Cornell University

Grapevine red blotch and leafroll viruses: biology, ecology, and management

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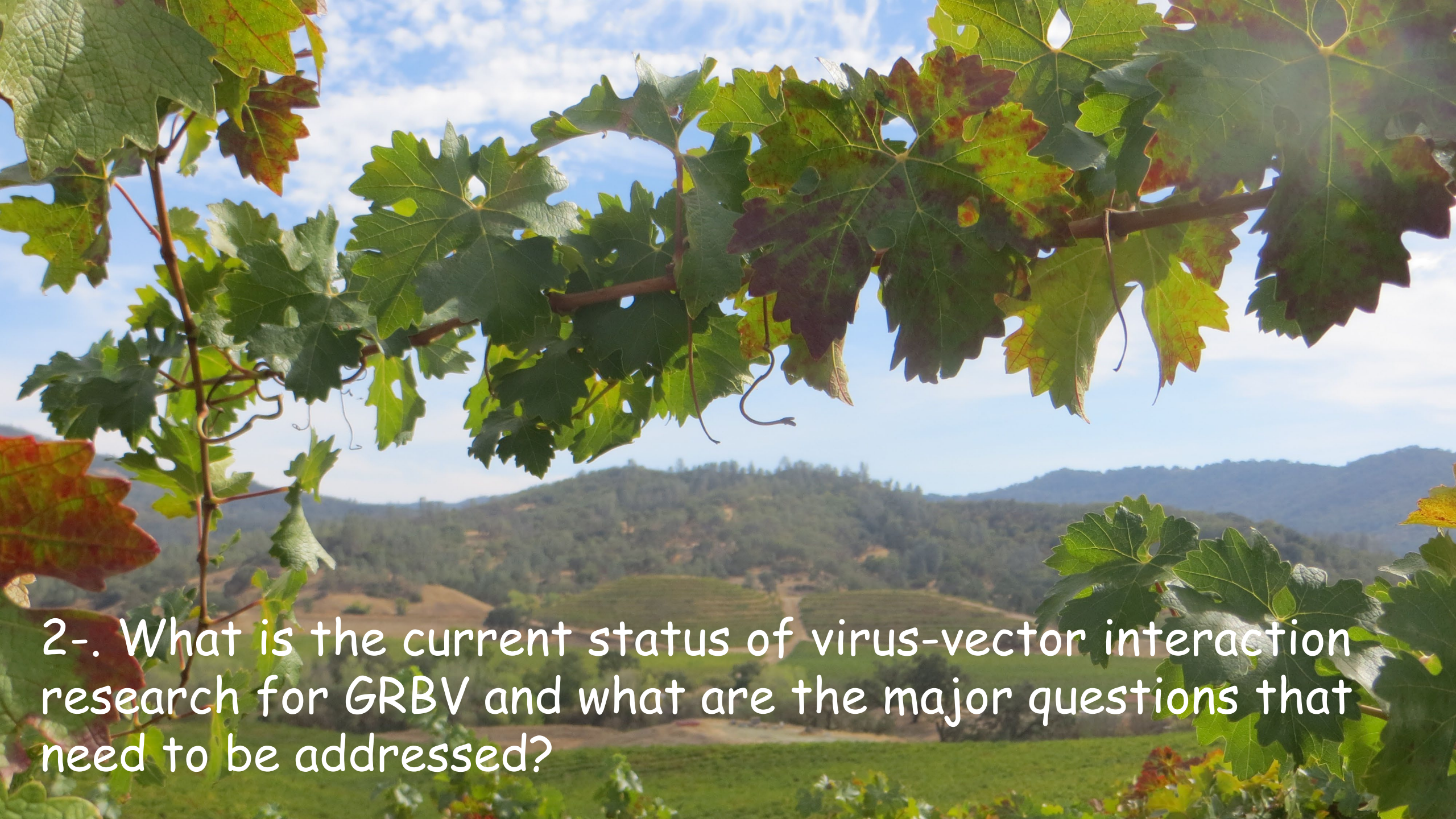
1-. Describe GRBV transmission biology by *Spissistilus festinus*

- Transmission of GRBV by *S. festinus* is circulative with a long latent period (10 days)
- Transmission of GRBV by *S. festinus* is non-propagative
- GRBV is not seed transmitted
- Transmission of GRBV by *S. festinus* is transstadial
- Transmission of GRBV by *S. festinus* is not transovarial
- *S. festinus* adults are more efficient vectors compared with nymphs
- Transmission of GRBV from and to winegrapes
- Transmission of GRBV from and to free-living vines
- Transmission of GRBV from and to winegrapes & free-living vines
- Transmission efficiency varies with the plant species

Flasco et al. 2021
Flasco et al. 2023
Hoyle et al. 2022

- *S. festinus* is a vector of epidemiological relevance
- Seasonal distribution of *S. festinus* in vineyards (June-July)
- Seasonal variation in GRBV titer
- Inefficient transmission of GRBV by *S. festinus* in vineyards (6%) and greenhouse (19%)
- Latency period: > 16 months
- Incubation period: 4-12 months
- Disease symptoms are visible 1-2 years post-planting if the scion cultivar is infected
- Disease symptoms are visible 3-5 years post-planting if the rootstock is infected
- *S. festinus*-mediated transmission of GRBV is mostly random
- Vine-to-vine transmission of GRBV by *S. festinus* from a hotspot
- Disease dynamics related to GRBV prevalence and *S. festinus* population

Cieniewicz et al. 2019
Flasco et al. 2021
Flasco et al. 2023
Flasco et al. 2024
Hoyle et al. 2022



2-. What is the current status of virus-vector interaction research for GRBV and what are the major questions that need to be addressed?

- A single insect vector (*S. festinus*) has been conclusively identified so far
- *S. festinus* is not a pest of grapevines, although it can cause limited damage upon feeding
- *S. festinus* transiently visits vineyards
- Low detectable populations levels of *S. festinus* in vineyards
- Grapevine is not a preferred feeding host of *S. festinus*
- *S. festinus* does not use grapevine as a reproductive host
- Two genotypes of *S. festinus* with potential differential transmission ability

Cieniewicz et al. 2017
Cieniewicz et al. 2020
Flasco et al. 2021
Flasco et al. 2023
Hoyle et al. 2022
Preto et al. 2018
Preto et al. 2019
Sisterson et al. 2023
Wilson et al. 2020

Insect vector

- Are there other insect vectors of red blotch disease?
- Why is there a 10-day latency period (virus movement from hemolymph to salivary glands)?
- Do endosymbionts have a role in GRBV transmission?
- Does *S. festinus* sex influence GRBV transmission?
- Are there distinct feeding behaviors of *S. festinus* on different plant species?
- What cues (visual, chemical, auditory, etc.) are used by *S. festinus* to select a feeding or a reproductive host?
- What are the overwintering hosts of *S. festinus* in vineyard ecosystems?
- Are they distinct movement patterns of *S. festinus*?

Krenz et al. 2023

Virus

- Is GRBV the only causal agent of red blotch disease?
- How does GRBV manipulate grapevines to facilitate transmission?
- How does GRBV manipulate *S. festinus* to facilitate transmission?
- What is the biological relevance of the two genetic variants of GRBV?
- Can roguing reduce red blotch disease impacts?
- Should roguing be considered with a higher tolerance to disease prevalence than for leafroll?
- Is zonal roguing more appropriate than conventional roguing?
- How can latent infections be account for?
- Can faster and less costly tests be developed for identifying the disease in vineyards?

Krenz et al. 2023


3-. Provide your perspective on GRBV transmission ecology by
S. festinus in different vineyard ecosystems

- Planting material is the major source of GRBV
- *S. festinus* uses numerous plant species as feeding hosts
- Asteraceae are the most visited plants
- Most preferred feeding hosts grow outside vineyard settings
- Free-living vines are preferred feeding hosts compared with winegrapes
- Some *S. festinus* (22%, 59 of 269) ingested the virus
- More *S. festinus* ingested the virus in 2021 (38%) than in 2022 (14%)
- More *S. festinus* males (16%) than females (7%) ingested the virus
- Flying distance of at least 1 mile
- Flight mill:
  - average 0.5 miles and up to 4 miles for males
  - average 0.2 miles and up to 2 miles for females

Antolinez et al. 2024
Hoyle et al. 2023


4-. Are there regional differences or even site differences in the epidemiology of red blotch and leafroll in CA?

Marked regional and site differences in disease epidemiology

Leafroll

- Mealybug species
- Mealybug populations
- Virus prevalence
- Mealybug management program
- Adoption scale of mealybug management program
- Environmental conditions

Red blotch

- *S. festinus* populations
- Virus prevalence
- Proximity to riparian areas
- Environmental conditions

Arnold et al. 2017
Donda et al. 2023
Cieniewicz et al. 2019
Flasco et al. 2023
Hobbs et al. 2021
Hobbs et al. 2023
KC et al. 2023
MacDonald et al. 2021
Schartel et al. 2021


5-. Provide an update on your research aimed at controlling vector-borne viruses impacting winegrapes. Provide your perspective on the potential and acceptance of biotechnological approaches for virus and vector control

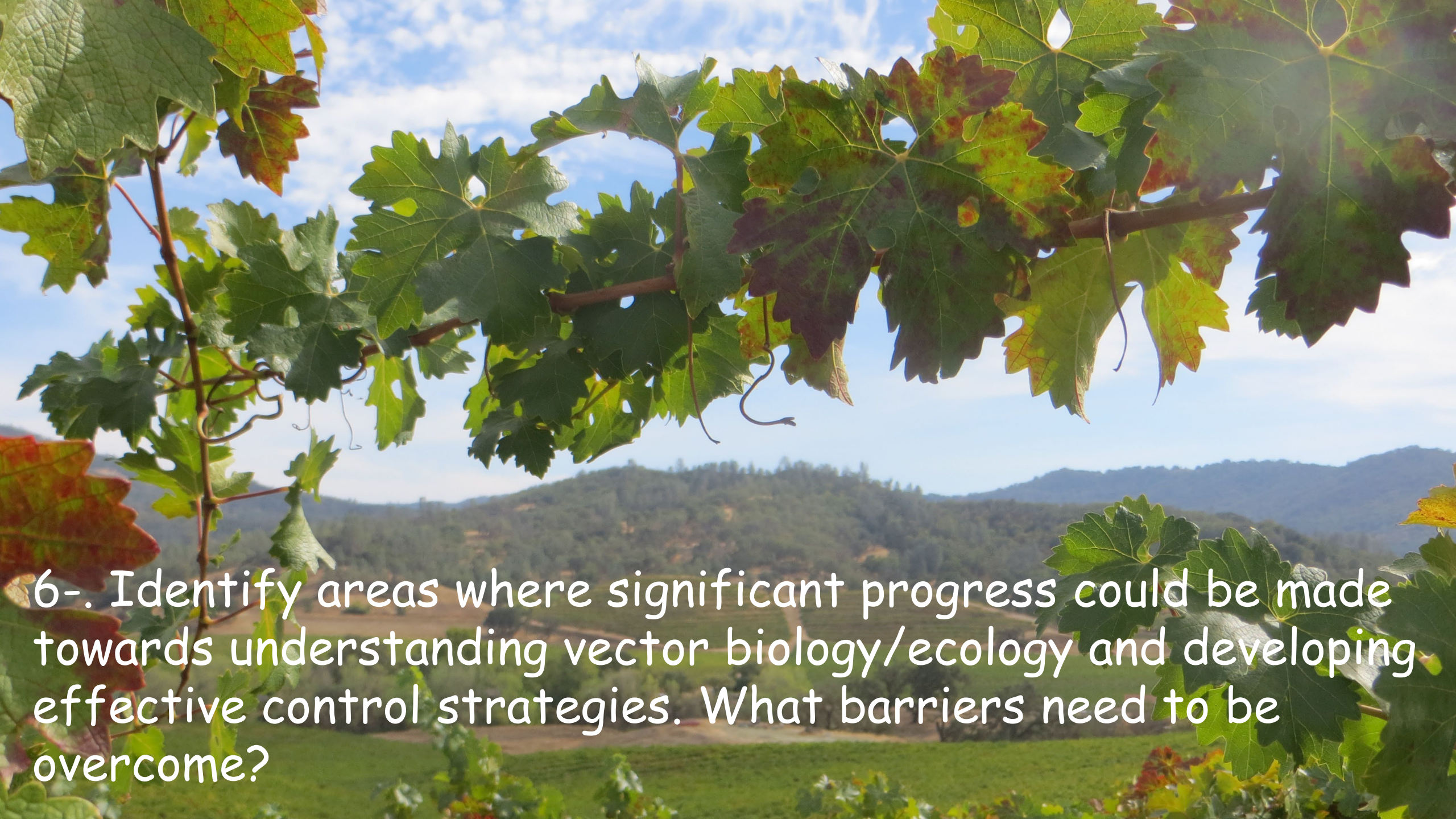
- Spatial roguing for GLRaV1

- RNAi-mediated resistance to GLRaV3 and its two major mealybug vectors

Arora et al. 2020
Arora et al. 2022
Hessler et al. 2022

Acceptance of biotechnological approaches

- Resistance is a recognized asset for the management of leafroll disease based on IPM tactics
  - Insecticides that affect not only the target pests but also endangered or threatened insect species
  - Best stewards of the land
- 2021 American Vineyard Foundation surveys
  - Disease and insect control (top research priority)
  - Support biotechnology/genetic modification research (74% favorable support)
- Range of potential acceptance
- Knowledge and trust
- Winery/company philosophy, practices, and markets



6-. Identify areas where significant progress could be made towards understanding vector biology/ecology and developing effective control strategies. What barriers need to be overcome?

Virus-vector interactions

	Mealybugs -Leafroll	*S. festinus* – Red blotch
Pest status	Yes	No
Winegrapes are a feeding host	Yes	Not preferred
Winegrapes are a reproductive host	Yes	No
Behavior in vineyards	Resident	Transient
Mobility in vineyards	Crawling	Flying
Is the insect a host of the virus?	No	No
Transmission mode	Semi-persistent	Circulative
Acquisition access period	1-24 hours	10 days
Inoculation access period	1-24 hours	4 days
Retention period	4-16 days	>74days
Inoculation period	1 year	>16 months
Trans-stadial transmission	No	Yes
No transovarial transmission	No	No
Transmission efficiency	High	Poor
Most efficient vector stage	Crawlers	Adults

Disease management

Leafroll

- **Control mealybugs**
- **Reduce or eliminate the virus inoculum**
  - ✓ Scout in late summer/fall
  - ✓ Rogue diseased vines if <25% prevalence
  - ✓ Eliminate entire vineyard block if >25% prevalence
  - ✓ Carefully select the planting material

Red blotch

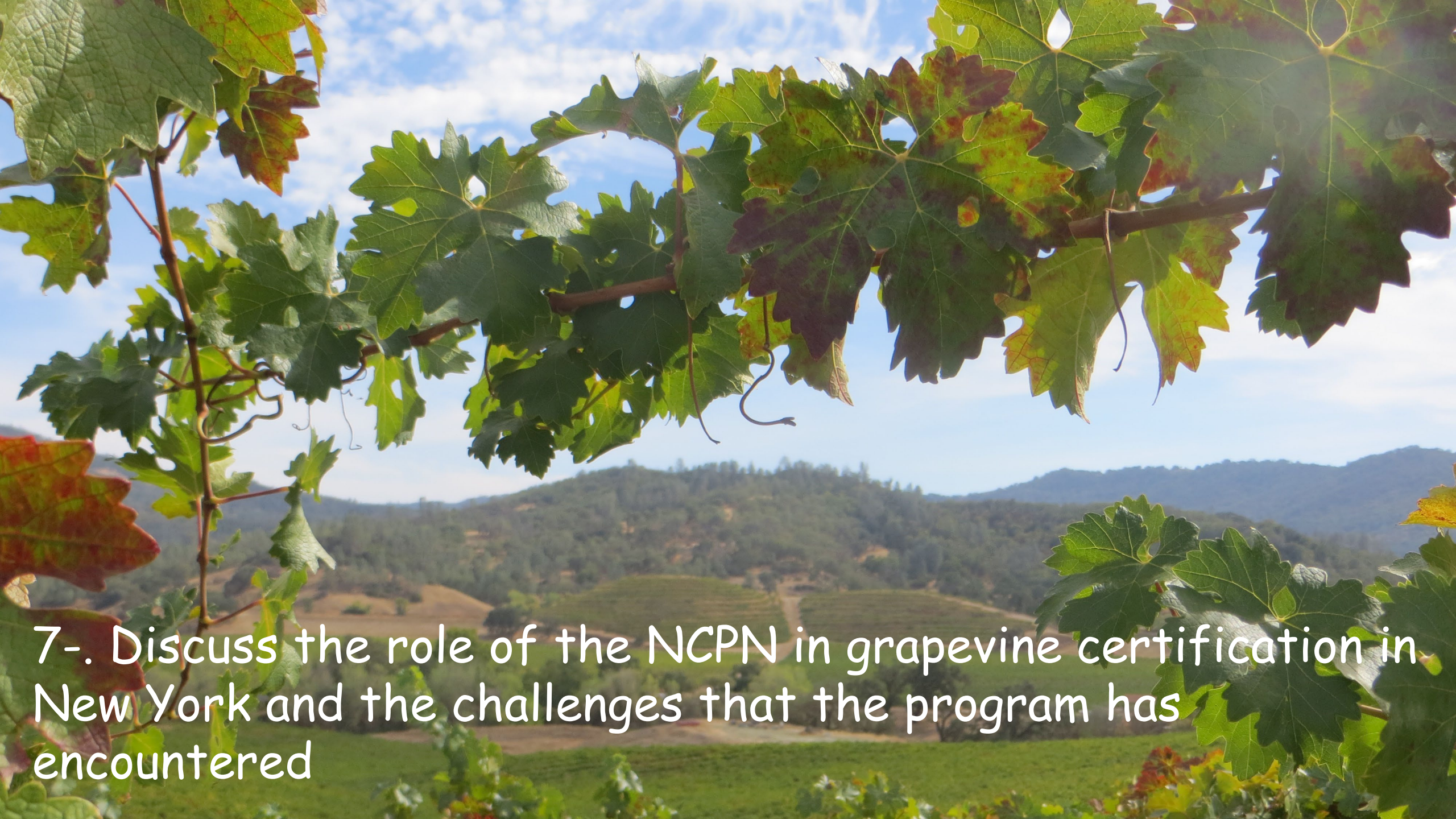
- **No actions against *S. festinus***
- **Reduce or eliminate the virus inoculum**
  - ✓ Scout in late summer/fall
  - ✓ Rogue diseased vines if <30% prevalence
  - ✓ Eliminate entire vineyard block if >30% prevalence
  - ✓ Carefully select the planting material

Fuchs 2020
Hobbs et al. 2021
Hobbs et al. 2023
Ricketts et al. 2015
Ricketts et al. 2017

Roguing is a cornerstone of management

- Improve certification standards / Reliable sources of clean planting stocks
- Develop a point-of-care diagnostic assay for GLRaV3
- Increase educational efforts to raise awareness of the role of viruses in disease
- Enhance educational efforts to increase the adoption of roguing at a regional scale
- Understand socioeconomic factors driving the adoption of roguing
- Assist behavioral changes
- Evaluate zonal roguing for red blotch
- Consider a pheromone strategy against *S. festinus*, if males are major contributors to spread

Fuchs 2020
Hobbs et al. 2021
Hobbs et al. 2023



7-. Discuss the role of the NCPN in grapevine certification in New York and the challenges that the program has encountered

New York Certification Program

Imports

Clean Plant Center Northwest
Prosser, WA

Foundation Plant Services
Davis, CA

Clean Plant Center

Clean Plant

Foundation Block (G1)

Increase block (G2)

Nursery

Vineyard

Domestic accessions

New York State State Department of Agriculture

- New York grapevine certification program was reinstated in 2021
  - Bottom-up approach
- New York grapevine certification program is unique
  - 25% of G2 vines are tested annually for nine viruses
  - Spring and fall testing periods (spring, fall)
- High-throughput laboratory testing
  - 20,000-80,000 samples tested annually

8-. Share your perspective on grower adoption of management strategies and similarities and differences across virus-vector systems

Uncertainties related to the management of virus diseases

- Poor awareness of the detrimental impact of viruses
- A crop is still harvested: why take any action?
- Perceived high cost
- No obvious financial incentive (no price differential)
- Neighbor influence
- Unreliable source of information
- Distrust in certification programs
- Conflicting approaches between vineyard managers and winemakers
- Wineries/companies have unique business models

Hobbs et al. 2023
Fuchs et al. 2020
Oliver and Fuchs 2011
Ricketts et al. 2015
Ricketts et al. 2017

Addressing uncertainties with behavioral changes

- Relentlessly communicate on the biology and ecology of virus diseases to growers and policy makers
- Engage with agriculture economists to integrate an economically-appealing component into ecologically-sound disease management options
- Build trust and establish lasting collaborative interactions with growers and policy makers to continuously encourage and guide disease management efforts
- Disseminate recommendations on customized disease management responses that are realistic and resonate with growers
- Learn the lessons from past failures or not so-rewarding efforts to continuously refine disease management solutions

Fuchs et al. 2020

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Thank you

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