Soil Quality: What's Relevant to Growing Almonds?

December 10, 2015

growing
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The Almond Conference

Speakers

Gabriele Ludwig, Almond Board (Moderator)

Karen Lowell, USDA – NRCS

Daniel Schellenberg, UC Davis

Roger Duncan, UCCE – Stanislaus County

Brent Holtz, UCCE – San Joaquin County

Managing For Soil Health: Opportunities and Challenges

Karen Lowell, Ph.D., CA CCA

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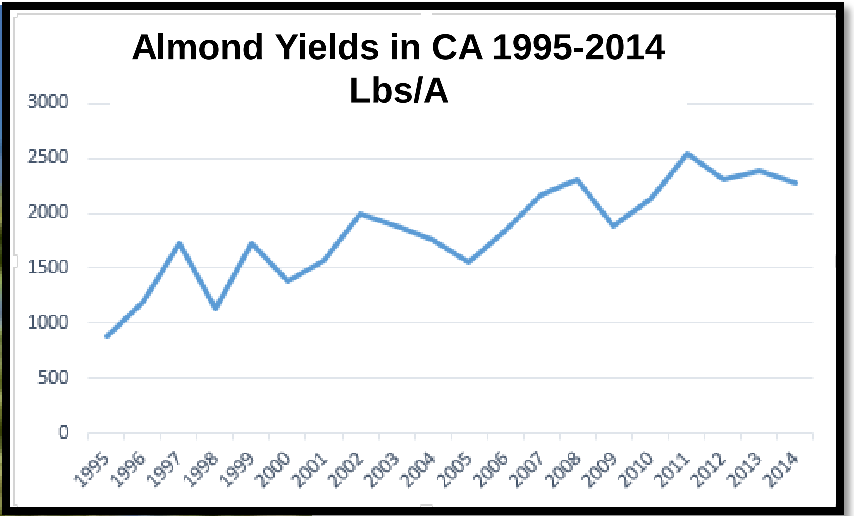
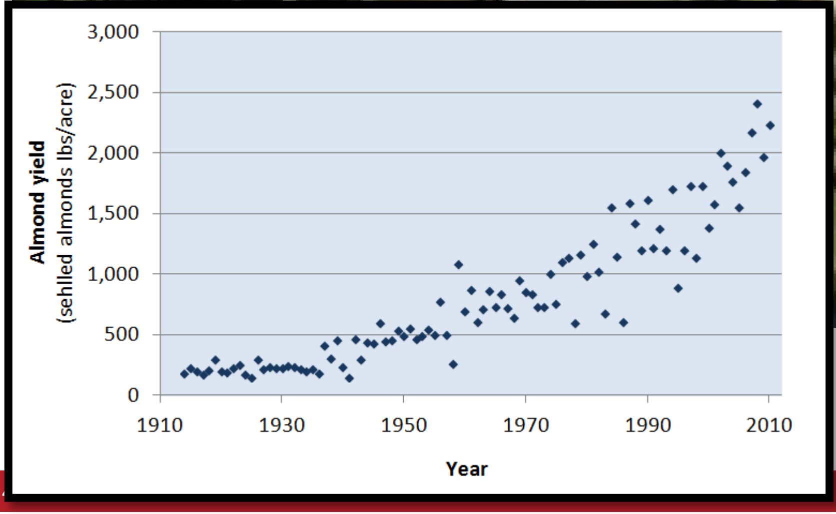
Problem? Where?





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https://apps1.cdfa.ca.gov/FertilizerResearch/docs/Almond_Production_CA.pdf

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Changing Management

Increased

- Tillage power
- Use of irrigation
- Use of fertilizer
- Use of chemical control strategies for pests/disease

Reduced

- Use of manure to supply crop nutrients
- Crop rotation to manage disease/pest cycles

Impacts Soil Health

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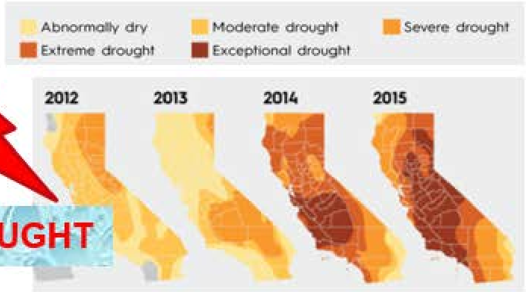
Challenging Conditions

DROUGHT



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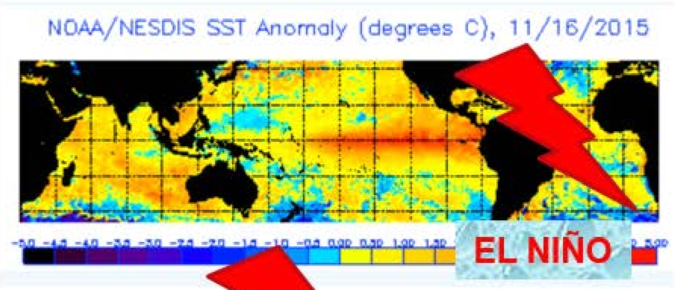

GROUNDWATER DEPLETION and SUBSIDENCE

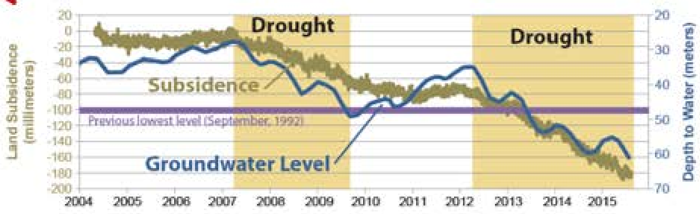

Figure 2 Graph showing vertical displacement at a selected GPS station and depth to water in a nearby well for 2004–2015 (see Figure 1 for location)

FUMIGANT EFFECTIVENESS

Increased Water Holding Capacity

Carbon Sequestration

Nutrient Cycling

Pest & Disease Suppression

Reduced Crusting & Sealing

Increased Available Water

Improved Infiltration & Drainage

Improved Buffering Capacity

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What Is Soil Health?

PHYSICAL INDICATORS

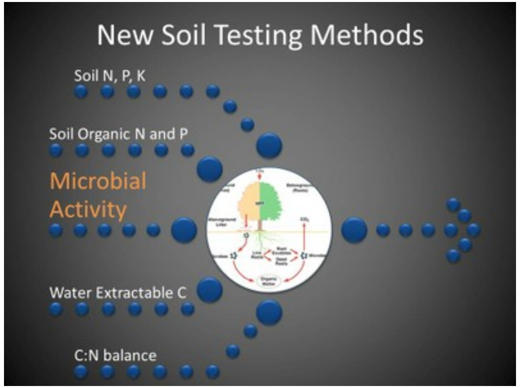
Aggregate Stability
Available Water Capacity
Surface Hardness
Subsurface Hardness

BIOLOGICAL INDICATORS

Organic Matter
Active C
Potentially Mineralizable N
Root Health Rating

CHEMICAL INDICATORS

pH
Extractable P
Extractable K
Minor Elements



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Managing for soil health is one of the easiest and most effective ways for farmers to increase crop productivity and profitability while improving the environment.

1. Keep the soil covered as much as possible
2. Disturb the soil as little as possible
3. Keep plants growing throughout the year to feed the soil
4. Diversify as much as possible using crop rotation and cover crops

Soil Health in Almond Orchards

Importance of soil carbon

- Increased infiltration and available water holding capacity
- Non-chemical disease suppression

What practices increase soil carbon?

- Organic soil amendments
- Cover crops

Management

- How can these practices be put in play in an almond orchard?
- What constraints are there for use in almond orchards?
- How can these constraints be overcome?

Increased Infiltration

Accumulated infiltration at 120 minutes through various cover crops and bare soils in a mature almond orchard		
	Early Season (mm)	Late Season (mm)
Clover	66.8 a	63.2 a
Resident Vegetation	52.3 a	54.9 a
Bromegrass	52.8 a	65.3 a
Chemical Mowing	63.0 a	39.1 b
Bare Soil	53.5 a	32.5 b
Numbers followed by different letters are significantly different @ <0.05 level.		

Source: Prichard et al. 1989. Orchard water use and soil characteristics
http://californiaagriculture.ucanr.org/landingpage.cfm?article=ca.v043n04p23&abstract=yes

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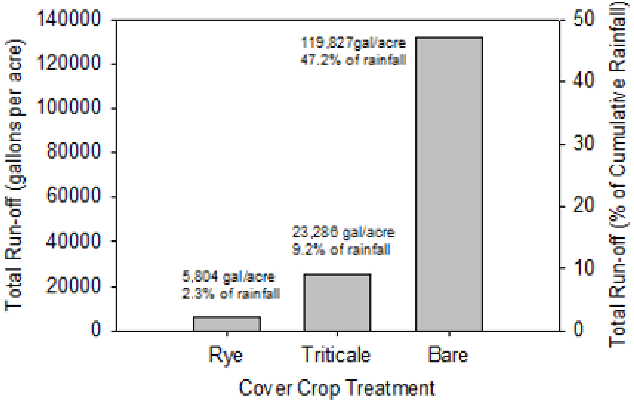
Increased Infiltration



Increased infiltration in the low residue rye cover crop treatment increased the quantity of chloride and sodium leached from the soil by >80% over the bare fallow treatment.

Figure 4. Winter dormant triticale (Trios 102) planted on the furrow bottom. Photo on right is 3 weeks after being treated with glyphosate. Note dead residue covers furrow bottoms.

Low residue cover crops where window for cover is short.

Work by Richard Smith et al. Monterey County UCCE

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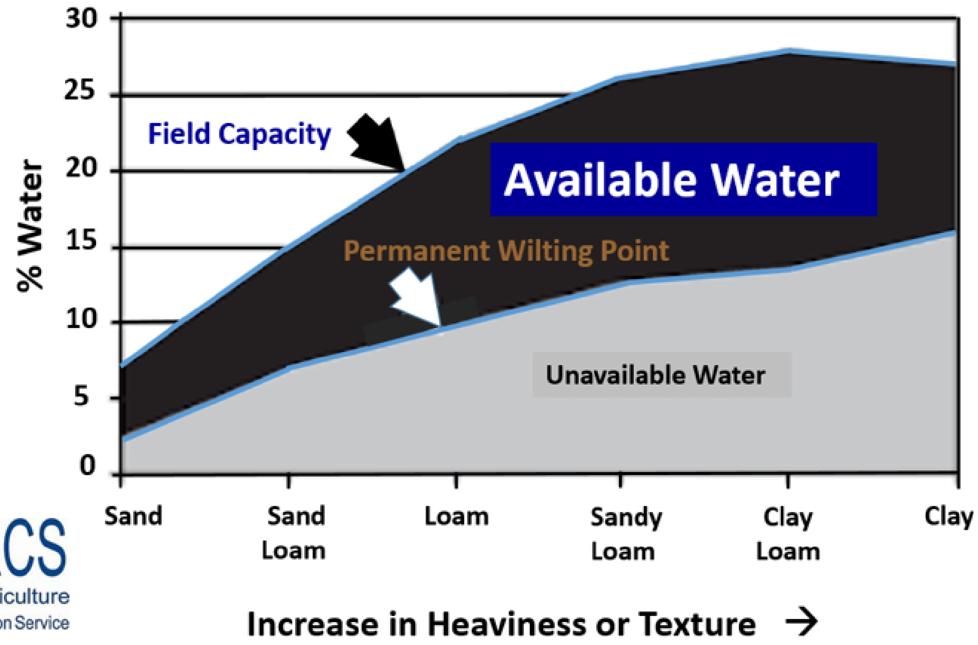
Article Available Online: UC ANR Blog: http://cemonterey.ucanr.edu/files/219694.pdf

Changing thinking about SOM and available water



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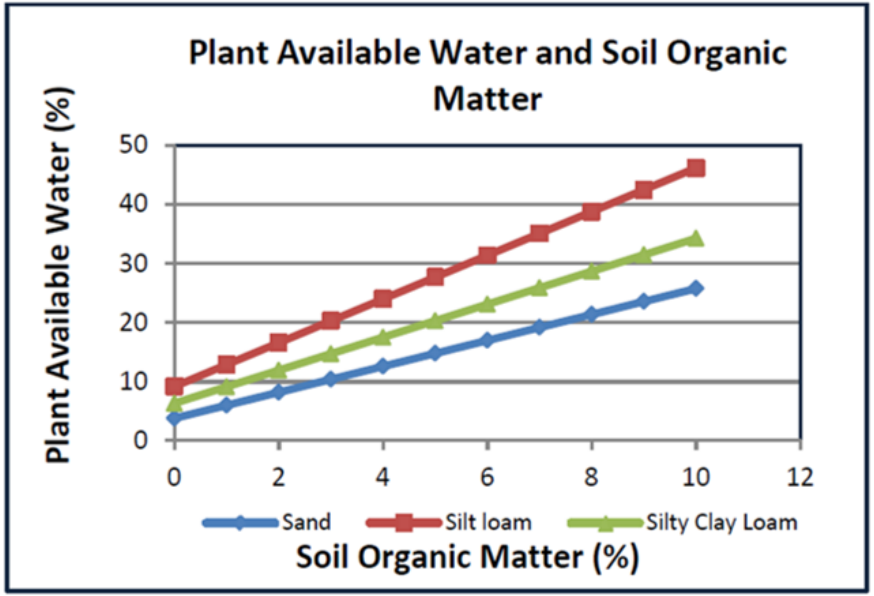
Contribution of SOM to Plant Available Water



Key opportunities to amend full volume of soil profile at planting

Adapted from Hudson (1994)

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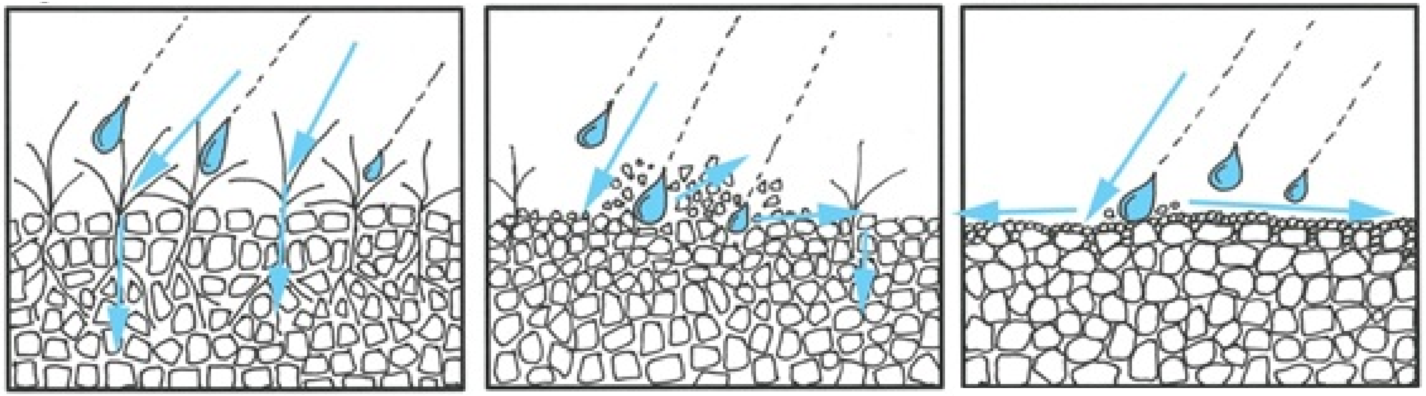
Surface Applied OM: Don't Let Perfection Be the Enemy of Progress

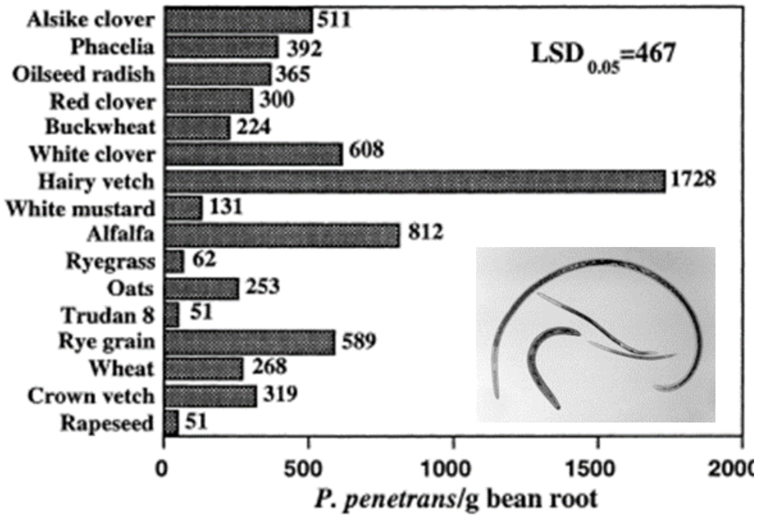
Protected soil surface High Infiltration	Exposed soil surface	Capped soil surface Low Infiltration

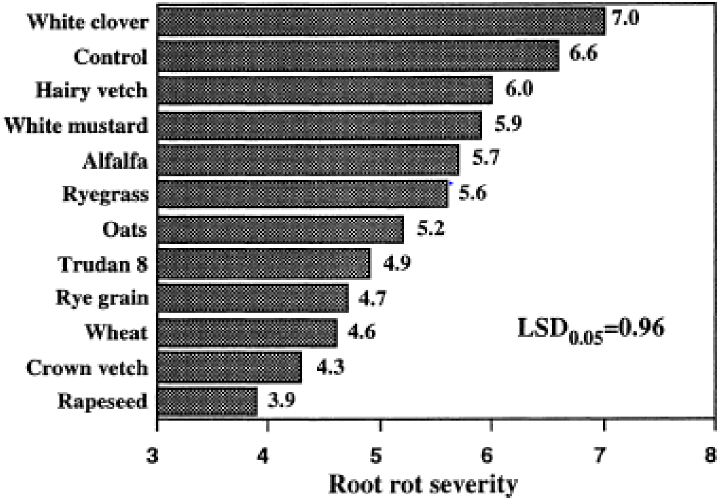


Plants protect soil from the impact of the raindrops. Water infiltrates.	Bare ground exposed to the full force of raindrops. Impact shatters soil crumbs and fine particles seal surface.	Dislodged soil particles block soil pores to form cap, leaving no holes for water to enter soil. Water forced to run off.

Source: http://www.evergraze.com.au/library-content/manage-ground-cover/

Managing Disease and Pest Pressure





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Abawi et al., 2000

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Measure What You Want to Manage

USDA

United States
Department of
Agriculture

Agricultural
Research Service

Natural Resources
Conservation Service

Soil Quality Institute

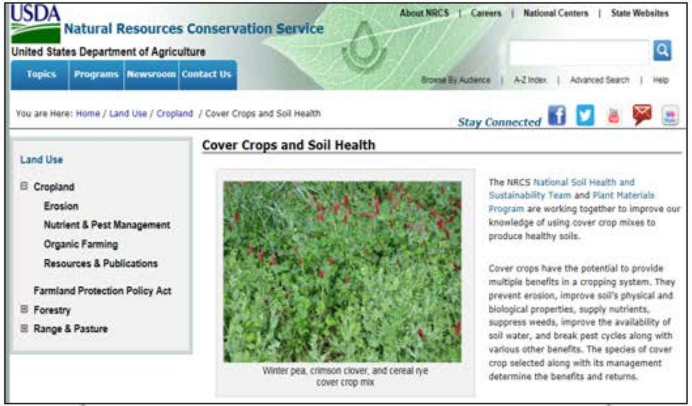
Soil Quality Test Kit Guide

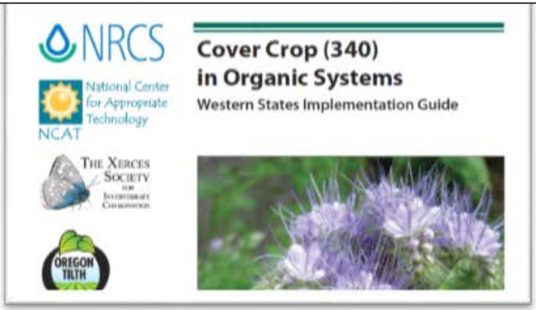
PHYSICAL INDICATORS

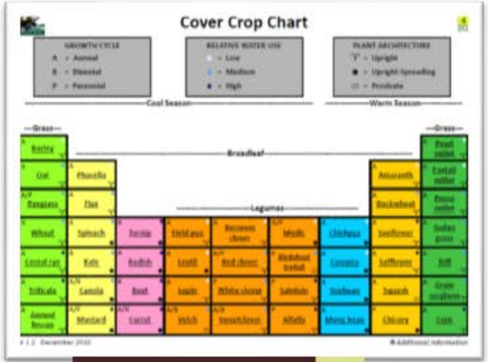
BIOLOGICAL INDICATORS

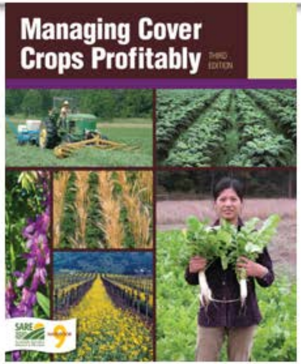
CHEMICAL INDICATORS

Find and Use Resources









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How Can You Make It Work for YOU?

- **What do you want to accomplish?**
- **What works somewhere?**
- **Can you figure out why it works?**
- **What can you realistically do?**

Karen Lowell, Ph.D., CCA

Area Agronomist

USDA-NRCS

Salinas, CA

Karen.Lowell@ca.usda.gov

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I welcome your calls and emails to find creative ways to support Soil Health!

Organic Matter Amendments – Use in Almonds, Research Needs, and Recent Developments

Daniel Schellenberg
Postdoctoral Scholar
Department of Plant Sciences
University of California Davis

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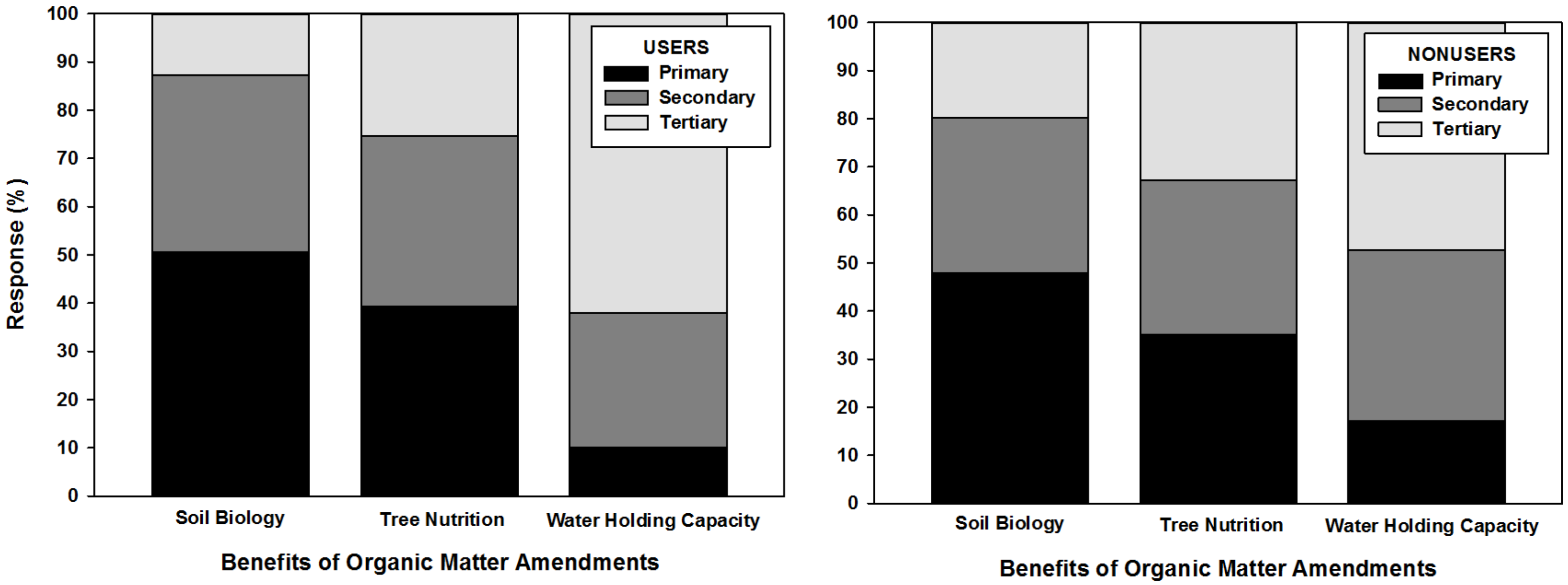
Overview

- What are the perceived benefits and concerns?
- Are there issues of access?
- Where are organic matter amendments used?
- What are the important research needs?
- Are there any recent developments?

Survey Overview

- 1,650 replies out of 6,230 unique addresses
- 26% response rate
- 1,120 usable surveys
- 500 opt outs
- 334,300+ acres

What are the perceived benefits and concerns?



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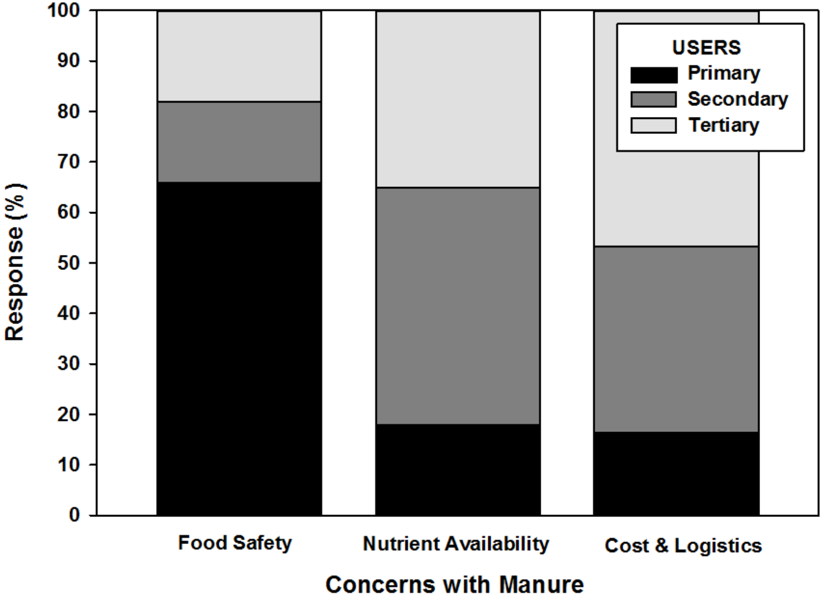

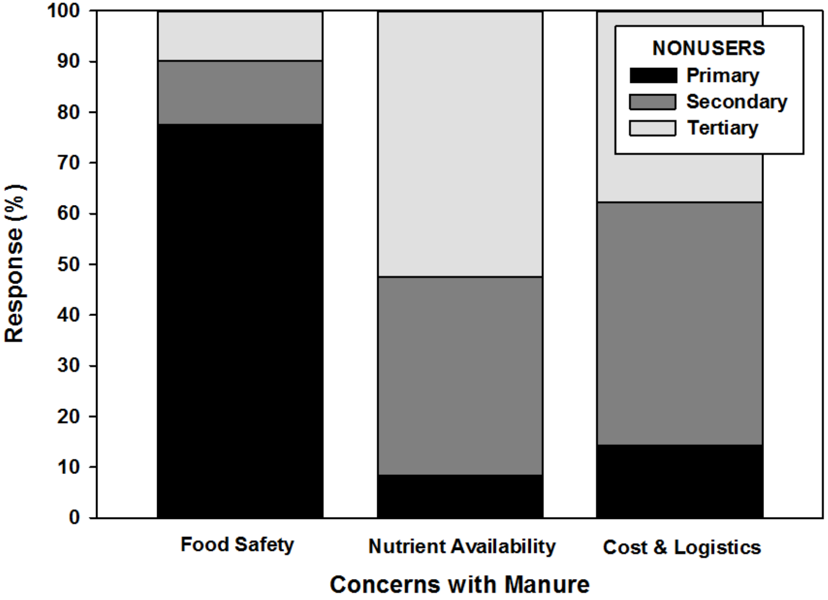

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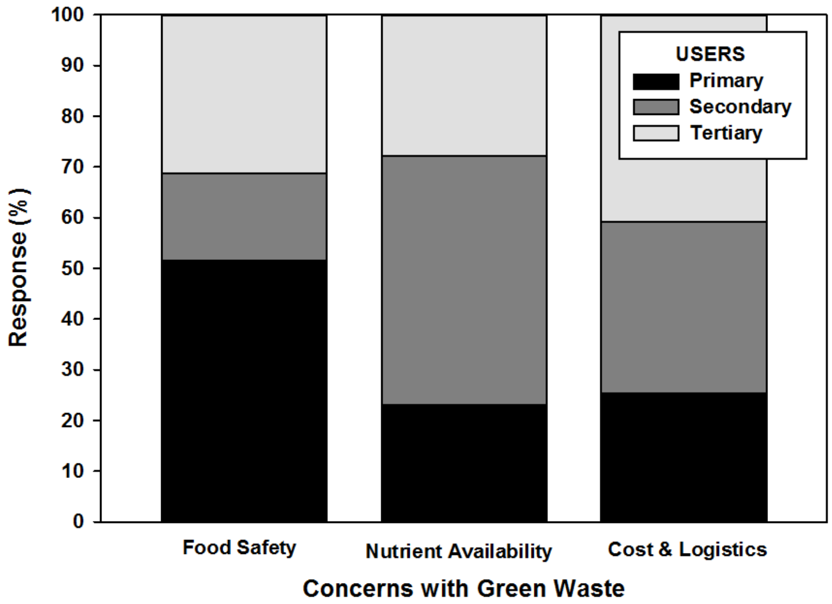
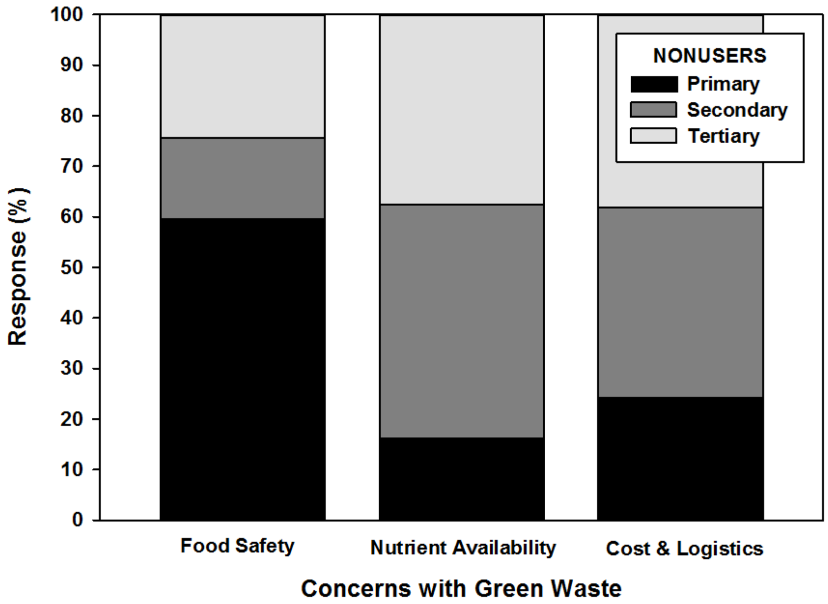
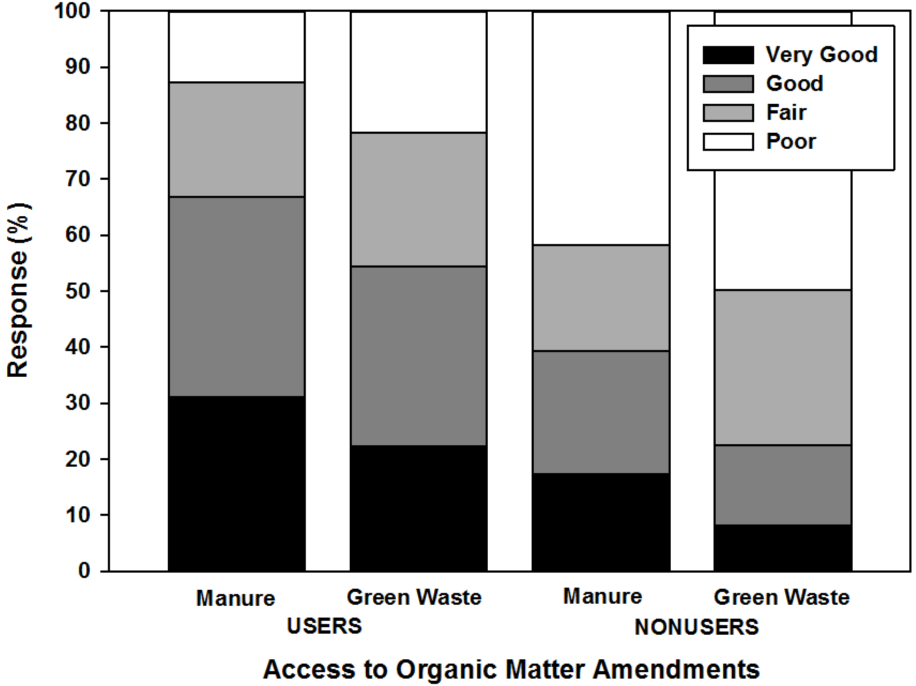
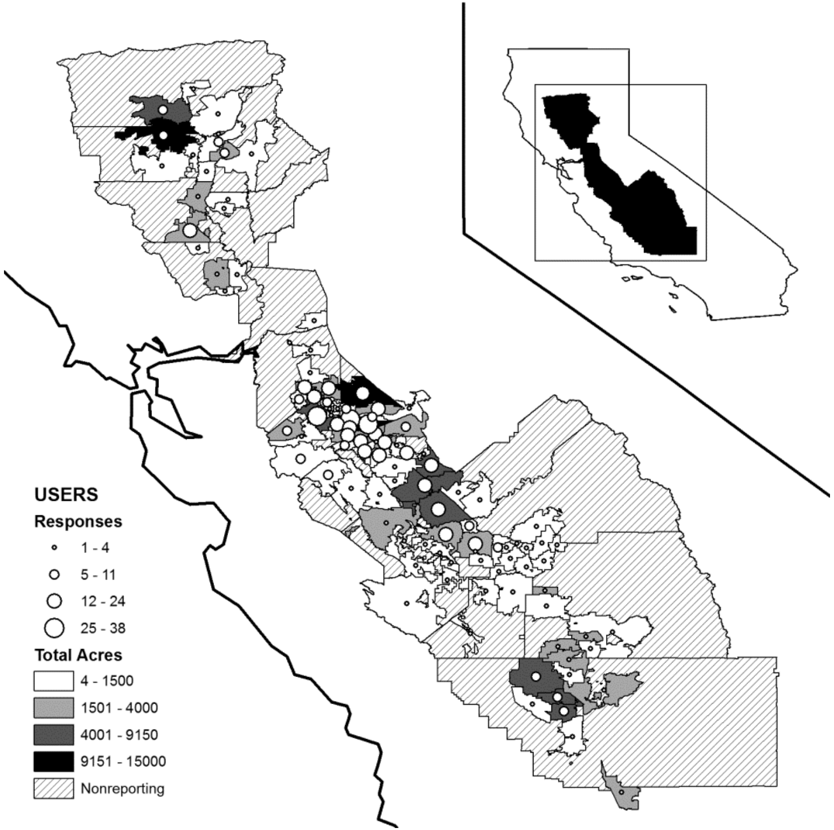




Are there issues of access?



Where are organic matter amendments used?



What are the important research needs?

- Dichotomy of Soil Type
- Amelioration after Planting
- Fertilizer Substitute (Mainly N and K)
- Water Water Water
- Effects on Orchard Age
- Consistency of Access
- Reproducibility

Are there any recent developments?

- 2016 Stanislaus Trial – Clay versus Sandy Soil
- Focus on Young Trees
- N Storage and K Inputs
- 2016 Escalon Trial – Stem Water Potential
- Long Term Research – 5+ years and Old Orchards
- Partnership with Livestock Operators

Can We Improve Soil "Health" and Orchard Performance With Organic Amendments?

Roger Duncan, UCCE Farm Advisor

Stanislaus County

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Theoretically, adding OM to the soil is a good thing

- Can we significantly increase OM in orchards with soil amendments in a reasonable, economically viable way?

- Does it produce meaningful changes / benefits we can measure that a grower would care about?

A Comparative Analysis of Soil Amendments Used in Peach Production, 1992-96

- *Harry Andris, UCCE Pomology Advisor, Fresno County*
- *Integrated Waste Management Board, State of California*

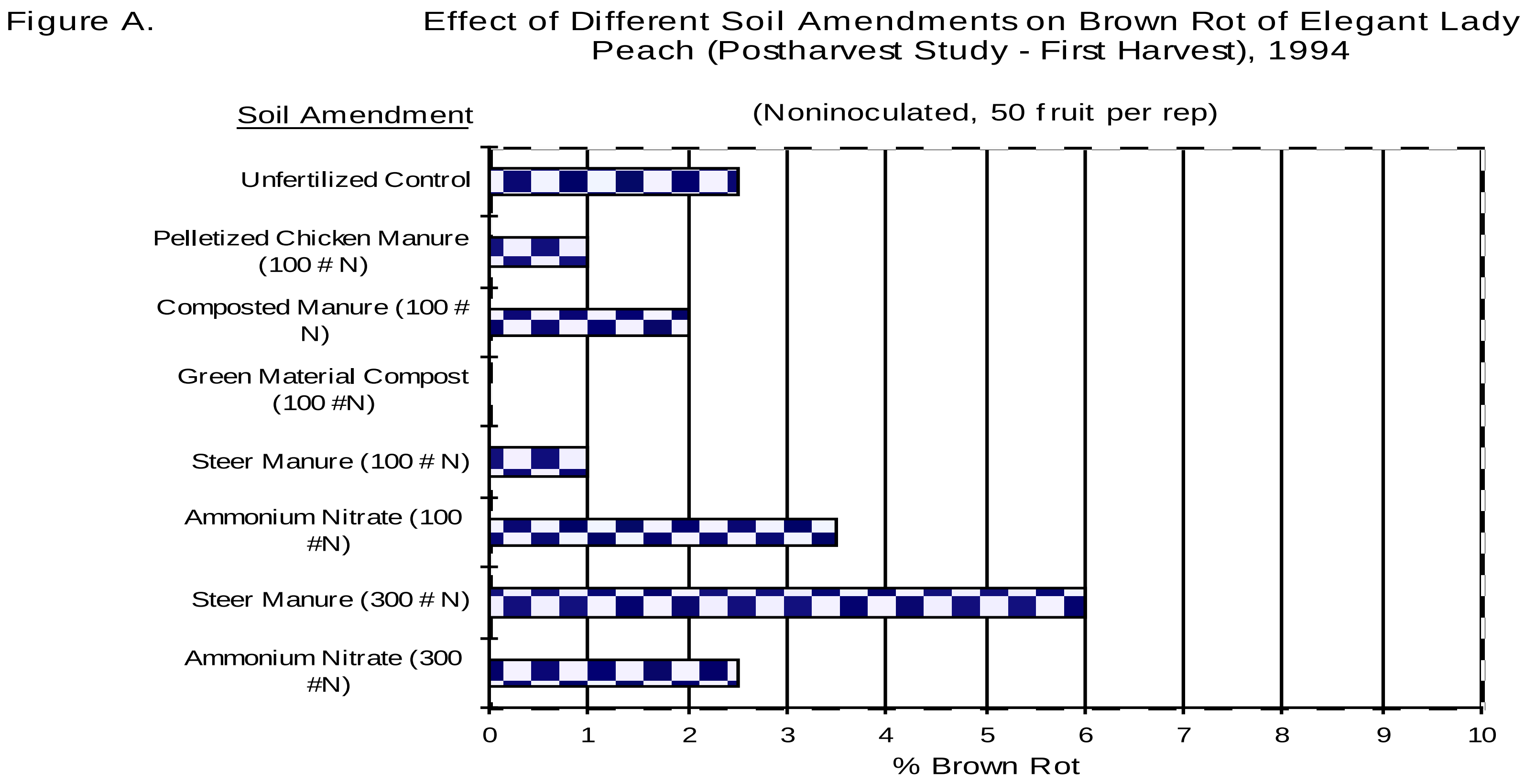
- *Dr. Scott Johnson, Extension Pomologist*
- *Dr. Kent M. Daane, Entomology Specialist, U. C. Berkeley*
- *Dr. Themis Michailides, Plant Pathologist, Kearney Ag Center*
- *Dr. Carlos H. Crisosto, Postharvest Physiologist, U. C. Davis*
- *Dr. Tim Prather, Weed IPM Specialist, Kearney Ag Center*
- *Wawona Orchards, Clovis, California 93611*
- *Community Recycling & Resource Recovery, Inc., Lamont, California*
- *City of Sanger, Disposal/Recycling/Compost Division*

Amendments were tested against ammonium nitrate fertilizer for four years – NOT SUPPLEMENTED

1. Unfertilized Control
2. 100 lbs. N/ac. Pelletized Chicken Manure
3. 100 lbs. N/ac. Steer Manure Compost
4. 100 lbs. N/ac. Green Waste Compost
5. 100 lbs. N/ac. Ammonium Nitrate
6. 100 lbs. N/ac. Steer Manure
7. 300 lbs. N/ac. Steer Manure
8. 300 lbs. N/ac. Ammonium Nitrate

Commercial ‘Elegant Lady’ Peach Orchard
¼ acre reps

In one year out of four, significant reduction in brown rot in compost area fruit



Bottom line after four years:

- No significant differences in
  - Yield
  - Fruit size
  - Fruit calcium or potassium
  - Most fruit quality parameters
  - Postharvest parameters

- Lower leaf and fruit nitrogen in compost treatments
- Less brown rot fruit rot in one year in green waste compost treatment
- Consumer taste tests preferred ammonium nitrate over organic amendments (less mushy)

2000 – 2004 Peach Replant Trial, Stanislaus County

- Can we use a combination of pre-plant and post-plant treatments to obtain results equal to, or better than, methyl bromide fumigation?

- What about organic & microbiological soil amendments?

Peach Replant Trial

Field Specifics

- Third generation peach orchard.
- Soil = loamy sand.
- History of replant problem / bacterial canker.
- Moderate / high populations of ring and root lesion nematodes.

Cling Peach Replant Trial

- **Pre-plant treatments; October 2000**
  - Methyl bromide tarped @ 400 lb per acre
  - Vapam HL at 250 ppm (75 gpa) drenched
  - *Telone II strip shanked @ 32 gpa.
  - Nonfumigated

Fumigation treatments applied across rows

Post-plant treatments applied down the rows

Cling Peach Replant Trial

Post-plant treatments applied across all preplant fumigation treatments

-Post-plant treatments applied for three years

- Composted green waste & manure + oyster shell flour at planting
- Compost + microbial amendments injected through drip system
- Compost + humic acid, commercial kelp product + microbial amendment

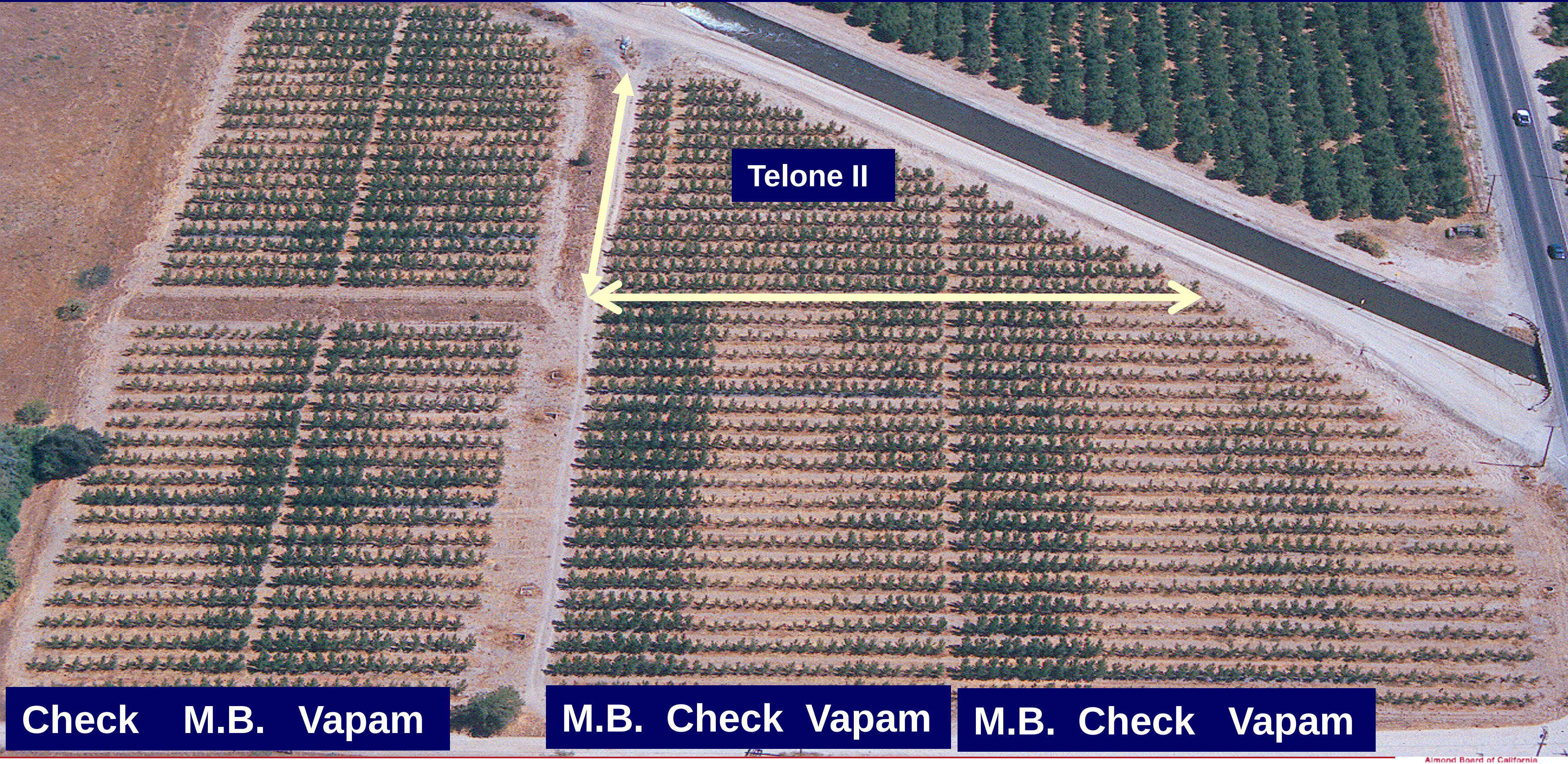
Application of compost to berms prior to planting; backfilled at planting.

4.7 tons composted green waste / acre

+ 4.7 tons composted manure / acre

+ calcium amendment

Peach Replant Trial, Stanislaus County. September.
Second leaf 'Loadel' on Lovell Rootstock



Parameters Measured

- Plant parasitic & free-living nematodes
- Soil microbial community dynamics
- Tree nutrition
- Tree vigor
    - dormant pruning weight
    - summer pruning weight
    - trunk circumference
- Yield, fruit size, fruit firmness
- Treatment costs per acre

Pruning Weights (lb / tree) after Three Years of Post-plant Treatments

	Unfumigated	Methyl Bromide	Vapam
Check	2.7	13.5	7.2 a
Compost alone	1.4	11.4	4.9 ab
Compost + monthly injected microbes	2.6	12.5	5.2 ab
Compost + monthly kelp & humic acid	2.1	10.0	4.5 b
	n.s.	n.s.	

Yield (Kg) of Fruit per Tree. Third Leaf

	Unfumigated	Methyl Bromide	Vapam
Check	9.9	26.7	20.8 a
Compost alone	9.3	21.0	14.3 b
Compost + monthly injected microbes	10.2	22.5	16.1 ab
Compost + monthly kelp & humic acid	9.0	24.4	14.6 b
	n.s.	n.s.	

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Bottom Line after Three Years

- Preplant and post-plant compost, with or without added microbial supplements, humic acid, kelp, etc., had no significant effect* on:
  - Peach Yield
  - Fruit size
  - Tree growth
  - Tree nutrition
  - Pathogenic nematodes

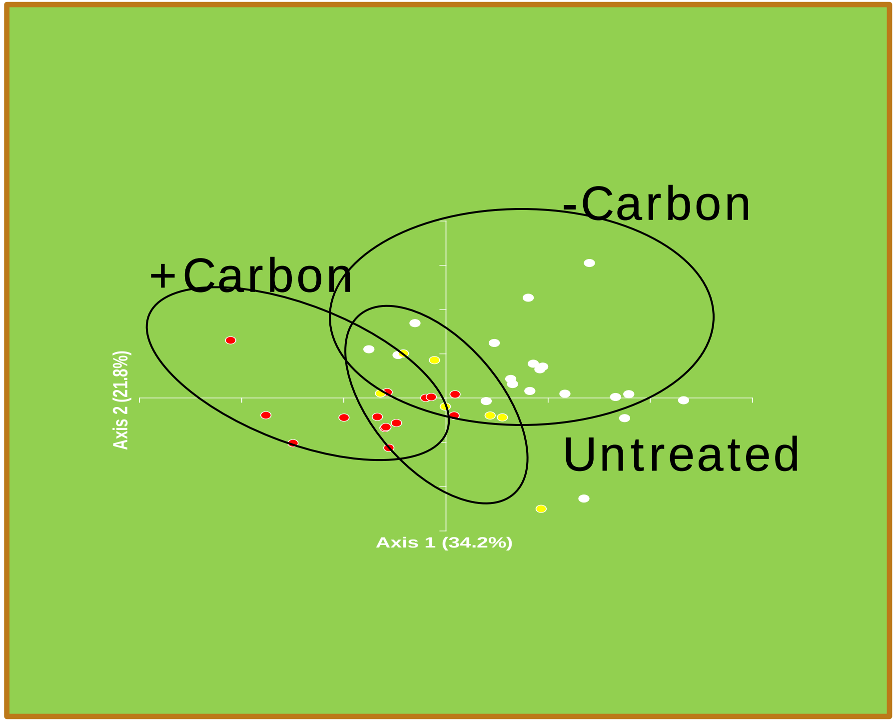
  - *tendency for lower yield in Vapam treated-areas with compost

Effects of Amendments on Soil Microbial Community
- in cooperation with Dr. Kate Scow, LAWR, UC Davis

- How do alternative fumigants and soil amendments alter soil microbial communities?

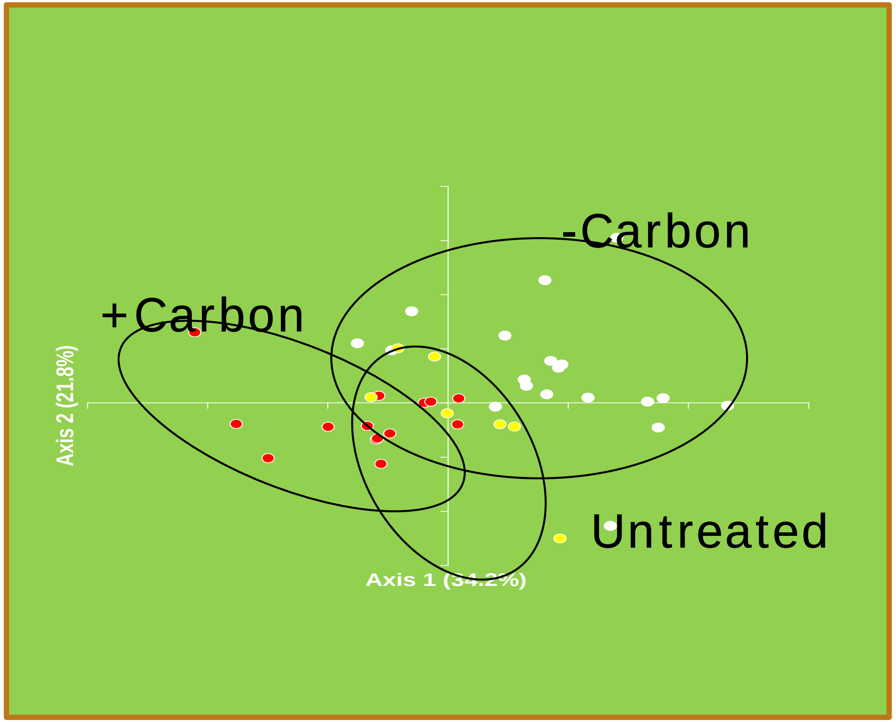
- How do soil microbial communities relate to plant performance?

Peach Soil Microbial Community



- Carbon (compost) addition most important in shaping microbial community
- Microbial biomass higher in +C treatments, lowest in MB fumigated and mulched plots
- Microbial inoculants had no overall effect on community composition

Peach Soil Microbial Community



- MB decreased biomass and certain functional groups
- Tree growth best in fumigated treatments
- Long term benefits of larger microbial community?

Preplant & Post-plant Compost on Young Almond Trees -2015 first leaf

- Composted green waste @ 5.16 tons applied per acre (equivalent to 28 tons broadcast)
- Composted dairy manure
- Urea @ 0.2 lb / tree (equivalent to N in composted green waste; assuming 20% available)
- Unamended

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Amendments incorporated at planting time. Additional ½ ton after planting.
- Two locations

Effect of Preplant Compost on 1st Year Tree Growth. Stanislaus County.

	Kiernan Road 'Nonpareil' (Nemaguard)		Ladd Road 'Independence' (Viking)
	Trunk circumference (cm)	Tree Height (feet)	Trunk circumference (cm)
Check	20.1	8.3	16.4
Green waste	19.3	7.9	16.4
Manure	19.3	8.3	15.5
Urea	19.4	8.5	16.0
	n.s.	n.s.	n.s.

- No measureable benefit in tree performance yet

Grower Compost (Green Waste) Demonstration Trial – West Modesto

Planted January 2012 (4th leaf)

- 75 tons applied to strips of 7.5 acres (10 applied tons / acre) preplant
- Not incorporated into berm
- 10 tons applied next to trees annually in fall
- Compost is in addition to grower's normal good fertility program
- Drip irrigation with some water penetration issues
- Applied to 15 rows in center of orchard, compared to sections east & west

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Grower Compost Demonstration Trial – West Modesto

Grower Compost Demonstration Trial – West Modesto

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Effect of Compost on Soil Chemistry

	Sampling Depth	Saturation Percentage	pH	CEC (meq/100g)	% Organic Matter
Compost	0 - 4"	36	6.8	12.8	2.68
	4"-12"	25	6.9	7.0	0.97
	12"-18"	27	7.2	7.3	0.77
No Compost	0 - 4"	29	6.7	7.6	1.12
	4"-12"	29	6.2	7.9	0.87
	12"-18"	27	6.0	8.6	0.83

Effect of Compost on Soil Chemistry

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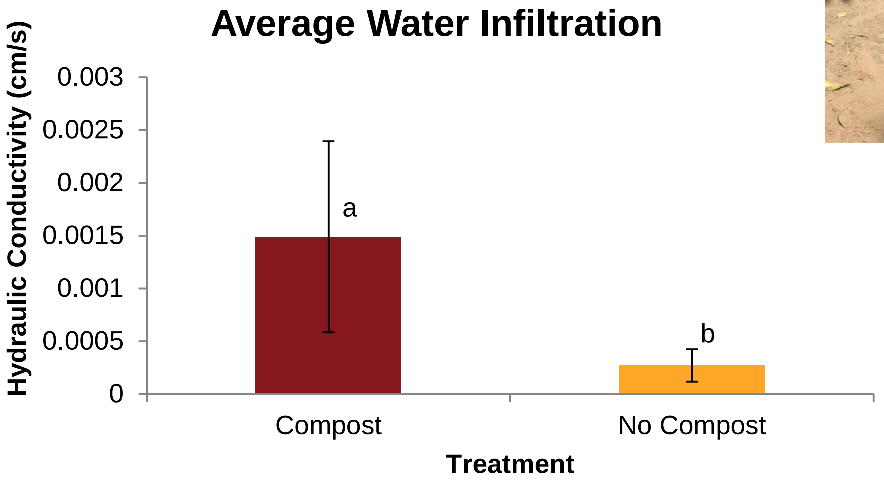
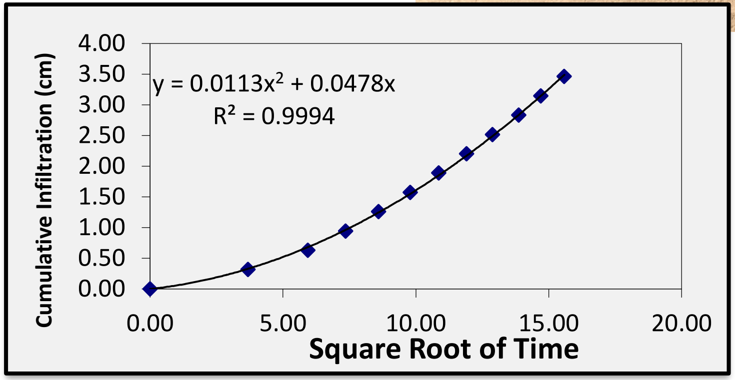
	12”-18”	27	7.2	7.3	0.77
No Compost	0 - 4”	29	6.7	7.6	1.12
	4”-12”	29	6.2	7.9	0.87
	12”-18”	27	6.0	8.6	0.83

Water Infiltration Test

-Vivian Lopez, UCCE Merced





Surface infiltration was better in compost area

Trunk Circumference Comparison – Nonpareil on Nemaguard

Grower compost demonstration trial – West Modesto

No Compost Rows -East of compost area	Composted Rows	No Compost Rows -West of compost area
51.3 cm	52.8 cm	52.7 cm

No apparent size difference or leaf nutrient status after four years of compost applications

Cost of Compost Application

Grower compost demonstration trial – West Modesto

- $17 / ton delivered + ~ $6 / ton to spread (1 day to apply on 7.5 acres)
- ~ $230 / acre annually
- ~$920 / acre cumulatively over four years

Many Questions to Answer:

- Is there a way to significantly increase OM in California orchards beyond the top inch or two?
- Spreading compost seems very inefficient and expensive and probably increases the carbon footprint. Can we accomplish the same thing with resident vegetation or planted cover? Maybe preplant is best?
- Does adding carbon / increasing microbial biomass make a meaningful difference to the trees (or the grower)?
- Improving “soil health” with amendments may be a very long term (and expensive?) process

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The Effect of Shredded Prunings and Grinding Whole Trees on Soil Quality and Second Generation Tree Growth

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

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- With urban encroachment we could no longer burn orchard prunings

Slow Burn

by Dan Campbell

Modesto growers find chipping preferable to brush burning

With the urban sprawl of Modesto abutting their almond ranch, Stan Holtz and his son, Brent, find it increasingly difficult to burn orchard prunings. Designated burn days seem to be getting fewer (they estimate there were only 20 last year), and sometimes when they do burn, the city folk complain. All it takes is one wayward breeze to produce a rash of complaints from the nearby housing tracts.

Brush burning has other drawbacks as well. The Holtzes don't like brush piles taking up valuable orchard space and scorching trees too near the burning piles. They also don't like to see all that good organic material going up in flames year after year.

Having decided three years ago that the days of brush burning were fast coming to an end, the Holtzes began chipping their orchard prunings. Stan had been chipping wood from the family's one-acre garden for 10 years and liked the way the organic material left behind by the decomposing chips improved the soil structure and increased soil fertility. So he and Brent decided to try chipping almond prunings.

The first year they rented a small chipper and did a four-acre section of their home ranch, which had been heavily pruned. Instead of hauling the wood chips to a biomass plant, they spread the one-quarter inch pieces across the orchard floor and raked them into a uniform layer.

For the last two years, they have chipped prunings from all 70 acres of almonds that they farm. It takes a three-man crew four days to complete the job. This year Stan didn't even buy a burning permit.

They feel the cost of their $10,000 chipper is already being offset by improvements in soil fertility, soil structure and water-holding capacity. In fact, they had their best harvest ever last year.

"Farmers have known about the benefits of adding organic material to soil for thousands of years," says Brent, a plant pathology graduate student at UC Berkeley. "But it's been difficult for almond growers to incorporate their pruned brush back into the soil because of the large size of the branches."

The Holtzes approached chipping their prunings with caution. Initially, they were concerned about whether the chips would decompose fast enough to avoid interfering with the following harvest. But that issue was put to rest the first year when they discovered that the wood chips readily decomposed in one season.

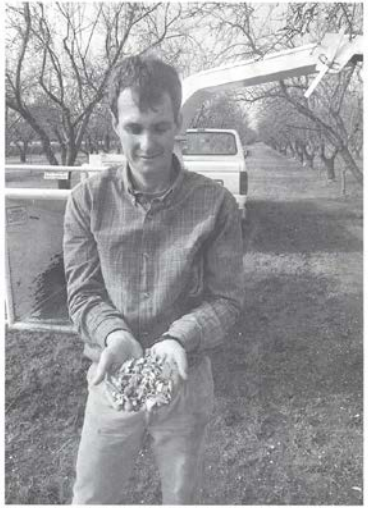
And they wondered about increased foreign material counts in their deliveries. However, there have not been any problems with that, even on their non-tillage orchard near Oakdale. "Our foreign material counts have not gone up," says Stan, a Blue Diamond member. "Our huller is pretty picky, and he has seen no difference in our deliveries since we started chipping."

They also worried about whether the wood chips might initially tie up too much nitrogen and cause a nitrogen deficiency for the trees. But that does not appear to be the case.

Brent explains that as soil micro-organisms and warm, moist conditions during the summer decompose chips into humus, the water and nutrient-holding capacity of the soil is increased. And, he adds, organic material is an important source of phosphorous, sulfur and nitrogen, and the humus increases aeration and the pH buffering and cation exchange capacity of the soil.

"We pour lots of nitrogen on almonds, but how much is actually utilized?" asks Stan. The Holtzes' soils are very sandy and they believe nitrogen is lost through leaching when they irrigate. "If this process allows us to reduce our need for fertilizers — even if it takes five years to reach that point — it would be a big plus," says Stan.

Organic material also increases fungi and bacterial populations which compete with plant parasitic nematodes. "Some Valley soils have become so sandy that nematode populations are way up — they like sand," says Brent. "Some fungi found in soils with high levels of organic matter can actually kill nematodes by snagging them with microscopic lassoes."



Brent Holtz (opposite page and above) feeds orchard brush into chipper, which reduces prunings to small fragments that quickly decompose, improving the structure and fertility of the Holtz' orchard soil.

They now have the system down well enough that the chipper can be adjusted to shoot the chips out on a trajectory which distributes them adequately without raking. The chipper, towed down the orchard row by a tractor, shoots the chips out over the heads of workers, who hand-feed the brush.

"Our chipper takes everything we prune with ease," says Stan. "Once in a while an elbow gets bound up, but its not size so much as shape," he says, adding that the chipper will accept wood up to nine-inches in diameter.

"I can see a big difference in soil fertility," says Brent. "After the first big rain of the year, we had a heavy growth of mushrooms, a sure sign of increased soil fertility and organic matter." Organic material also makes the orchard floor more resistant to soil compaction, he adds.

Says Brent: "Burning brush causes air pollution and wastes organic matter that would have been good for the soil." He notes that the concept of generating power with orchard prunings in biomass powerplants is "a good one on the surface." But in reality, he says, "with all of the energy spent creating chips and hauling them to biomass plants, I wonder how much real energy savings is being realized — especially when energy again is used to make synthetic fertilizers that replace the organic matter hauled off of an orchard in the form of nuts and prunings. I believe chipping the brush and returning it to the soil is a better alternative." ■

Are these wood chips affecting soil nutrients and the microbial community of almond soils?

Wood chipped vs Non-chipped

Wood chipped almond orchard soils were sampled and compared to non-wood chipped orchards

Wood chipped vs Non-chipped Orchard

Wood Chipped Almond Orchards:

- more wood rotting basidiomycetes
- more bacterial and fungal feeding nematodes
- increased soil nutrient levels
- lower pH
- more organic matter, higher soil carbon

Almond farmers lead as environmental stewards

by Christine Souza

To improve air quality, California almond growers are implementing a shredding technique shown above, to dispose of prunings and limit the amount of agricultural burning that takes place in the field. Shredded prunings, at right, are reduced to the size of a quarter

As California's population continues to escalate and the number of vehicles on the state's roadways reaches an all-time high, concern about air quality increases with more pressure put on farmers and ranchers to make changes in their everyday operations.

Like their counterparts in other commodity groups, the state's almond growers, who produce almost all of the domestic supply in the nation and more than 75 percent of worldwide production, have done their part to improve air quality by reducing the amount of agricultural burning.

"Reducing agricultural burning is something we can work on to improve the air quality in the Central Valley and we are intent on doing that," said Chris Heintz, Almond Board of California director of production research and environmental affairs. "Of course our bottom line is selling almonds, but we have to do it within the framework of agricultural and urban dwellers in the valley. We want to do our part. It is about making this a better place to live. It is about being sensitive to our environment."

The almond sector has set air quality as a top priority and is looking at research projects that lead to viable alternatives for disposal of orchard prunings, other than burning. Since the 1980s, the Almond Board has funded various projects related to brush utilization.

"Our board several years ago designated the environ-

"The time will come when we won't be able to open-field burn brush anymore. A lot of growers have seen the writing on the wall and it is amazing as to how many are opting to have guys come in and shred now, even when they could burn if they wanted to," Holtz said. "I think a lot of the growers have always felt that it was a waste to put on water and fertilizer and then take all of the prunings and burn them. With the shredding technique, I think there is a feeling that not only are you not polluting the air, you are also putting fertilizer back into the ground."

Until now, growers have been reluctant to consider this technique an alternative to burning due to the cost of the equipment necessary to chip the prunings. They also found that the early chippers left pieces of wood in the orchard that were too large, resulting in slow decomposition and interference with pickup of nuts at harvest. However, with strict air pollution control standards on the horizon for the Central Valley and more efficient equipment now available, more growers are willing to chip or shred rather than burn. Growers are also pleased to discover the benefits of incorporating the organic matter into the soil.

Madera County Farm Bureau member Larry Lowder, of Andrews Farms, a multi-generational family farm in Madera, worked with Holtz and hired Joe DiAnna to break down and remove several thousand acres

is more cost involved
t we got out of it, I think
her alternative," Lowder
urn days that we need to
are of, so I don't see any

to wood chipping, grow-

CONTINUED ON PAGE 26

Photos/Christine Souza

Almond grower Larry Lowder, top, implemented the shredding technique on several thousand acres at his orchard in Madera. Brent Holtz, University of California Cooperative Extension farm advisor in Madera County, above, researched the chipping and shredding of almond orchard prunings.

Almond growers adapted to shredding their brush and shredders evolved to meet the demand…..

2003 Orchard Experiment

2003 wood chipping experiment, Larry Lowder

C	NP	M	NP	C	NP	M	NP	C	NP	M	NP	C	NP	M	NP	C
C	NP	M	NP	C	NP	M	NP	C	NP	M	NP	C	NP	M	NP	C
C	NP	M	NP	C	NP	M	NP	C	NP	M	NP	C	NP	M	NP	C
C	NP	M	NP	C	NP	M	NP	C	NP	M	NP	C	NP	M	NP	C
C	NP	M	NP	C	NP	M	NP	C	NP	M	NP	C	NP	M	NP	C

NP= Nonpareil
C= carmel
M= Monterey
brush and wood chips
no brush and no wood chips

The Nonpareil rows will be the center rows of the two treatments
In the no brush NP rows, brush will be thrown into the adjacent M and C rows.
In the brush and wood chips NP rows, brush will be added from the no brush rows

An average of 1,398 and 560 kilograms per hectare of wet weight prunings were pruned in the orchard trial in 2003 and 2004, considered a light pruning.

california almonds Almond Board of California

A Flory Shredder was used to shred the prunings in this trial from 2003-2014.

11 year shredding study

Wood shreddings were examined at harvest

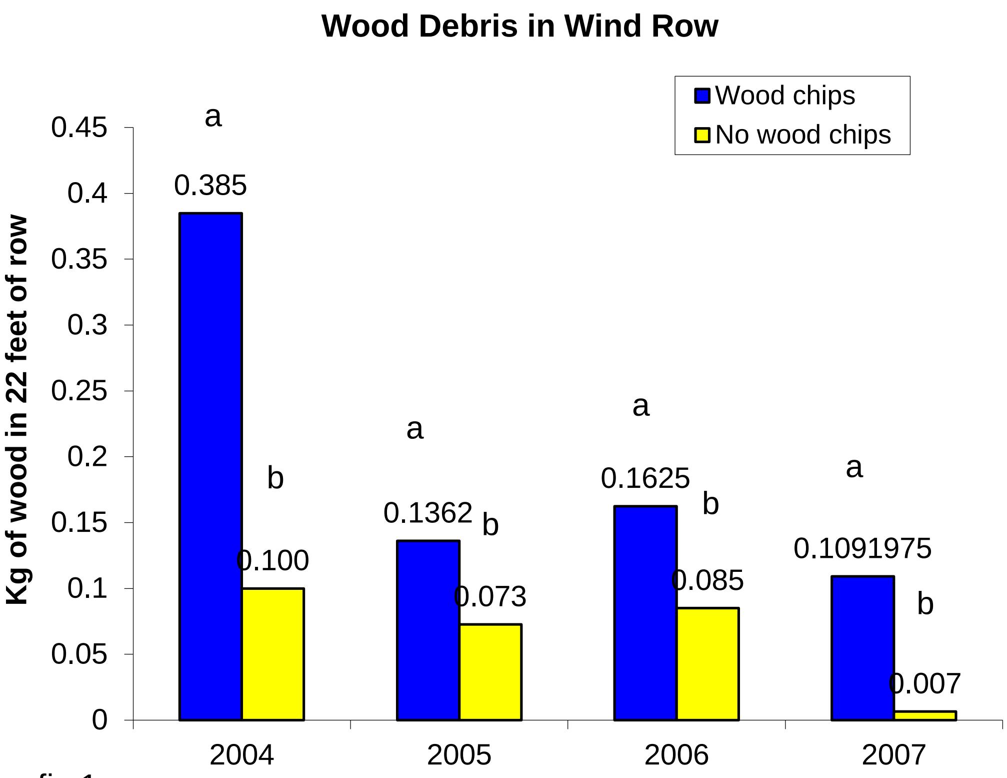


fig 1

- the amount of wood debris was determined per 22 feet of wind-row by hand sorting and weighing

Northwest Tiller-till, level, and roll in one pass

After heavy pruning and shredding the woody debris should be lightly incorporated in order to avoid being picked up at harvest

california almonds Almond Board of California

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
2004	2.23	2.25	0.104	0.104	1.254	1.272	0.886	0.888	29.6	33.2	425.8	407.0	457.4 a	834.0 b
2005	2.30	2.21	0.11	0.11	1.59 a	1.37 b	0.89	0.95	23.8 a	27.4 b	410	342	558.0 a	733.0 b
2006	2.104	2.104	0.10	0.10	1.52 a	1.15 b	0.88 a	0.99 b	33.0	34.6	586.6	610.8	622.6 a	901.2 b
2007	1.74	1.74	0.11	0.11	1.34 a	1.19 b	0.87	0.93	33.0 a	43.2 b	376.4 a	455.2 b	1055 a	1468 b
2008	2.09	2.01	0.11	0.11	1.25	1.14	1.15	1.17	33.0	33.8	690.2 a	720.4 b	1684 a	2254 b
2009	2.11	2.08	0.10	0.09	1.06	0.97	0.99	1.02	25.3 a	30.6 b	351.6 a	436.6 b	2253.2	2545.6
2010	2.36 a	2.46 b	0.11	0.12	1.26	1.26	1.09	0.99	25.32 a	38.25 b	248.84 a	278.20 b	455.5 a	1969 b
2011	2.18	2.17	0.10	0.10	0.85	0.85	1.15	1.14	37.76 a	45.94 b	269.78 a	309.20 b	1511.2	1561.4
2012	2.19	2.18	0.12	0.11	1.03 a	0.86 b	1.07 a	1.17 b	37.42	32.90	285.96 a	335.38 b	2205 a	2892 b
2013	2.33	2.35	0.11	0.12	1.28	1.35	0.97	0.99	31.98 a	38.00 b	174.48	184.16	1877.8	1756.8
2014	2.21	2.22	0.11	0.11	1.56	1.55	0.93	1.03 b	29.44 a	36.09 b	235.92	235.99	2201.8	1781.0

Blue Pair = shredding was significantly less

Yellow pair = shredding was significantly greater

Soil Analysis

	2012		2013		2014	
	Grind	Burn	Grind	Burn	Grind	Burn
Ca (meq/L)	6.19	7.37	15.85 a	9.82 b	32.82 a	23.19 b
Na (ppm)	1.57	2.07	2.46 a	1.65 b	8.98 a	4.70 a
Mn (ppm)	39.58 a	32.72 b	12.98	13.40	38.72	44.20
Fe (ppm)	84.14 a	55.52 b	19.02 a	17.32 b	298.74 a	251.20 b
Mg (ppm)	2.85 a	4.11 b	7.76 a	4.43 b	62.71	79.23
B (mg/L)	0.60	0.88	0.82 a	1.09 b	0.50 a	0.66 b
NO_3-N (ppm)	21.38	31.30	62.76 a	24.71 b	69.30	70.72
NH_4-N (ppm)	2.37	2.98	3.01	2.31	12.13	18.06
pH	7.80	7.85	7.63 a	7.81 b	7.45	7.17
EC (dS/m)	1.15	1.42	2.53 a	1.45 b	7.44	10.01
CEC(meq/100g)	9.52	9.20	12.92 a	10.78 b	9.74	9.26
OM %	2.12 a	1.66 b	2.57 a	1.89 b	2.52 a	2.14 b
C (total) %	1.20 a	1.06 b	1.43 a	1.23 b	1.10 a	0.95 b
C-Org-LOI	1.23 a	0.96 b	1.49 a	1.11 b	1.46 a	1.24 b
Cu (ppm)	33.00	31.80	7.94	7.15	5.88	4.21
K (mg/L)	346.80 a	323.60 b	360.40 a	297.58 b	178.46 a	81.12 b

Blue Pair = shredding was significantly less

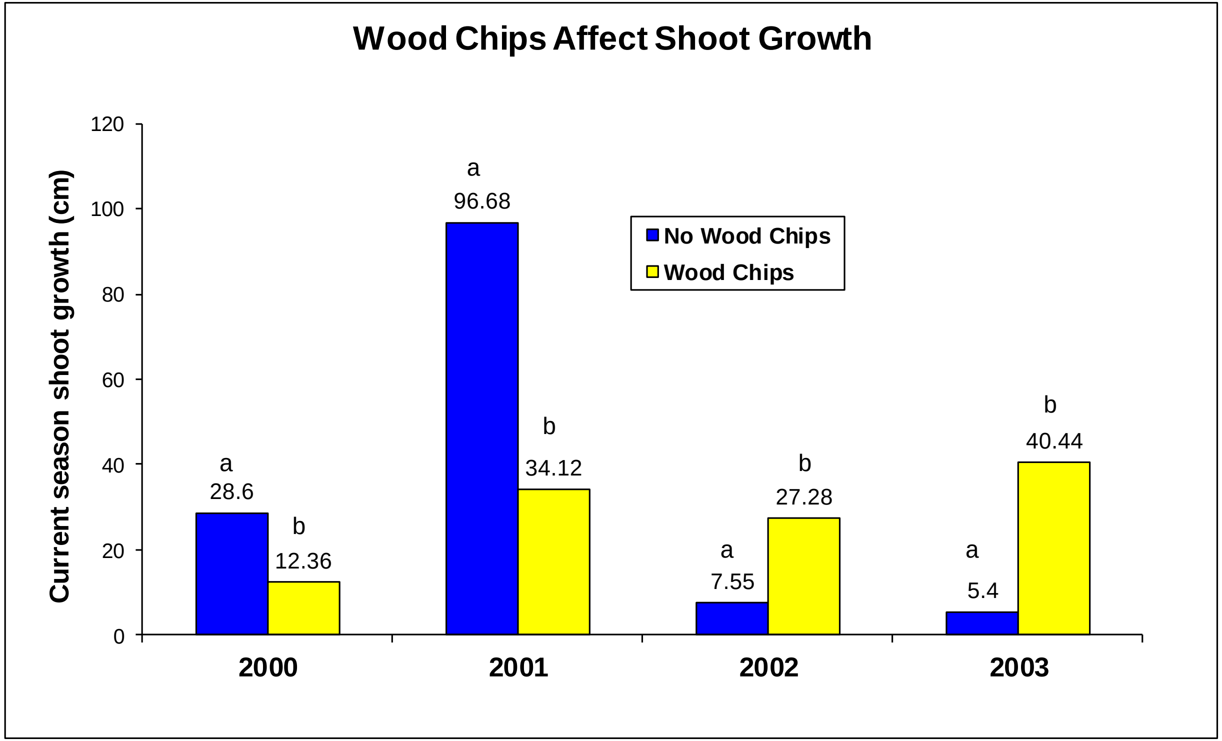
Yellow pair = shredding was significantly greater

- An experiment was established where 1/3 part wood chips was mixed with 2/3 parts soil

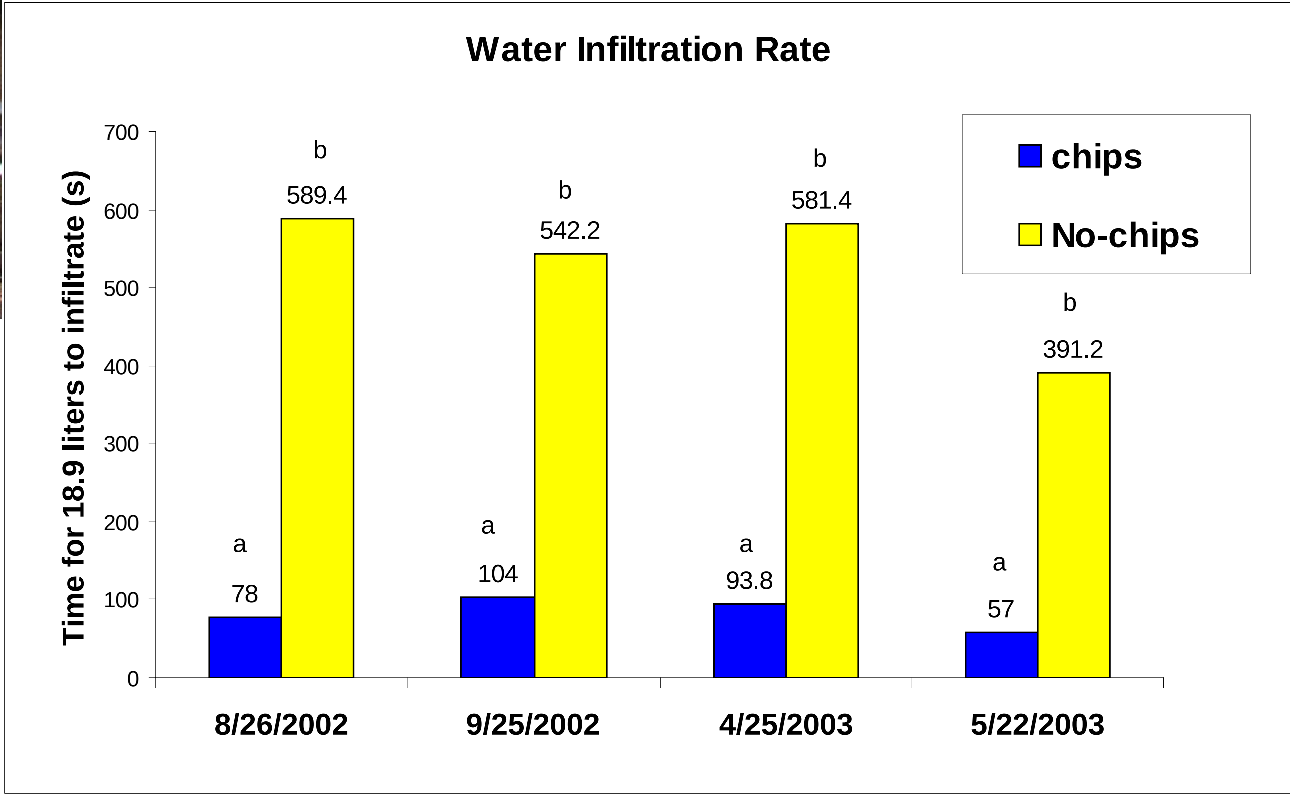
- Mixed soil and wood chips were placed in 35 gallon containers

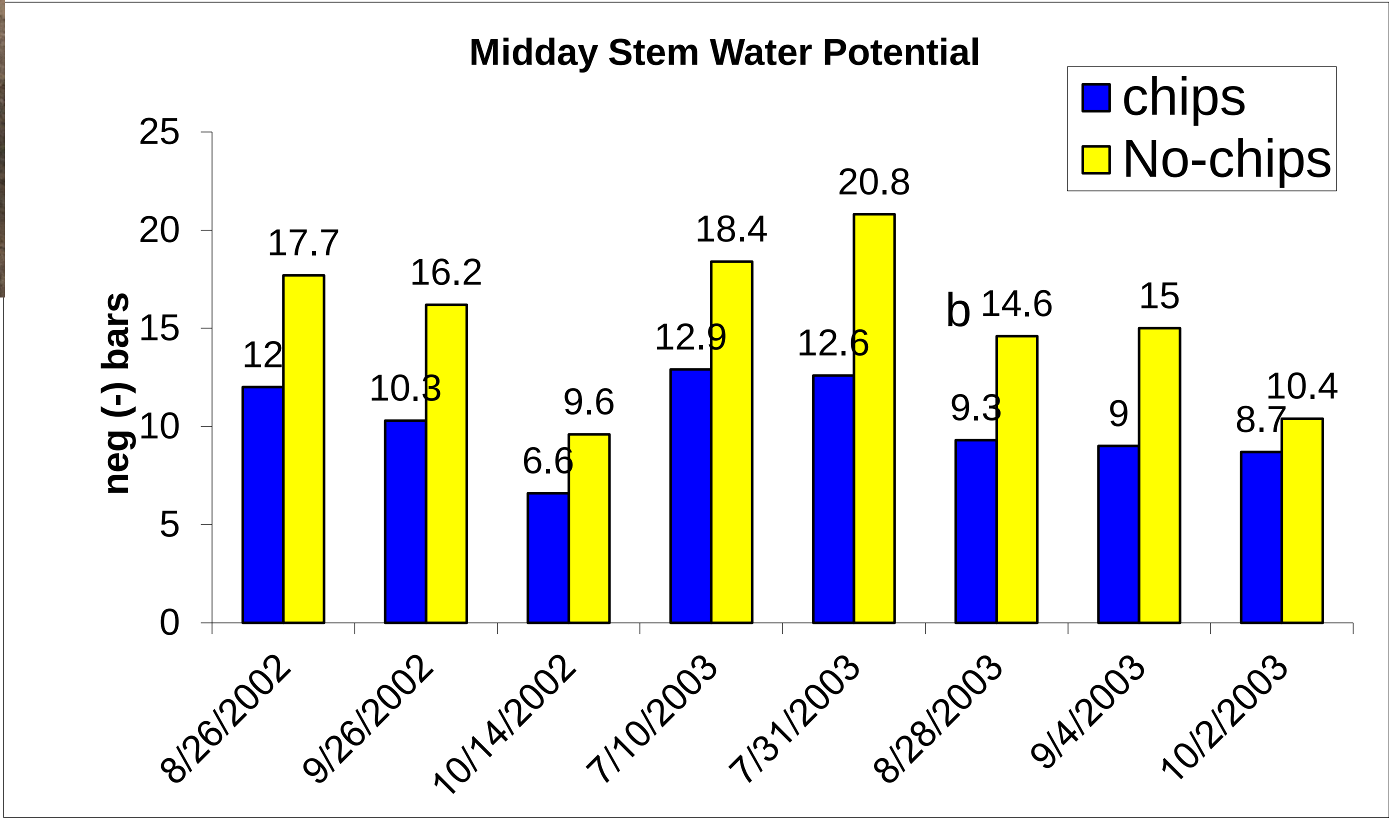
- Ten barrels received the wood chip and soil mixture while another 10 just received soil (1 tree/barrel)

- Current season shoot growth was measured



- At every irrigation, soil amended with wood chips had faster water infiltration rates

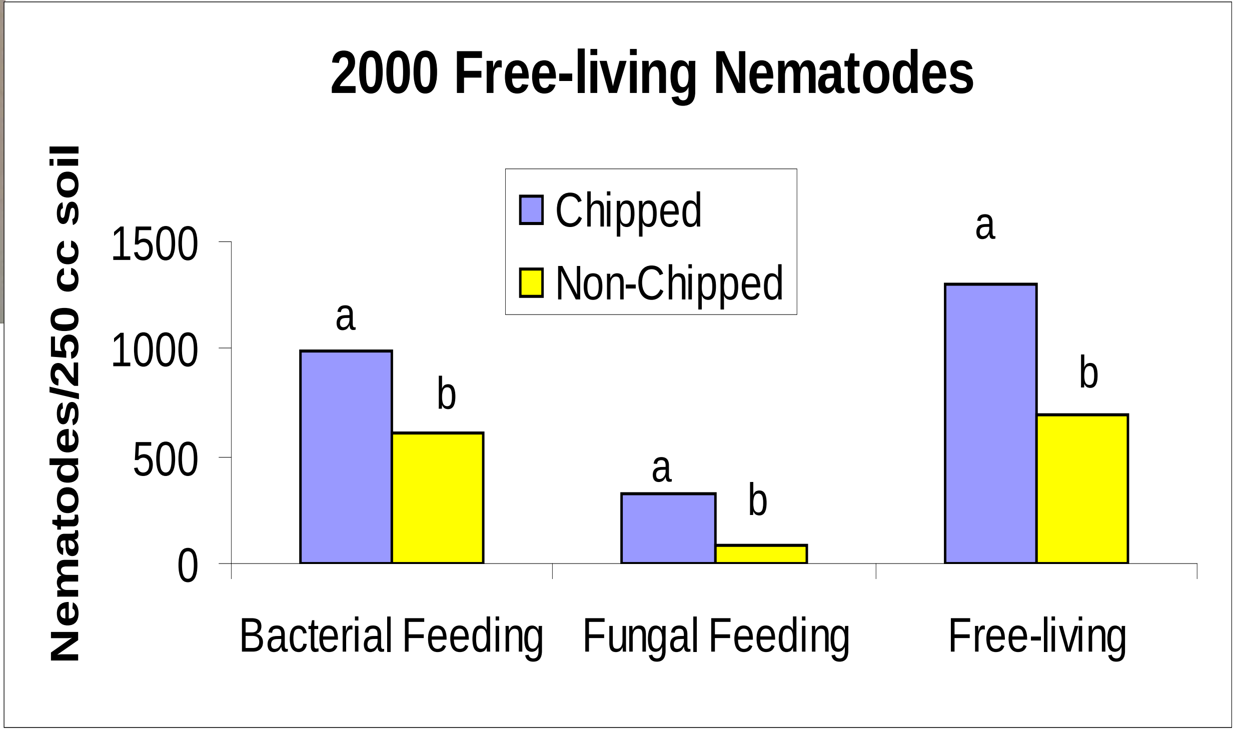




Midday Leaf Stem Water Potential

- Mushrooms were found frequently after rainfall and irrigations in the chipped plots

Acrobeloides species



Yellow = paired comparison where wood chips were significantly greater than no wood chips

Blue = paired comparison where wood chips were significantly less than no wood chips

	2003	2003	2004	2004	2006	2006	2007	2007
	Wood chips	No-chips	Wood chips	No-chips	Wood chips	No-chips	Wood chips	No-chips
pH	6.53	6.80	6.80	7.03	6.97	7.13	6.87	7.37
EC dS/m	0.69	0.52	0.57	0.41	0.67	0.33	0.67	0.41
CEC meq/100g	7.03	4.05	10.75	4.77	8.98	3.93	14.27	4.23
N (Total) %	0.15	0.04	0.12	0.05	0.08	0.04	0.15	0.04
NH4-N ppm	3.40	1.90	5.07	3.43	3.95	2.25	14.55	2.12
N03-N ppm	1.35	0.70	2.47	0.50	2.45	1.10	0.83	1.02
Bray P ppm	21.27	19.97	35.03	25.40	24.20	22.48	18.65	11.77
X-K meq/100g	0.13	0.10	0.20	0.15	0.16	0.12	0.35	0.15
X-K ppm	56.17	47.83	79.17	55.50	62.83	45.67	136.67	58.17
TKN %	0.08	0.03	0.09	0.04	0.09	0.04	0.18	0.04
Zn (DPTA) ppm	9.55	4.62	10.73	4.37	20.07	10.07	20.43	11.15
Zn (Total) ppm	38.67	31.33	52.67	37.17	49.00	40.50	52.67	43.00
Ca (SP) meq/L	4.20	2.78	3.75	2.27	4.67	1.85	3.93	2.13
X-Ca meq/100g	4.02	1.97	5.33	2.28	5.62	2.52	7.26	2.70
Mg (SP) meq/L	2.78	1.93	2.42	1.55	3.00	1.25	2.45	1.57
X-Mg meq/100g	1.28	0.77	1.62	0.86	1.70	0.90	1.98	0.91
Na (SP) meq/L	1.67	1.12	0.82	0.60	0.95	0.58	0.88	0.68
X-Na meq/100g	0.10	0.10	0.06	0.04	0.07	0.04	0.08	0.04
X-Na ppm	21.83	11.83	14.50	8.17	16.00	9.33	18.67	9.17
Cl (SP) meq/L	1.40	0.90	1.22	0.83	1.22	0.67	1.52	1.03
B (SP) mg/L	0.12	0.10	0.22	0.15	0.13	0.10	0.13	0.10
Mn (DTPA) ppm	21.58	29.48	13.97	12.37	33.08	25.82	29.87	21.88
Mn (Total) ppm	129.17	141.00	146.50	135.50	136.67	130.50	134.67	137.17
Fe (DTPA) ppm	74.08	84.43	17.75	8.70	100.78	60.72	44.88	44.03
Fe (Total) ppm	5203.33	4840.00	6038.33	5311.67	6605.00	6306.67	6290.00	6250.00
Cu (DTPA) ppm	5.07	3.07	5.20	2.35	5.80	2.75	7.18	2.40
Cu (Total) ppm	17.00	11.67	61.83	20.33	18.17	11.50	25.00	11.67
C (Total) %	1.98	0.48	1.70	0.42	1.39	0.45	2.98	0.44
OM %	1.67	0.58	2.72	0.64	2.35	0.69	4.84	0.92
C-Org %	0.97	0.34	1.58	0.37	1.36	0.40	2.81	0.53
Sand %	92.25	92.40	89.25	90.50	87.00	89.00	88.33	89.33
Silt %	6.75	5.80	6.00	5.00	9.50	7.17	9.00	6.83
Clay %	1.00	1.80	4.75	4.50	3.50	3.83	2.67	3.83
CaCO3 %	1.02	0.93	0.20	0.20	0.32	0.28	0.22	0.20
HCO3 (SP) meq/L	3.45	2.80	3.62	2.10	3.33	1.55	3.80	3.30
5 ATM %	5.10	2.18	7.44	3.00	6.17	2.60	12.08	3.12
SP %	36.6	25	36.60	25.00	38.60	30.00	50.60	27.40

My Vision--I would like to see whole orchards 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 affecting 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 accumulation and haul it away. 25-30 years of organic matter is lost from our system, estimated at 30 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]

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[3]USDA-ARS, UC Davis, of Plant Pathology

growing ADVANTAGE

The Almond Conference

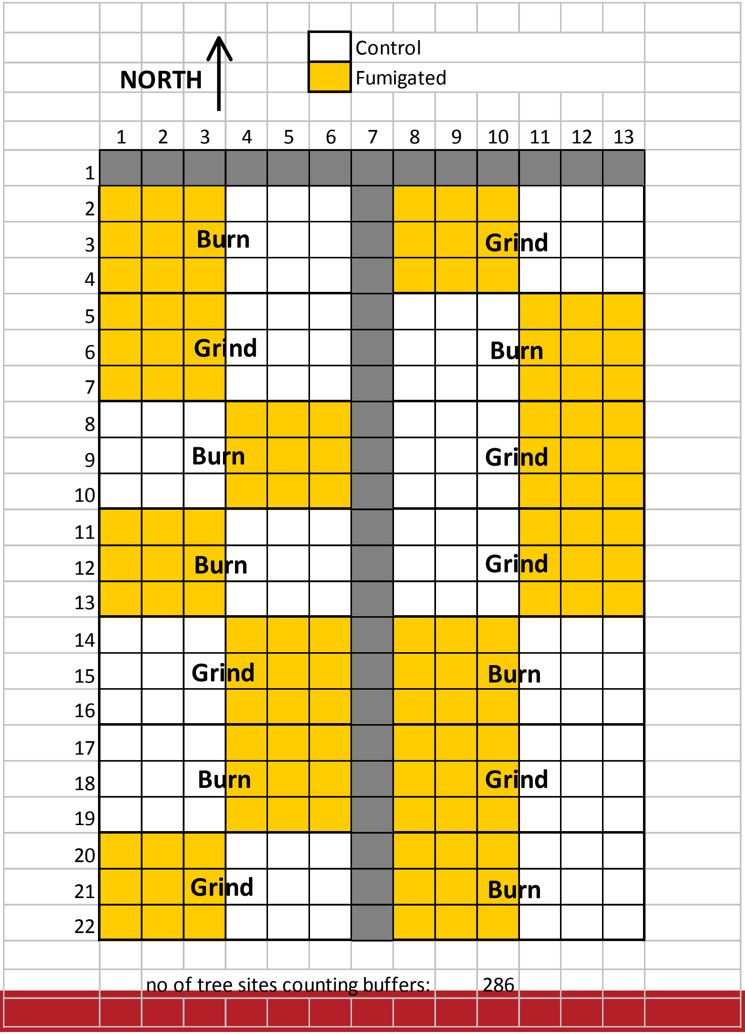
The Iron Wolf

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


NORTH
Control
Fumigated
1 2 3 4 5 6 7 8 9 10 11 12 13
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
Burn
Grind
Grind
Burn
Burn
Grind
Burn
Grind
Grind
Burn
Burn
Grind
Grind
Burn
no of tree sites counting buffers: 286

2009 First leaf trees growing in grinding plot

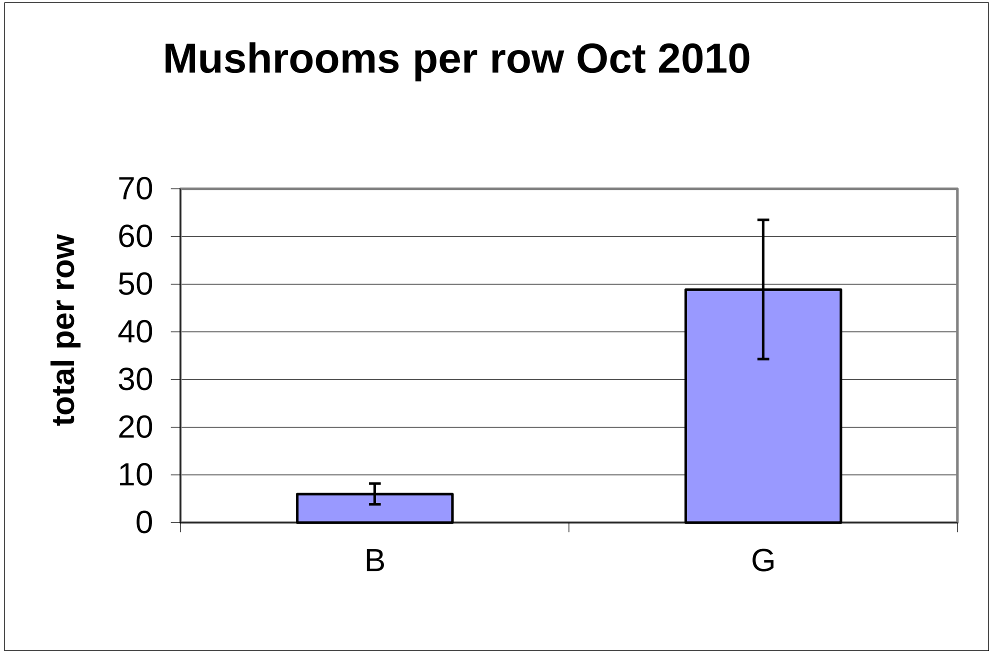
2010 Second leaf trees

No difference in tree circumference

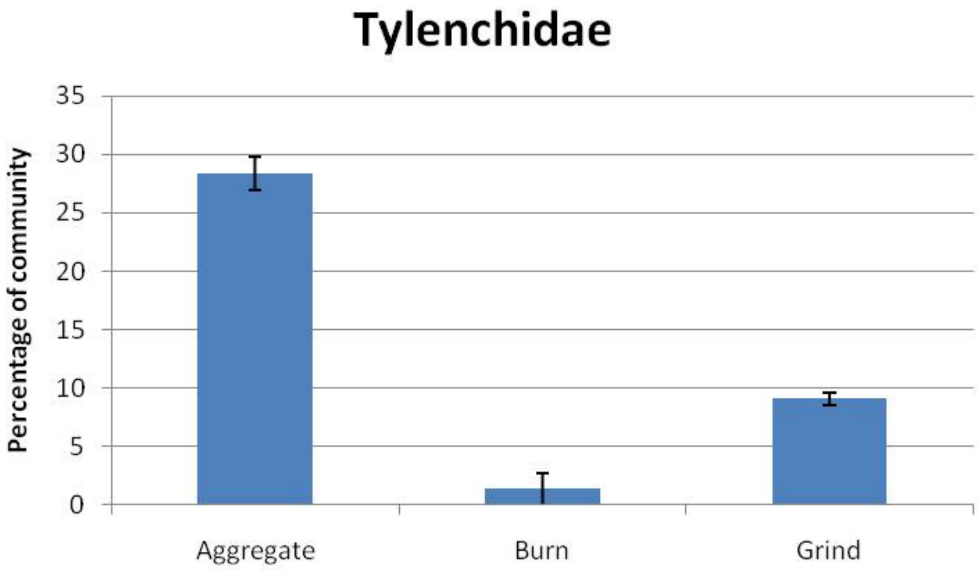
The Grinding did not stunt the second generation orchard

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).



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

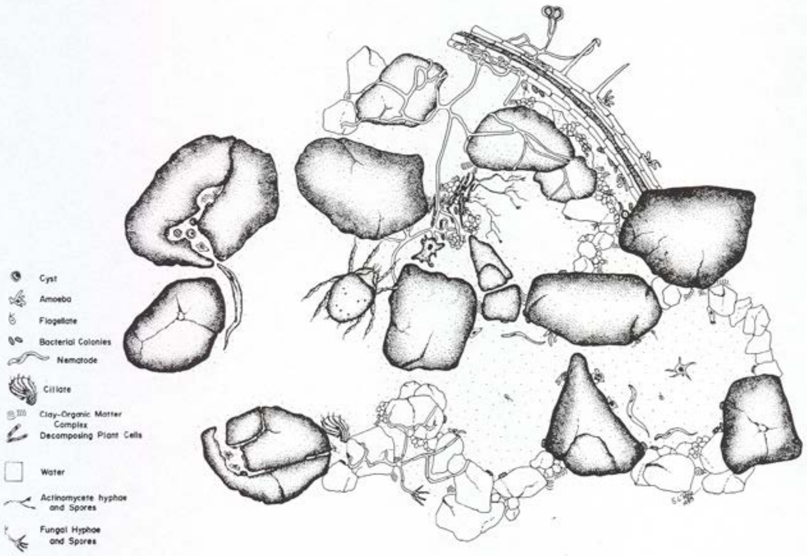
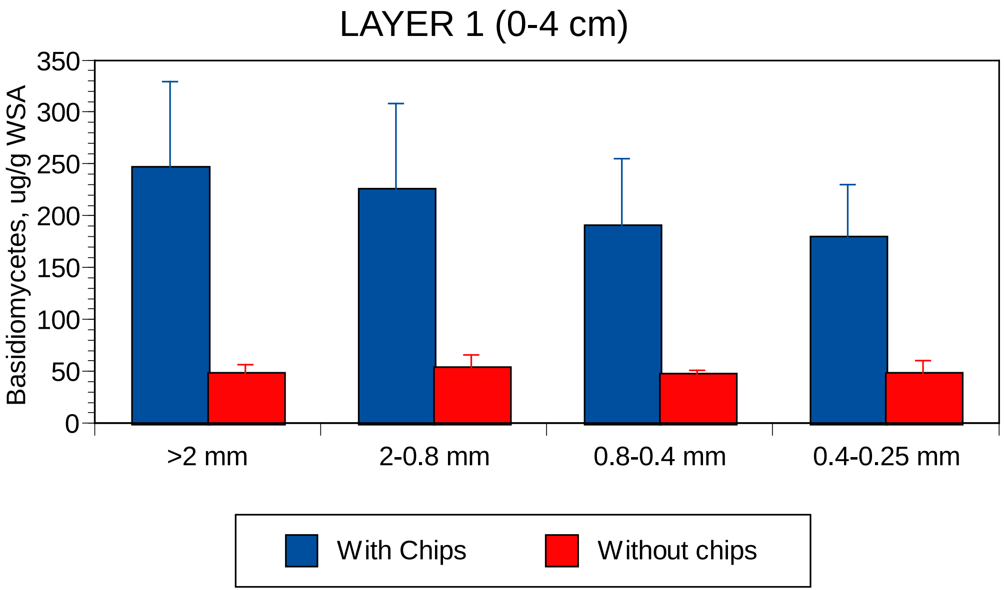


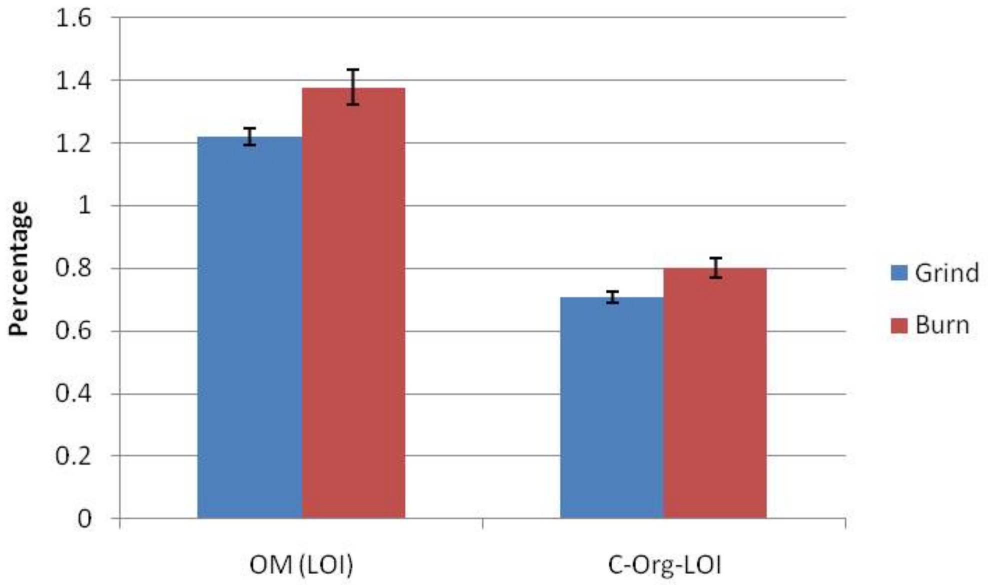
Figure 5.2. Trophic relationships among different groups of soil organisms are controlled by accessibility to their resources. This illustration represents approximately 1 cm^2 of a highly structured microzone in the surface horizon of a grassland soil. Courtesy of S. Rose and T. Elliott, personal communication.)

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

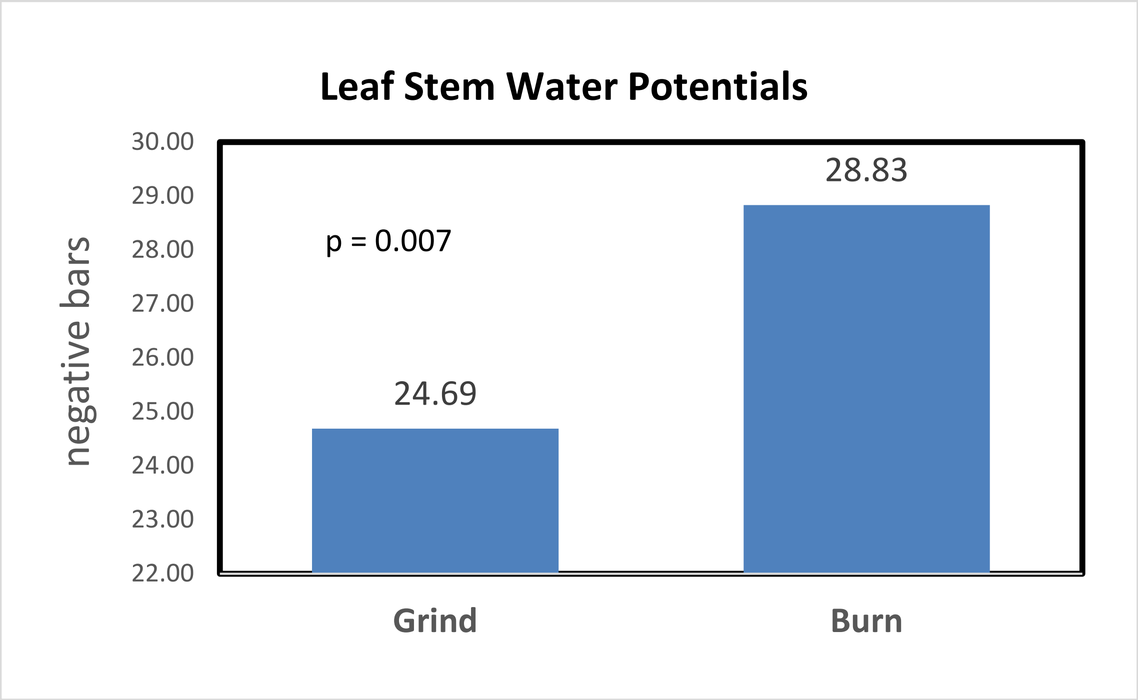
Blue Pair = grinding significantly less than burning

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)

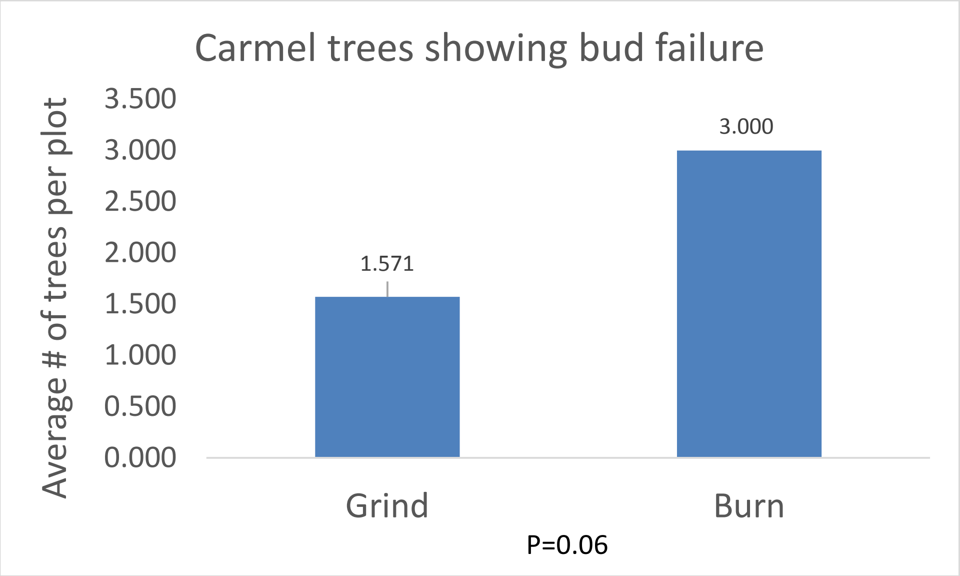


The trial went 57 days without an irrigation during harvest

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



Orchard recycling has:

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

Will orchard recycling:

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

Soil Organic Matter

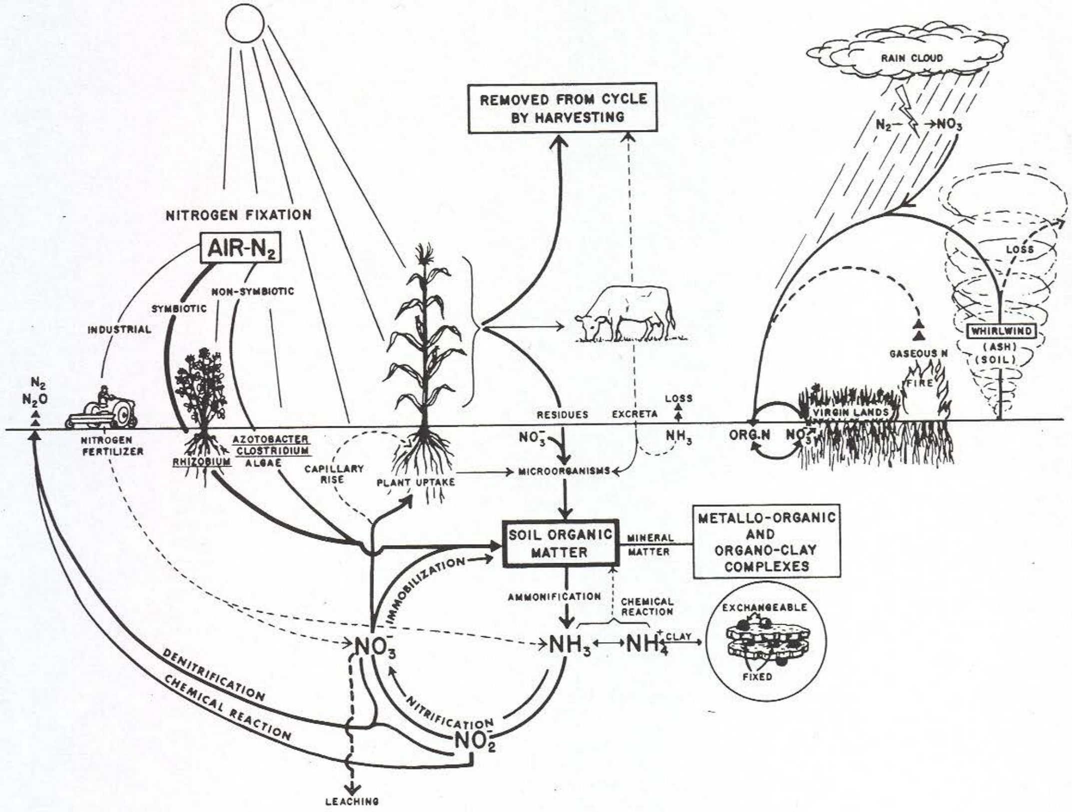


Figure 8.1. Nitrogen cycle in soil. (From Stevenson, 1982.)

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

california almonds
Almond Board of California

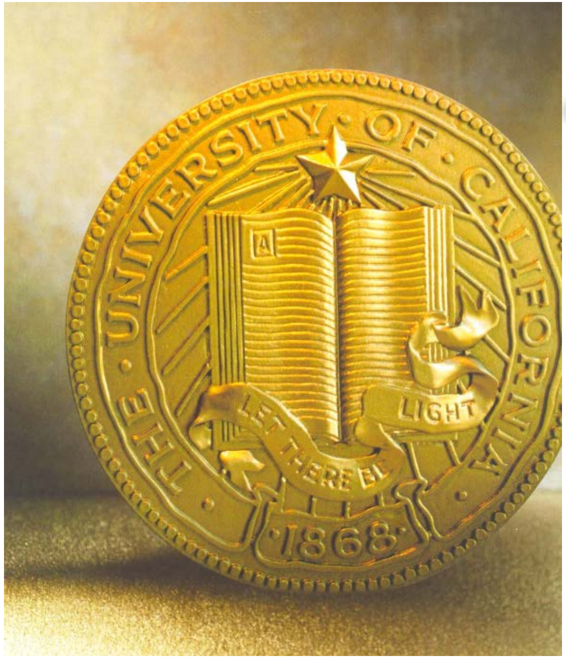
700B Series Iron Wolf

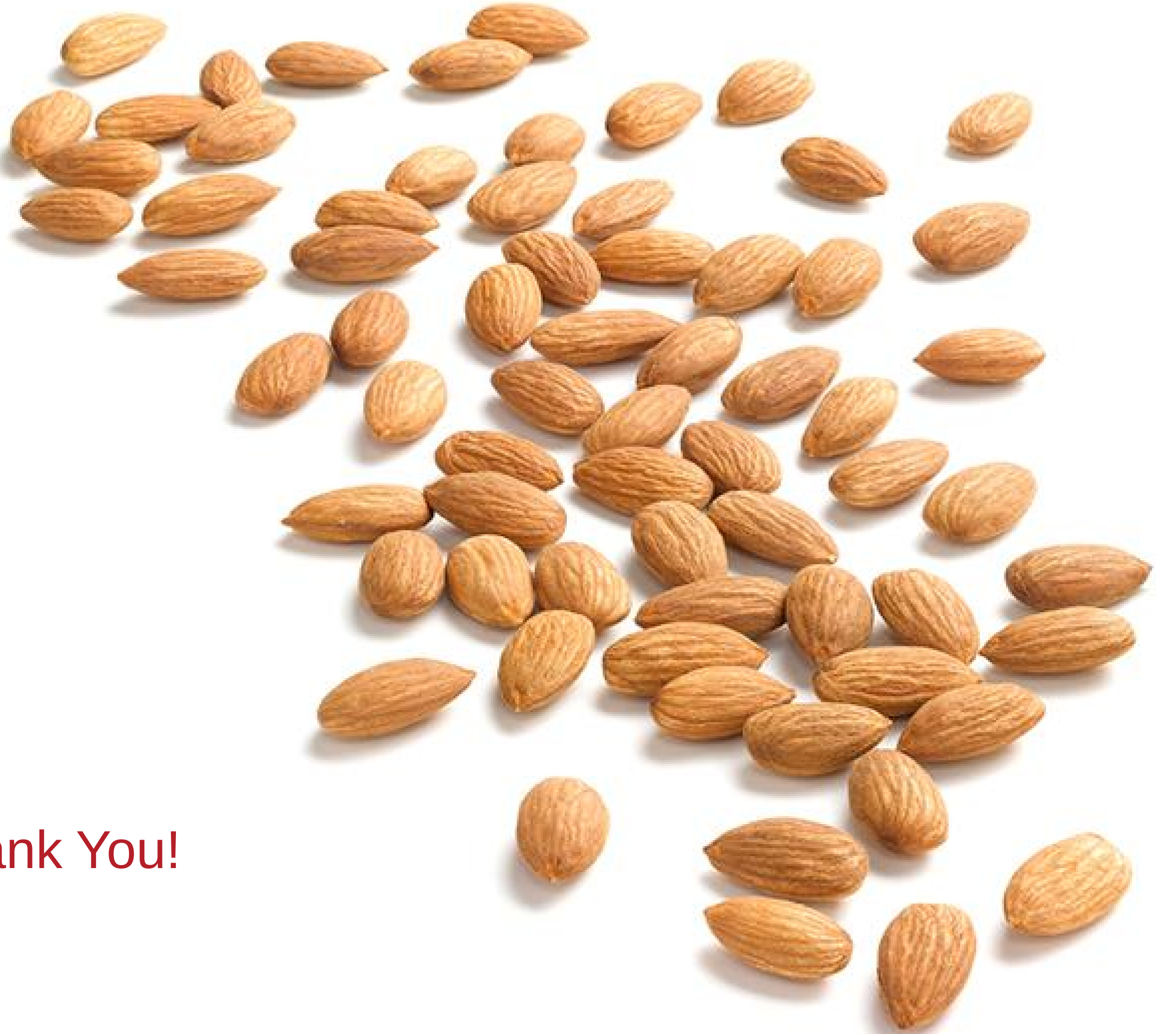
CDFA Pre-proposal to research category A, Specialty Crop Block Grant
Environmental Stewardship and Conservation

PI:
Amélie Gaudin, Assistant Professor, UC Davis

Co-PI:
Brent Holtz, UC-ANR Cooperative Extension
Gregory Brown, Research Plant Pathologist, USDA-ARS,
David Doll, Farm Advisor, UC-ANR Cooperative Extension
Sonja Brodt, UC-ANR Sustainable Ag Research and Education
Alissa Kendall, Associate Professor, UC Davis
Elias Marvinney, Post-doctoral Researcher, UC Davis

Collaborators:
Jerrad Pierucci, bringing in Iron Wolf
Rebekah Christensen, Google Innovation Labs
Growers interested in incorporating removed orchards?





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Thank You!