites

Pronounced edge effects (< 150 m)

Less PD in the interior of blocks



Pierce's disease epidemiology



- few vine infections after June persist through Winter

Overwinter recovery for late-season infections

Dominated by "primary spread", not vine-to-vine spread

Management implications

Vector control:

- early season treatments, focused on the edge
- often little management needed at sites without clear BGSS source nearby
- no management focused on other *Xf* vectors?
- no late season treatments?

Plant management at riparian sites focused on key hosts

Little value to roguing diseased vines

What explains the current PD epidemic?

A. Detailed monitoring at 32 sites in Napa and Sonoma

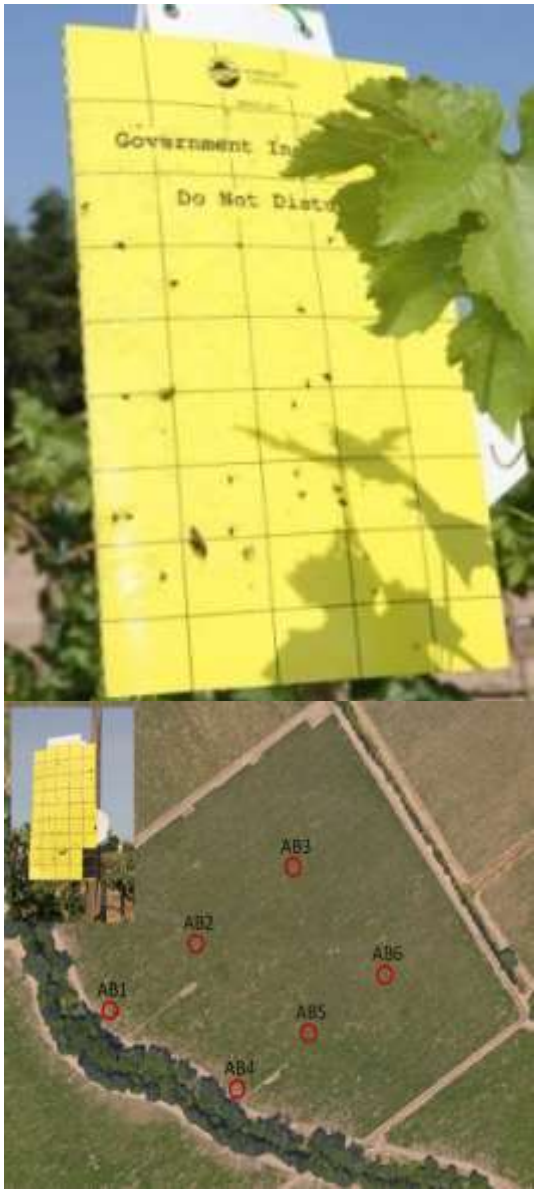
- BGSS spatiotemporal patterns
- BGSS natural infectivity
- PD patterns
- effect of plant community composition on BGSS pressure
- role of other “minor” vectors

B. Studies of potential changes to pathosystem

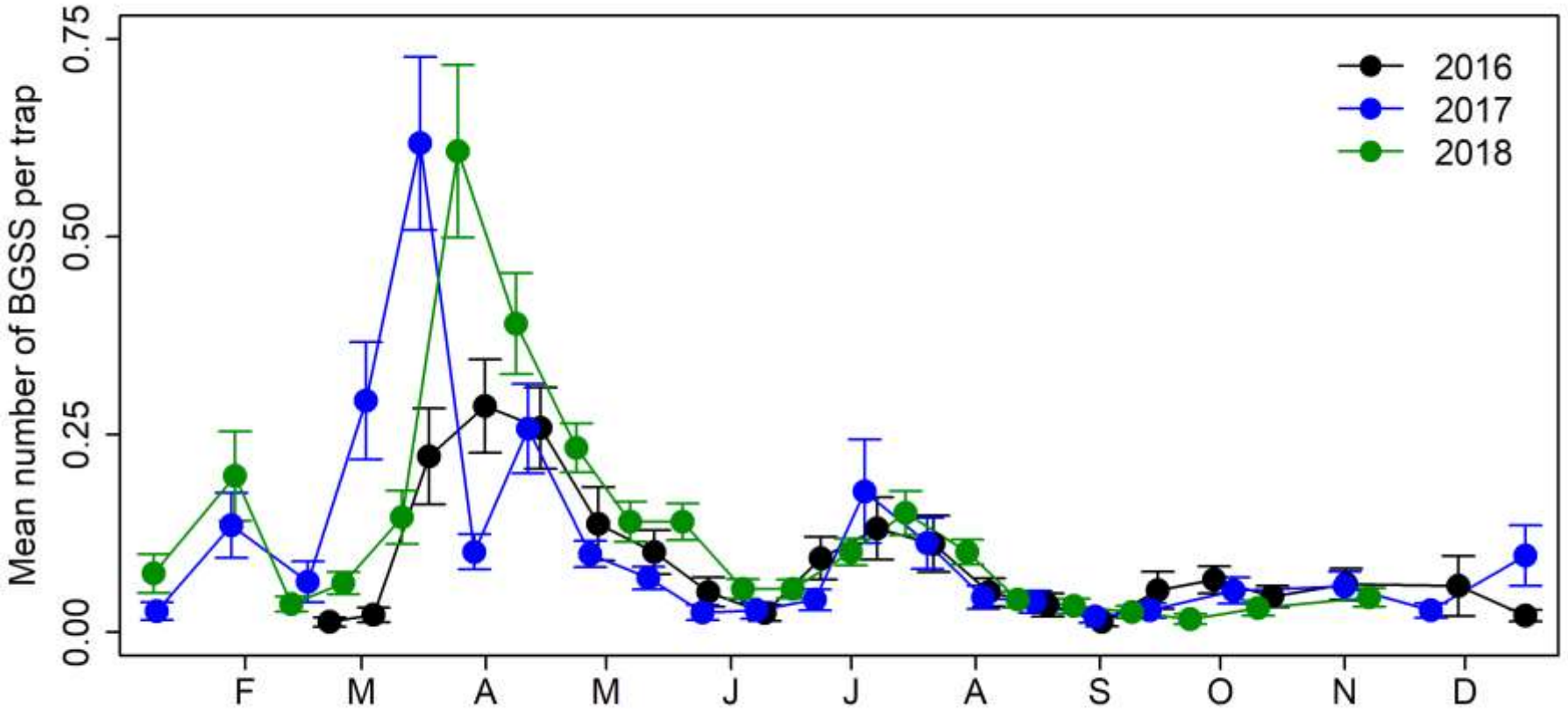
- novel pathogen strain?
- climate as a trigger?

1. BGSS spatiotemporal patterns

- yellow sticky trapping at all 32 vineyard sites
- 6 – 12 traps per site, distributed throughout vineyards
- checked twice a month during growing season, monthly over winter
- BGSS and other vectors identified and counted

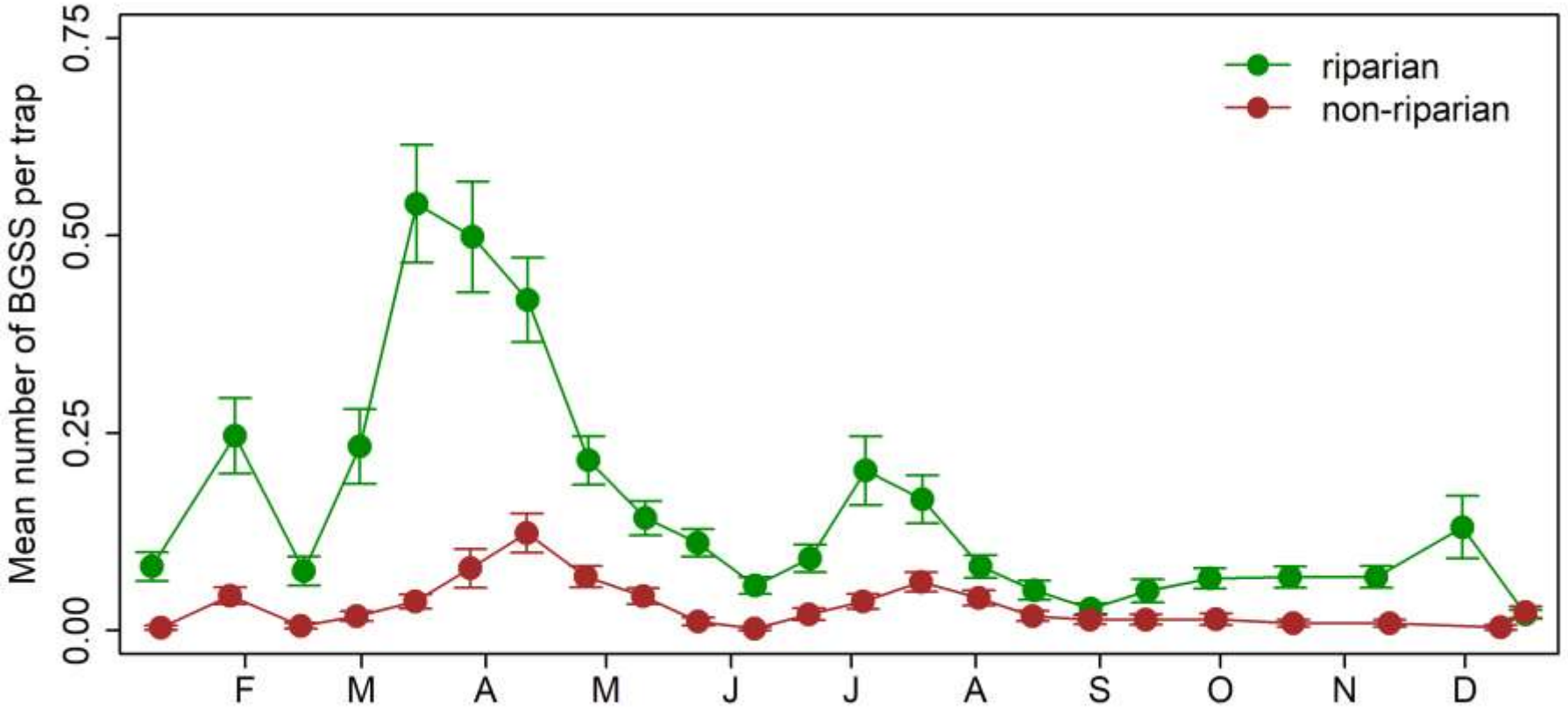


mid-Spring and mid-Summer peaks in BGSS activity?



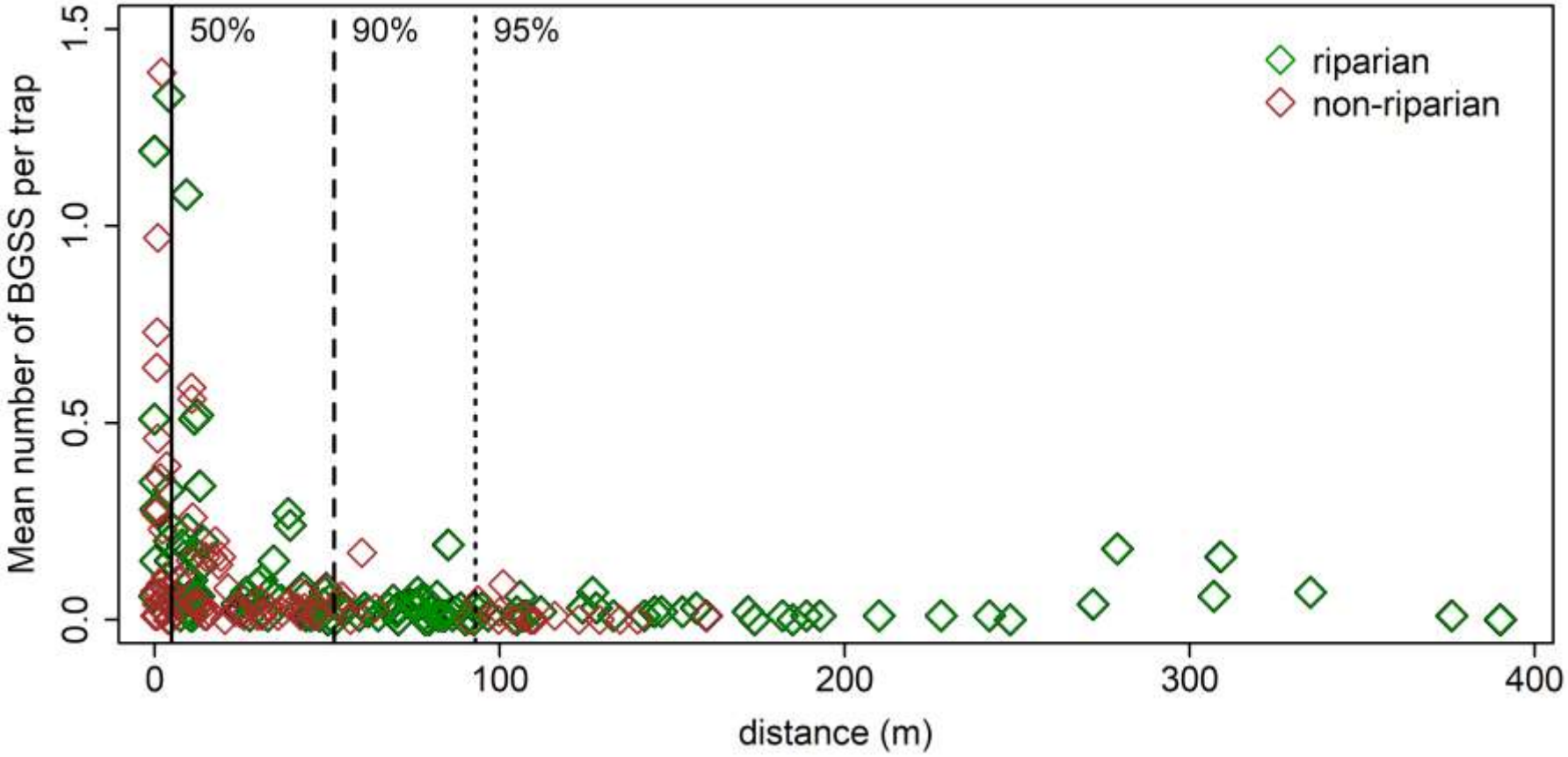
-large Spring peak, smaller summer peak, consistent among years

Higher BGSS pressure at sites near riparian habitat?



-vineyards near riparian habitat caught consistently more BGSS, seasonal patterns similar

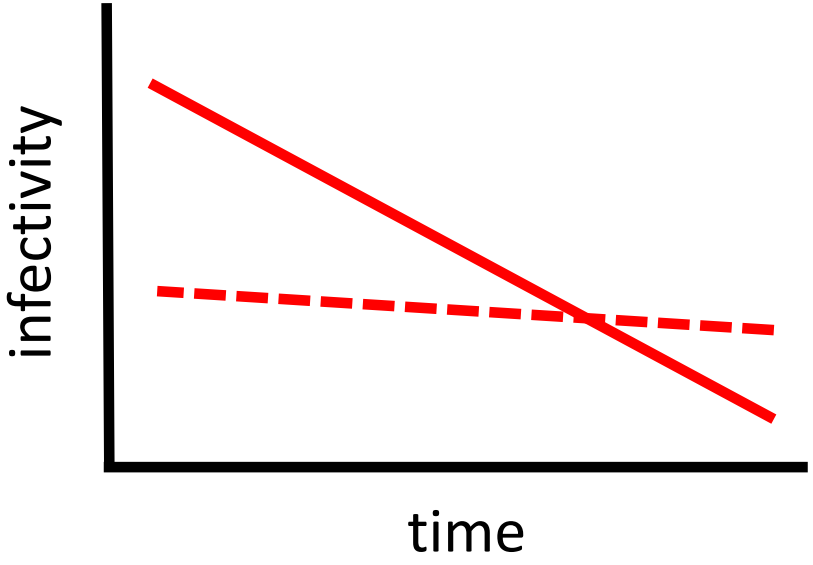
BGSS edge effect? Mostly within ~75 m?



-vast majority of BGSS caught within 50 m

2. BGSS natural infectivity

- collected all BGSS from traps
- cleaned, extracted, tested for *X. fastidiosa* via qPCR
- what fraction of vectors are infective?



- if acquisition occurs outside vineyards, infectivity may decline or stay flat over the season?

2. BGSS natural infectivity

- collected all BGSS from traps
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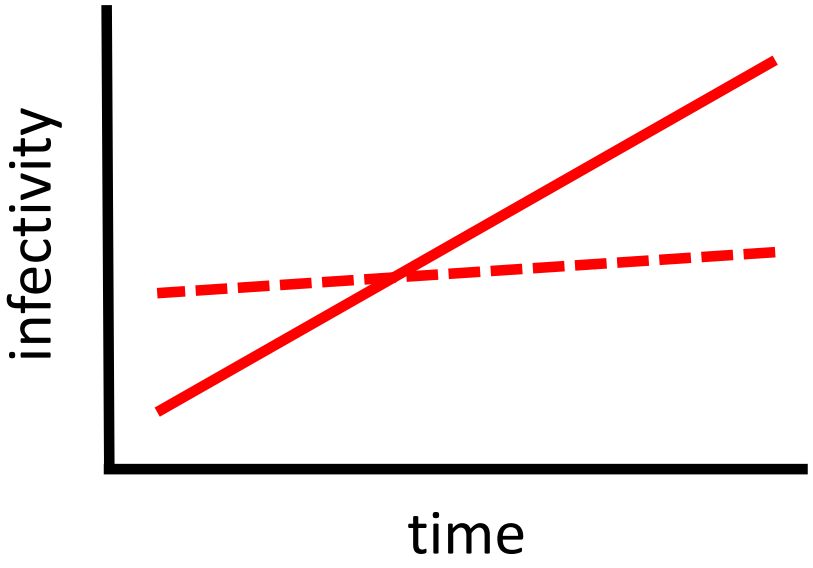
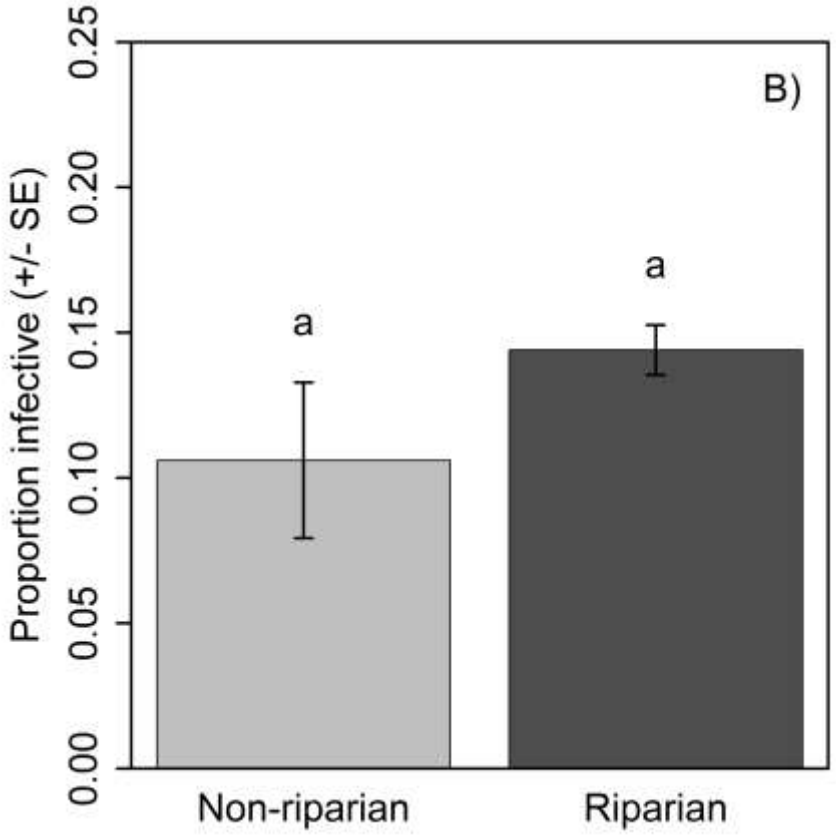


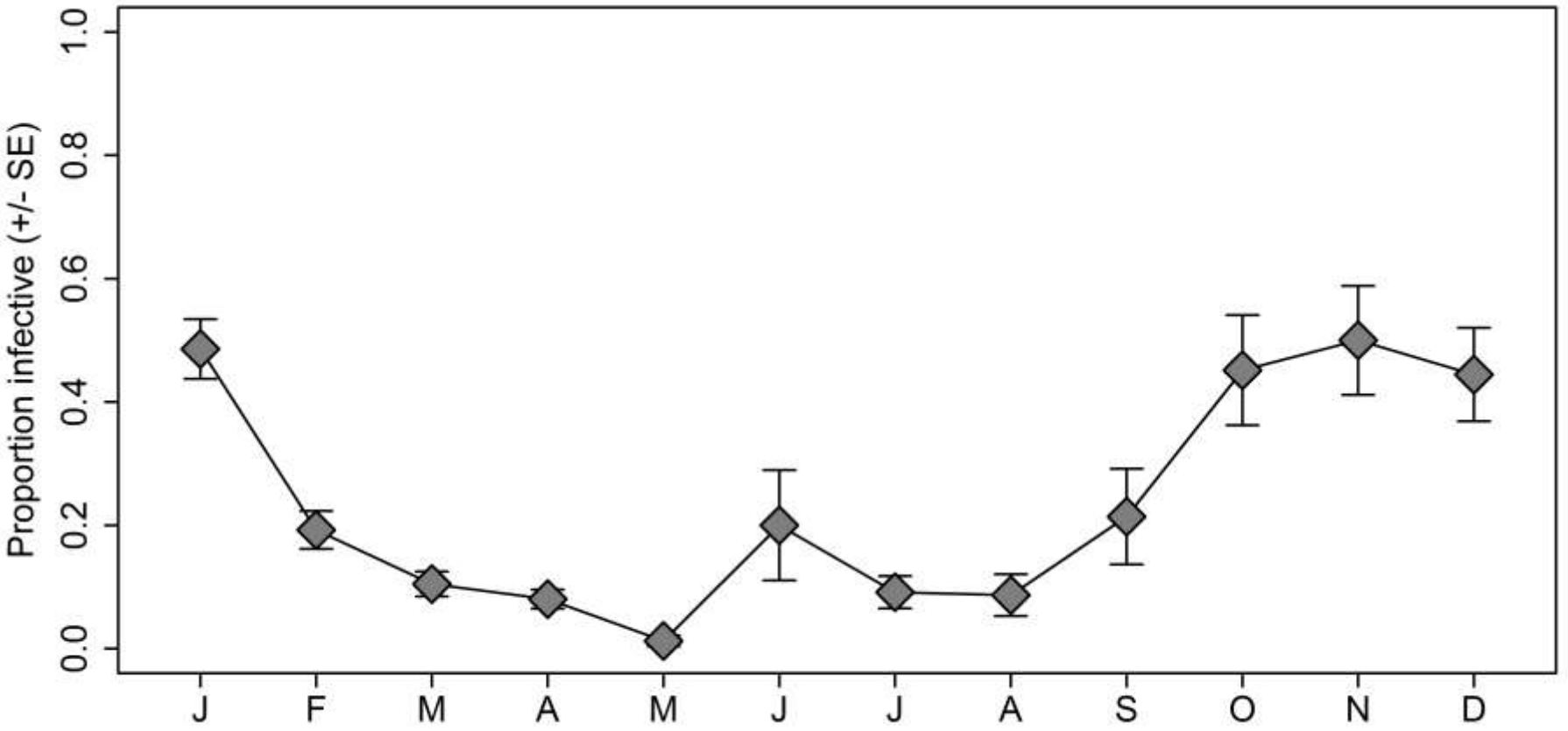
- if acquisition occurs in vineyards, infectivity may increase over the season?

Overall, ~15% of BGSS were infective



-similar for BGSS from edge vs. within vineyard, and for riparian and non-riparian sites

Natural infectivity of BGSS over the season?



-declines Winter through Spring, increases late-Summer through Fall

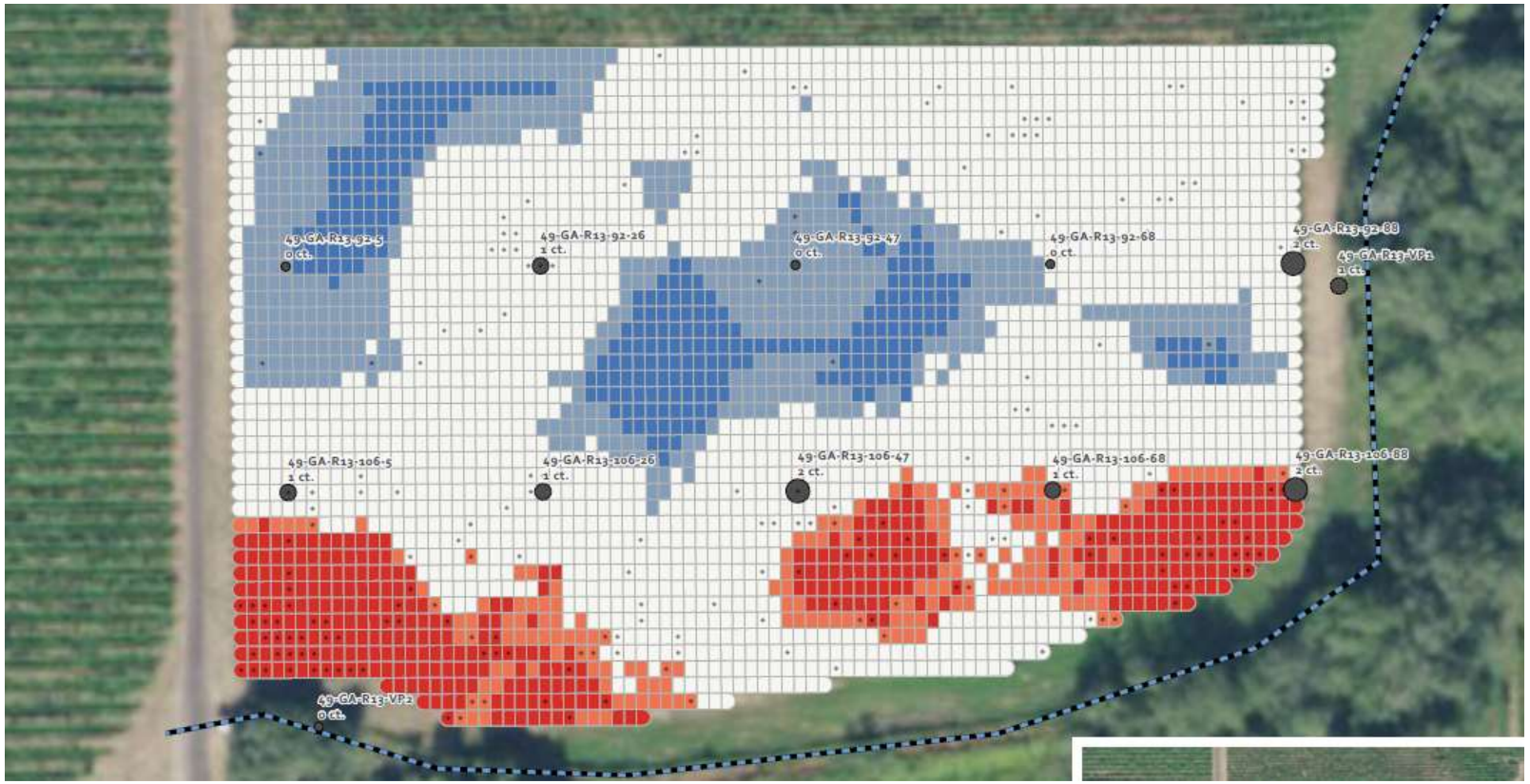
3. Patterns of Pierce's disease prevalence

- 3 years of PD surveys in the Fall at each site
- visually inspect each vine and note whether PD symptoms are present or not
- note dead, missing, replant vines
- estimate overall PD prevalence, map where diseased vines are located

Among 32 site:

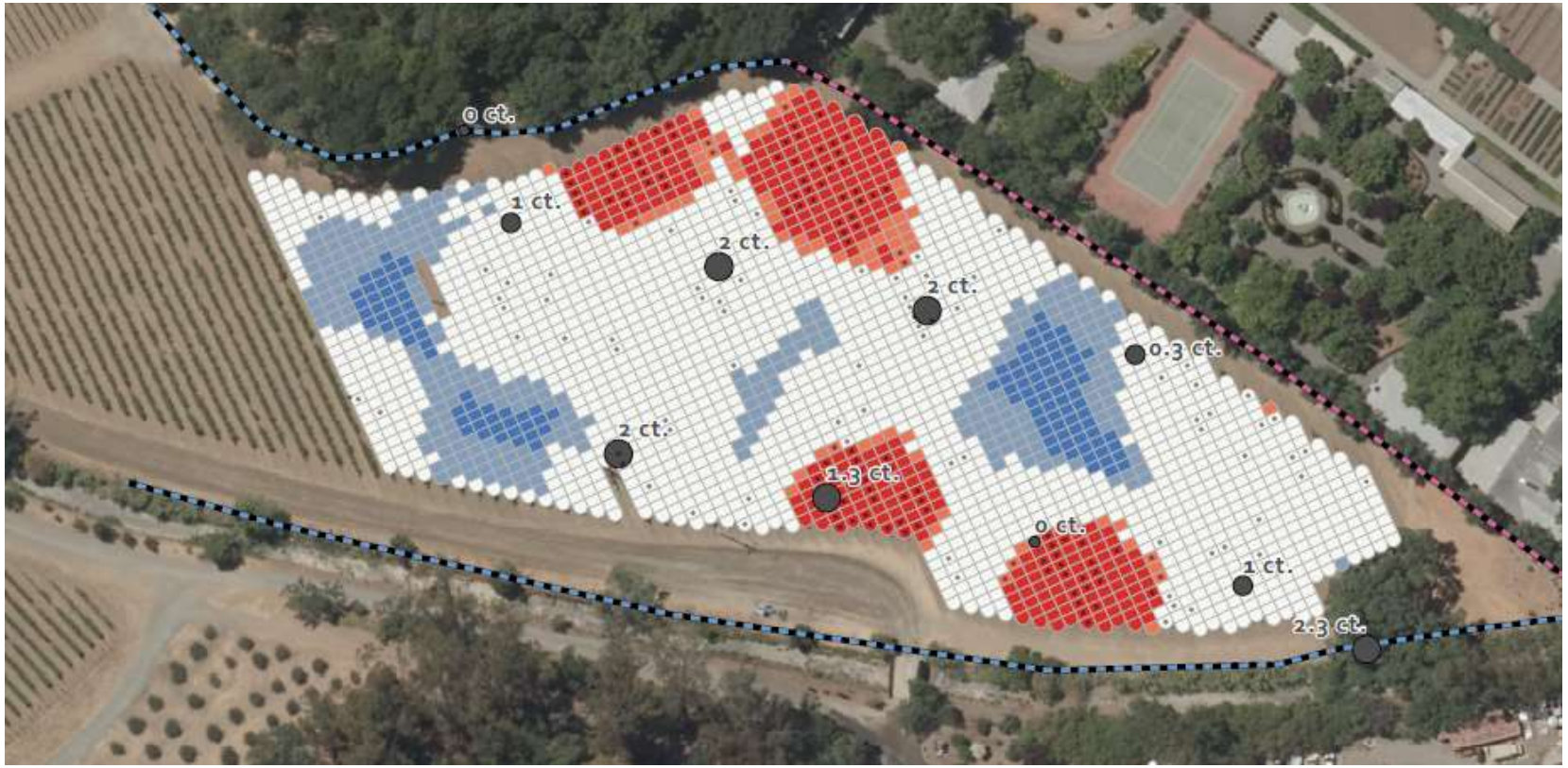
- overall PD: 11.2%
- non-riparian sites: 4.1% (< 1 – 11%)
- riparian sites: 16.6% (<1 – 39%)

Edge effect in PD cases? Some examples….



-PD mostly along edge, near riparian area; “coldspots” in interior

Edge effect in PD cases? Some examples….

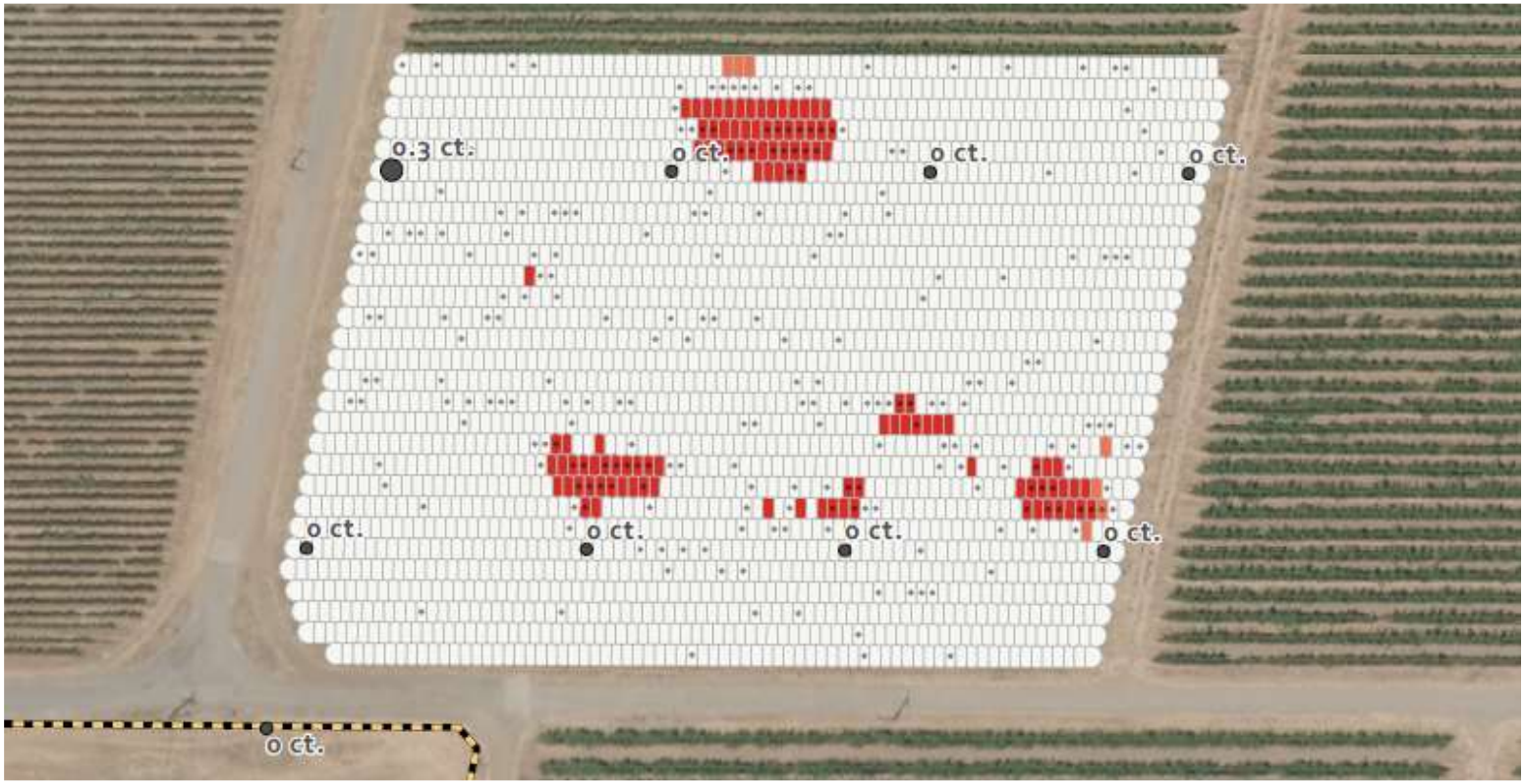


-PD mostly along edge, but not just near riparian area

Edge effect in PD cases? Some examples….

-PD hotspots mostly in interior, little PD along edge

Edge effect in PD cases? Some examples….



-PD hotspots mostly in interior, little PD along edge

4. Plant community composition and BGSS pressure

Key riparian hosts:

- *Artemisia douglasiana*, *Baccharis salicifolia*, *Rubus discolor*, *Rubus ursinus*, *Sambucus Mexicana*, *Urtica dioica*, *Vinca major*, *Vitis californica*, *Vitis* sp.

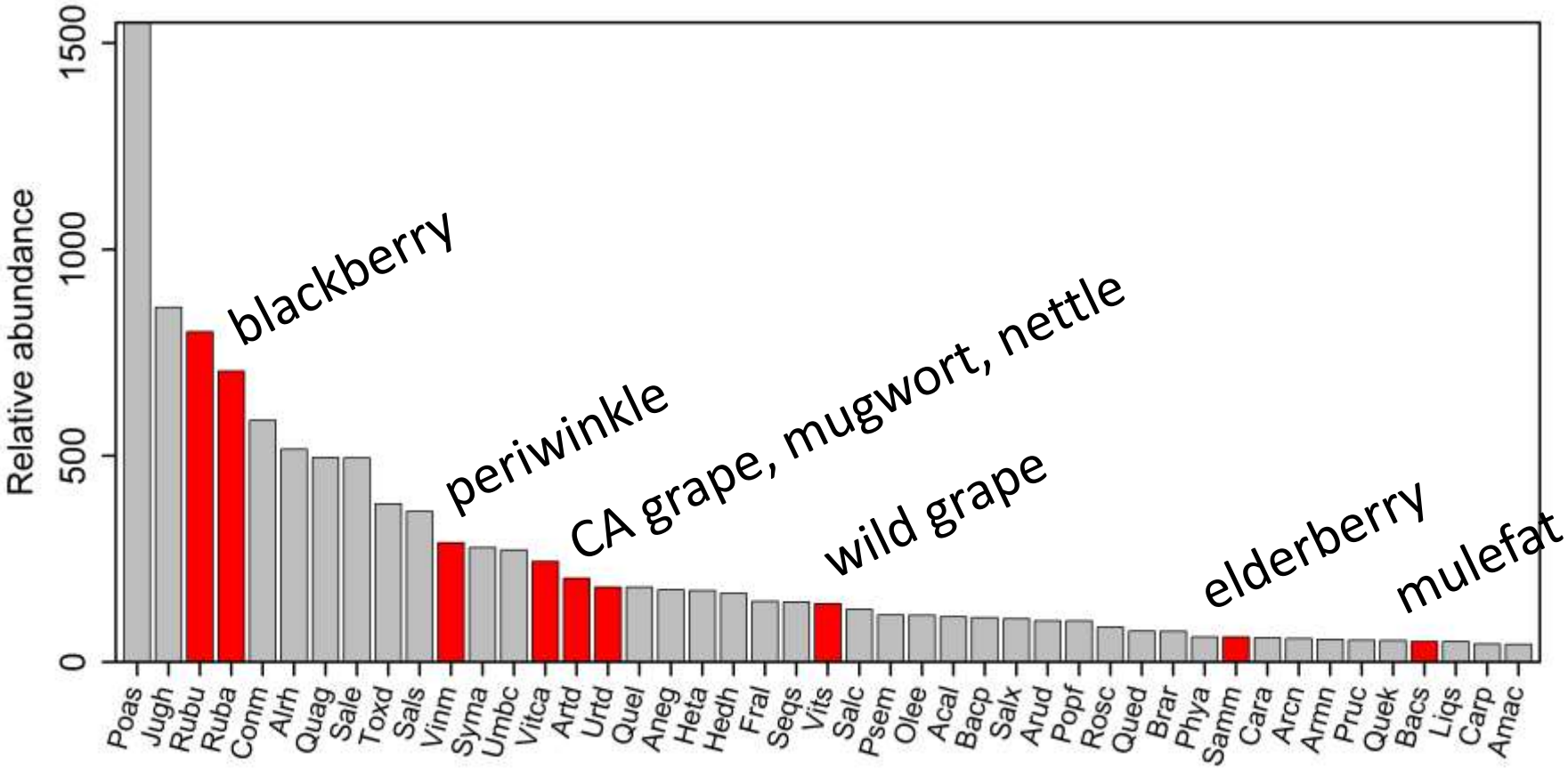
BGSS associated with several other common host plants:

- coast live oak, bay, buckeye, valley oak, walnut, big-leaf maple, ash, box-elder, alder, cottonwood, willows

- most not believed to be important reproductive hosts

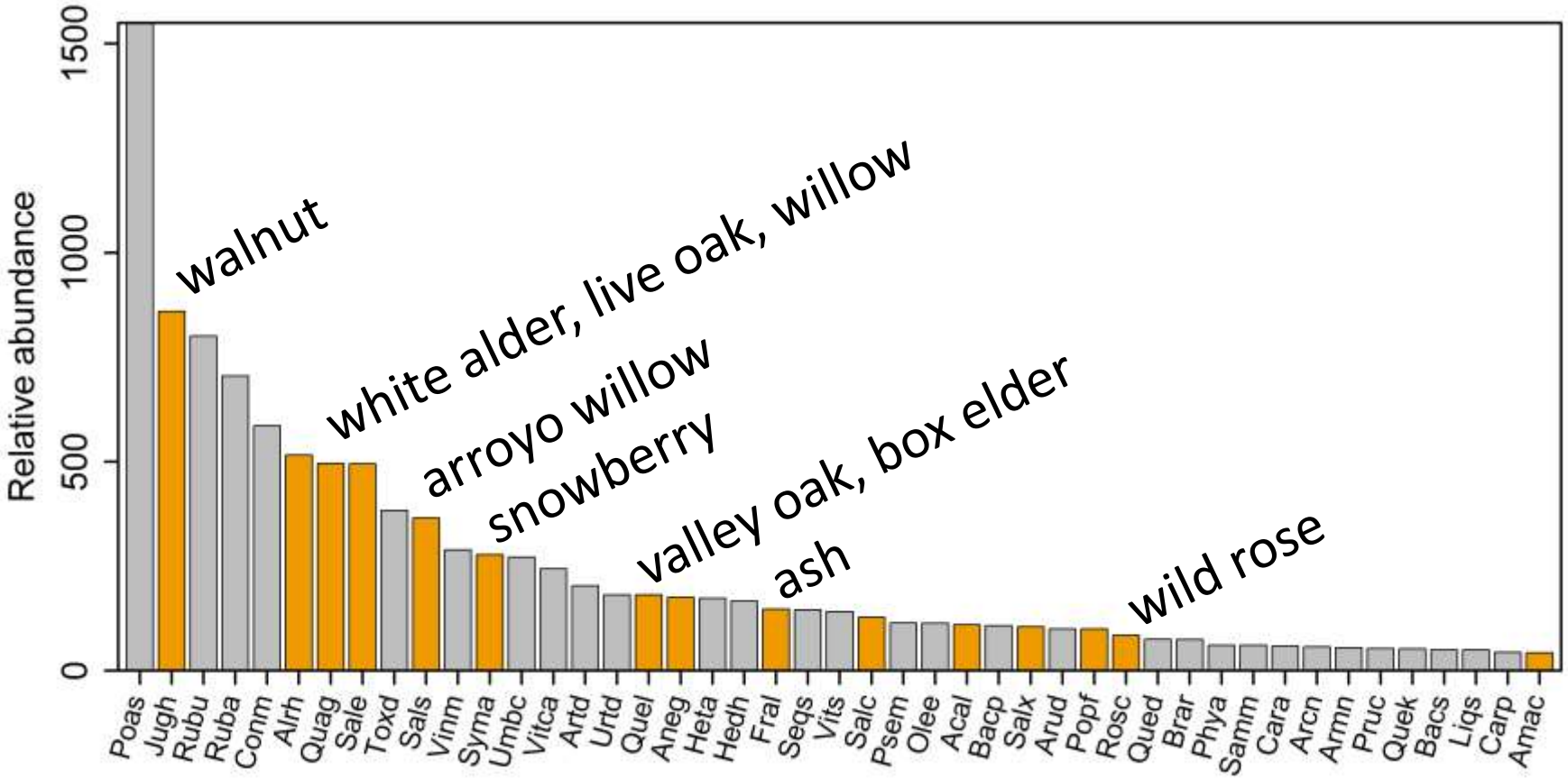
- surveyed plant composition in the most dominant habitat near each vineyard site
- 50 m transects from vineyard edge into adjacent habitat
- counted stems and identified species < 2 m of transect tape
- estimated species cover in 10 x 50 m area surrounding transect
- related plant cover to BGSS catch on edge of vineyard

150 plant taxa identified



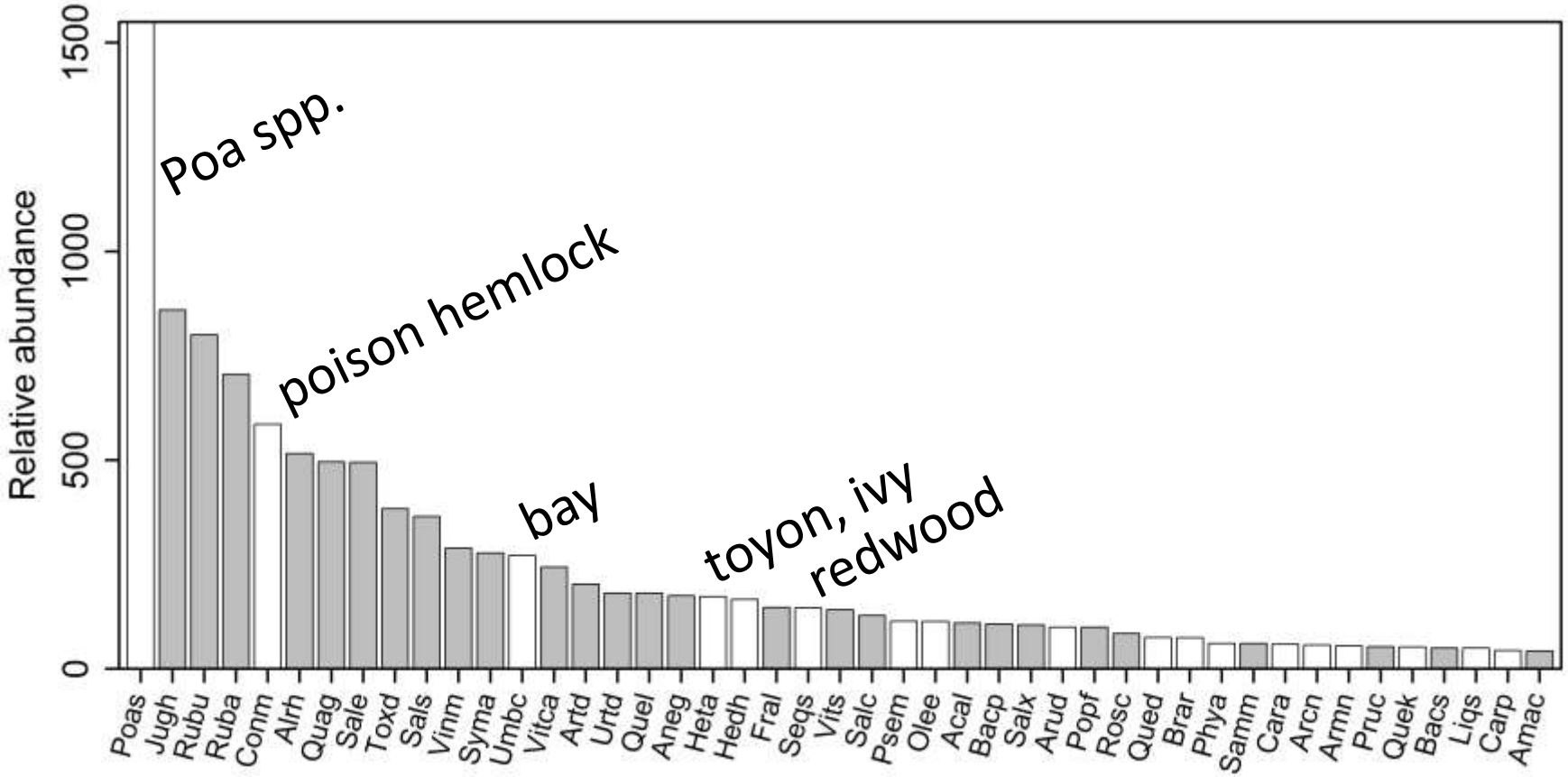
-most of the key BGSS hosts were relatively common

150 plant taxa identified



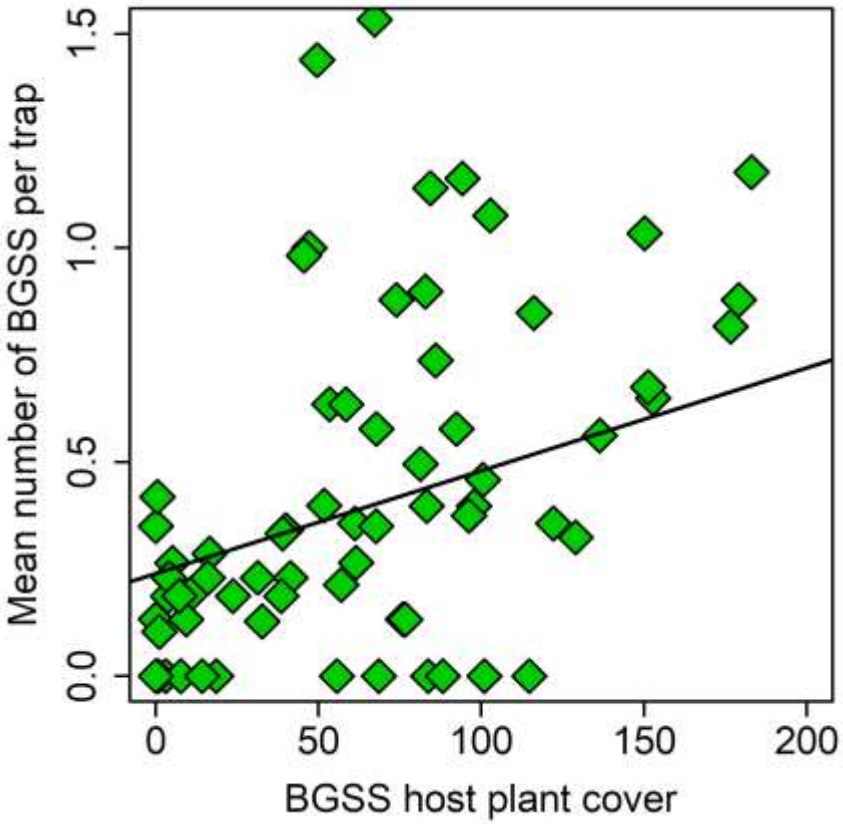
-several other potential BGSS hosts were common among sites

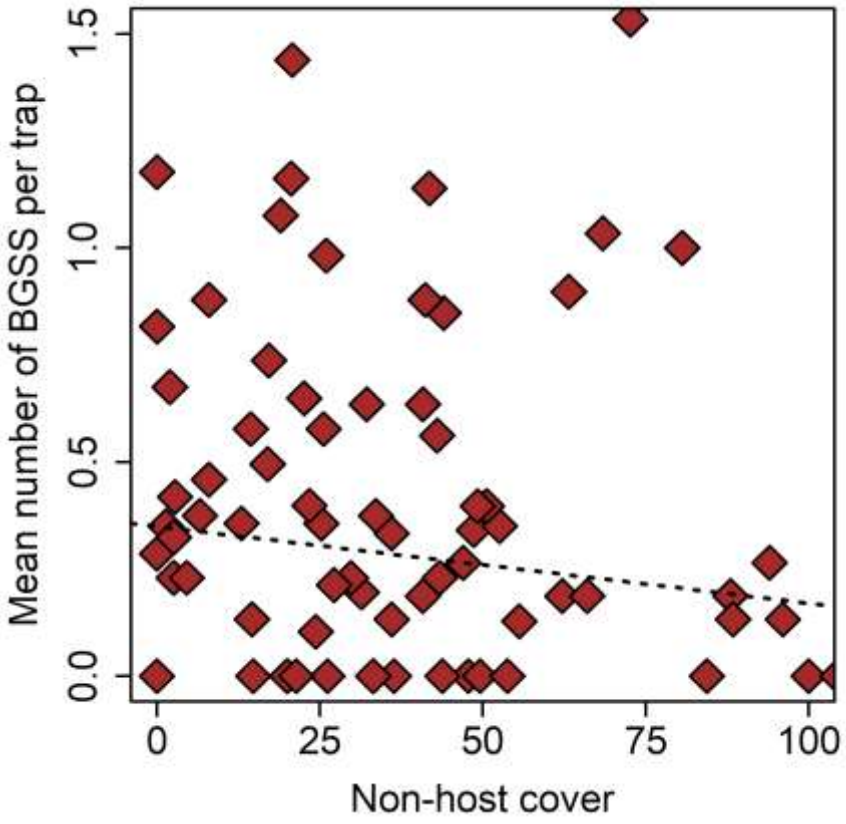
150 plant taxa identified



-several non-hosts were common among sites

What explains BGSS pressure?





-sites with more known BGSS host-plant cover and less non-host cover had a higher number of BGSS

What explains BGSS pressure?

Key hosts

Taxon	Slope	SE
Sambucus Mexicana, blue elderberry	**0.029**	**0.017**
Vitis californica, California wild grape	0.0069	0.004
Rubus armeniacus, Himalayan blackberry	0.0023	0.0016

-California grape, blackberry and especially elderberry were most strongly (and positively) associated with higher BGSS numbers

What explains BGSS pressure?

Other hosts

Taxon	Slope	SE
Acer macrophylum, big-leaf maple	**0.014**	**0.005**
Calycanthus occidentalis, spicebush	**0.277**	**0.111**
Juglan hindsii, northern black walnut	**0.0036**	**0.0016**
Populus fremontii, *Fremont cottonwood*	0.0078	0.0052
Symphoricarpos albus, snowberry	0.0031	0.0023
Toxicodendron diversilobum, poison oak	0.0024	0.002
Salix lasiopepsis, arroyo willow	-0.0042	0.0025

-big-leaf maple, spicebush, and walnut were strongly associated with higher BGSS numbers, other hosts less so

What explains BGSS pressure?

"Non-hosts"

Taxon	Slope	SE
Hedera helix, English ivy	0.005	0.003
Conium maculatum, poison hemlock	0.0029	0.002
Olea europaea, olive	-0.0039	0.0029
Arctostaphylos canescens, hoary manzanita	-0.021	0.017
Brasica rapa, yellow mustard	-0.022	0.012
Heteromeles arbutifolia, toyon	**-0.011**	**0.005**
Poaceae spp., multiple species	**-0.0037**	**0.0012**

-ivy and poison hemlock were moderately positively associated with higher BGSS numbers

-toyon and grasses are strongly negatively associated with BGSS number

5. Importance of “minor” vectors

BGSS viewed as dominant vector because it is very efficient at transmitting *Xf* and fairly abundant

Other *Xf* vectors include at least 3 sharpshooters and 2 spittlebugs:

- red-headed sharpshooter (*Xyphon fulgida*), green sharpshooter (*Draeculacephala minerva*), *Pagaronia* sp.
- meadow spittlebug (*Philaenus spumarius*), *Aphrophora* sp.

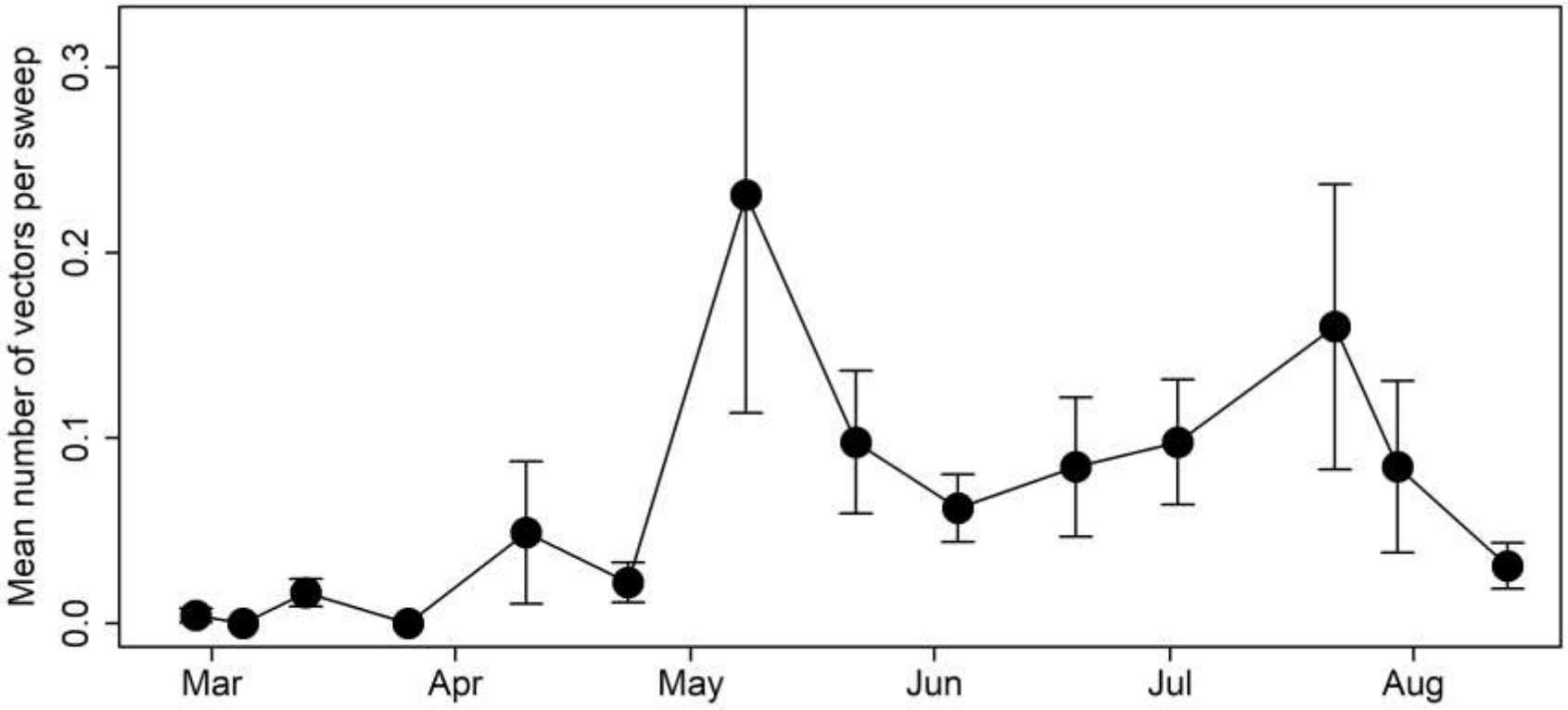
Other vectors assumed to be unimportant for PD spread because they are less efficient and common

Ongoing transmission studies, vector surveys, host plant surveys

Vector surveys:

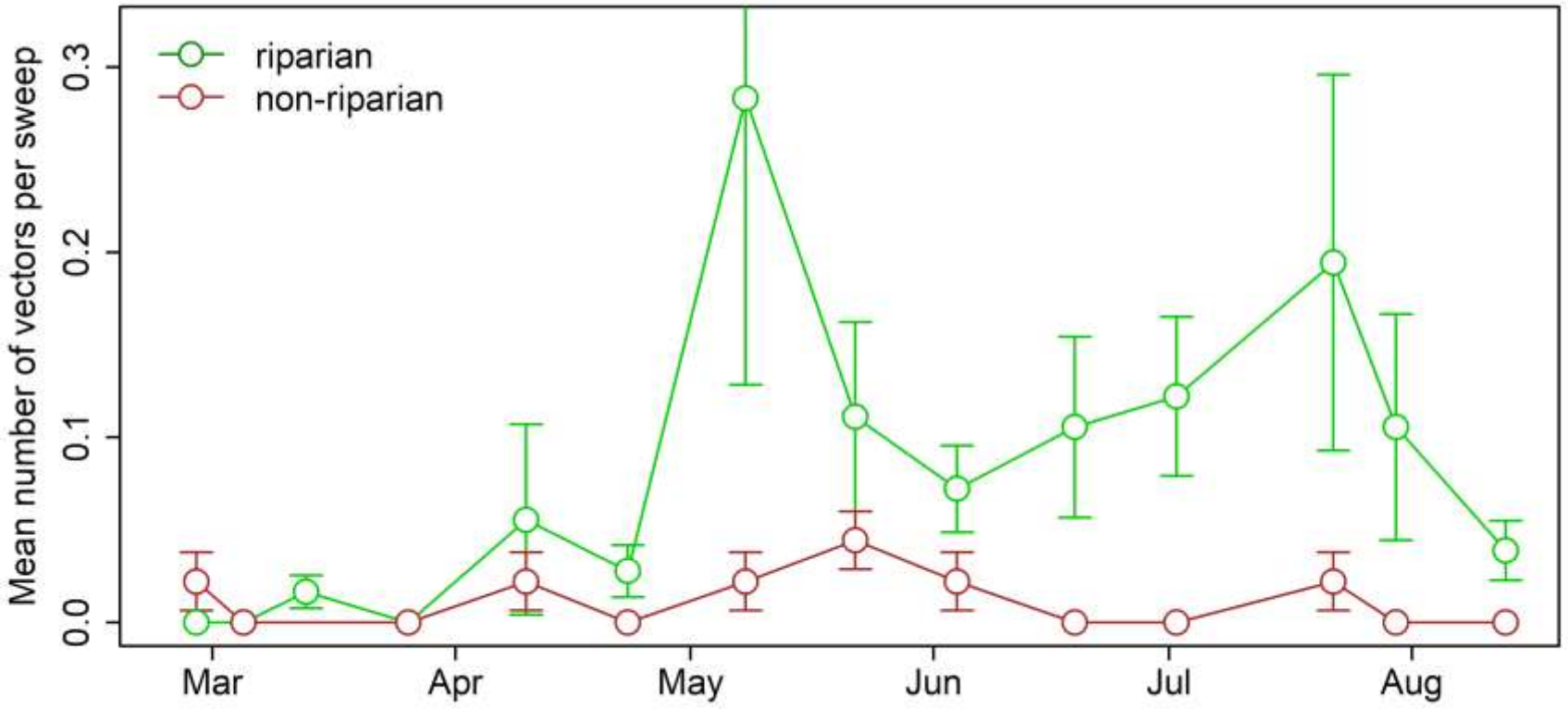
- sweep-net sampling over the growing season along the edge and within vineyards
- all insects identified and counted
- visual surveys for spittlebug nymphs (spittle mass) in replicate transects

Abundance of all vectors in sweep-net surveys



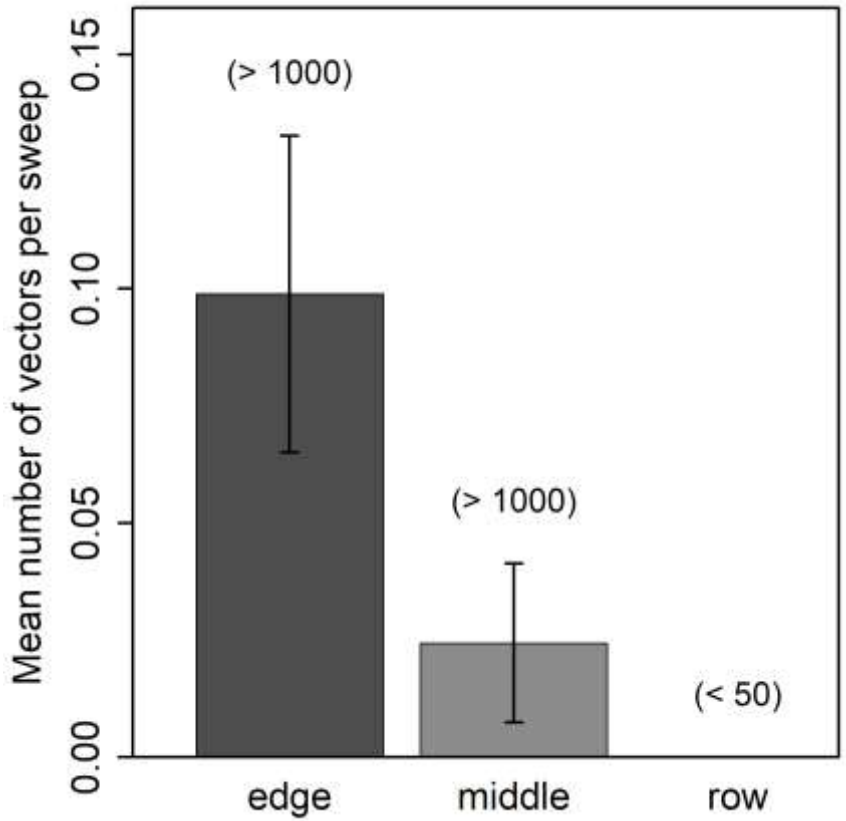
-vectors common mid-Spring through mid-Summer

Abundance of all vectors in sweep-net surveys



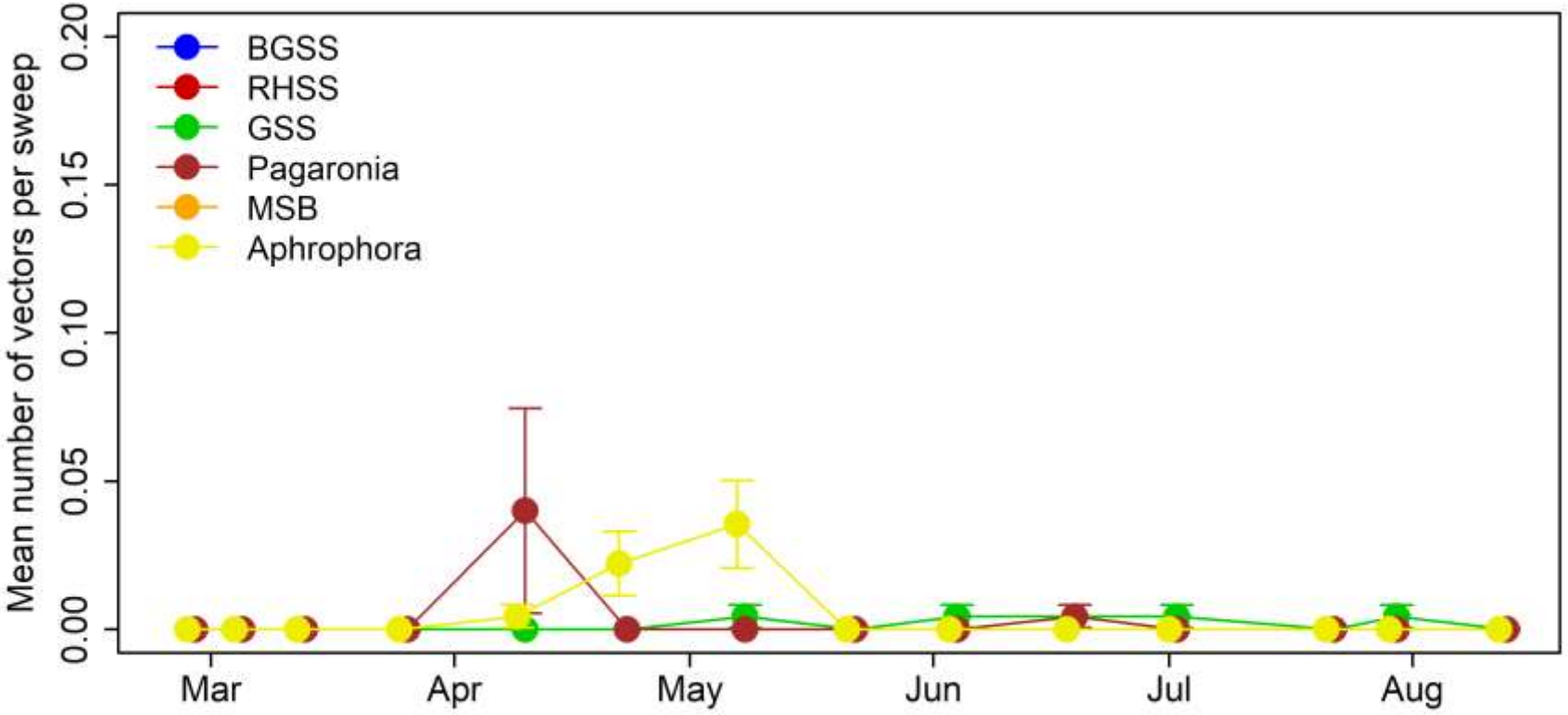
-vectors more common in sweep-netting at riparian sites

Abundance of all vectors in sweep-net surveys



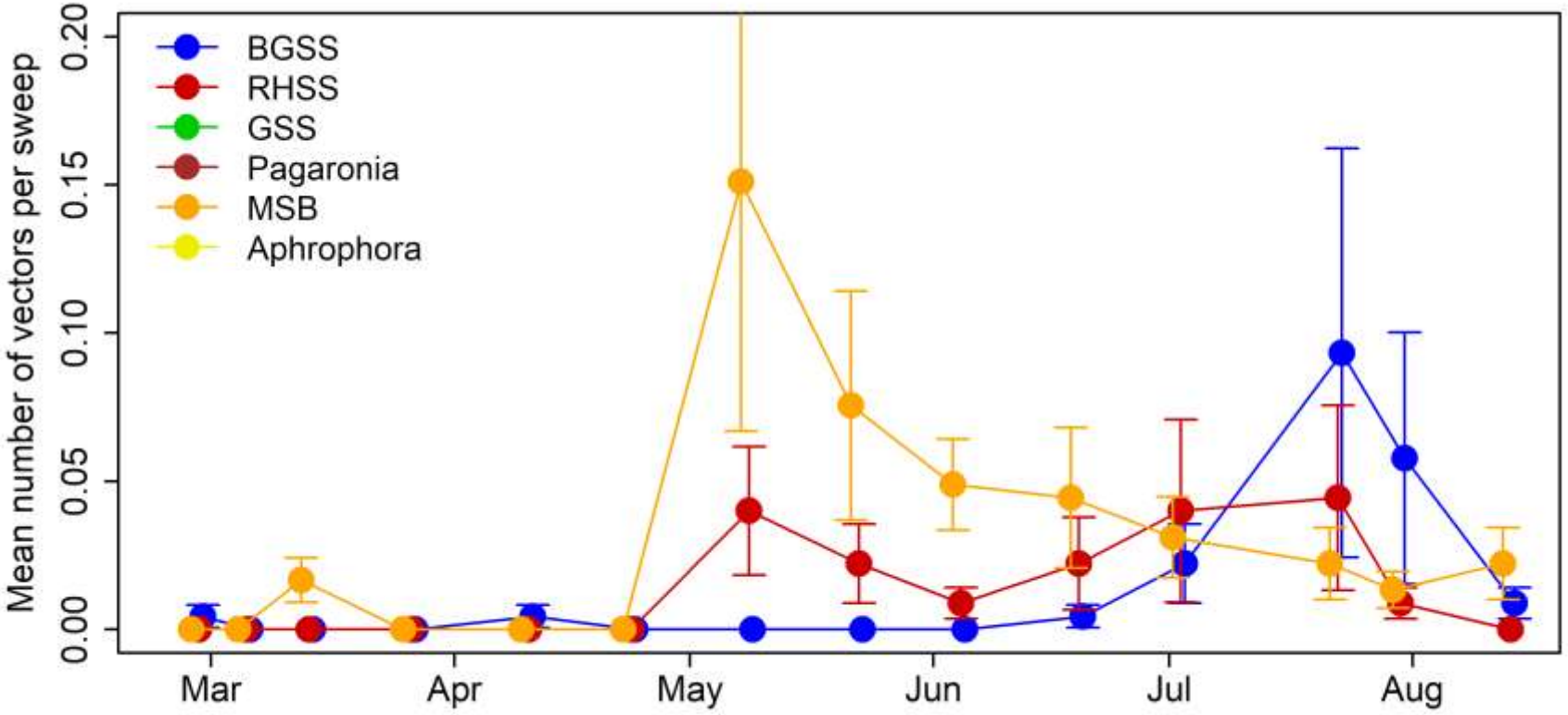
-vectors more common on edge of vineyards than vineyard rows or under vines

Most common vector taxa?



-GSS was uncommon; *Pagaronia* and *Aphrophora* were moderately common only in the Spring

Most common vector taxa?



-BGSS, RHSS, and MSB were more abundant, but showed very different seasonal patterns

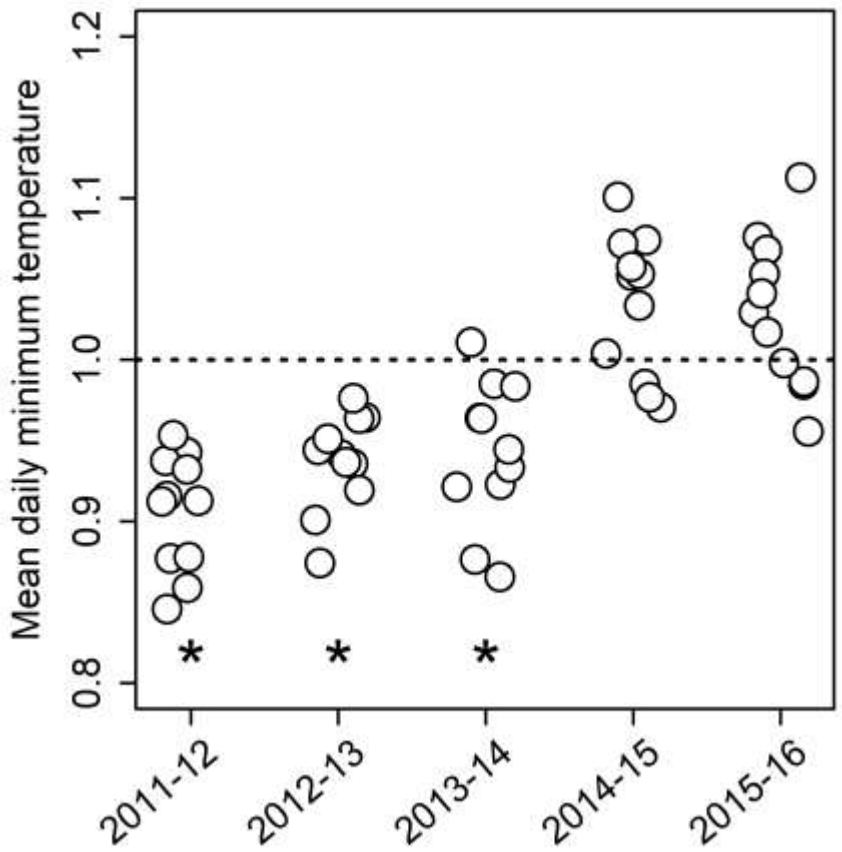
6. The role of climate in PD epidemics

Temperature and precipitation have a range of effects in the PD pathosystem

- wet/warm winters associated with higher BGSS population densities
- higher temperatures increase vector feeding, activity, *Xf* transmission rate, multiplication rate, symptom onset
- cold winters increase vector mortality and vine recovery rate

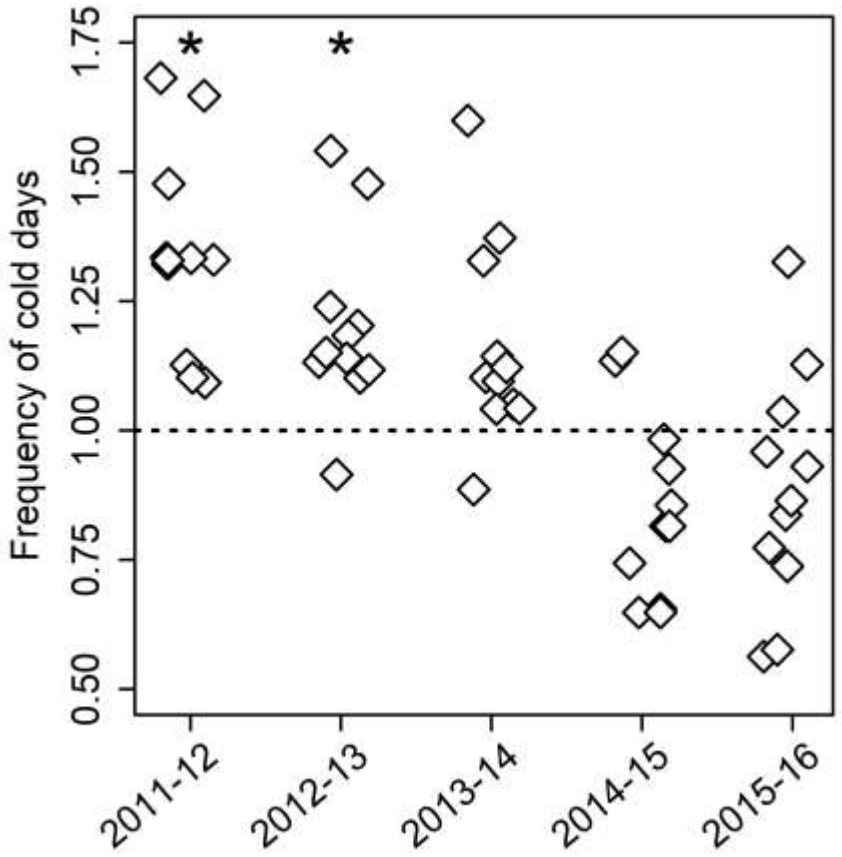
Are climatic conditions the last 5-6 years noticeably different than historic averages in a way that would favor PD incidence?

Are recent winter temperatures “less cold”?



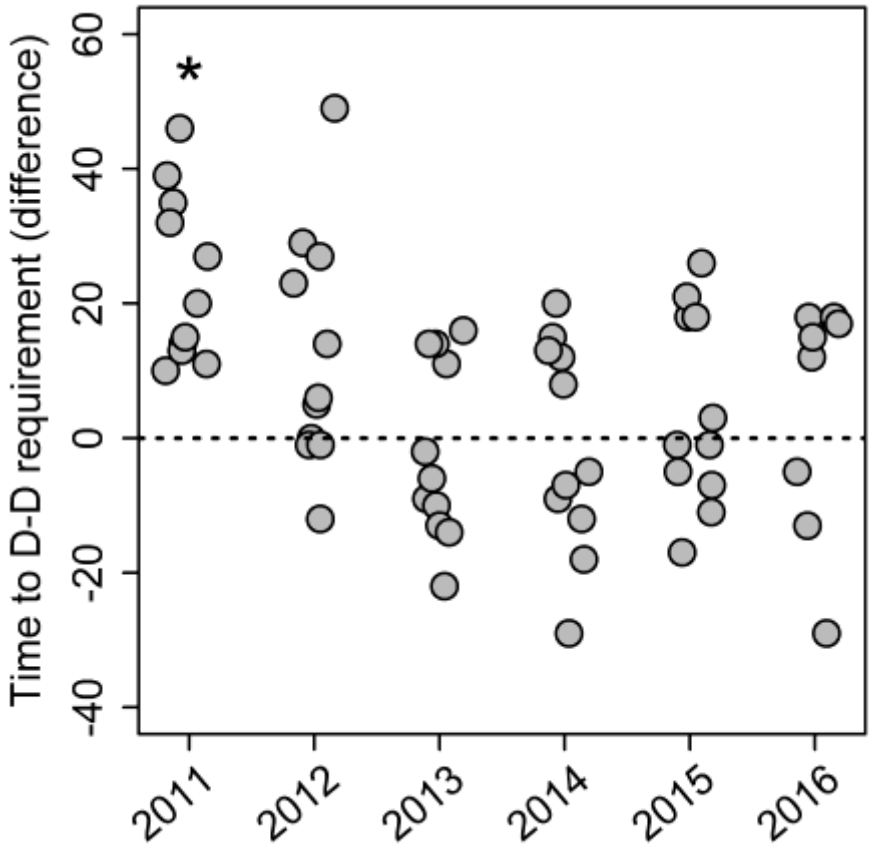
-daily minimum temperatures were significantly colder than historic average 2011-14, and average since then

Are recent winter temperatures “less cold”?



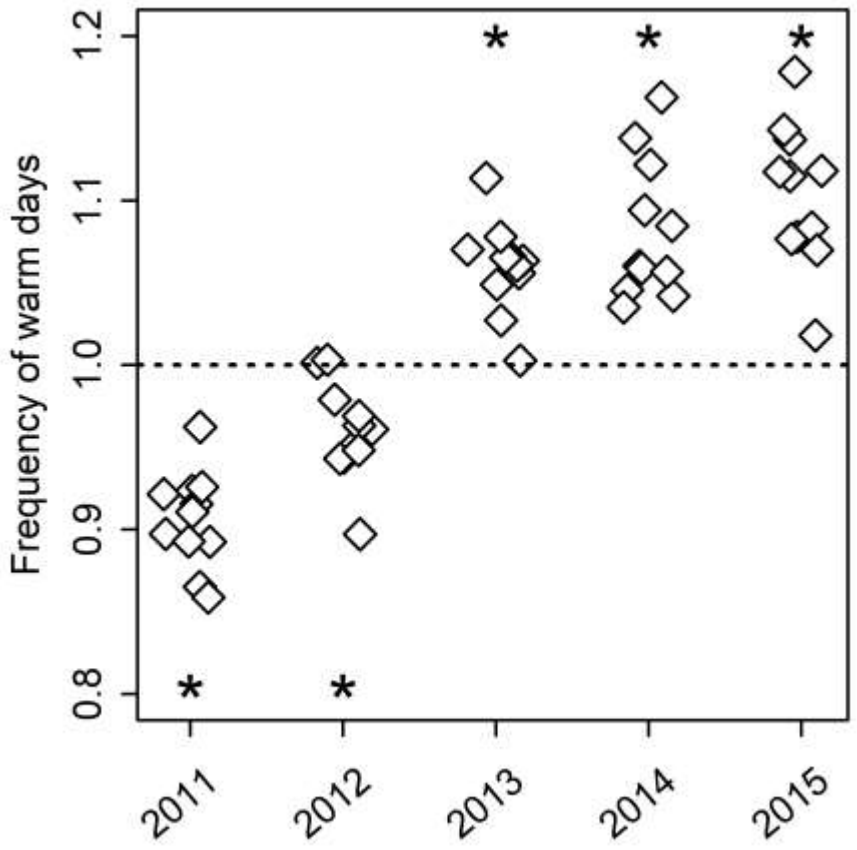
-there were significantly more “cold days” (min < 4 C) than historic average 2011-13, and average since then

Are recent warm growing seasons increasing vector activity?



-the degree-day requirement (~150) for BGSS not met earlier than historic average

Are recent warm growing seasons increasing vector activity?



-though less common 2011-12, there were significantly more "warm days" (min > 14 C) than historic average 2013-15

Contemporary patterns of BGSS abundance mostly match historic patterns

BGSS natural infectivity is highly seasonal

- perhaps consistent with some acquisition occurring in vineyards

PD prevalence is high, with expected differences between site types and expected edge effects

- but, some sites show atypical patterns of PD distribution

Plant community composition explains some site-to-site variation in BGSS pressure

- additional analyses needed to pinpoint which plants are most important (+ and -)

Aside from BGSS, RHSS and MSB were most abundant

- additional analyses needed to understand the role non-BGSS play

Weather station data offer equivocal evidence that recent climatic conditions contributed to PD