2017 THE ALMOND CONFERENCE

RESEARCH UPDATE: SOIL HEALTH, AERIAL ALMOND MAPPING AND ALMOND LIFECYCLE ASSESSMENT

Room 312-313 | December 5 2017

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Almond Board of California

growing ADVANTAGE
The Almond Conference

CEUs – New Process

Certified Crop Advisor (CCA)

- <u>Sign in and out of each session you attend.</u>
- Pickup verification sheet at conclusion of each session.
- *Repeat this process for each session, and each day you with to receive credits.*

Pest Control Advisor (PCA), Qualified Applicator (QA), Private Applicator (PA)

- Pickup scantron at the start of the day at first session you attend; complete form.
- <u>Sign in and out of each session you attend.</u>
- Pickup verification sheet at conclusion of each session.
- Turn in your scantron at the end of the day at the last session you attend.

Sign in sheets and verification sheets are located at the back of each session room.

AGENDA

- **Bob Curtis**, Almond Board of California, moderator
- **Amélie Gaudin**, University of California, Davis
- **Dani Lightle**, UC Cooperative Extension – Glenn County
- **Teamrat Ghezzehei**, UC Merced
- **Brent Holtz**, UCCE San Joaquin County
- **Sat Darshan Khalsa**, University of California, Davis
- **Alissa Kendall**, University of California, Davis
- **Joel Kimmelshue**, Land IQ

Amélie Gaudin

Assistant Professor of Agroecology,

Department of Plant Science UC Davis

DEVELOPING COVER CROP SYSTEMS FOR ALMOND ORCHARDS

C.Creze, J.Mitchell, A.Westphal, D.Doll, D.Lightle, M.Culumber, M.Yaghmour, B.Hanson, N.Williams, A.Hodson

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WINTER COVER CROPS ARE NOT FREQUENTLY PLANTED IN CALIFORNIA ORCHARDS

- Risk of frost
- Increase in water usage
- Issues at harvest
- Additional difficulties in management
  - Weed control
  - Winter sanitation
  - Vertebrate pest management
- Cost and uncertainties of economic return
- Lack of information on cover crop management (species, planting dates, termination…)

Resident vegetation is common
Clean berms, unmanaged middles
Mowed during bloom
Allowed to die or terminated prior to harvest

……DESPITE POTENTIAL BENEFITS

BENEFITS

- Build up of organic matter and healthier soils
    - Decrease compaction
    - Improve aggregation/infiltration
    - Conservation of precip water -iWUE
    - Earlier field access
    - Dust reduction
- Pollinator health
- Management of problematic weeds
- Management of soil born pests

OUR OBJECTIVES AND MAIN RESEARCH QUESTIONS

#1 : develop feasible and practice winter cover crop systems for almond growers which maximize agronomic benefits and reduce operational concerns

What levels of C and N capture and increased in **soil health** may be provided by common cover crop mixtures or natural vegetation during the winter?

Do cover crop **use or help conserve** water in our climate?

How does it impact soil and surface temperature and **frost risk** at blooming?

Can cover crops be used to deter soil born-pests such as **nematodes**?

Do cover crop impact weed pressure and help **control noxious weeds**?

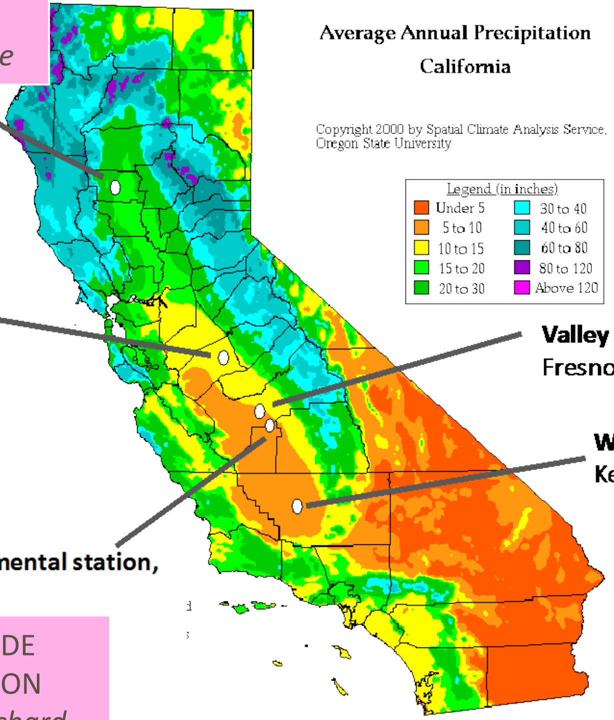
What is the impact on **pollination** of almond orchards?

How to best manage cover crops to maximize benefits?

STUDY SITES ACROSS RAINFALL GRADIENT

Temp/FROST MONITORING
Soil, surface and tree

Glenn Country



Castle Farm
Merced County

TERMINATION DATES
Before bloom or summer

Valley Pride Farming
Fresno County

Wegis & Young
Kern County

COMPACTION
Compare to ripping

Kearney experimental station,
Fresno County

NEMATODE SUPRESSION
Infected orchard

4 treatments, replicated designs

PAM "Pollinator mix"

Bracco White Mustard, Diakon Radish, Nemfix Yellow Mustard, Common Yellow Mustard, Canola

"Soil mix"

Bracco White Mustard, Diakon Radish, Merced ryegrass, Berseem clover, Common vetch

Perennial resident vegetation

Bare soil

Conventional herbicide control

WHERE ARE WE AT?

- 1^{st} field season – 3-year study
- All sites recently planted

<u>Measurements</u>

- Cover crop establishment and biomass (C/N inputs)
- Soil health parameters (including aggregation, compaction, OM, salinity…)
- Soil food web and macro fauna
- Winter water dynamics and storage (neutron probes), tree water status in the spring (SWP)
- Weed pressure and species
- Flower visitation by pollinators
- Yields


Seeding , Corning


Emergence, Merced


Nematode infested orchard

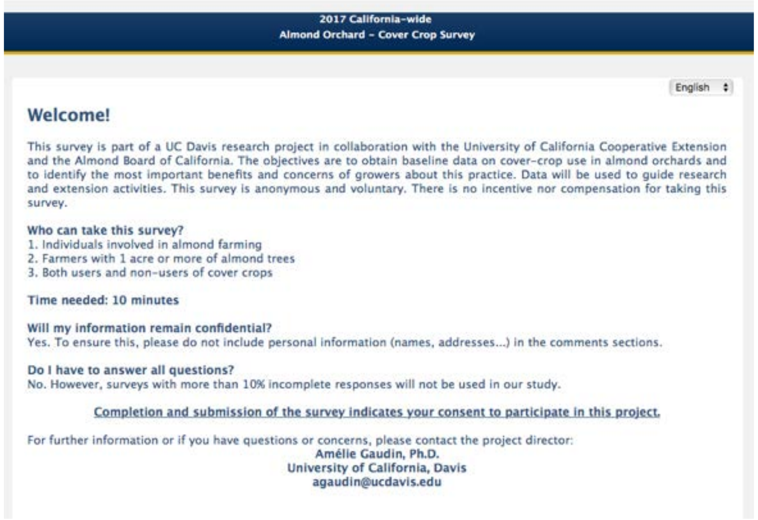

Emergence, Bakersfield


Ripping, Bakersfield

GROWER SURVEY – WE WANT TO HEAR FROM YOU

Online

UCDAVIS
UNIVERSITY OF CALIFORNIA



2017 California-wide
Almond Orchard – Cover Crop Survey

English

Welcome!

This survey is part of a UC Davis research project in collaboration with the University of California Cooperative Extension and the Almond Board of California. The objectives are to obtain baseline data on cover-crop use in almond orchards and to identify the most important benefits and concerns of growers about this practice. Data will be used to guide research and extension activities. This survey is anonymous and voluntary. There is no incentive nor compensation for taking this survey.

Who can take this survey?
1. Individuals involved in almond farming
2. Farmers with 1 acre or more of almond trees
3. Both users and non-users of cover crops

Time needed: 10 minutes

Will my information remain confidential?
Yes. To ensure this, please do not include personal information (names, addresses...) in the comments sections.

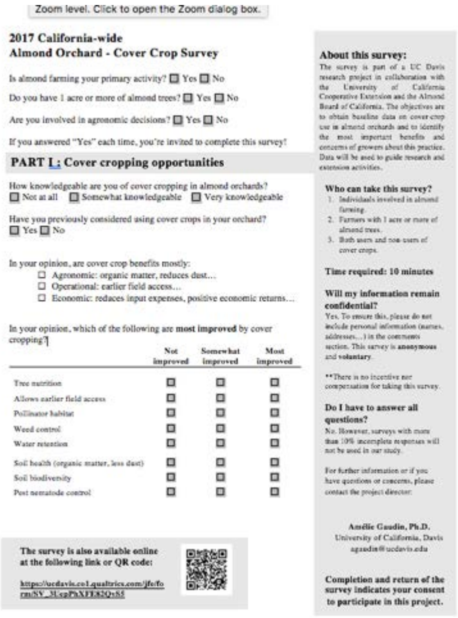
Do I have to answer all questions?
No. However, surveys with more than 10% incomplete responses will not be used in our study.

Completion and submission of the survey indicates your consent to participate in this project.

For further information or if you have questions or concerns, please contact the project director:
Amélie Gaudin, Ph.D.
University of California, Davis
agaudin@ucdavis.edu

https://ucdavis.co1.qualtrics.com/jfe/form/SV_3UepPhXFE82QvS5

Paper – mail / available here



Zoom level. Click to open the Zoom dialog box.

2017 California-wide
Almond Orchard - Cover Crop Survey

Is almond farming your primary activity? ☐ Yes ☐ No

Do you have 1 acre or more of almond trees? ☐ Yes ☐ No

Are you involved in agronomic decisions? ☐ Yes ☐ No

If you answered "Yes" each time, you're invited to complete this survey!

PART I: Cover cropping opportunities

How knowledgeable are you of cover cropping in almond orchards?
☐ Not at all ☐ Somewhat knowledgeable ☐ Very knowledgeable

Have you previously considered using cover crops in your orchard?
☐ Yes ☐ No

In your opinion, are cover crop benefits mostly:
- ☐ Agronomic: organic matter, reduces dust…
- ☐ Operational: earlier field access…
- ☐ Economic: reduces input expenses, positive economic returns…

In your opinion, which of the following are **most improved** by cover cropping?

	Not improved	Somewhat improved	Most improved
Tree nutrition	☐	☐	☐
Allows earlier field access	☐	☐	☐
Pollinator habitat	☐	☐	☐
Weed control	☐	☐	☐
Water retention	☐	☐	☐
Soil health (organic matter, less dust)	☐	☐	☐
Soil biodiversity	☐	☐	☐
Pest nematode control	☐	☐	☐

The survey is also available online at the following link or QR code:

https://ucdavis.co1.qualtrics.com/jfe/form/SV_3UepPhXFE82QvS5

About this survey:
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Amélie Gaudin, Ph.D.
University of California, Davis
agaudin@ucdavis.edu

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Visit us @ our poster location # 58

PROJECTED PROJECT OUTCOMES

Opportunities

Mostly Agronomic

Concerns

Mostly Operational

- Regionalized and updated data relevant to a large number of grower
- Systems approach to help you evaluate benefits and potential tradeoffs in your system/region
- Strong basis to start optimizing cover crop mixes and management according to your objectives

THANK YOU

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WEB: GAUDIN.UCDAVIS.EDU

ORCHARD ALMOND HULL INCORPORATION

Dani Lightle, UCCE Glenn, Butte & Tehama

David Doll, UCCE Merced

Amelie Gaudin, Plant Sciences, UC Davis

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ALMOND INDUSTRY 'BY-PRODUCT': HULL & SHELL

Current value/ton:

- Prime hull: $45-65
- Hull/shell mix: $15-40
- Pure shell: $0-6

Potential future uses:

- Biochar
- CoGen
- Sugar for ethanol production

Supply is increasing while demand is decreasing.

ALMOND INDUSTRY 'BY-PRODUCT': HULL & SHELL

Current value/ ton:

- Prime hull: $45-65
- Hull/shell mix: $15-40
- Pure shell: $0-6

Reapplication of hull & shell to almond orchards

Potential future uses:

- Biochar
  CoGen
  Sugar for ethanol production

POSSIBLE ADVANTAGES FOR ADDING TO ORCHARDS

- Reduced food safety risk relative to manure based composts

- Nutrient analysis

Nutrient	Average hull content (%)	Pounds of nutrient per ton	Estimated value[3]
Nitrogen	0.96	17.4	$8.70
Phosphorous	0.10	2.1[2]	$1.70
Potassium	2.00	43.5[2]	$34.80
Calcium	0.20	3.6	$0.90
		Total per ton	$46.10

OBJECTIVES

This study evaluates tree health and yield to determine if:

1. Almond hulls and shells can be reapplied to orchard floors without impacting production

2. Rates of almond hull and shell application influence tree performance

3. In-season compost applications are as effective as almond hull and shell application.

METHODS

Butte County	Merced County
Almond hull/shell mix (2T/ ac)	Almond hull and shell mix (1T/ ac)
Almond shell (2T / ac)	Almond hull and shell mix (2T/ ac)
Locally sourced compost tea	Almond shell (1T/ ac)
Untreated control	Locally sourced compost (1T/ ac)
	Untreated control

OBJECTIVE 1: DETERMINE IF ALMOND HULL AND SHELL CAN BE RE-APPLIED TO ORCHARD FLOORS WITHOUT INTERFERING WITH PRODUCTION PRACTICES

Merced

March

April

July

OBJECTIVES 2 & 3: DOES APPLICATION AFFECT TREE PERFORMANCE; AND HOW DO APPLICATIONS COMPARE TO COMPOST?

- Leaf samples collected in July
- Soil samples also collected & are being analyzed

OBJECTIVES 2 & 3: DOES APPLICATION AFFECT TREE PERFORMANCE; AND HOW DO APPLICATIONS COMPARE TO COMPOST?

- Leaf samples collected in July
- Soil samples also collected & are being analyzed
- No differences in nutrient status between treatments
- May need multiple seasons to see effects on soil &/or leaf tissue analysis
- If interested in specific leaf analysis values, see our poster

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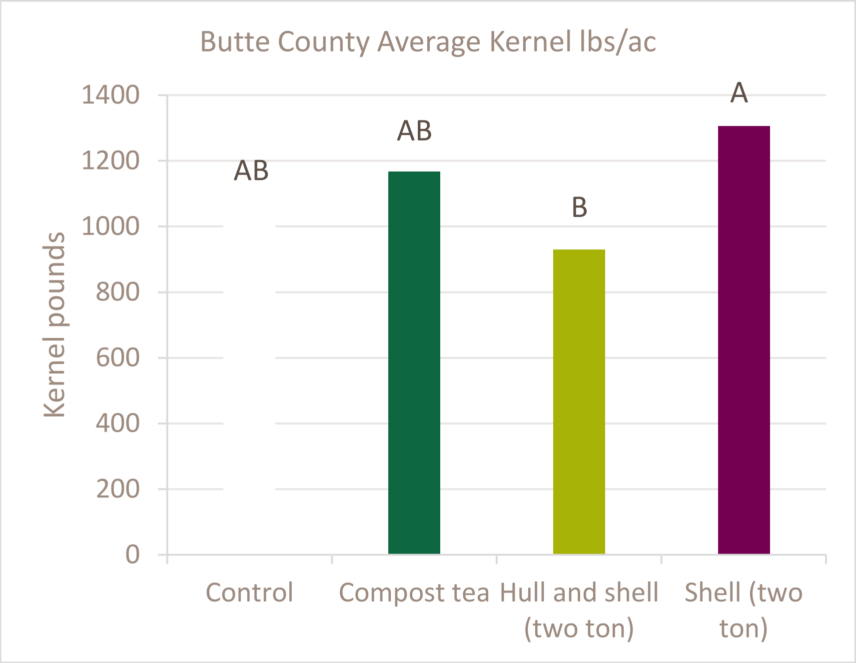
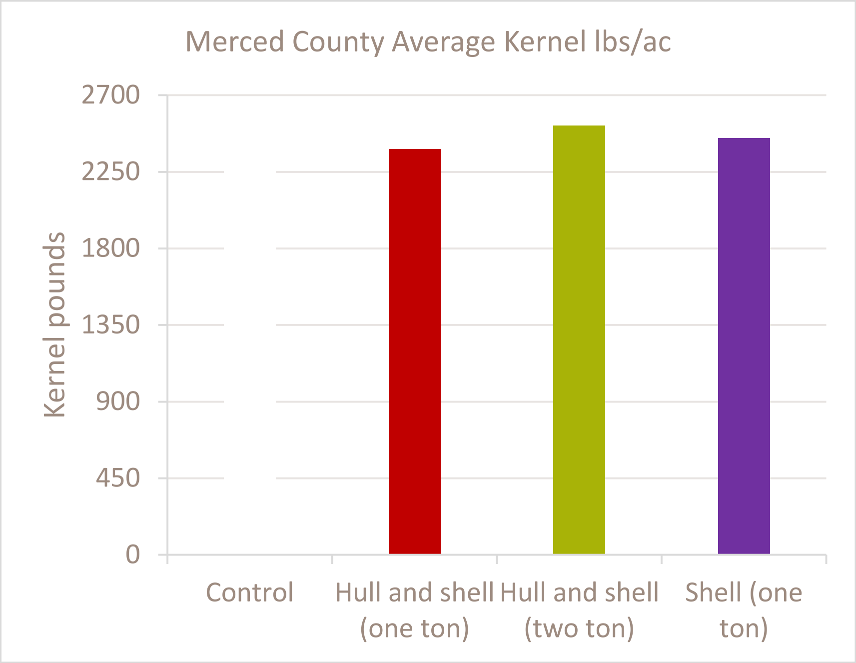
OBJECTIVES 2 & 3: DOES APPLICATION AFFECT TREE PERFORMANCE; AND HOW DO APPLICATIONS COMPARE TO COMPOST?





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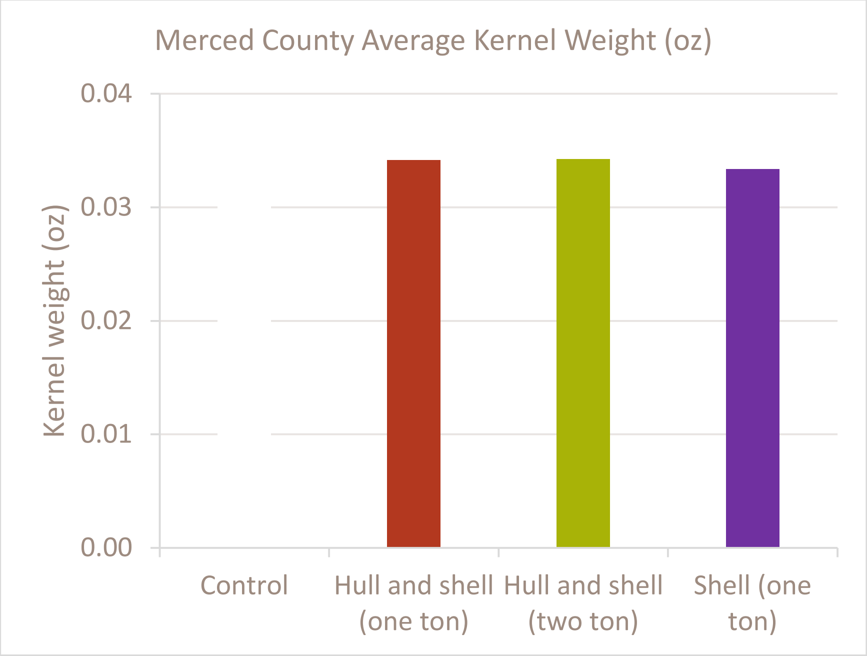
OBJECTIVES 2 & 3: DOES APPLICATION AFFECT TREE PERFORMANCE; AND HOW DO APPLICATIONS COMPARE TO COMPOST?



- Average kernel weight did not differ between treatments at other sites
- Treatments were applied after bloom & nut set
- Therefore differences in yield may have been to other factors (e.g. bacterial blast or brown rot incidence)

ACKNOWLEDGEMENTS

- Cooperating growers: Rory Crowley with Nicolaus Nut Company, Burroughs Family Farms, and Hilltop Ranch Inc.

- Cooperating personnel: Anthony Cantu, Giovanni Marquez, Cindy Montes, & Allen Vizcarra

- Funding: Almond Board of California

University of California
Agriculture and Natural Resources

Teamrat Khalsa

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WHOLE ORCHARD RECYCLING

Holtz, B.[*1*], Browne, G.[2], Doll, D.[3], Westphal, A.[8], Gaudin, A.[4], Culumber, M.[5], Yaghmour, M.[6], Marvinney, E.[4], Gordon, P.[7], Niederholzer, F.[9], and Jahanzad, E.[4]

University of California Cooperative Extension, San Joaquin[1], Merced[3], Fresno[5], Kern[6], Madera[7], and Colusa-Sutter-Yuba Counties[9], USA

[2]USDA-ARS, University of California, Davis, USA

[4]Plant Science, University of California, Davis, USA

[8] Nematology, University of California, Riverside, USA

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Can whole orchards be incorporated into the soil when they are removed and not burned in the field or in a co-generation plant?

Can we return this organic matter to our orchard soils without negatively effecting the next orchard that will be planted?

The Iron Wolf

http://ucanr.edu/?blogpost=16603&
blogasset=74534

The Iron Wolf
a 100,000 lb (45,000 kg)
rototiller


The Iron Wolf

Two Treatments:
Orchard Grinding with Iron Wolf
Pushing and Burning Trees

2009 First leaf trees growing in grinding plot

2010 Second leaf trees

No difference in tree circumference

The Grinding did not stunt the second generation orchard

Soil Analysis

	2010		2011		2012	
	Grind	Burn	Grind	Burn	Grind	Burn
Ca (meq/L)	4.06 a	4.40 b	2.93 a	3.82 b	4.27 a	3.17 b
Na (ppm)	19.43 a	28.14 b	13.00 a	11.33 b	11.67 a	12.67 a
Mn (ppm)	11.83 a	8.86 b	12.78 a	9.19 b	29.82 a	15.82 b
Fe (ppm)	32.47 a	26.59 b	27.78 a	22.82 b	62.48 a	36.17 b
Mg (ppm)	0.76 a	1.52 b	1.34 a	1.66 a	2.05 a	1.46 b
B (mg/L)	0.08 a	0.07 a	0.08 a	0.08 a	0.08 a	0.05 b
NO_3-N (ppm)	3.90 a	14.34 b	8.99 a	11.60 a	19.97 a	10.80 b
NH_4-N (ppm)	1.03 a	1.06 a	2.68 a	2.28 a	1.09 a	1.06 a
pH	7.41	7.36	6.96 a	7.15 b	6.78 a	7.12 b
EC (dS/m)	0.33 a	0.64 b	0.53	0.64	0.82 a	0.59 b
CEC(meq/100g)	7.40 a	8.47 b	8.04	7.88	5.34	5.32
OM %	1.22 a	1.38 b	1.24	1.20	1.50 a	1.18 b
C (total) %	0.73 a	0.81 a	0.79 a	0.73 a	0.81 a	0.63 b
C-Org-LOI	0.71 a	0.80 b	0.72	0.70	0.87 a	0.68 b
Cu (ppm)	6.94 a	6.99 a	7.94 a	7.54 a	8.87 a	7.92 b

Blue Pair = grinding significantly less than burning

Yellow pair = grinding significantly greater than burning

Soil Analysis

	2013		2014		2015	
	Grind	Burn	Grind	Burn	Grind	Burn
Ca (meq/L)	3.78 a	3.25 b	7.55 a	5.45 b	4.02 a	1.36 b
Na (ppm)	2.74 a	1.90 b	3.41 a	2.34 b	2.32 a	1.21 b
Mn (ppm)	26.35 a	5.71 b	14.46 a	10.65 b	7.31 a	4.67 b
Fe (ppm)	32.56 a	20.38 b	38.58 a	29.30 b	24.29 a	17.21 b
Mg (ppm)	2.15 a	1.20 b	3.61 a	2.57 b	2.01 a	0.68 b
B (mg/L)	0.06	0.07	0.07 a	0.10 b	0.05 a	0.07 b
NO_3-N (ppm)	20.11	12.27	26.53 a	18.89 b	20.64 a	5.23 b
NH_4-N (ppm)	0.37	0.33	1.59 a	1.36 b	0.89 a	0.65 b
K (mg/L)	94.50	84.88	28.50 a	13.60 b	19.76 a	16.97 b
pH	7.39 a	7.53 b	6.95	7.06	7.27 a	7.60 b
EC (dS/m)	0.91 a	0.68 b	1.54 a	1.08 b	0.90 a	0.38 b
CEC(meq/100g)	9.54	10.16	7.78	8.30	5.16	5.14
OM %	1.55 a	1.06 b	1.21 a	0.93 b	1.37 a	1.08 b
C (total) %	0.87 a	0.51 b	0.71 a	0.54 b	0.66 a	0.50 b
C-Org-LOI	0.87 a	0.61 b	0.70 a	0.54 b	0.79 a	0.62 b
Cu (ppm)	8.26 a	7.11 b	8.03	7.73	7.51 a	7.03 b

Blue Pair = grinding significantly less than burning

Yellow pair = grinding significantly greater than burning

Soil Analysis

	2016		2017		2018	
	Grind	Burn	Grind	Burn	Grind	Burn
Ca (meq/L)	5.53 a	2.66 b	3.02	3.05		
Na (ppm)	1.50 a	1.20 b	0.89 a	0.72 b		
Mn (ppm)	10.86 a	7.66 b	9.03 a	6.79 b		
Fe (ppm)	30.25 a	23.15 b	33.23 a	28.01 b		
Mg (ppm)	2.60 a	1.29 b	1.46	1.43		
B (mg/L)	<0.05	<0.05	0.30	0.31		
NO_3-N (ppm)	13.87 a	10.50 b	11.93	12.66		
NH_4-N (ppm)	1.15 a	0.98 b	1.39	1.31		
K (mg/L)	54.78 a	11.33 b	11.06	11.68		
pH	7.20 a	7.37 b	6.94	7.02		
EC (dS/m)	1.21 a	0.56 b	0.57	0.58		
CEC(meq/100g)	8.35	9.25	8.23	7.78		
OM %	1.41 a	1.10 b	1.52 a	1.07 b		
C (total) %	0.82 a	0.55 b	0.79 a	0.55 b		
C-Org-LOI	0.82 a	0.64 b	0.88 a	0.62 b		
Cu (ppm)	8.43	8.20	9.25	9.25		

Blue Pair = grinding significantly less than burning

Yellow pair = grinding significantly greater than burning

Trunk Diameter

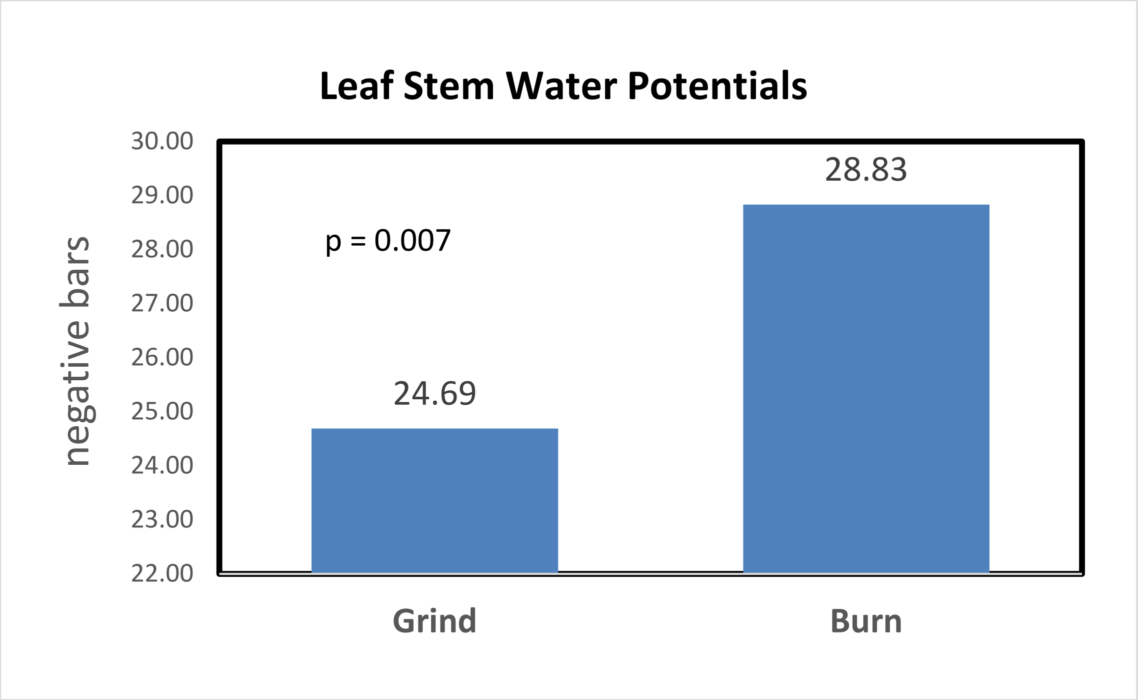
Butte Variety (cm)			
Year	**Grind**	**Burn**	**P value**
2009	4.87	4.96	P= 0.19
2010	14.56	15.22	P=0.07
2011	22.39	22.72	P=0.38
2012	30.53	30.23	P=0.18
2013	38.52	37.73	P=0.09
2014	46.50 a	45.24 b	P=0.01
2015	55.71 a	53.79 b	P=0.01
2016	63.15 a	60.58 b	P=0.007
2017			

Butte Variety, Kernel pounds/acre

Year	Grind	Burn	Difference
2011	687.40 lbs/ac	687.37 lbs/ac	0.03 lbs/ac (P= 0.49)
2012	1,472.40 lbs/ac	1,379.42 lbs/ac	92.98 lbs/ac (P=0.19)
2013	1909.64 lbs/ac	1667.91 lbs/ac	241.73 lbs/ac (P=0.05)
2014	2272.11 lbs/ac	1767.25 lbs/ac	504.86 lbs/ac (P=0.12)
2015	1,072.90 lbs/ac	877.54 lbs/ac	195.36 lbs/ac (P=0.11)
2016	1,341.97 lbs/ac	1,206.96 lbs/ac	135.01 lbs/ac (P=0.14)
2017	1956.01 lbs/ac	1539.17 lbs/ac	416.84 lbs/ac (P=0.07)
Total	**10,712.43 lbs/ac**	**9,125.62 lbs/ac**	**1,586.81 lbs/ac**

Nonpareil Variety, Kernel pounds/acre

Year	Grind	Burn	Difference
2014	2,147.02 lbs/ac	1,957.97 lbs/ac	189.05 lbs/ac (P=0.02)
2016	2,821.86 lbs/ac	2,386.02 lbs/ac	435.84 lbs/ac (P=0.03)
2017	2,246.66 lbs/ac	1,871.86 lbs/ac	374.80 lbs/ac (P=0.01)
Total	**10,712.43 lbs/ac**	**9,125.62 lbs/ac**	**999.69 lbs/ac**



The trial went 57 days without an irrigation during harvest

Trees growing in the grind plots had less water stress

POTENTIAL OF WHOLE ORCHARD RECYCLING TO INCREASE RESILIENCY OF ALMOND PRODUCTION TO WATER SHORTAGES

Gaudin,A.[4], Jahanzad,E.[4], Doll, D.[3], Peterson, C.[4], Holtz, B.[1], Browne, G.[2], and Culumber, M.[5]

University of California Cooperative Extension, San Joaquin[1], Merced[3], Fresno[5], Counties, USA

[2]USDA-ARS, University of California, Davis, USA

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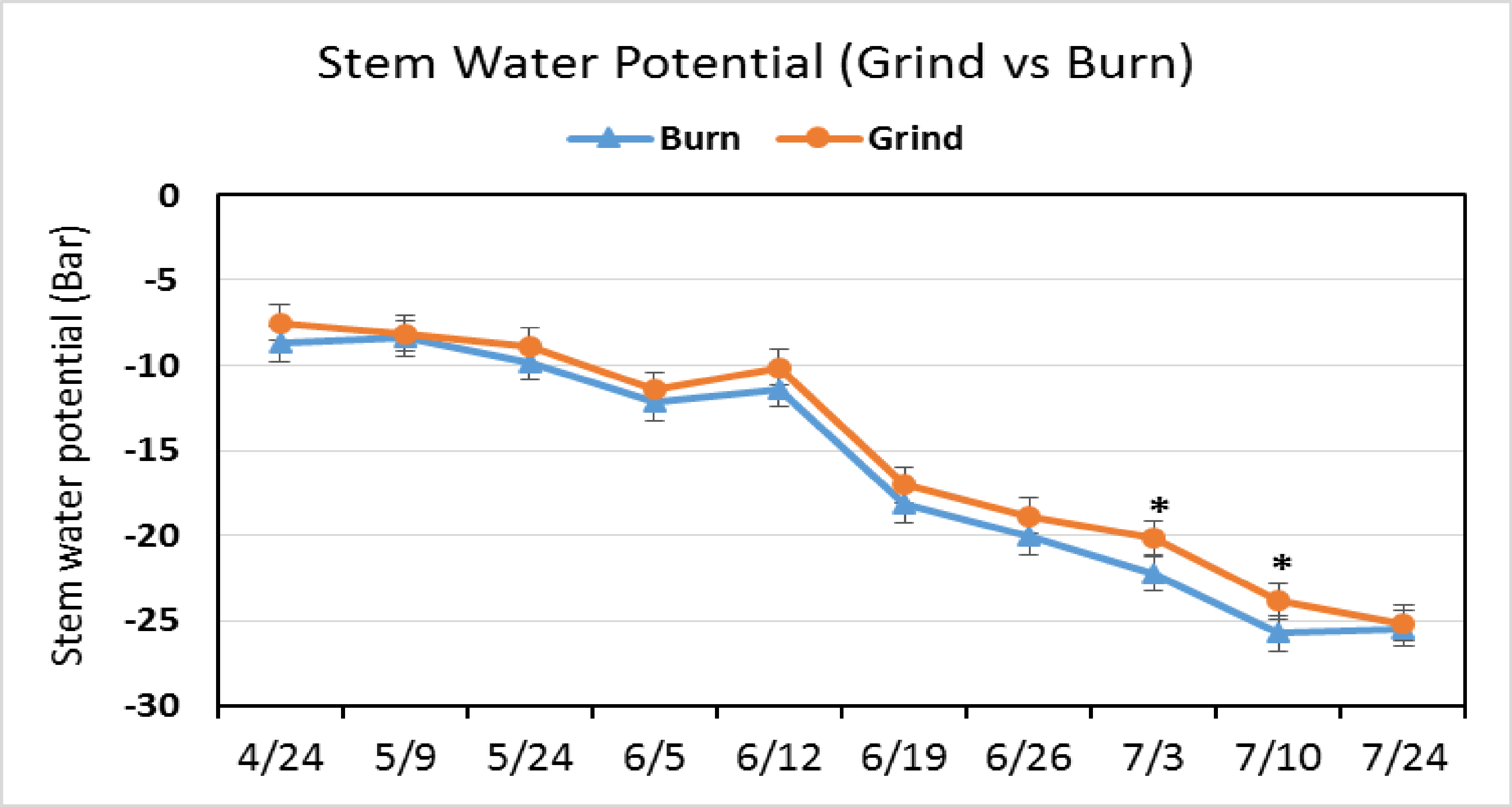
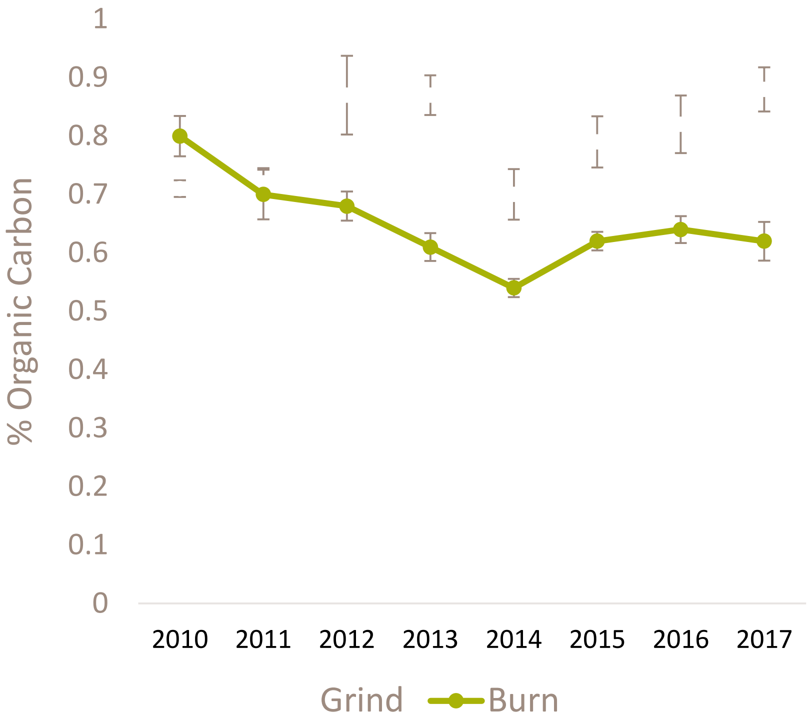
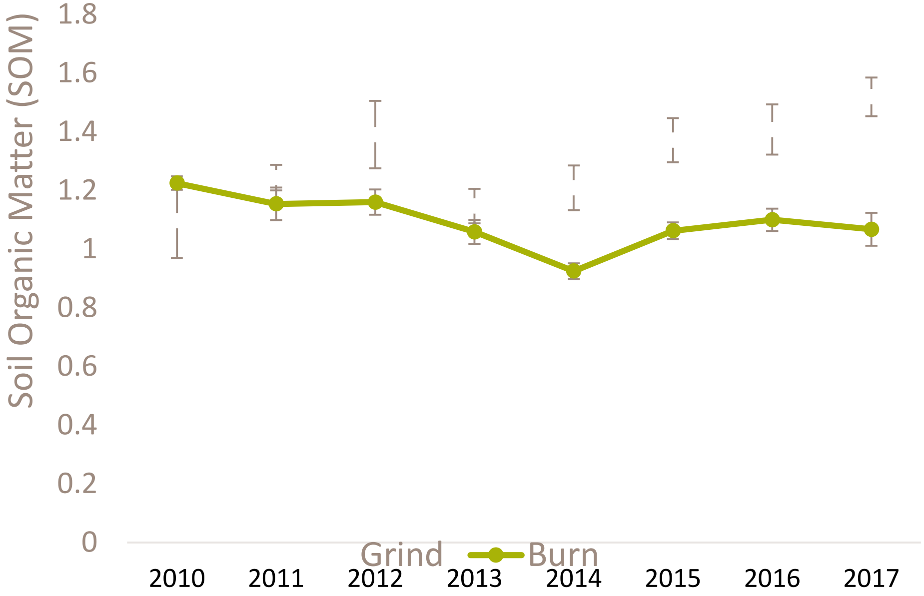

Stem Water Potential (Grind vs Burn)
Burn
Grind
Stem water potential (Bar)
0
-5
-10
-15
-20
-25
-30
*
*
4/24
5/9
5/24
6/5
6/12
6/19
6/26
7/3
7/10
7/24



1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
% Organic Carbon
2010
2011
2012
2013
2014
2015
2016
2017
Grind
Burn



1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Soil Organic Matter (SOM)
2010
2011
2012
2013
2014
2015
2016
2017
Grind
Burn

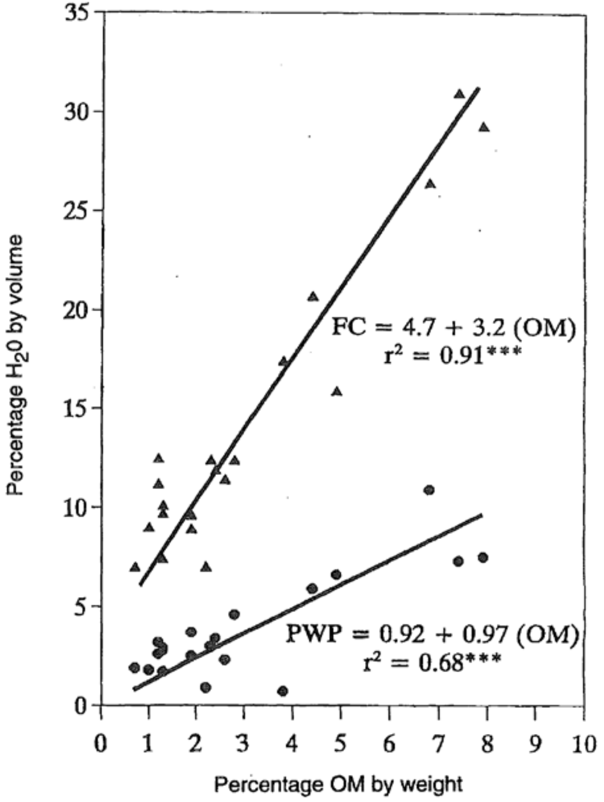


Figure 1. Water content at FC and PWP versus OM content of sand surface horizons.

Soil Organic Matter and Available Water Capacity
by
Berman D. Hudson
J. Soil and Water Cons. 49(2):189-194.

We estimate that Whole Orchard recycling has increased the water holding capacity of our soil by 15% based on this curve and that SOM has increased from in 1.07 (burn) to 1.52 (grind) (2017 results).

WHOLE ORCHARD RECYCLING HAS:

- Increased soil organic matter
- Increased soil organic carbon
- Increased soil nutrients
- Increase soil microbial diversity
- Increased orchard productivity

WILL WHOLE ORCHARD RECYCLING:

- Increase water holding capacity?
- Bind pesticides and fertilizers?
- Increase Nitrogen efficiency?
- Increase/decrease Green House Gas production?
- Provide carbon credits to farmers?

AgAlert®

THE WEEKLY NEWSPAPER FOR CALIFORNIA AGRICULTURE

Closure of more biomass plants reduces options

By Christine Souza

The closure or threatened closure of more California biomass power plants leaves farmers with fewer options for disposing of tree prunings or of trees uprooted during planned orchard removals.

"The last few projects that we've done,

A few growers have used manure spreaders to spread wood chips back on the soil surface

G & F Ag Services orchard removal typically involves 5 machines and costs ~$600 acre

Wood chips are spread uniformly over entire field surface

G & F Ag Services in Ripon has purchased two Kuhn & Knight Spreaders and modified them for spreading wood chips.

Keeping the chips and having them spread back onto your orchard floor will cost and additional $400 acre.

When 64 tons of wood chips are returned to the soil per acre:

N= 0.31 %, 396 lbs/ac
K= 0.20 %, 256 lbs/ac
Ca= 0.60 %, 768 lbs/ac
C= 50 %, 64,000 lbs/ac

The nutrients will be released gradually and naturally

Tallerico Orchards
Manteca

In areas of the orchard where the wood chips where heavily applied there is total weed control.

We are trying to make sure the trees don't stunt—applying nitrogen through water weekly.

This Duratech grinder is mobile and spreads the wood chips evenly as it grinds.

Efficiencies are improved every year that whole orchard recycling is performed.

Thank You!

ORGANIC MATTER AMENDMENTS

Sat Darshan S. Khalsa

University of California Davis

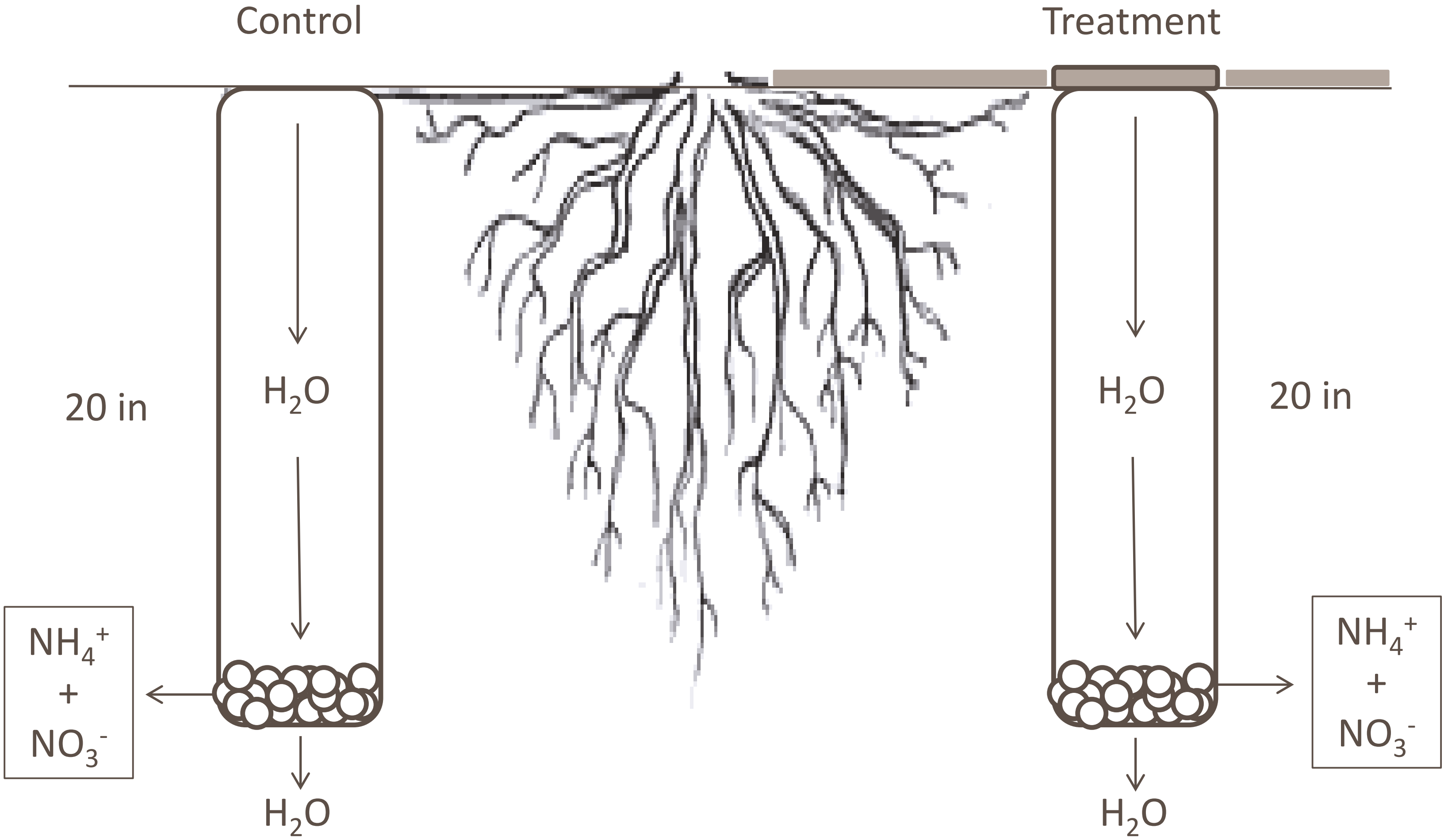
california almonds

Almond Board of California

RESEARCH

- Integrated management
- Composted sources
  - Dairy manure
  - Green waste
- Timing
  - October
  - April
- Rate – 4 tons/ac
- Placement – Tree berm
- Analyses
  - Soil nutrients
  - Nitrogen availability

APPROACH



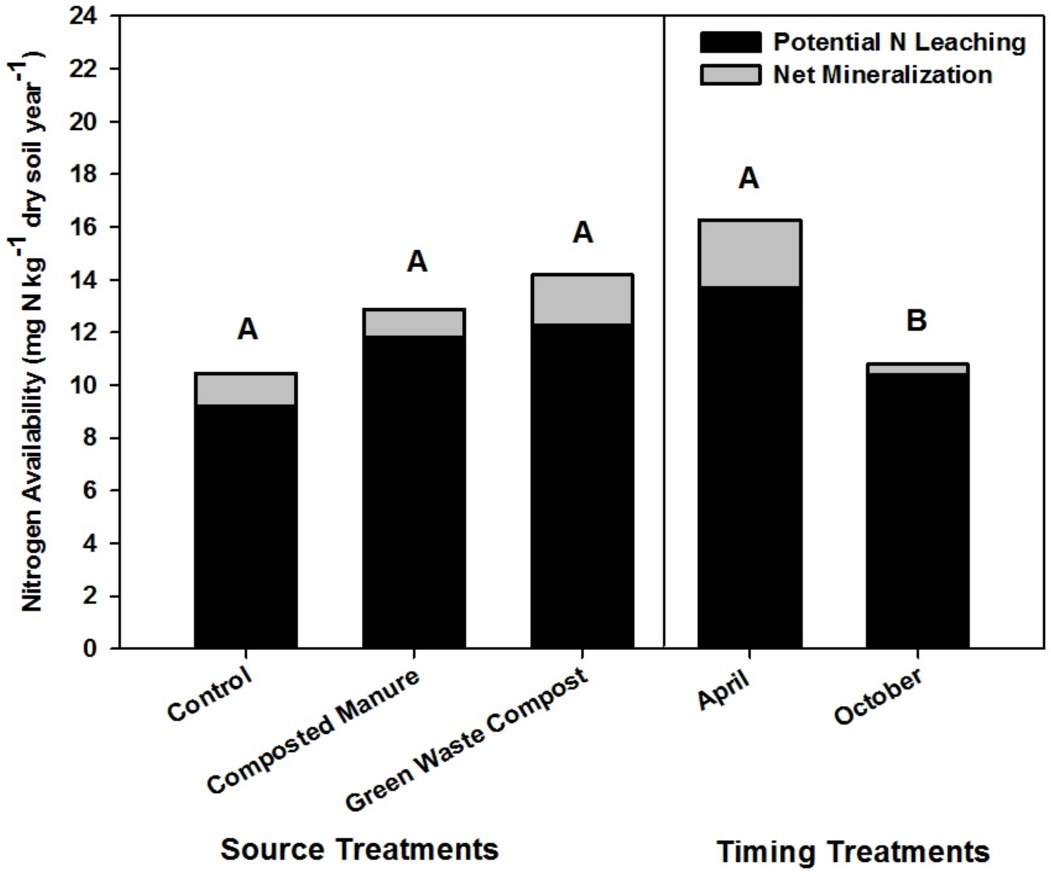
SOIL ORGANIC MATTER

	Total organic carbon	Total nitrogen
	g C kg^{-1} soil	*g N kg^{-1} soil*
Source		
Control	4.72 b	0.49 b
Composted manure	5.12 b	0.53 b
Green waste compost	5.90 a	0.60 a
***p* value**	*0.03*	*0.02*
Timing		
April application	5.12 b	0.54 b
October application	5.90 a	0.59 a
***p* value**	*<0.01*	*0.04*

SOIL NUTRIENTS

	NH_4^+-N	NO_3^--N	PO_4^{3-}-P	K^+
	mg N kg^{-1} soil	*mg N kg^{-1} soil*	*mg P kg^{-1} soil*	*mg K kg^{-1} soil*
Source				
Control	0.66 a	12.3 a	6.86 a	142 b
Composted manure	0.39 a	11.9 a	10.5 a	178 a
Green waste compost	0.66 a	13.8 a	10.0 a	166 b
***p* value**	**0.22**	**0.34**	**0.06**	*0.02*
Timing				
April application	0.56 a	22.0 a	8.07 b	154 b
October application	0.50 a	8.80 b	12.4 a	193 a
***p* value**	**0.66**	*<0.01*	*<0.01*	*<0.01*

NITROGEN AVAILABILITY



CONCLUSIONS

- Gains in soil organic matter including soil N
- Building of soil P and K
- Largest effects in October treatment
- Composted manure viable K source
- Increasing N availability
- Risk of N leaching from April application
- See our poster for effects on **soil moisture and tree stress**

ALMOND LCA MODEL UPDATES: CHANGING BIOMASS CO-PRODUCT FATES

Dr. Elias Marvinney and Prof. Alissa Kendall

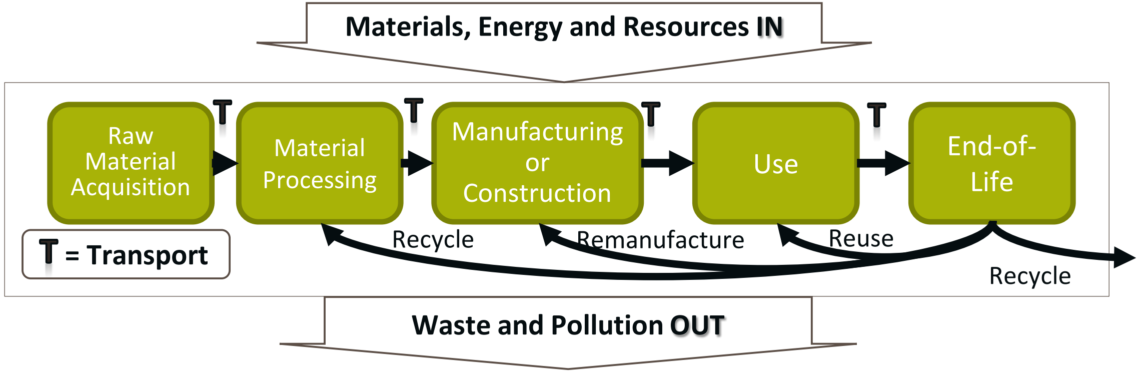
Dept. of Civil & Environmental Engineering, UC Davis

california almonds

Almond Board of California

LIFE CYCLE ASSESSMENT (LCA)

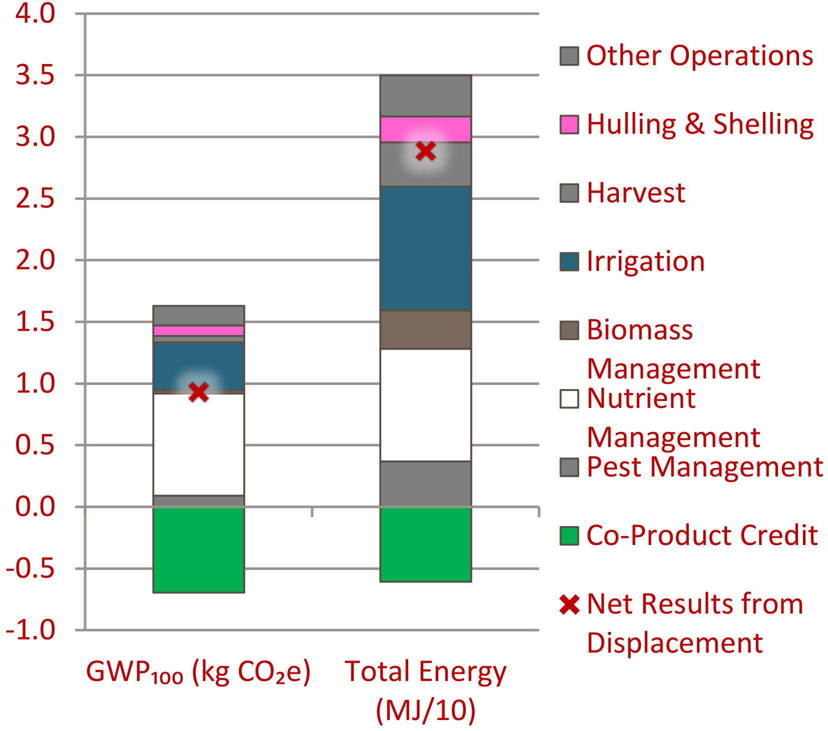
A method for characterizing, quantifying, and interpreting environmental flows for a product or service from a "cradle-to-grave" perspective.



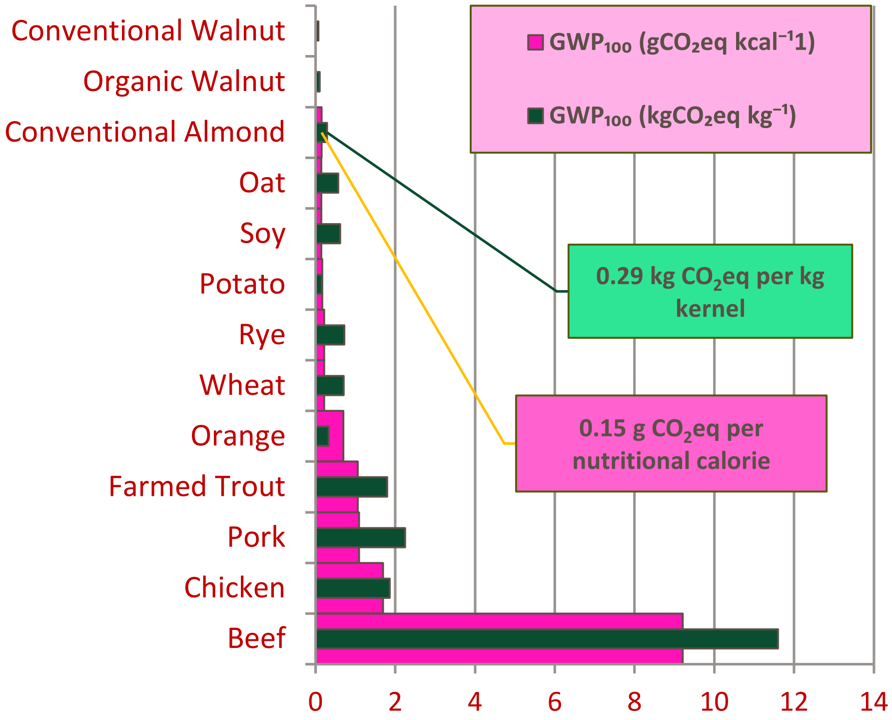
Our previous model focused on energy use, global warming potential, and air pollution. Our future model focuses on an expanded group of environmental impact categories and detailed modeling of direct and indirect water use.

LCA BASELINE AND SCENARIO ANALYSIS RESULTS

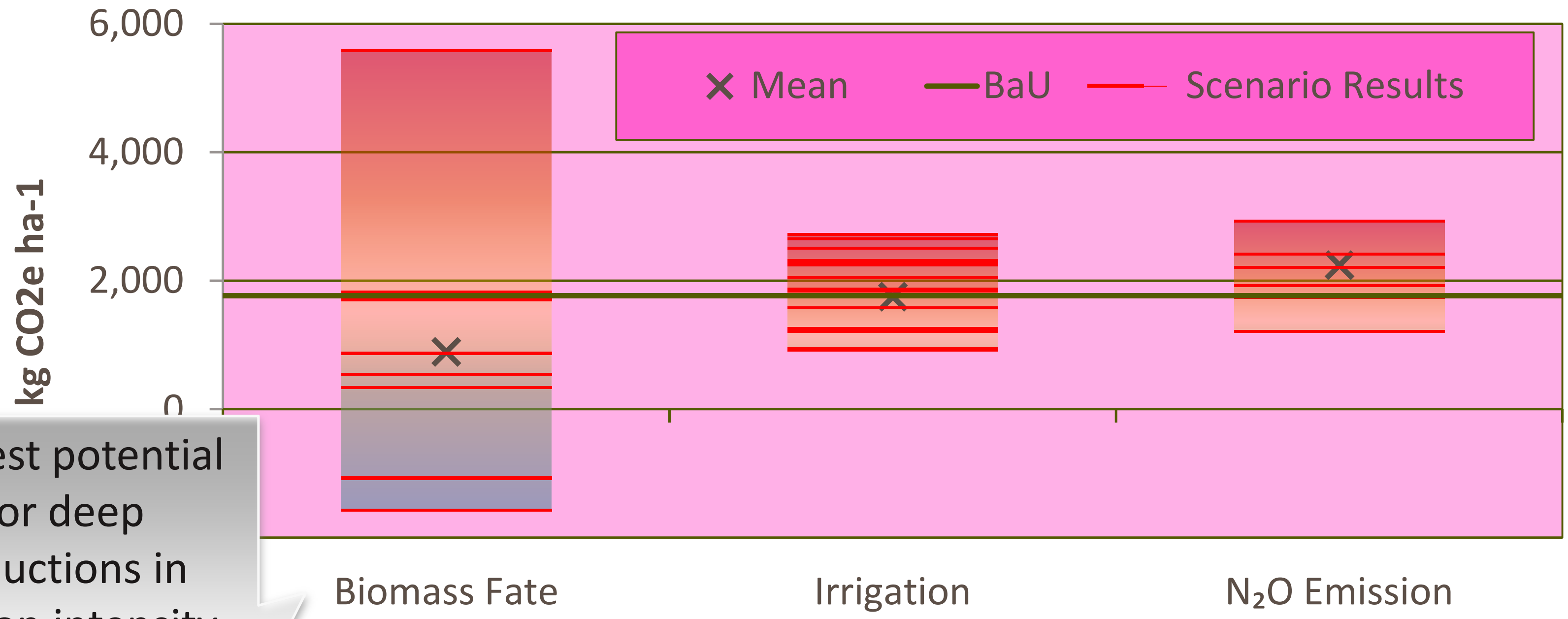
Baseline Results for Brownskin Almond



Comparison to other unprocessed foods



SCENARIO ANALYSIS SHOWS THE BIOMASS FATE IS MOST IMPORTANT FACTOR



Biggest potential for deep reductions in carbon intensity of almonds

BaU = Business-as-Usual

UPDATES FOCUS ON BIOMASS FATE

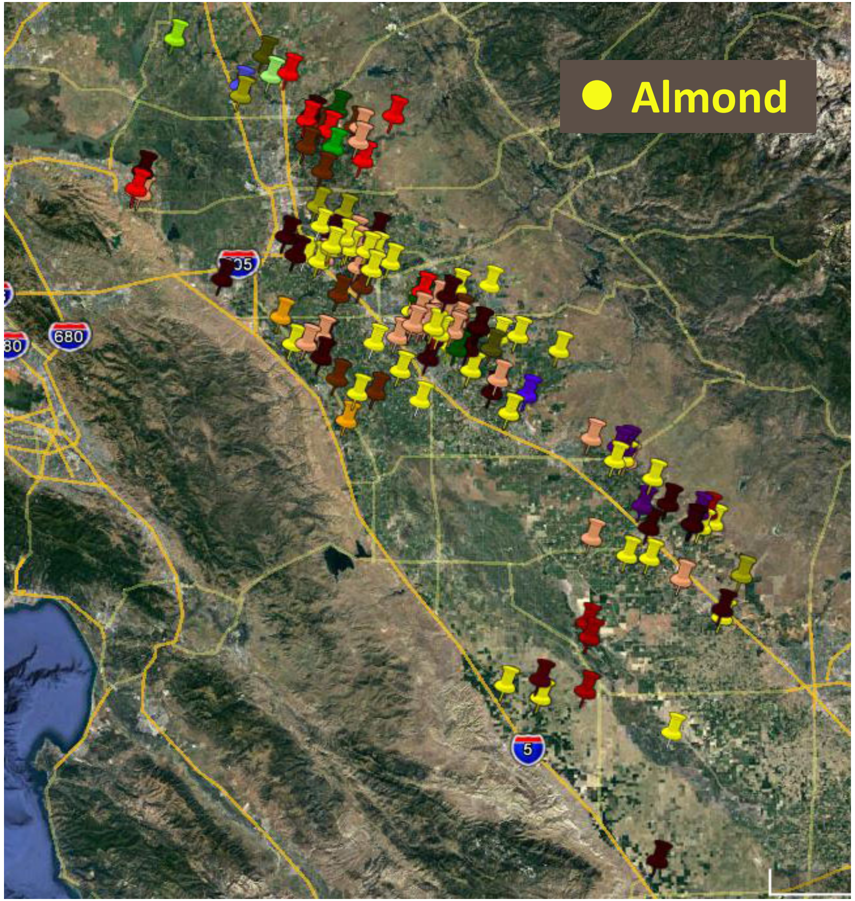
- Biomass utilization is focused on orchard removal biomass, though shells and prunings are also biomass generated by orchards
- Options for biomass fate are changing fast
    - Biomass plant closures happening across the valley, changing the potential for energy recovery from orchard removals
    - New research on the potential for long term carbon storage through whole-orchard recycling could provide deep reductions in almond carbon intensity
- Ongoing research is focusing on these two areas

NEW DATA:
CLEARING RECORDS

Extracted data on orchard biomass feedstock from clearing company records and estimate

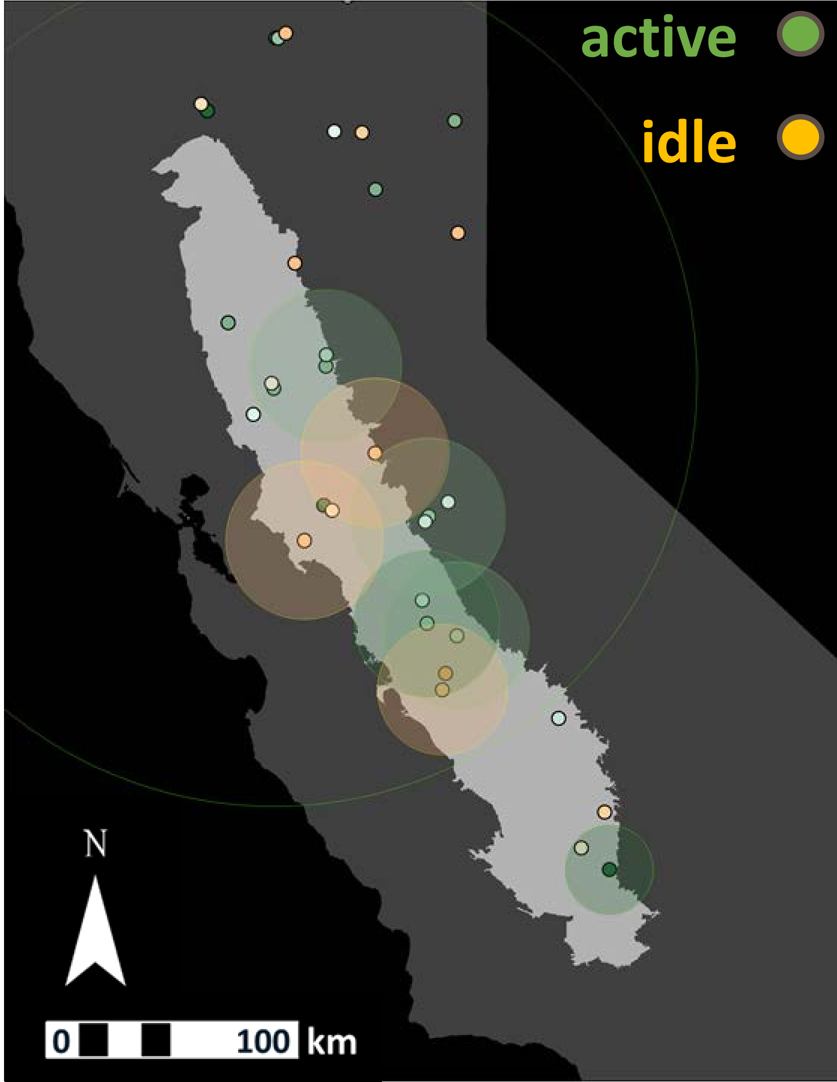
- Transport Cost
- Transport Distance
- Feedstock Value at Power Plant

Refined estimates of almond biomass production using aerial imagery to correct acreage estimates (BDT per acre)



BIOMASS POWER PLANT ECONOMIC “BREAKEVEN” RADIUS

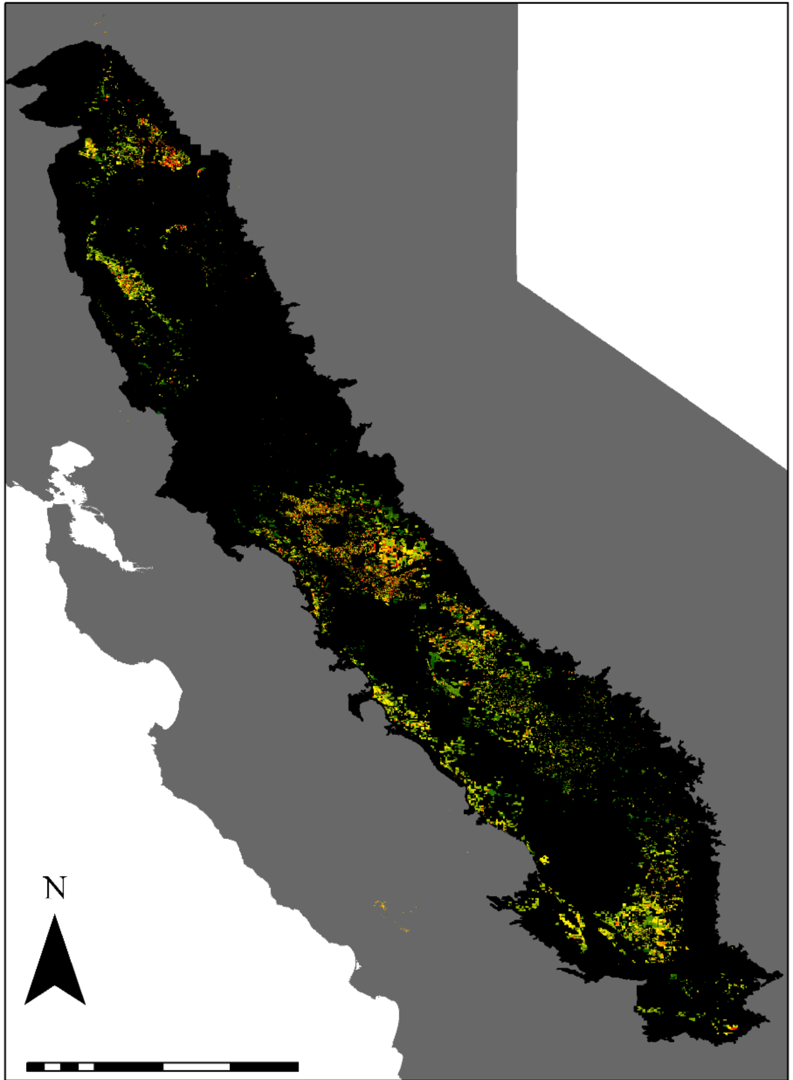
- Calculated using the following data:
  - EOL biomass transport cost
  - power plant payment for feedstock
  - Distance from orchard clearing site
- Determines which power plants can feasibly accept biomass co-product from almond orchards



UPDATE TO EXTENT AND AGE OF ALMOND ORCHARDS IN CALIFORNIA

- Allows LCA model to consider each orchard block as an individual entity to account for variation in age-specific factors

- For example, likelihood of orchard removal in any given year, which can be used to model future biomass supply to power plants

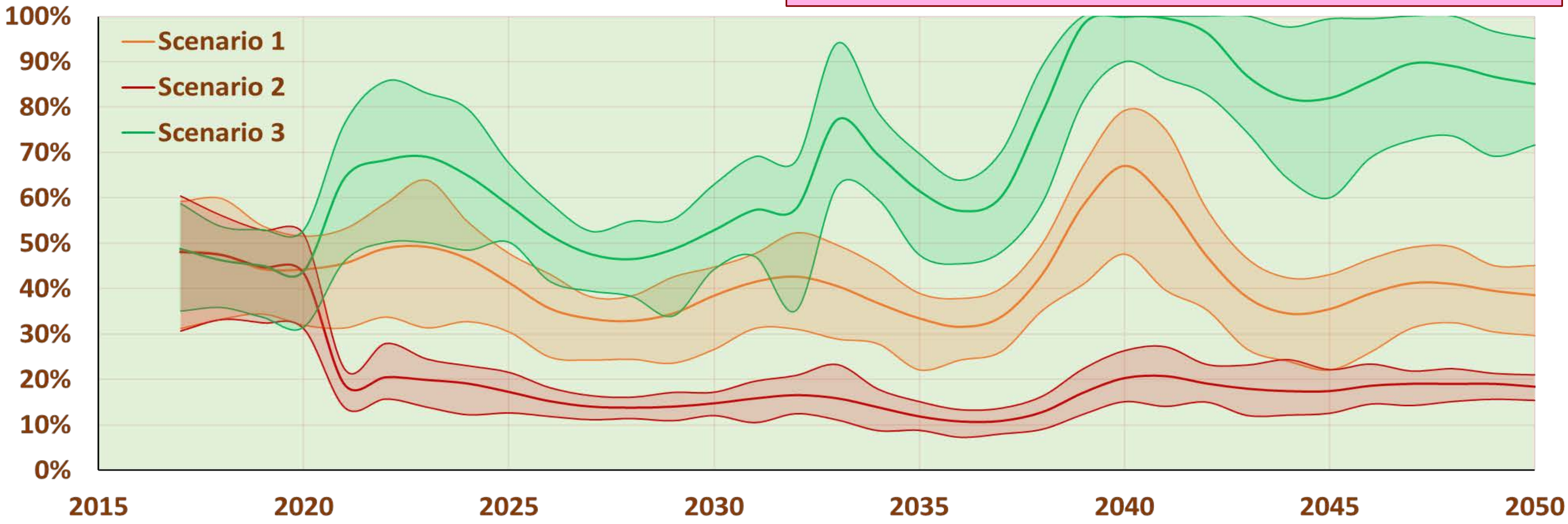


Estimated Almond Biomass to Energy (Central Valley)

Scenario 1: currently active power plants maintained through 2050

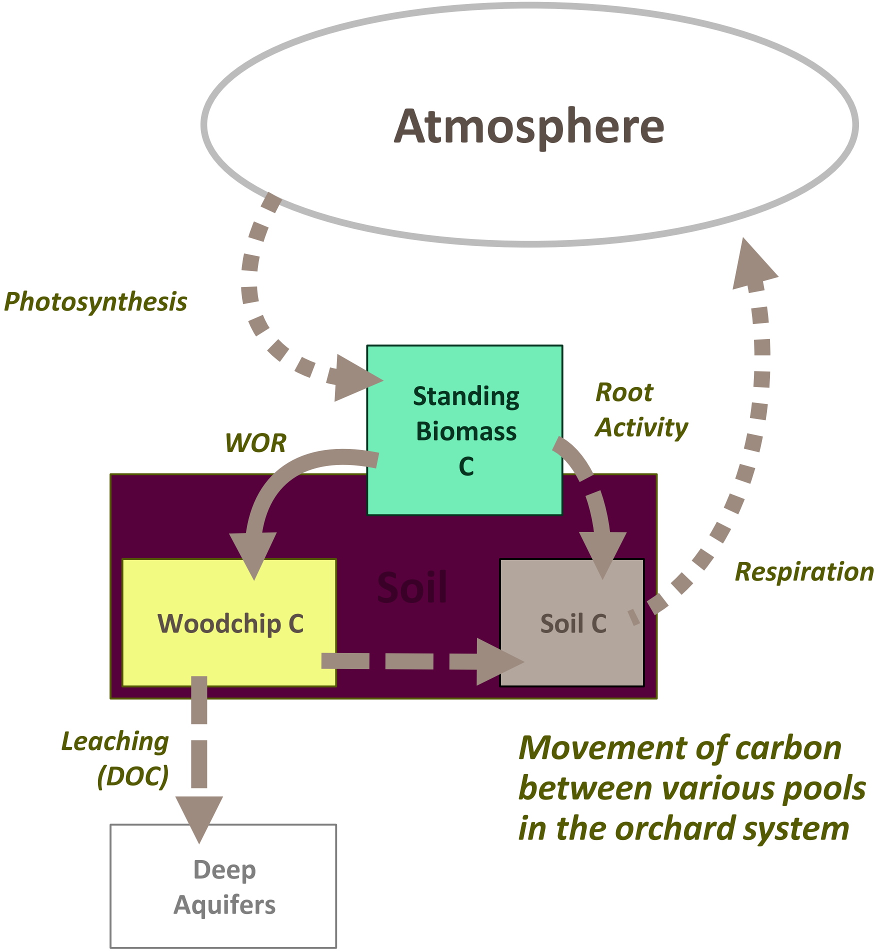
Scenario 2: Most currently active BMPPs closed by 2020, only new projects/ proposals active through 2050

Scenario 3: Current plants maintained through 2050, plus currently idled BMPPs returned to active status starting in 2020 (2 reactivated every 5 years)



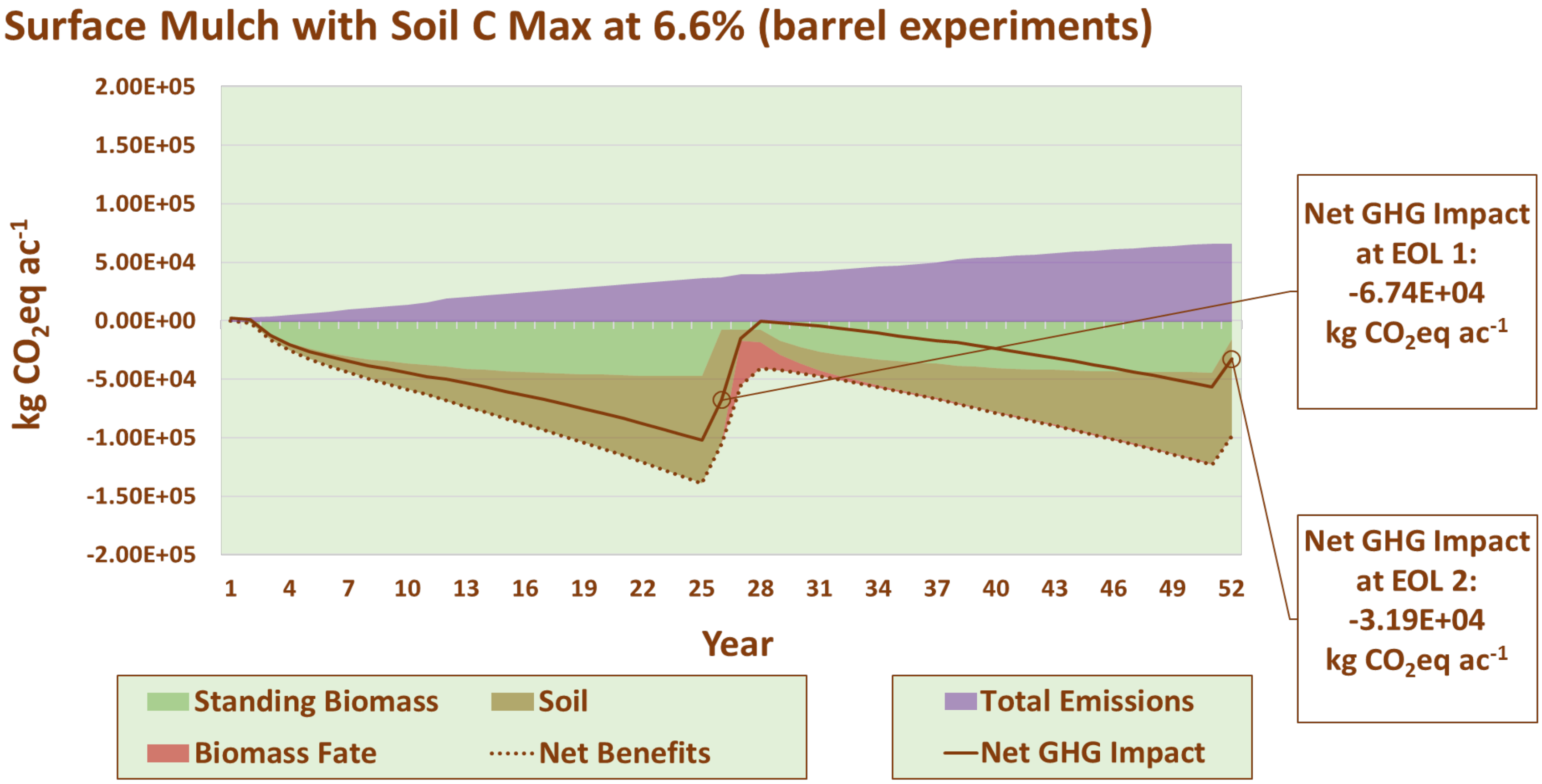
TEMPORARY CARBON STORAGE AND ORCHARD RECYCLING

- Carbon Pools (Stocks) and Flows in the Orchard System
- Pools: standing biomass, woodchips in soil, soil carbon, atmosphere and aquifers
- Flows: transfer of carbon between pools
- Data being analyzed from Brent Holtz's barrel experiments
  - Chipped woody biomass, unincorporated
  - Chipped woody biomass, incorporated

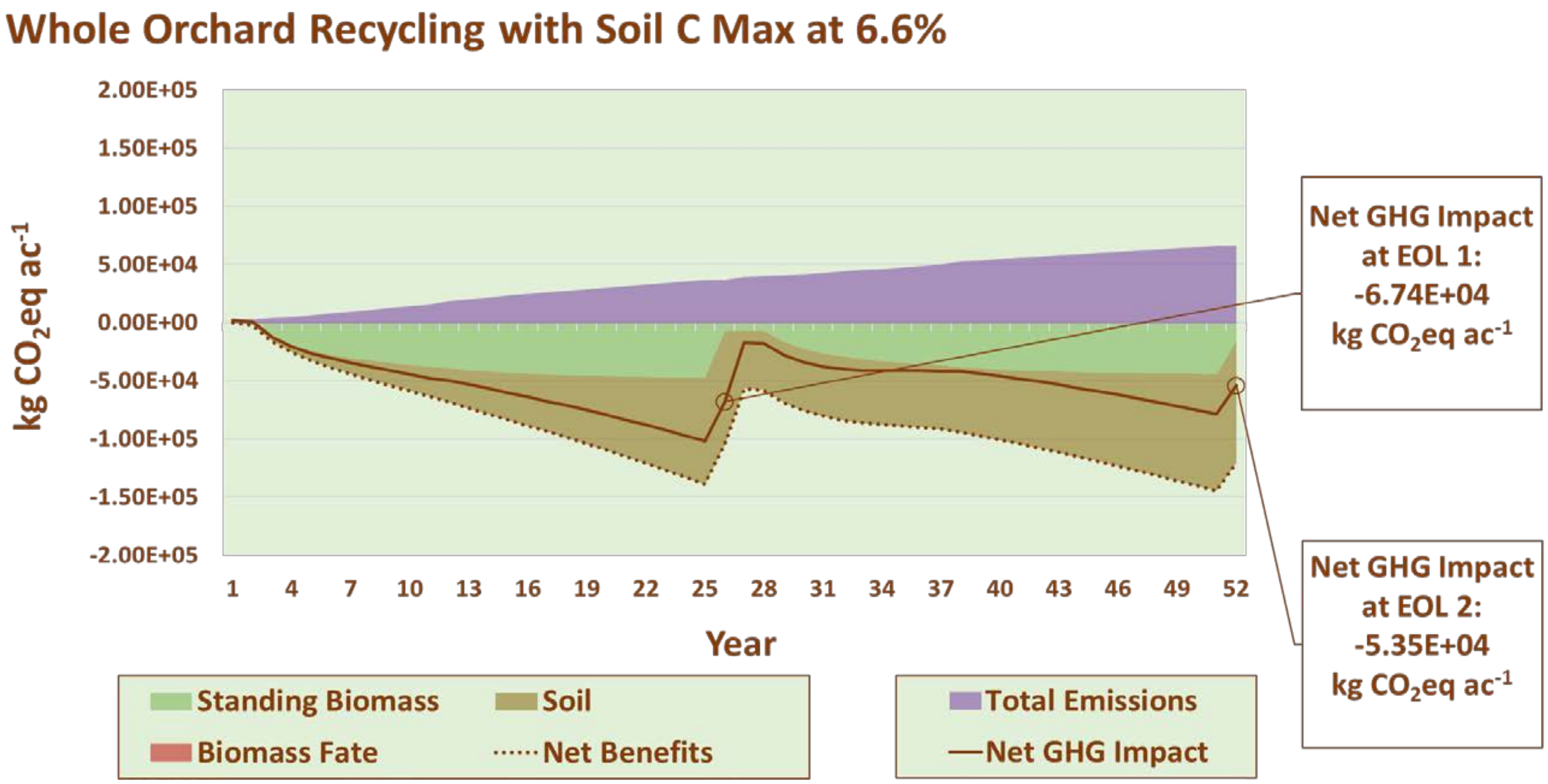


Movement of carbon between various pools in the orchard system

Early estimates for effect of surface mulch



Early estimates for effects of whole orchard recycling



FUTURE AND ONGOING WORK

- Continued research on LCA model improvements include
  - Continued modeling of soil carbon dynamics under recycling
  - Continued modeling of biomass powerplant commissioning and decommissioning effect on orchard biomass fate
  - Improved modeling of market dynamics for almond co-products (e.g. hulls) in LCA model
  - Improved and spatially resolved modeling of irrigation water-related energy

AERIAL ALMOND MAPPING

Joel Kimmelshue, PhD, CPSS
Land IQ

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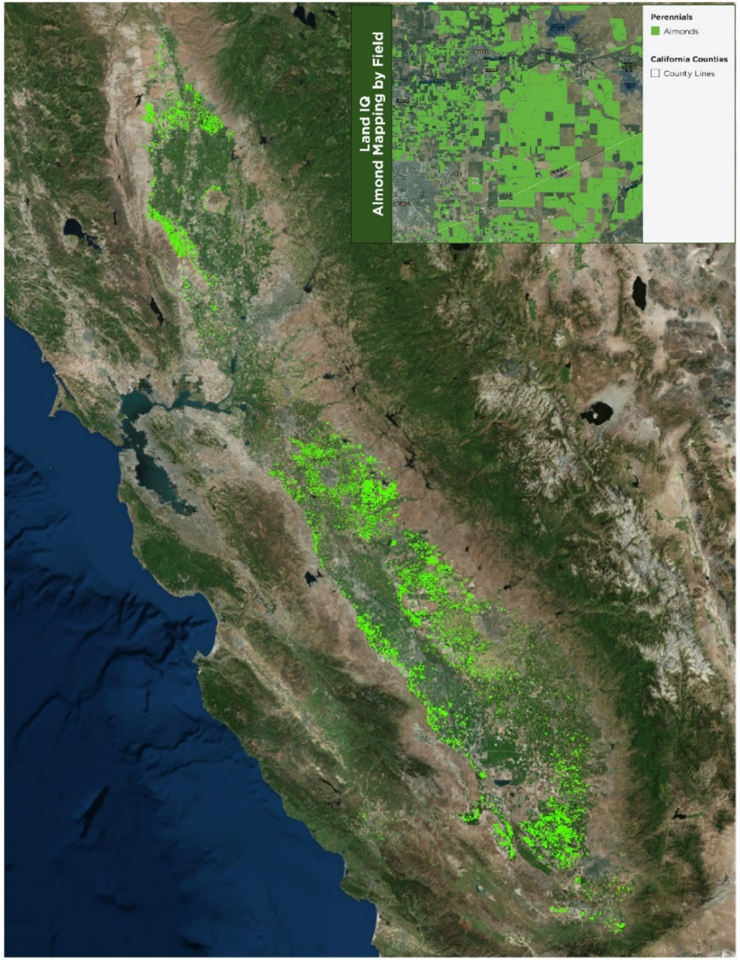
Cooperators and Resources

- Primary Cooperators
  - Almond Board of California (ABC)
  - Land IQ, LLC
- Main Resources
  - United States Department of Agriculture (USDA) National Agricultural Imaging Program (NAIP) imagery
  - Landsat and other imagery
  - California Department of Water Resources (DWR) County Crop Mapping
  - USDA-National Agricultural Statistics Service (NASS) CropScape Mapping
  - USDA-NASS Tabular Records
  - California Department of Pesticide Regulation (DPR) Records
  - County Agricultural Commissioner Crop Reports
  - Grower Knowledge
  - Agronomic and Remote Sensing Expertise



ACREAGE RESULTS

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ACREAGE RESULTS - BEARING

- USDA-NASS and Land IQ Acreage Comparisons

	2010	2012	2014	2016
USDA-NASS	*770,000*	*820,000*	*880,000*	*940,000*
Land IQ	*810,386*	*885,575*	*938,441*	*981,813*
Difference	*40,386*	*65,575*	*58,441*	*41,813*
% Difference	*5.2%*	*8.0%*	*6.6%*	*4.4%*

- Key Conclusions
  - Algorithms and approaches have been developed and implemented with a remote sensing approach
  - Ground truthing, accurate field boundaries, agronomic knowledge, key algorithms are all key components
  - Accuracy = 98.8%

ACREAGE RESULTS – NON BEARING

- USDA-NASS and Land IQ Acreage Comparisons

	2010	2012	2014	2016
USDA-NASS	*85,000*	*110,000*	*170,000*	*300,000*
Land IQ	*124,568*	*118,595*	*189,505*	*280,102*
Difference	*39,568*	*8,595*	*19,505*	*(19,898)*
% Difference	*46.6%*	*7.8%*	*11.5%*	*-6.6%*

- Key Conclusions
  - Non-Bearing acreage is the most difficult to estimate
  - Cannot be remotely sensed
  - Must rely on ground truthing information and other non-spatial information
  - Implementing some modifications to ground truthing in 2017
  - Accuracy = 93.9%

ACREAGE RESULTS – TOTAL

- USDA-NASS and Land IQ Acreage Comparisons

	2010	2012	2014	2016
USDA-NASS	*855,000*	*930,000*	*1,050,000*	*1,240,000*
Land IQ	*934,954*	*1,004,170*	*1,127,946*	*1,261,915*
Difference	*79,954*	*74,170*	*77,976*	*21,915*
% Difference	*9.4%*	*8.0%*	*7.4%*	*1.8%*

- Key Conclusions
  - Combination of bearing and non-bearing
  - Continuing to increase year over year
  - Large increase in removed orchards in Kern, Kings, and Tulare counties from 2014 to 2016
  - Large increase in plantings as well statewide
  - Accuracy = 98.1%

WEB MAP APPLICATION

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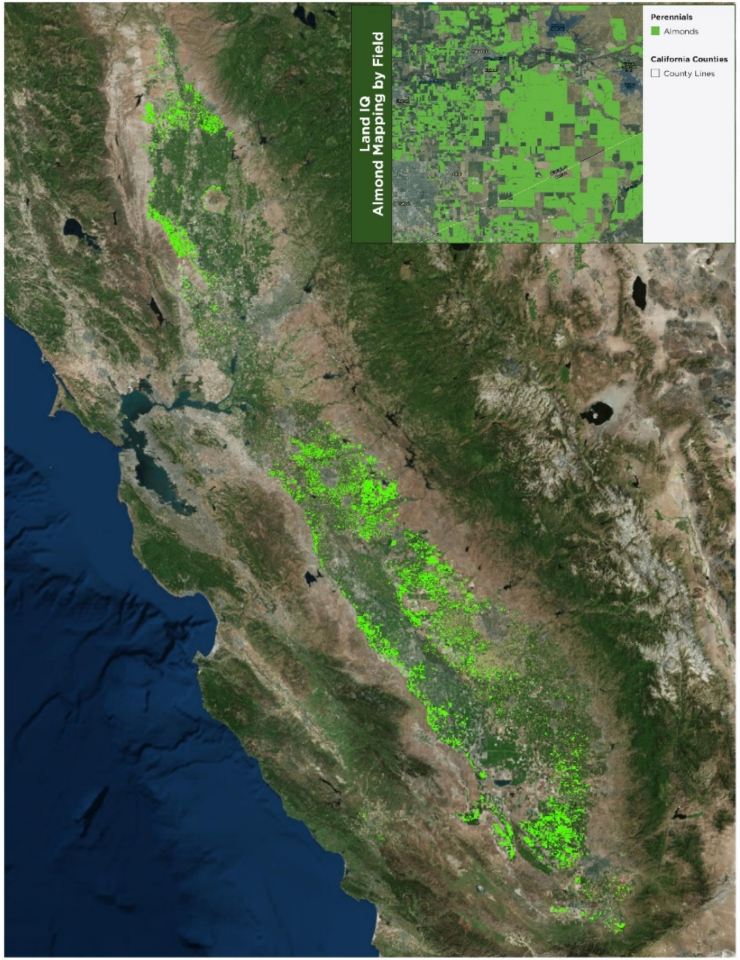
Almond Board of California

WEB MAP APPLICATION

- www.almonds.com/maps
- It’s a “living” map and will continually be updated over time as new analysis results become available (e.g. 2016 mapping).
- Web map components:
  - Various map backgrounds
  - 2010, 2012, 2014, 2016 Almond Acreage
  - Age Analysis by Orchard
  - Recharge Suitability by Orchard
  - Irrigation/Water Supply Districts
  - Irrigated Lands Regulatory Program Boundaries
  - State Assembly, State Senate and Congressional District Boundaries



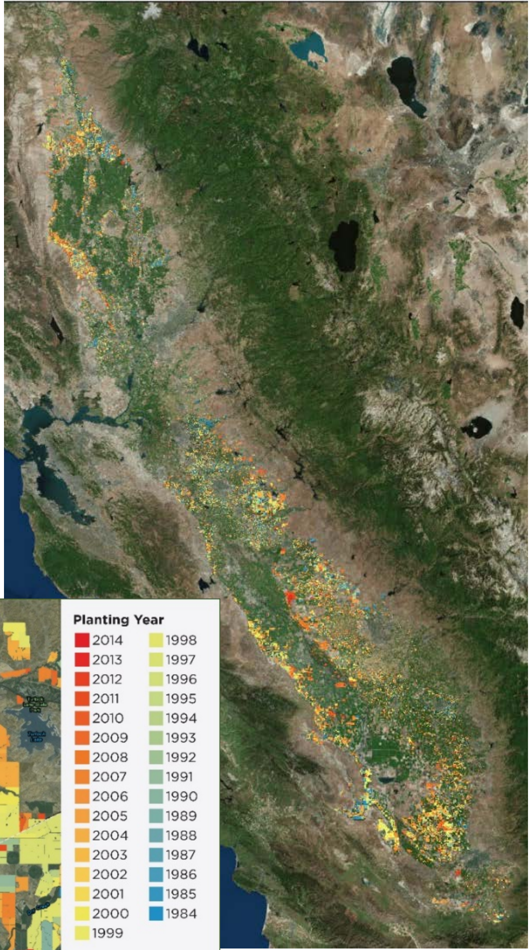
APPLICATIONS OF MAPPING

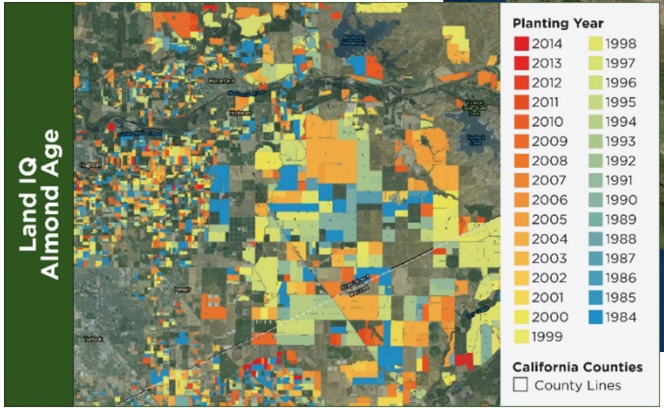
california almonds

Almond Board of California

AGE ANALYSIS

- Question: Can you also determine the age of each orchard?
- Answer: Yes
  - Once orchards are mapped, only then can age be determined
  - A backwards looking approach (through 1984) at various imagery sources is conducted
  - Once “signature” appears as open ground, then this establishes planting date
  - +/- 1-2 years
  - Accuracy = 90-95%
- Significance: Potential Uses
  - Yield forecasts/enhancements
  - Biomass/carbon accumulation



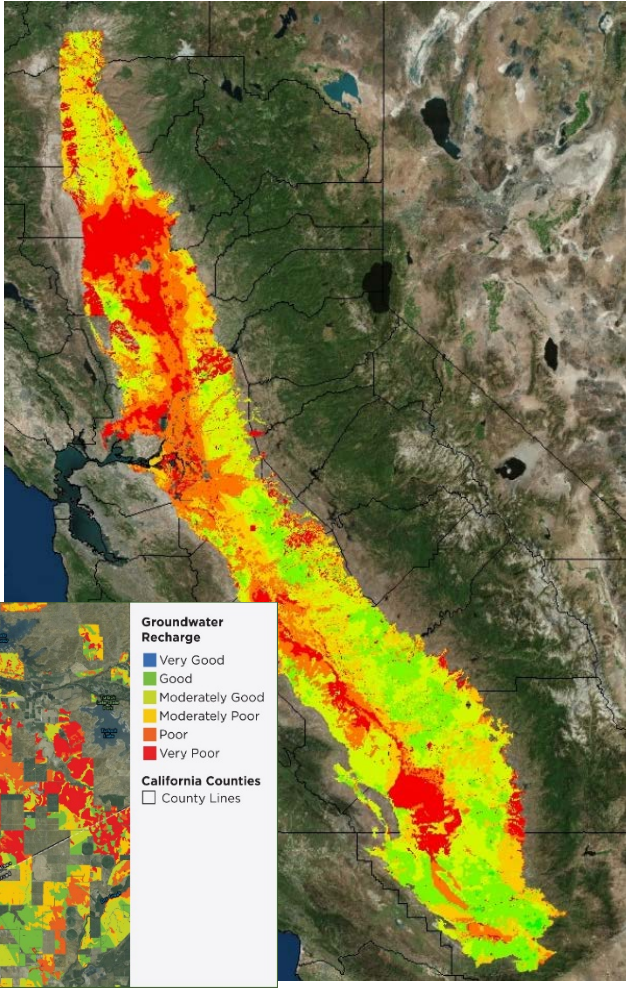


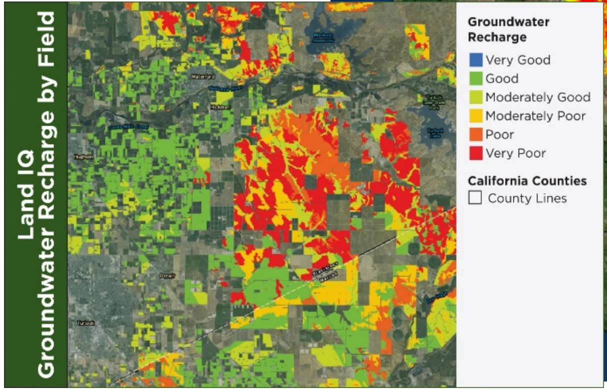
GROUNDWATER RECHARGE

- Question: Given increased interest in winter recharge, can you tell which areas are most suitable for intentional recharge in almonds?
- Answer: Yes

  The index provides a locating tool for determination of suitable areas for intentional groundwater recharge in any crop.

- Significance
  - ✓ Resulted in approximately 600,000 acres of suitable almond orchards
  - ✓ Allows growers and water providers the ability to locate most suitable orchards in relation to water supply infrastructure
  - ✓ Prioritizes land for recharge opportunities
  - ✓ Does not replace site-specific investigations
  - ✓ Allows for interaction with other researchers for assessing impact on crop, soils, leaching, etc.





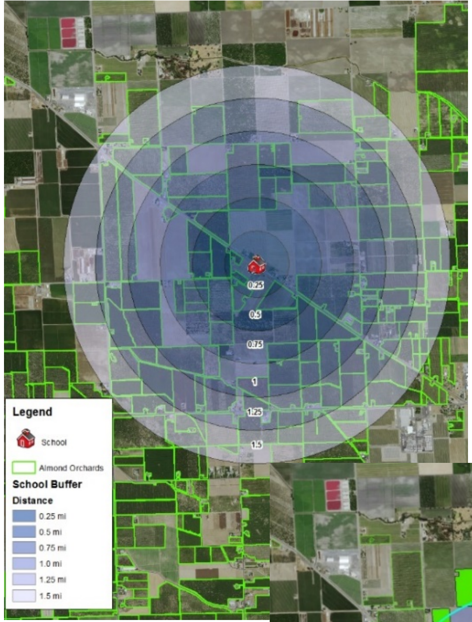
CROP EXPANSION

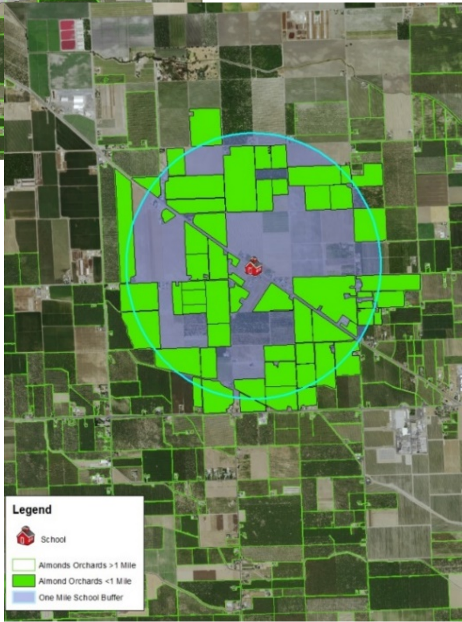
- Question: Can you determine what was there before almonds, was it irrigated and how much water did it use?
- Answer: Yes
  - By knowing where almonds are on an orchard by orchard basis AND the age of orchards,
  - A comparison between the statewide mapping and previous DWR county mapping results from 10-15 years prior can be made.
- Significance
  - Comparison of water use by crop
  - Consumptive use vs. applied water
  - Efficiency

Previous crop	Acres converted to almonds within change analysis period	Percentage of total analyzed almond acres converted within change analysis period
Alfalfa	40,074	9%
Almonds	101,522	23%
Citrus	1,127	0%
Corn	15,210	4%
Cotton	46,331	11%
Developed	2,245	1%
Fallow/Idle	6,921	2%
Field and Row Crops	21,241	5%
Forage	36,845	9%
Grains/Cereals	3,117	1%
Grapes	43,621	10%
Melons and Squash	5,657	1%
Native	34,302	8%
Other Fruit/Nut Tree	8,578	2%
Pasture	11,015	3%
Peaches and Nectarines	8,350	2%
Plums/Prunes	5,506	1%
Rice	4,424	1%
Root and Tuber Crops	3,344	1%
Seed Crops	2,451	1%
Specialty	2,551	1%
Tomatoes	21,443	5%
Vegetable Crop	1,633	0%
Walnuts	4,579	1%

SCHOOL PROXIMITY ANALYSIS

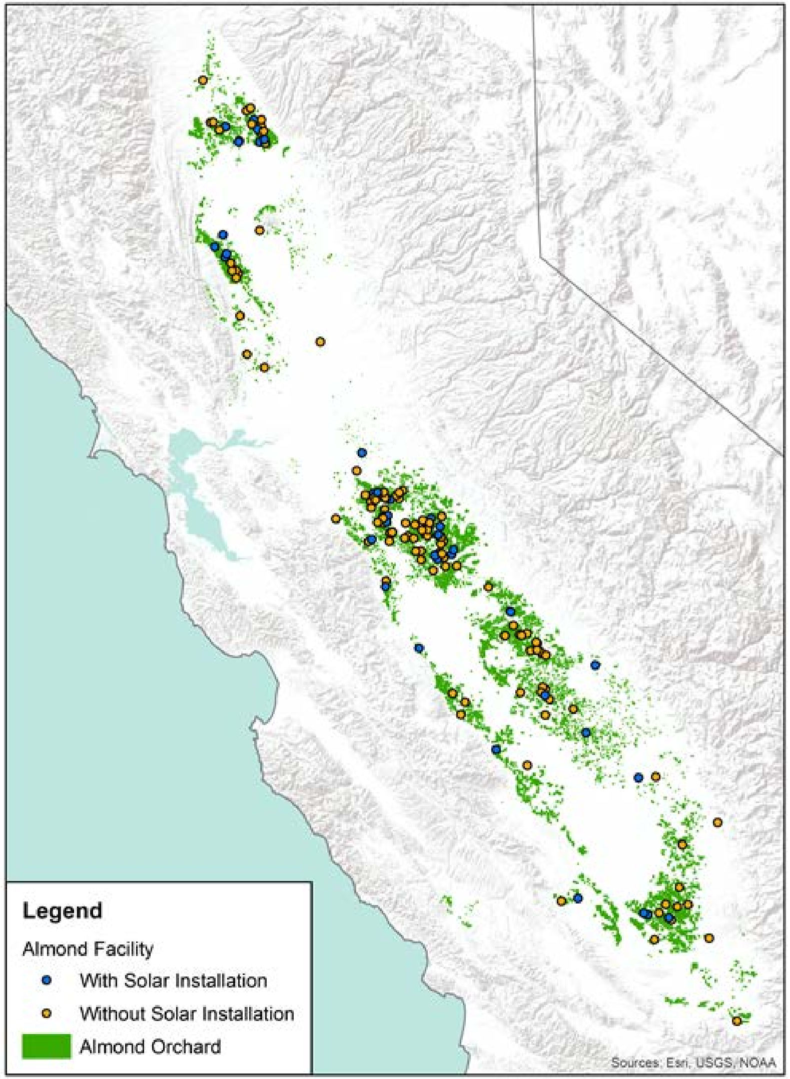
- Question: Driven by regulations at the Department of Pesticide Regulation, can you determine how many orchards would be impacted by a notification to spray rule.
- Answer: Yes
  - By knowing where almonds are on an orchard by orchard basis AND the location of schools and daycares, a proximity analysis was conducted to determine how many orchards would be impacted.
- Significance
  - Approximately 51,450 acres would be impacted
  - Average orchard size was 34 acres
  - Representing 1,513 orchards





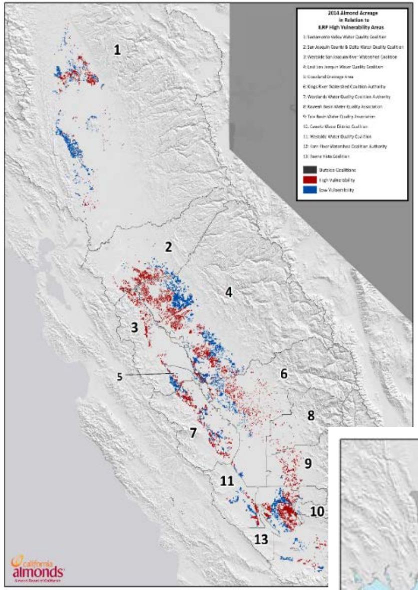
SOLAR FACILITIES

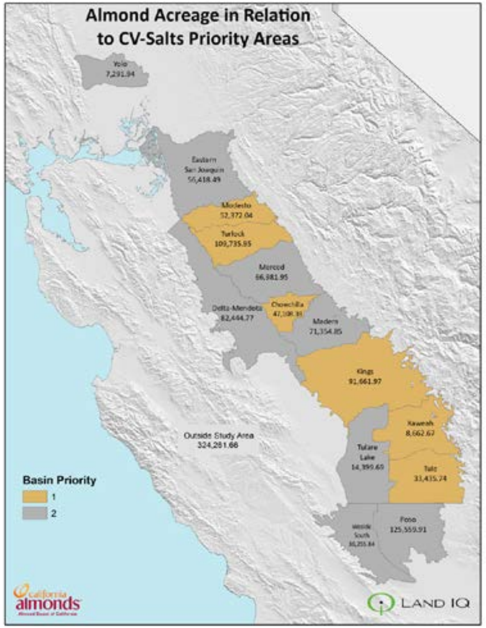
- Question: Can you determine the extent of solar installations and generation in almond orchards and processing facilities?
- Answer: Yes
    - By knowing where almonds are on an orchard by orchard basis AND the location of hullers, shellers, processors and handles, a spatial point layer was created to identify solar facilities.
- Significance
    - Nearly one-third (29%) of almond facilities use solar energy.
    - Just seven percent (7%) of almond orchards have a solar facility within or immediately adjacent to the orchard.



NITROGEN ASSESSMENT

- Question: As a result of pending legislation, can you determine how many almond orchards are within areas of concern for high concern for nitrogen concentrations?
- Answer: Yes
  - By knowing where almonds are on an orchard by orchard basis AND the areas identified as high concern for nitrogen through various regulatory programs and spatial analysis can be completed.
- Significance
  - Over half (55.6%) of the almond acreage in the state falls in a high vulnerability area for ILRP.
  - One third of the almond acreage (30.4%) falls in Priority 1 Basins for CV-Salts.





Acknowledgements

- Almond Board of California
- Land IQ
    - Mica Heilmann, BS, CPSS
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    - Stephanie Tillman, MS, CPAg
    - Chris Stall, MS
    - Casey Gudel, MS
    - Naveed Sami, MS
    - Justin Sitton, BS
    - Cody Fink, MS
    - Andrew Loberg, BS
    - Nolan Schultz

CEUs – New Process

Certified Crop Advisor (CCA)

- <u>Sign in and out of each session you attend.</u>
- Pickup verification sheet at conclusion of each session.
- *Repeat this process for each session, and each day you with to receive credits.*

Pest Control Advisor (PCA), Qualified Applicator (QA), Private Applicator (PA)

- Pickup scantron at the start of the day at first session you attend; complete form.
- <u>Sign in and out of each session you attend.</u>
- Pickup verification sheet at conclusion of each session.
- Turn in your scantron at the end of the day at the last session you attend.

Sign in sheets and verification sheets are located at the back of each session room.

Research Poster Sessions

Wednesday, December 6
3:00 p.m. – 5:00 p.m.

Featured topics:
- Irrigation, nutrient management
- Breeding
- Soils, if related to organic matter input
- Sustainability, irrigation improvement continuum, life cycle assessment, dust
- Food quality and safety

Thursday, December 7
1:30 p.m. – 2:30 p.m.

Featured topics:
- Insect and disease management
- Fumigation and alternatives
- Biomass (including biochar-related efforts)
- Pollination
- Almond Leadership Program

2017 Research Update Book

- Pickup your copy at the ABC Booth in Hall A+B
- Includes a one-page summary of every current ABC-funded research project

What’s Next

Tuesday, December 5 at 4:15 p.m.

- State of the Industry – Hall C

Be sure to join us at 5:30 p.m. in Hall A+B for Dedicate Trade Show Time and Opening Reception, sponsored by The Bank of Stockton