Whole Orchard Recycling in California

by

Brent A. Holtz, Ph.D.

Tour of South Australian Almond Regions

January 15th - 19th, 2024

University of California
Agriculture and Natural Resources

This project evolved from farming on the urban edge

STOP TO THINK !?

Are these wood chips effecting 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

How fast do woodchips or shreddings decompose? Can we speed up the rate of decomposition?

- In 1997 an experiment was initiated to determine how quickly woodchips and shreddings decomposed.
- 300 gram samples of wood chips and shreddings were weighed out. There were 11 replications per treatment.

- The nylon bags containing wood chips and shreddings were placed on the soil surface of an almond orchard

- Fungal mycelium was also observed observed colonizing and decomposing the wood debris in the nylon bags.

- The soil was washed through a ¼ inch screen. If wood debris passed through the screen it was considered decomposed. The remaining debris was weighed and measured.

- If wood debris did not pass through the screen the 25 largest woodchips or shreddings per bag were measured (length, width, height) to determine area (cubic mm), and individually weighed, then returned to the nylon sacks and soil and placed back on the orchard floor. Size, weight, and rate of decomposition (% reduction in weight) were examined. Over 12,000 individual measurements were made from 1997 to 2005.

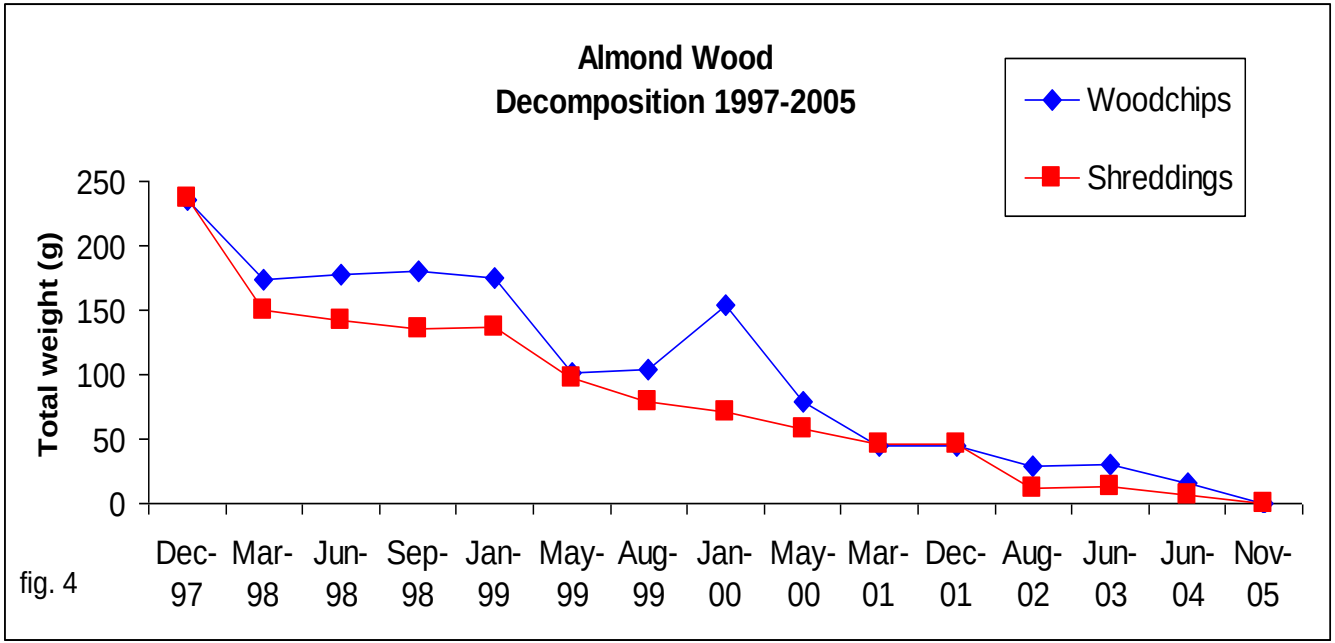


fig. 4

- If woodchips and shreddings did not pass through the screen they were weighed and returned to nylon sacks and the orchard floor. The percent decomposition (% reduction in weight) of the total 300 g sample was determined.

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

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?

2000 barrel experiment:

Almond brush was chipped up with a Brush Bandit wood chipper

Uniform sandy loam soil was mixed with wood chips, 1/3 chips to 2/3 soil

I thought this rate would be similar to whole orchard recycling?

It turned out to be much greater— a 300 tons per acre rate

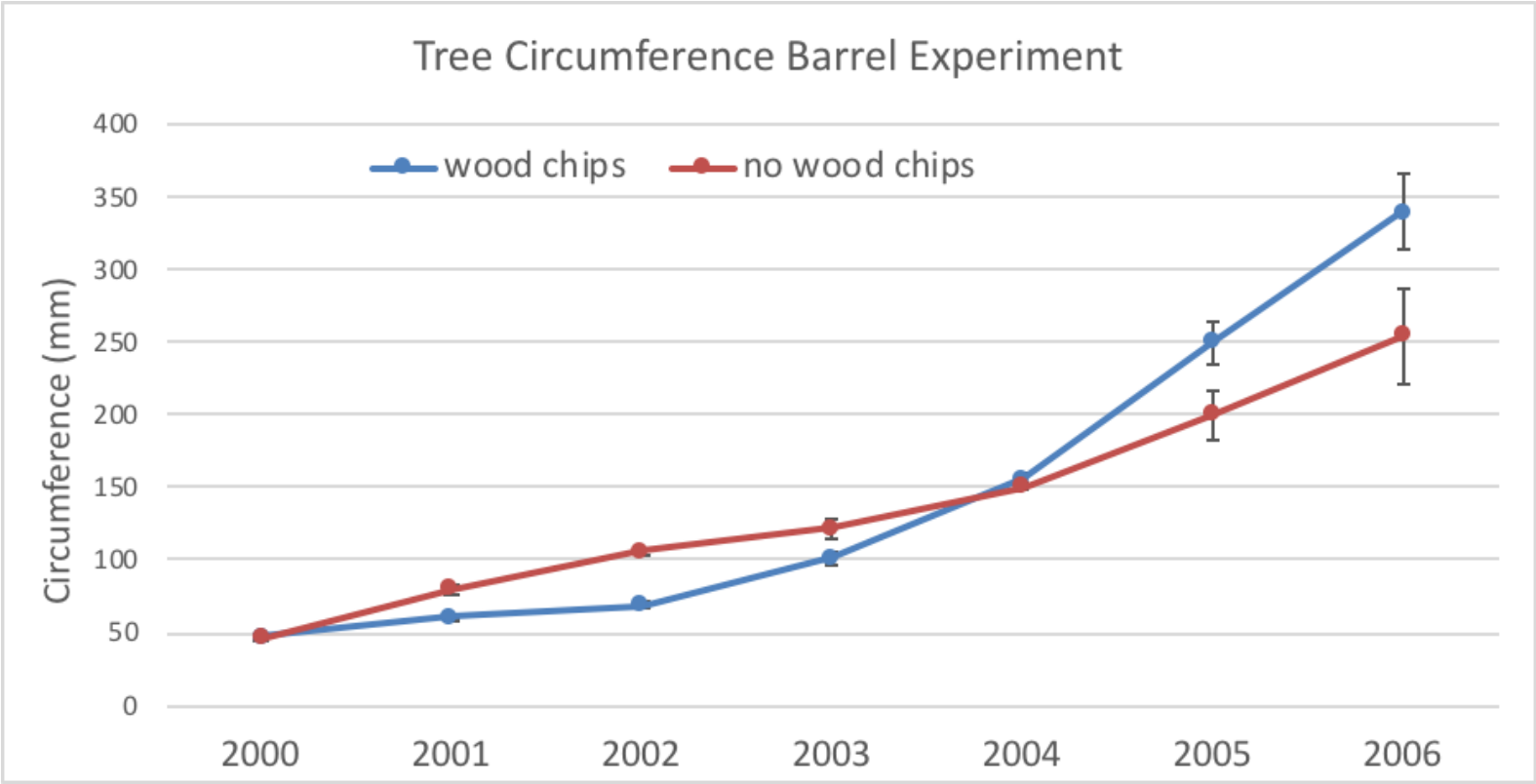
- 1/3 part wood chips were mixed with 2/3 parts soil
- Placed in 35 gallon containers

- One almond tree was planted per barrel

49 ppm Nitrate in irrigation water

- Ten barrels received the wood chip and soil mixture while another 10 just received soil

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


Tree Circumference Barrel Experiment
wood chips
no wood chips
Circumference (mm)
400
350
300
250
200
150
100
50
0
2000
2001
2002
2003
2004
2005
2006

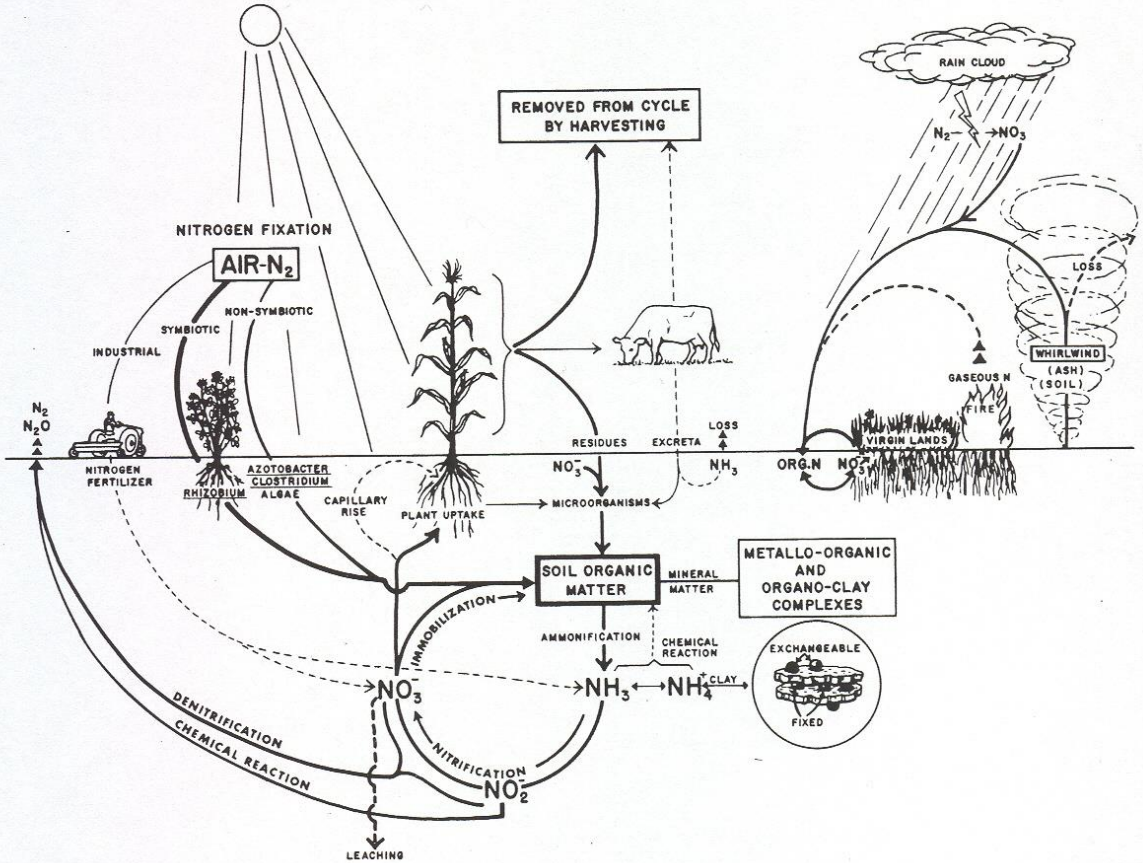
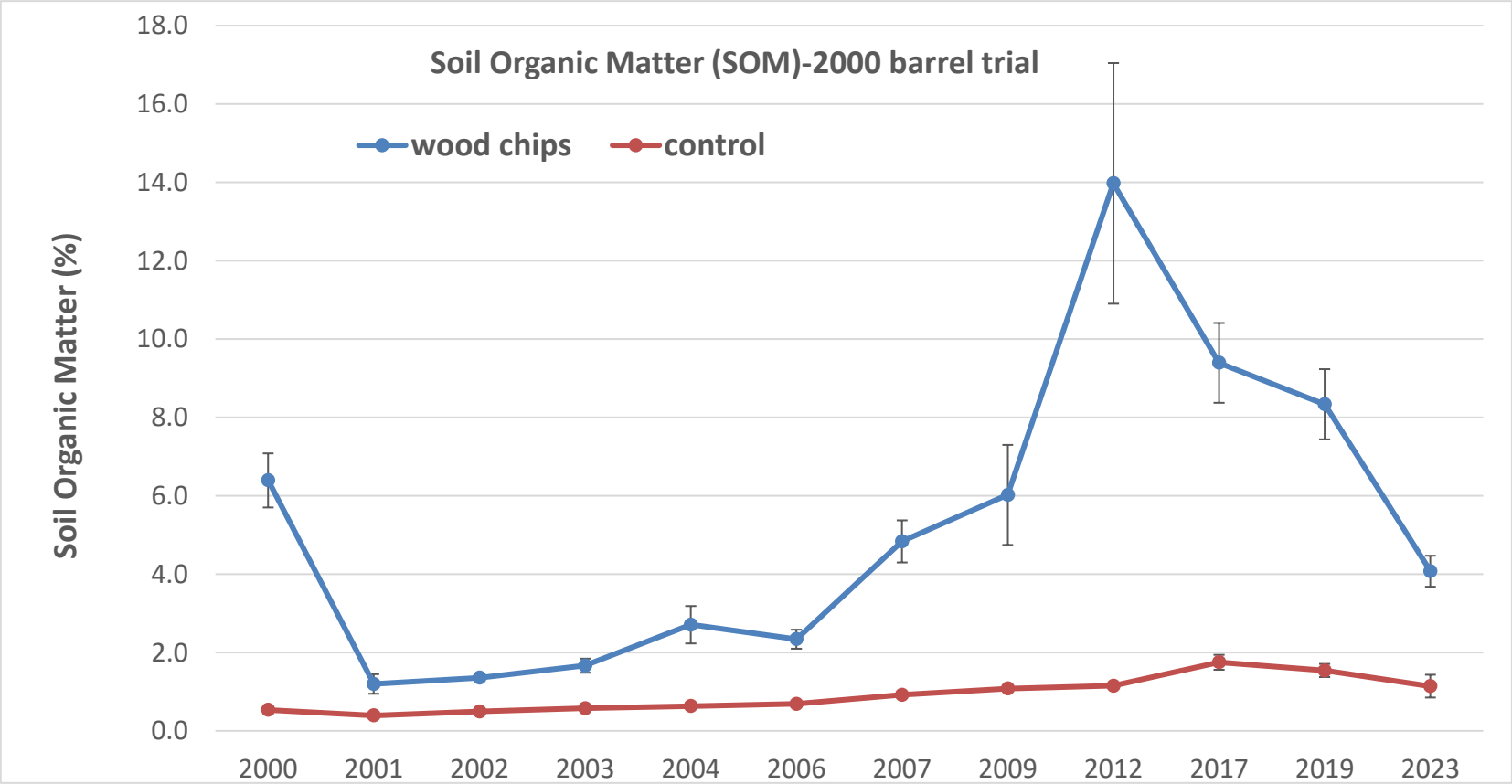
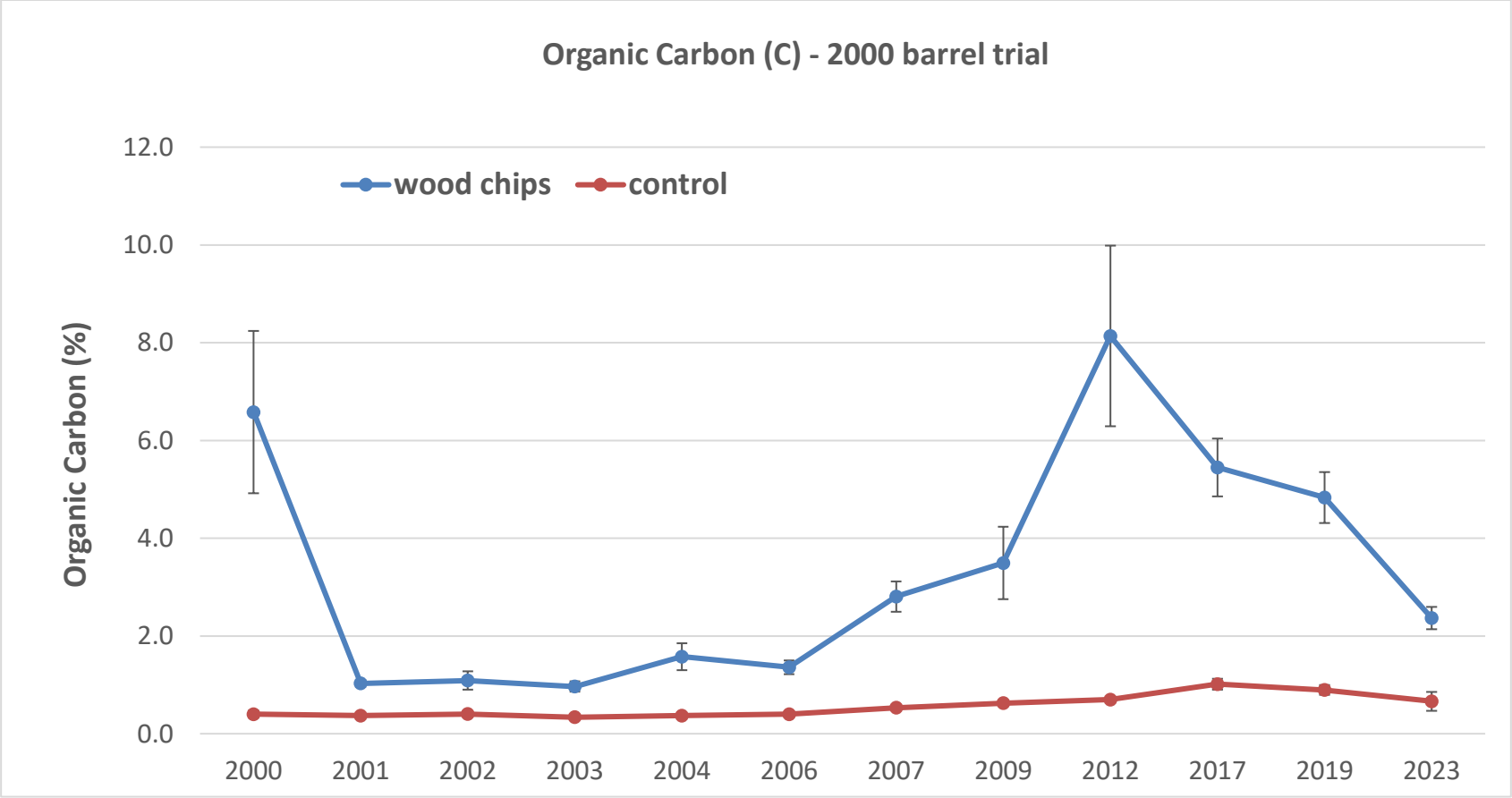


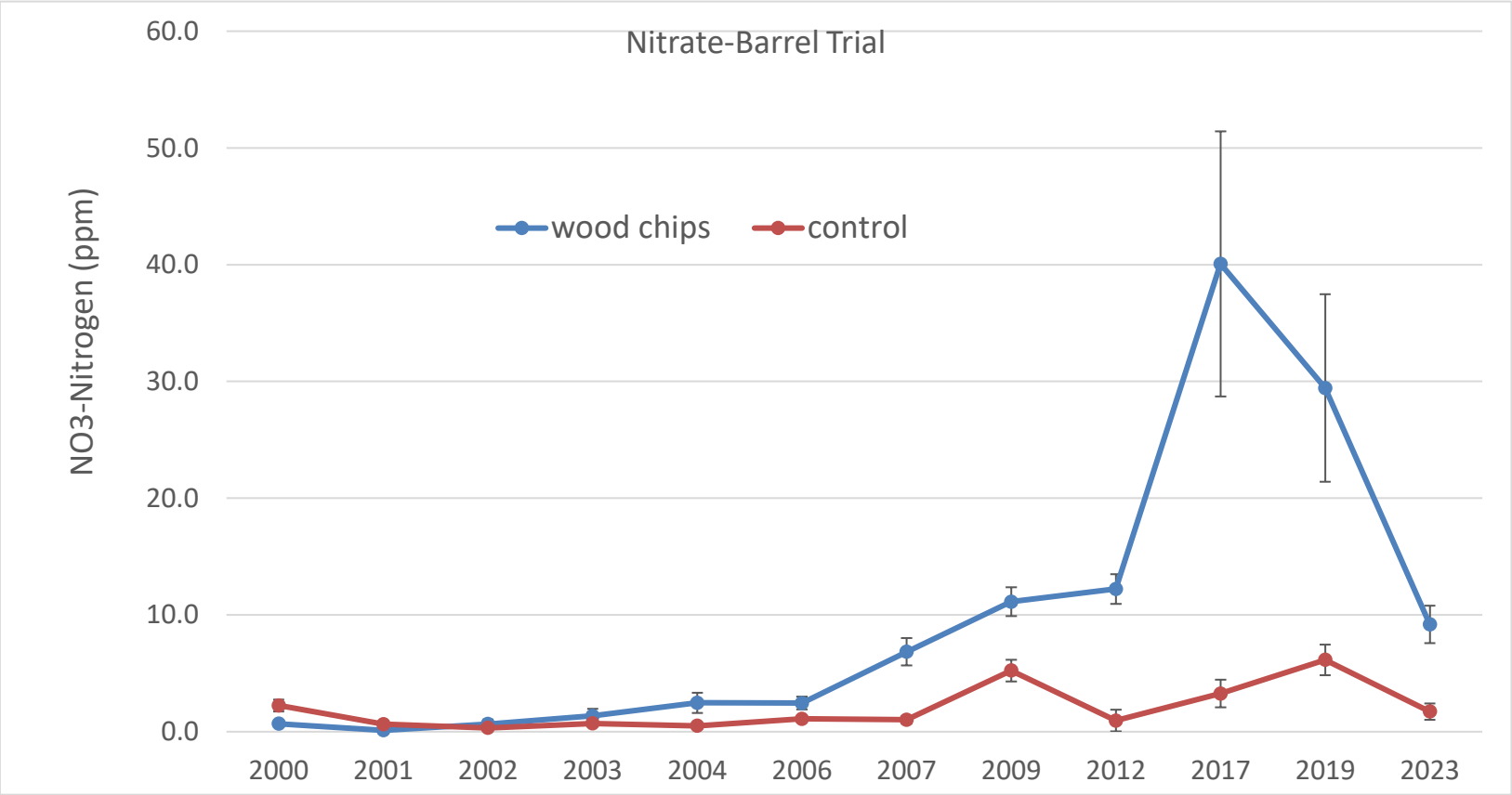
Figure 8.1. Nitrogen cycle in soil. (From Stevenson, 1982.)



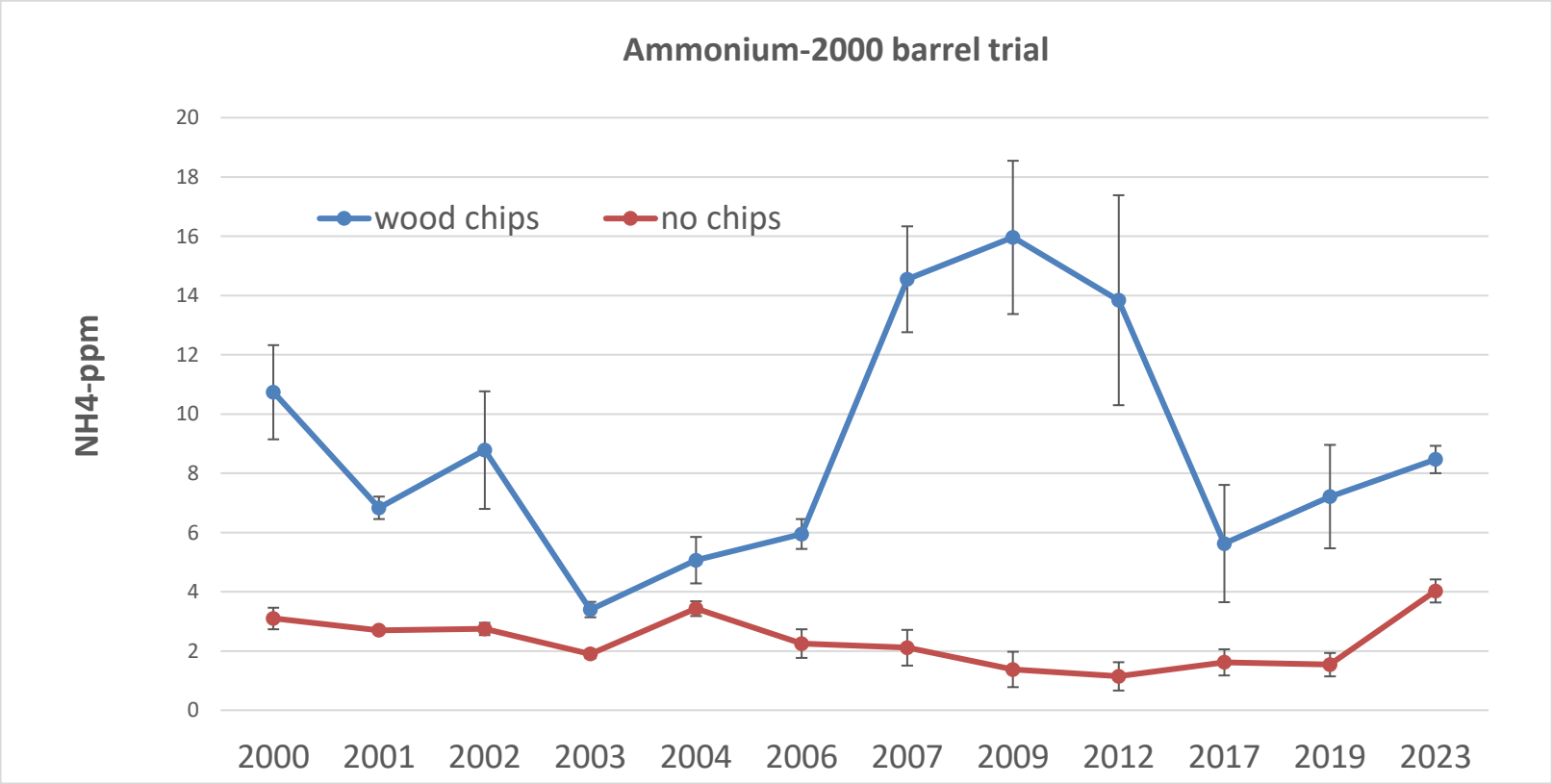
University of California
Agriculture and Natural Resources

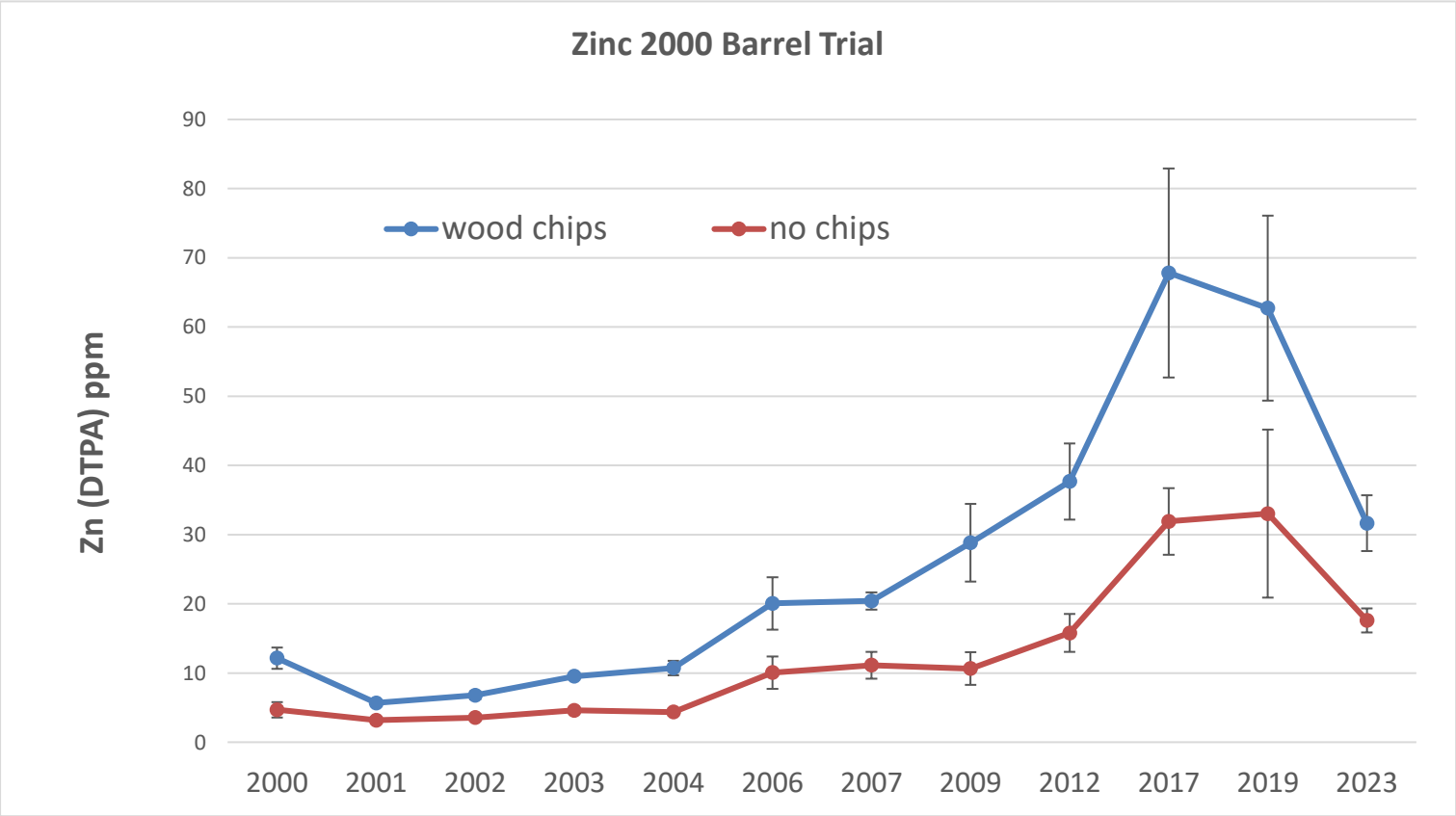


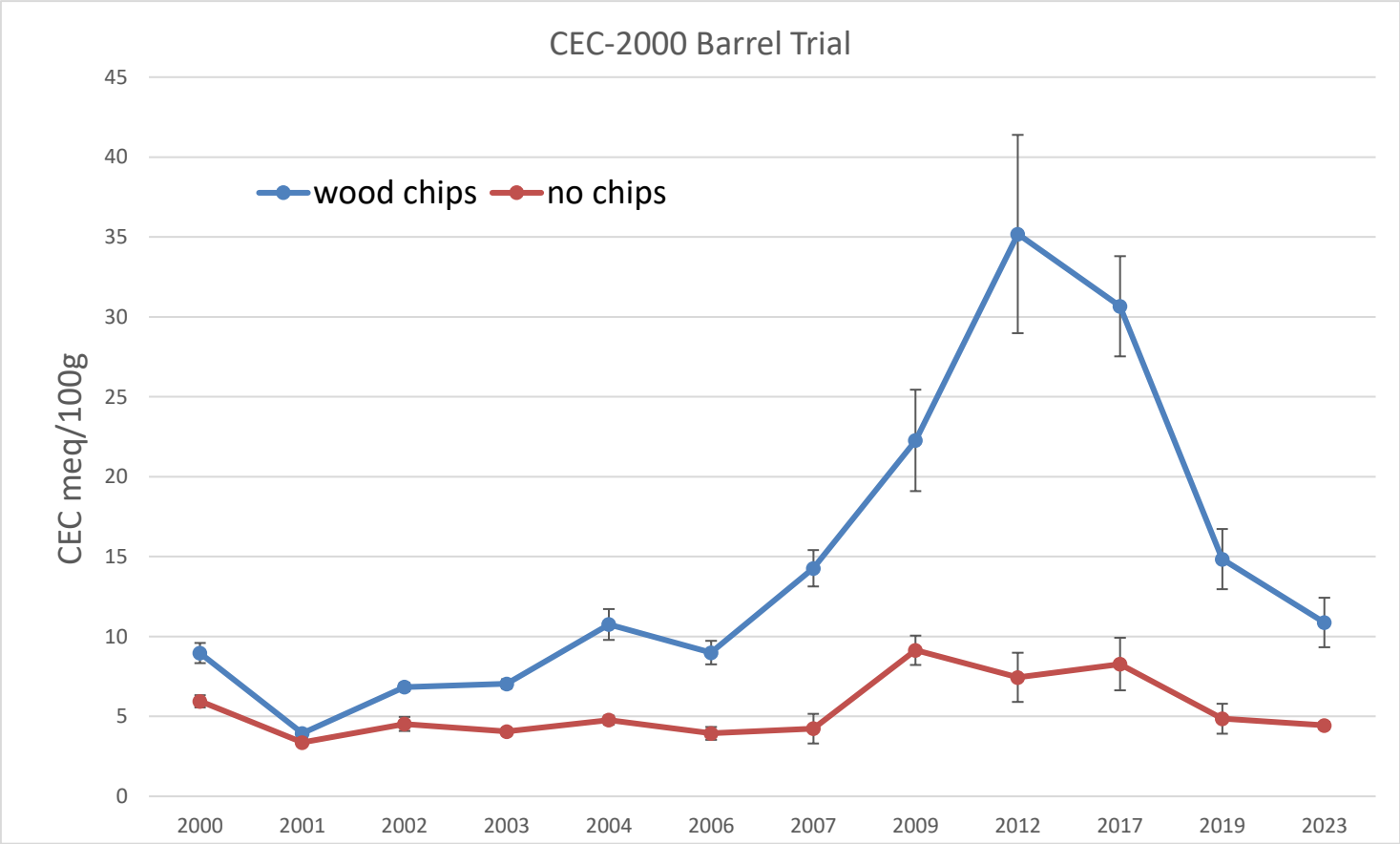
University of California
Agriculture and Natural Resources



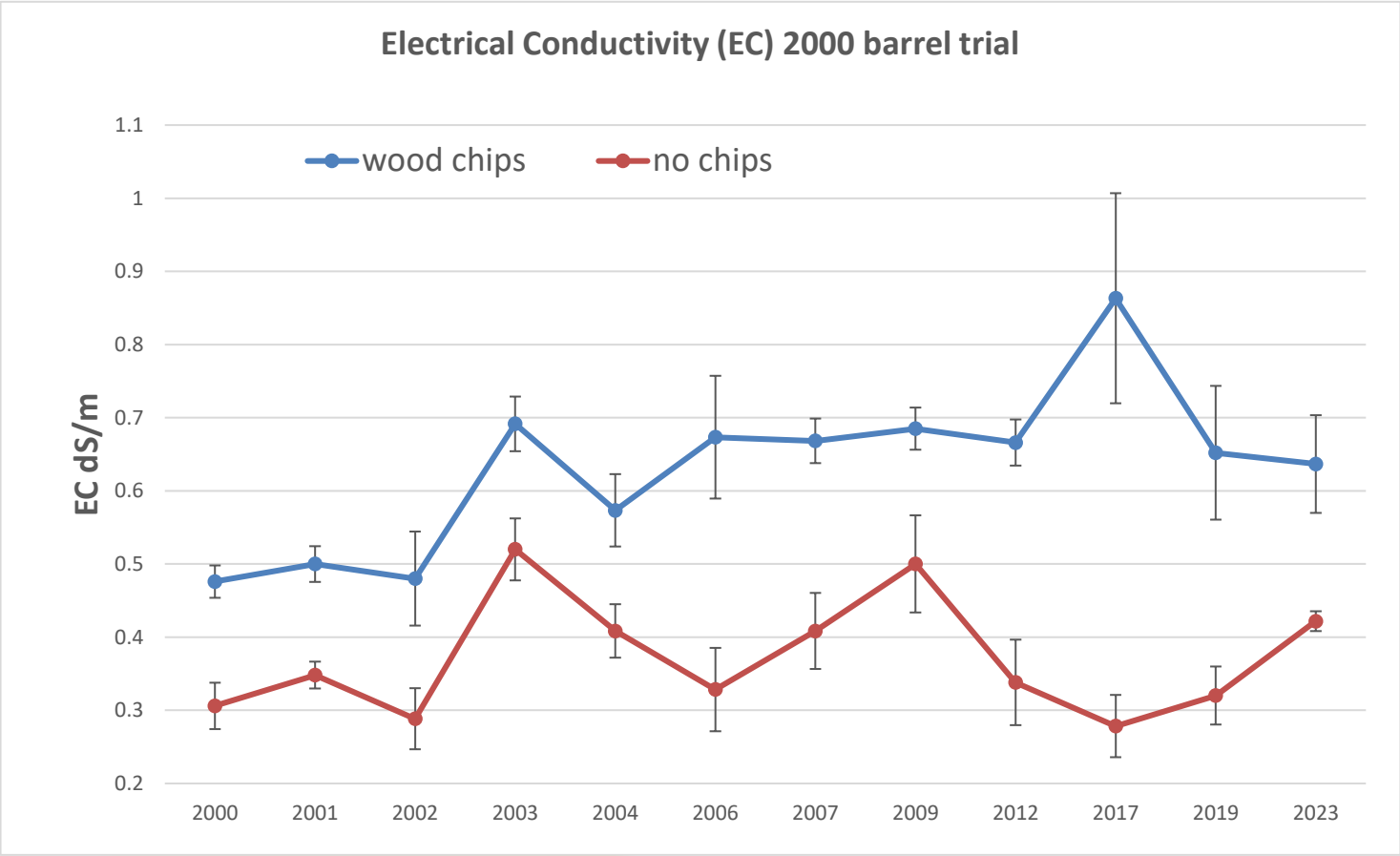
University of California
Agriculture and Natural Resources

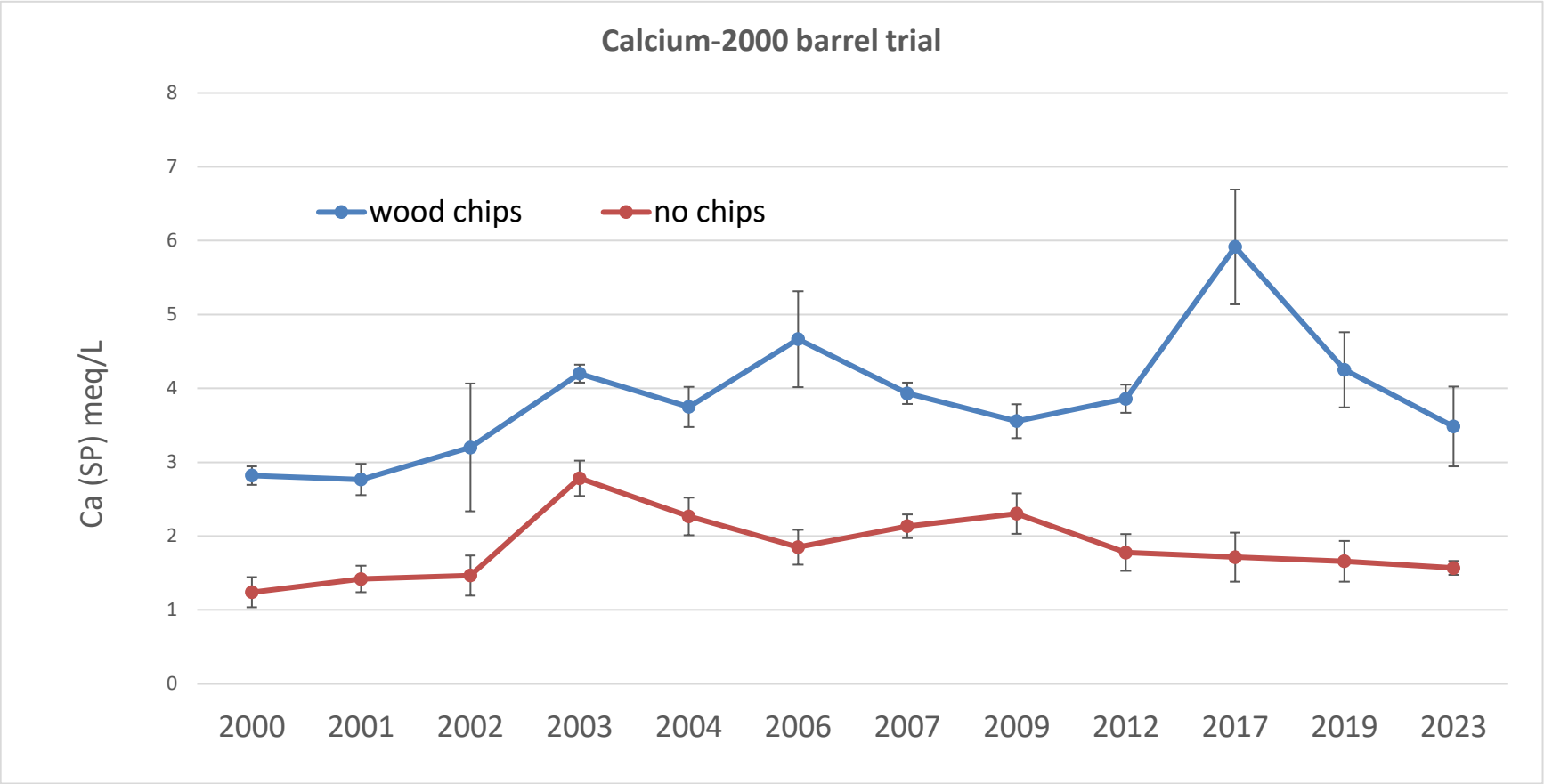

Ammonium-2000 barrel trial
NH4-ppm
20
18
16
14
12
10
8
6
4
2
0
wood chips
no chips
2000
2001
2002
2003
2004
2006
2007
2009
2012
2017
2019
2023


Zinc 2000 Barrel Trial
Zn (DTPA) ppm
90
80
70
60
50
40
30
20
10
0
wood chips
no chips
2000
2001
2002
2003
2004
2006
2007
2009
2012
2017
2019
2023

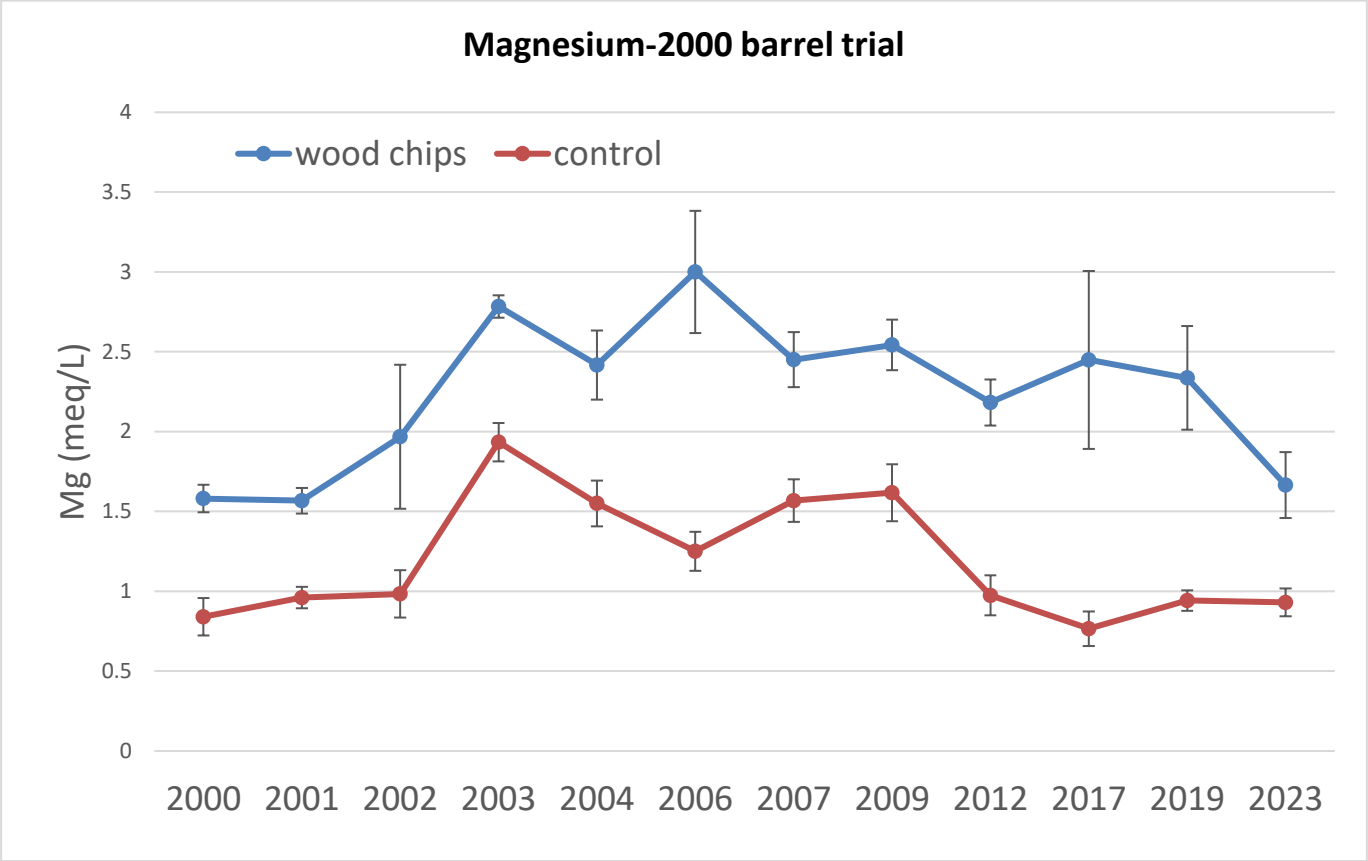


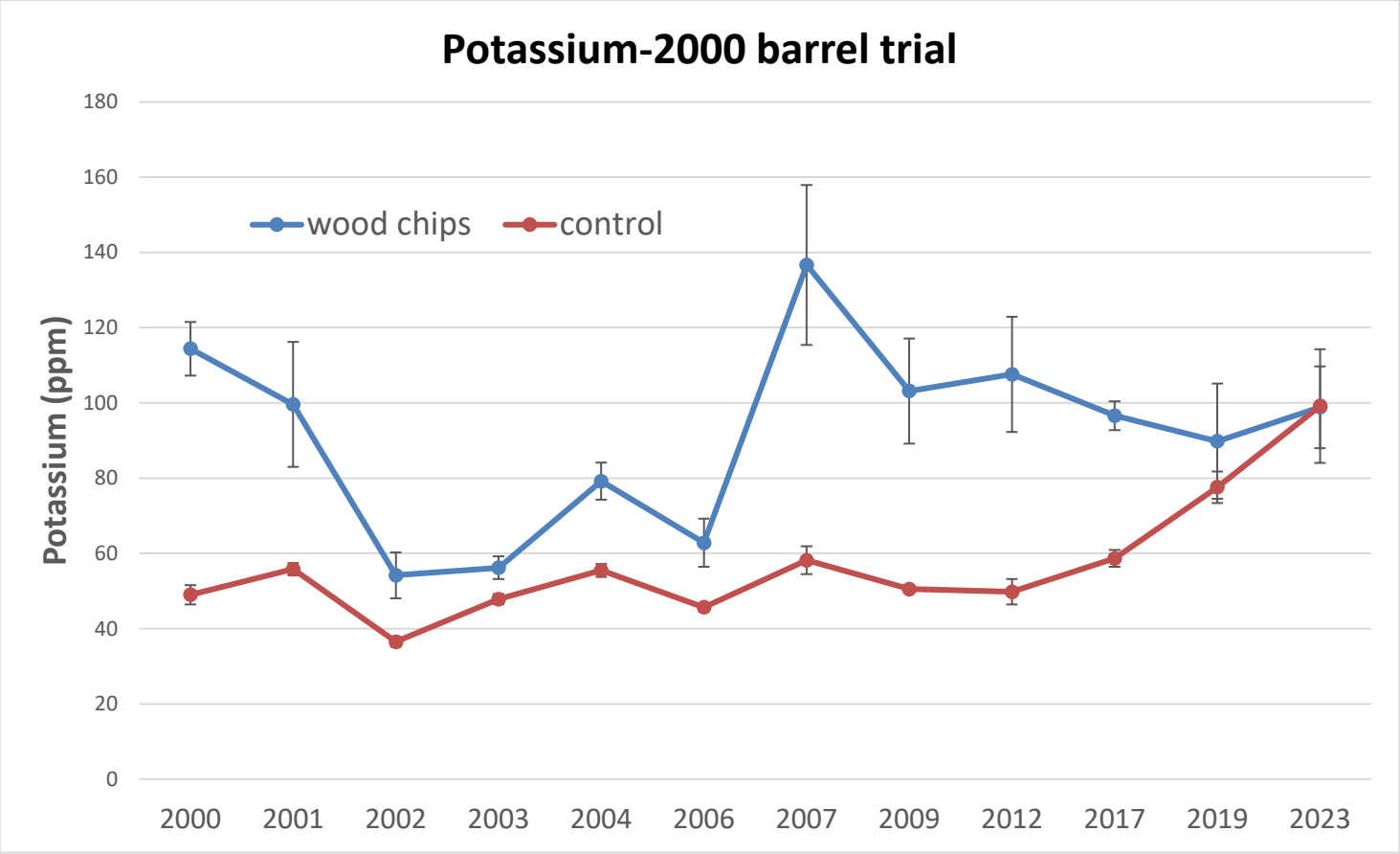
University of California
Agriculture and Natural Resources


Electrical Conductivity (EC) 2000 barrel trial
wood chips
no chips
EC dS/m
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
2000
2001
2002
2003
2004
2006
2007
2009
2012
2017
2019
2023

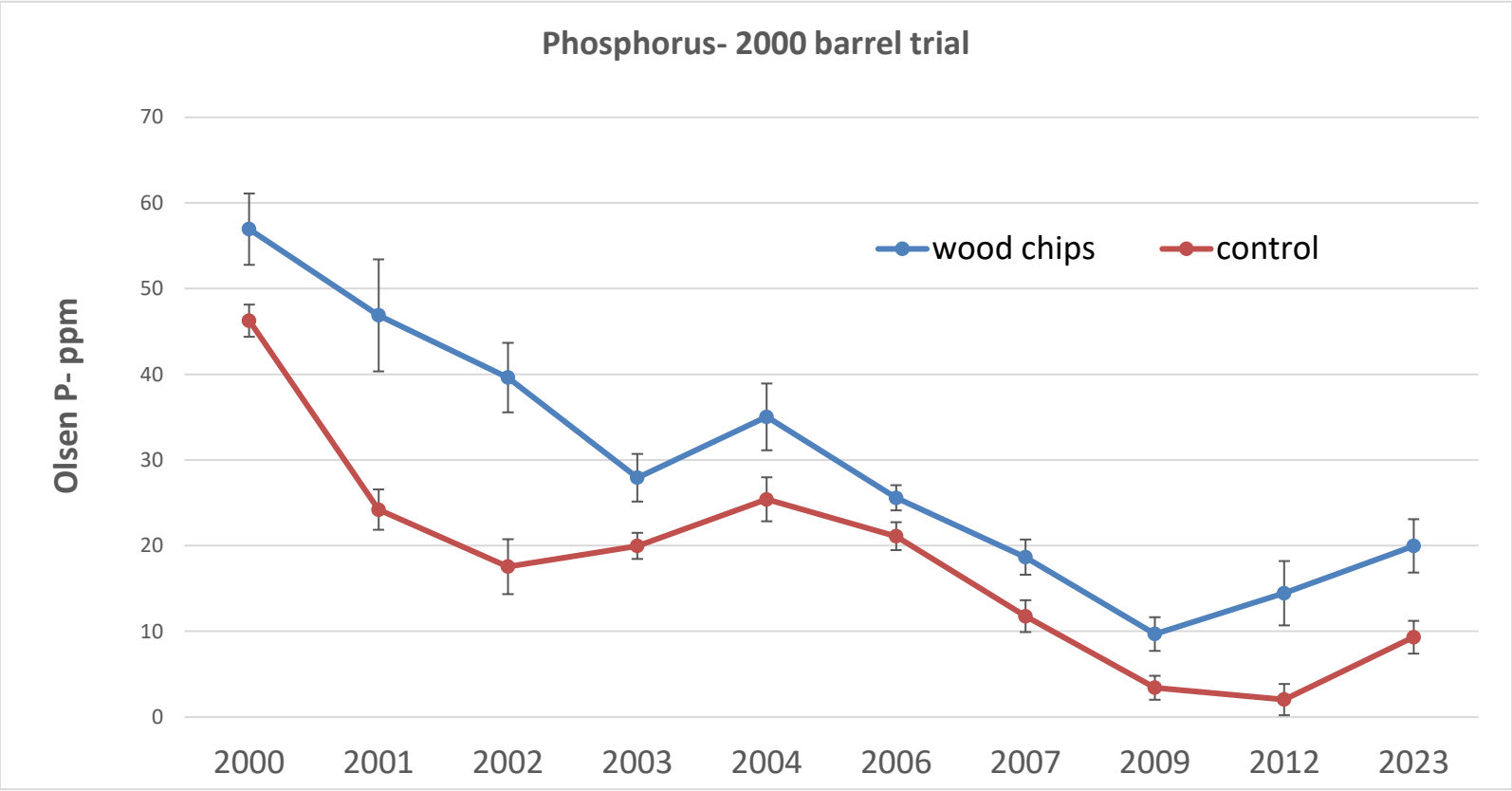


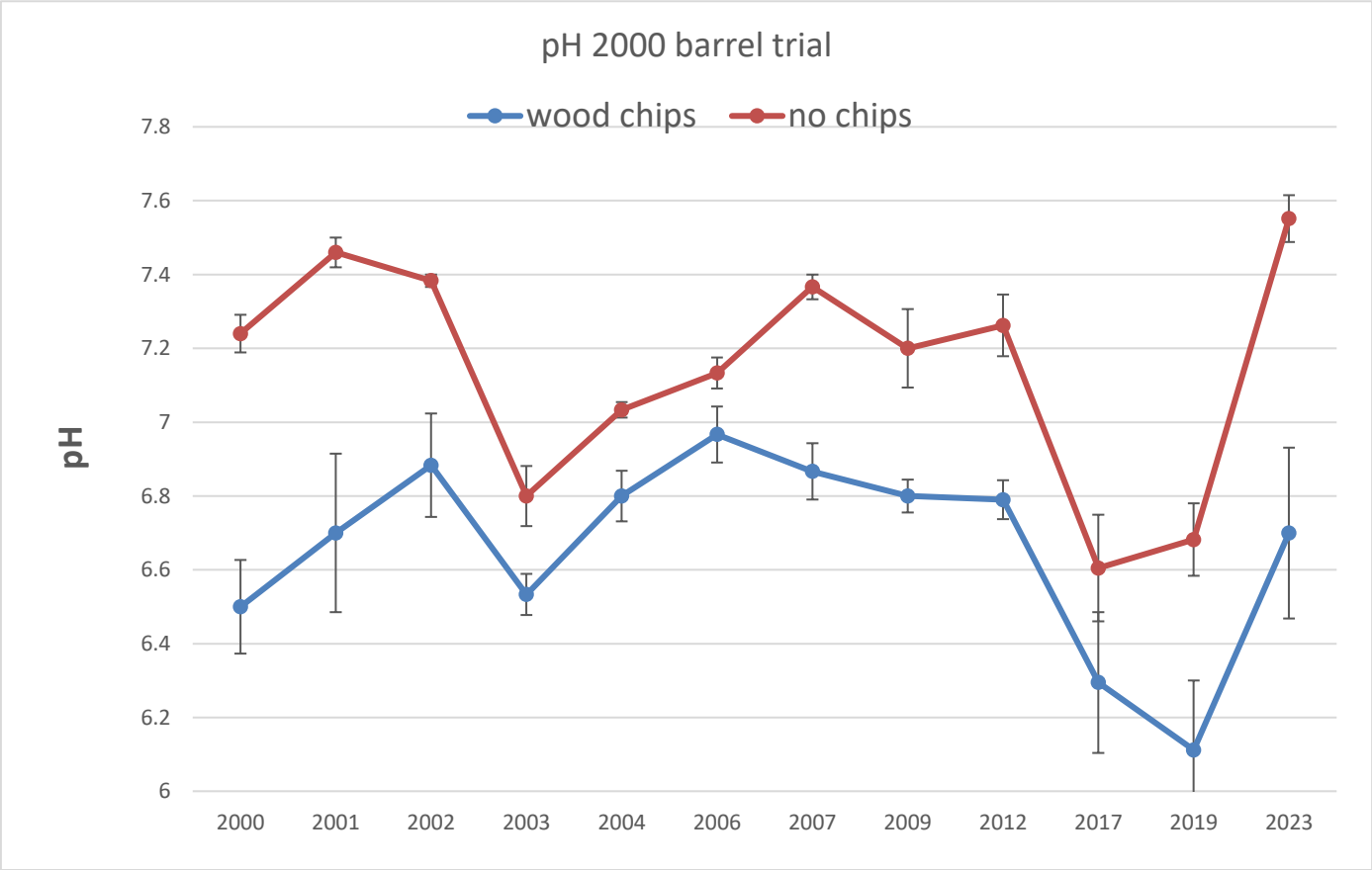
University of California
Agriculture and Natural Resources


Magnesium-2000 barrel trial
wood chips
control
Mg (meq/L)
4
3.5
3
2.5
2
1.5
1
0.5
0
2000
2001
2002
2003
2004
2006
2007
2009
2012
2017
2019
2023



University of California
Agriculture and Natural Resources


Phosphorus- 2000 barrel trial
Olsen P- ppm
70
60
50
40
30
20
10
0
wood chips
control
2000
2001
2002
2003
2004
2006
2007
2009
2012
2023


pH 2000 barrel trial
wood chips
no chips
pH
7.8
7.6
7.4
7.2
7
6.8
6.6
6.4
6.2
6
2000
2001
2002
2003
2004
2006
2007
2009
2012
2017
2019
2023

NISSAN

After 23 years in the barrels, the soil amended with the wood chips had become visually different from the controls

University of California
Agriculture and Natural Resources

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

Iron wolf

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

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

In a natural forest system– Tree nutrients come from either decomposing logs or ashes from forest fires.

NORTH

Control

Fumigated

	1	2	3	4	5	6	7	8	9	10	11	12	13
1													
2													
3			Burn							Grind			
4													
5													
6			Grind							Burn			
7													
8													
9			Burn							Grind			
10													
11													
12			Burn							Grind			
13													
14													
15			Grind							Burn			
16													
17													
18			Burn							Grind			
19													
20													
21			Grind							Burn			
22													

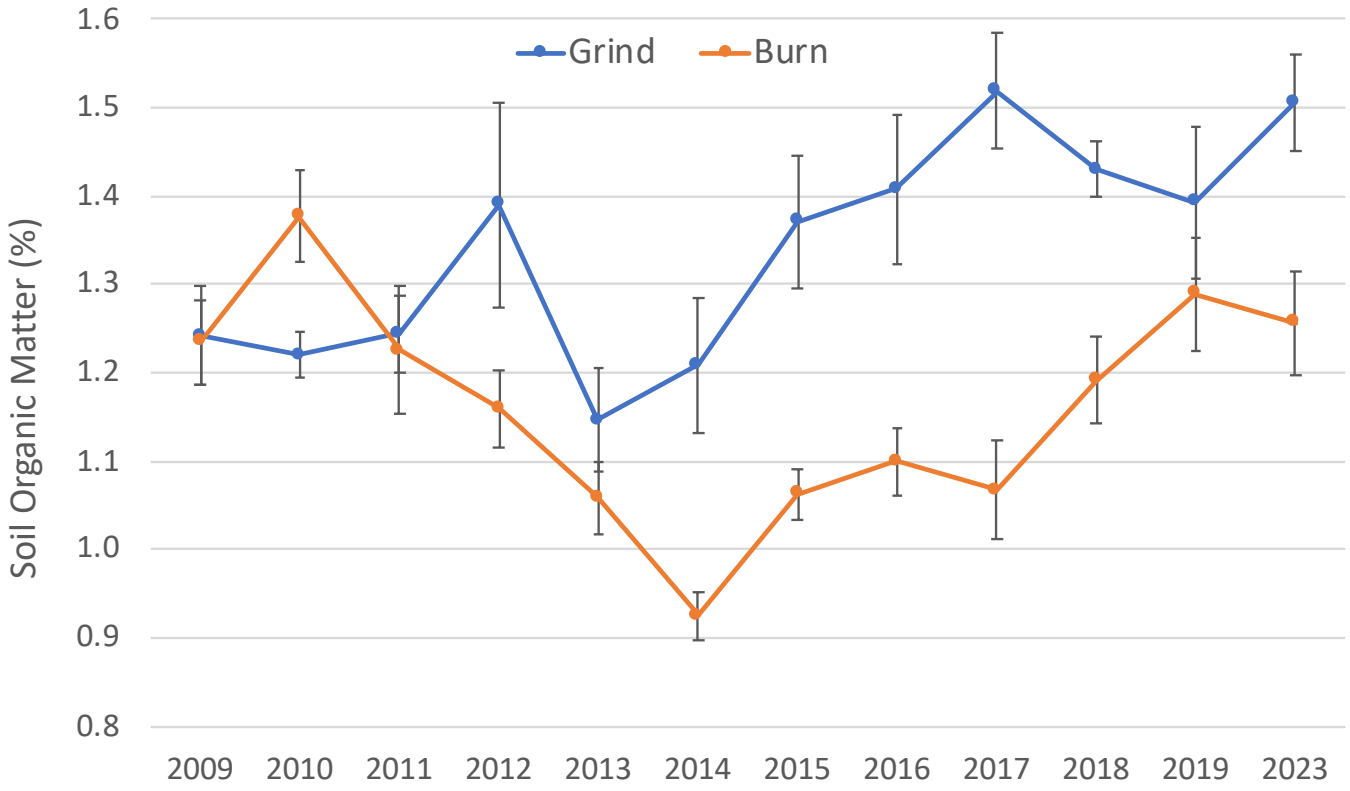
no of tree sites counting buffers: 286

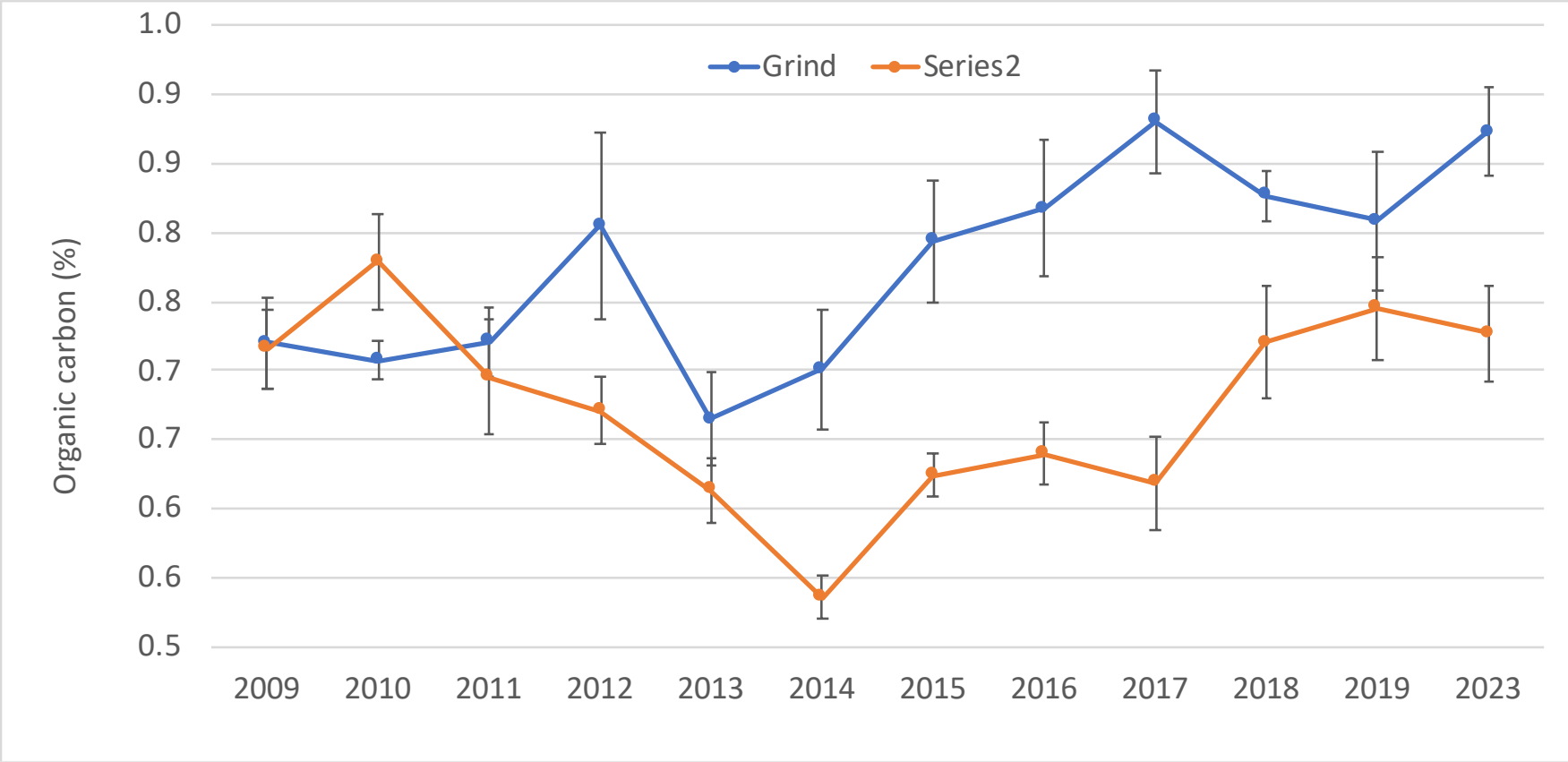
2009 First leaf trees growing in grinding plot

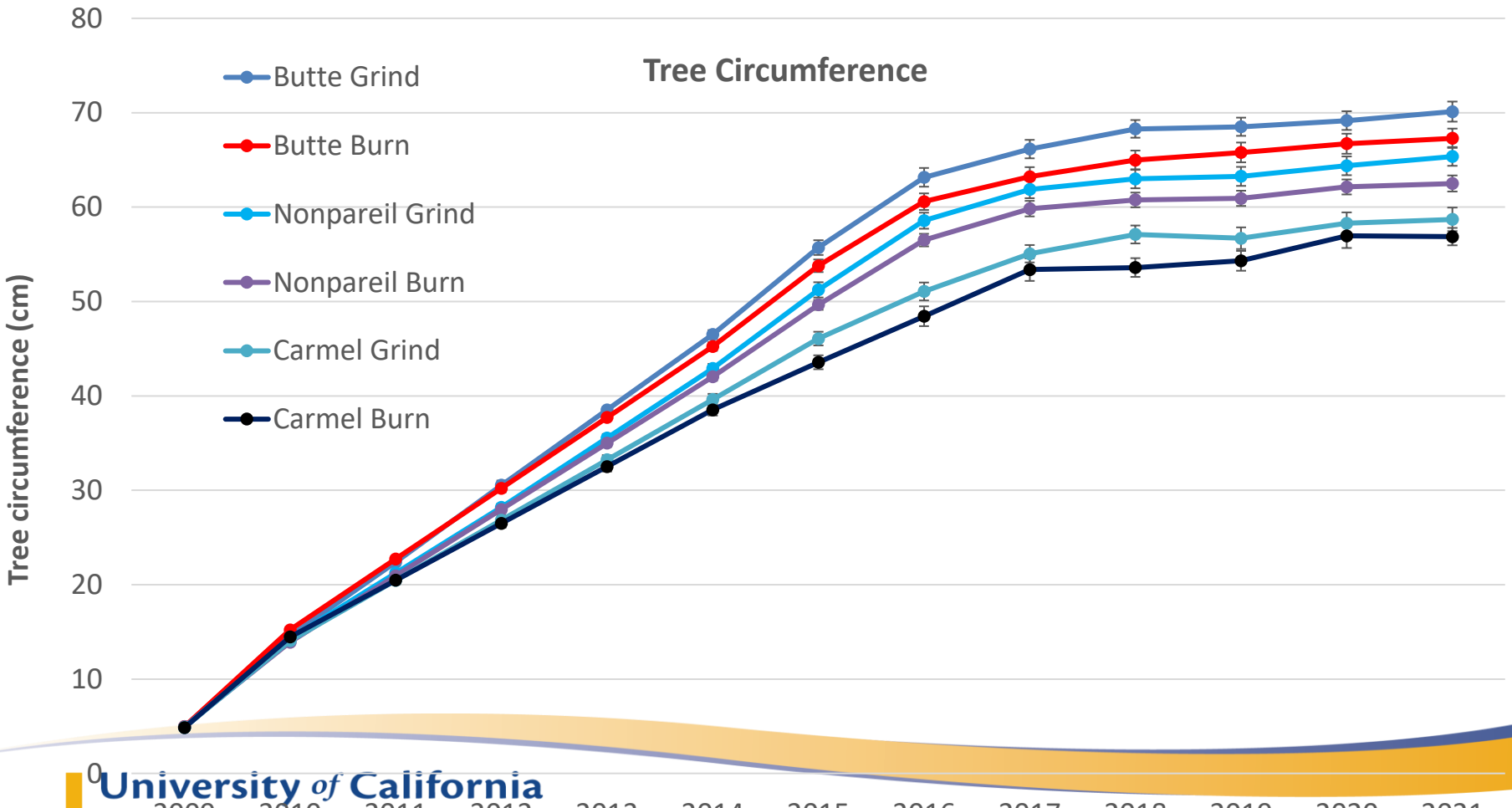
2010 Second leaf trees

No difference in tree circumference

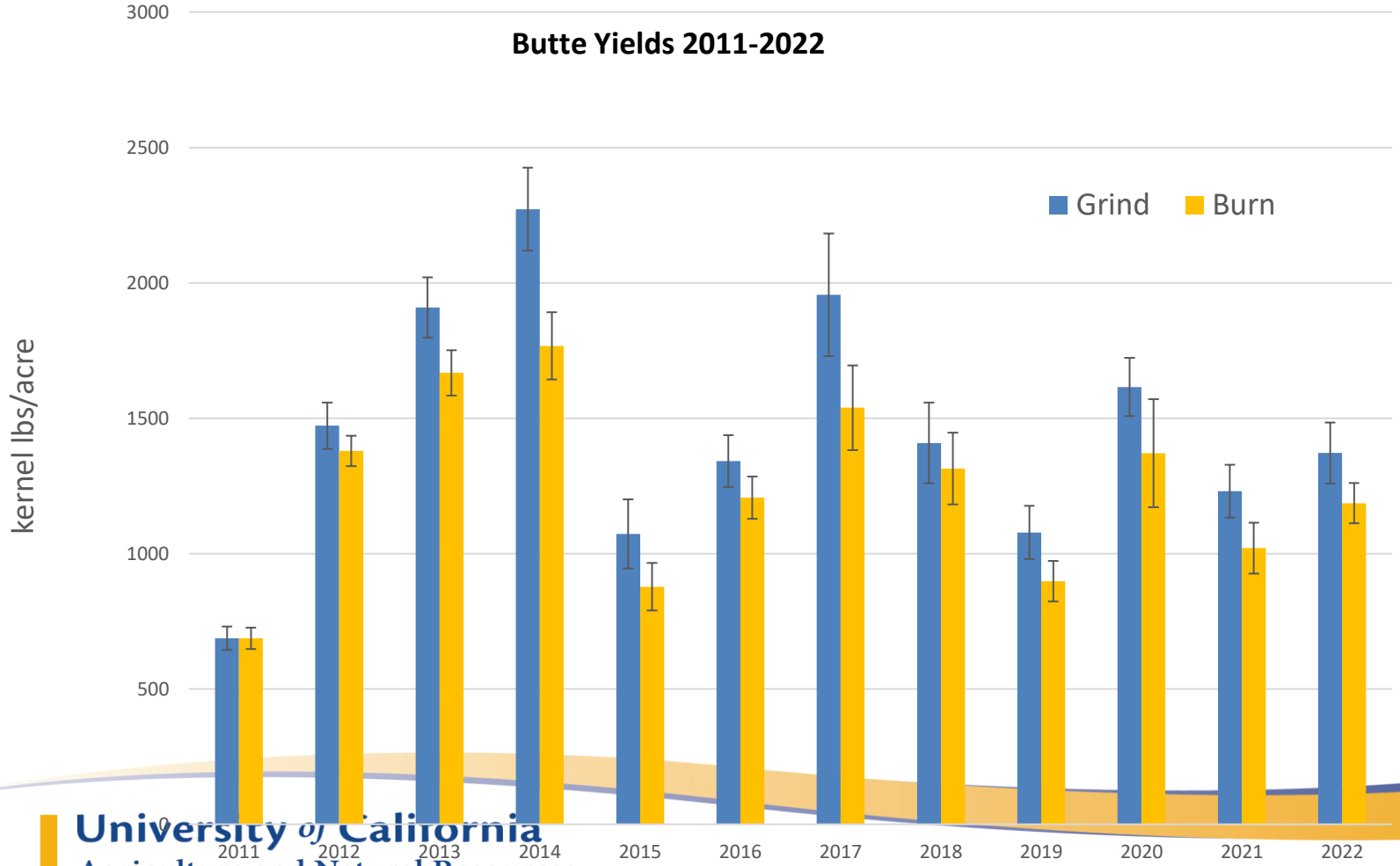
The Grinding did not stunt the second generation orchard


Grind
Burn
Soil Organic Matter (%)
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2023

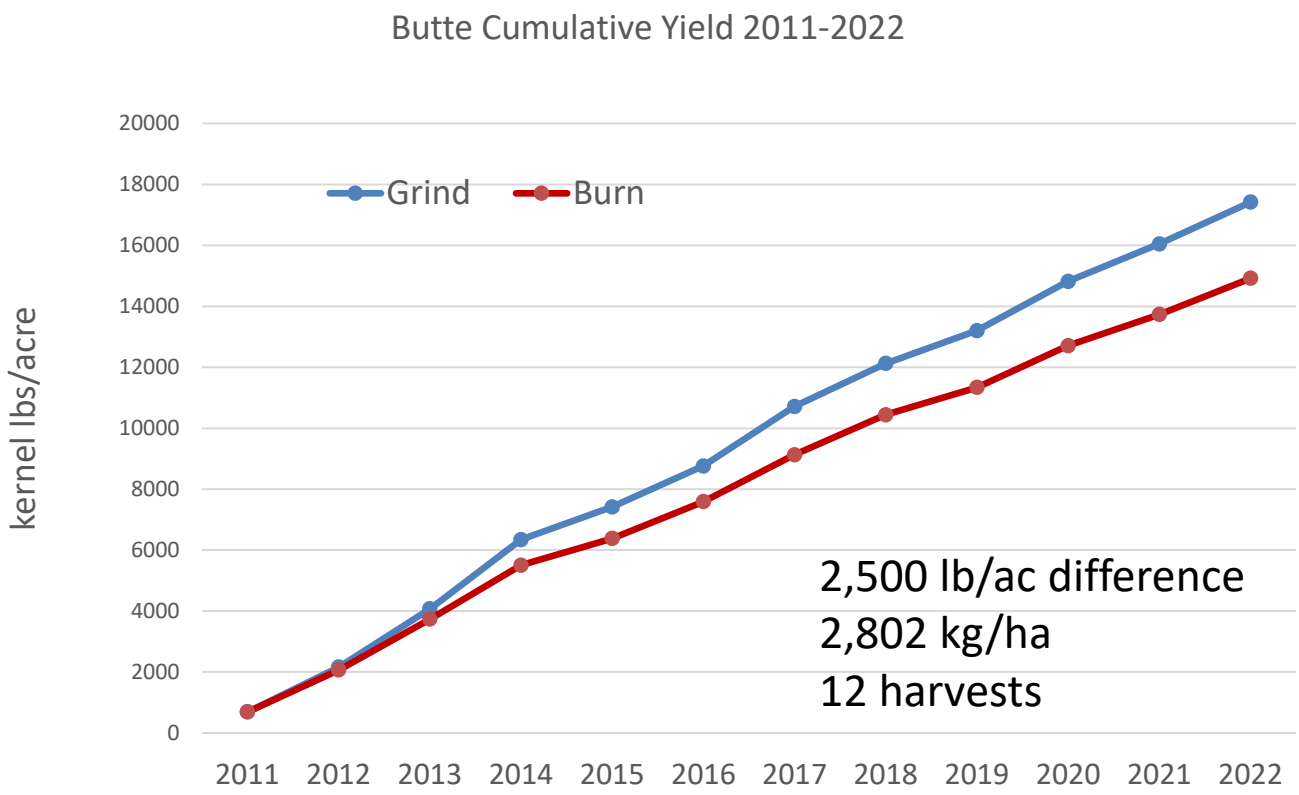

Grind
Series2
Organic carbon (%)
1.0
0.9
0.9
0.8
0.8
0.7
0.7
0.6
0.6
0.5
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2023



University of California
Agriculture and Natural Resources



University of California
Agriculture and Natural Resources


Butte Cumulative Yield 2011-2022
kernel lbs/acre
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Grind
Burn
2,500 lb/ac difference
2,802 kg/ha
12 harvests
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022

Whole Orchard Recycling has:

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

PLOS ONE

RESEARCH ARTICLE

Orchard recycling improves climate change adaptation and mitigation potential of almond production systems

Emad Jahanzad[1], Brent A. Holtz[2], Cameron A. Zuber[2], David Doll[2], Kelsey M. Brewer[1], Sean Hogan[2], Amélie C. M. Gaudin[1]*

1 Department of Plant Sciences, University of California, Davis, California, United States of America,
2 University of California Agriculture and Natural Recourses, Davis, California, United States of America

* agaudin@ucdavis.edu

Check for updates

OPEN ACCESS

Citation: Jahanzad E, Holtz BA, Zuber CA, Doll D, Brewer KM, Hogan S, et al. (2020) Orchard recycling improves climate change adaptation and mitigation potential of almond production systems. PLoS ONE 15(3): e0229588. https://doi.org/10.1371/journal.pone.0229588

Editor: Ying Ma, Universidade de Coimbra, PORTUGAL

Abstract

There is an urgent need to develop climate smart agroecosystems capable of mitigating climate change and adapting to its effects. In California, high commodity prices and increased frequency of drought have encouraged orchard turnover, providing an opportunity to recycle tree biomass *in situ* prior to replanting an orchard. Whole orchard recycling (WOR) has potential as a carbon (C) negative cultural practice to build soil C storage, soil health, and orchard productivity. We tested the potential of this practice for long term C sequestration and hypothesized that associated co-benefits to soil health will enhance sustainability and resiliency of almond orchards to water-deficit conditions. We measured soil health metrics and productivity of an almond orchard following grinding and incorporation of woody biomass vs. burning of old orchard biomass 9 years after implementation. We also conducted a deficit irrigation trial with control and deficit irrigation (-20%) treatments to quantify shifts in

Received: 18 March 2022 | Accepted: 13 June 2022

DOI: 10.1002/jeq2.20385

Journal of Environmental Quality

TECHNICAL REPORT

Groundwater Quality

Effects of whole-orchard recycling on nitrate leaching potential in almond production systems

Emad Jahanzad[1] | Kelsey M. Brewer[2] | Amisha T. Poret-Peterson[3] | Catherine M. Culumber[4] | Brent A. Holtz[4] | Amélie C. M. Gaudin[2]

[1]California Department of Food and Agriculture, Sacramento, CA 95814, USA

[2]Dep. of Plant Sciences, Univ. of California, Davis, CA 95616, USA

[3]USDA-ARS, Crops Pathology and Genetics Research Unit, Davis, CA 95616, USA

[4]Division of Agriculture and Natural Recourses, Univ. of California, Davis, CA 95616, USA

Correspondence
Amélie C. M. Gaudin, Dep. of Plant Sciences, Univ. of California, Davis, CA 95616, USA.
Email: agaudin@ucdavis.edu

Assigned to Associate Editor Tamie Veith.

Funding information
Specialty Crop Block Grant Program of the California Department of Food and Agriculture

Abstract

Inefficient nitrogen (N) fertilization and irrigation have led to unhealthy nitrate levels in groundwater bodies of agricultural areas in California. Simultaneously, high commodity prices and drought have encouraged perennial crop growers to turnover less-productive orchards, providing opportunities to recycle tree biomass in situ and to use high-carbon (C) residues to conserve soil and water resources. Although climate change adaptation and mitigation benefits of high-C soil amendments have been shown, uncertainties remain regarding the benefits and trade-offs of this practice for N cycling and retention. We used established almond [*Prunus dulcis* (Mill.) D. A. Webb] orchard trials on Hanford fine sandy loam with short-term and long-term biomass recycling legacies to better understand the changes in N dynamics and retention capacity associated with this practice. In a soil column experiment, labeled N fertilizer was added and traced into various N pools, including microbial biomass and inorganic fractions in soil and leachate. Shifts in microbial communities were characterized using the abundance of key N cycling functional genes regulating nitrification and denitrification processes. Our findings showed that, in the short term, biomass recycling led to N immobilization within the orchard biomass incorpora-

Univ
Agricu

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,

AgAlert®

THE WEEKLY NEWSPAPER FOR CALIFORNIA AGRICULTURE

In 2015 growers started using manure spreaders to spread wood chips back on the soil surface

University of California
Agriculture and Natural Resources

University *of* California
Agriculture and Natural Resources

Horizontal grinders can chip 15-20 acres per day.

Orchard removal typically involves five machines and costs between $600-700 acre. Horizontal grinders can chip up 15-20 acres per day. Two inch screen sizes are recommended rather than four inch screens to reduce chip size.

Kuhn & Knight manure spreaders were modified to spread wood chips.

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

Wood chips are spread uniformly over entire field surface

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

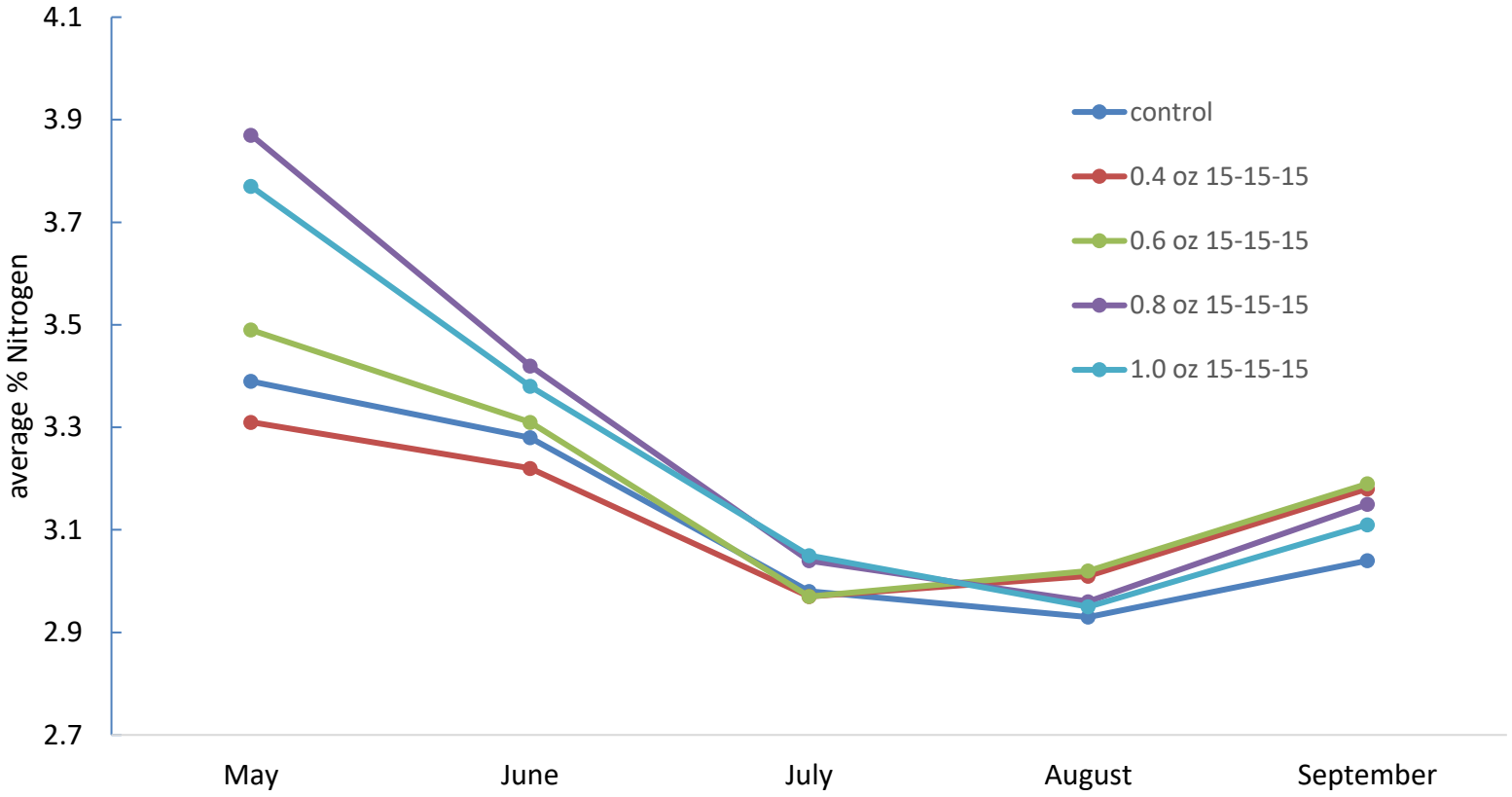
The nutrients will be released gradually and naturally

64 tons per acre caused initial tree stunting and total weed suppression. The C:N ratio was out of balance.

We doubled our nitrogen applications through fertigation in order to get the desired growth.

Control

0.8 oz of N applied in March


4.1
3.9
3.7
3.5
3.3
3.1
2.9
2.7
average % Nitrogen
May
June
July
August
September
control
0.4 oz 15-15-15
0.6 oz 15-15-15
0.8 oz 15-15-15
1.0 oz 15-15-15

Control

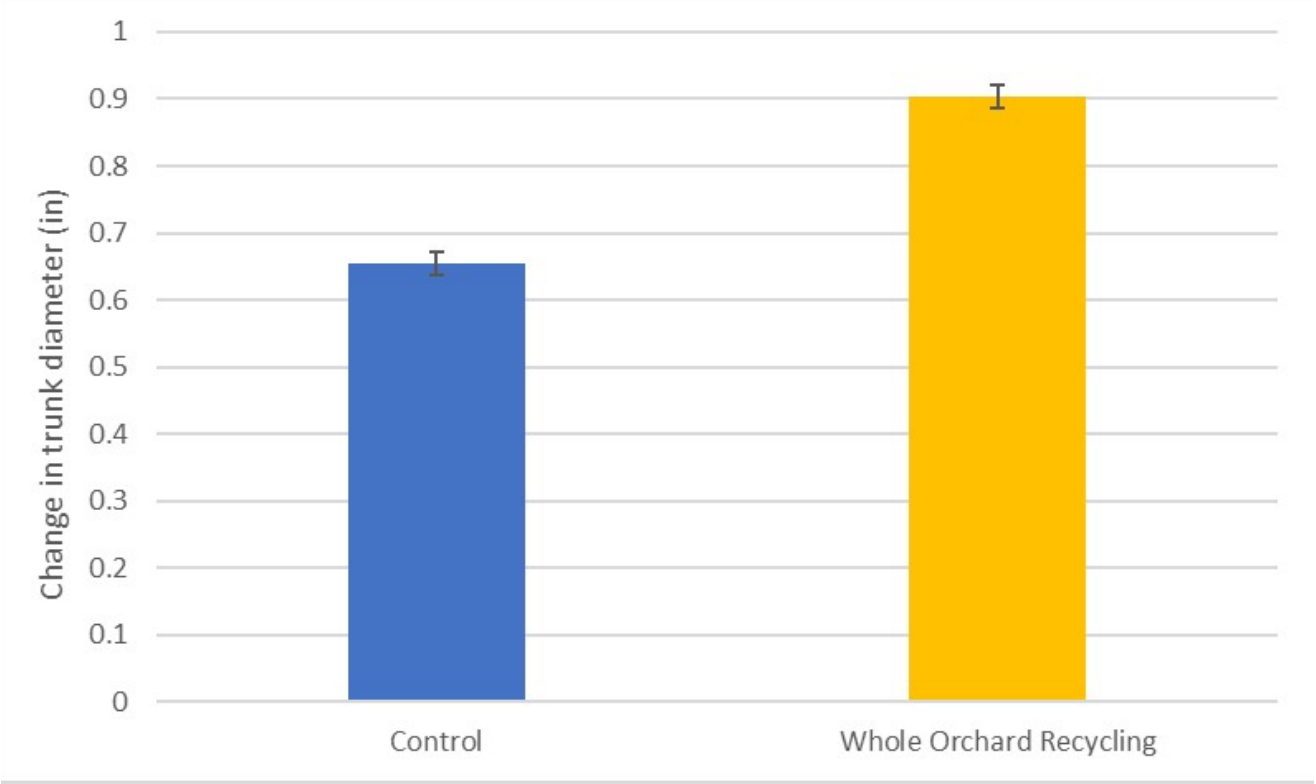
70 tons per acre rate

Control

70 tons per acre rate

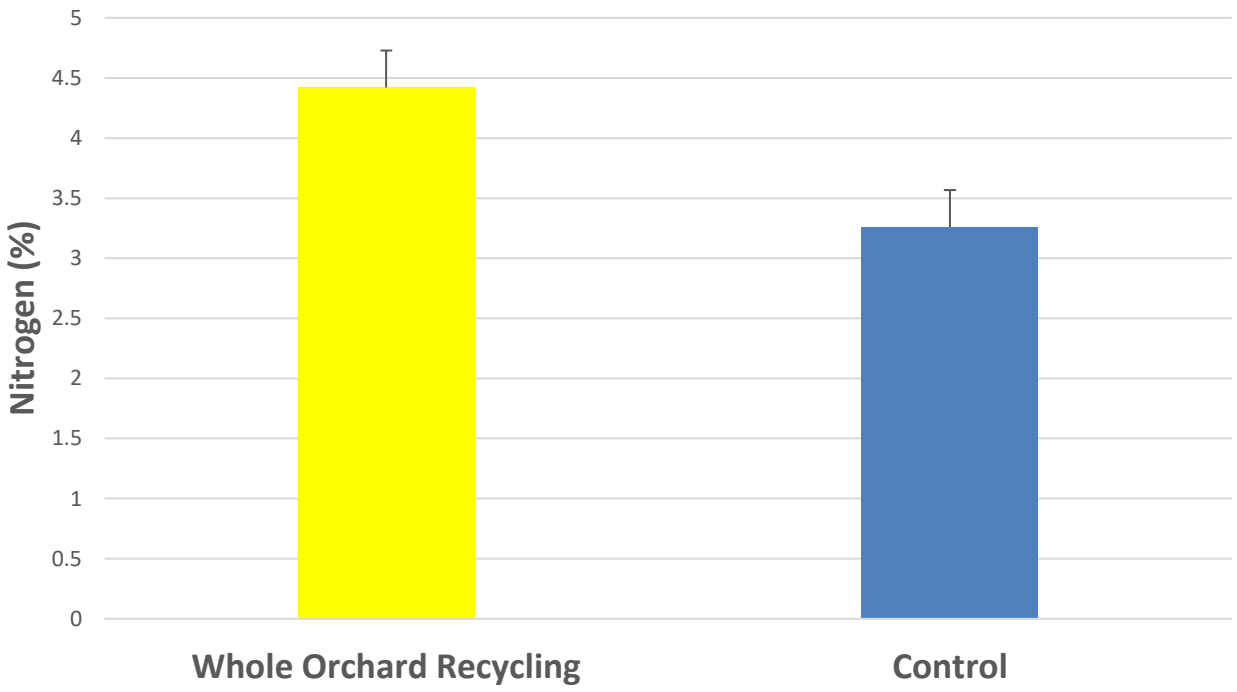
University of California
Agriculture and Natural Resources

Both treatments received 45 lbs N/acre



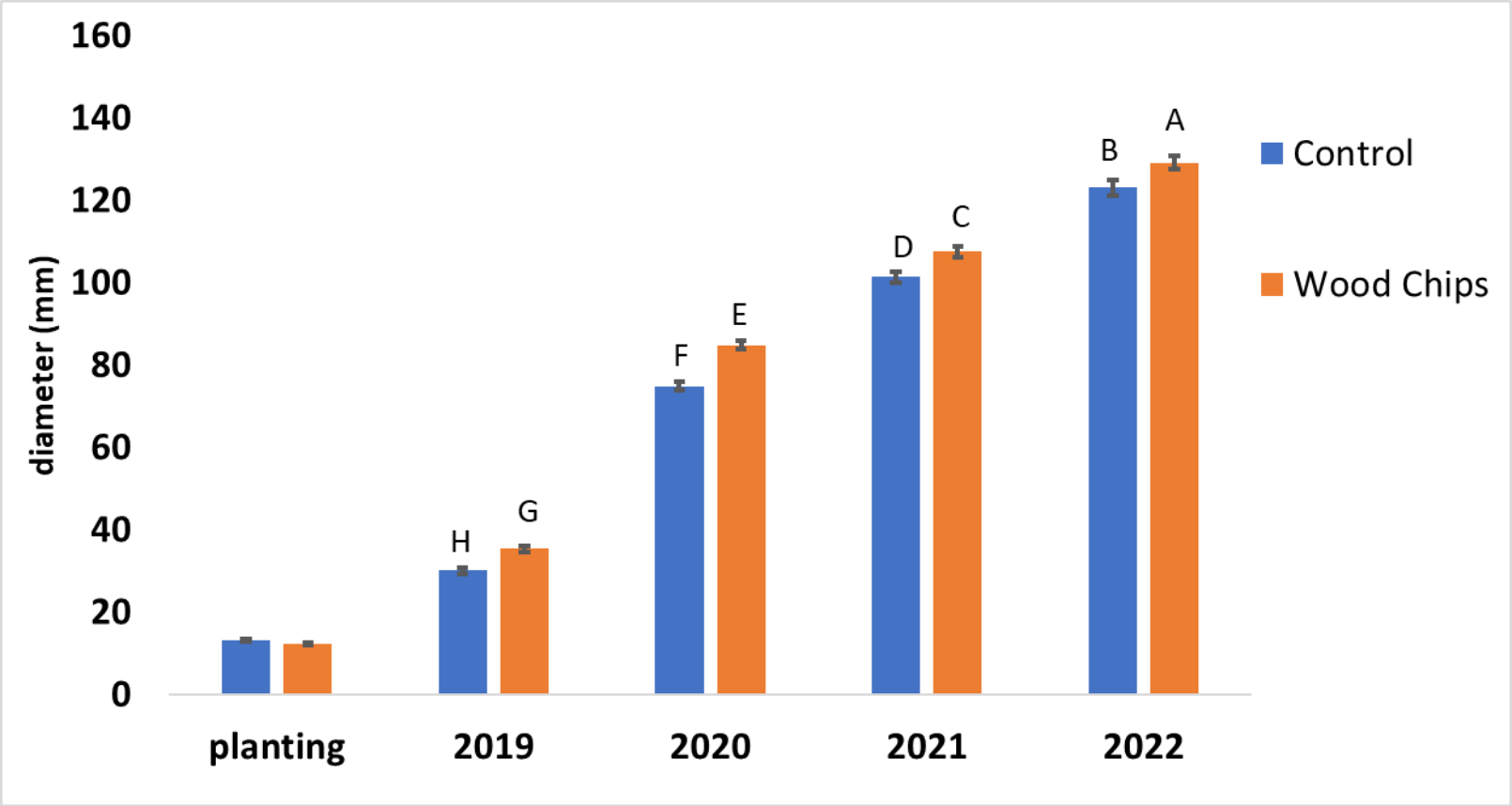
Both treatments received 45 lbs N/acre (5 oz N per tree)

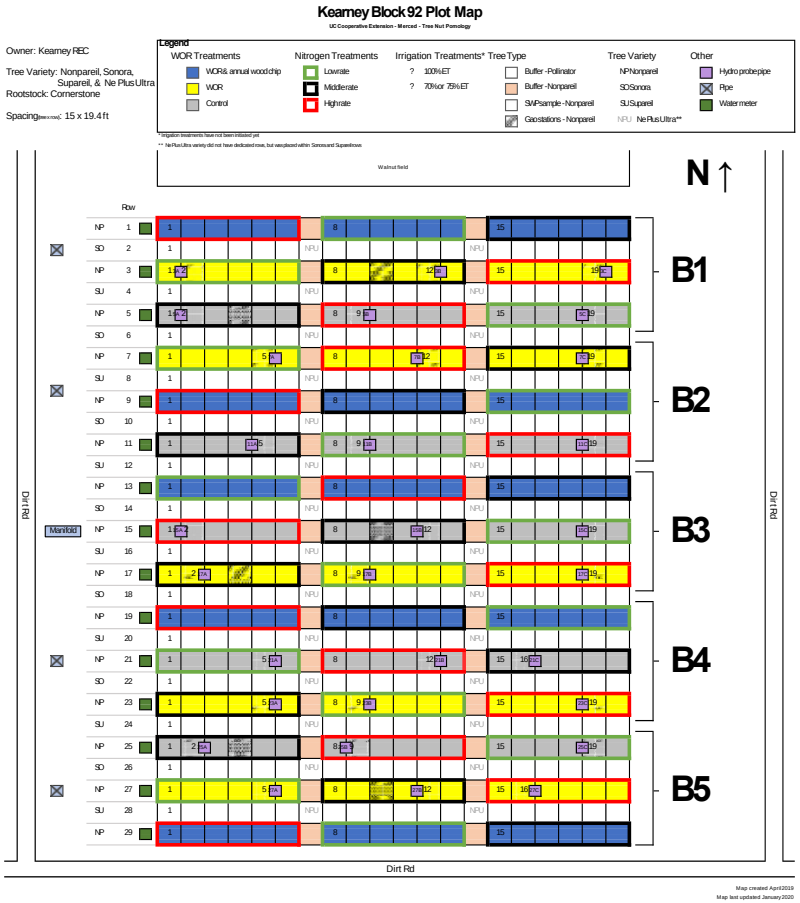
Leaf Petiole Analysis



University of California
Agriculture and Natural Resources

Both received 45 lbs N/acre (5 oz N per tree)


160
140
120
100
80
60
40
20
0
diameter (mm)
H
G
F
E
D
C
B
A
Control
Wood Chips
planting
2019
2020
2021
2022



Three WOR treatments:

WOR + annual wood chips (15 tons)

WOR

Control

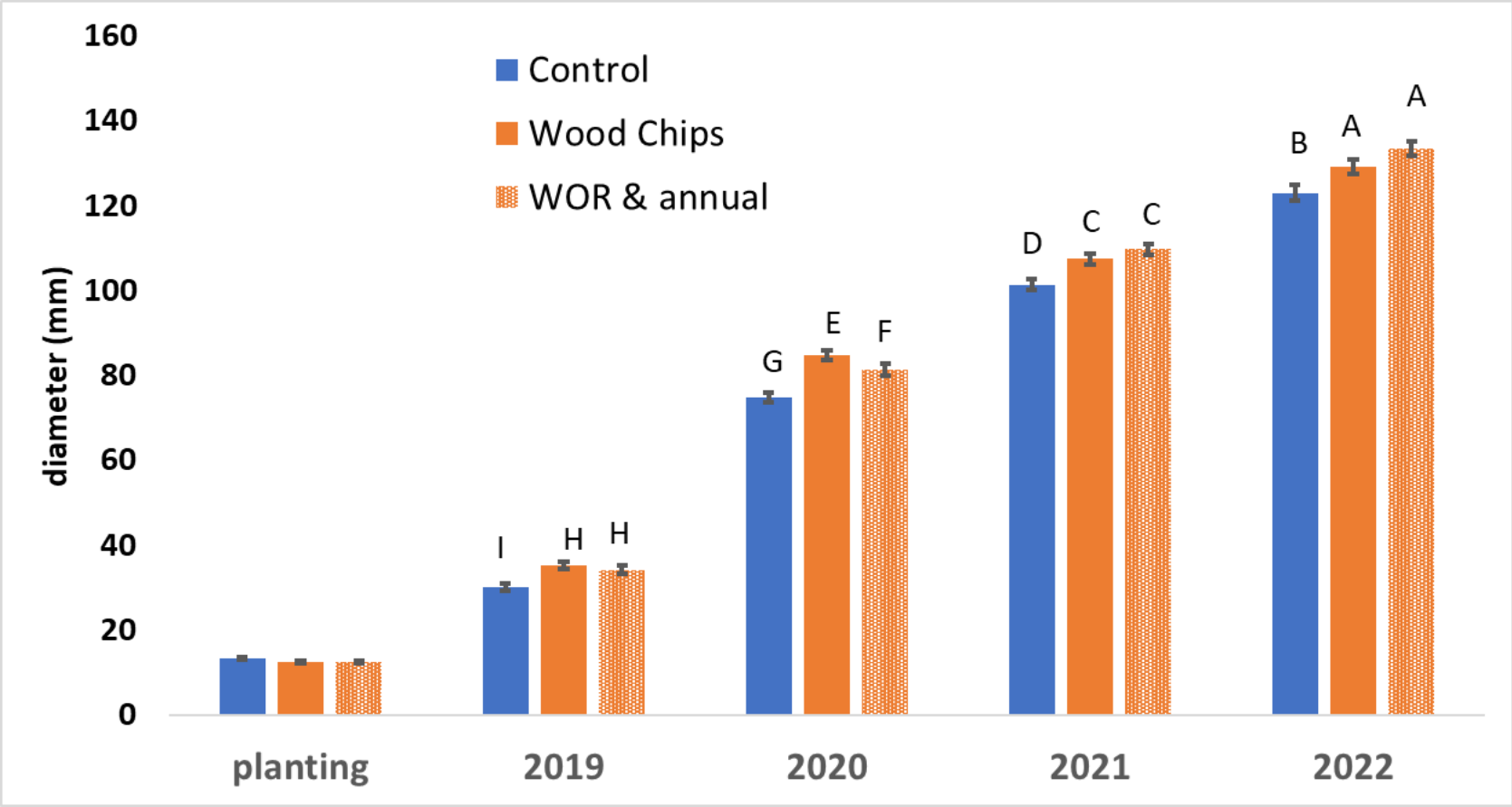
Three sub-treatments:

Low N rate

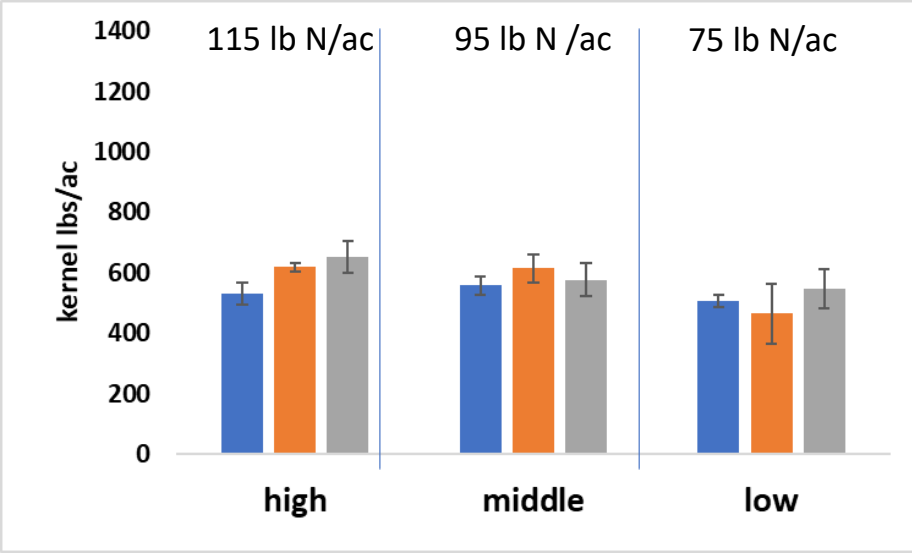
Middle N

High N (Patrick Brown's)

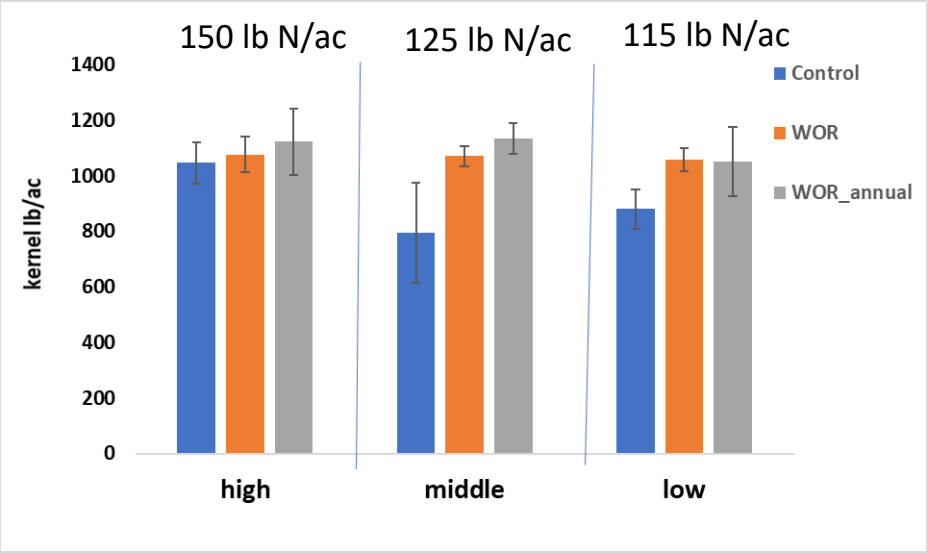
Annual applications:
15 tons per acre/annually
Hope to see similar benefits to cover cropping


160
140
120
100
80
60
40
20
0
diameter (mm)
Control
Wood Chips
WOR & annual
I
H
H
G
E
F
D
C
C
B
A
A
planting
2019
2020
2021
2022

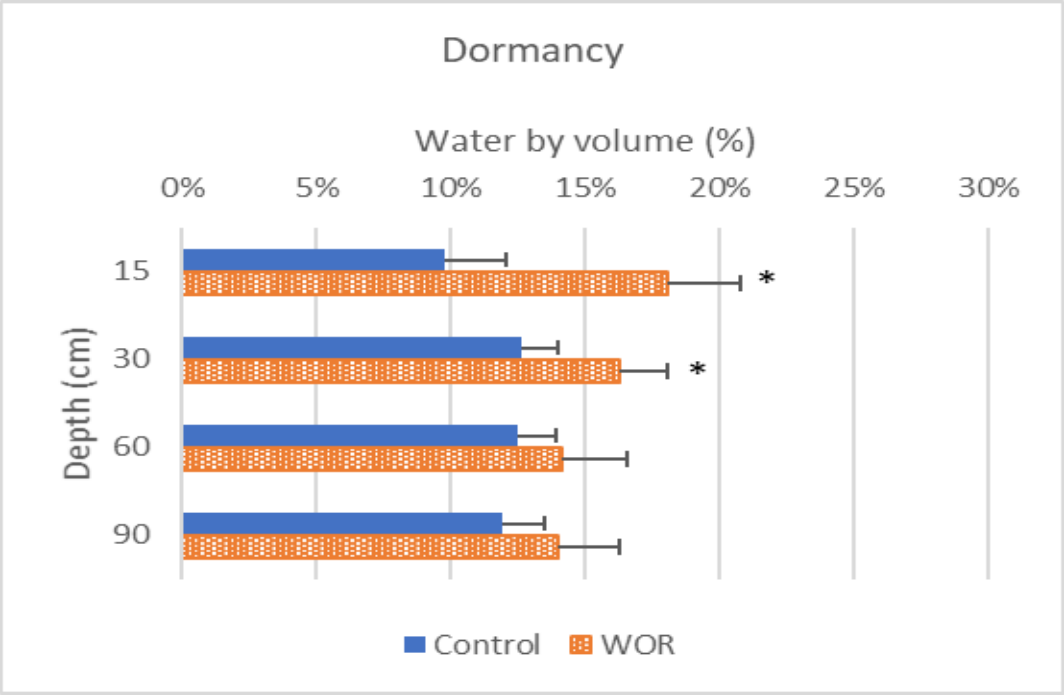
Almond yield after WOR same or better than control with no N rate effect



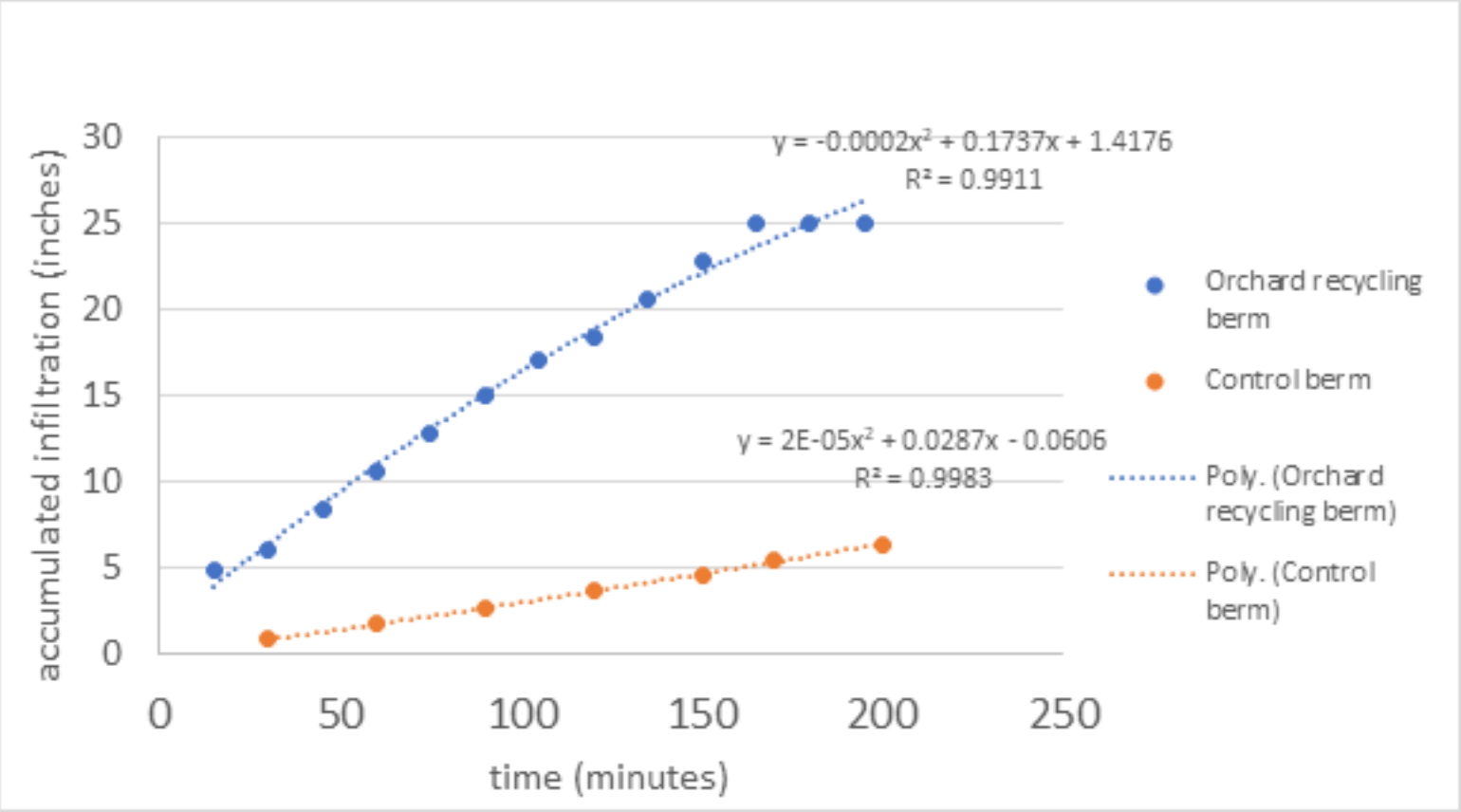
3rd leaf

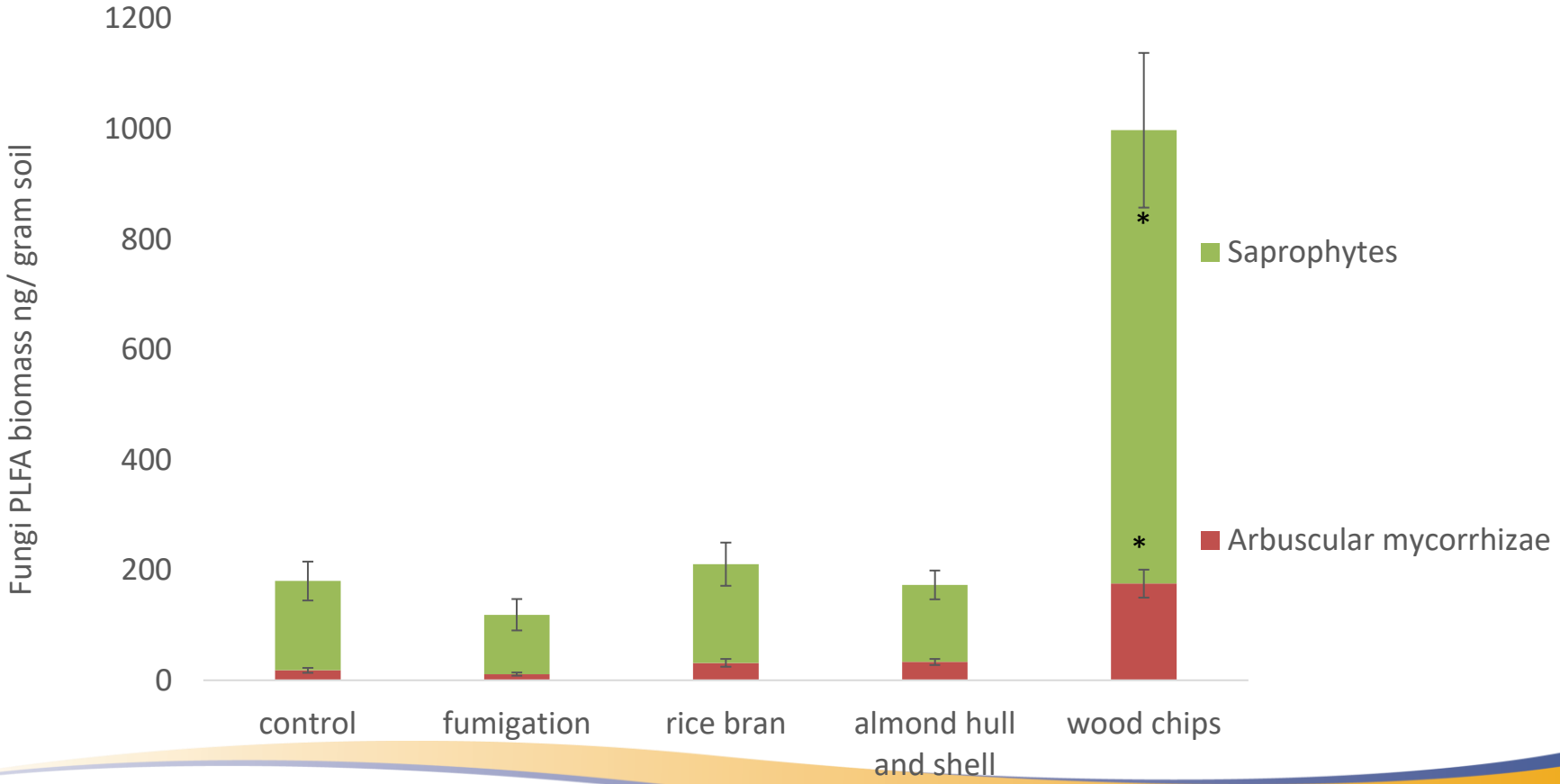


4th leaf



A 42% increase in soil moisture by volume was observed in WOR treatments (17% VWC) compared to the control (11% VWC) during the 2019-2020 dormant period in the top 30 cm


y = -0.0002x² + 0.1737x + 1.4176
R² = 0.9911
y = 2E-05x² + 0.0287x - 0.0606
R² = 0.9983
accumulated infiltration (inches)
30
25
20
15
10
5
0
0
50
100
150
200
250
time (minutes)
Orchard recycling berm
Control berm
Poly. (Orchard recycling berm)
Poly. (Control berm)



University of California
Agriculture and Natural Resources

San Joaquin Valley Air Pollution Control District

Table 2: State Funding Executed 9/1/2021 - Present

Category	Total Funding Available	Total Funding Executed	Total Funding Remaining
New Equipment Purchase	$30,000,000	$29,634,243	$365,757
Alternative Practices	$137,062,500	$80,277,119	$57,151,138
Totals:	**$167,062,500***	**$109,911,362**	**$57,516,895**

*total project funds available

Since inception, the program has resulted in the deployment of alternative practices at over 162,000 acres of orchard and vineyard removals, for nearly 4,500,000 tons of agricultural materials, resulting in the reduction of 8,791 tons of NOx, 16,212 tons of PM and 13,702 tons of ROG emissions as compared to open burning. Table 3 below illustrates program participation details by crop type.

$185 million since 2018

Table 3: Participation by Crop Type (All Time)

Crop Type	Executed Projects	Acres	Tons of Material	Tons of Material (% Valley Total)
Almonds	1,313	105,303	3,159,103	71%
Grapes	611	26,916	403,741	9%
Walnuts	287	11,028	330,841	7%
Citrus	185	4,876	146,271	3%
Plums	142	3,629	108,876	2%
Peaches	165	3,225	96,753	2%
Cherry	78	2,090	62,706	1%
Nectarines	98	1,630	48,897	1%
Olives	49	1,319	39,570	1%
Apricots	33	1,159	34,767	1%
Other	58	1,600	47,351	1%
Total	**3,019**	**162,775**	**4,478,874**	**100%**

University of C
Agriculture and Nat

CDFA's Healthy Soils Program has approved Whole Orchard Recycling as a practice that growers can receive incentives for practicing. www.cdfa.ca.gov

USDA-Natural Resources Conservation Services' (NRCS) Environmental Quality Incentives Program (EQIP) has implemented mulching and soil incorporation as program to help growers implement WOR.

In July 19, 2022, Governor Newsom signed AB 2101 (Flora) California Carbon Sequestration and Climate Resiliency Project Registry: Whole Orchard Recycling Projects. An additional $178 M was approved for WOR.

WOR Co-Investigators:

Catherine Culumber, Ph.D., Farm Advisor, UCCE in Fresno County, cmculumber@ucanr.edu

Suduan Gao, Ph.D., Soil Scientist, USDA-ARS in Fresno, Suduan.Gao@ars.usda.gov

Amisha Poret-Peterson, Ph.D., Microbiologist, USDA-ARS, UCD, aporetpeterson@ucdavis.edu

Greg Browne, Ph.D., Research Plant Pathologist, USDA-ARS, UCD, gtbrowne@ucdavis.edu

Amélie CM Gaudin, Ph.D., Assistant Professor, Agroecology, UCD, Plant Science, agaudin@ucdavis.edu

Emad Jahanzad, Ph.D., Senior Environmental Scientist, CDFA, Emad.Jahanzad@cdfa.ca.gov

Amanda Hodson, Ph.D., Assistant Professor, Entomology and Nematology, UC Davis,

Cameron Zuber, Farm Advisor, UCCE Merced County, cazuber@ucanr.edu

Astrid Volder, Ph.D., Professor, Plant Sciences, UCD, avolder@ucdavis.edu

David Doll, ex-Farm Advisor, Rua Dordio Gomes, daviddoll01@gmail.com

Franz Niederholzer, Ph.D., Farm Advisor, UCCE in Colusa/Sutter/Yuba Counties, fjniederholzer@ucanr.edu

Mohammad Yaghmour, Ph.D., Farm Advisor, UCCE in Kern County, mayaghmour@ucanr.edu

Phoebe Gordon, Ph.D., Farm Advisor, UCCE in Madera County, pegordon@ucanr.edu

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.

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.

MORBARK
50/48
DRUM CHIPPER
MORBARK
MORBARK

BANDIT
BANDIT
BANDIT

BANDIT INDUSTRIES, INC. • *CUSTOMER NEWSLETTER* • VOLUME 50 FALL/WINTER 2015

NORTHERN EXPOSURE

Penn Line Service

IN THIS ISSUE:

- Bailey Tree Company On the Job
- Industry News & Product Updates
- Unsung Heroes: Model 90XP Chipper

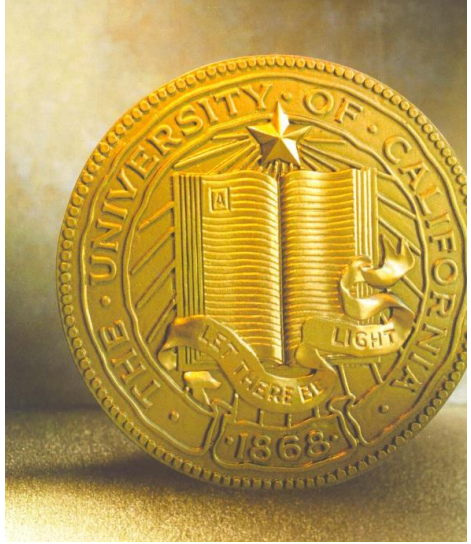
FAMILY MATTERS:
Meinhart's Tree Service

ROGERS WOOD PRODUCTS
Headed for Continued Success

BCAP Provides Economic Boost for Biomass Producers

FOR THE LATEST STORIES, VIDEOS, AND PHOTOS, VISIT BANDIT ON THE WEB!
HTTP://WWW.BANDITCHIPPERS.COM

BANDIT



Thank You!

cdfa
CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

california almonds
AlmondBoard.com

USDA
ars