Use of Copper for Frost Control in Cold-Climate Vineyards 2023 Pest Observations

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North Coast

Frost Risk and Issues
in Northern California

Timing for Frost Risk

- Spring Frost
  - Anytime after budbreak
  - Late March to Late April
  - Damages new shoots
  - Influenced by populations of ice-nucleating bacteria present on spring cover crops

- Fall Frost
  - Occurs around harvest
  - October – November
  - Less likely to be impacted by ice-nucleating bacteria

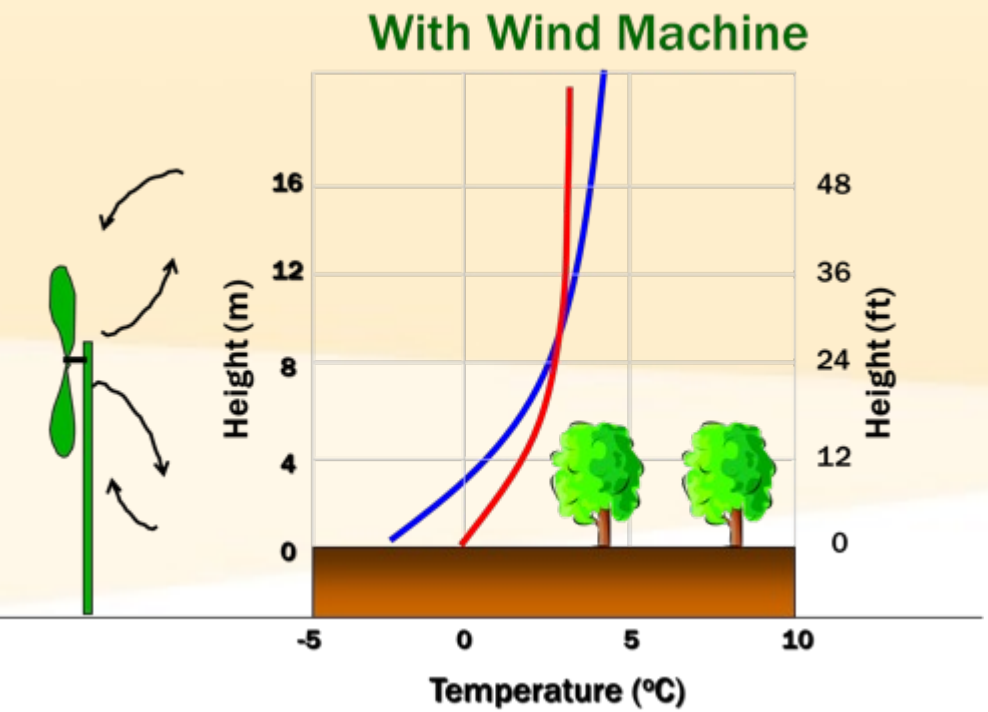
2022 Spring Frost Event

- Large frost event occurred on April 12-13, 2022
- Temperatures were in the 70 ºF range just days before
  - This led to de-acclimation of vines to cold temperatures
  - Making them more susceptible to frost damage
- Damage occurred as far south as Fresno

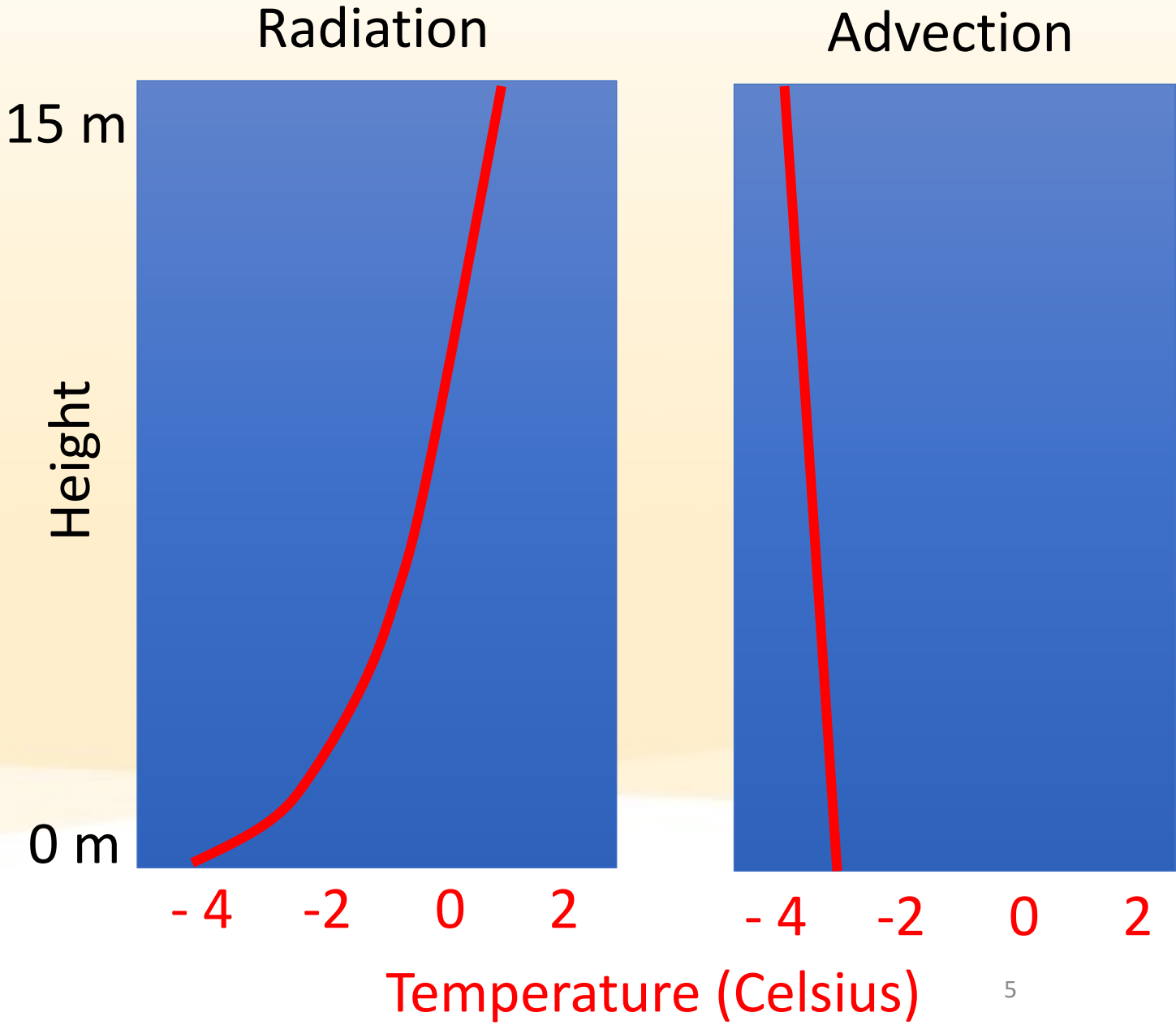
Source: Stephanie Boulton

Wind Machines

- Require a **radiative freeze**
- Only works in the right conditions



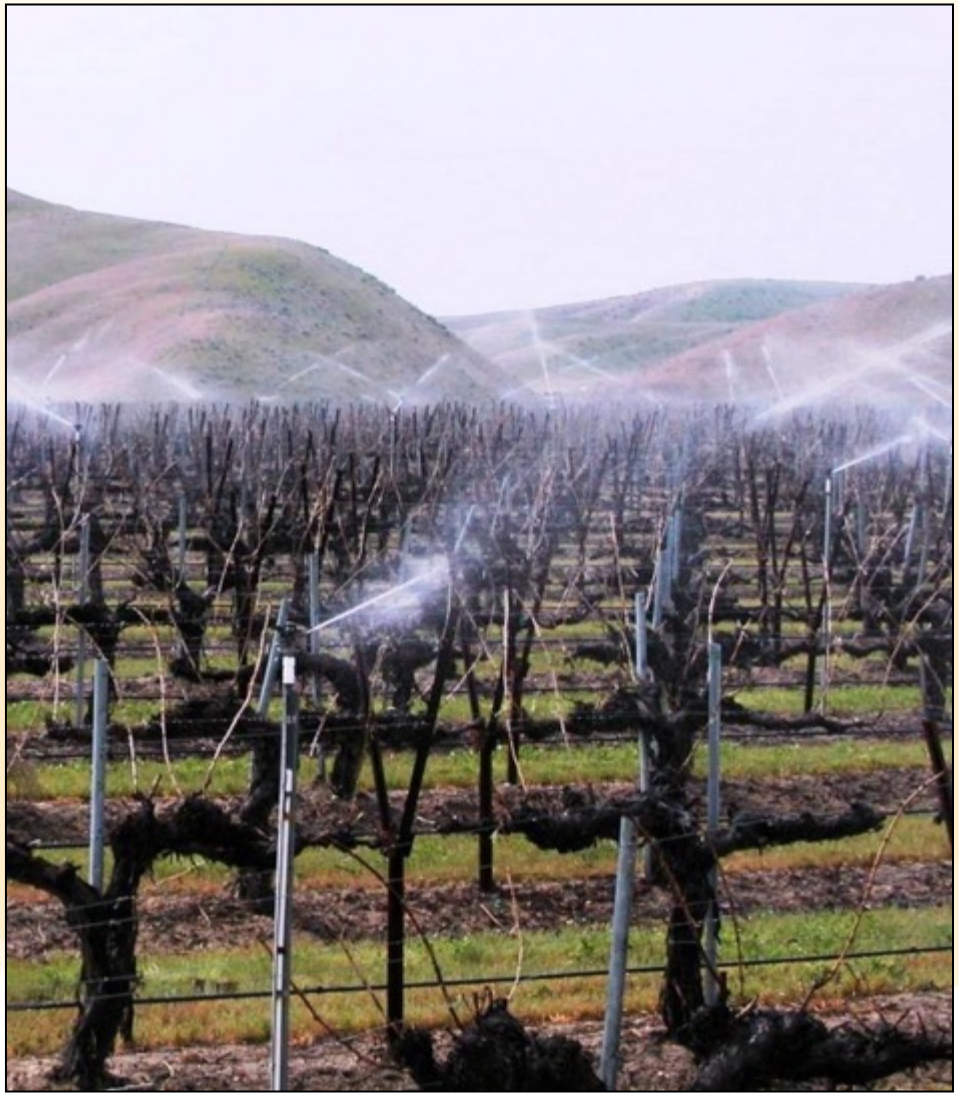
Source: Mark Battany



Overhead Sprinklers

- Challenges:
  - Wet soils
  - Humidity, diseases
  - Nutrient leaching (nitrates)
  - Erosion
  - Fall use limited

Source: Mark Battany



Limiting Frost Risk

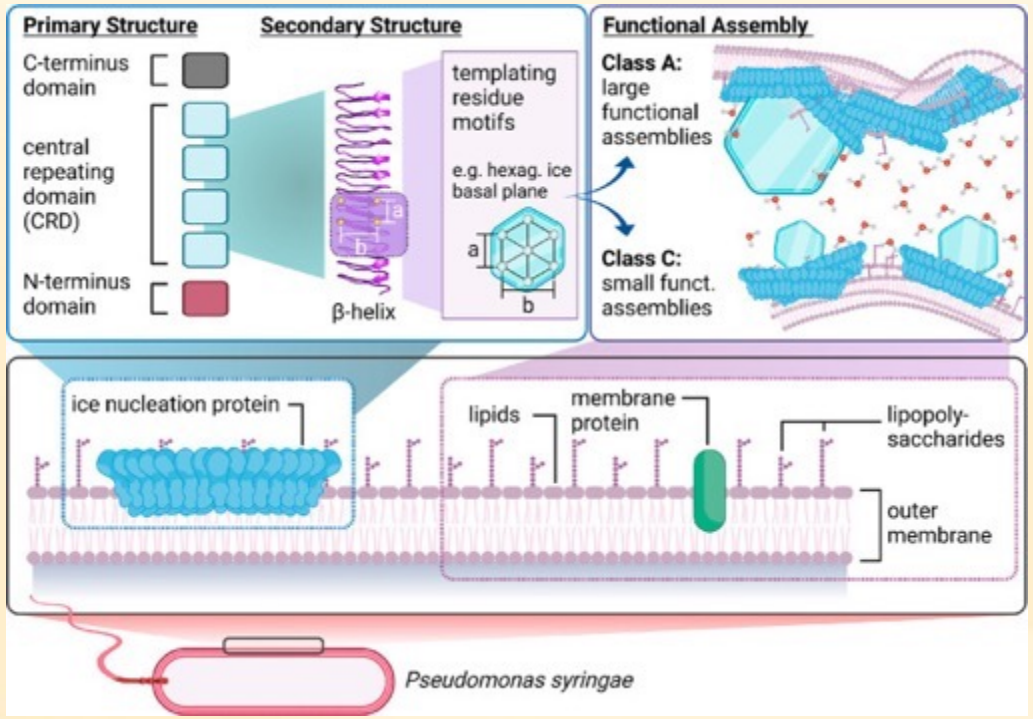
- We can limit frost risk though ground management
- Cover crops are particularly influential on frost risk
- Cover crops can increase frost risk in vineyards through:
  - Vegetation height
  - Hosting ice-nucleating bacteria

Ice-Nucleating Bacteria

Impacts on Frost Risk

How Ice-Nucleating Bacteria Increase Frost Risk

- Ice-Nucleating bacteria have the ability to facilitate ice formation
- This is due to specialized ice-nucleating proteins (INPs) anchored to the outer bacterial cell membrane
  - These INPs lead to ice crystallization at higher temperatures in plant tissues
- In absence of ice-nucleating bacteria, plants can **'supercool'** down to 23 °F without damage to tissues
  - Removing populations of INBs can decrease the upper limit of frost risk by **3-4 °F** in vineyards

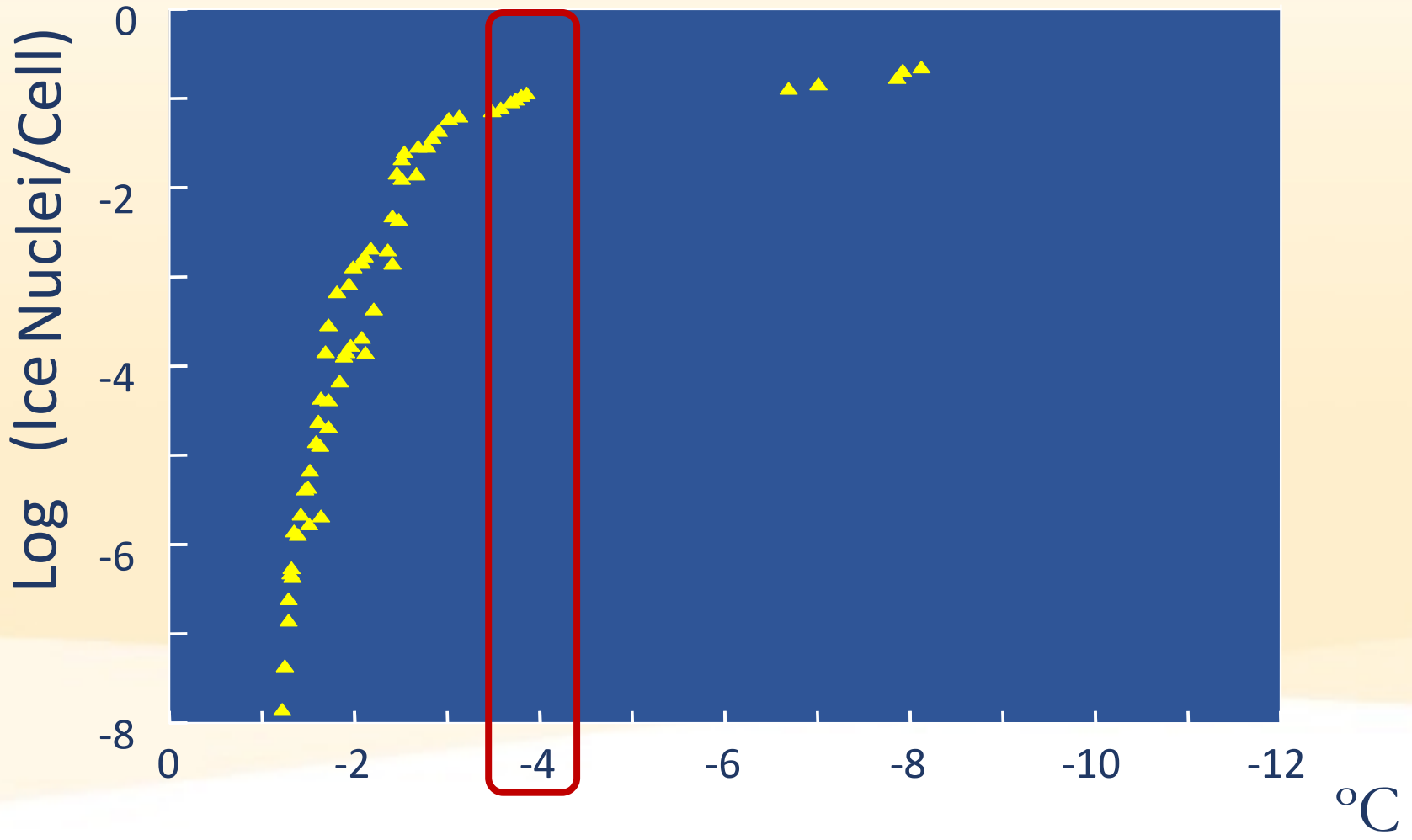


Ice-Nucleating Bacterial Species

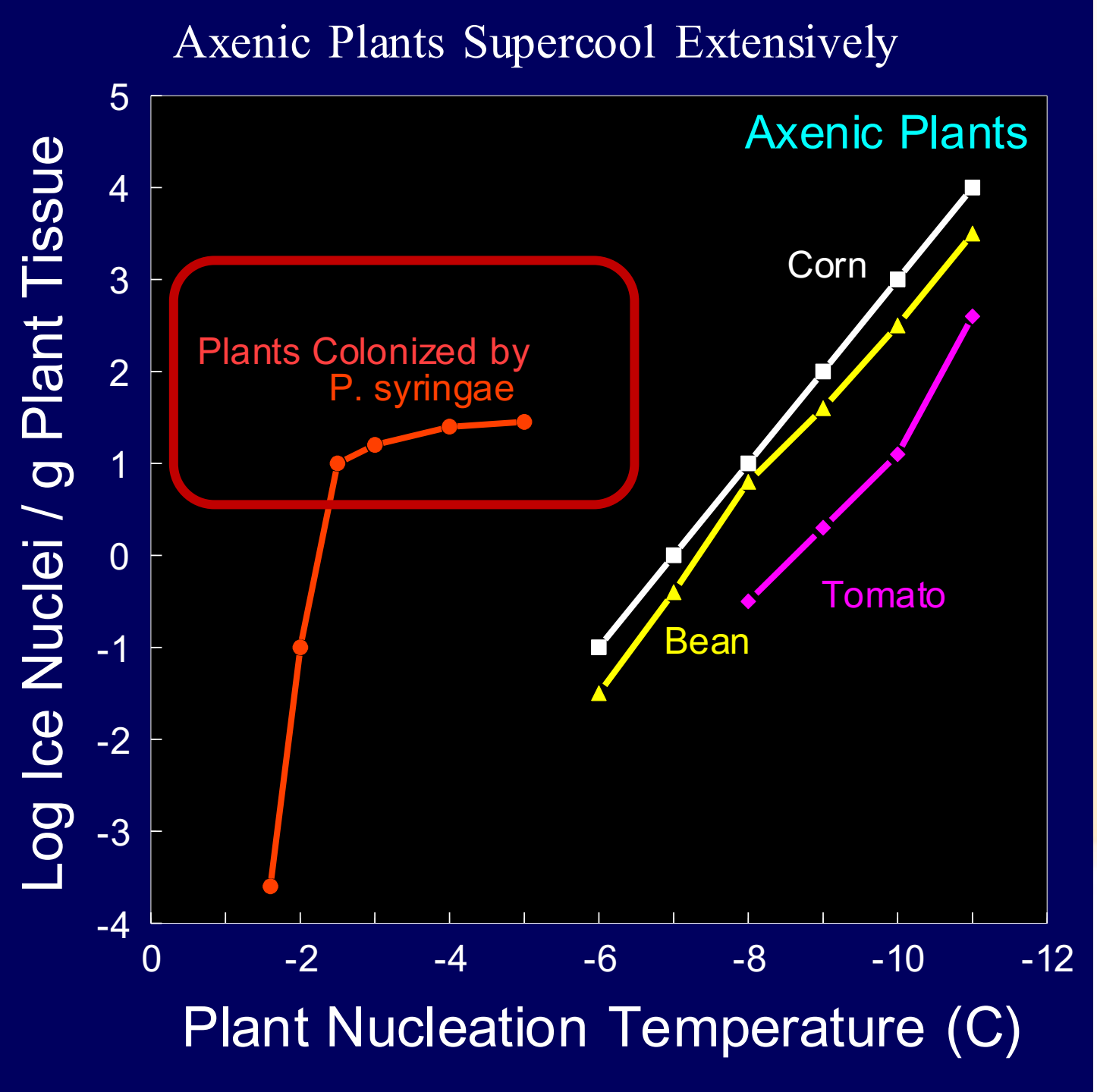
- There are a handful of ice-nucleating bacterial species that can impact frost risk in vineyards:

  - *Pseudomonas syringae*
  - *Erwinia herbicola*
  - *Pseudomonas viridiflava*
  - *Pseudomonas flourescens*
  - *Xanthomonas campestris* pv. translucens

Ice-Nucleation Activity – *Pseudomonas syringae*



Source: Glenn McGourty



Axenic Plants Supercool Extensively

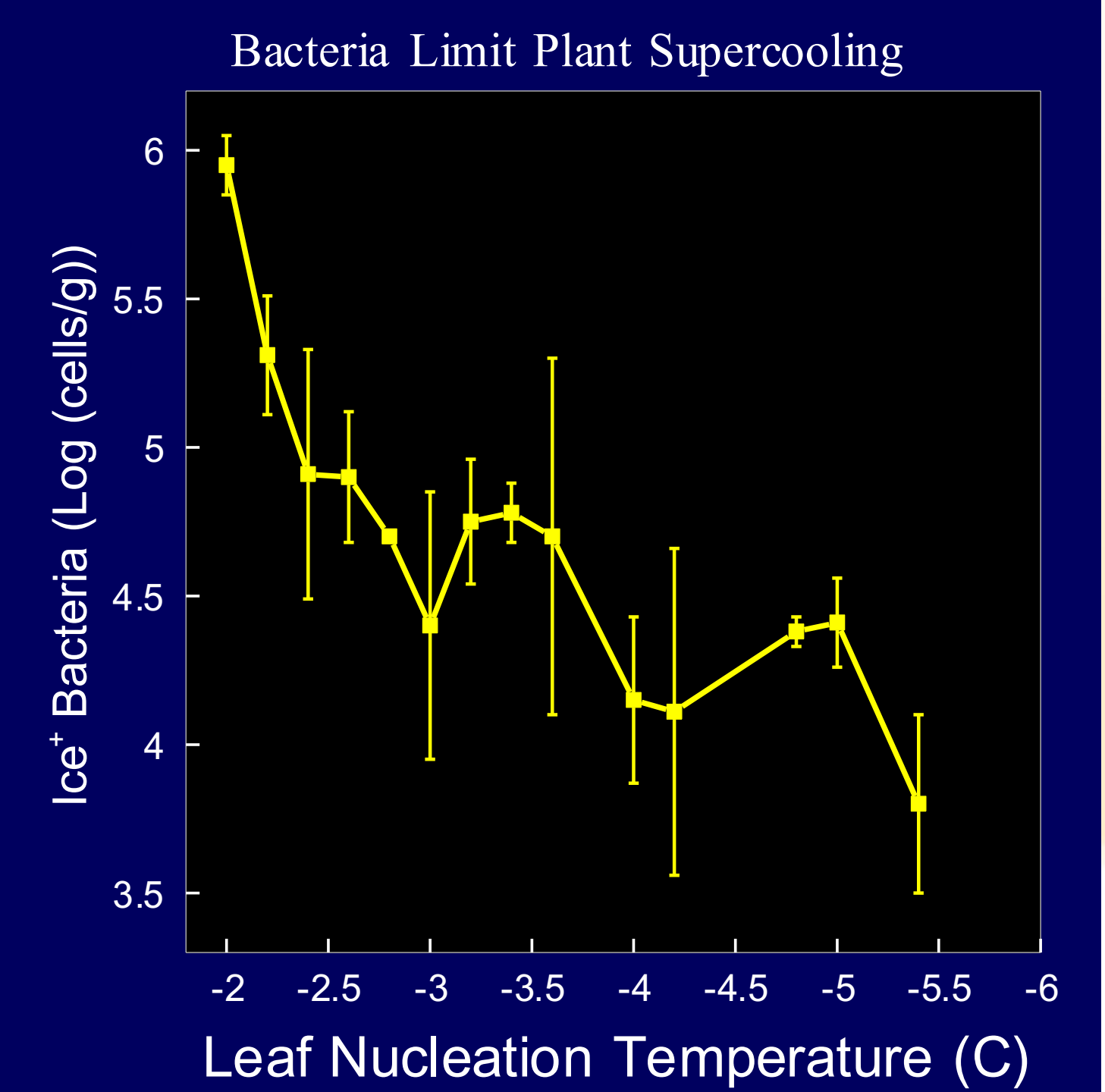
Axenic

- Sterilized
- Consisting of no cultivatable organism other than itself
- Having a completely defined microbiological flora

Supercooling

- The cooling of a liquid below the normal freezing temperature that is expected for that liquid based on solute concentration

Source: Glenn McGourty



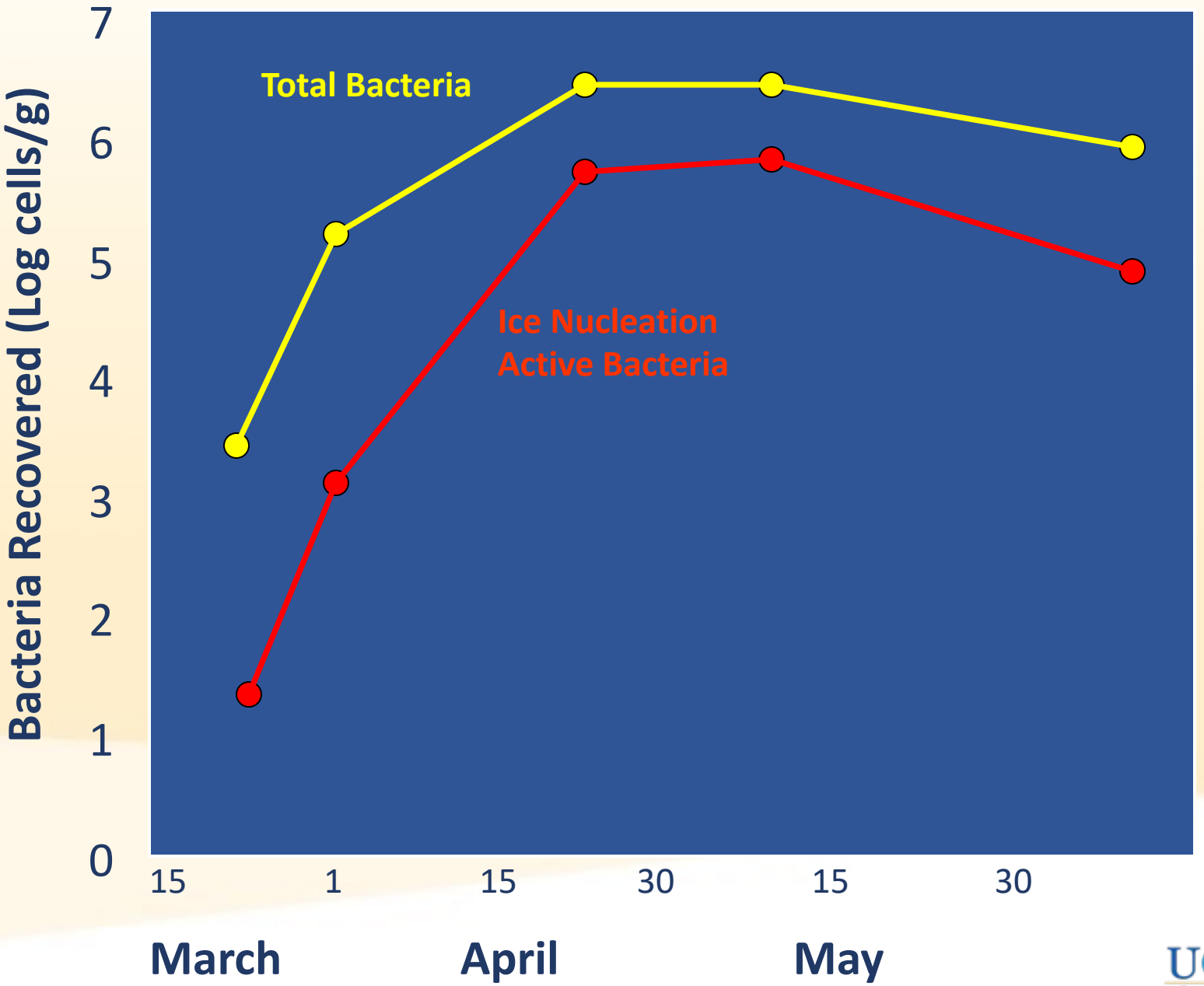
Bacterial Impacts on Supercooling

- When contaminated with bacterial populations leaf-ice-nucleation occurs at warmer temperatures
- The temperature at which ice nucleates is inversely related to the bacterial population on the leaf

$$\log N_{Leaf\ Bacteria} = \frac{X^{y}}{Temp_{Ice-Nucleation}}$$

Source: Glenn McGourty

Source: Glenn McGourty



New Plant Tissues harbor few bacteria

- Newer plant tissues have low populations of ice-nucleating bacteria
  - Bacterial populations rapidly accumulate as the tissue ages
- Ice-Nucleating Bacteria leaf populations peak early in the season
- Mirrors other bacterial population growth

$$\log N_{Leaf\ Bacteria} = e^{-Tissue\ age^2}$$

Orange trees adjacent to **grass pasture**

Orange trees next to other orange trees and **bare soil**

Source: Glenn McGourty

Proximity to Other Vegetation

Vegetation nearby	Distance from edge of orchard (trees)	Bacteria deposited per petri plate/hr	Leaf Bacteria (Log cells/g)
NO	0	33 a	4.8 a
	7	29 a	4.7 a
	14	37 a	4.7 a
	21	38 a	4.9 a
	28	37 a	4.7 a
YES	0	126 a	6.1 a
	7	97 a	5.7 a
	14	51 b	5.8 a
	21	46 b	5.5 ab
	28	34 b	5.3

≈

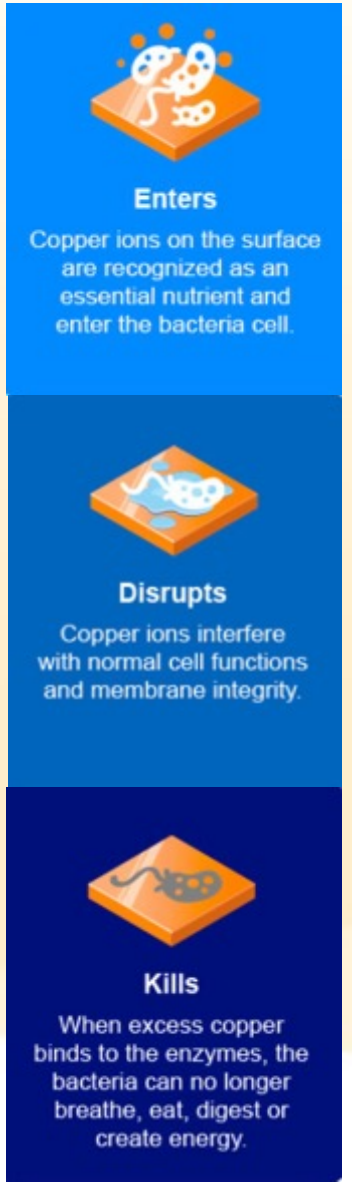
Bacterial populations on citrus and numbers of airborne bacteria related to proximity to vegetation with high epiphytic bacterial populations

From Lindow & Andersen, AEM 62:2978-2987 (1996)

Use of Copper Sprays
for Reducing Frost Risk

How Copper limits Frost Risk

- Copper has been used as a disinfectant for centuries
  - Hospital railings used to be made entirely of copper for this reason
- Copper ions can damage cell membranes or DNA and disrupt enzymatic activity in bacteria
  - This leads to cell death and control over bacterial populations
- This is true for ice-nucleating bacterial species as well



McGourty Study - 2017

Study Objectives

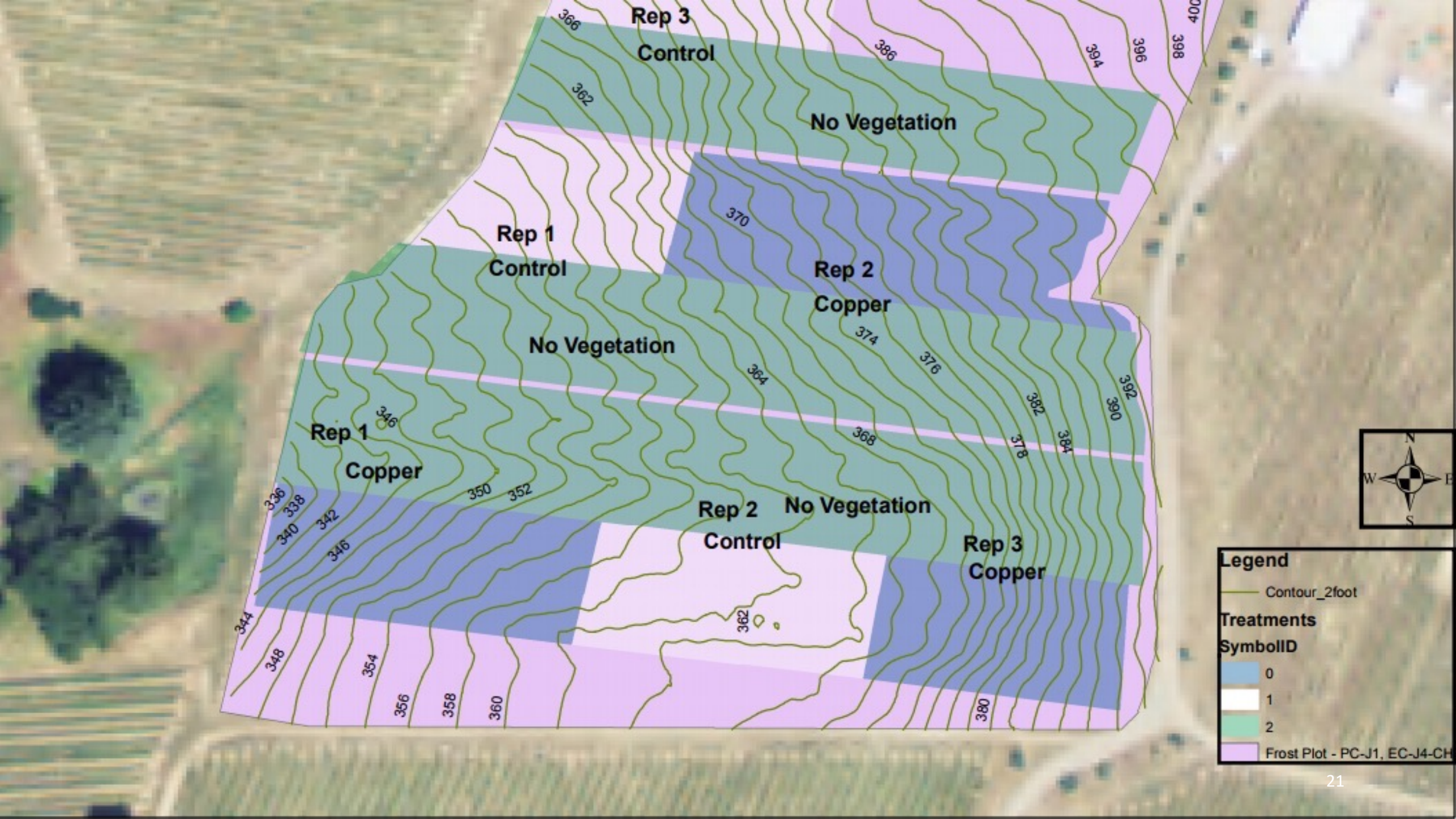
- Determine if copper sprays can protect grapes from freezing, and how vineyard floor management interacts with frost risk

- Investigate how ice nucleating bacteria are acquired from cover crops and develop during the winter

- Determine if *Pseudomonas fluorescens* 'A506' can be established on cover crops to suppress ice nucleating bacteria

Study Design

- Split plot ANOVA design
- Copper vs. unsprayed main effect
- Cover crops vs. shortly mowed cover or herbicide-removed cover
- 3 replications for each treatment
- 6 acres total

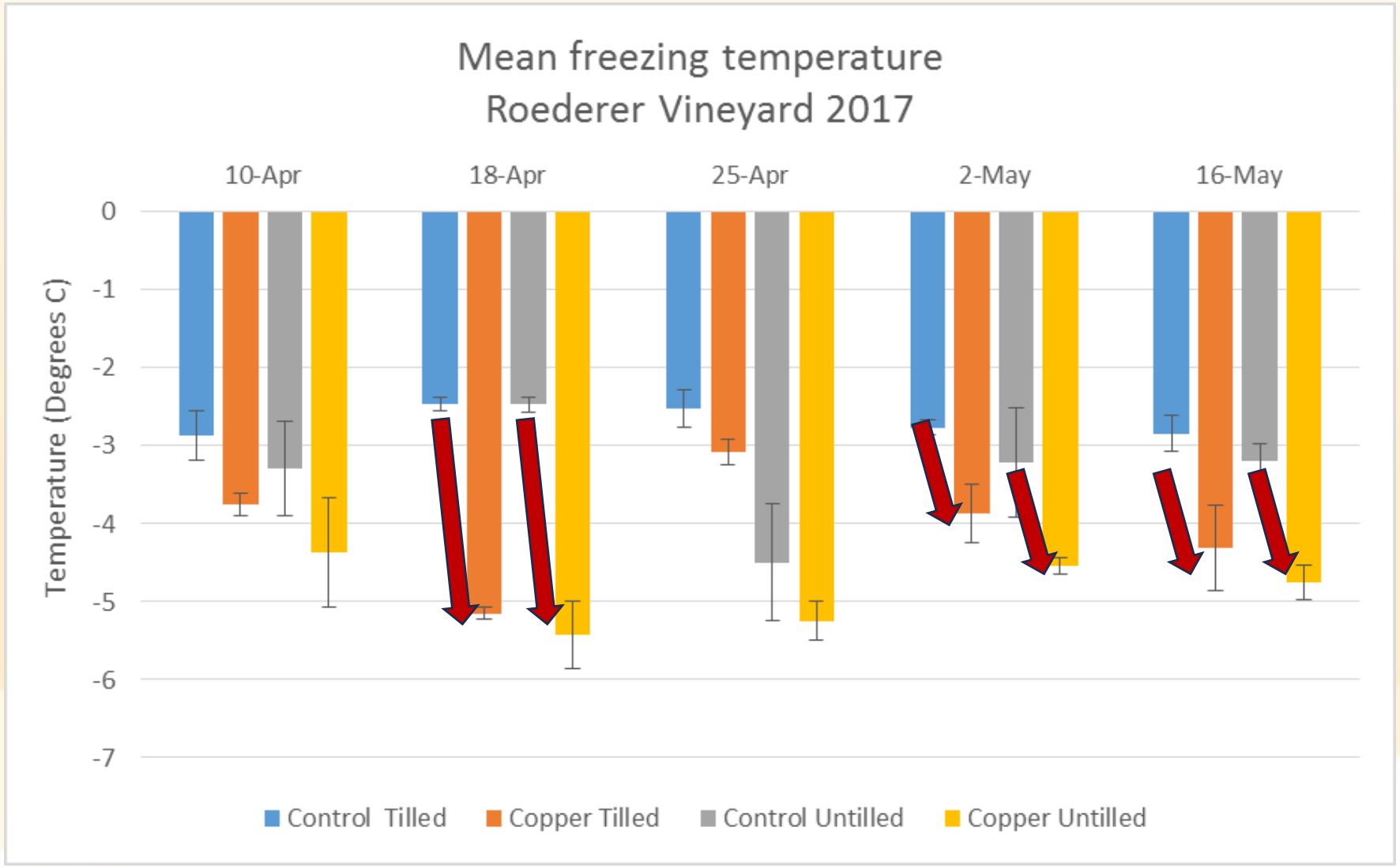

Rep 3
Control
No Vegetation
Rep 1
Control
Rep 2
Copper
No Vegetation
Rep 1
Copper
Rep 2
Control
No Vegetation
Rep 3
Copper
366
362
386
394
396
398
370
374
376
364
382
390
392
368
378
384
346
336
338
340
342
346
350
352
344
348
354
356
358
360
362
380
N
W
E
S
Legend
Contour_2foot
Treatments
SymbolID
0
1
2
Frost Plot - PC-J1, EC-J4-CH

Cover Vegetation Removal

2017 | **2018**

Mowed | Not mowed | Herbicidal cover crop removal

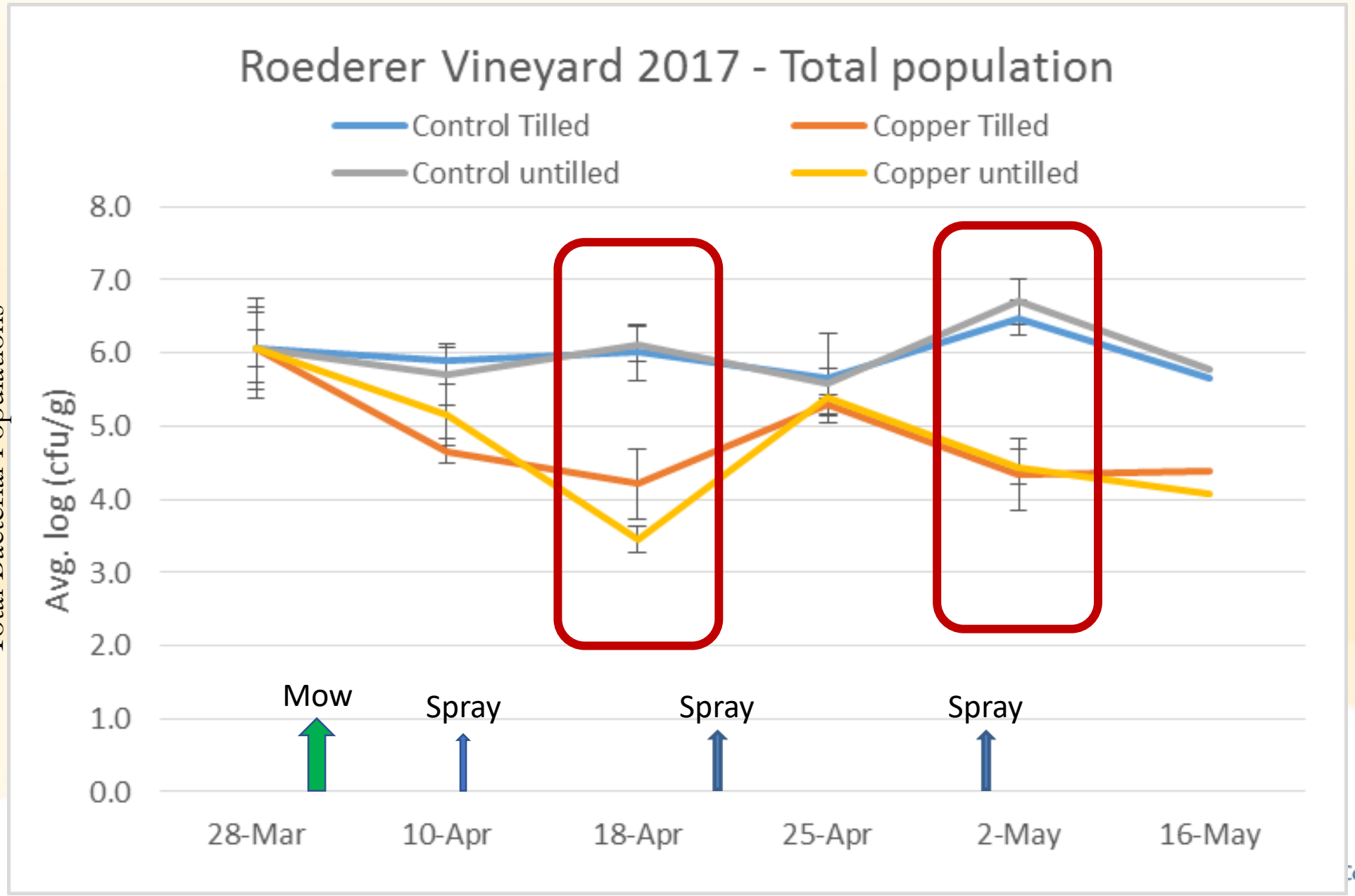
Cu reduces freezing temperatures of shoots



Source: Glenn McGourty

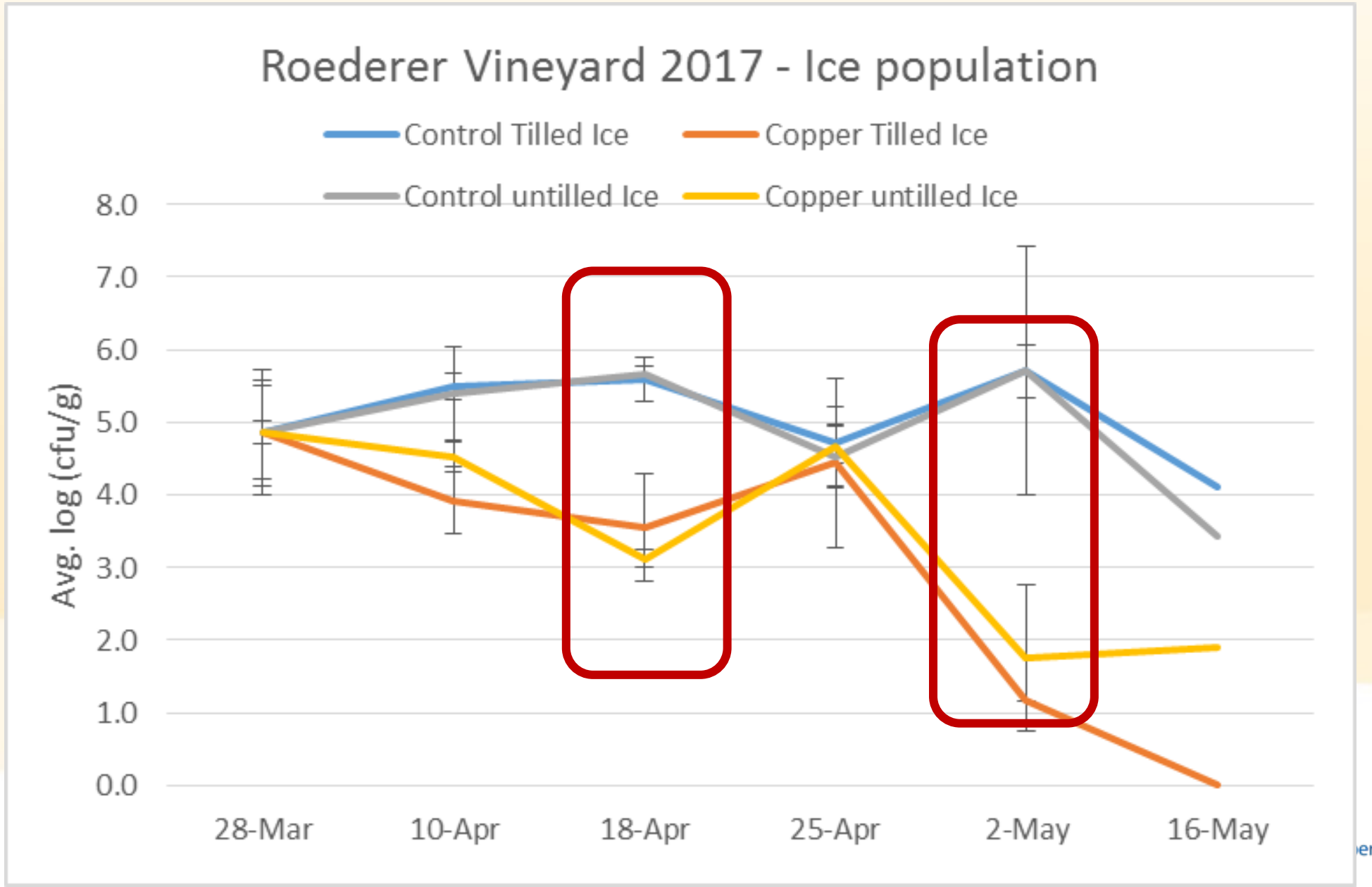
Copper greatly reduces bacterial numbers

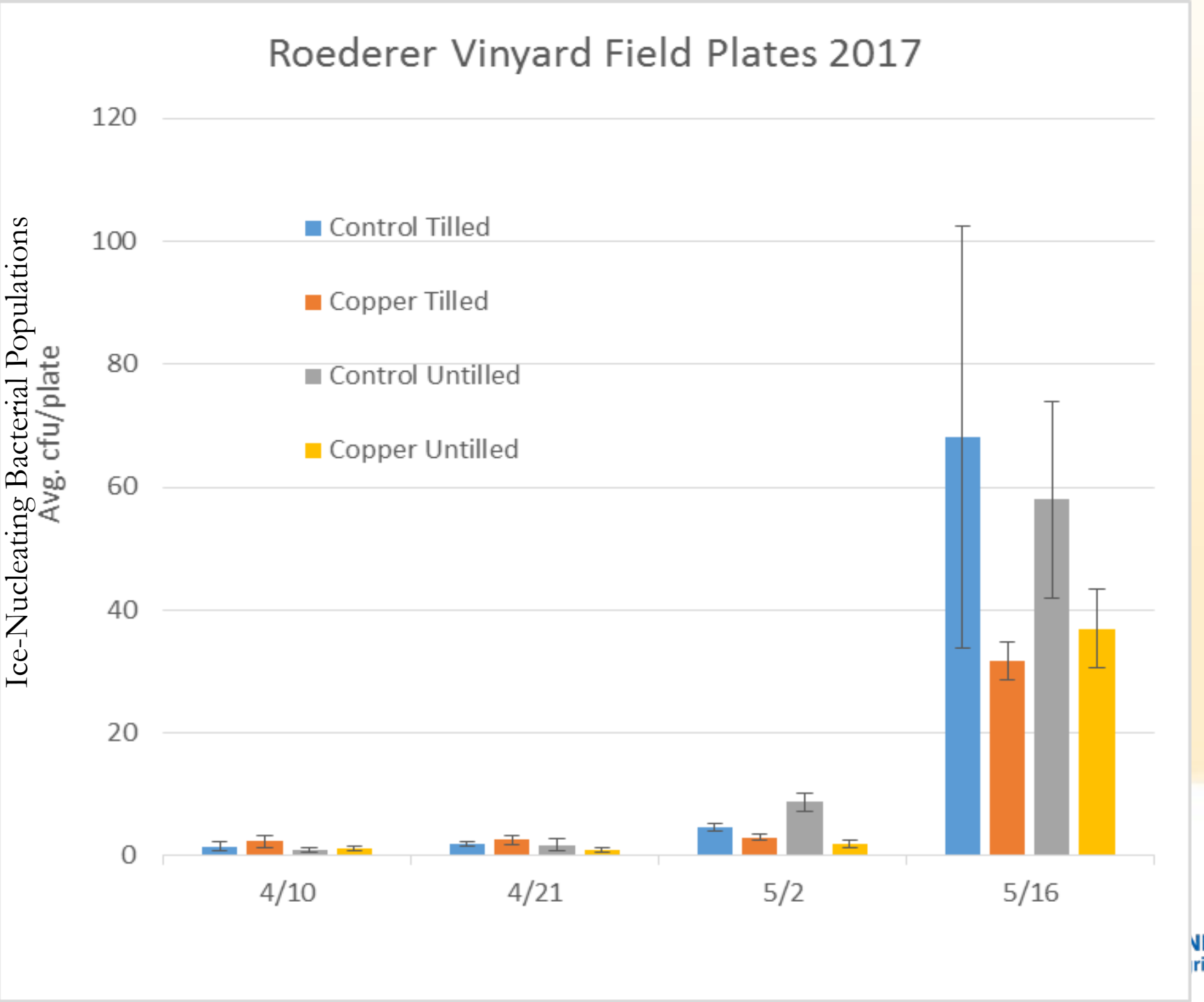
Total Bacterial Populations



Copper reduces ice nucleation active bacteria on shoots

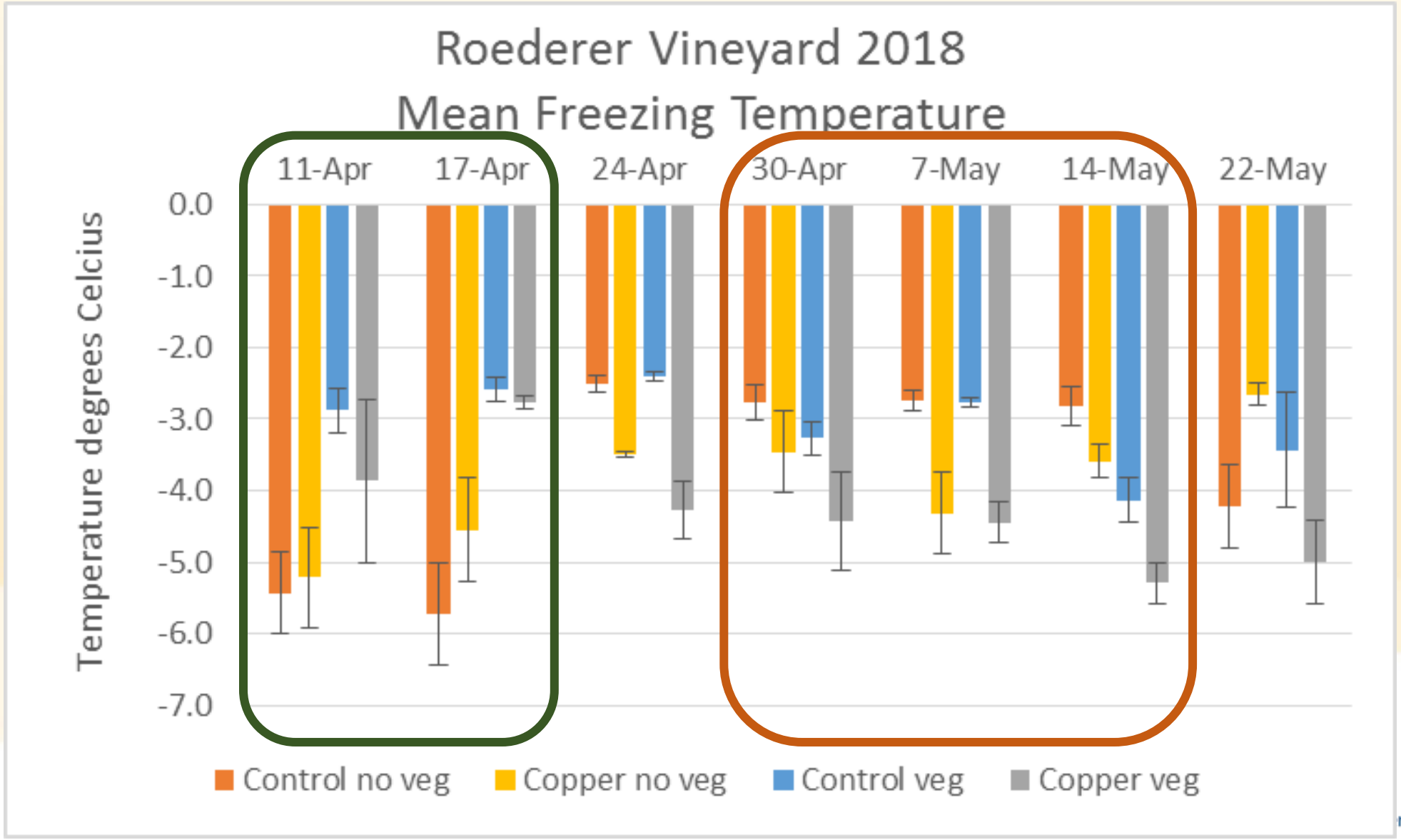
Ice-Nucleating Bacterial Populations



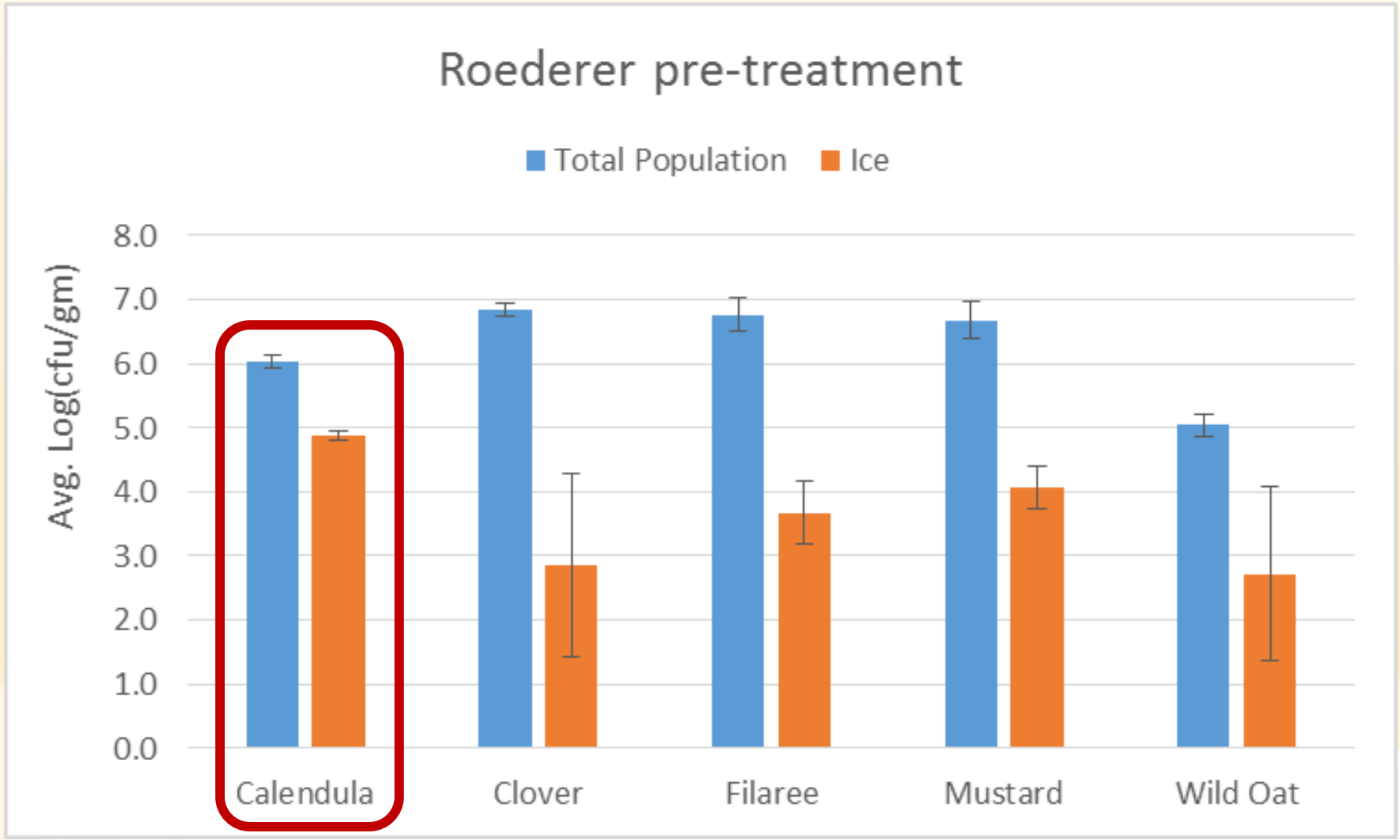


Some reduction in airborne bacteria in copper-treated areas

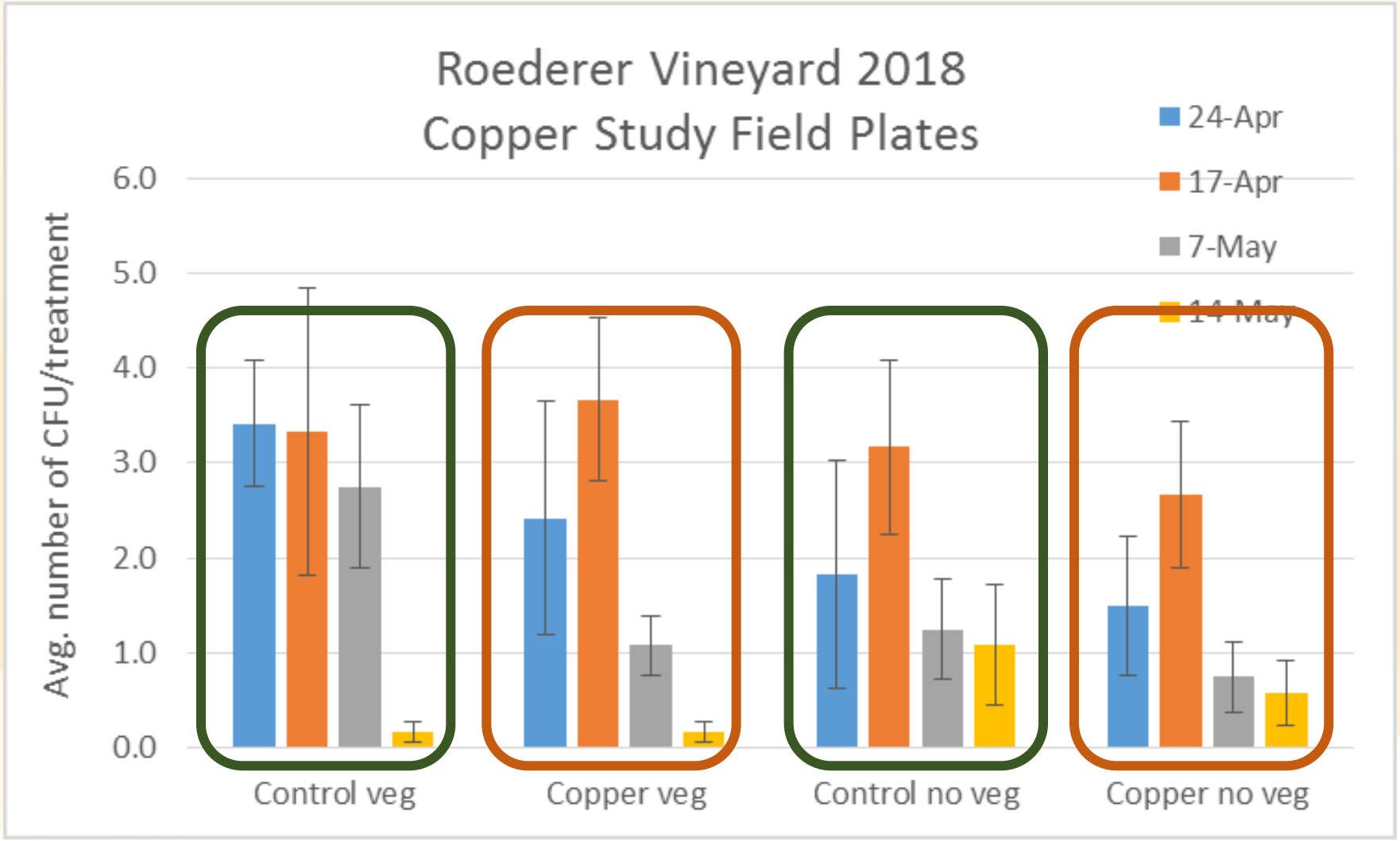
Large reduction in freezing temperatures of shoots early when cover crop removed - Larger effects of copper later in spring



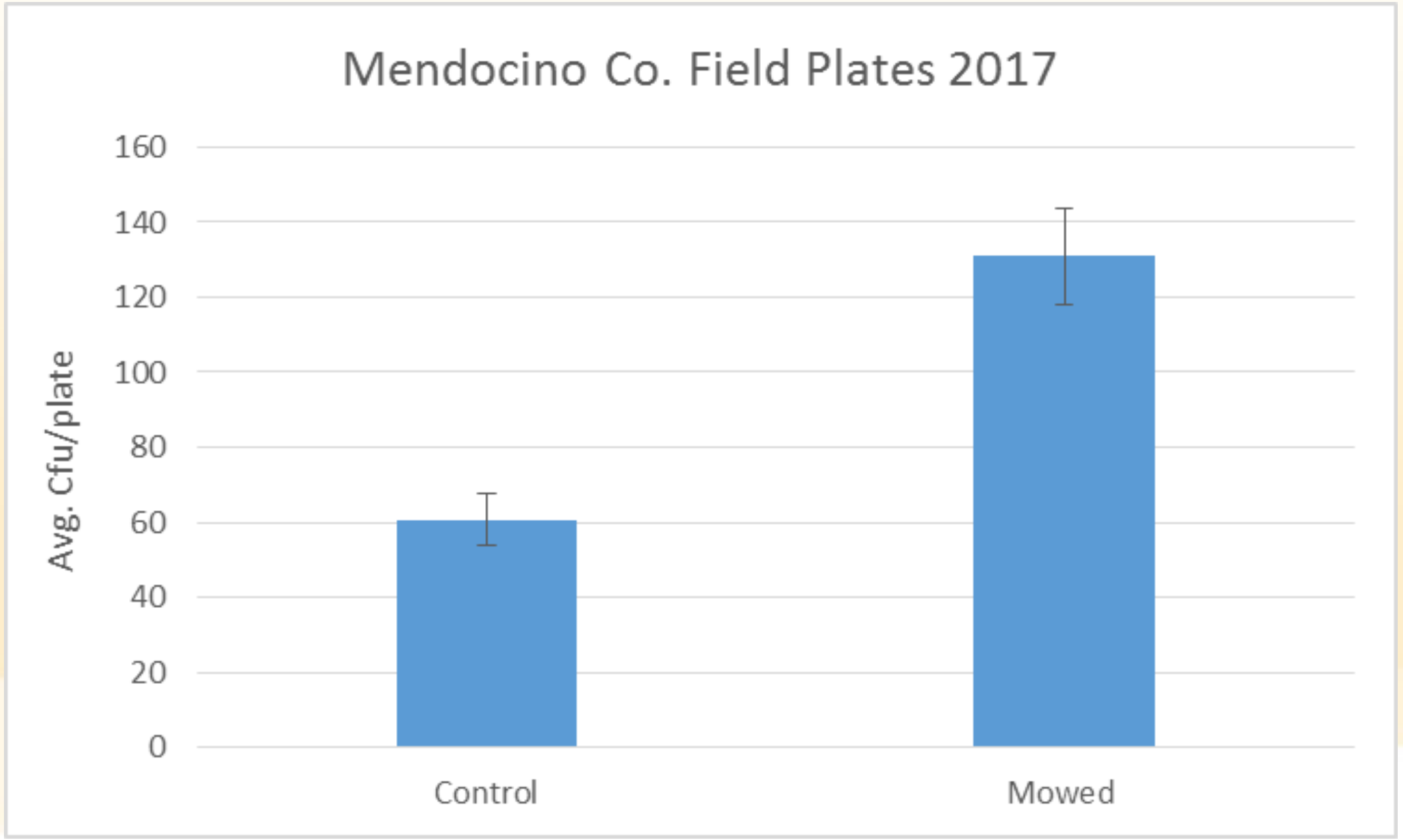
Cover Crop Species 2018

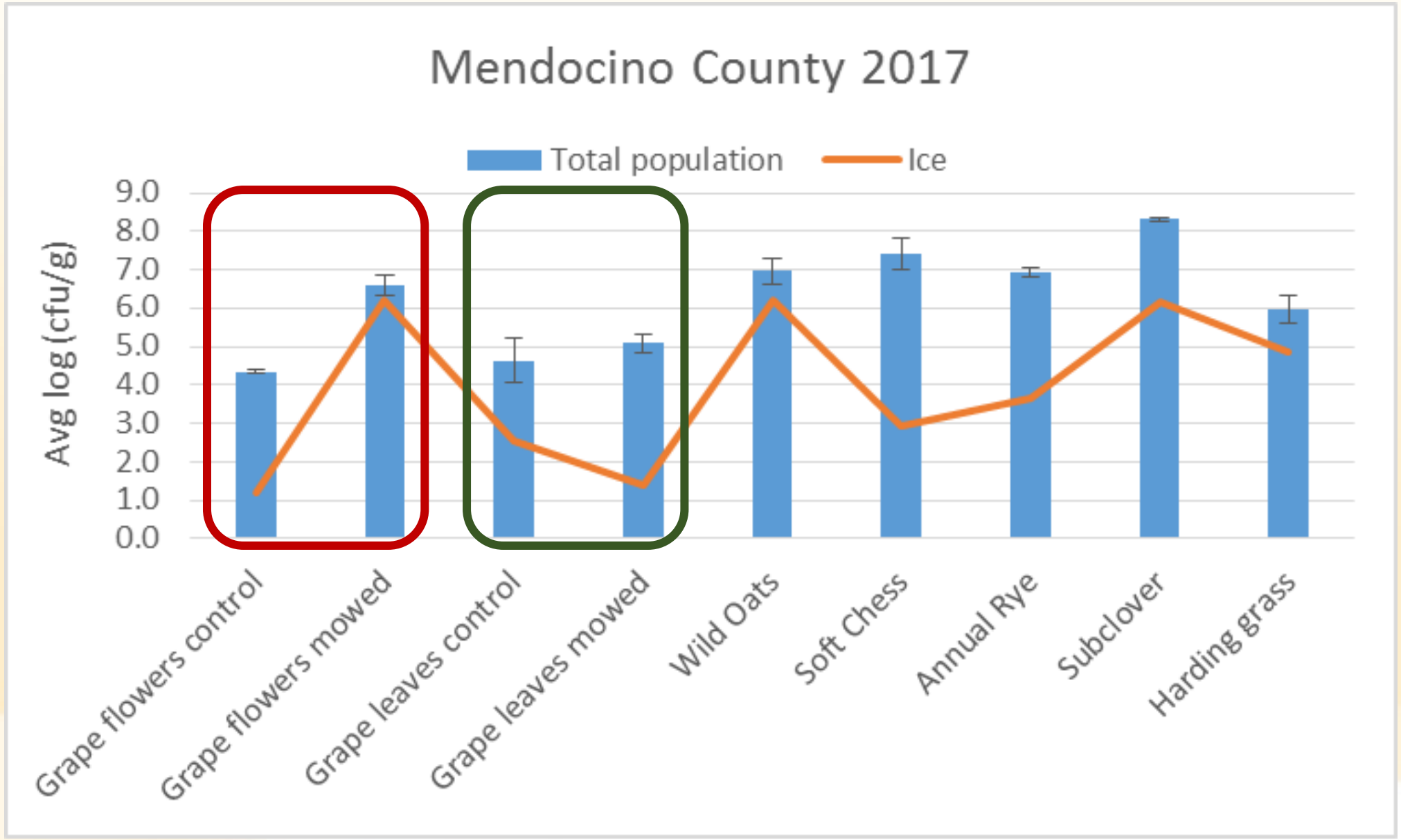


Higher bacterial numbers in air in vegetated areas of plot



Effects of Mowing on Bacterial Spread


Mendocino Co. Field Plates 2017
Avg. Cfu/plate
160
140
120
100
80
60
40
20
0
Control
Mowed


Mendocino County 2017
Total population
Ice
Avg log (cfu/g)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Grape flowers control
Grape flowers mowed
Grape leaves control
Grape leaves mowed
Wild Oats
Soft Chess
Annual Rye
Subclover
Harding grass

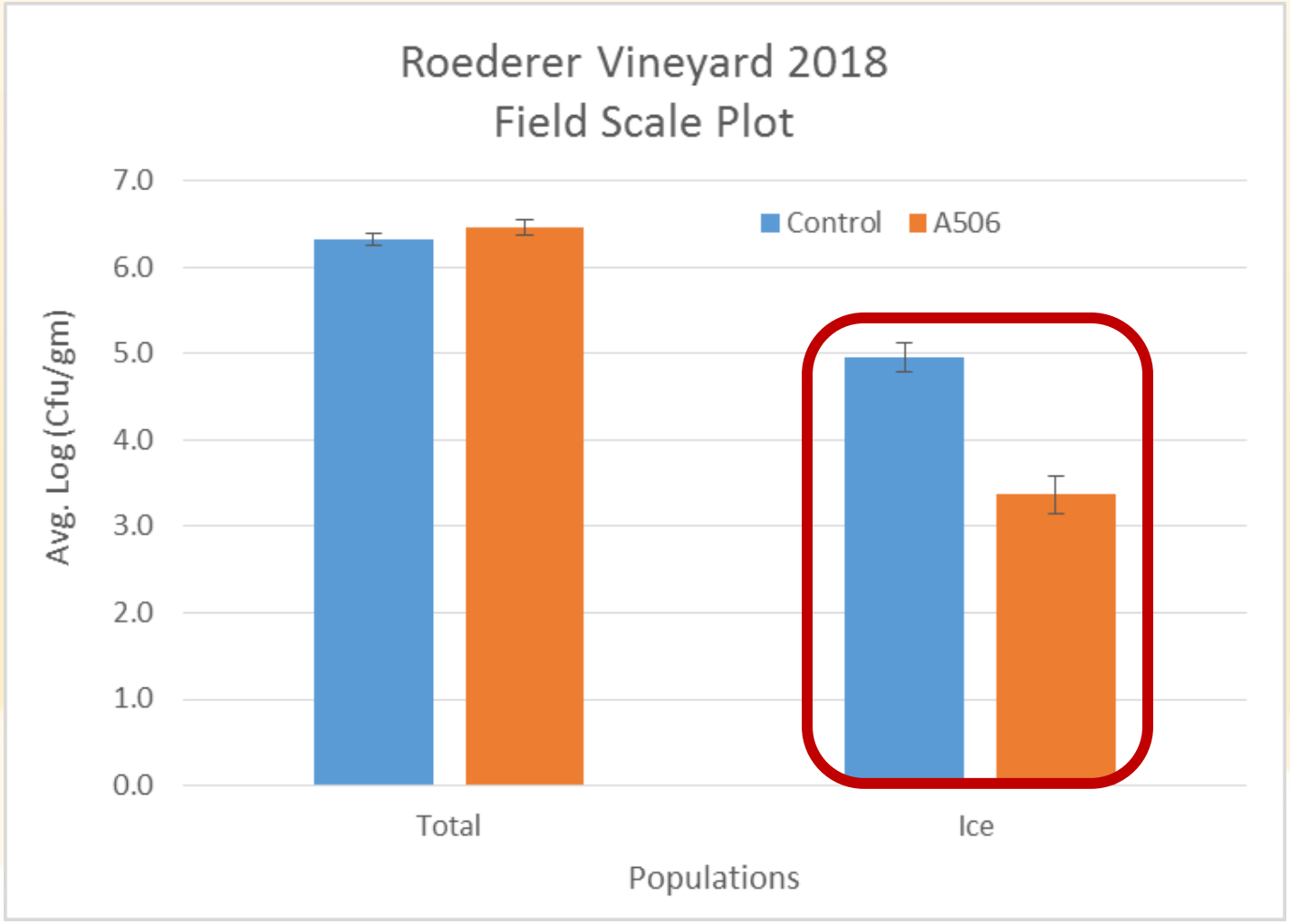
Mowing

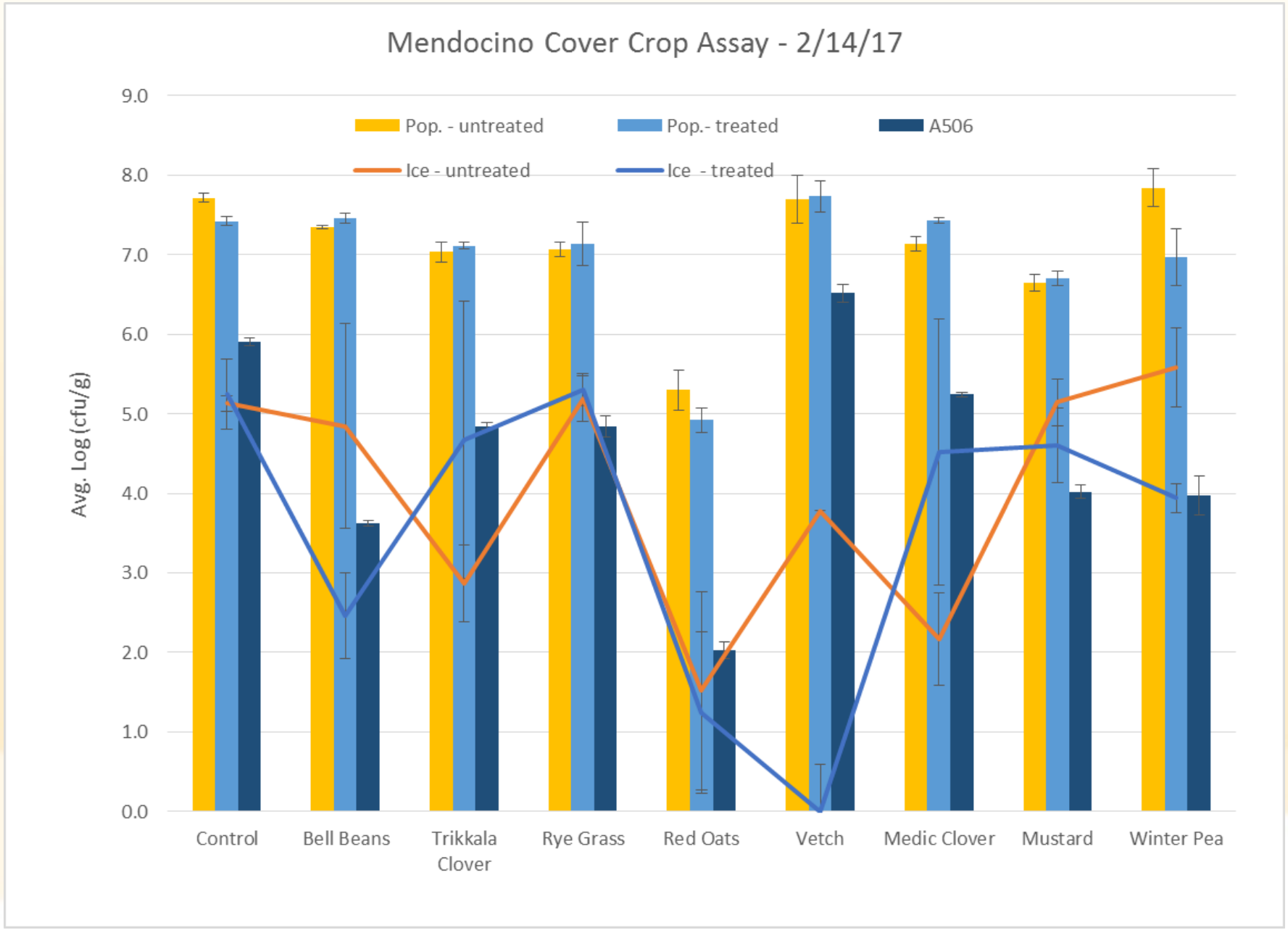
- Mowing significantly increases the spread of ice-nucleating bacteria in vineyards
- Can be seen in the data from the Mendocino County trial we looked at
- Recommended to avoid mowing during key frost periods

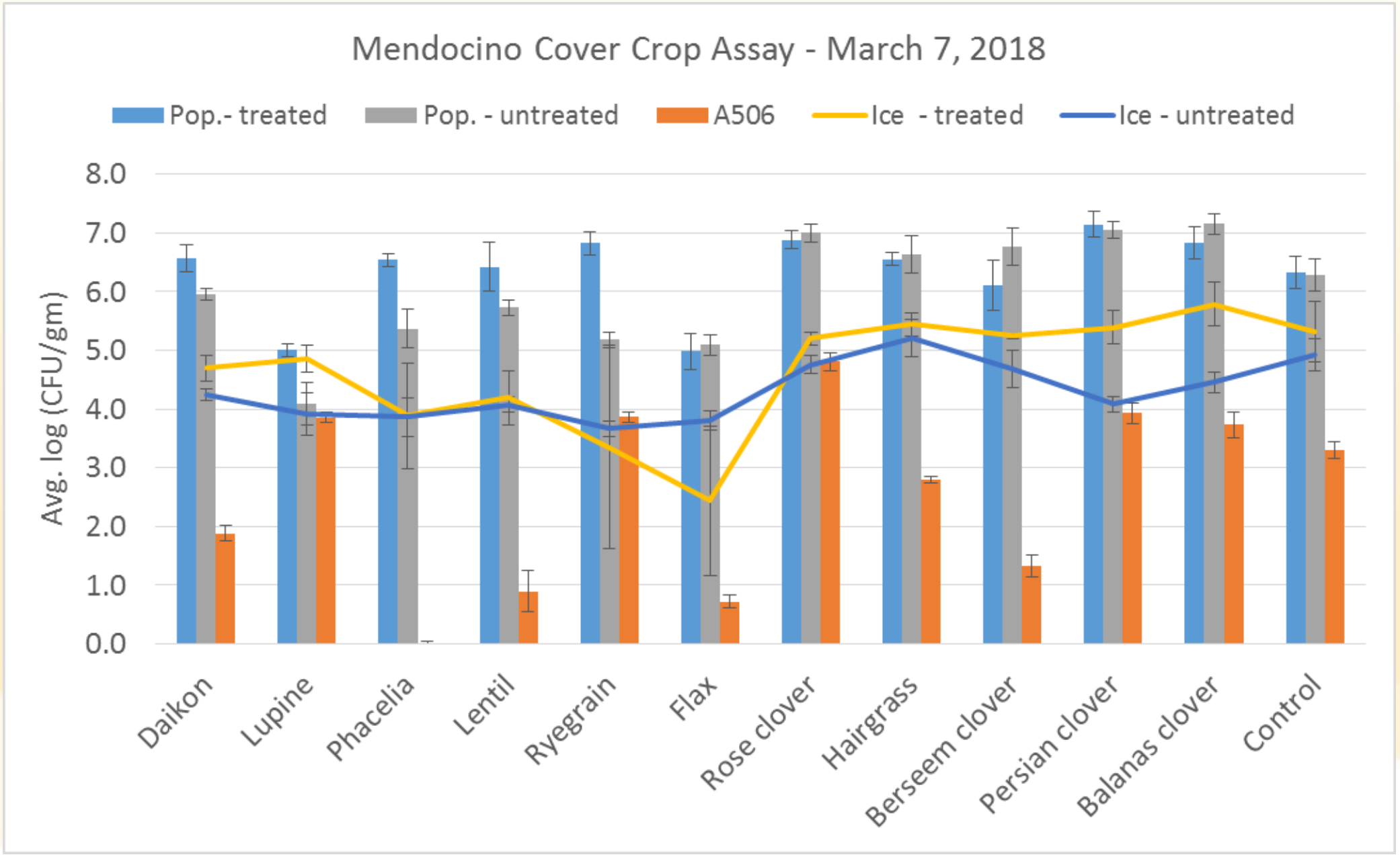
Controlling Ice-Nucleating Bacteria on Cover

- *Pseudomonas fluorescens* 'A506'
- Competitive colonizer
- Used for Fireblight and fruit finish on apples and pears
- Registered for grapes

Reduction in Ice-Nucleating Bacteria




Mendocino Cover Crop Assay - 2/14/17
Pop. - untreated
Pop.- treated
A506
Ice - untreated
Ice - treated
Avg. Log (cfu/g)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Control
Bell Beans
Trikkala Clover
Rye Grass
Red Oats
Vetch
Medic Clover
Mustard
Winter Pea


Mendocino Cover Crop Assay - March 7, 2018
Pop.- treated
Pop. - untreated
A506
Ice - treated
Ice - untreated
Avg. log (CFU/gm)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Daikon
Lupine
Phacelia
Lentil
Ryegrain
Flax
Rose clover
Hairgrass
Berseem clover
Persian clover
Balanas clover
Control

Findings

- Cover crops acquire bacterial populations early
- Significant differences between species
- A506 can be successful established over time on cover crop foliage
- Only modest effect of A506 colonization on populations of ice nucleating bacteria

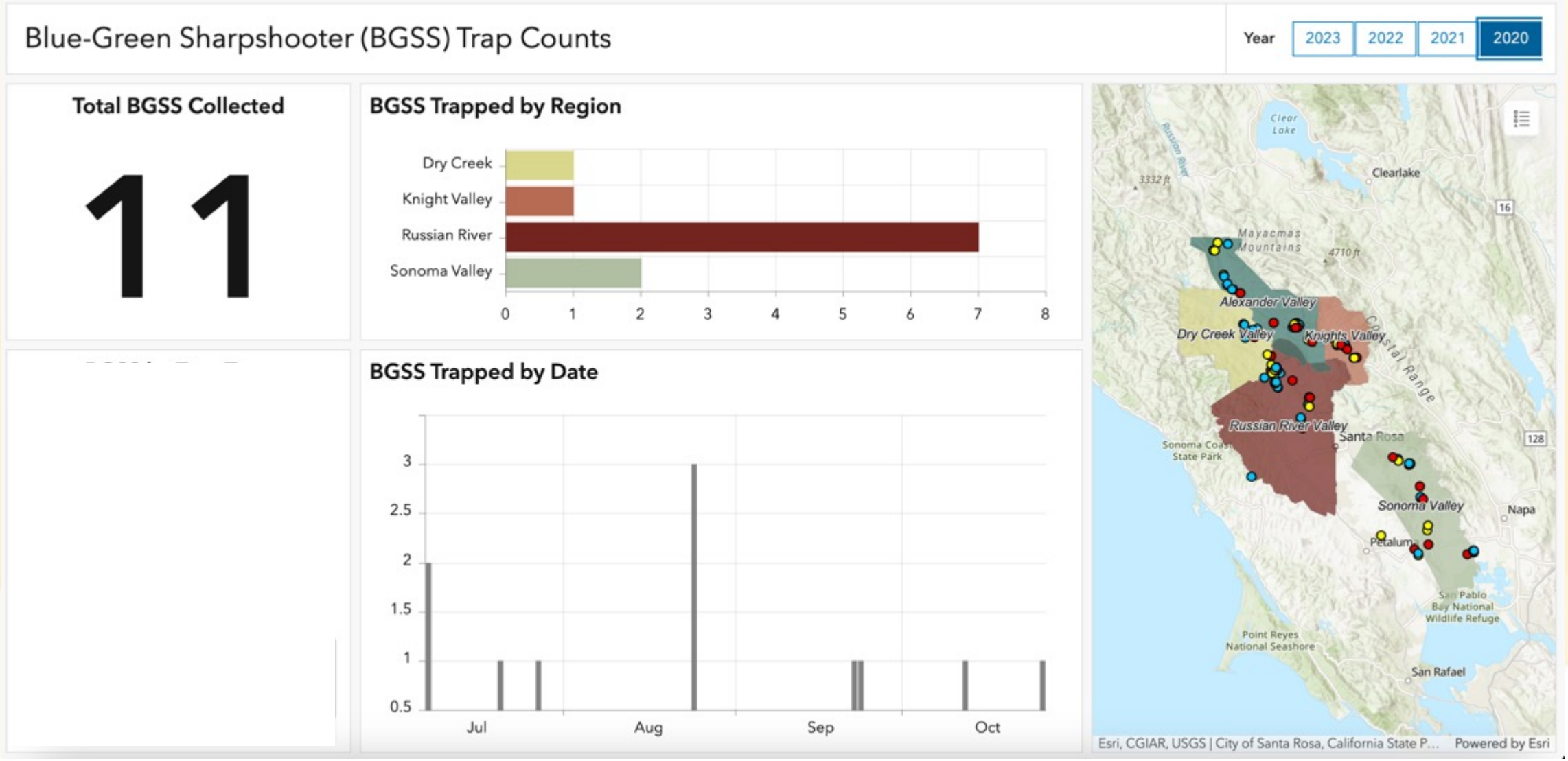
Pest and Disease Trends

Northern California
(2023 Growing Season)

UC CE | UNIVERSITY OF CALIFORNIA Agriculture and Natural Resources | Cooperative Extension

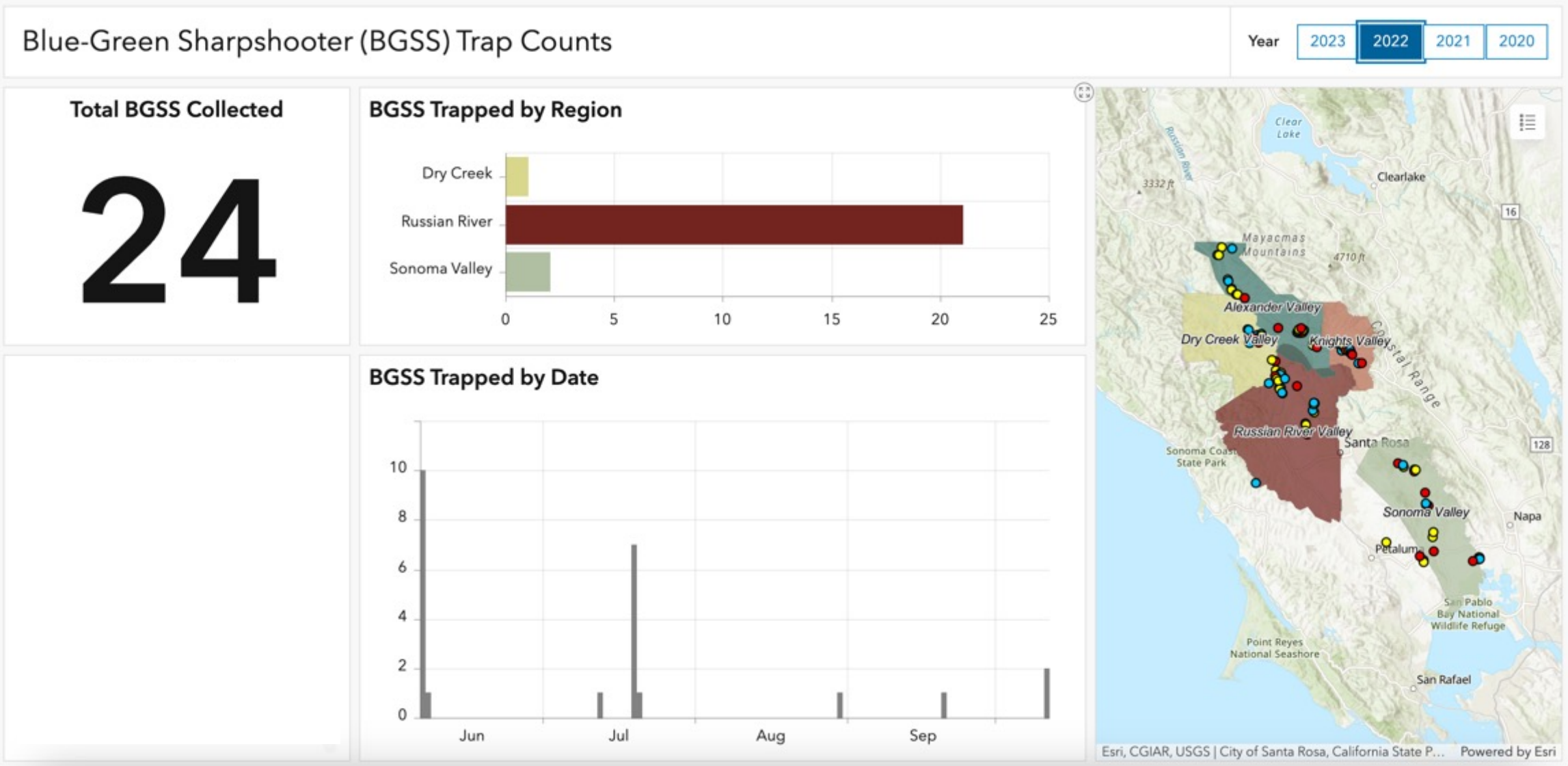
Blue-Green Sharpshooters
Sonoma County Analogues

BGSS - 2020



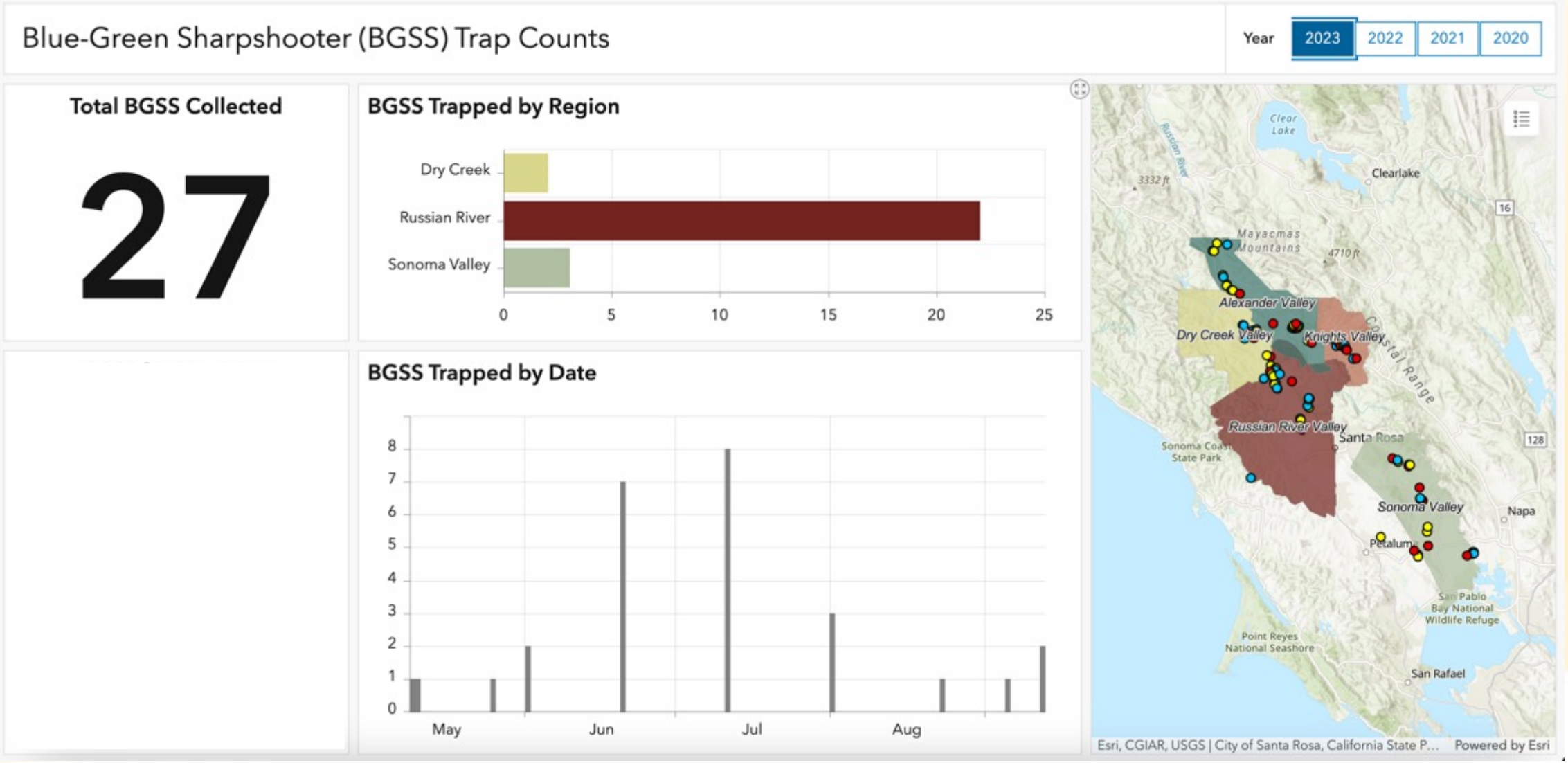
Credit: UC ANR IGIS & IPM

BGSS - 2022



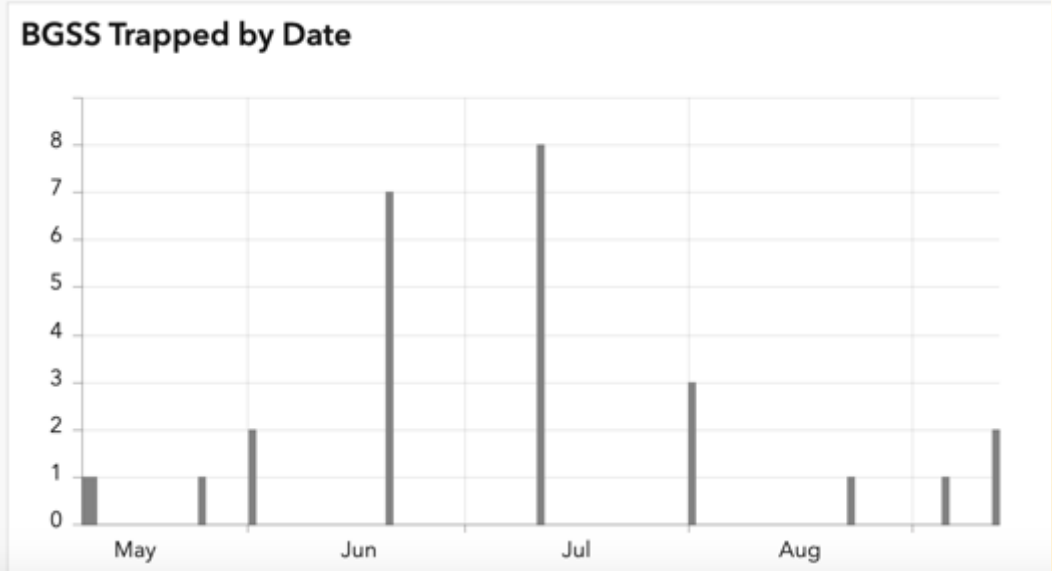
Credit: UC ANR IGIS & IPM

BGSS - 2023

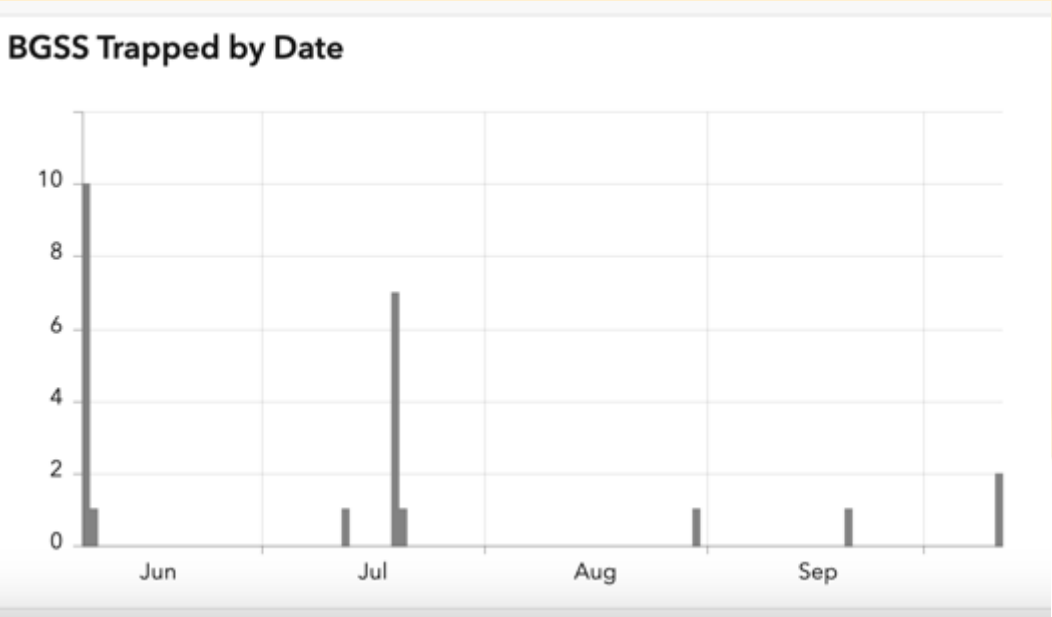


Credit: UC ANR IGIS & IPM

2023


BGSS Trapped by Date
8
7
6
5
4
3
2
1
0
May
Jun
Jul
Aug

2022


BGSS Trapped by Date
10
8
6
4
2
0
Jun
Jul
Aug
Sep

Growing Degree Days

2022

Date	Daily	GDDs
Jul 08 2022	35.50	2934.22
Jul 09 2022	34.50	2968.72
Jul 10 2022	39.50	3008.22
Jul 11 2022	38.00	3046.22
Jul 12 2022	33.00	3079.22
Jul 13 2022	33.00	3112.22

+ 7 or 8 days

To reach same GDDs

2023

Date	Daily	GDDs
Jul 15 2023	39.00	2904.50
Jul 16 2023	33.50	2938.00
Jul 17 2023	41.50	2979.50
Jul 18 2023	32.00	3011.50
Jul 19 2023	34.00	3045.50
Jul 20 2023	35.00	3080.50

Fungal Diseases
Powdery Mildew and Trunk Disease Symptoms

Disease Expression

- Host-Pathogen interaction is broadly impacted by environmental conditions
- Certain abiotic stressors can increase susceptibility of grapevines to pathogens or trigger symptomatic expression of the pathogen (10)
- Fungal trunk diseases
  - Have expressed more symptoms in vines than usual in N. Coast
  - Two years of extreme drought followed by late spring frost and summer rains

10. A Songy, O Fernandez, C Cl'ement, P Larignon, and F Fontaine. Grapevine trunk diseases under thermal and water stresses. Planta, 249:1655– 1679, 2019. ISSN 1432-2048. doi: 10.1007/s00425-019-03111-8.

Grapevine Trunk Diseases

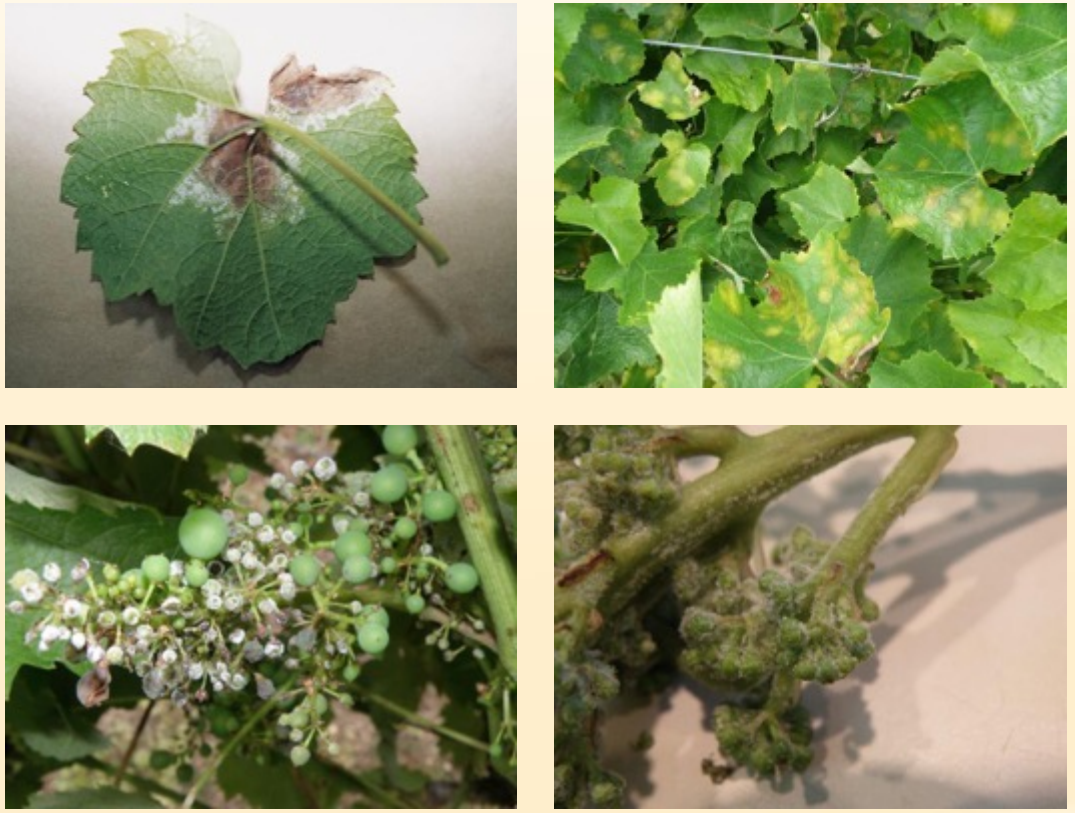
- I observed an increase in the number of calls I received for vines showing symptoms of fungal trunk diseases
- This included dead positions, stunted shoots, and poor fruit set
- May be due to cycles of drought increasing susceptibility of vine to infection followed by heavy precipitation, allowing mycelia to spread

Powdery Mildew

- Mildew pressure was exceptionally high in 2023
- I received multiple calls about PM resistant to fungicide applications in May/June
- PM wasn't resistant, it was just growing too rapidly to control with standard spray schedules

Downy Mildew

- May have seen a case or two
- Did not stick and took care of itself
- Be on the lookout this year
- Call me if you think you find some



Credit: Gov. Western Australia

Summary

1. Copper applications can reduce ice-nucleating bacteria populations in vineyards if timed right

2. Mowing cover can be a significant source of spread for ice-nucleating bacteria

3. Presence of cover crops is a large factor on the impacts of ice-nucleating bacteria in early spring

4. Look out for signs and symptoms of fungal pathogens this year

Upcoming UC Cooperative Extension Events

- PCA Breakfasts (890 N. Bush St, Ukiah)
  - March 21 7:30am – 9:00am
  - April 25 7:30am – 9:00am
  - May 16 7:30am – 9:00am

- Pear and Grape Field Day
  - May 28 8:00am – 11:00am (14200 Old River Rd., Hopland)
  - May 28 12:00pm – 3:00pm (13601 Old River Rd, Hopland)

Thank You

Sources

- You can find this presentation at:

1. https://ucanr.edu/sites/chenlab
2. Speaker Presentations
3. "Other Presentations"
4. "Copper for Frost Control – Grow West Seminar (2023)"

- Or go to: https://ucanr.edu/sites/ChenLab/Speaker_Presentations_425/

- Some original images created by OpenAI Labs Dall-E Program