Biomass: Utilizing Trees and Hulls in the Orchard

December 7, 2016

california almonds

Almond Board of California

Biomass: Utilizing Trees and Hulls in the Orchard

Gabriele Ludwig, Almond Board of California (Moderator)

Kelly Covello, Almond Alliance of California

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Almond Board of California

Gabriele Ludwig,
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Kelly Covello,
Almond Alliance of California

Almond Alliance OF CALIFORNIA

Everything but the Nut: Utilizing Hulls, Shells and Trees

Kelly Covello, President

Who is the Almond Alliance?

ALMOND HULLERS & PROCESSORS ASSOCIATION

Almond Alliance OF CALIFORNIA

Value Proposition

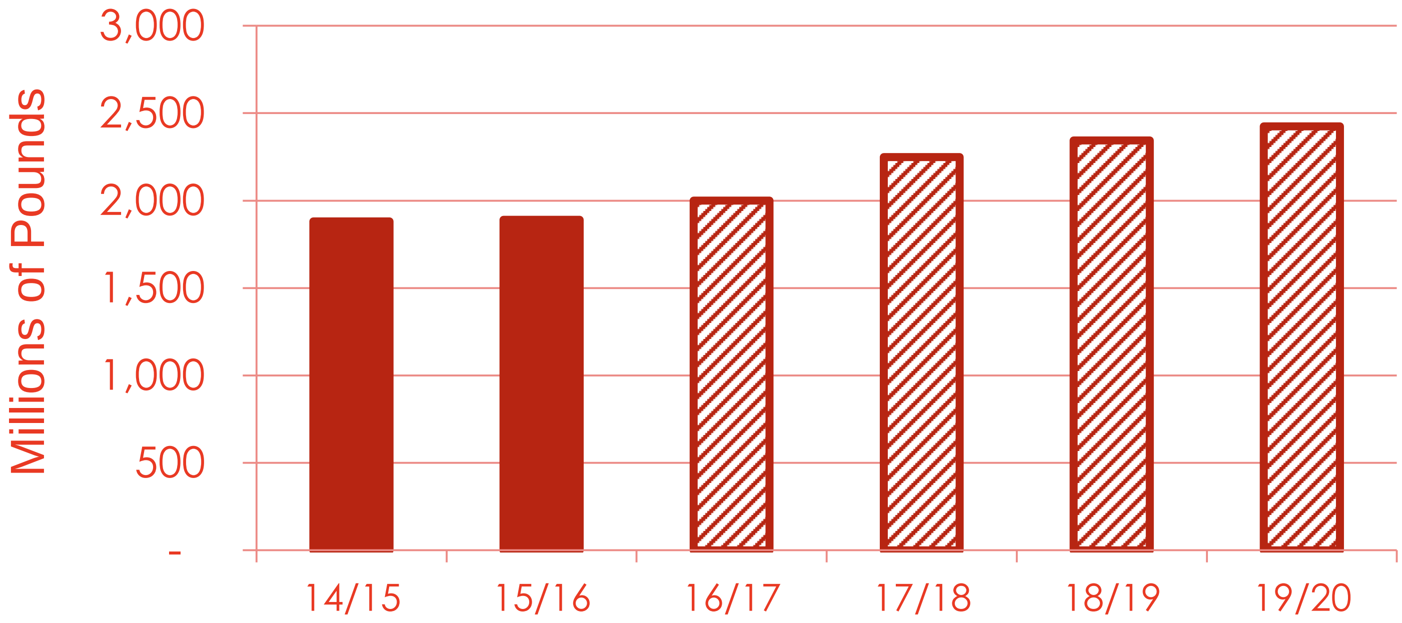
The only trade association fully dedicated to advocating and protecting your investment in the almond industry

Partnering With the Almond Board

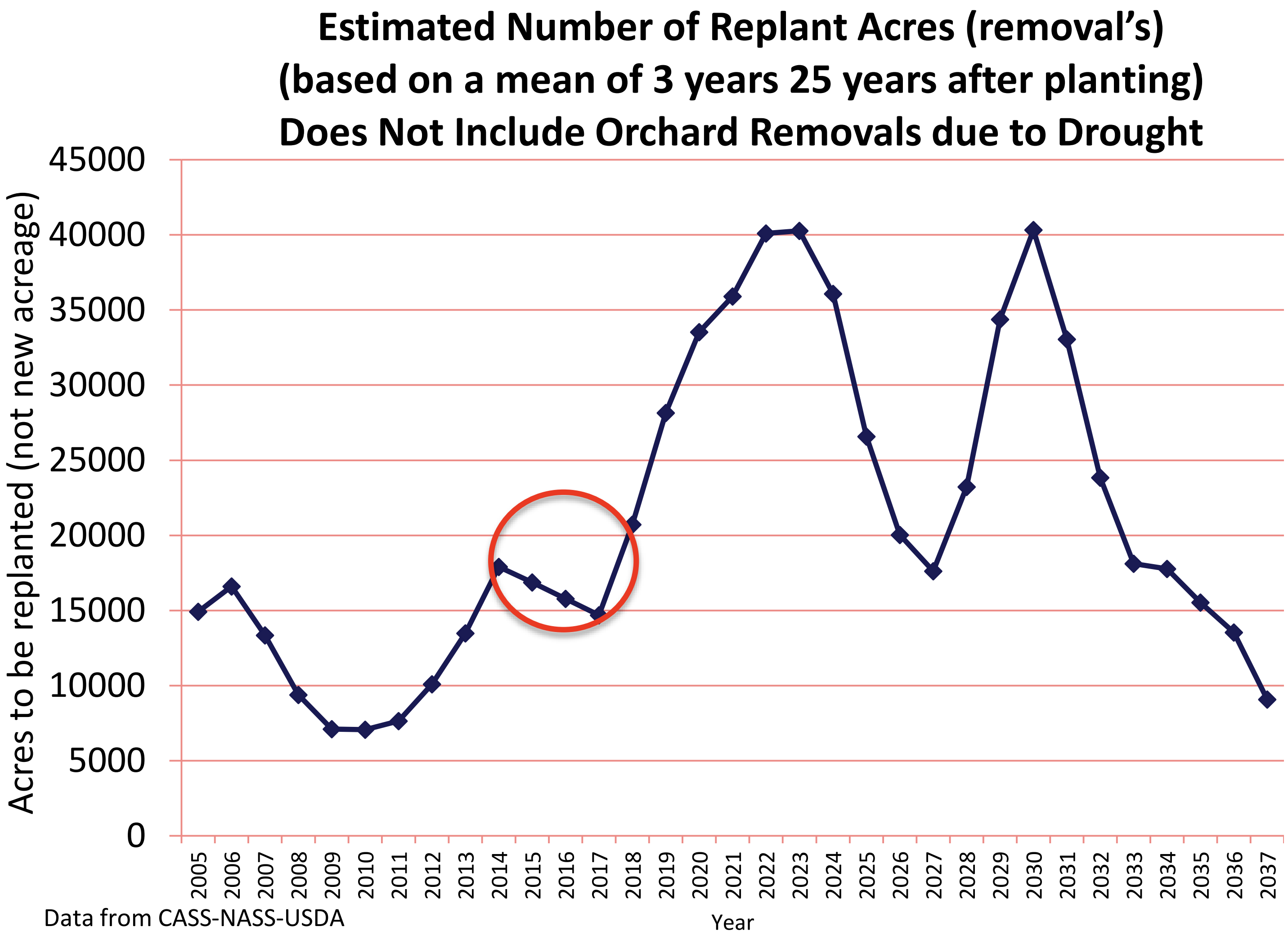
Complementing...Not Competing

	california almonds Almond Board of California	Almond Alliance OF CALIFORNIA
Research	● ● ●	
Advertising/ Promotion	● ● ●	
Statistical Analysis	● ● ●	
Public, Media Relations	● ● ●	●
Technical Assistance	● ●	● ●
Training	● ●	● ●
Advocacy		● ● ●
Group Benefits		● ●

Production Expected to Increase by 25% by 2020



*NOTE: Production Outlook assumes adequate moisture.
Though, research is being done to understand how to maximize yields given lower levels of water availability.

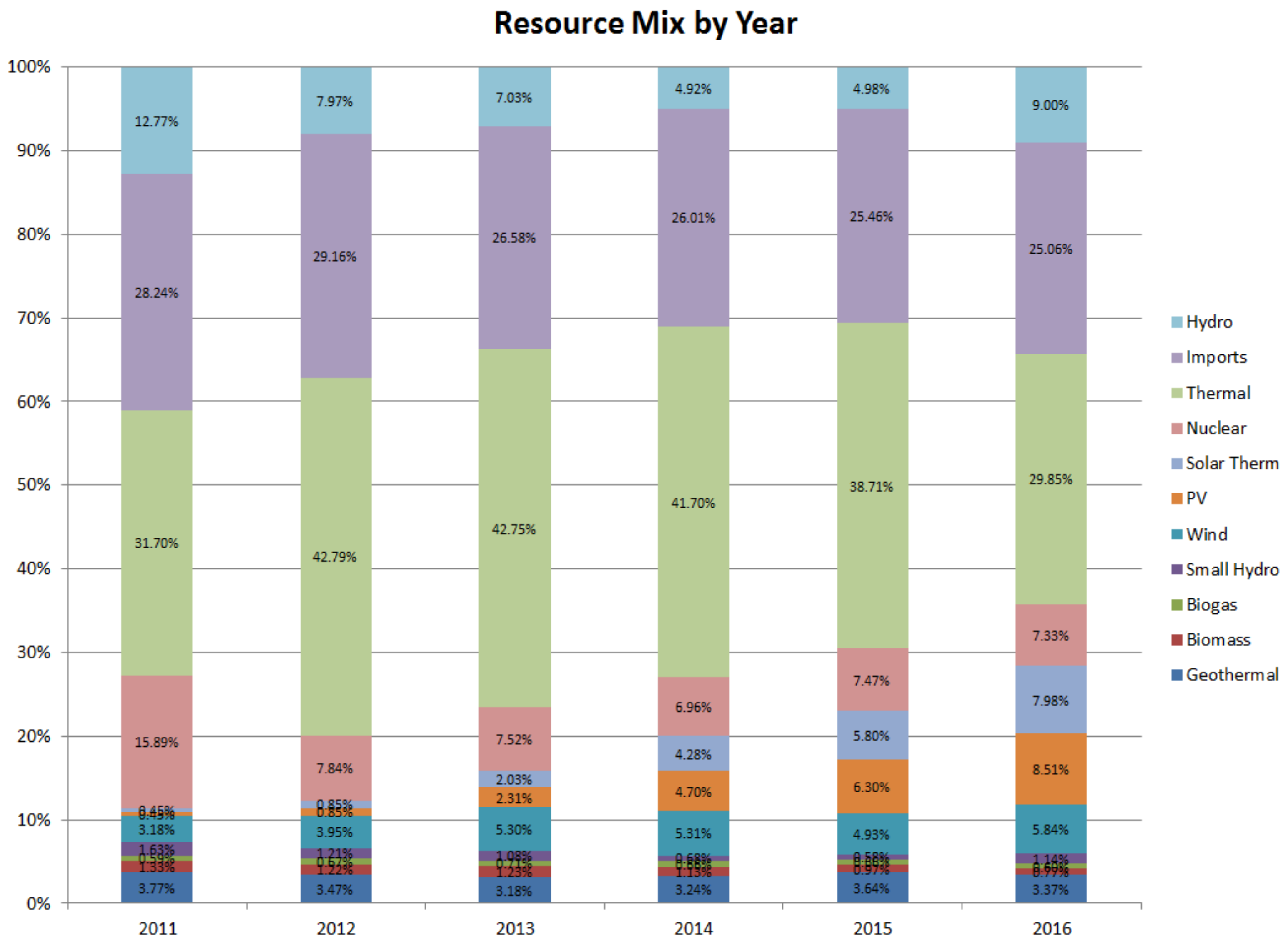

Estimated Number of Replant Acres (removal's)
(based on a mean of 3 years 25 years after planting)
Does Not Include Orchard Removals due to Drought
Acres to be replanted (not new acreage)
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
Year
Data from CASS-NASS-USDA

Biomass Relief in SB859

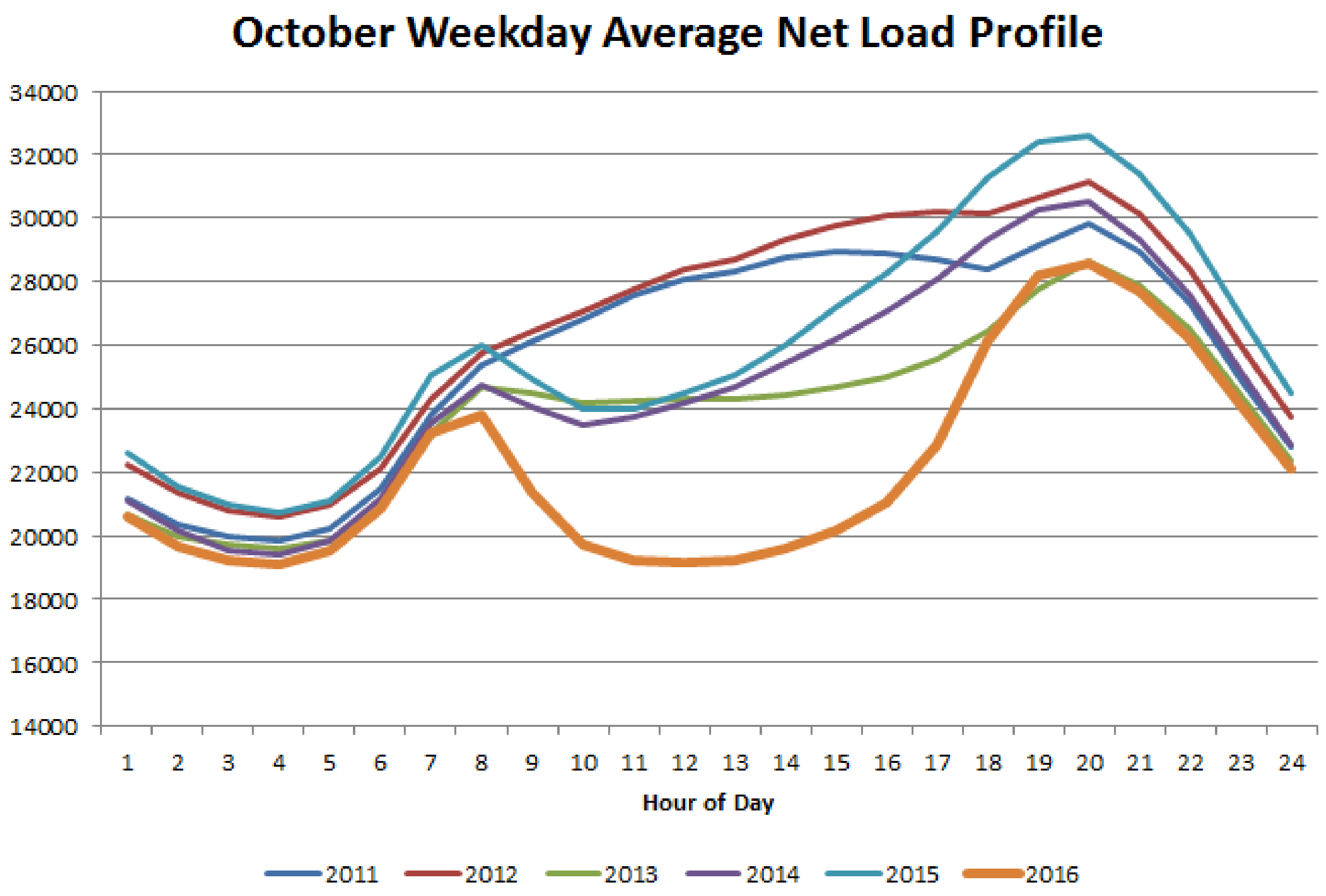
- The Almond Alliance, working with Assemblymembers Dahle and Gordon was successful in getting biomass relief in SB 859
- An important but modest mechanism to ensure biomass facilities continue to operate as an integral piece of the state's management of wood waste for the next five years
- Requires the State's utilities to procure 125 MWs of biomass power annually for the next five years
  - Feedstock at 80% Forestry & 20% from ag and urban sources
- Closed plants will have access to the bidding process as long as they were operational prior to June 1, 2013

Rio Bravo in Fresno to Stay Open

- Rio Bravo Fresno, which was slated to close December 31st, recently won its bid so will continue to supply 24 megawatts of electricity to the grid, an equivalent of 24,000 homes.
- But this is a short term solution and we need to identify long term solutions as challenges exist with biomass plants



Resource Mix by Year
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2011
2012
2013
2014
2015
2016
12.77%
28.24%
31.70%
15.89%
3.18%
1.63%
1.33%
3.77%
7.97%
29.16%
42.79%
7.84%
0.85%
3.95%
1.21%
1.22%
3.47%
7.03%
26.58%
42.75%
7.52%
2.03%
2.31%
5.30%
1.08%
1.23%
3.18%
4.92%
26.01%
41.70%
6.96%
4.28%
4.70%
5.31%
1.13%
3.24%
4.98%
25.46%
38.71%
7.47%
5.80%
6.30%
4.93%
0.97%
3.64%
9.00%
25.06%
29.85%
7.33%
7.98%
8.51%
5.84%
1.14%
0.77%
3.37%
Hydro
Imports
Thermal
Nuclear
Solar Therm
PV
Wind
Small Hydro
Biogas
Biomass
Geothermal



October Weekday Average Net Load Profile
34000
32000
30000
28000
26000
24000
22000
20000
18000
16000
14000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour of Day
2011
2012
2013
2014
2015
2016

Returning By-Products to the Orchard

- In 2014/15 Cal Recycle proposed new regulations that:
  - Could have made hulls and shells subject to the composting regulations when they are already being "recycled"
    - AAC got an exemption added for facilities with a Feed License
  - Modified the definition "ag material" and "ag by-product material"
    - AAC got hulls, shells, sticks, culls, and leaves produced on **and off farm** included in both definitions
    - Can now return to the orchard in like amounts with out regulation by Cal Recycle or Local Agencies
  - Exclusion from regulation if your land applications were already regulated by the Water Resources Control Board.

Facilities & By-Products can be Regulated

- CalRecycle can regulate a facility and by-product disposition:
  - you don't have a feed license; and/or,
  - your by-products are land applied at sites other than their origins,
- If either are true, CalRecycle and the local enforcement agencies have the discretion to regulate your facility and/or the land application of your by-products.

Land Application Requirements

Almond Ag Materials or Processing By-Products

- ACC ensured very liberal standards for land application of our by-products (not their origins):
  - On land zoned for agriculture – three times a year at a depth of not more than 12” or
  - On land NOT zoned for agricultural – once a year at a depth of not more than 12”.
- There are self policing minimal heavy metal and coliform pathogen standards for the applications that shouldn’t be problematic for our by-products.

Whole Orchard Recycling

- If biomass is NOT incorporated into the soil at time of grinding/chipping, e.g. stockpiled and/or composted.
- To Stay Exempt from Compost Regulation
  - Needs to Stay on Site and NO more than 1,000 cubic yards are sold or given away annually.
- Otherwise, composting and certain storage conditions will likely require “notification” of your local enforcement agency.

Thank You!

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Brent Holtz,
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Whole Orchard Recycling

Brent A. Holtz, Ph.D.
UC Farm Advisor in San Joaquin County

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Almond Board of California

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?

Forest nutrition comes from decomposing logs (carbon) or burning

These logs or stored carbon represent the productivity of a forest ecosystem over thousands of years.

Nobody is adding fertilizer to forests

- When we remove an orchard we grind up 25-30 years worth of photosynthesis and carbon and nutrient accumulation and haul it away. 25-30 years of organic matter is lost from our system, estimated at 60 tons per acre for almond.

Whole Almond Orchard Recycling and the Effect on Second Generation Tree Growth, Soil Carbon, and Fertility

by

Brent A. Holtz[1], David Doll[2], and Greg Browne[3]

University of California

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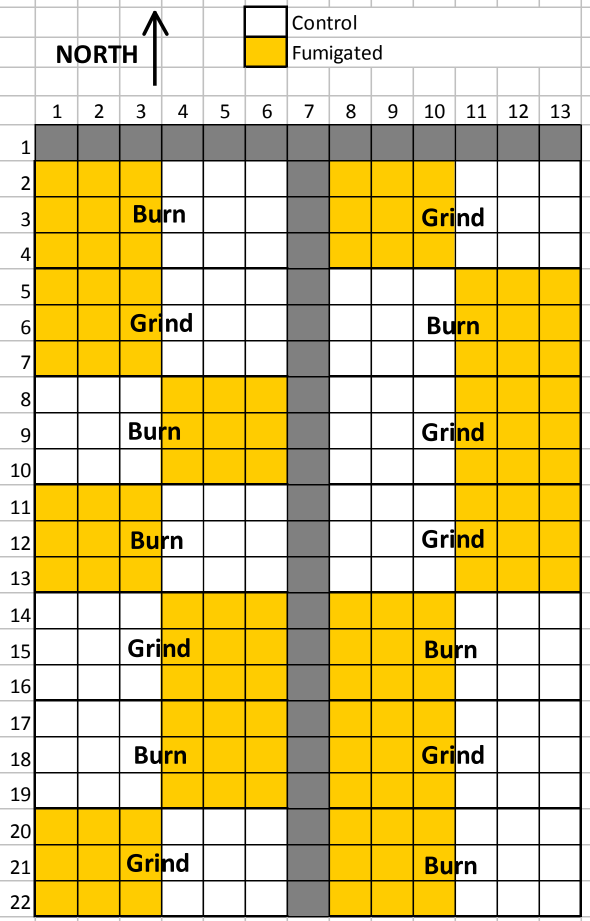
The Iron Wolf

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



no of tree sites counting buffers: 286

2009 First leaf trees growing in grinding plot

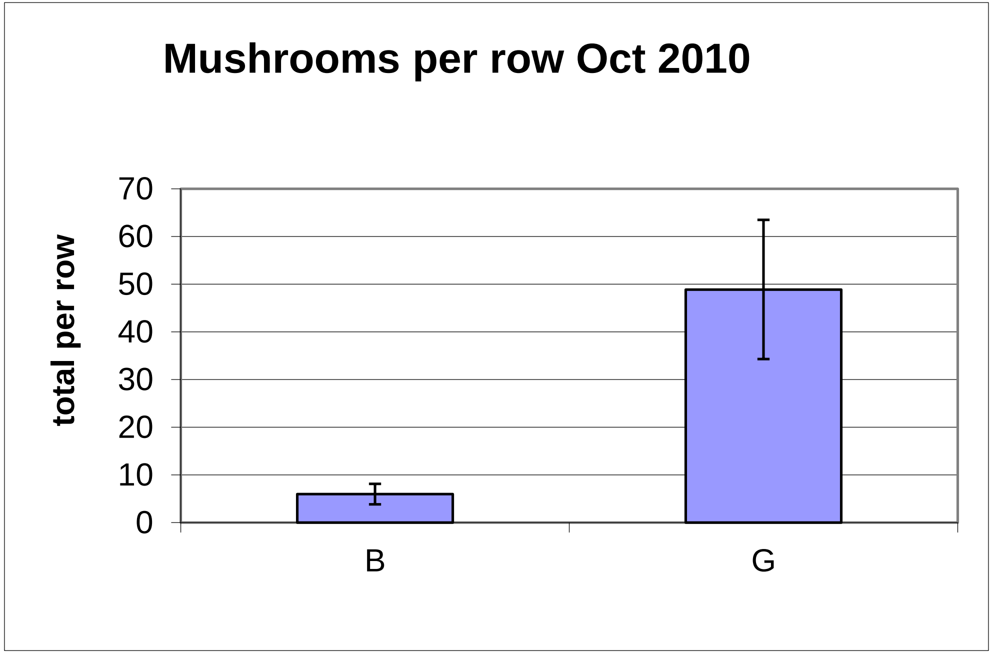
2010 Second leaf trees

No difference in tree circumference

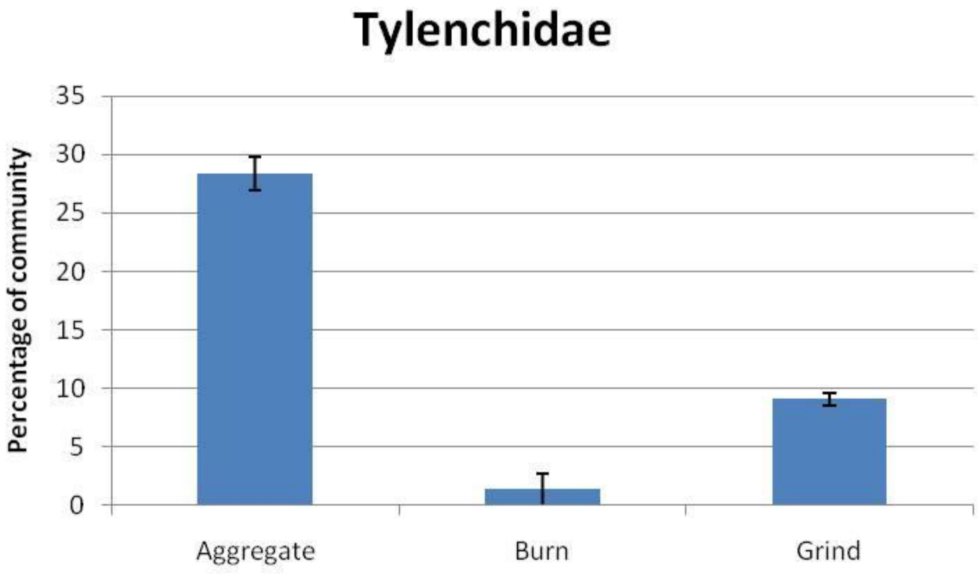
The Grinding did not stunt the second generation orchard

2011 Third leaf trees growing in grinding plot

2012 Fourth leaf trees growing in grinding plot


Mushrooms per row Oct 2010
total per row
70
60
50
40
30
20
10
0
B
G

Nematode species of the family Tylenchidae feed on algae and fungi and are not parasitic to trees. Significantly greater Tylenchidae were observed in the grind plots, especially next to woody pieces (aggregates).



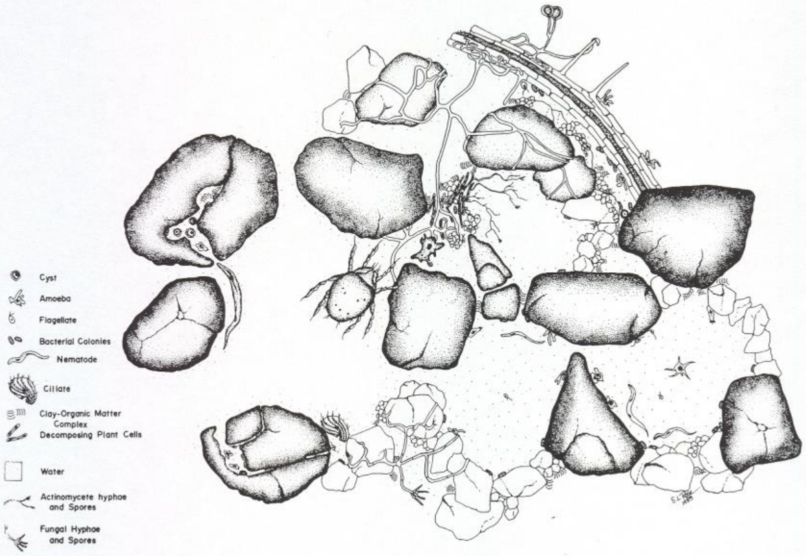
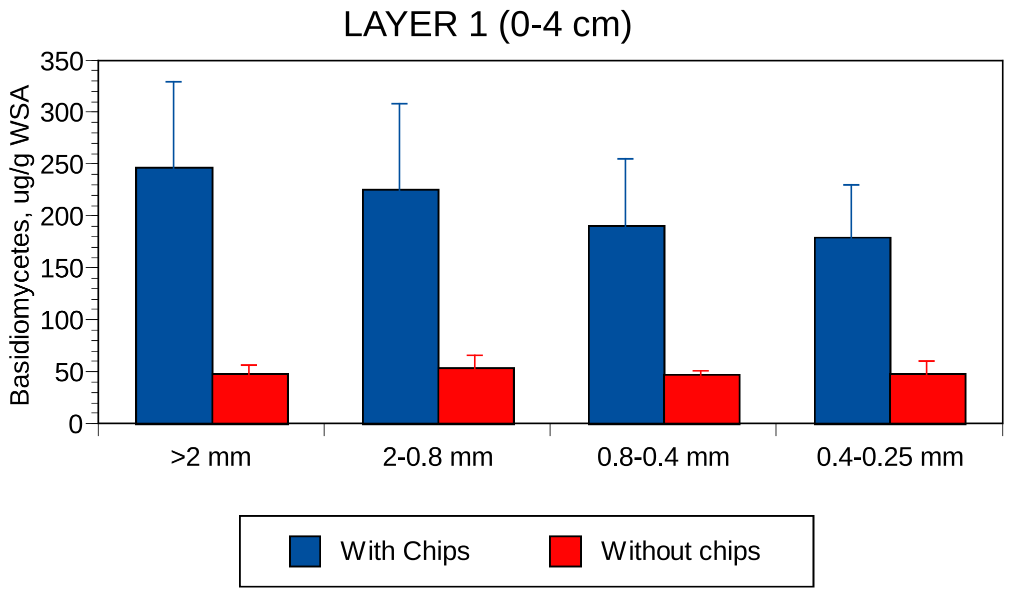


Figure 5.2. Trophic relationships among different groups of soil organisms are controlled by accessibility to their resources. This illustration represents approximately 1 cm^2 of a highly structured microzone in the surface horizon of a grassland soil. Courtesy of S. Rose and T. Elliott, personal communication.)

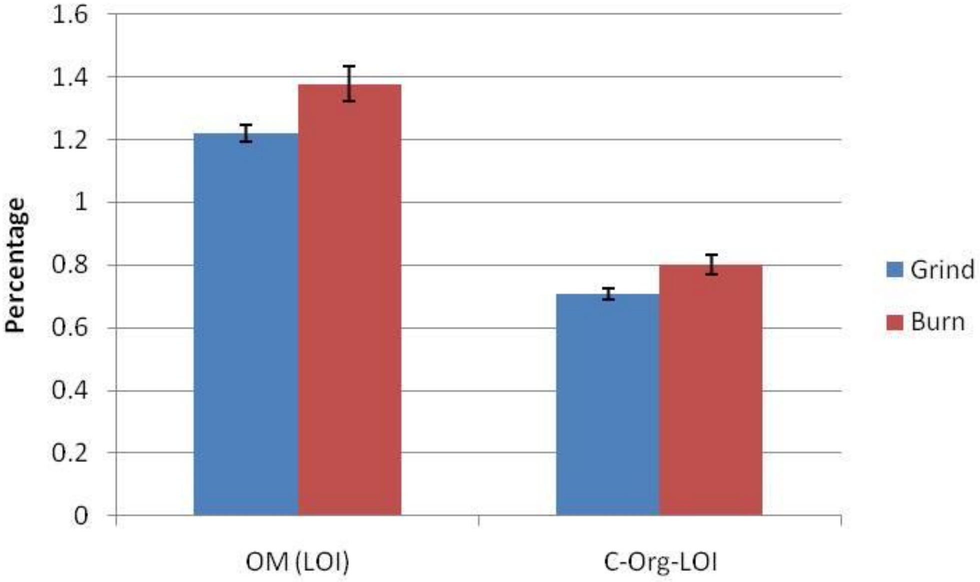
- If wood debris is in contact with soil it stays moist and is rapidly colonized by fungal mycelium that incorporates woody material into soil aggregates.

Experiment on field plots amended or not with wood chips.

Soil aggregating basidiomycete amount in water stable aggregates (WSA) retrieved from the top surface layer



In 2010, Burn treatments had significantly more organic matter (OM), carbon (C), and Cation Exchange Capacity (CEC) in the top 10-15 cm of soil.



Burning appears to release nutrients back into the orchard soil more rapidly than decomposition.

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-LOl	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

Leaf Analysis

	Nitrogen %		Phosphorus %		Potassium %		Magnesium %		Manganese ppm		Iron ppm		Sodium ppm	
	Grind	Burn	Grind	Burn	Grind	Burn	Grind	Burn	Grind	Burn	Grind	Burn	Grind	Burn
2010	2.40 a	2.33 b	0.11 a	0.10 b	1.76 a	1.44 b	0.98 a	1.03 b	23.63 a	17.44 b	102.5	104.3	340.5 a	455.5 b
2011	2.58	2.58	0.14	0.14	1.92 a	1.67 b	0.66 a	0.71 b	25.70	24.91	91.34	93.75	19.38 a	54.00 b
2012	2.46	2.44	0.13	0.13	1.14 a	1.02 b	0.87	0.90	20.13	19.13	84.84	83.95	24.88 a	49.50 b
2013	2.57 a	2.49 b	0.112 a	0.106 b	0.94 a	0.73 b	1.04 a	1.12 b	27.83 a	23.25 b	113.59 a	102.79 b	634.6 a	957.5 b
2014	2.40 a	2.33 b	0.11 a	0.10 b	1.76 a	1.44 b	0.98 a	1.03 b	23.63 a	17.44 b	102.5	104.0	340.5 a	455.5 b
2015	2.42	2.39	0.12	0.11	1.66 a	1.43 b	0.97	1.01	23.96 a	17.88 b	142.5	148.22	243.8 a	358.22 b

Blue Pair = grinding significantly less than burning

Yellow pair = grinding significantly greater than burning

- Fungal decomposition of the organic matter may be contributing to available nutrient levels which would be gradually released as the woody aggregates are decomposed.

Grinding vs. Burning the first generation orchard on the second generation orchard:

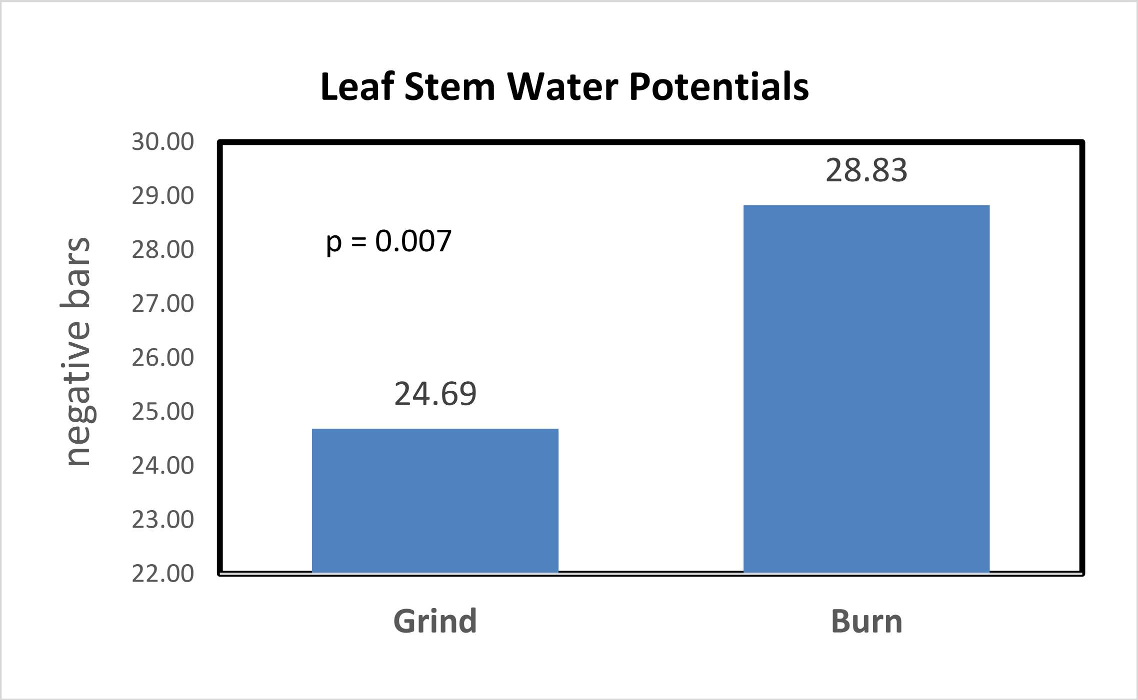
Yield lbs (kg)

Green Weight per 6 tree plots

Year	Grind	Burn	P value
2011	166.5 a (75.7 kg)	152.9 a (69.5 kg)	(P= 0.26)
2012	267. 5 a (121.6 kg)	253.4 a (115.1 kg)	(P = 0.20)
2013	347.2 a (157.8 kg)	306.3 b (139.2 kg)	(P = 0.08)
2014	467.7 (212.1 kg)	385.3 (174.8 kg)	(P = 0.08)
2015	264.4 (120.2 kg)	235.94 (107.3 kg)	(P = 0.17)
2016	265.0 (120.2 kg)	248.7 (112.8 Kg)	(P = 0.24)

Grinding vs. Burning the first generation orchard on the second generation orchard:

Kernel Weight lbs/acre			
Year	Grind	Burn	Difference
2011	1,007.3 lbs/ac	925.0 lbs/ac	82.3 lbs/ac
2012	1,618.4 lbs/ac	1,533.1 lbs/ac	85.3 lbs/ac
2013	2,100.6 lbs/ac	1,853.1 lbs/ac	247.5 lbs/ac
2014	2,829.5 lbs/ac	2,331.1 lbs/ac	498.4 lbs/ac
2015	1,599.6 lbs/ac	1,427.1 lbs/ac	172.5 lbs/ac
2016	1,603.2 lbs/ac	1,504.6 lbs/ac	98.6 lbs/ac
Total	**10,758.6 lbs/ac**	**9,574 lbs/ac**	**1,184.6 lbs/ac**

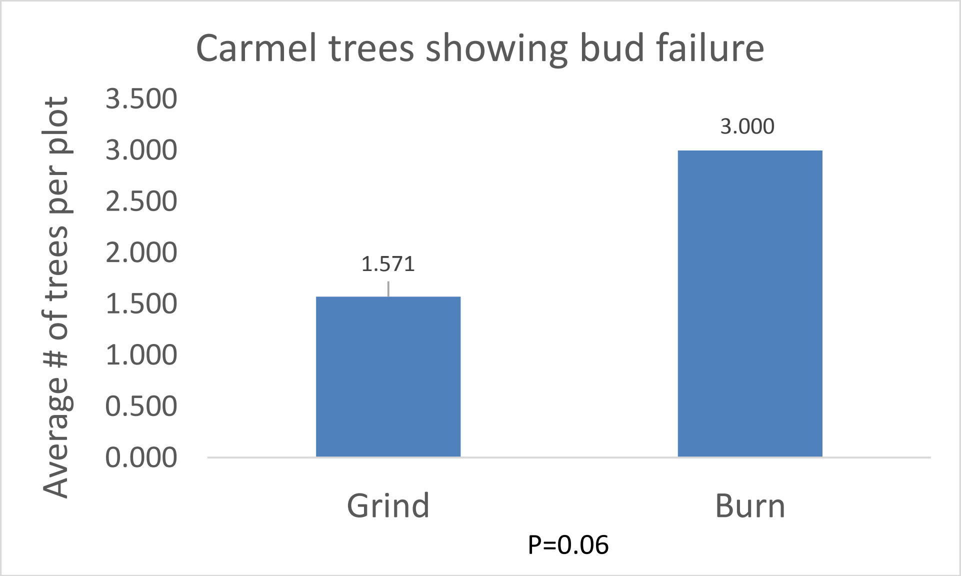


The trial went 57 days without an irrigation during harvest

Trees growing in the grind plots had less water stress

Carmel trees were rated for bud failure symptoms

Trees growing in the grind plots had less bud failure



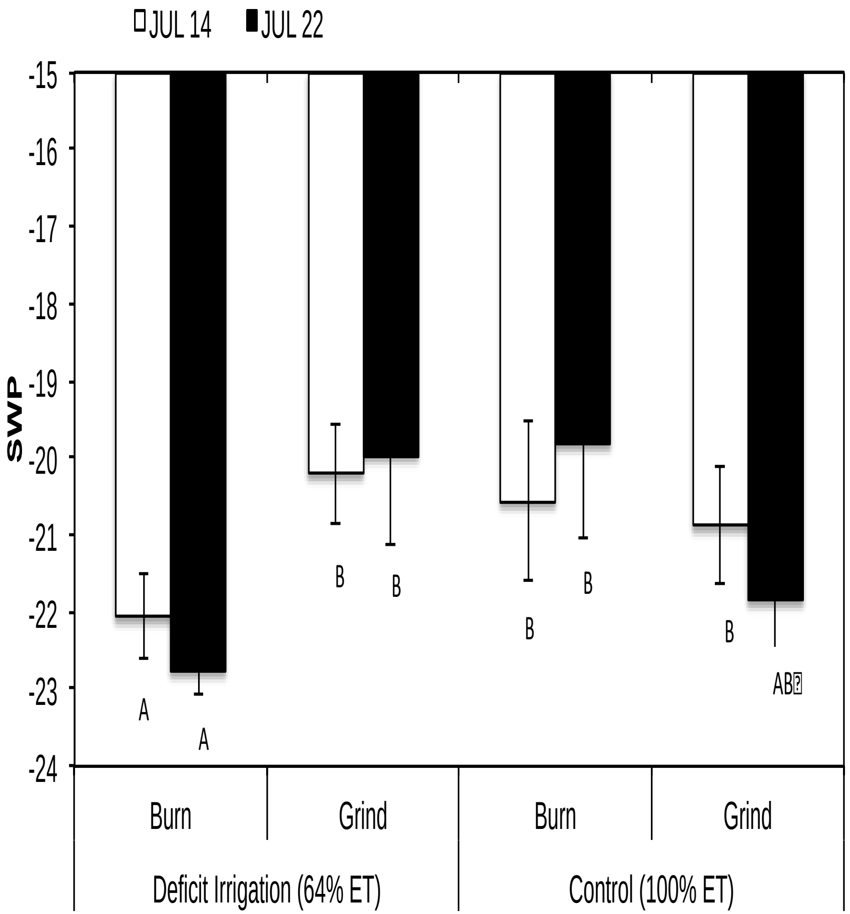


Figure 1. Stem water potential was measured with pressure bomb on July 14 and 22 after onset of the deficit irrigation treatment in the WOR-G plots (grind) and burned control. Treatments with the same letter were not significantly different (p=0.05).

Soil Organic Matter and Available Water Capacity
by

Berman D. Hudson

J. Soil and Water Cons. 49(2):189-194.

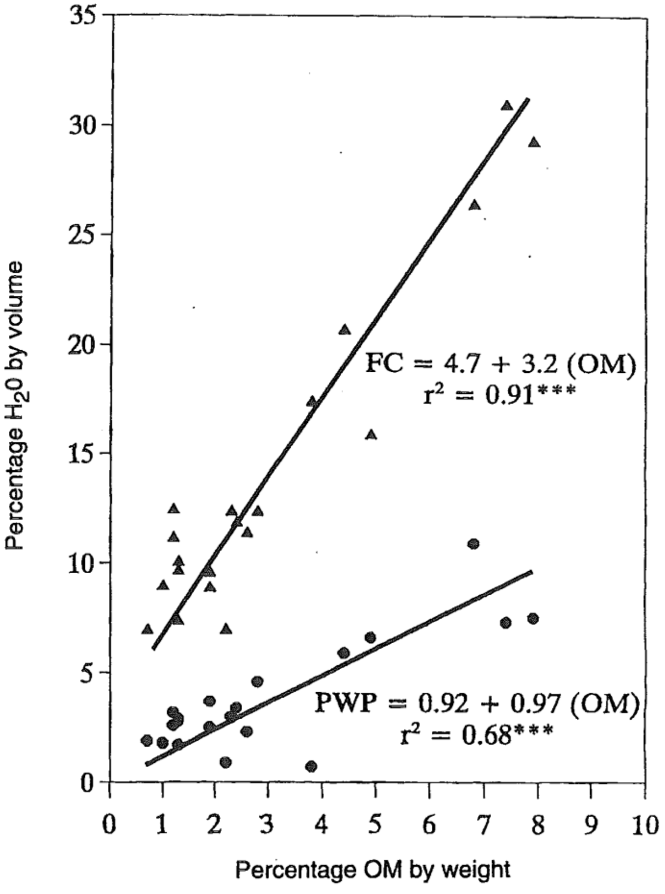


Figure 1. Water content at FC and PWP versus OM content of sand surface horizons.

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Orchard recycling has:

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

Will orchard recycling:

- Increase water holding capacity? Yes!
- Increase orchard productivity? Yes!
- Bind pesticides and fertilizers? ?
- Provide carbon credits to farmers? ?

Soil Organic Matter

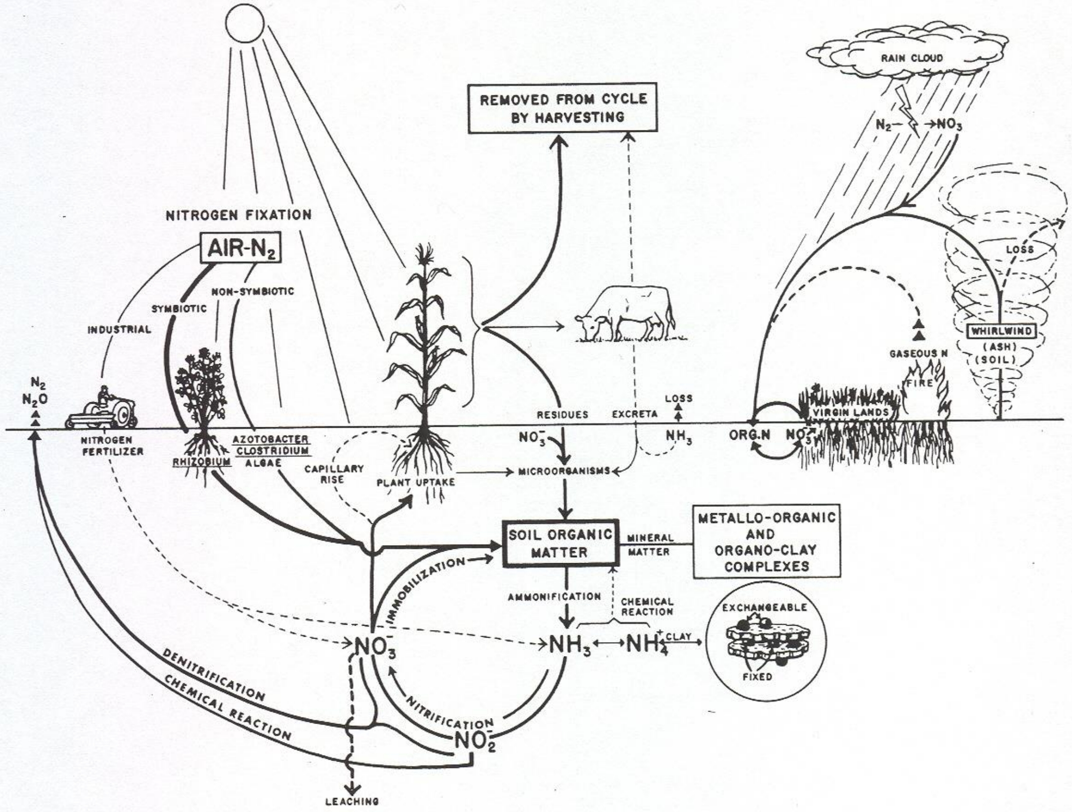

Figure 8.1. Nitrogen cycle in soil. (From Stevenson, 1982.)

REVIEW SUMMARY

SOIL SCIENCE

Soil and human security in the 21st century

Ronald Amundson,* Asmeret Asefaw Berhe, Jan W. Hopmans, Carolyn Olson, A. Ester Sztein, Donald L. Sparks

BACKGROUND: Earth's soil has formed by processes that have maintained a persistent and expansive global soil mantle, one that in turn provided the stage for the evolution of the vast diversity of life on land. The underlying stability of soil systems is controlled by their inherent balance between inputs and losses of nutrients and carbon. Human exploitation of these soil resources, beginning a few thousand years ago, allowed agriculture to become an enormous success. The vastness of the planet and its soil resources allowed agriculture to expand, with growing populations, or to move, when soil resources were depleted. However, the practice of farming greatly accelerated rates of erosion relative to soil production, and soil has been and continues to be lost at rates that are orders of magnitude greater than mechanisms that replenish soil. Additionally, agricultural practices greatly altered natural soil carbon balances and feedbacks. Cultivation thus began an ongoing slow ignition of Earth's largest surficial reservoir of carbon—one that, when combined with the anthropogenic warming of many biomes, is capable of driving large positive feedbacks that will further increase the accumulation of atmospheric greenhouse gases and exacerbate associated climate change.

ADVANCES: The study of soil is now the domain of diverse schools of physical and biological science. Rapid advances in empirical and theoretical understanding of soil processes are occurring. These advances have brought an international, and global, perspective to the study of soil processes and focused the implications of soil stewardship for societal well-being. Major advances in the past decade include our first quantitative understanding of the natural rates of soil production, derived from isotopic methods developed by collaboration of geochemists and geomorphologists. Proliferation of research by soil and ecological scientists in the northern latitudes continues to illuminate and improve estimates of the magnitude of soil carbon storage in these regions and its sensitivity and response to warming. The role of soil processes in global carbon and climate models is entering a period of growing attention and increasing maturity. These activities in turn reveal the severity of soil-related issues at stake for the remainder of this century—the need to rapidly regain a balance to the physical and biological processes that drive and maintain soil properties, and the societal implications that will result if we do not.

OUTLOOK: Both great challenges and opportunities exist in regards to maintaining soil's role in food, climate, and human security. Erosion continues to exceed natural rates of soil renewal even in highly developed countries. The recent focus by economists and natural scientists on potential future shortages of phosphorus fertilizer offers opportunities for novel partnerships to develop efficient methods of nutrient recycling and redistribution systems in urban settings. Possibly the most challenging issues will be to better understand the magnitude of global soil carbon feedbacks to climate change and to mitigating climate change in a timely fashion. The net results of human impacts on soil resources this century will be global in scale and will have direct impacts on human security for centuries to come. ■

ON OUR WEB SITE

Read the full article at http://dx.doi.org/10.1126/science.1261071

The list of author affiliations is available in the full article online.
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Cite this article as R. Amundson et al., Science 348, 1261071 (2015). DOI:10.1126/science.1261071

CREDIT: BRENT STIRTON/GETTY IMAGES

Large-scale erosion forming a gully system in the watershed of Lake Bogoria, Kenya. Accelerated soil erosion here is due to both overgrazing and improper agricultural management, which are partially due to political-social impacts of past colonization and inadequate resources and infrastructure. The erosion additionally affects the long-term future of Lake Bogoria because of rapid sedimentation. This example illustrates the disruption of the natural balance of soil production and erosion over geological time scales by human activity and the rapidity of the consequences of this imbalance.

Science 2015 Volumne 348 Issue 6235

ter stewardship of domesticated soils that leads to higher organic matter contents is a valuable practice from an ecological perspective and from an agronomic point of view (24). There is now a large body of research on the rates of C sequestration under differing management practices.

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

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 up-rooted during planned orchard removals.

"The last few projects that we've done,

AgAlert®

THE WEEKLY NEWSPAPER FOR CALIFORNIA AGRICULTURE

california almonds Almond Board of California

Project Title: **Almond Orchard Recycling**

Principal Investigator and Coordinator:
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Co-Principal Investigators:
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David Doll, UC Pomology Farm Advisor, University of California Cooperative Extension, Merced County,

Mohammad Yaghmour, Ph.D., Farm Advisor, University of California Cooperative Extension, Kern,

Elias Marvinney, Ph.D., Post-doctoral Scientist, Department of Plant Science, University of California,

Almond Board Funding: $50,000 April 1, 2016-July 31, 2016
Almond Board Funding: $94,000 August 1, 2016-July 31, 2017

Orchard Recycling Objectives:

To compare two methods of whole orchard recycling (WOR), chipping (WOR-C) vs. grinding (WOR-G) with the Iron Wolf, with orchard removal for energy co-generation.

Our specific objectives are to:

Refine life cycle assessment (LCA) model for evaluation of carbon dynamics and balance

Quantify effects of the treatments on the physical and chemical soil properties and tree nutrients

Quantify effects of the treatments on biological soil properties

Assess impacts of the treatments on replanted orchard growth, health, nutrition, production, and water relations

The Iron Wolf pushes the trees over going forward and grinds up the branches and trunk

Then Iron Wolf goes in reverse and incorporates the wood into the ground. Just one 50 ton machine that costs $1,500 acre to operate. Can do ~2 acres per day.

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Whole almond rows after being ground up and incorporated with the Iron Wolf 700 B. Wood distribution is uneven and large chunks are left behind ‘bowling ball pins’

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

The Morbark horizontal chipper can chip up 15-20 acres per day.

Screens can be used to limit chip size to 2 inches or less.

The Iron Wolf is being compared to this Morbark Chipper at Agriland Farming in Chowchilla.

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:

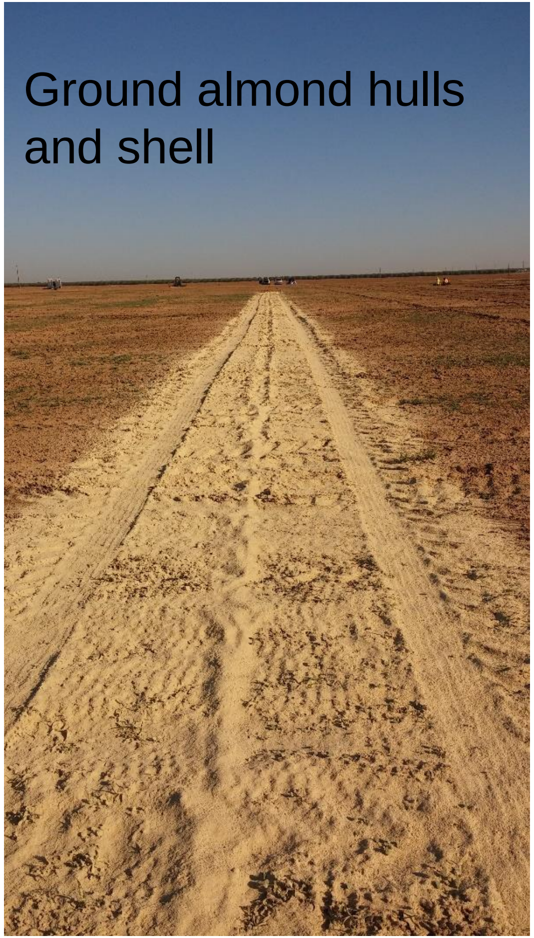
N= 0.31 %, 396 lbs/ac
K= 0.20 %, 256 lbs/ac
Ca= 0.60 %, 768 lbs/ac
C= 50 %, 64,000 lbs/ac

The nutrients will be released gradually and naturally

After spreading the woodchips growers can proceed with typical land preparation practices for the next orchard: ripping, disking, fumigation….

Trials with Wonderful in Kern County


Anaerobic soil disinfestation trials with Wonderful
Rice meal


Ground almond hulls and shell


Woodchips

Northwest Tillers incorporated both woodchips and substrates

Anaerobic soil disinfestation trials with Wonderful

CDFA funding

CDFA (USDA-AMS funding) has funded: Specialty Crop Block Grant

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Collaborators:
Wonderful Orchards
Agriland Farming
Talerrico Farms
G & F Agricultural Products
Iron Wolf

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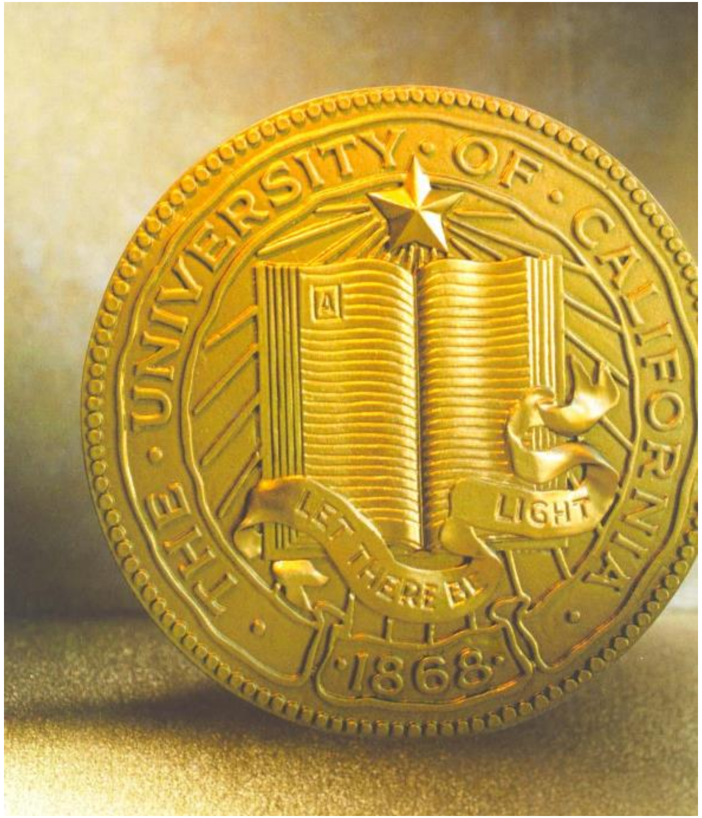
Seppi forest mulcher head
Seppi subsoil mulcher on tractor



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Thank You!

David Doll,
UCCE Merced

Orchard Almond Hull Incorporation

David Doll, UCCE Merced

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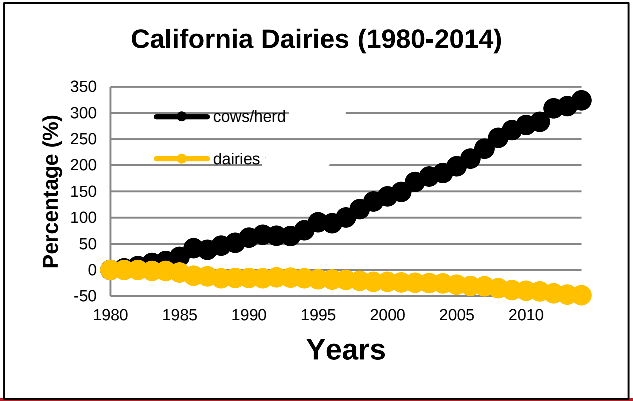
Almond Hull Production and Consumption

- The almond kernel is approximately 25% of the harvested field weight.
- The remainder is the shell (~25%) and hull (~50%)
- Almond industry produces around 4.2 billion pounds of hulls
- Currently, the dairy industry of 1.78 million cows can consume 2.6 billion pounds of hulls, assuming 8% TMR and current cow population
- Regulations are increasing dairy consolidation, herd size

Image sourced from http://www.thewholesomedish.com/



Data assembled by Dr. Alejandro Castillo, Emeritus UCCE Dairy Advisor, Sourced from CDFA

Almond Hull Analysis

Hull mixture was nutrient dense

Analytical work showed an estimated value of $51.92/ton assuming 90% dry weight, unspread

Fate of nitrogen is unknown, however, due to high C:N ratio

Nutrient	AVG Hull Content	Lbs/ton assuming 90% dry material	Value
Nitrogen %	0.76	13.68	$6.84
Phosphorous %	0.112	4.62 P_2O_5	$3.70
Potassium %	2.24	48.38 K_2O	$38.70
Sulfur PPM	370	0.65	
Boron PPM	82.7	0.14	$1.50
Calcium %	0.22	3.96	$1.18
Magnesium %	0.086	1.55	
Zinc PPM	12.6	0.02	
Manganese PPM	13.0	0.02	
Iron PPM	303	0.53	
Copper PPM	7	0.01	

Almond Hull Application Experiment

Amendment	Application Timing	Application Method	Application Amount
Control	-	-	-
Gypsum	Once, Week 0	Wetting profile	500 lbs/acre
Hulls	Once, Week 0	Wetting profile	1 ton/acre
Biochar	Once, beginning	Wetting profile	1000 lbs/acre
Humic Acid 1	Week 0, 2, 6	Dripline	3 gal/acre
Humic Acid 2	Week 0, 2, 6	Dripline	5gal/acre

Two locations

- – Sandy soil on drip
- – Clay loam on microsprinkler

Four blocks of 6 trees

- Soil health, chemistry, and physics evaluated
  - Microbial activity
  - Bulk density, infiltration, etc
  - Plant and soil analysis

Almond Hull Application

Hull mix was ground using a brush chipper to the size of a nickel

Applied to the ground at 1 ton/acre on April 28th

By late July, hull residue was minimal.

Outside of irrigation pattern, more remained

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Almond Hull Application: Negative Impacts?

		N %	P %	K %	S PPM	B PPM	Ca %	Mg %	Zn PPM	Mn PPM	Fe PPM	Cu PPM
Atwater	Control	2.56	0.15	1.66	1752	38	4.60	0.81	24	82	426	11
Atwater	Hull	2.54	0.15	1.93	1665	44	4.39	0.78	26	78	415	14
LeGrand	Control	2.60	0.15	2.49	1907	38	3.81	0.92	20	53	763	11
LeGrand	Hull	2.58	0.15	2.45	1917	39	4.06	1.00	23	56	789	11

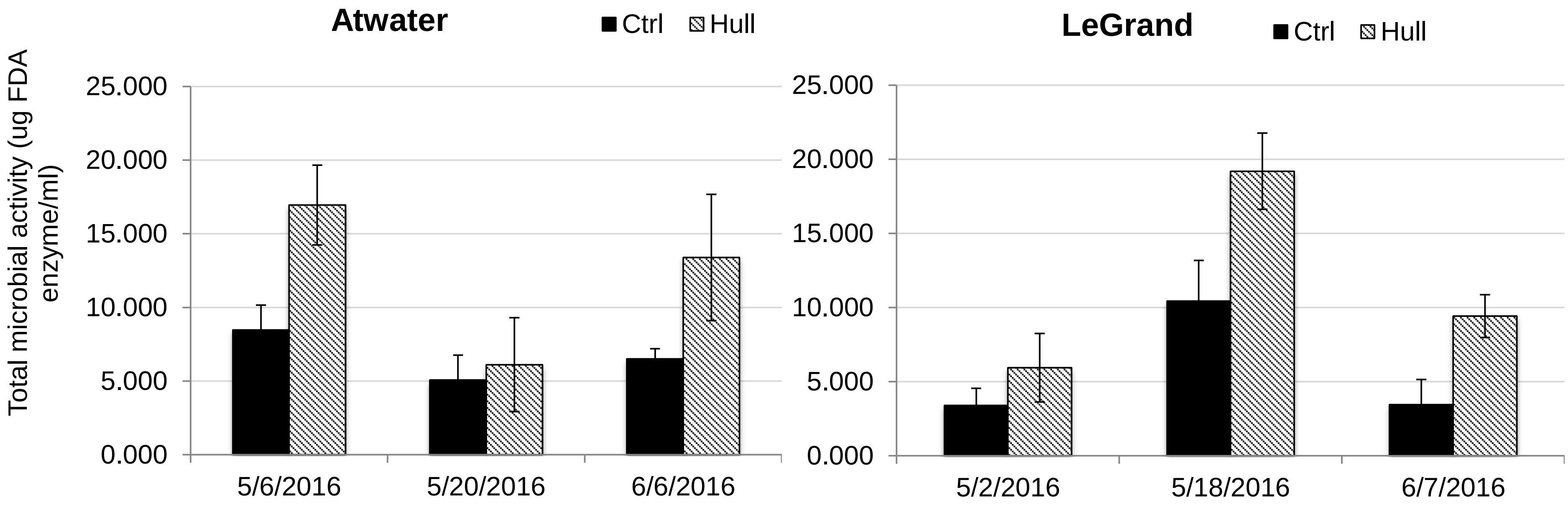
Mid-July Leaf Sampling (10 weeks post)

No impact on leaf tissue from almond hull application

No observed phytotoxicity at 1 ton/treated acre

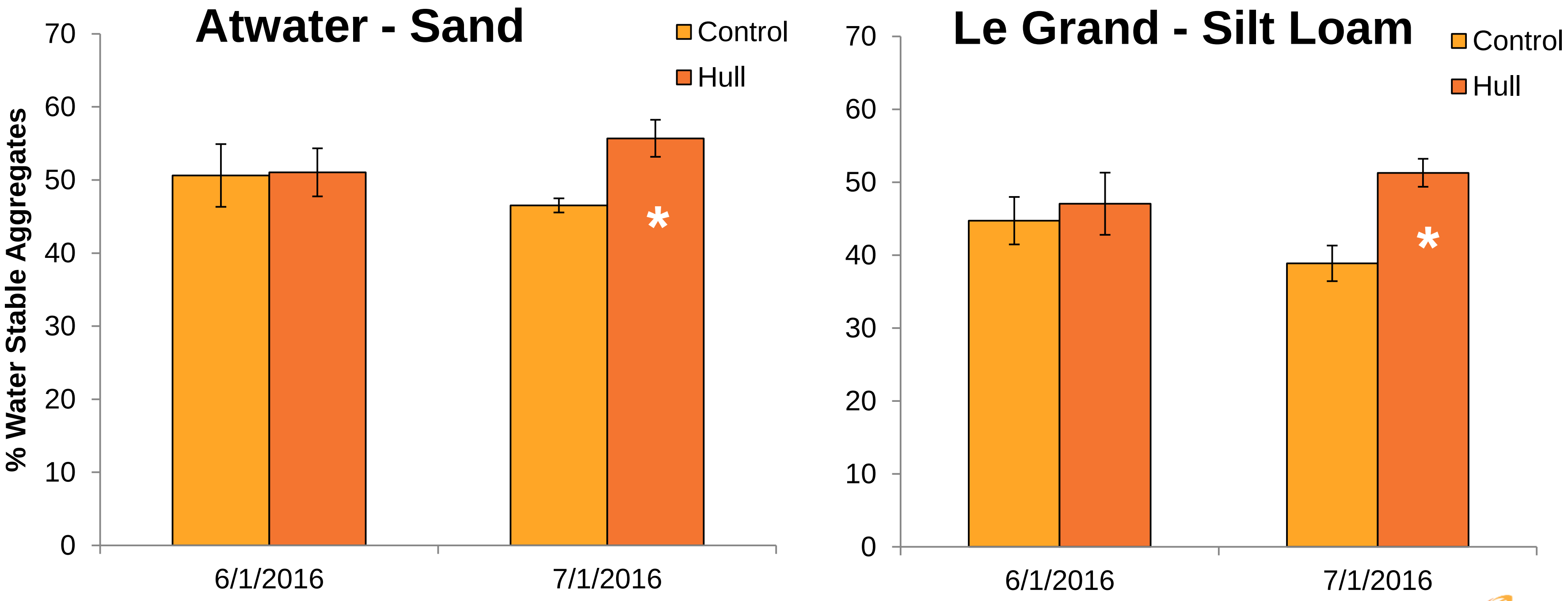
Almond Hull Application: Perceived Benefits

Increase in total microbial activity at both locations



Almond Hull Application: Perceived Benefits

Increase in aggregate stability over both locations



Almond Hull Application

Project Findings:

- No observed issues at 1 ton/treated acre;
- Did not appear to impact leaf nitrogen levels;
- Increased total soil microbial activity;
- Maintained aggregates within the soil;
- Addition of organic matter;
- Still working through the data, more on the poster, and hope to know more in a few months.

Almond Hull Application Feasibility

Compost v/s Almond Hulls

Compost	Consideration	Almond Hulls
15-40% (~25%)	Moisture	8-10%
Variable depending on source, NPK similar to hulls	Nutrient Content	General
$15-20/ton	Cost	$55/ton
$10/ton	Hauling Cost	$10/ton
$5/ton	Application	?
3-10 tons/acre	Rates	1-3 tons/acre
Fall	Timing	Fall-Spring
Moderate	Food Safety Risk	Minimal

Acknowledgments:

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Questions?

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The Almond Conference