

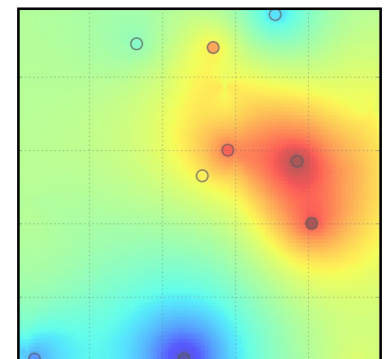
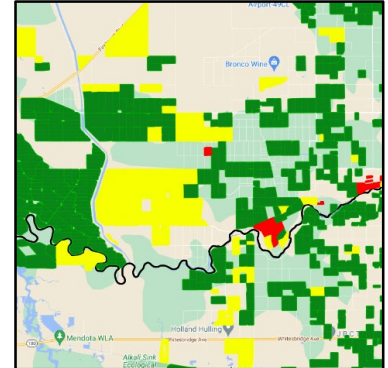
Development of an Online Pest and Phenology Map for NOW

Houston Wilson | Asst. Coop. Extension Specialist
Dept. Entomology, Univ. of California - Riverside

Andy Lyons | Program Coordinator
Informatics and GIS Statewide Program, UC ANR

Chuck Burks | Research Entomologist
Agricultural Research Service, US Dept. Agriculture

Kadie Britt | Areawide Program Coordinator
Dept. Entomology, Univ. of California - Riverside



Landscape Ecology of Navel Orangeworm

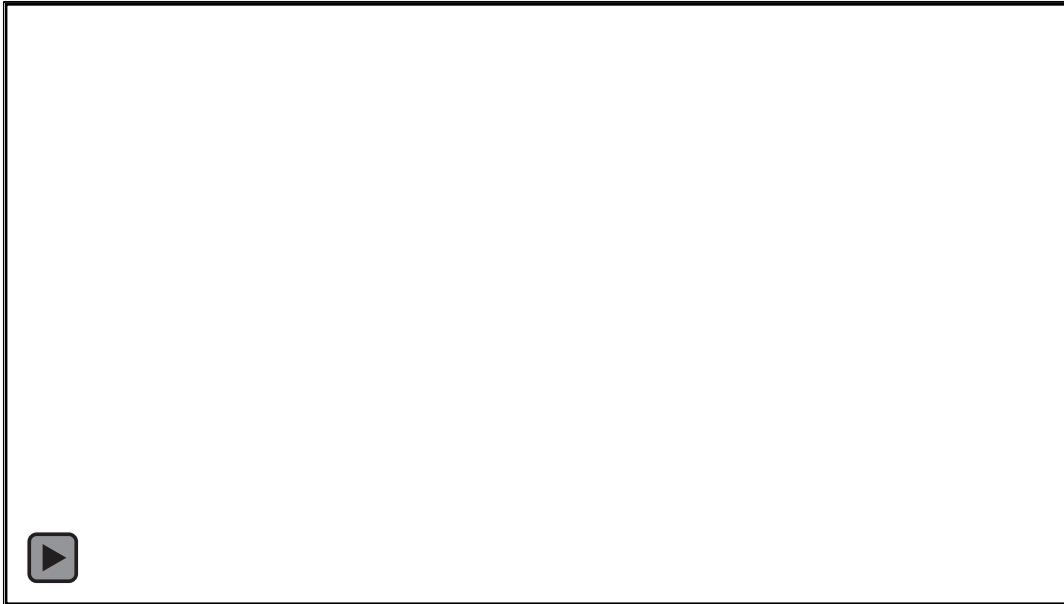
**Movement
and
Host Availability**

Movement and Dispersal of NOW

When? Where? How Far?

The Need for Areawide Management

- NOW are relatively strong fliers (Sappington and Burks 2018)
- Colonization from nearby orchards can undermine local management activities (i.e. sanitation, mating disruption etc.)



*Tandem NOW
on a flight mill*

*Video courtesy of
Joshua Reger, Ph.D. Student
Dept. Entomology, UC Riverside*

Seasonal Phenology

Shifting Resource Availability

Quantity of Crop Hosts

- Crop availability/vulnerability mediated by hull integrity
- Hull integrity is a function of tree phenology x weather x mgmt.
- Fairly consistent in almond, highly variable in pistachio

Quality of Crop Hosts

- Faster development on new crop nuts vs. remnant/mummy nuts

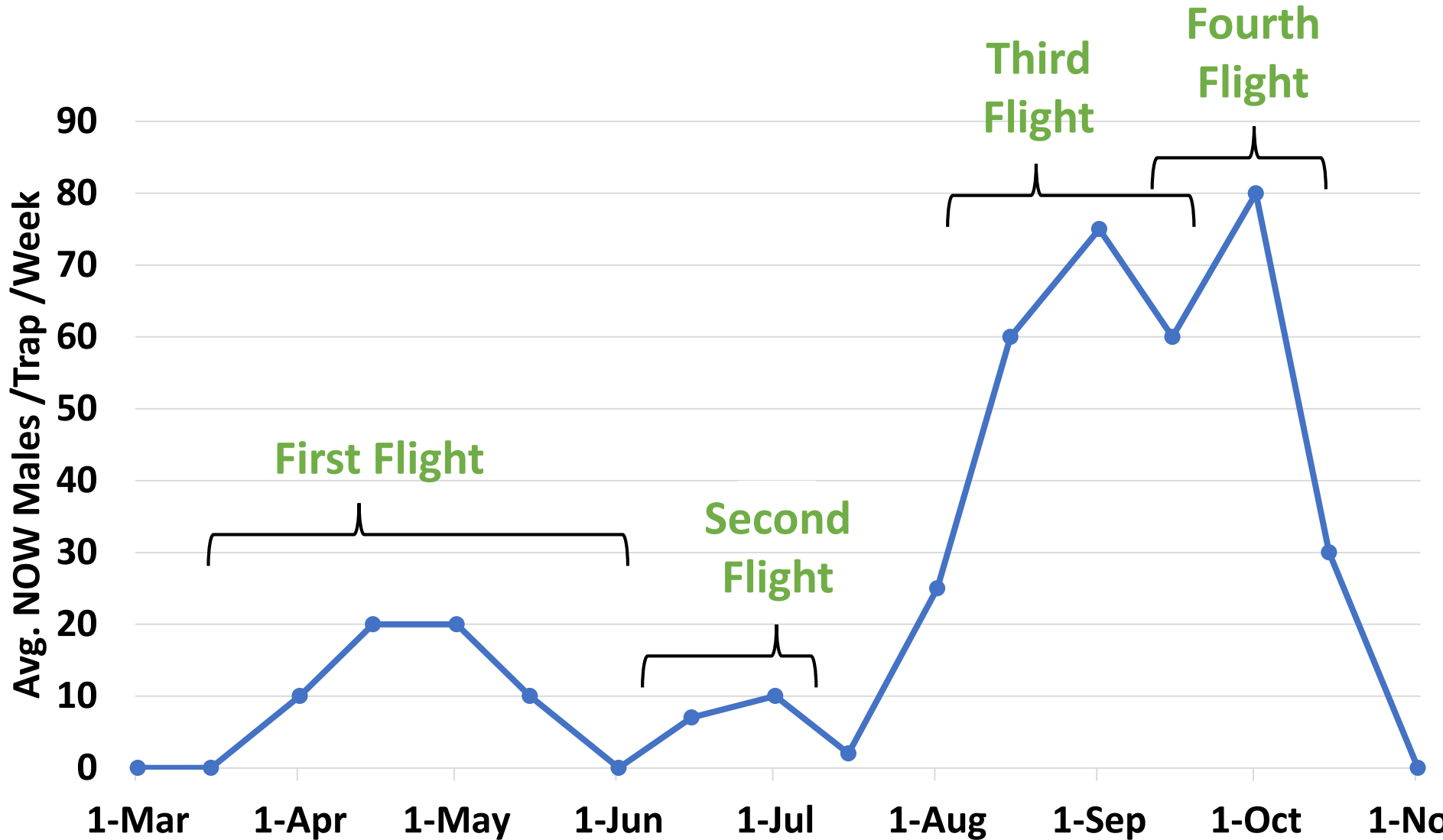


Increasing host availability as hull integrity declines

Mummy vs. New Crop Nuts

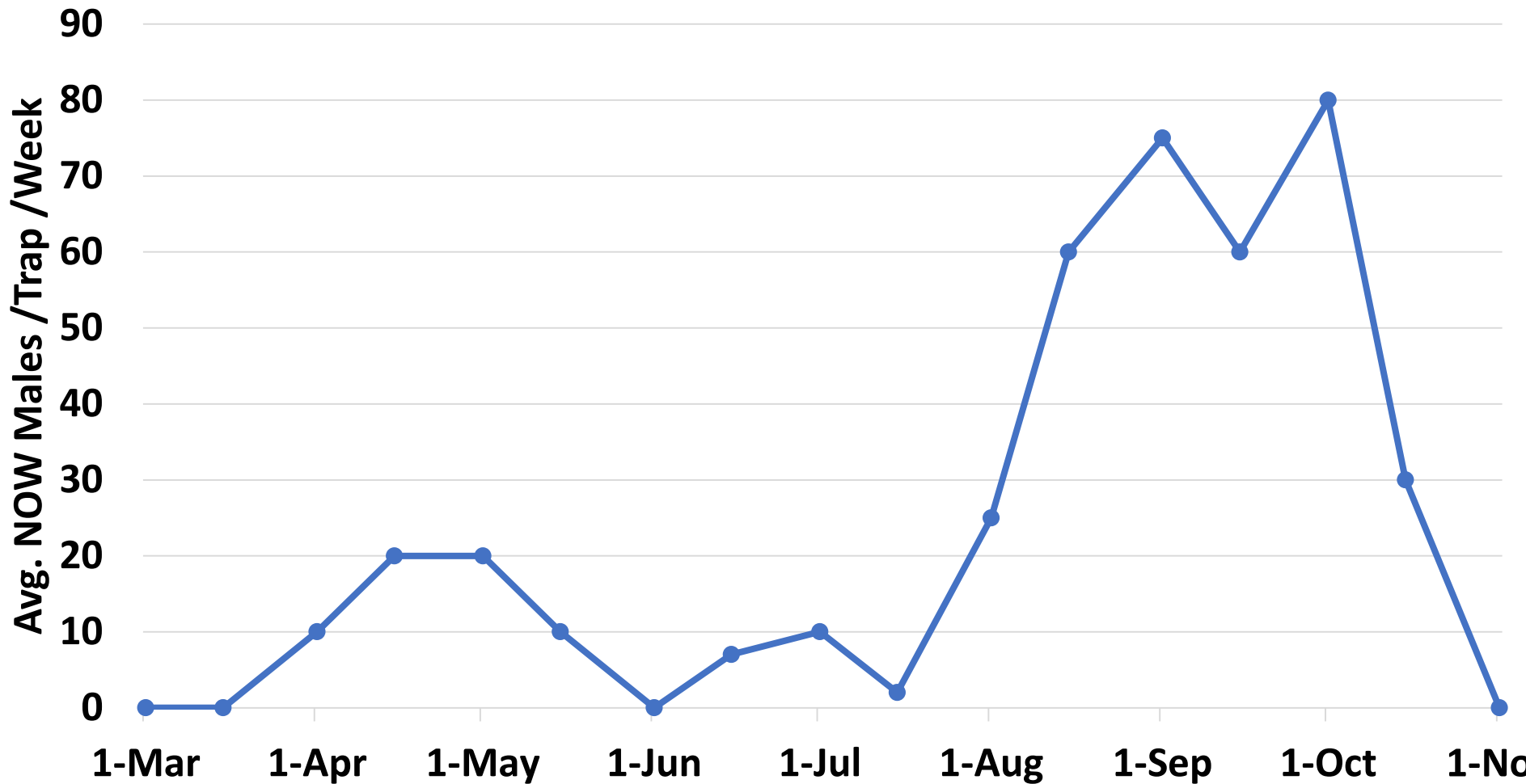
Seasonal Phenology

Increasing Populations Over Time



Seasonal Phenology

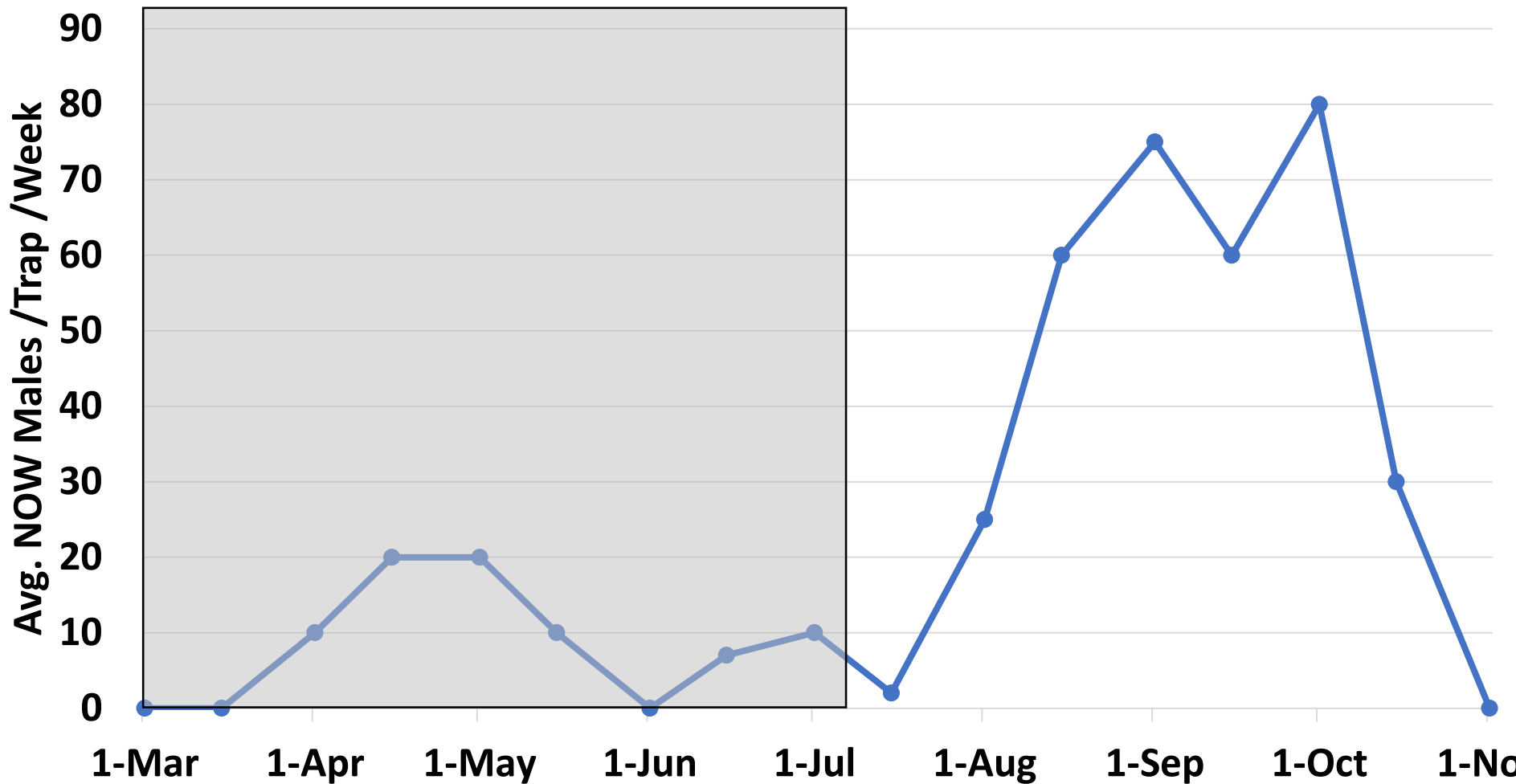
Increasing Populations Over Time



Seasonal Phenology

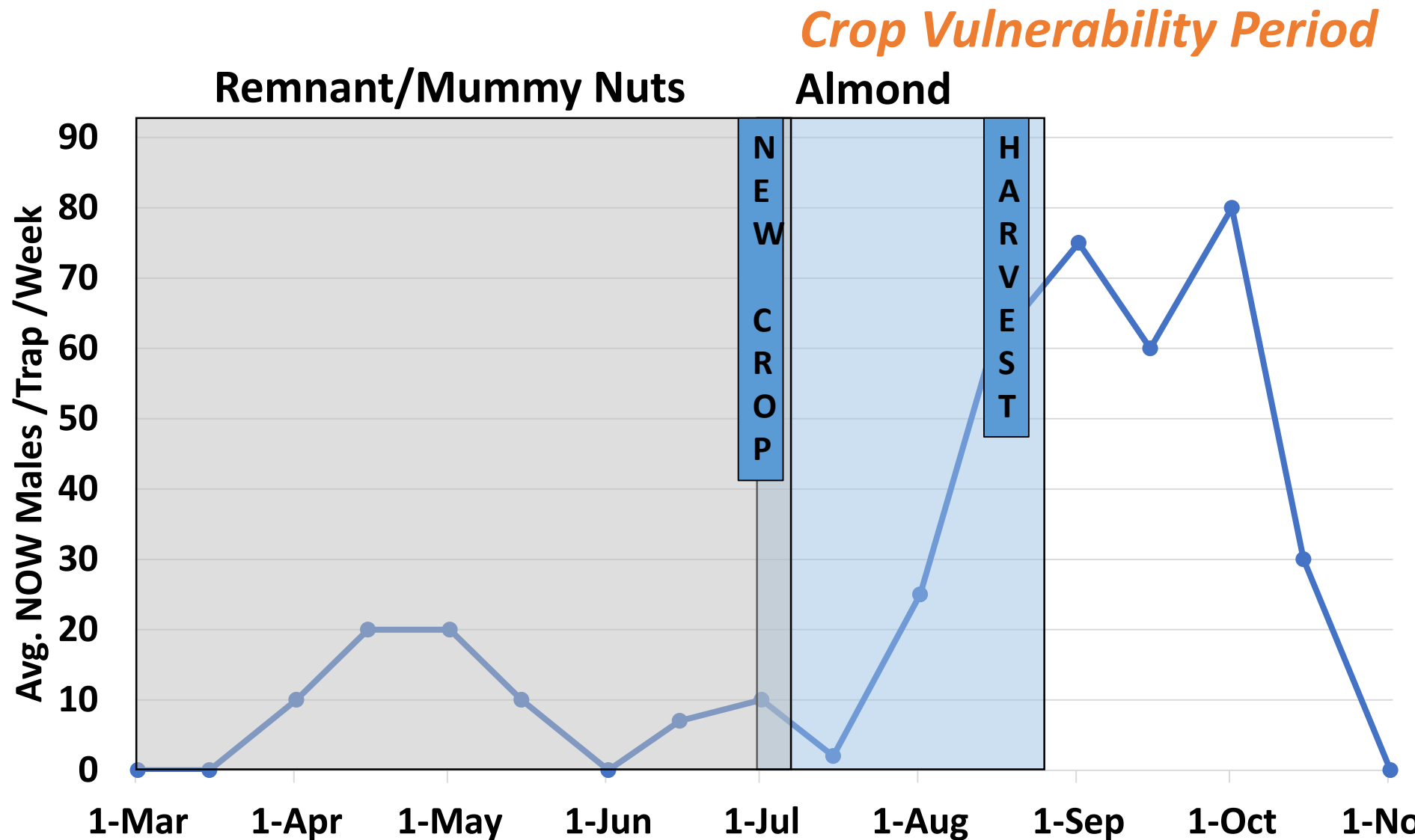
Increasing Populations Over Time

Remnant/Mummy Nuts



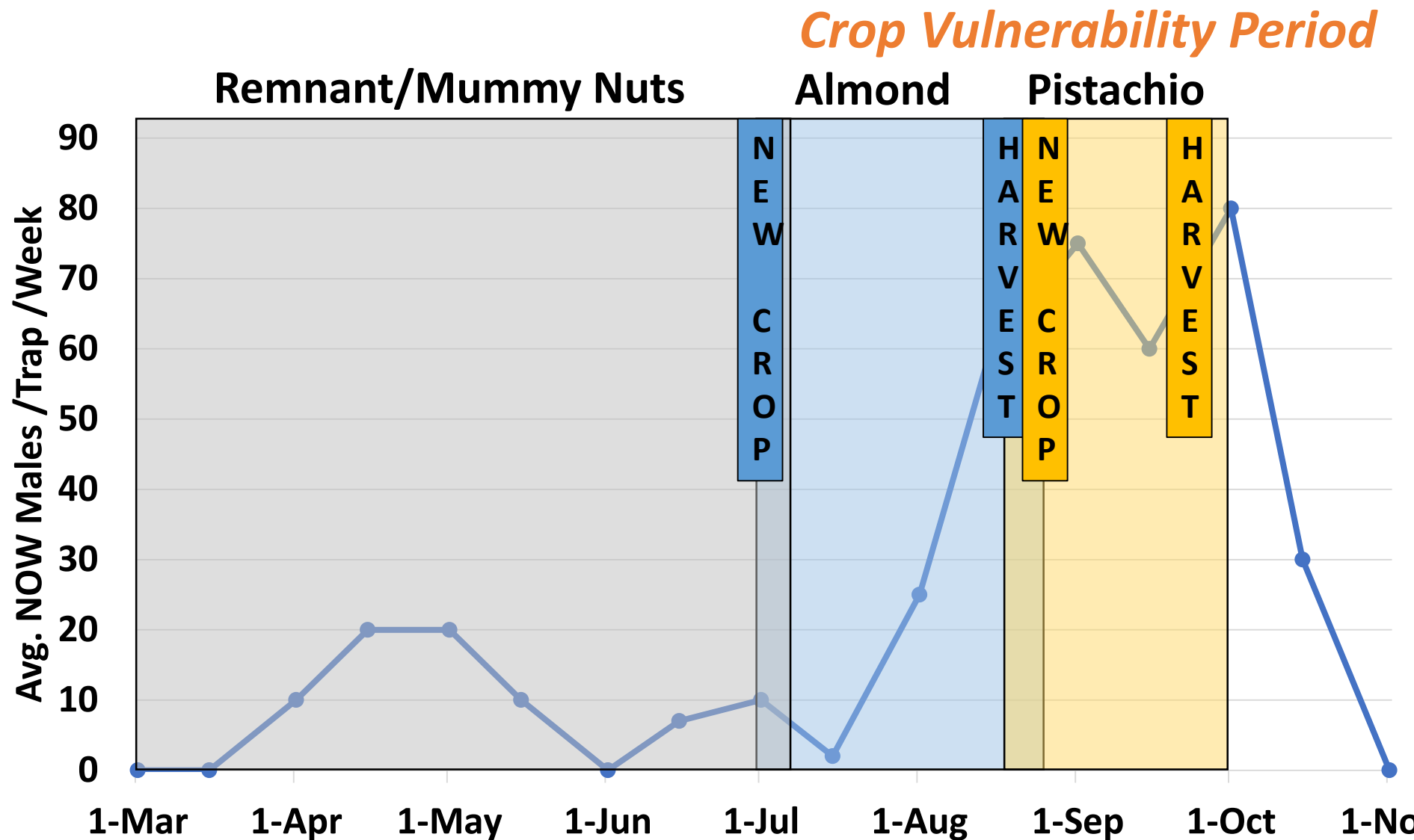
Seasonal Phenology

Increasing Populations Over Time



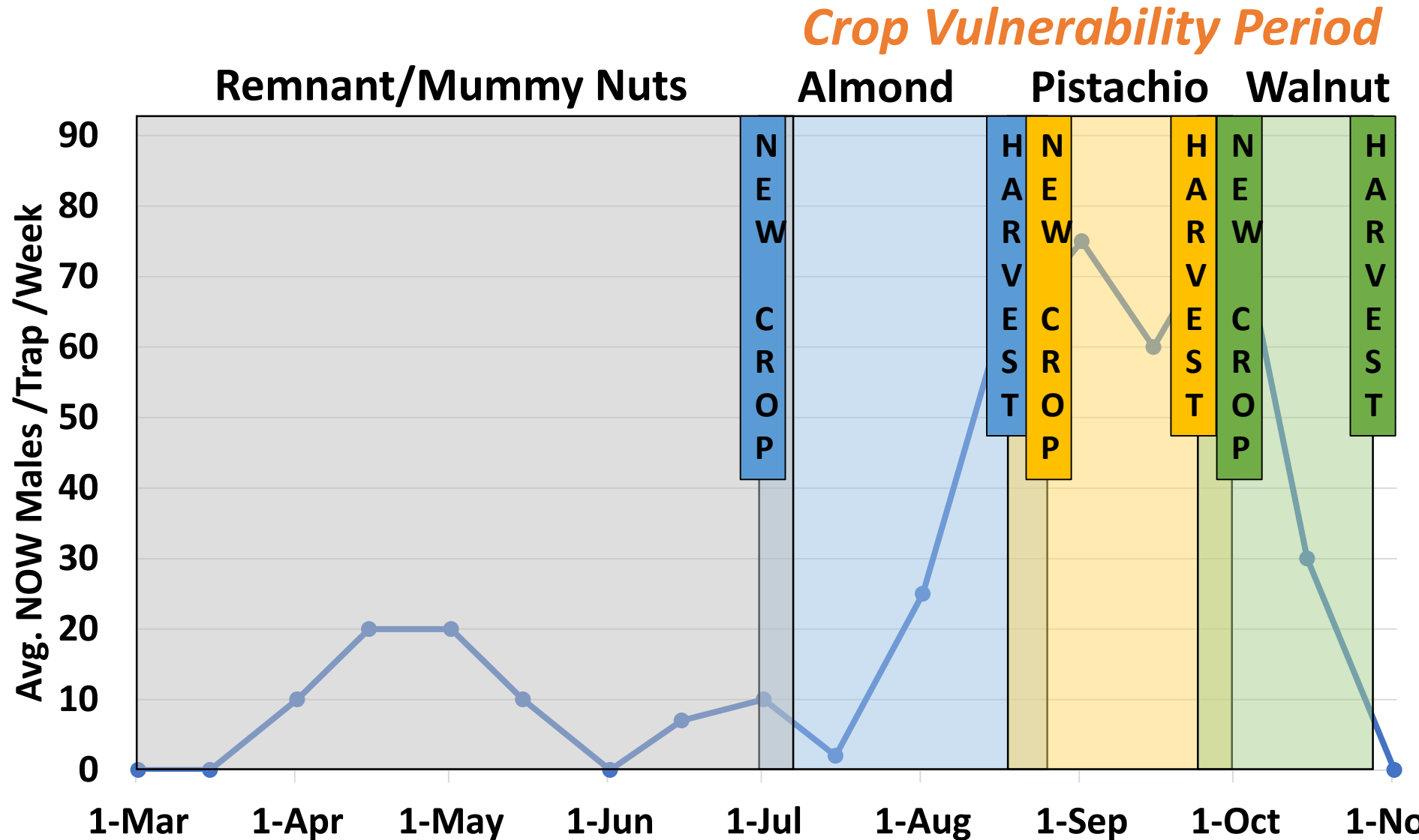
Seasonal Phenology

Increasing Populations Over Time



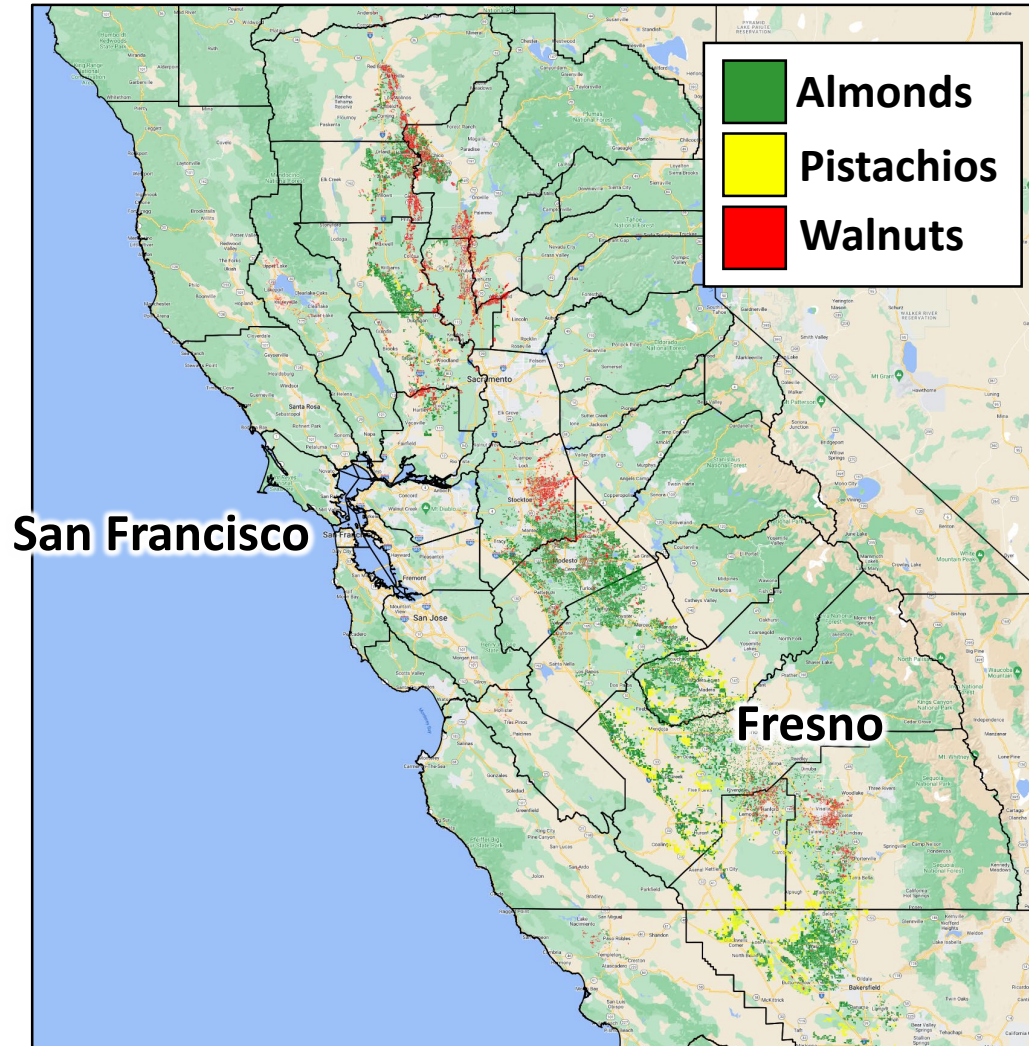
Seasonal Phenology

Increasing Populations Over Time



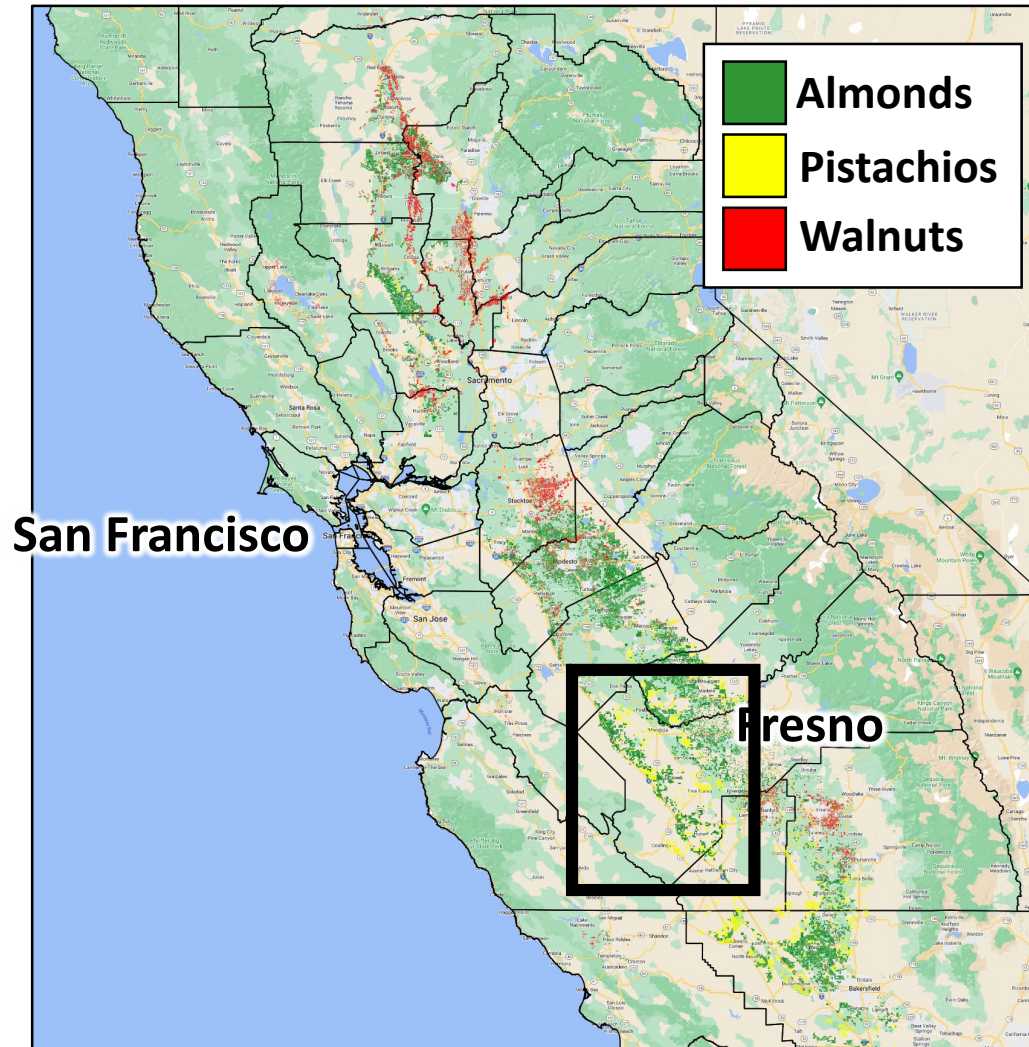
Seasonal Phenology

Likely Influence of Crop Composition on Regional Populations and Orchard Colonization



Seasonal Phenology

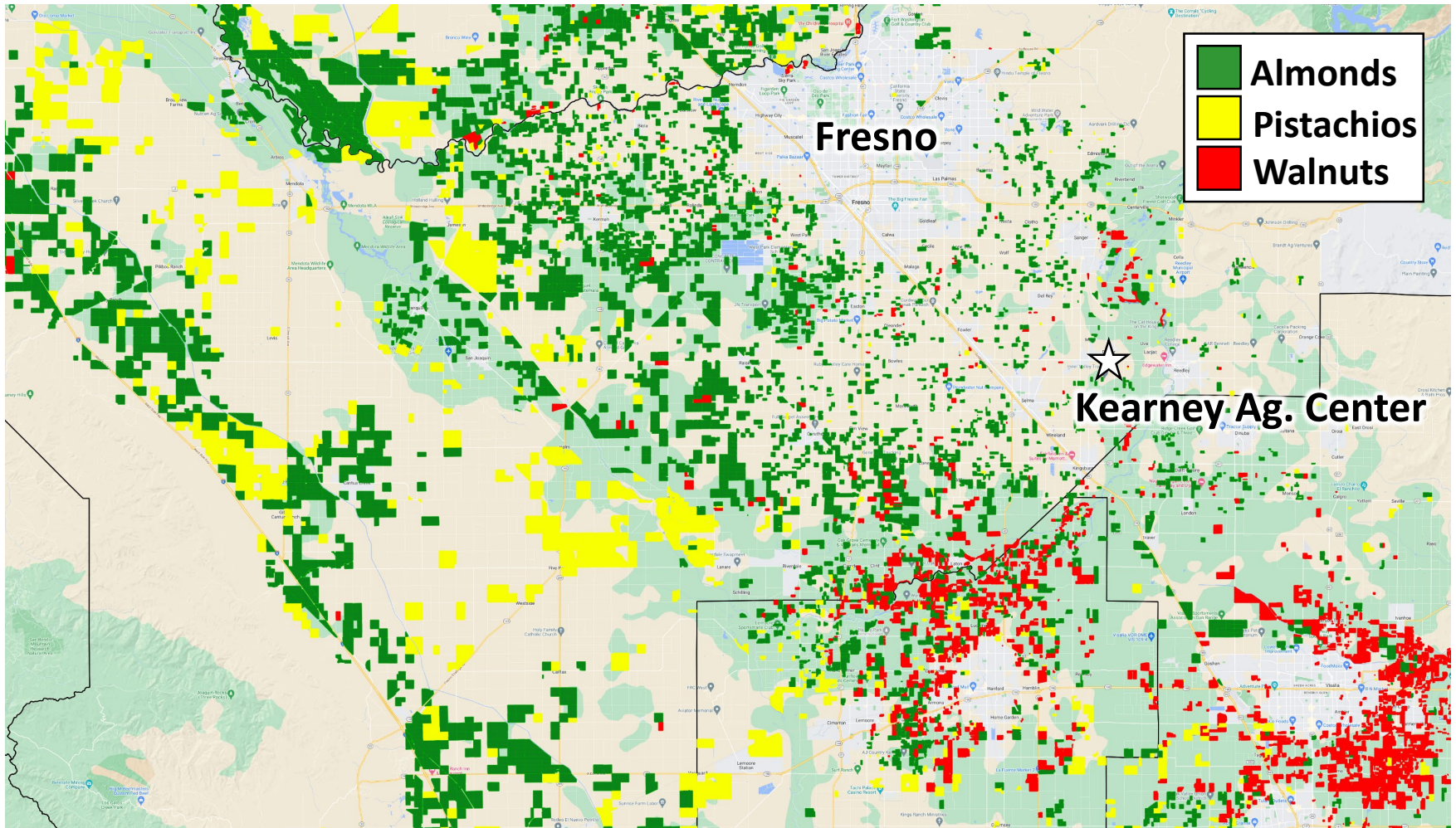
Likely Influence of Crop Composition on Regional Populations and Orchard Colonization



Seasonal Phenology

Crop Composition x Phenology x NOW

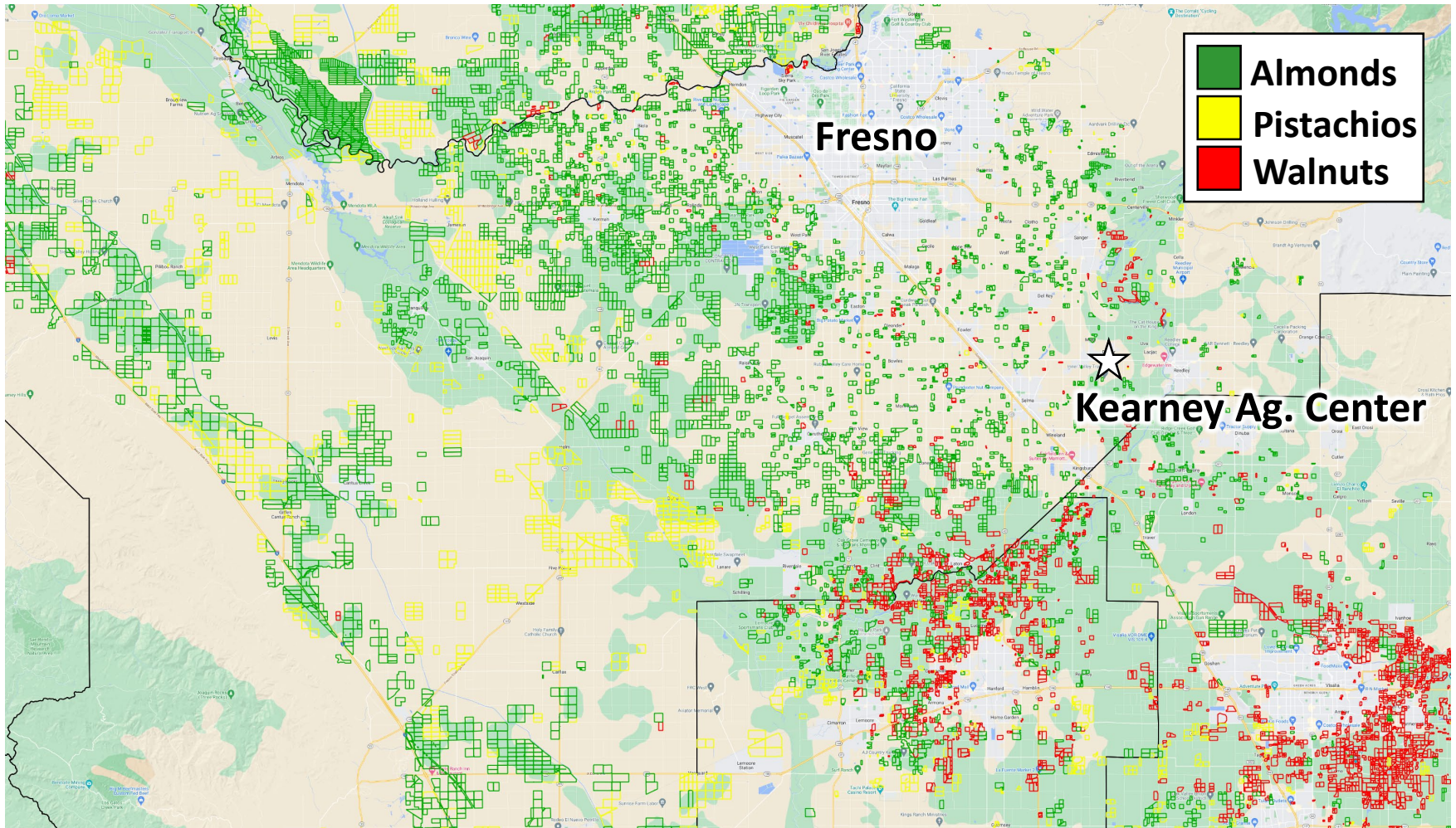
Acreage vs. Availability



Seasonal Phenology

Crop Composition x Phenology x NOW

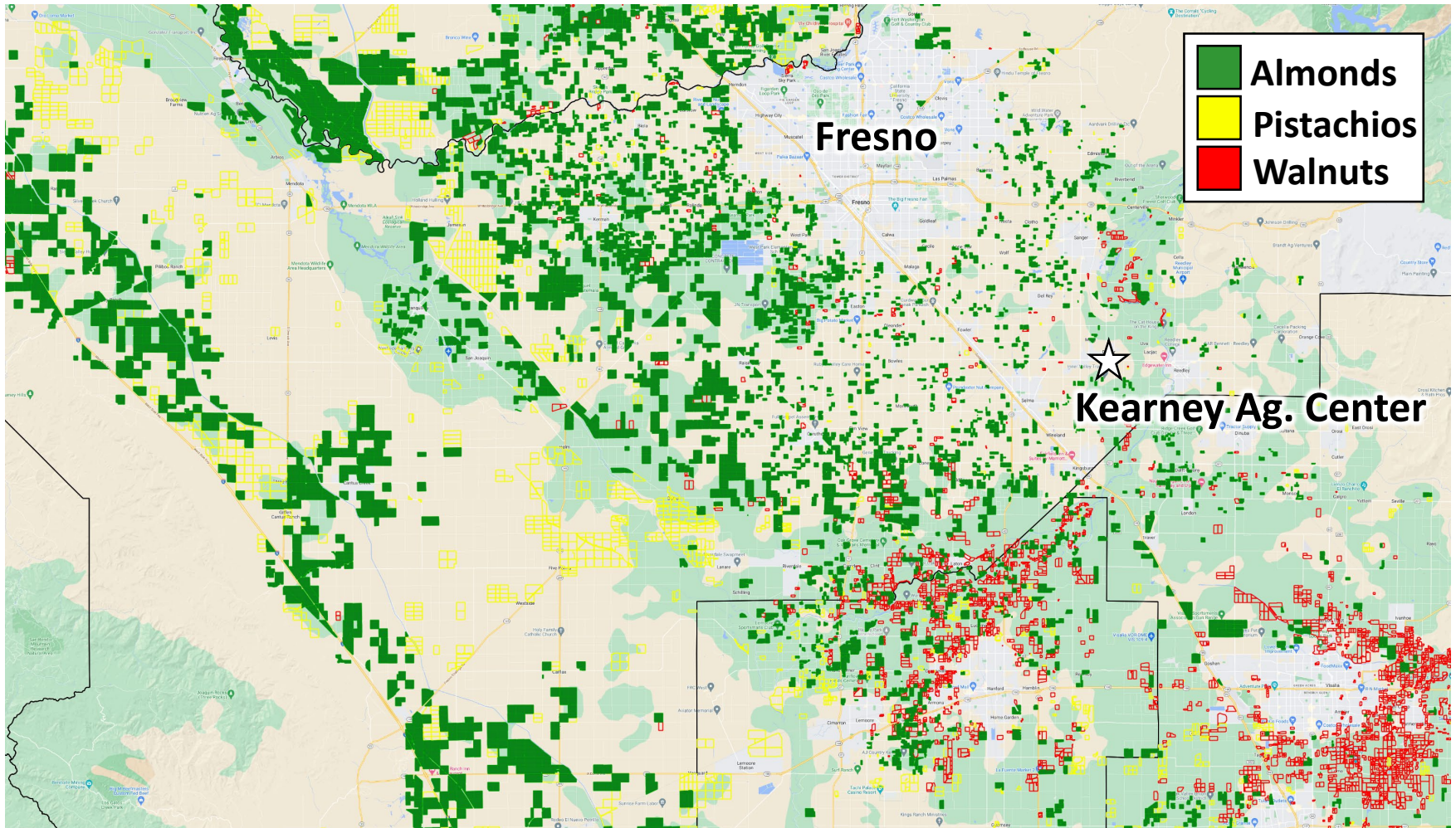
Winter/Spring – Just Remnant Nuts



Seasonal Phenology

Crop Composition x Phenology x NOW

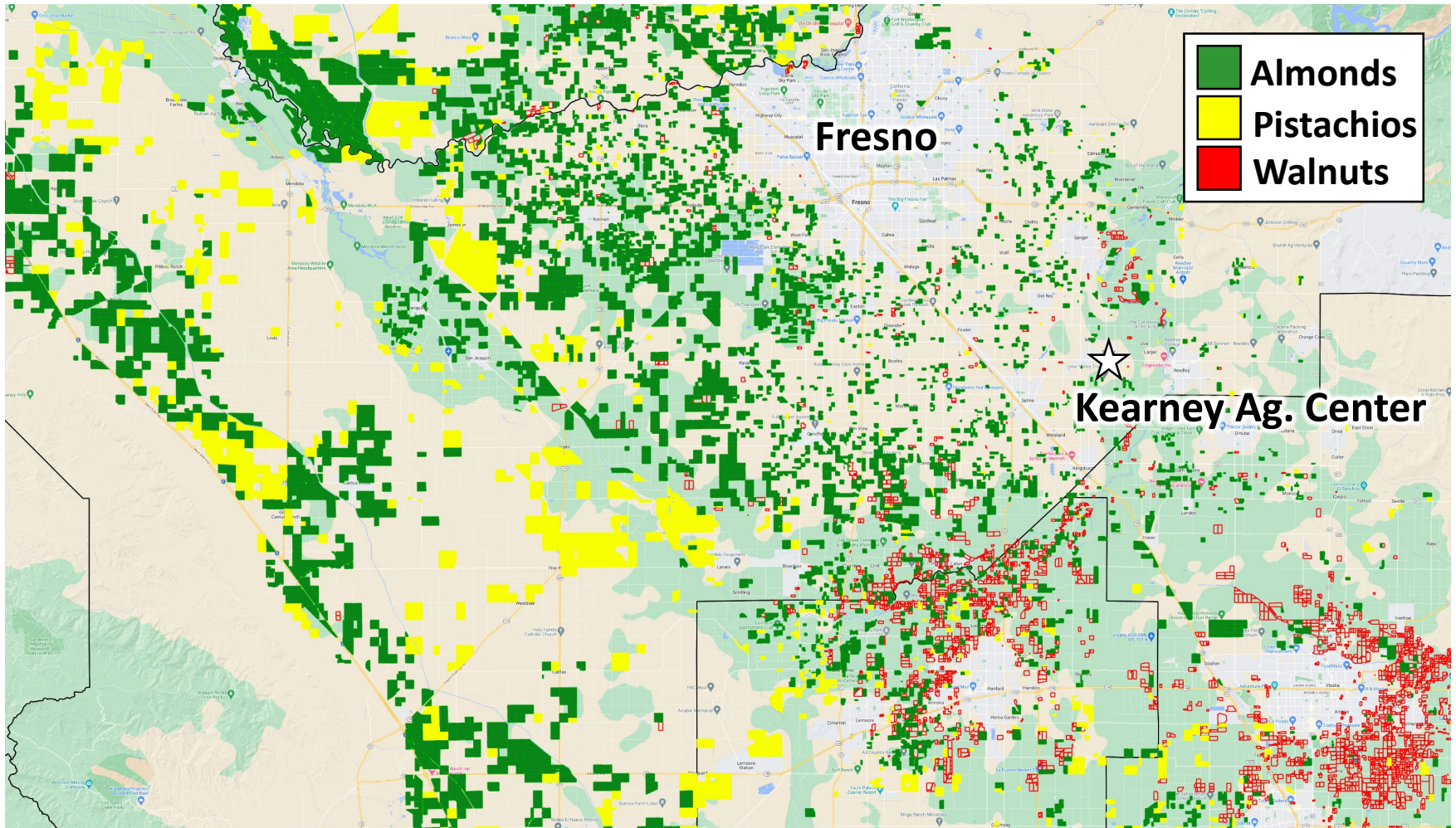
Early Summer - Almonds



Seasonal Phenology

Crop Composition x Phenology x NOW

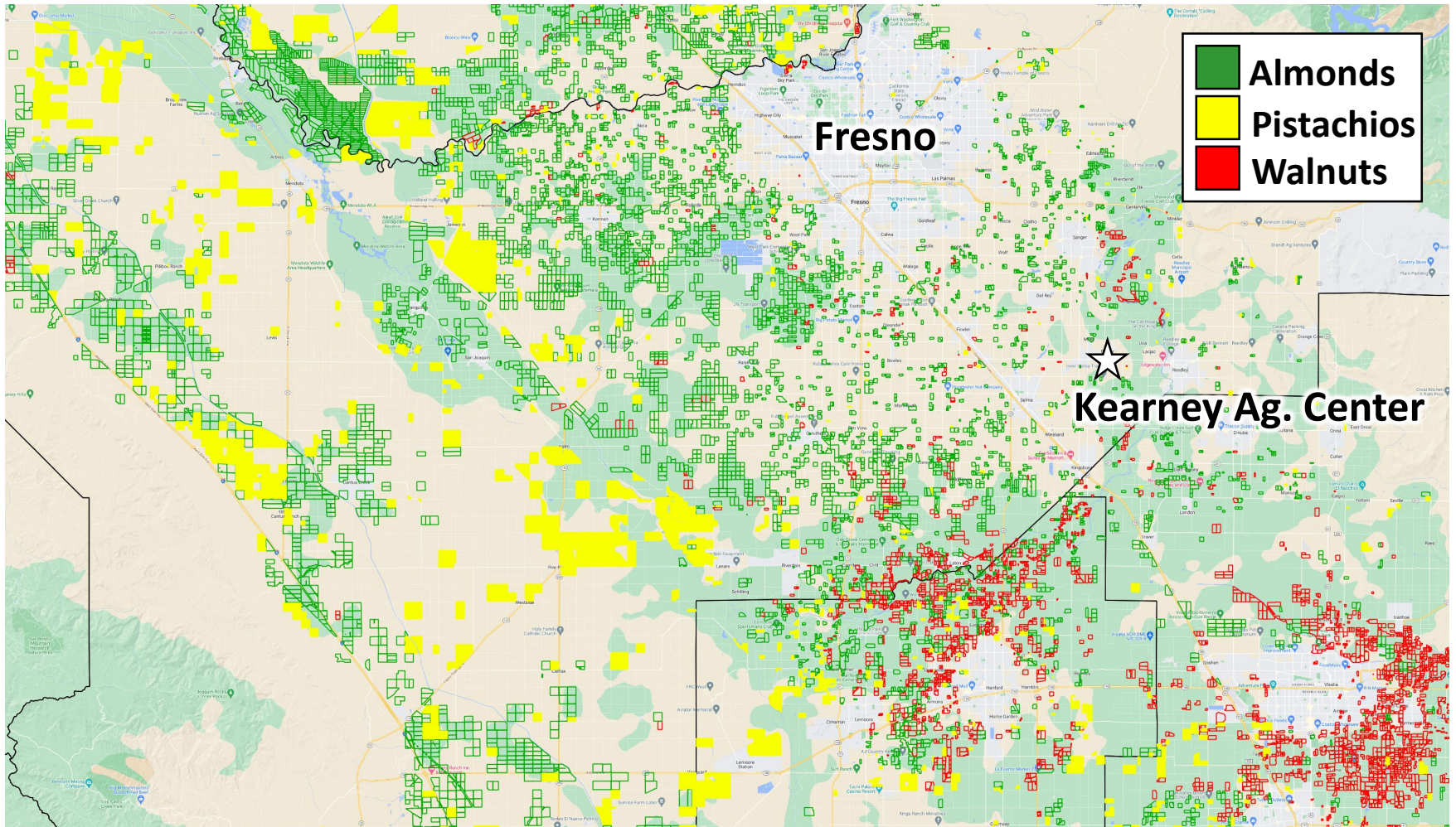
Mid Summer – Almonds / Pistachios



Seasonal Phenology

Crop Composition x Phenology x NOW

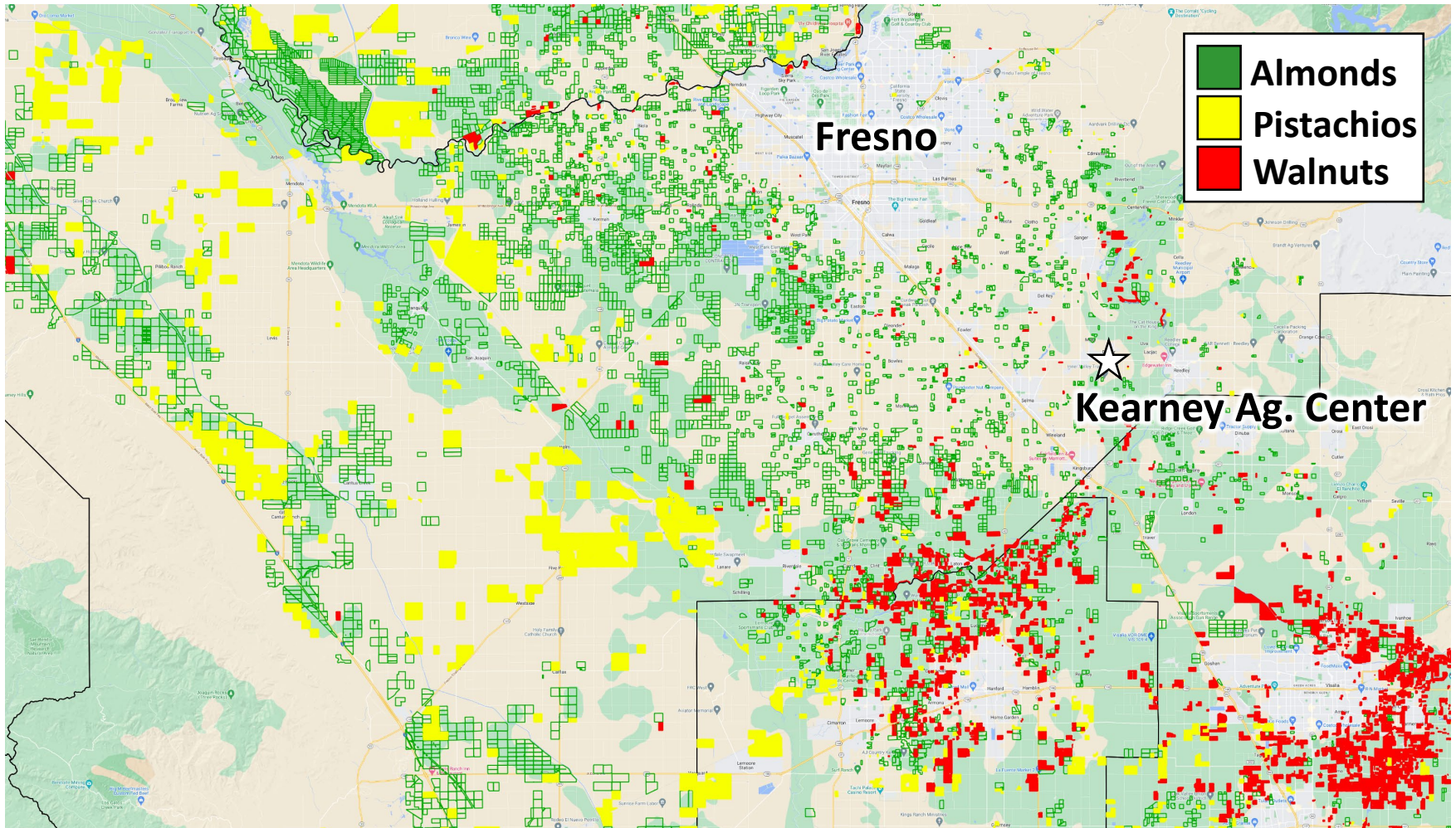
Late Summer - Pistachios



Seasonal Phenology

Crop Composition x Phenology x NOW

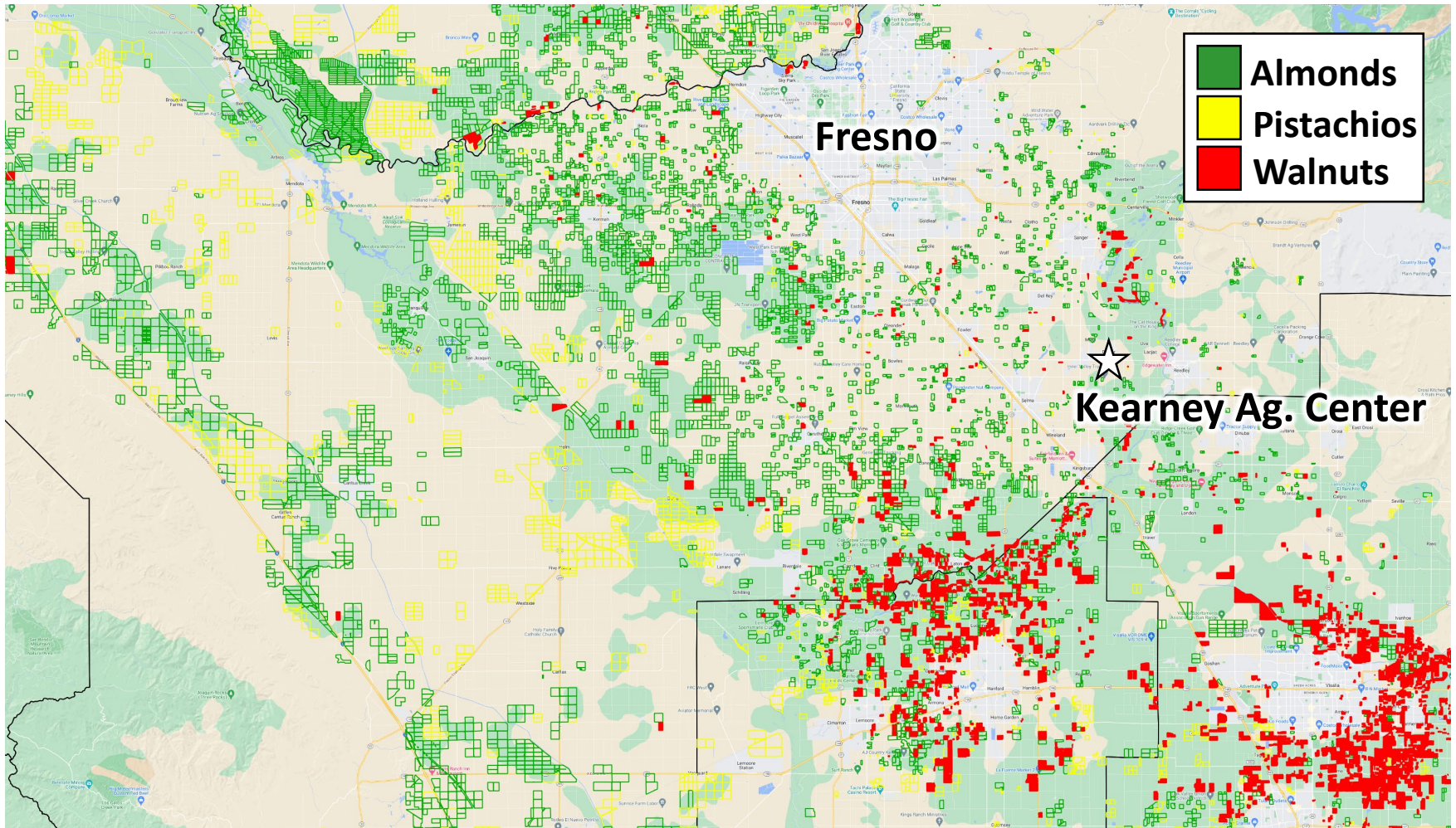
Early Fall – Pistachios/Walnuts



Seasonal Phenology

Crop Composition x Phenology x NOW

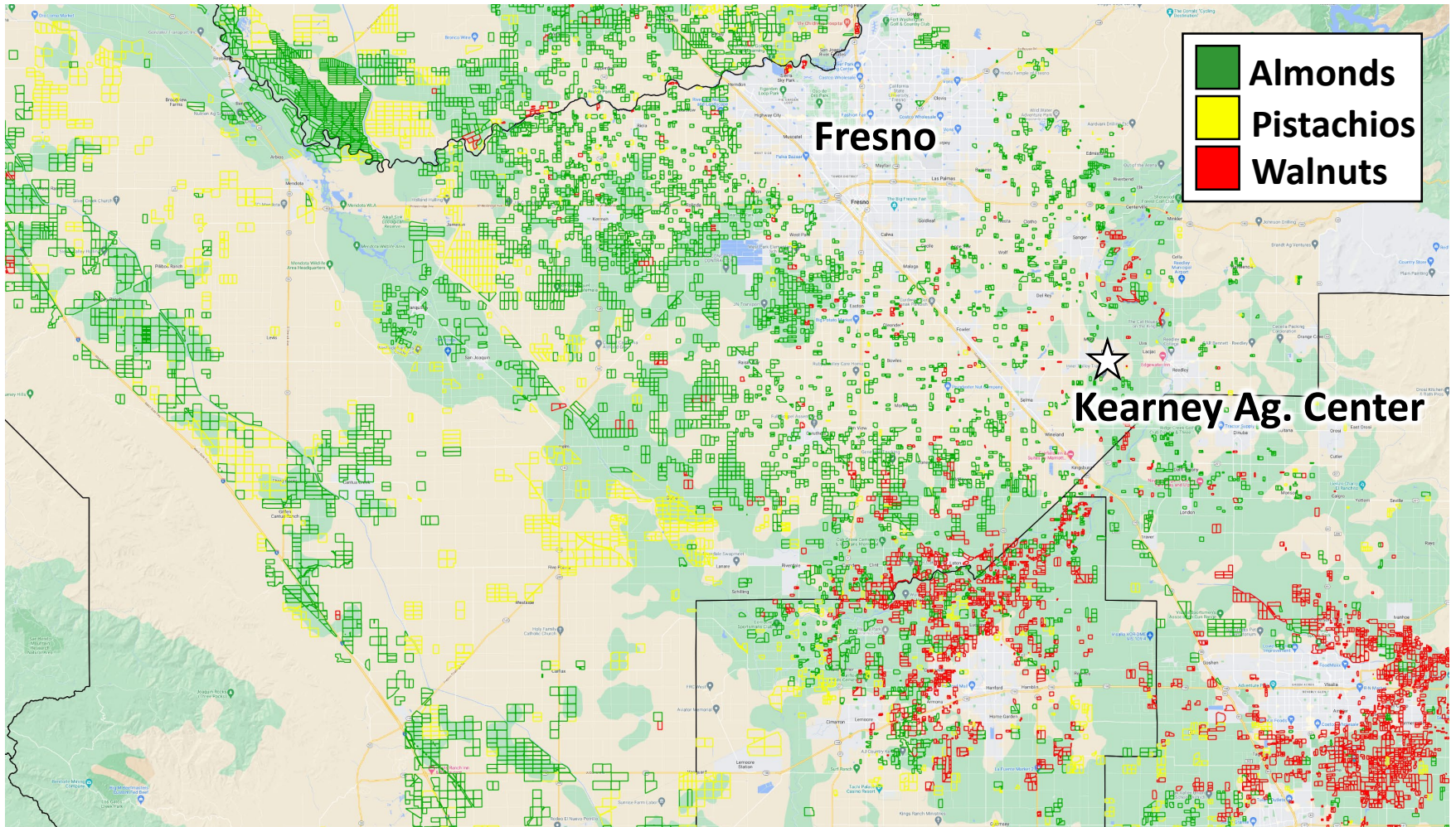
Fall - Walnuts



Seasonal Phenology

Crop Composition x Phenology x NOW

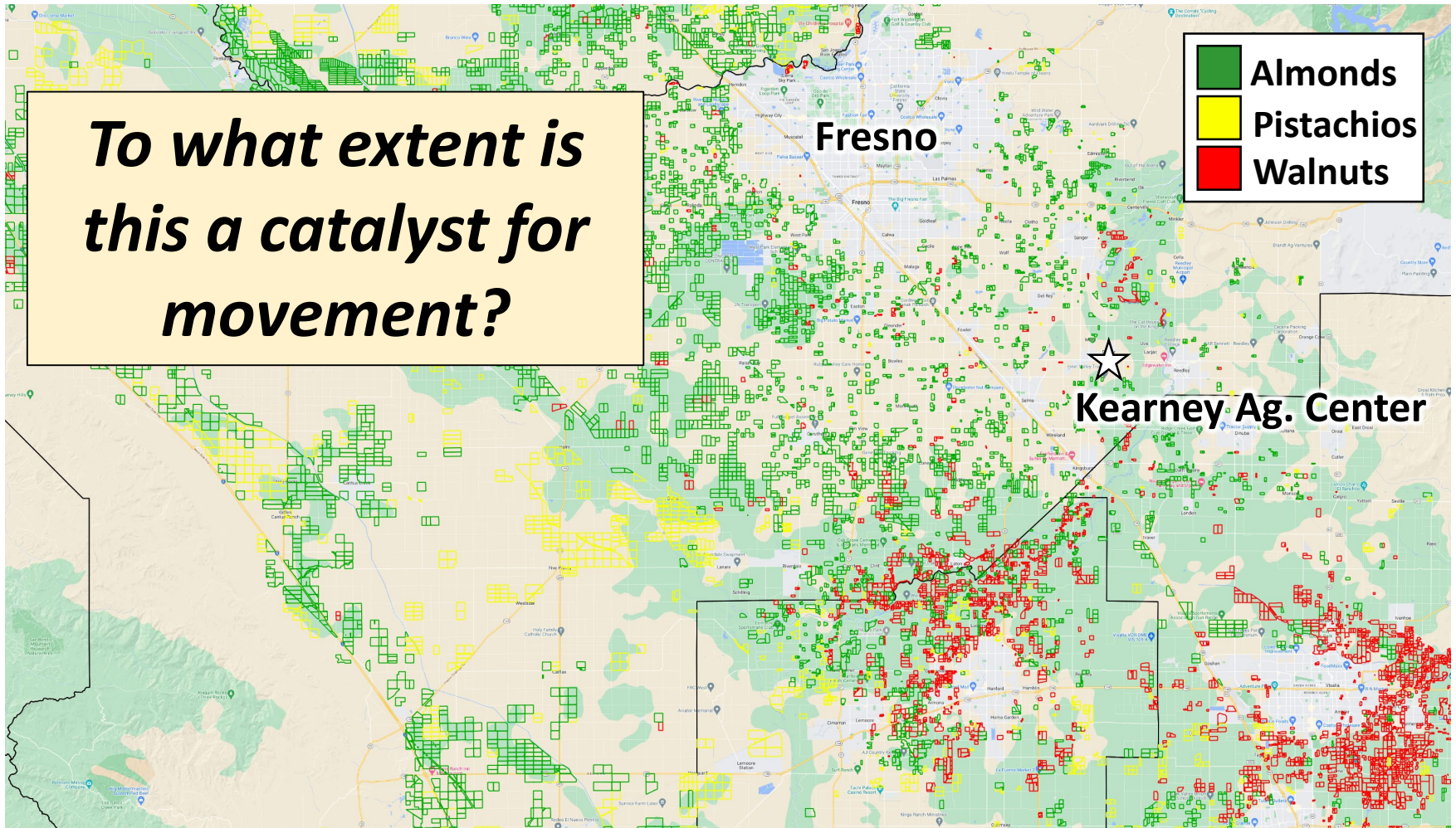
Back to Winter



Seasonal Phenology

Crop Composition x Phenology x NOW

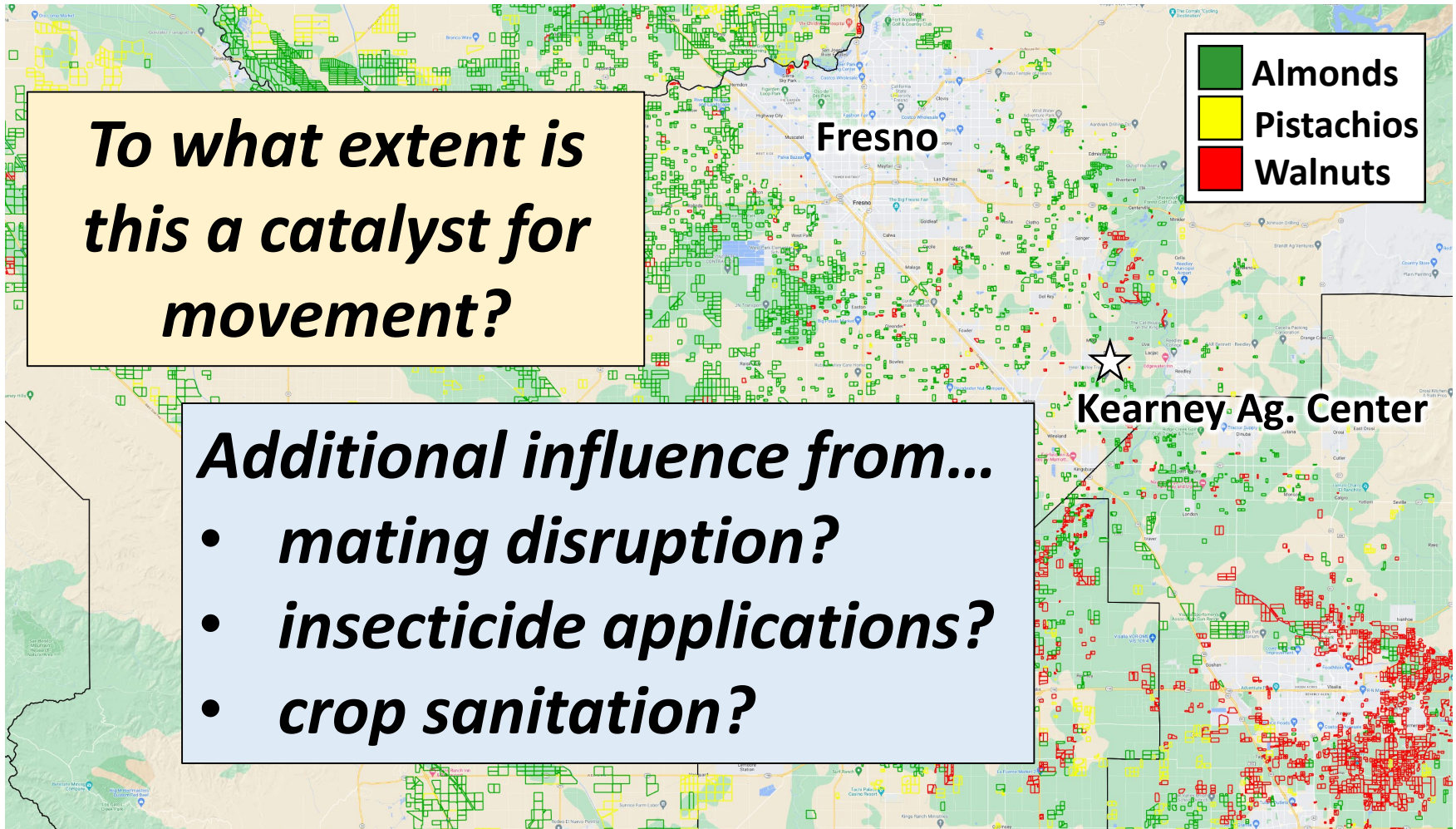
Back to Winter



Seasonal Phenology

Crop Composition x Phenology x NOW

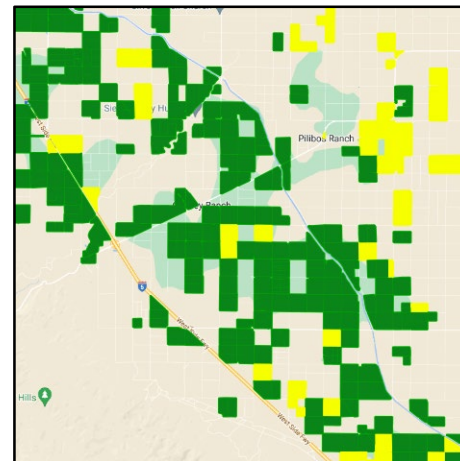
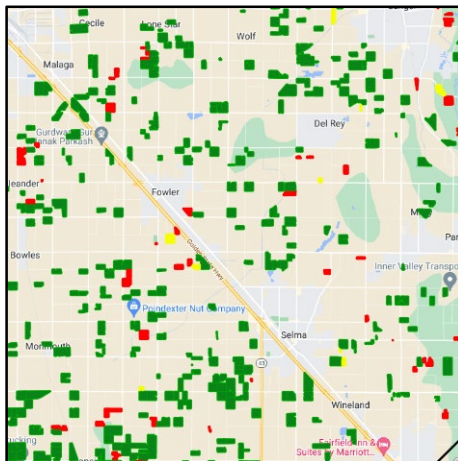
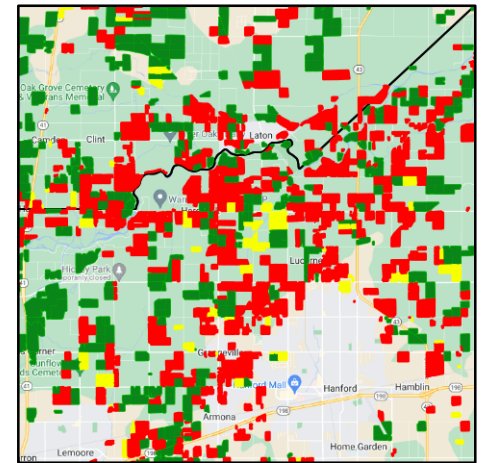
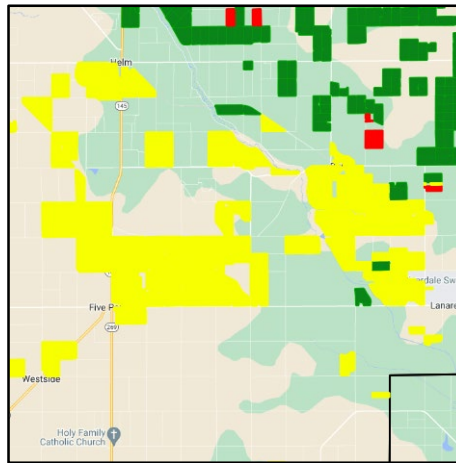
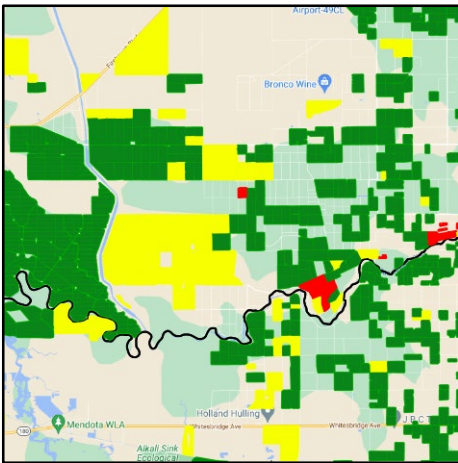
Back to Winter



Seasonal Phenology

Crop Composition x Phenology x NOW

How does landscape composition influence this?



Development of a Decision Support Tool

Taking a Multilayered Approach

Development of a Decision Support Tool

Taking a Multilayered Approach

Short Term – Phenology and Regional Monitoring

- Online pest x tree phenology tool – repackaging existing data
- Integrate with a network of automated traps

Development of a Decision Support Tool

Taking a Multilayered Approach

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- Online pest x tree phenology tool – repackaging existing data
- Integrate with a network of automated traps

Long Term – Movement Data and Models to Predict

- Creating new methods to trace/mark dispersing NOW
- New sensors to detect changes in pistachio hull integrity
- Ecological/economic scenario modeling

Development of a Decision Support Tool

Taking a Multilayered Approach

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- Online pest x tree phenology tool – repackaging existing data
- Integrate with a network of automated traps

Long Term – Movement Data and Models to Predict

- Creating new methods to trace/mark dispersing NOW
- New sensors to detect changes in pistachio hull integrity
- Ecological/economic scenario modeling

*Goal is to Provide Growers with
Improved Site-Specific Estimates
of NOW Timing and Risk*

Development of a Decision Support Tool

Key Steps

1. Making the NOW Phenology Tool Easier to Use
2. Improving NOW Model Accuracy with...
 - Automated Traps
 - Regional Monitoring Network
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Development of a Decision Support Tool

Making the NOW Phenology Tool Easier to Use

Development of a Decision Support Tool

Making the NOW Phenology Tool Easier to Use

Current Setup – Weather Station / Table Output

<https://ipm.ucanr.edu/calludt.cgi/DDMODEL?MODEL=NOW>

UNIVERSITY OF CALIFORNIA AGRICULTURE & NATURAL RESOURCES

UC IPM
Statewide Integrated Pest Management Program

HOME

SEARCH

ON THIS SITE

What is IPM?

Home & landscape pests

Agricultural pests

Natural environment pests

Exotic & invasive pests

Weed gallery

Natural enemies gallery

Weather, models & degree-days

Pesticide information

Research

Publications

Events & training

Links

Glossary

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Contact us

How to Manage Pests

Degree-days: Navel Orangeworm in Pistachios

Use this program to run a model of navel orangeworm in pistachios, recommended by UC Cooperative Extension. In calculating degree-days, the program uses temperatures from the UC IPM weather database, a file you supply, or data you enter online.

How to use this model in: pistachios, or almonds
[Calculate any degree-days](#) | [Using this calculator](#) | [Reference degree-day tables](#) | [About degree-days](#) |

Navel Orangeworm in Pistachios

- Lower/upper threshold: 55/94°F
- Calculation/upper cutoff method: single sine/horizontal
- Biofix: The biofix is the beginning of a consistent increase in egg laying on egg traps. When egg traps in a given location show increases in the number of eggs on two consecutive monitoring dates, the biofix is the first of those two dates.
- Additional information on using this model: [Pest Management Guideline](#)

Specify source of temperature data

Select the source of temperatures to be used to calculate degree-days. You may also use your own maximum and minimum temperatures and look up approximate daily degree-day values in a [reference degree-day table for navel orangeworm](#), then total them yourself.

<input checked="" type="radio"/> Weather station from UC IPM database	Select from stations in which California county? Alameda Alpine Amador Butte Calaveras <input checked="" type="checkbox"/> Include active stations only
<input type="radio"/> Your data file	<input type="button" value="Browse..."/> No file selected. Text file (comma or tab delimited) format
<input type="radio"/> Enter data online	

Development of a Decision Support Tool

Making the NOW Phenology Tool Easier to Use

Current Setup – Weather Station / Table Output

<https://ipm.ucanr.edu/calludt.cgi/DDMODEL?MODEL=NOW>

Degree-Days: Navel Orangeworm on Almonds

[How to use](#)
[Degree-day menu](#) | [Change county](#)

Navel Orangeworm on Almonds Model

- Lower/upper threshold: 55/94°F
- Calculation/upper cutoff method: single sine/horizontal
- Biofix: The first biofix is the beginning of a consistent increase in egg laying on egg traps. When the biofix is the first of those two dates.
- Additional information on using this model: [Pest Management Guideline](#)

To use these calculations:

Typical generation time

Generation Length (degree-days)
1056

Weather station: [FIVE_PTS.A \(CIMIS #2, Five Points/WSFS USDA\)](#)
Time period: March 15, 2023 to July 30, 2023, retrieved on July 31, 2023 (138 days).
Note: Only 92% of requested data were available from station FIVE_PTS.A. [See retrieval table.](#)

Date	Air temperatures (°F)		Degree-days		Notes
	Min *	Max *	Daily	Accumulated	
Mar 15 2023	45	60	1.27	1.27	
Mar 16 2023	40	64	2.44	3.71	
Mar 17 2023	42	68	4.14	7.85	
Mar 18 2023	42	71	5.39	13.24	
Mar 19 2023	52	63	3.18	16.42	
Mar 20 2023	50	65	3.77	20.20	
Mar 21 2023	45	61	1.63	21.82	
Mar 22 2023	44	56	0.12	21.95	
Mar 23 2023	42	59	0.84	22.79	
Mar 24 2023	38	58	0.50	23.29	
Mar 25 2023	33	59	0.68	23.97	
Mar 26 2023	34	58	0.46	24.42	
Mar 27 2023	31	65	2.38	26.80	
Mar 28 2023	42	64	2.56	29.36	
Mar 29 2023	41	58	0.54	29.90	
Mar 30 2023	38	59	0.76	30.66	
Mar 31 2023	34	65	2.50	33.16	
Apr 01 2023	40	67	3.57	36.73	
Apr 02 2023	42	68	4.14	40.87	
Apr 03 2023	38	58	0.50	41.37	
Apr 04 2023	35	60	0.97	42.34	
Apr 05 2023	33 1	64 1	2.12	44.46	
Apr 06 2023	35	71	4.77	49.23	
Apr 07 2023	48	69	5.28	54.51	

Challenges

- Location is inexact
- Table output
- Requires user to locate the correct degree-day

Development of a Decision Support Tool

Making the NOW Phenology Tool Easier to Use

New Setup – Map Interface with Charts

<https://ucanr-igis.shinyapps.io/noworm/>

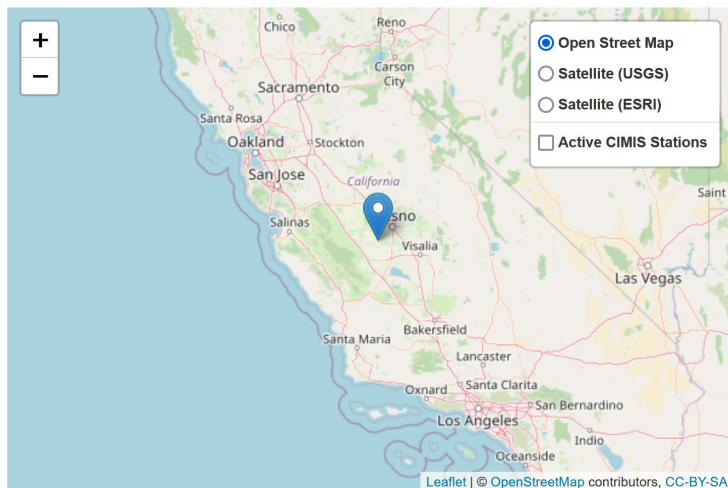
Navel Orangeworm Development Calculator

This calculator predicts the development stages of Navel Orangeworm at a specific location based on temperature data and growth model based on degree days. For more information, see the 'Instructions' tab.

NOTE: this app is still under development and should not be used for crop management.

Calculator Instructions Resources

1. Select Location



Coordinates:

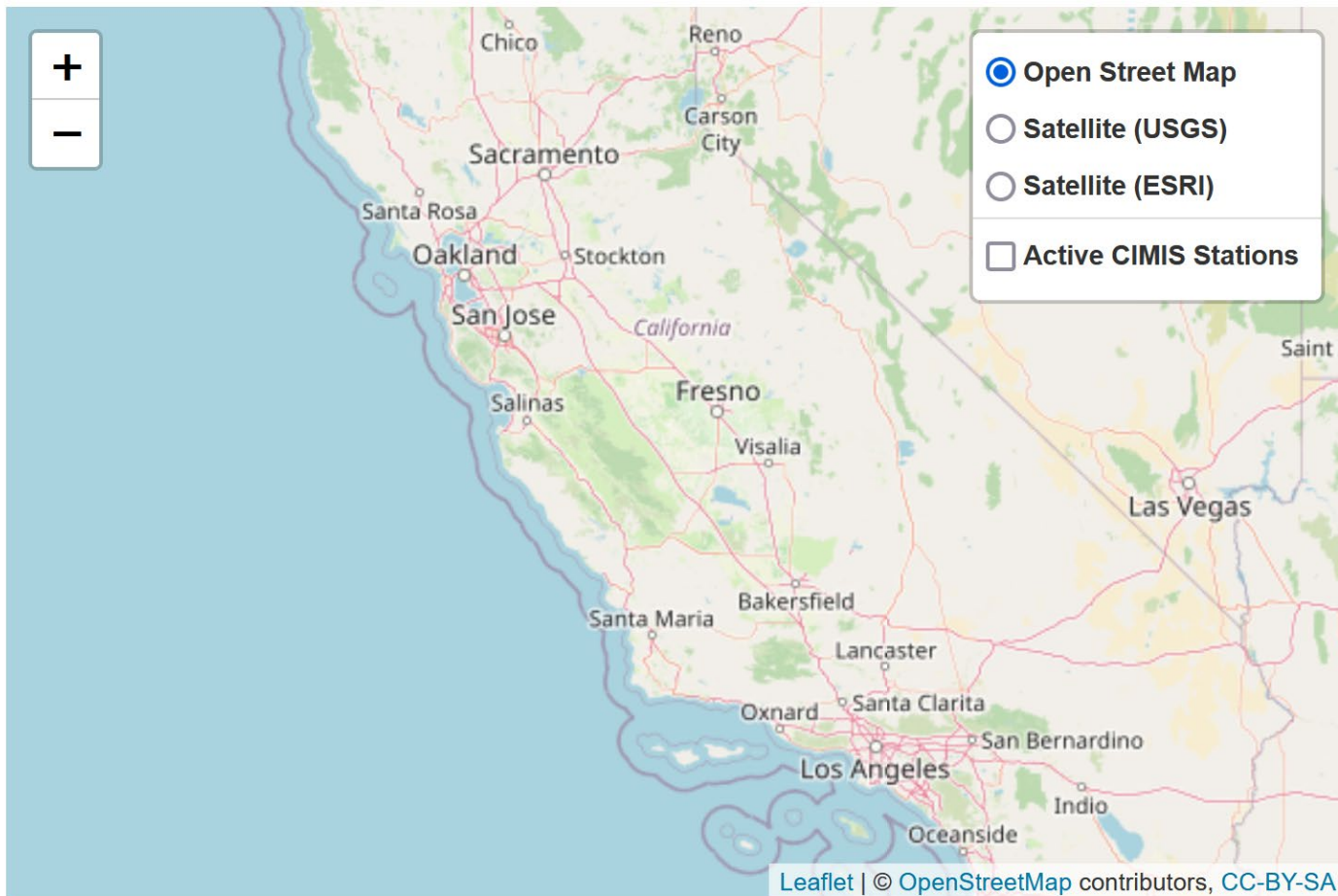
-120.05859, 36.51964

Development of a Decision Support Tool

Making the NOW Phenology Tool Easier to Use

New Setup – Map Interface with Charts


1. Select Location



Development of a Decision Support Tool


Making the NOW Phenology Tool Easier to Use

New Setup – Map Interface with Charts


Coordinates: 

-120.05859, 36.51964


2. Report options

Species & Crop 

Navel Orangeworm (almonds,pistachios) ▼

Biofix date 

2023-01-01


End date 

2023-07-31

Predict Phenology Events

- First Flight (1121.4 DD)
- Second Flight (765.9 DD)
- Third Flight (750 DD)
- Fourth Flight (750 DD)

3. Weather data



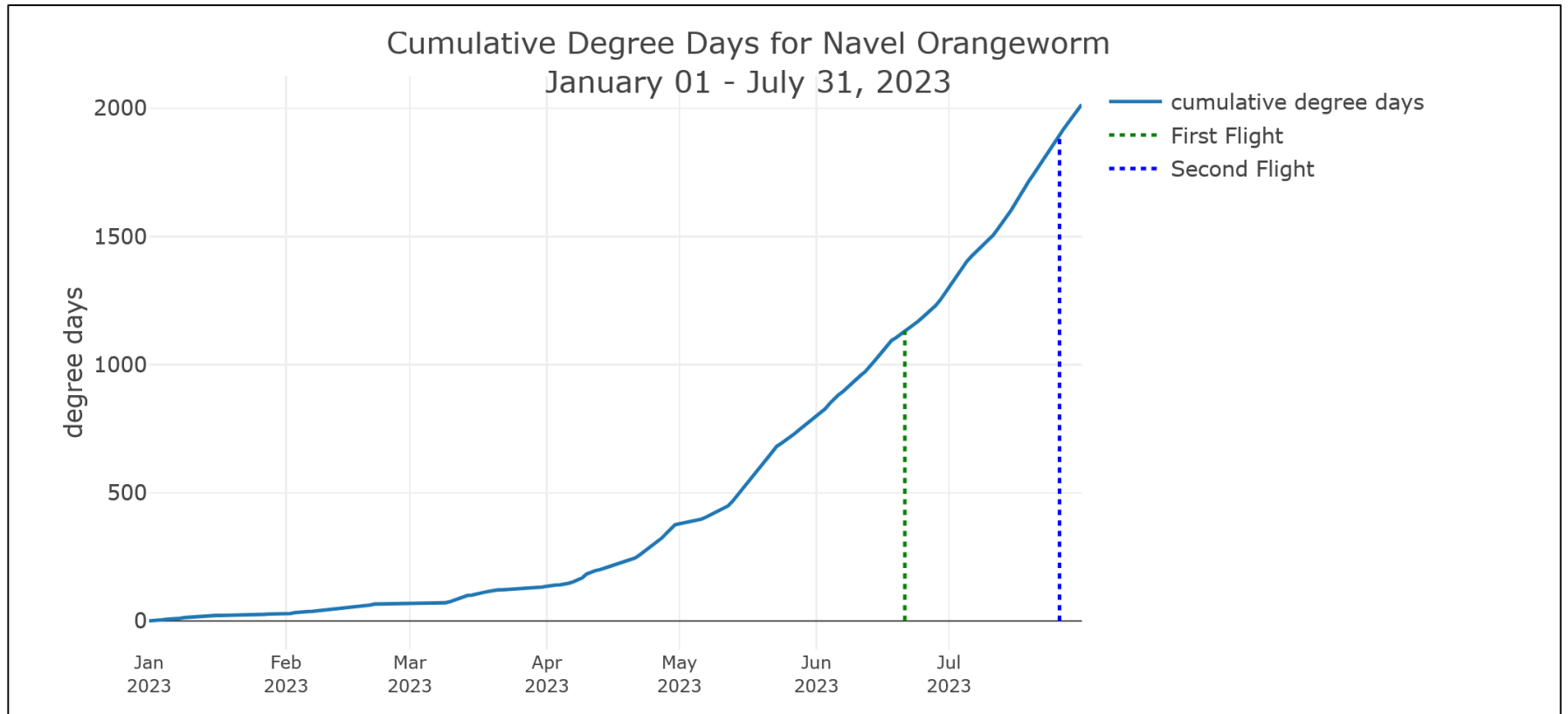
4. Report

Run!

Development of a Decision Support Tool

Making the NOW Phenology Tool Easier to Use

New Setup – Map Interface with Charts



Development of a Decision Support Tool

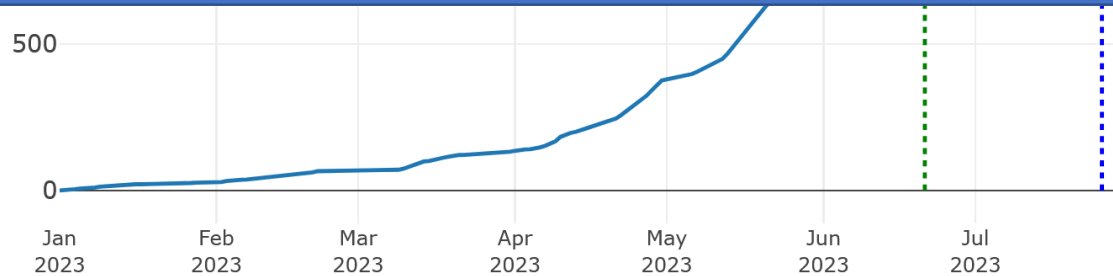
Making the NOW Phenology Tool Easier to Use

New Setup – Map Interface with Charts

Cumulative Degree Days for Navel Orangeworm
January 01 – July 31, 2023

Challenges

- Biofix must be entered by the user
- Variance between individual orchards
- Local weather data need to be refined



Development of a Decision Support Tool

Key Steps

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Development of a Decision Support Tool

Improving NOW Model Accuracy

Automated Traps + Regional Monitoring Network

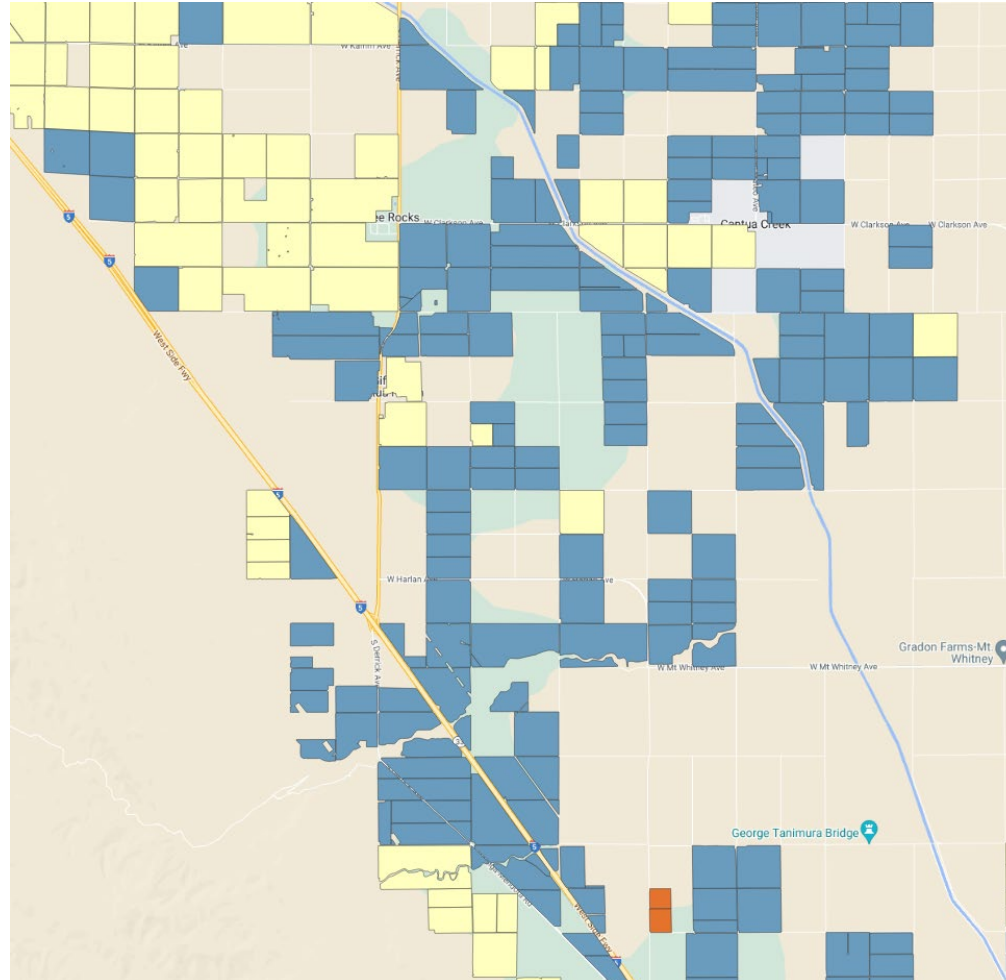
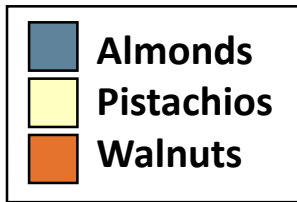
- Multiple possible automated traps/lures
 - Delta/wing, phero/ovibait/PPO
- Network established by UC/USDA
- Data will be anonymized and publicly available



Development of a Decision Support Tool

Improving NOW Model Accuracy

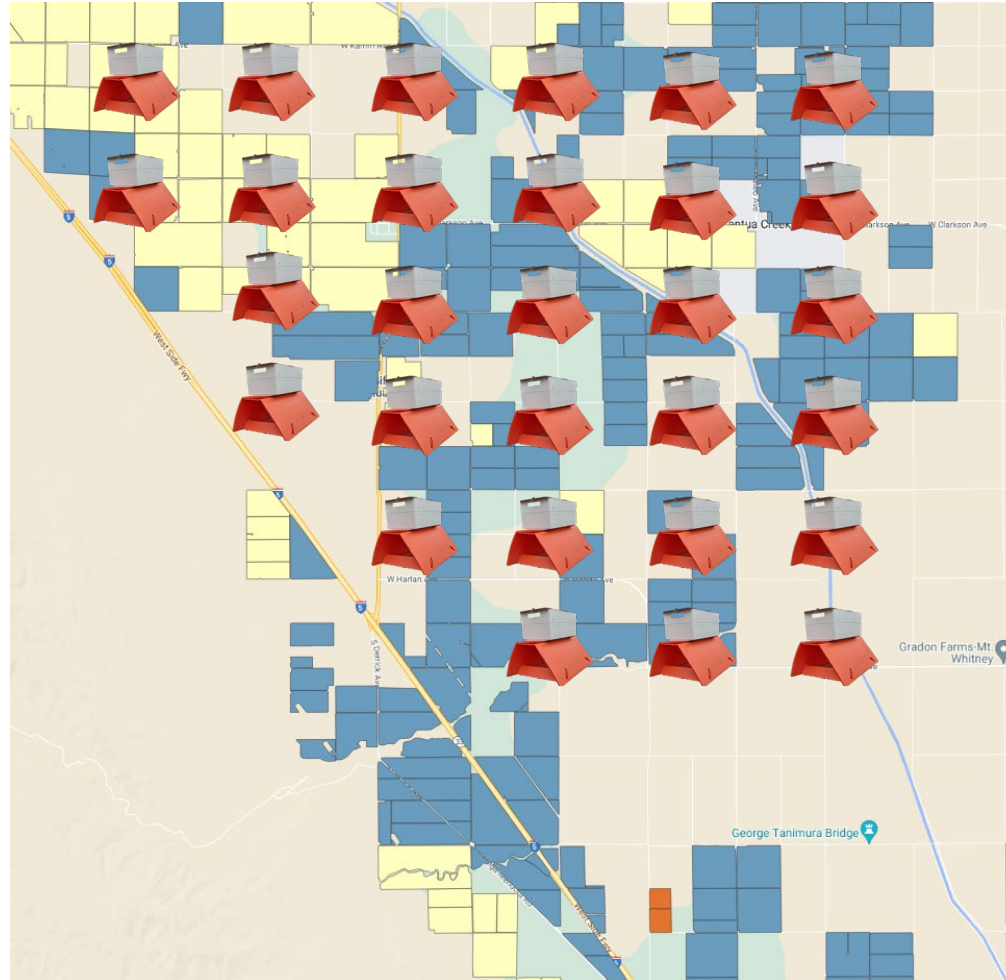
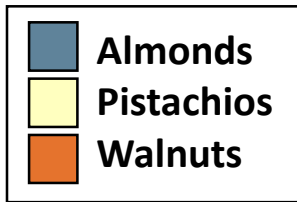
Automated Traps + Regional Monitoring Network



Development of a Decision Support Tool

Improving NOW Model Accuracy

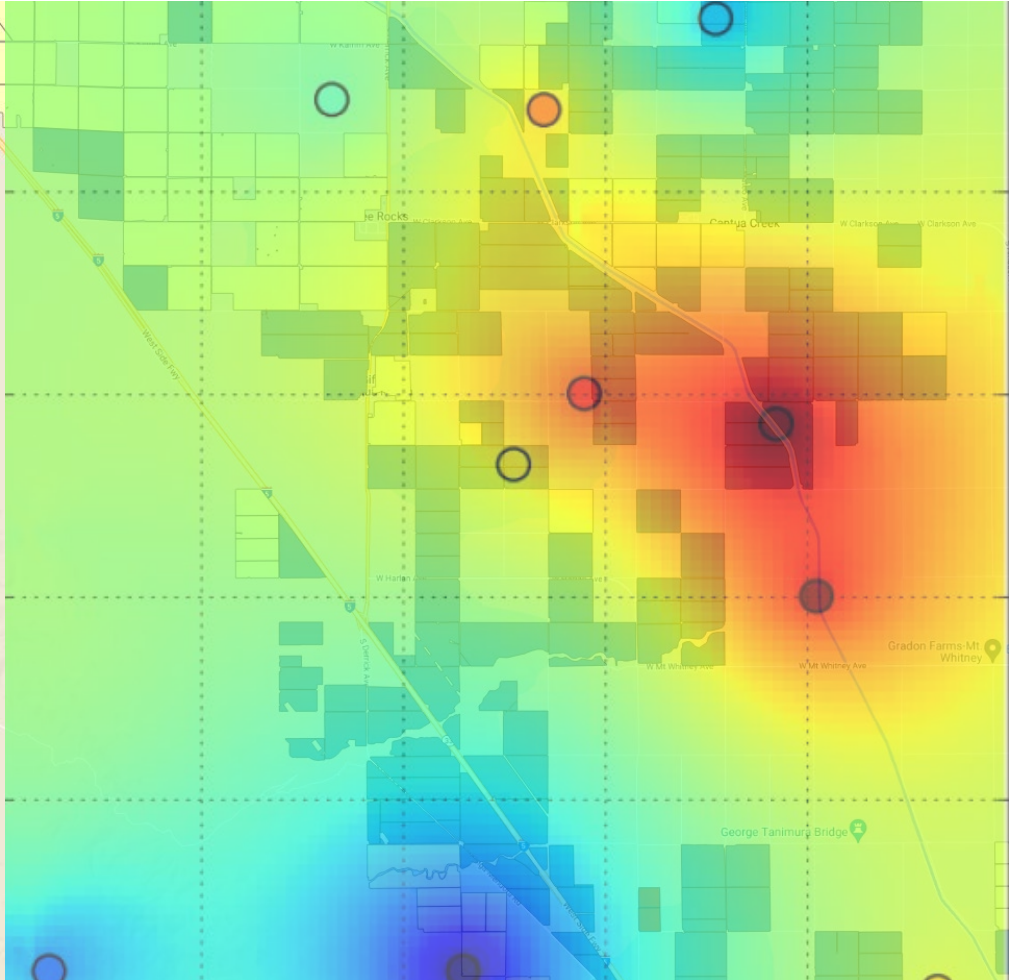
Automated Traps + Regional Monitoring Network



Development of a Decision Support Tool

Improving NOW Model Accuracy

Automated Traps + Regional Monitoring Network



Development of a Decision Support Tool

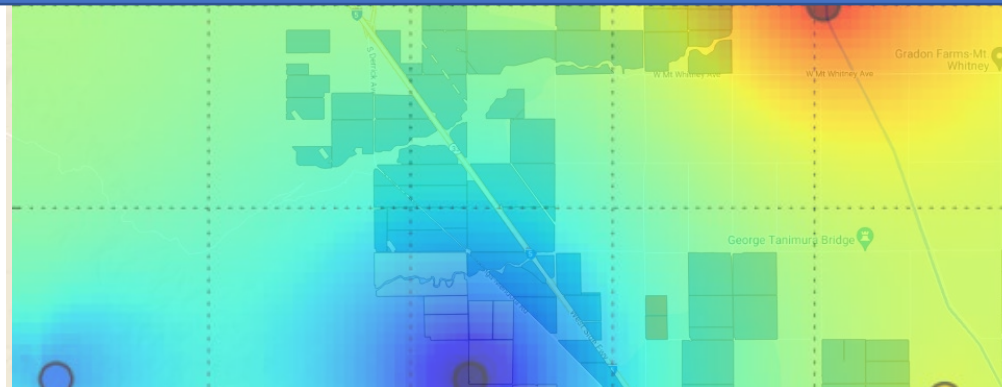
Improving NOW Model Accuracy

Automated Traps + Regional Monitoring Network



Challenges

- Trap density unclear
- Accuracy of interpolation
- Doesn't account for crop vulnerability



Development of a Decision Support Tool

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Development of a Decision Support Tool

Layering in Crop Vulnerability

Various Tree Nut Models to Overlay

Pistachio

Almond

Bloom

Nut Development

Hull Split

Pistachio Bloom Cast

Pistachio Bloom Cast | Model Development

(model in beta testing)

Projected bloom dates are modeled using chill and heat accumulation temperatures downloaded nightly for more than 100 CIMIS CIMIS station for progress towards bloom this year and estimated years.

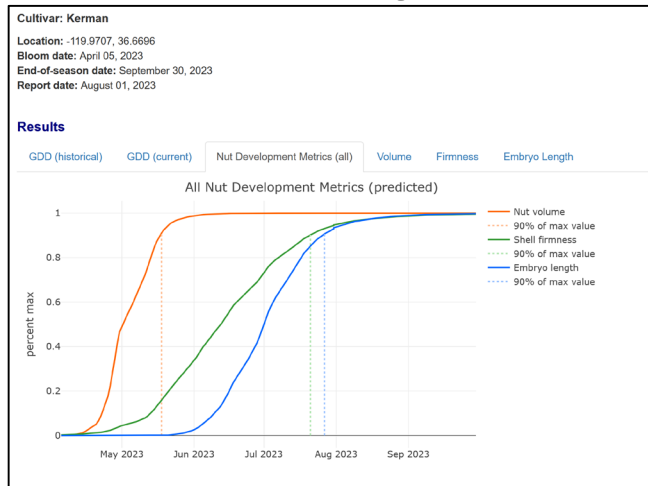
The timing of bloom is a result of both the accumulation of chill and heat. The model assumes pistachios need to accumulate 900 Chill Units and 11,500 Growing Degree Hours.

Chill accumulation count begins November 1st. Each year until the threshold of 900 Chill Units. It then shows the Growing Degree Hours to the threshold of 11,500 GDH. The first day at or above 11,500 GDH.

CIMIS Station: 002 FivePoints/WSFS USDA

View Data

Station	Date	2022	2021	2020	2019	2018	2017
002	11/01/2019 - 7/1/2020						
002	11/01/2019	-9.0	1.0	3.0	0.0	3.0	
002	11/02/2020	-19.0	0.5	5.0	-1.5	6.5	
002	11/03/2021	-25.5	1.5	9.5	-6.0	-2.0	
002	11/04/2022	-31.5	2.5	13.5	-9.0	-10.5	
002	11/05/2023	-31.5	1.5	15.0	-12.5	1.5	
002	11/06/2024	-35.0	5.5	16.0	-11.0	13.0	
002	11/07/2025	-31.5	23.0	18.0	-9.0	18.5	
002	11/08/2026	-27.5	39.0	19.0	-5.0	12.5	
002	11/09/2027	-26.0	49.0	22.0	2.5	-0.5	



UCDAVIS
 FRUIT & NUT
 RESEARCH & INFORMATION

Hull Split Calculator

About Hull Split Prediction | Model Development | GO TO THE MODEL | References

Please Select a Station
 Full Bloom Date: 2/20/23

CIMIS Station: 002 FivePoints/WSFS USDA

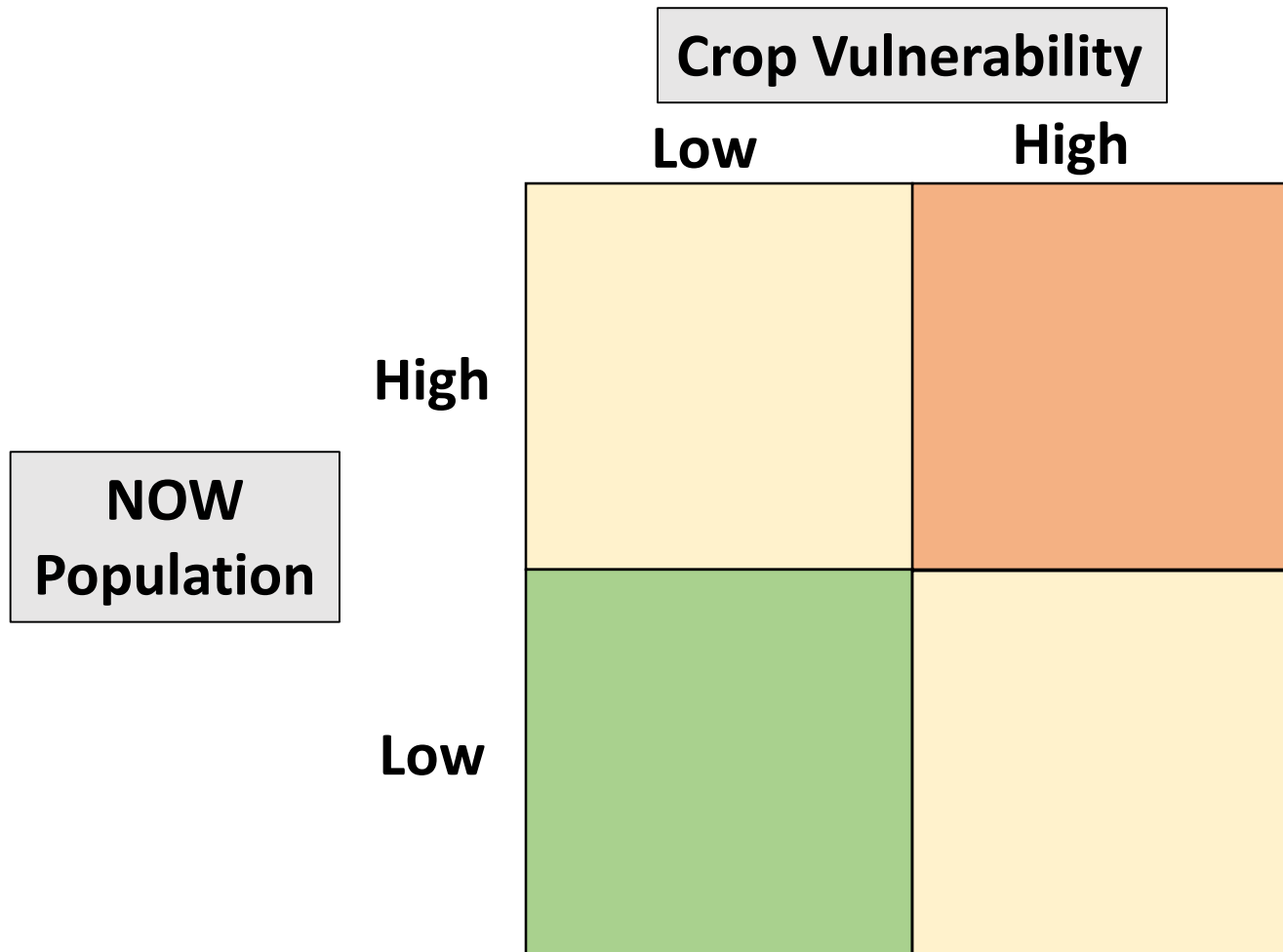
Cultivar: 2023 2022 2021 2020 2019 2018 2017
 NonPareil 07/12/07/04 07/03/07/04 07/03/07/06 07/04
 Sonora 07/27/07/18 07/15/07/17 07/16/07/20 07/17
 Price 07/30/07/21 07/20/07/21 07/21/07/24 07/22
 Wood Colony 08/10/08/02 08/01/08/02 08/01/08/04 08/02
 Winters 08/10/08/01 07/31/08/01 08/01/08/04 08/02
 Almond 08/13/08/03 08/02/08/03 08/02/08/05 08/03
 Almond Hull-Split Prediction 08/13/08/04 08/03/08/04 08/04/08/07 08/05
 Butte 08/16/08/09 08/09/08/09 08/09/08/12 08/10
 Ruby 08/21/08/13 08/12/08/13 08/12/08/15 08/13
 Carmel 08/22/08/15 08/15/08/15 08/15/08/18 08/16
 Monterey 08/23/08/14 08/13/08/14 08/14/08/17 08/15
 Mission 08/25/08/17 08/16/08/17 08/16/08/19 08/17

Pistachio Bloom Cast: You must wait until 90 days after bloom for this calculator to work.

Development of a Decision Support Tool

Layering in Crop Vulnerability

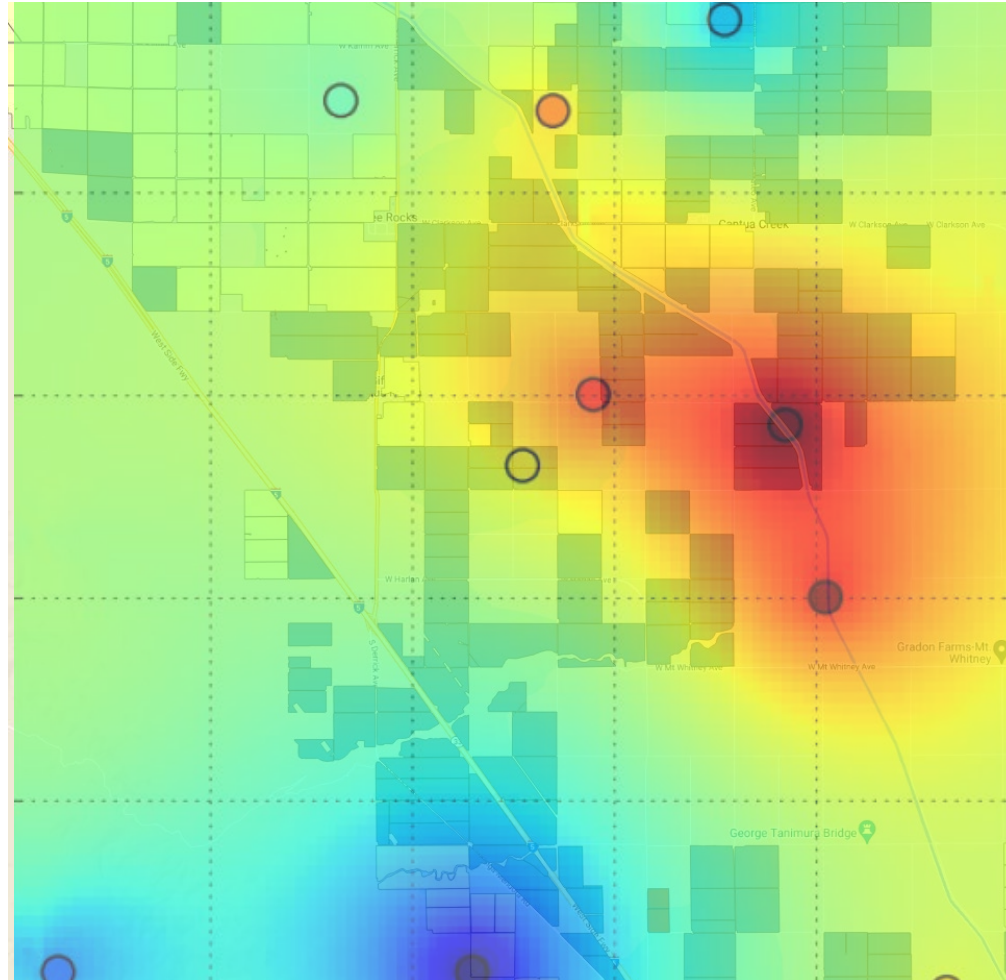
Various Tree Nut Models to Overlay



Development of a Decision Support Tool

Layering in Crop Vulnerability

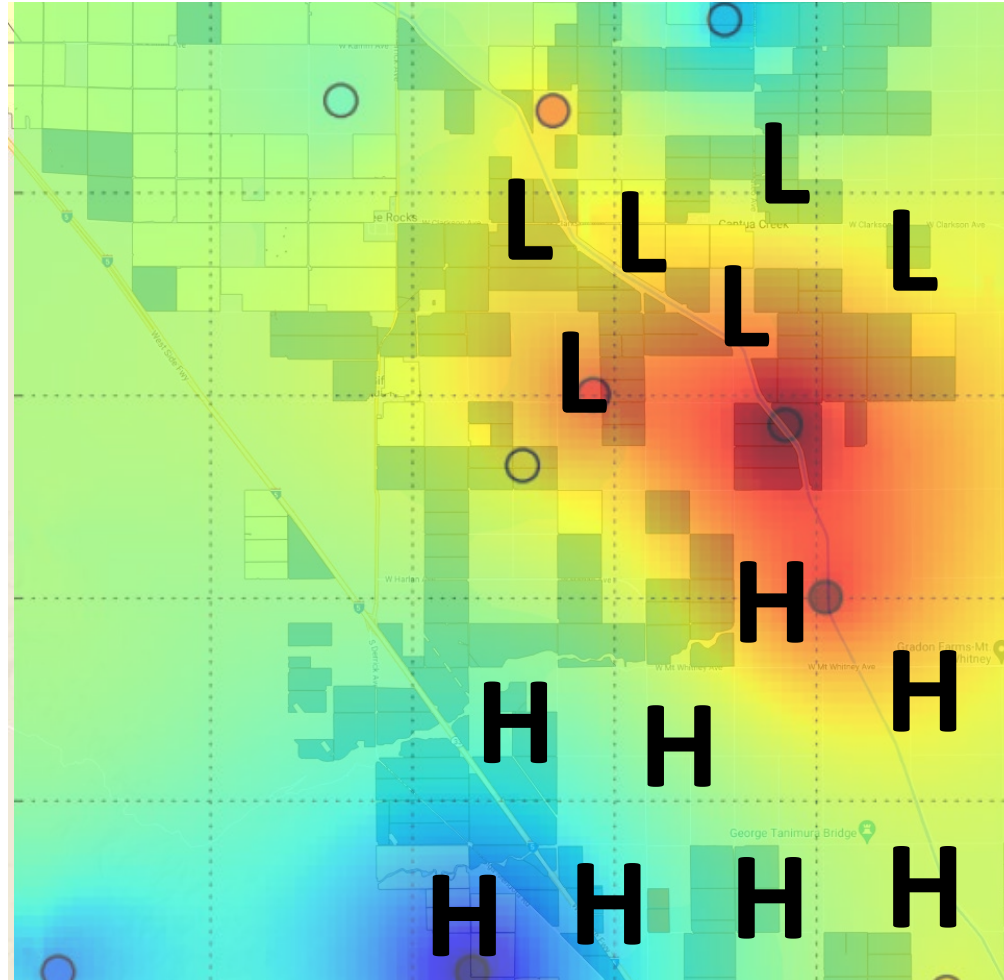
Various Tree Nut Models to Overlay



Development of a Decision Support Tool

Layering in Crop Vulnerability

Various Tree Nut Models to Overlay



Development of a Decision Support Tool

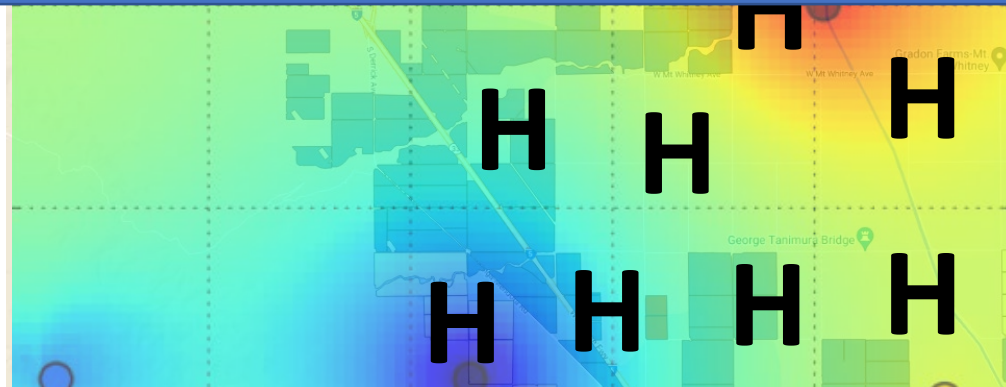
Layering in Crop Vulnerability

Various Tree Nut Models to Overlay



Challenges

- Models need to be tied together
- Not all models are complete
- Some models require sampling



Development of a Decision Support Tool

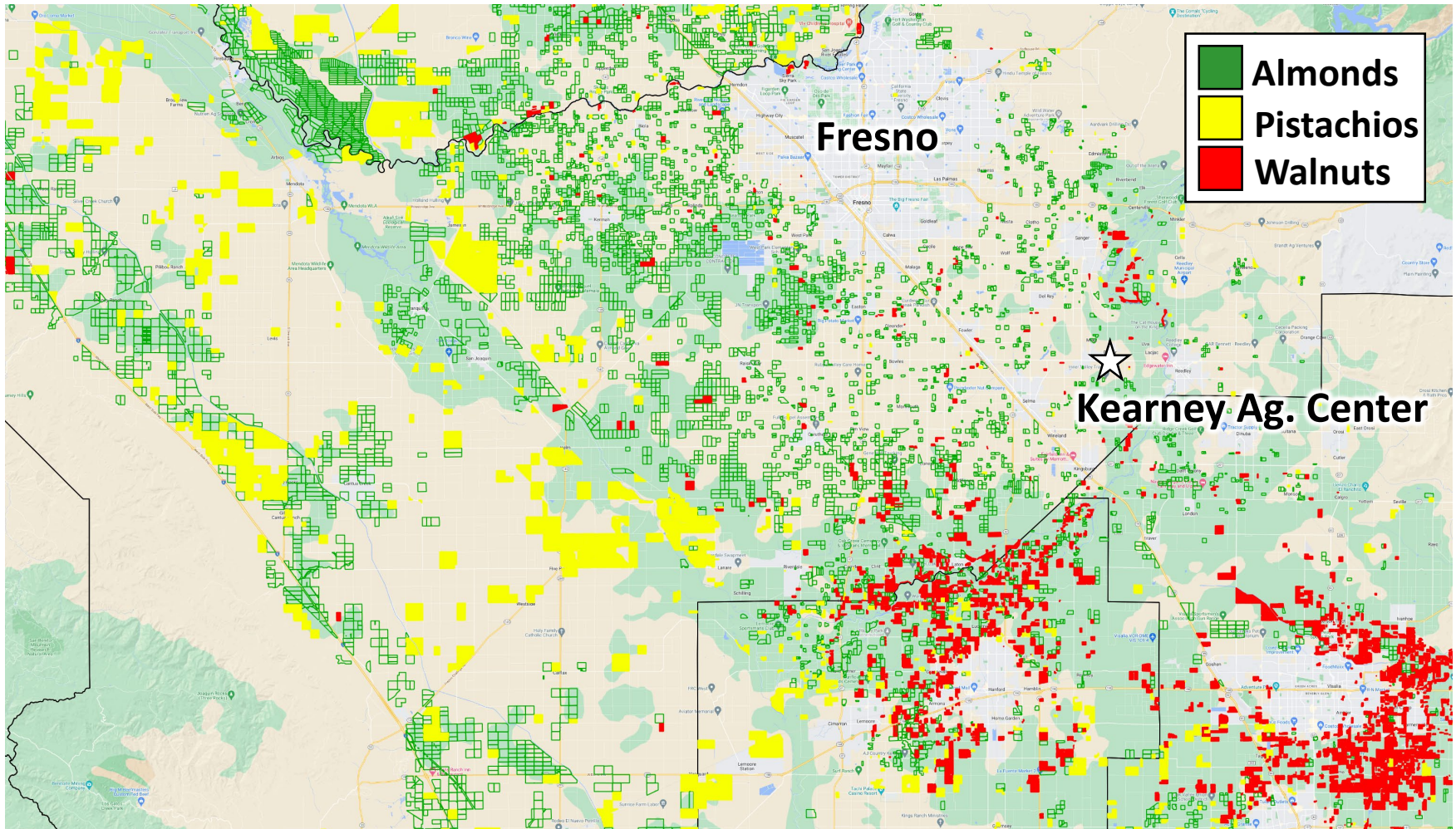
Key Steps

1. Making the NOW Phenology Tool Easier to Use
2. Improving NOW Model Accuracy with...
 - Automated Traps
 - Regional Monitoring Network
3. Layering in Crop Vulnerability with Tree/Nut Models
4. Accounting for Catalysts of NOW Movement

Development of a Decision Support Tool

Accounting for Catalysts of NOW Movement

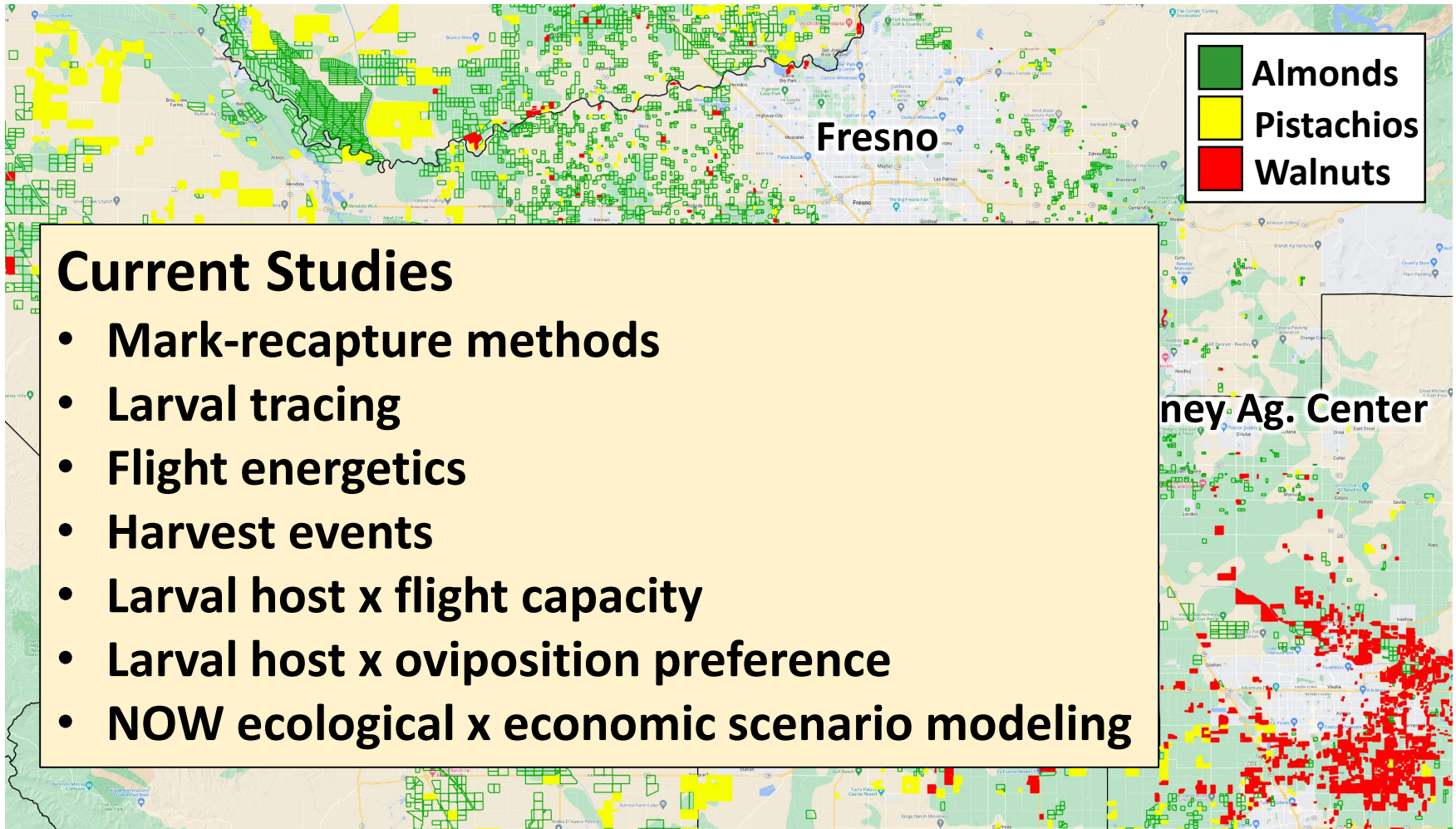
Various Projects Underway...



Development of a Decision Support Tool

Accounting for Catalysts of NOW Movement

Various Projects Underway...



Thank You!

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