Finding Needles in Haystacks: Disease Monitoring and Risk Assessment

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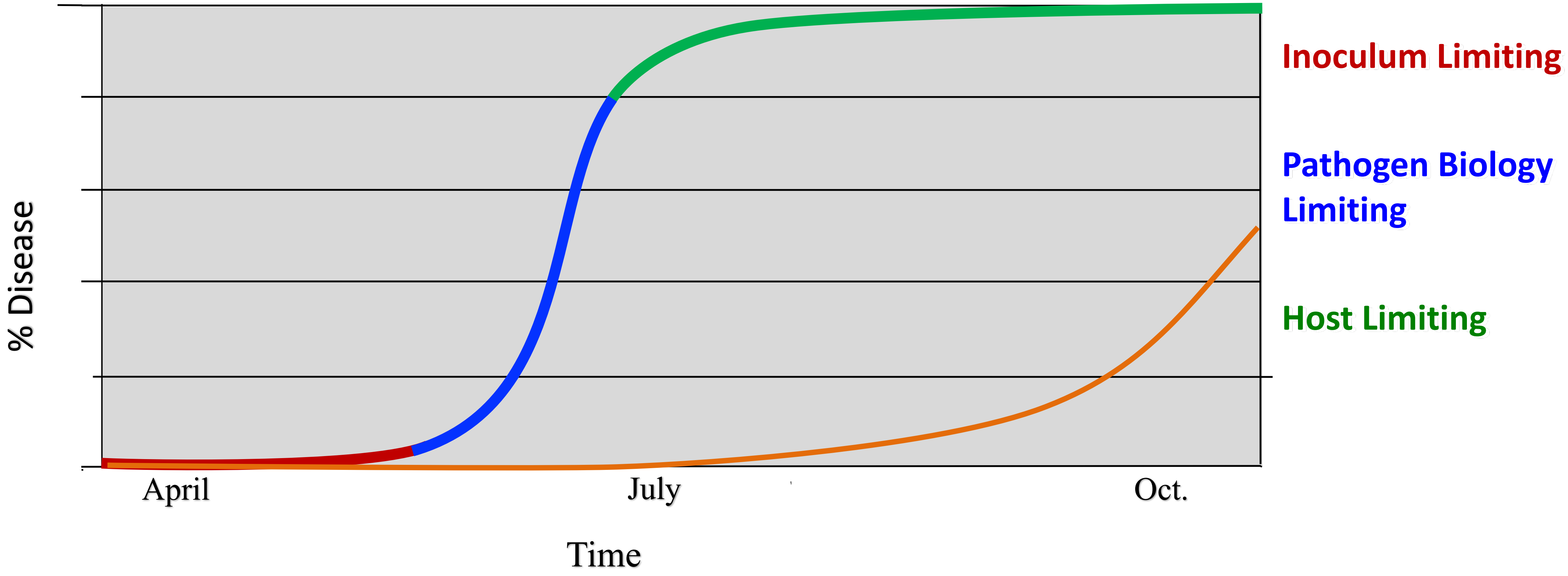
Disease management is about delaying the inevitable



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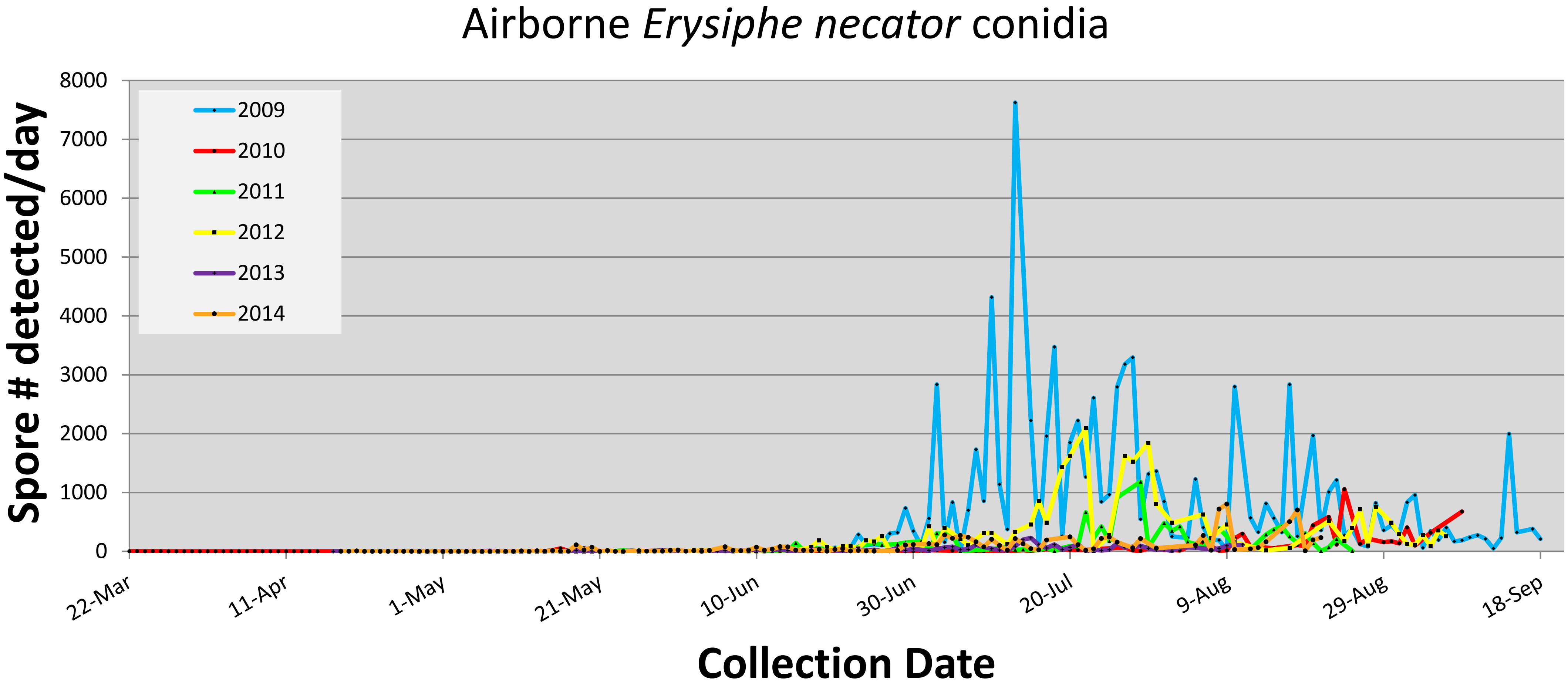
Not all years or days have the same risk



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There are no silver bullets

- **Successful disease management is about combining the right tools, to the right location, at the right times, and in the right sequence.**
  - Disease forecasting
    - Formal (active model use)
    - Informal (internalized model into their intuition)
  - Disease Scouting – action thresholds and adjustments
  - Cultural practices
    - Fertility
    - Canopy management (row structure, orientation, trellising, pruning, leaf removal, etc)
    - Genotypes (plant resistance)
    - Planting times
  - Pesticide applications
    - Mostly prophylactic

Well…
maybe one

Disease risk is not uniform or random but where is it?

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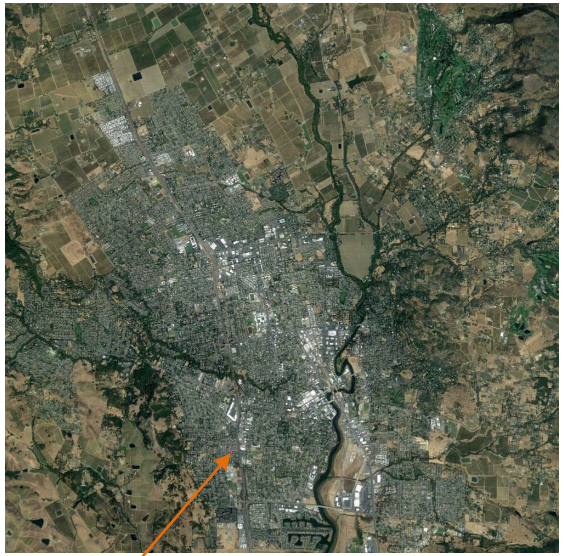
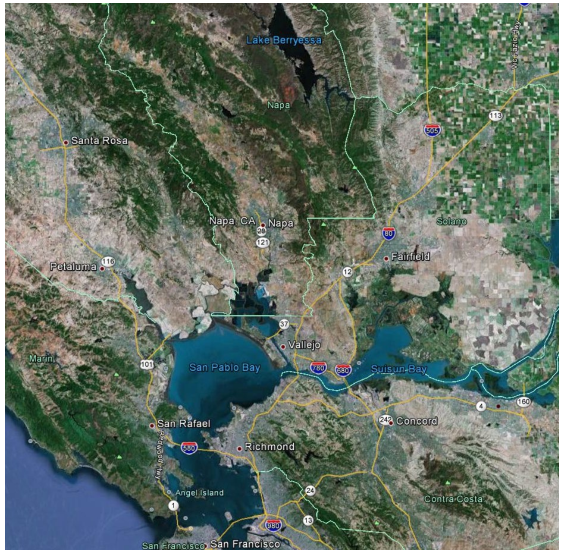
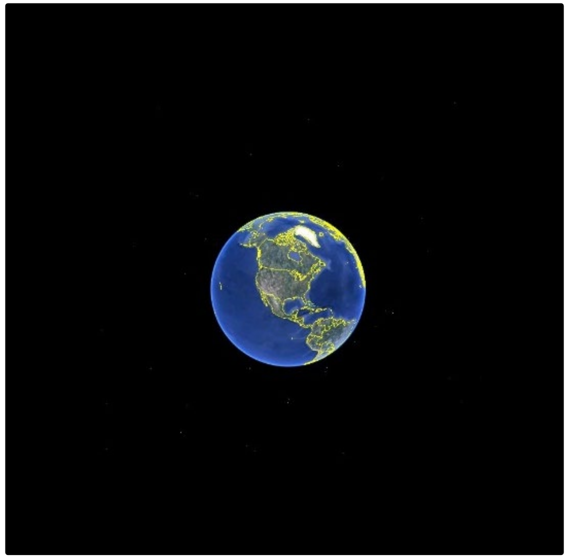
Scaling the Problem

- Let’s assume 1 µm = 1 m then I am 2 µm
- Then this is







1 cm^2

Readily observable
E. necator colony

100 cm^2

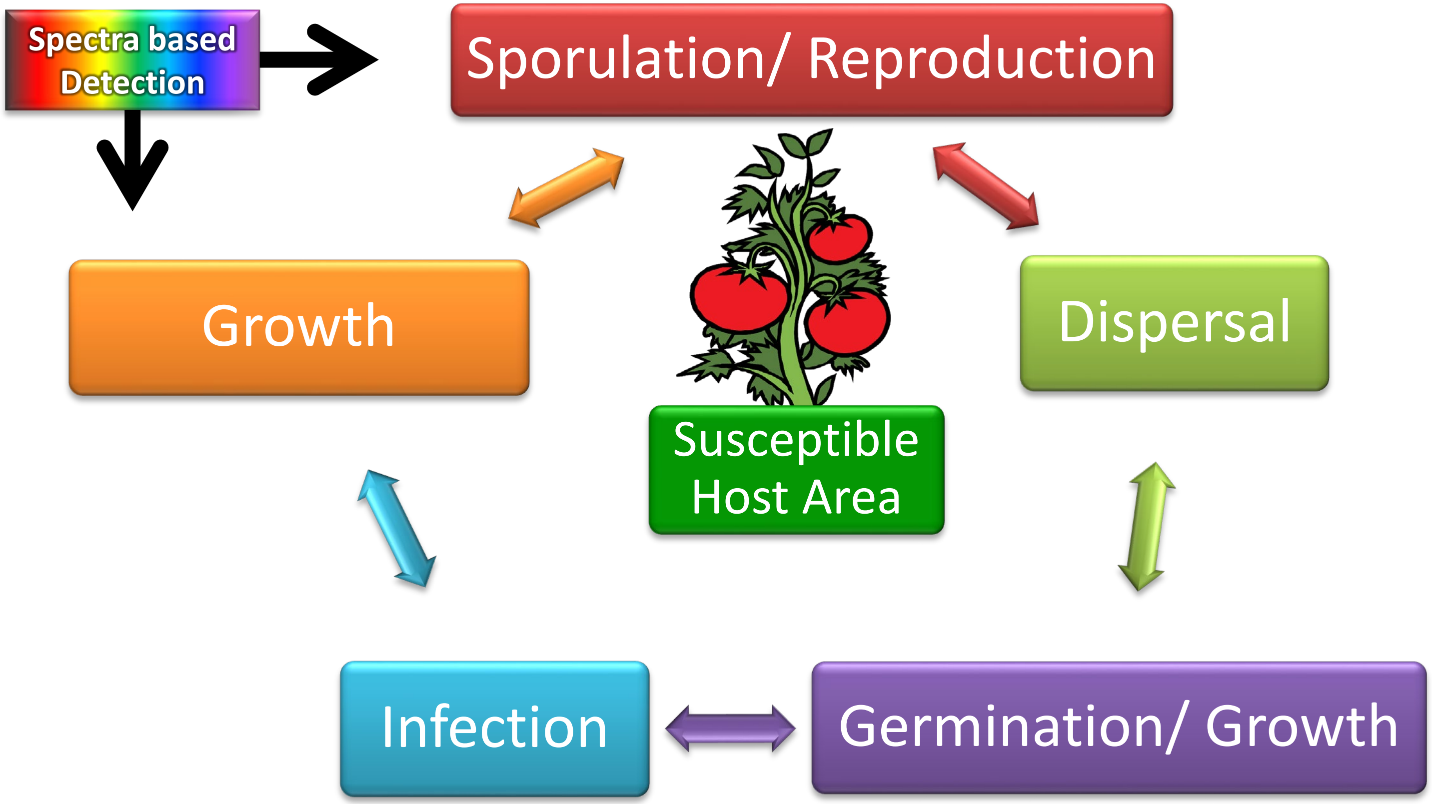
Average grape leaf

1 hectare

~2.5 acres

Scouting is focused on physical location

Pathogen Life Cycle



Spectra based Detection

Sporulation/ Reproduction

Growth

Dispersal

Susceptible Host Area

Infection

Germination/ Growth

Adapted from Aylor, 2017; Ch1

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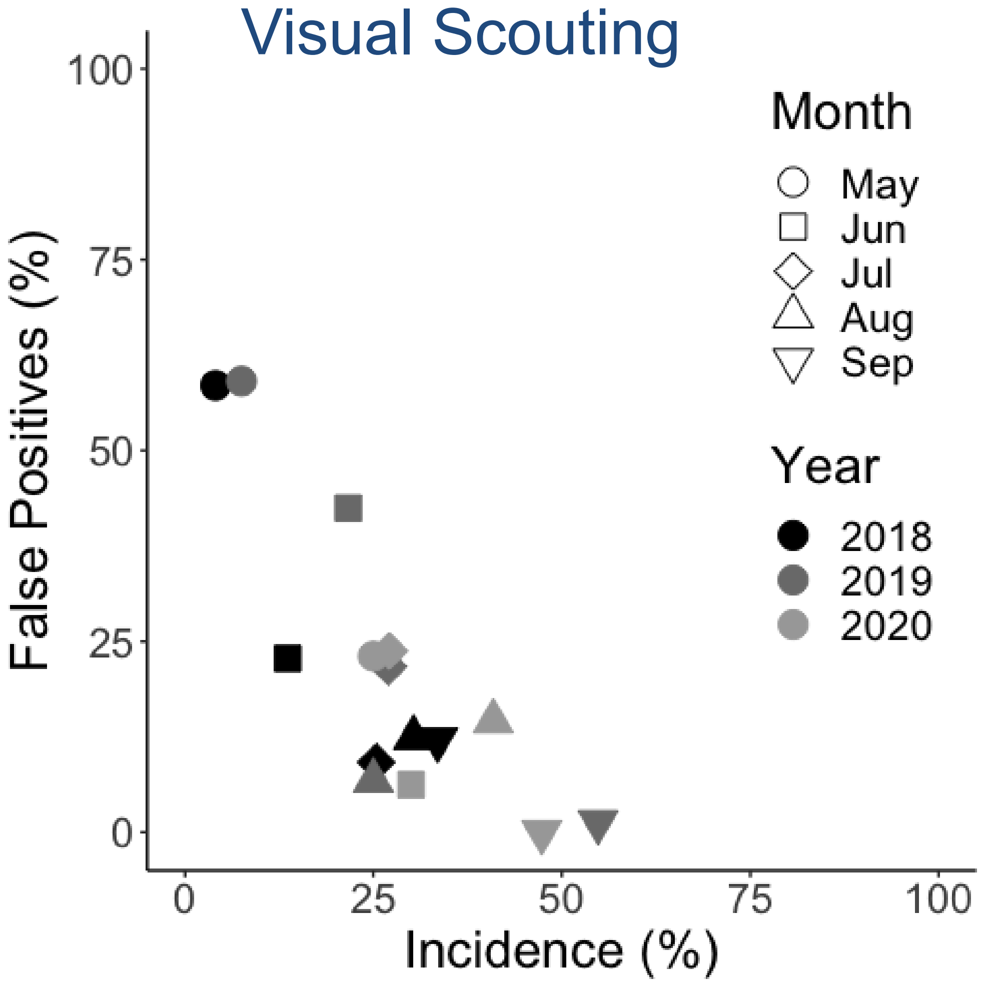
We aren’t very good at seeing it

Sarah Lowder


Visual Scouting

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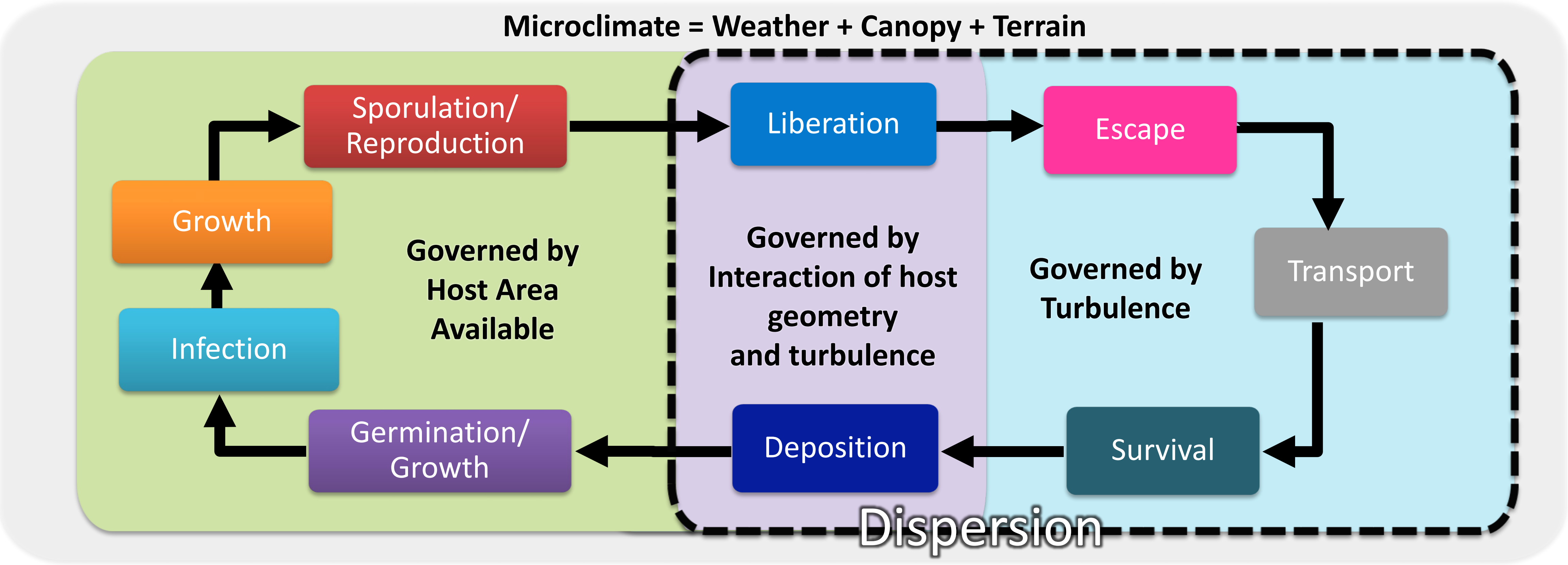
Pathogen Life Cycle



Microclimate = Weather + Canopy + Terrain

Sporulation/ Reproduction

Liberation

Escape

Growth

Governed by Host Area Available

Governed by Interaction of host geometry and turbulence

Governed by Turbulence

Transport

Infection

Germination/ Growth

Deposition

Survival

Dispersion

Mahaffee et al, 2022. Plant Disease https://doi.org/10.1094/PDIS-11-21-2570-FE

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Inoculum Monitoring

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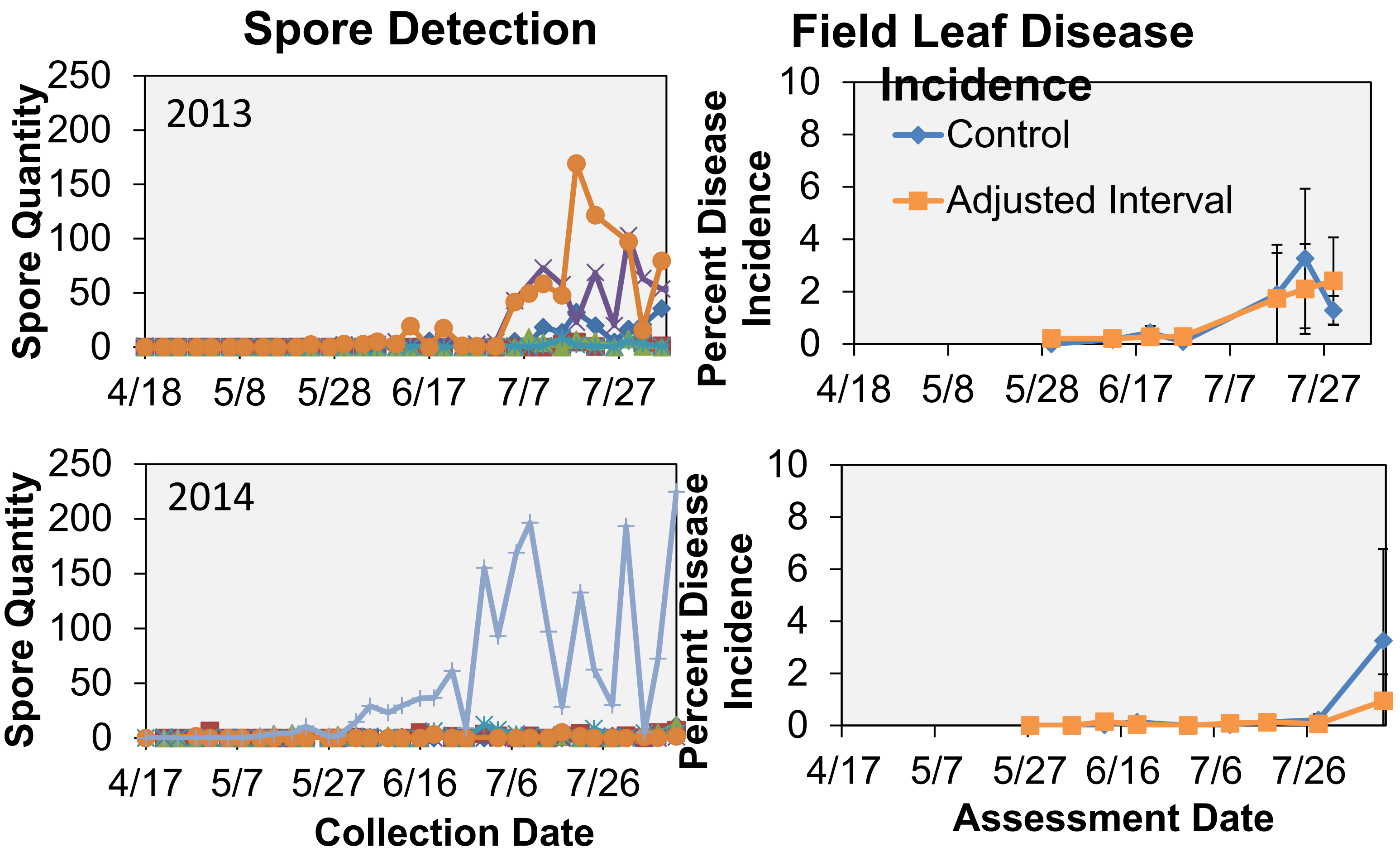
Inoculum Detection as a Decision Aid for Adjusting Fungicide Intervals

Lindsey Thiessen

- Program started with first detection and then intervals stretched based on spore number
- Average of 3.8 fungicide applications saved (8 seasons)
- Saving $150-250/A in fungicide
- Saving >13lbs/A of fungicide
- Currently, over 400 traps commercially deployed



CVC

Revolution Crop Consultants

AL&L Crop Solutions

Agri-Analysis

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Thiessen 2016 Plant Pathology 65:238-249; 2017 Plant Dis 101:1246-1252; 2018 PeerJ 6:e4639 doi:10.7717/peerj.4639.

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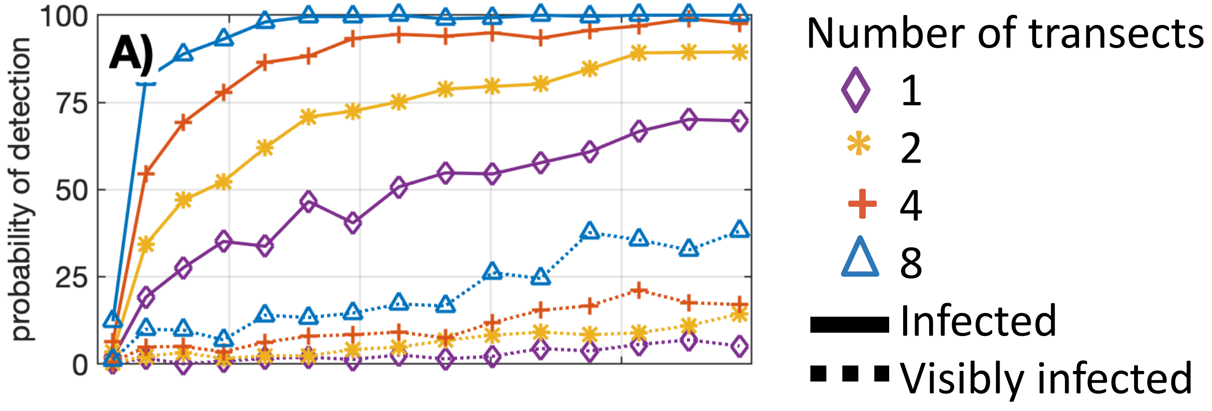
Simulated Disease Development

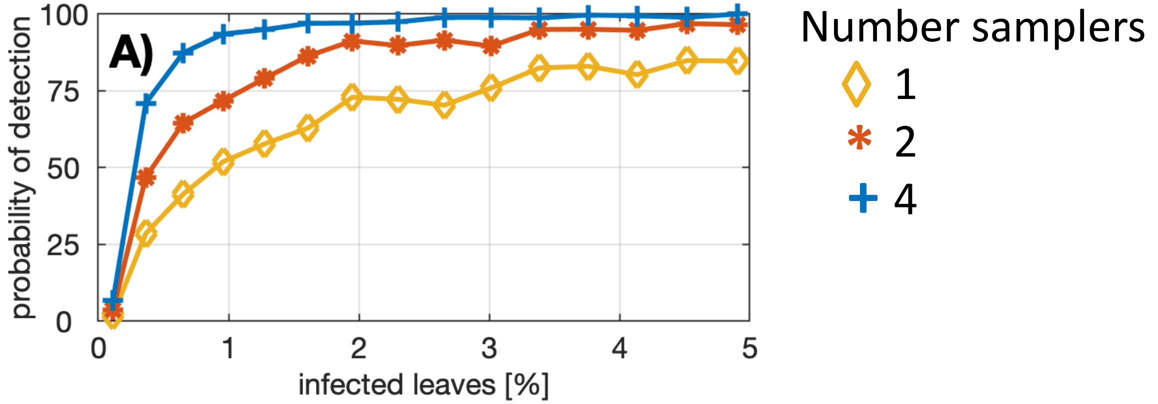
Simulated epidemic starting from one disease foci

3 Ha (7.4 Acres) - Vine spacing 5’x7’

Visual Detection



Spore Sampler



Data points ensemble of 2000 simulations

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A Different Kind of Spore Trap
Glove Swab

Sarah Lowder

Glove –v– Visual

Sarah Lowder

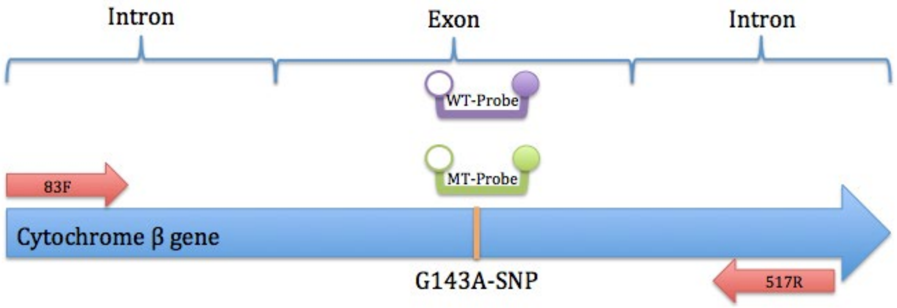
Comparison of glove swab and visual assessment for detection of *E. necator* in a row.

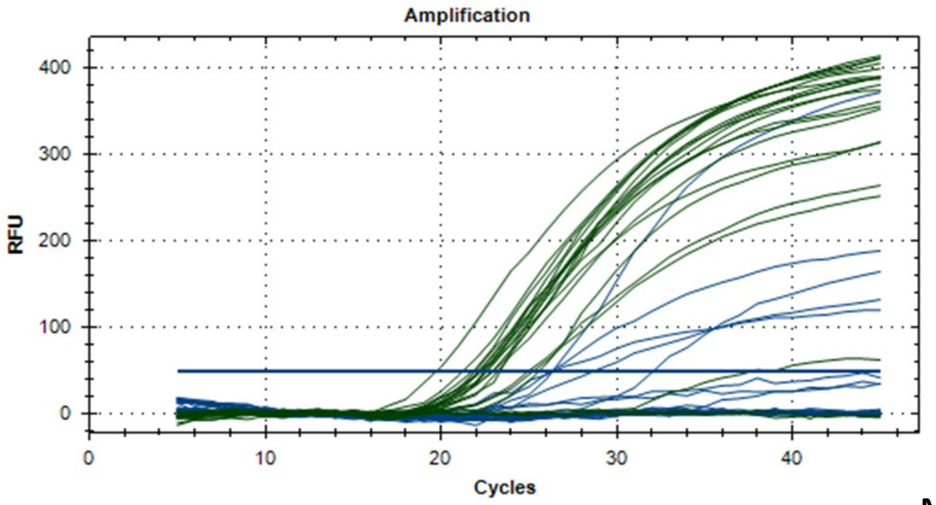
	Glove Detection	**No Glove Detection**
Visual Detection	247	14
No Visual Detection	199	204

Fisher's Exact Test, p-value: <0.001

Molecular Detection of QoI Resistance

- **Single nucleotide mutation (G143A)**
- **Developed TaqMan qPCR and ddPCR competitive Assays.**
- **Sensitive to a single spore**
- **Can detect alleles when >10% of population with qPCR and >5% with ddPCR**





Miles et al., 2021

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Collaborators – Tim Miles, Michelle Moyer, Ioannis Stergiopoulos, Melanie Ivy, Phil Brannen, Rachel Nagaele,

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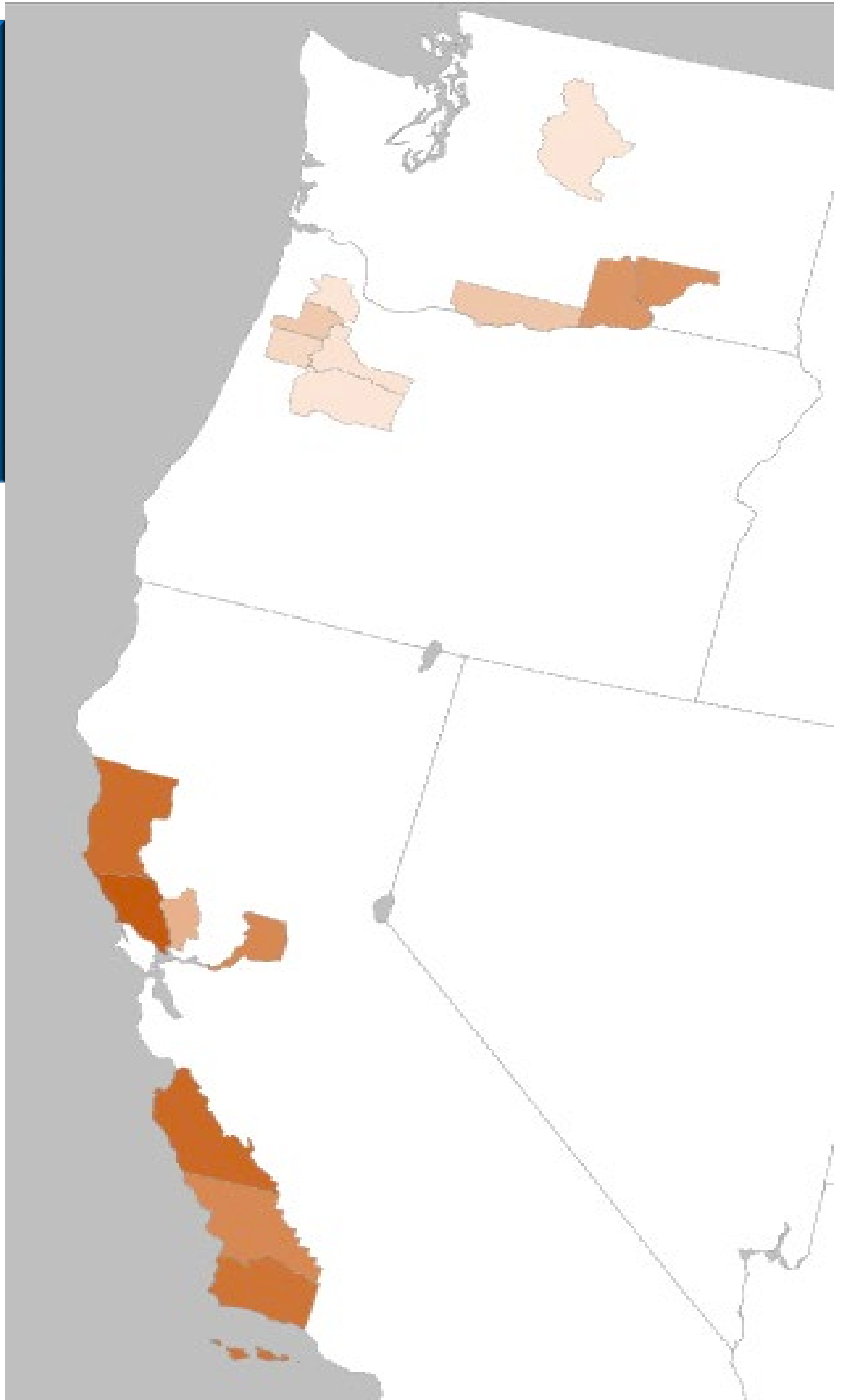
QoI Resistance Frequency across the Western US Counties sampled

107 vineyards
4857 samples
17 Counties in CA, OR, WA
2018-2020



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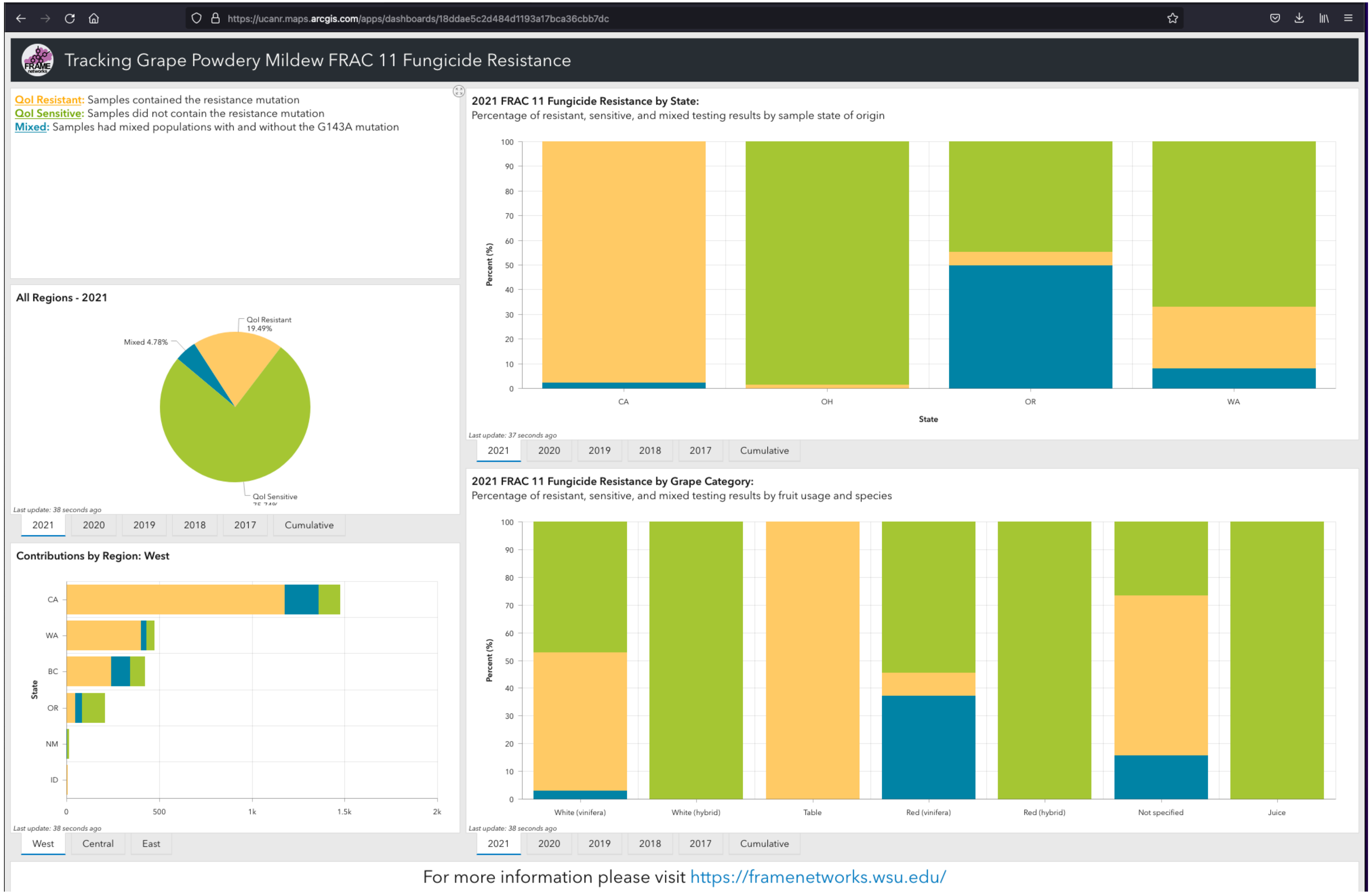
Public Database of Fungicide Resistance



https://ucanr.maps.arcgis.com/apps/dashboards/18ddae5c2d484d1193a17bca36cbb7dc

Tracking Grape Powdery Mildew FRAC 11 Fungicide Resistance

QoI Resistant: Samples contained the resistance mutation
QoI Sensitive: Samples did not contain the resistance mutation
Mixed: Samples had mixed populations with and without the G143A mutation

All Regions - 2021

Last update: 38 seconds ago

Contributions by Region: West

Last update: 38 seconds ago

2021 FRAC 11 Fungicide Resistance by State:
Percentage of resistant, sensitive, and mixed testing results by sample state of origin

Last update: 37 seconds ago

2021 FRAC 11 Fungicide Resistance by Grape Category:
Percentage of resistant, sensitive, and mixed testing results by fruit usage and species

Last update: 38 seconds ago

For more information please visit https://framenetworks.wsu.edu/

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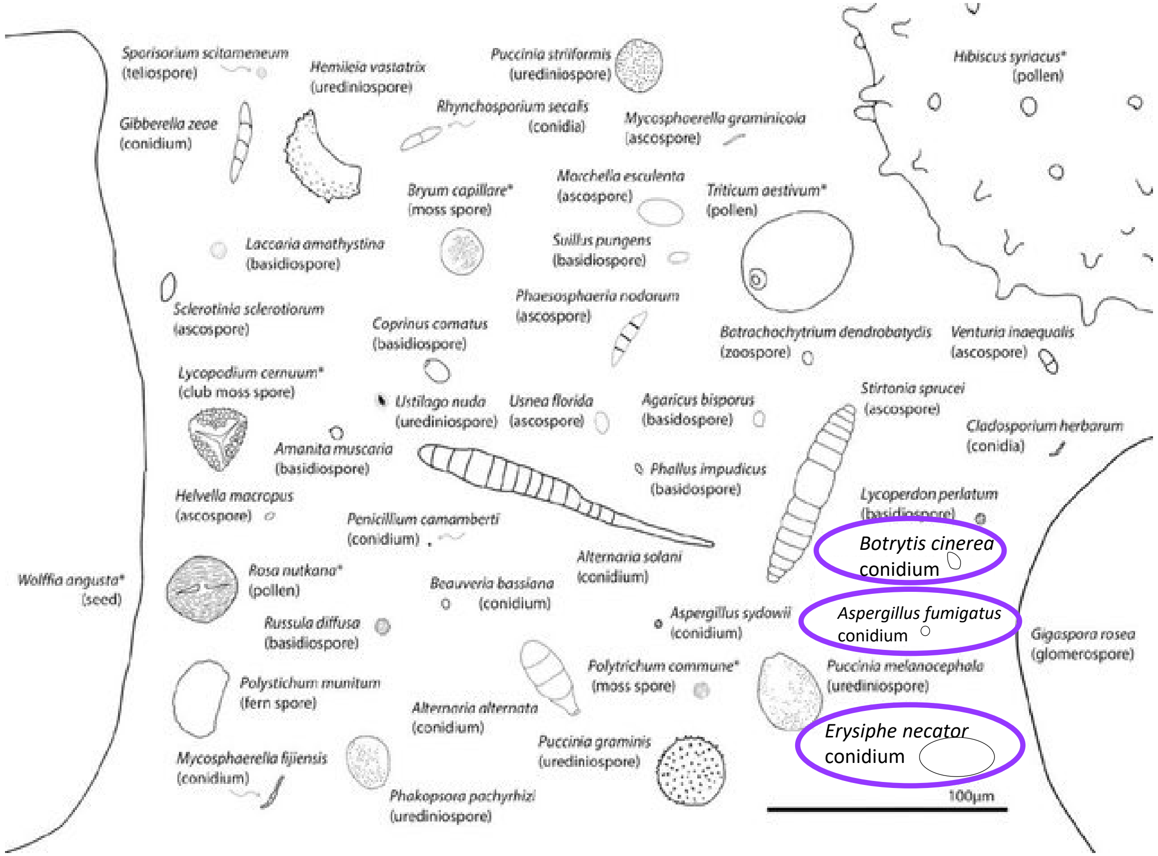
Azole resistance present?

- **273 air samples that had the Y136F mutation associated azole resistance in *E. necator***
- **No *A. fumigatus* detected using adapted methods for TR34 and TR46**
  - Samples spiked with DNA from Azole sensitive and resistant *A. fumigatus* isolates were positive
- **Also detected *B. cinerea* conidia.**



Adapted from GOLAN & PRINGLE. 2017. DOI: 10.1128/microbiolspec.FUNK-0047-2016

Collaborators – Virginia Stockwell
Bill Weldon

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8 days, the time required to treat all blocks

Management takes time and money

Farm managers are short on both

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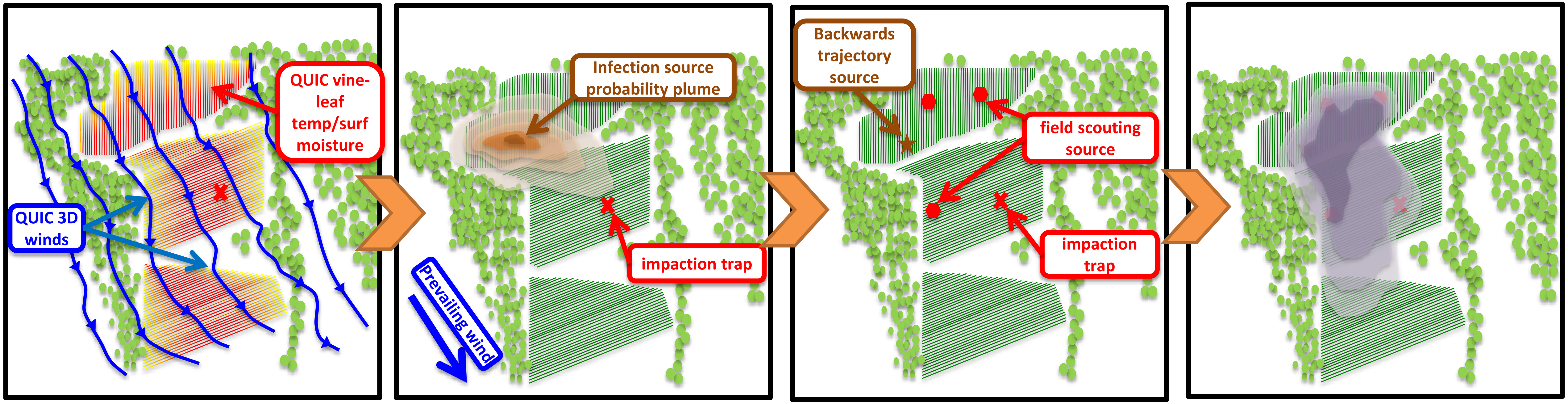
Can we predict the past (origin) and future (spread)?

Forward simulation of wind, temperature, and water vapor from WRF-QUIC

Backwards in time source location identification using WRF-QUIC output starting from inoculum detection points

Source map using backwards locations, WRF-QUIC vine-leaf temp/surf moisture, and field scouting

Prediction of risk regions for future spread based on source map and WRF-QUIC wind, temperature and H_2O



Collaborators – Rob Stoll
Eric Pardyjak
Brian Bailey

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Foliar Pathology Lab
2022

Hannah Soukup and Tara Neill: **USDA-ARS**

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