



Field Quality: Stockpile Management + Concealed Damage



Bob Curtis

Almond Board of California





Field Quality: Stockpile Management + Concealed Damage

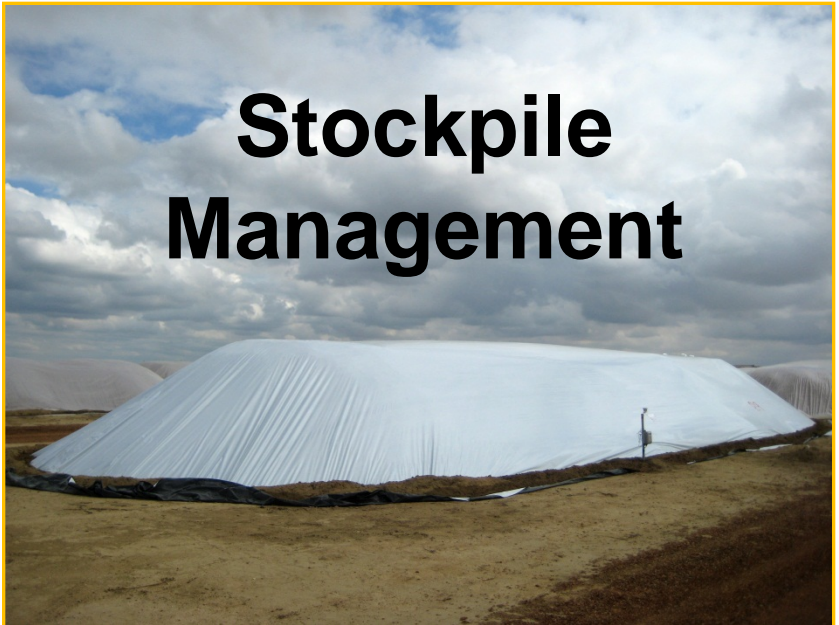
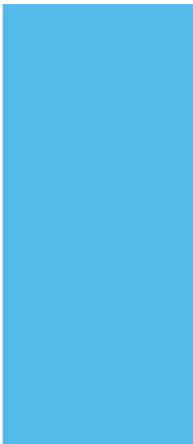
Bruce Lampinen

UC Davis

Franz Neiderholzer

UCCE-Sutter, Yuba, Colusa Counties





Stockpile Management

Bruce Lampinen (UC Davis)

Themis Michailides, (UC Davis/Kearney)

Jim Thompson, Sam Metcalf,
and William Stewart (UC Davis)

David Morgan, Heraclio Reyes,
Y. Luo, and B. Kabak (UC Davis/Kearney)



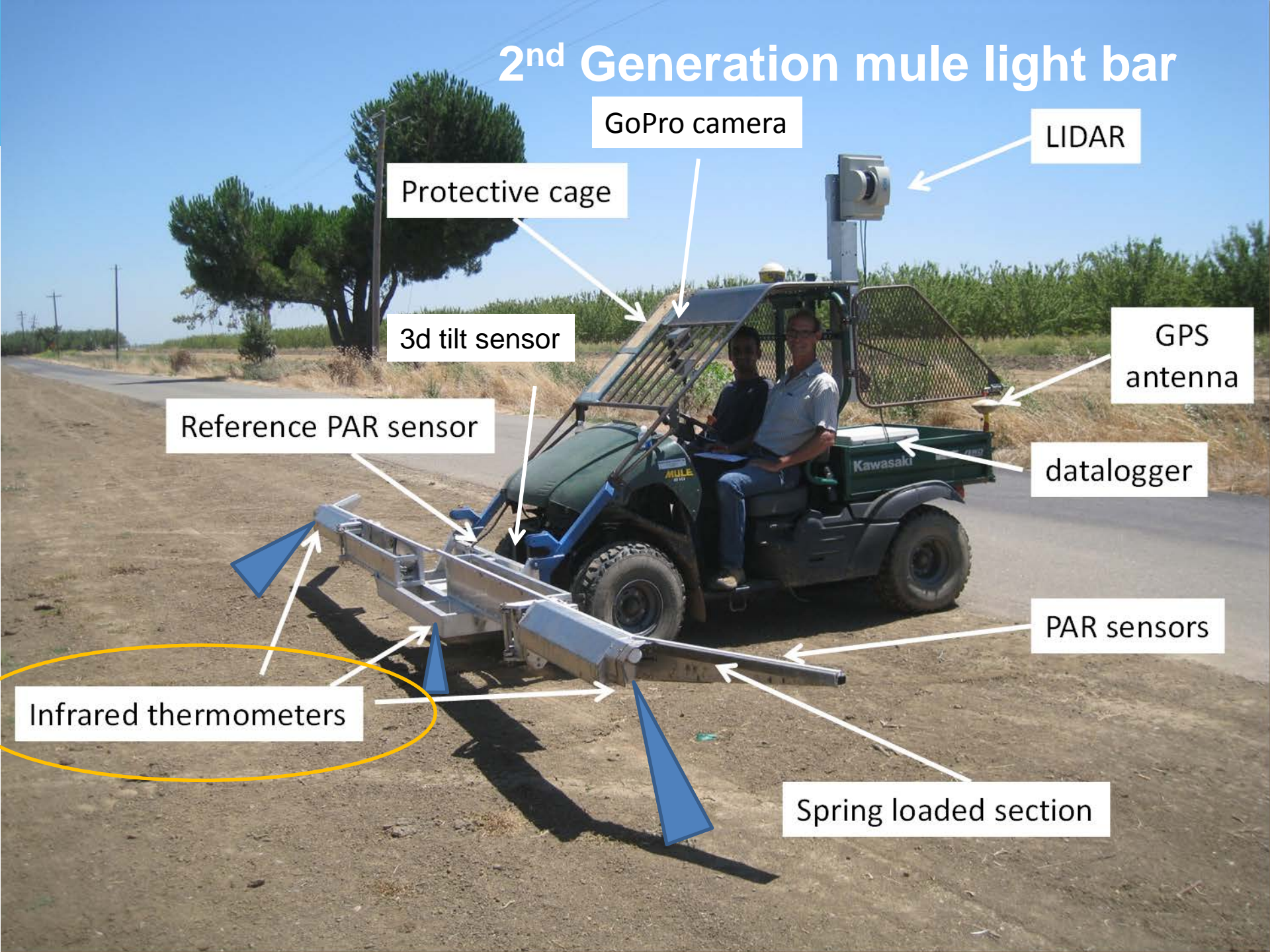
Orchard microclimate influence on food safety risk

- **Midday canopy light interception versus orchard floor temperature**
- **Nut drying on orchard floor- left in place versus conditioned and windrowed**
- **Row orientation**

Stockpiling

- **Tarp types**
 - **Clear, white, white on black**
- **Stockpile orientation**
 - **North south versus east west facing**
- **Moisture content- water activity versus moisture content**

2nd Generation mule light bar



GoPro camera

LIDAR

Protective cage

3d tilt sensor

GPS antenna

Reference PAR sensor

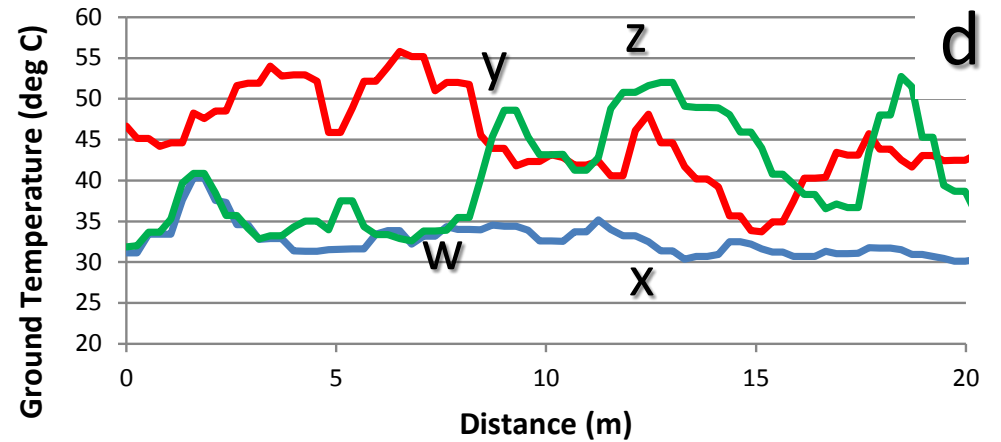
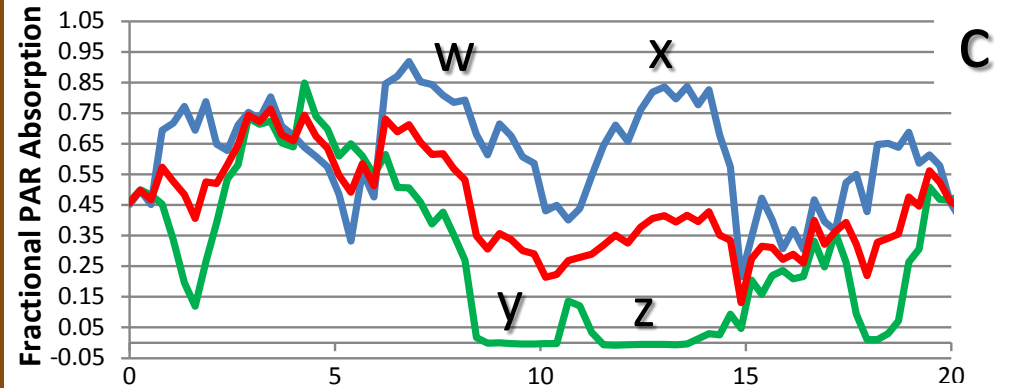
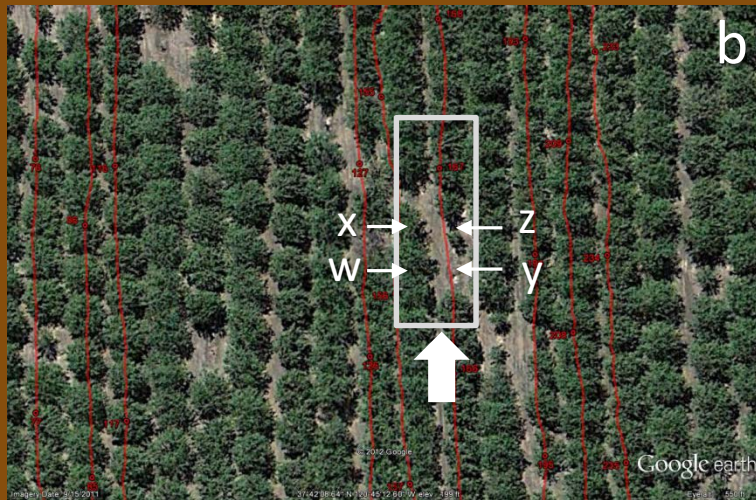
datalogger

Infrared thermometers

PAR sensors

Spring loaded section





— Left — Center — Right

w, x = heavy shade- low soil surface temperatures
 y, z = open area near missing tree- high soil temp

Canopy density as well as canopy size can have large impact on light interception/yield potential as well as food safety risk

Dense canopy letting very little light reach orchard floor under tree (higher yield, cooler temperatures)



Sparse canopy letting much more light reach orchard floor under tree (lower yield, warmer temperatures)



Hedgerow
(mechanical pruning)



More traditional spacing
(hand pruning)

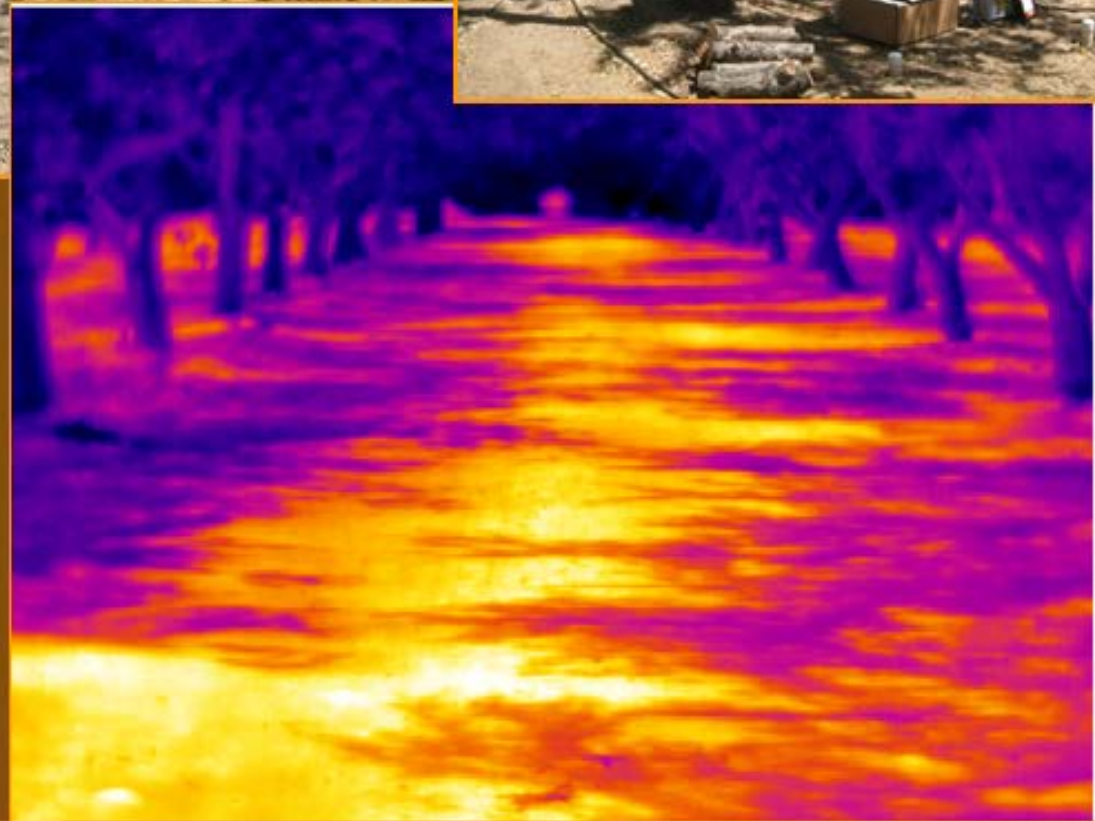


Result of cool,
shaded
conditions under
tree canopy in
dense
mechanically
hedged planting





Thermal imaging of orchard floor temperatures

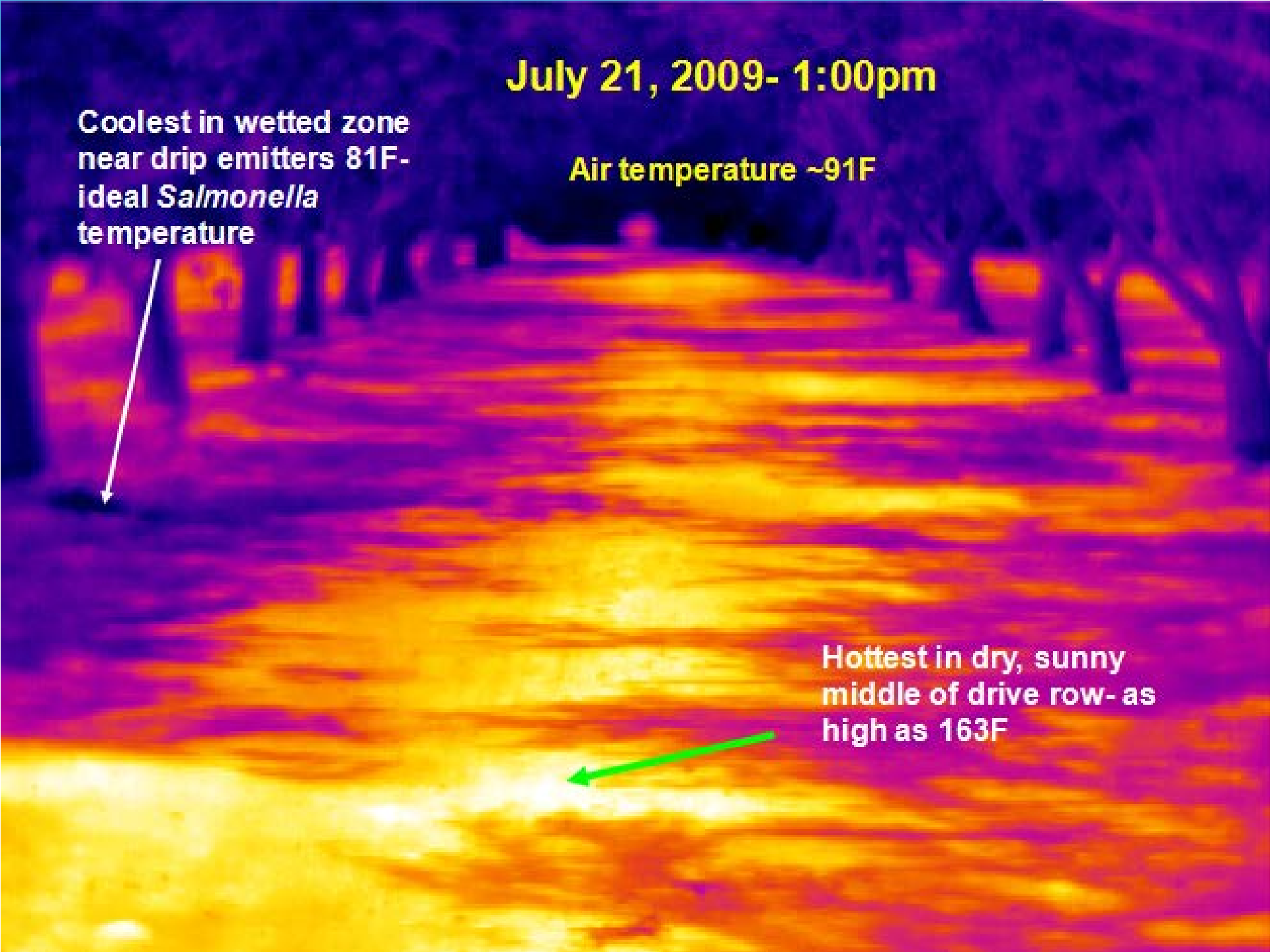


July 21, 2009- 1:00pm

**Cooler in wetted zone
near drip emitters 81F-
ideal *Salmonella*
temperature**

Air temperature ~91F

**Hottest in dry, sunny
middle of drive row- as
high as 163F**



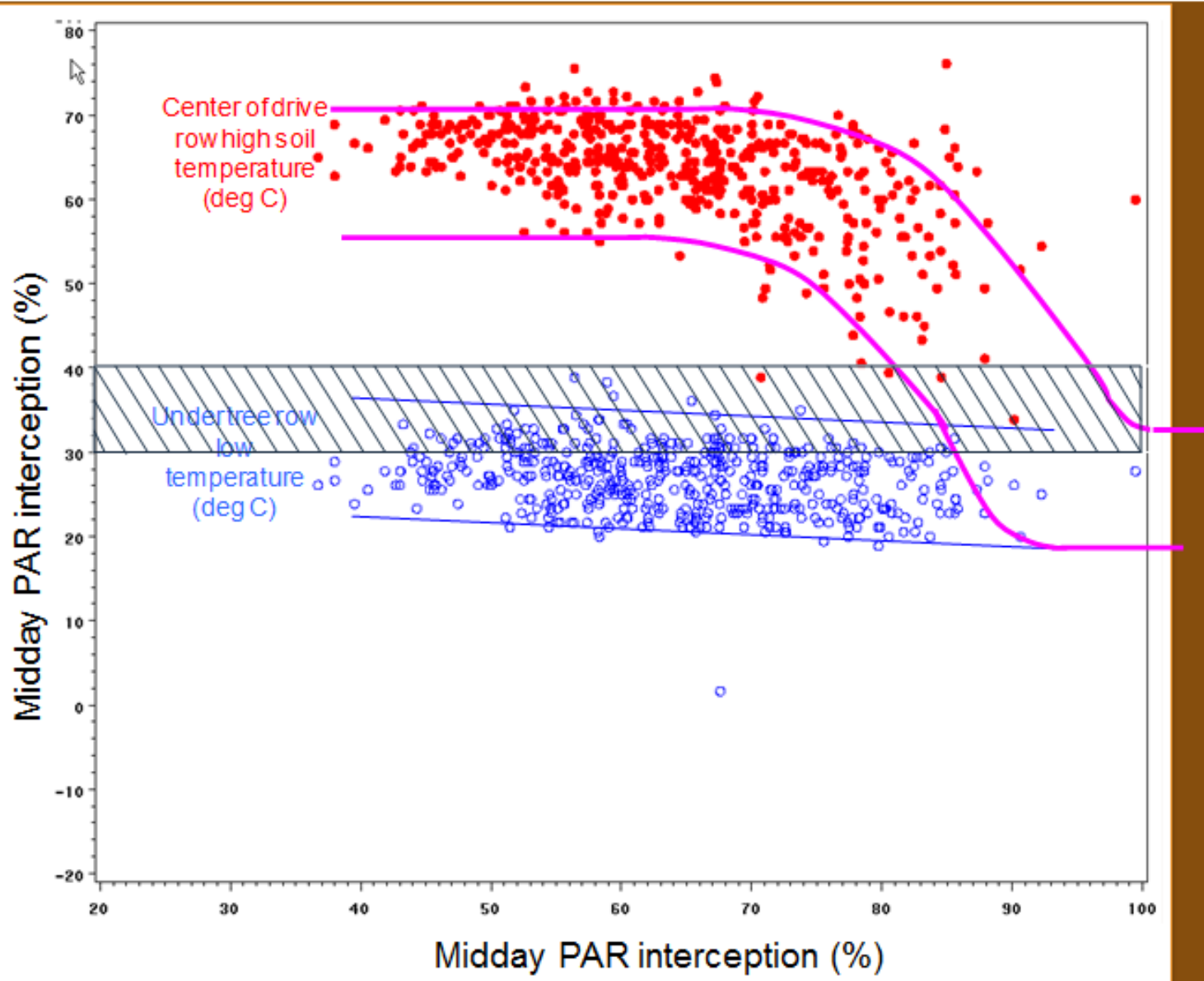
Maximum orchard floor temperature drops off dramatically as midday canopy light interception increases above about 70%

158 deg F

136 deg F

104 deg F

77 deg F



If your orchard is producing above 3500 kernel pounds per acre (above 70% light interception), you should pay particular attention to food safety risk.





Sampling nuts from orchard floor to decide if they are dry enough to harvest.



From across orchard floor in orchard where they are left to dry as shaken

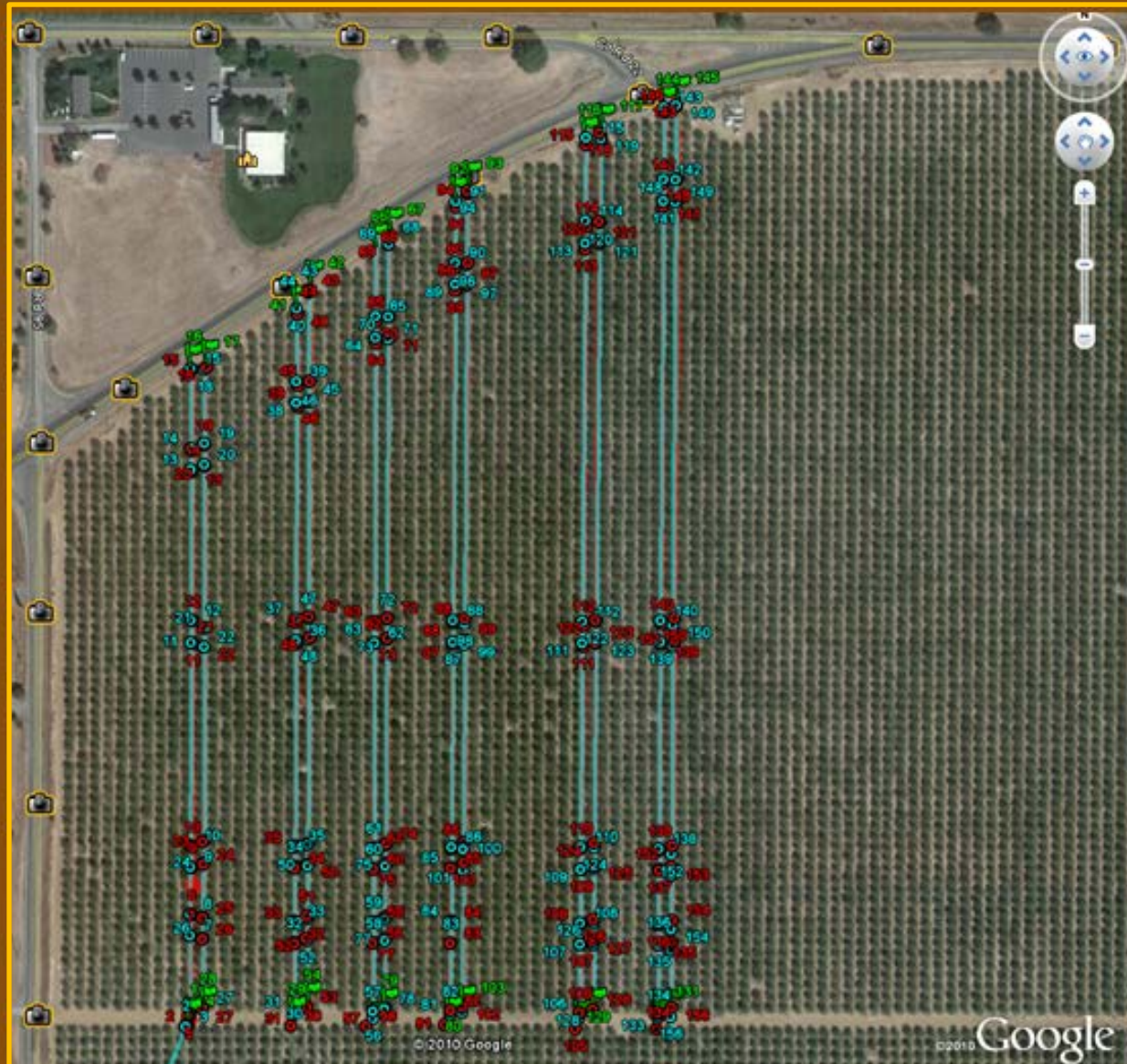
From top to bottom of windrow in orchard where nuts are dried in windrow



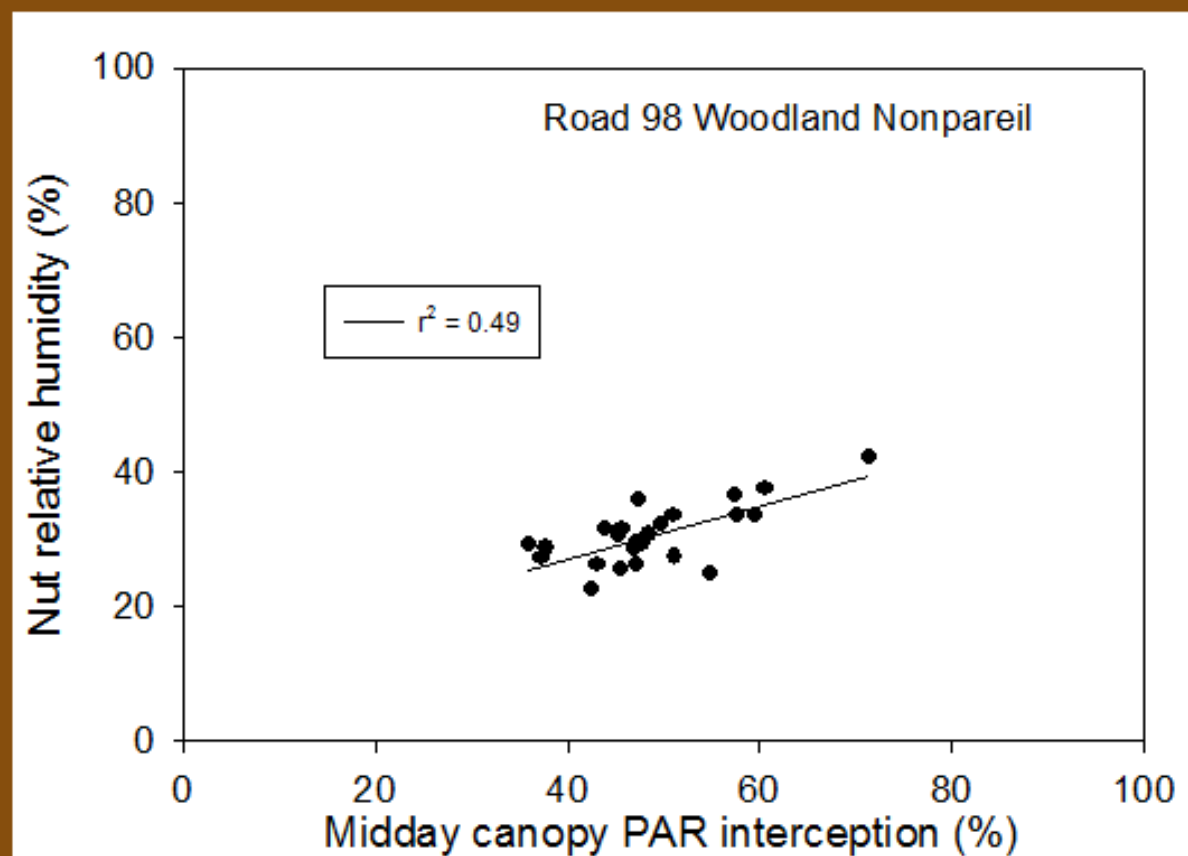


For nuts that were dried in windrow, moisture content was approximately 2% higher at bottom of windrow than at top

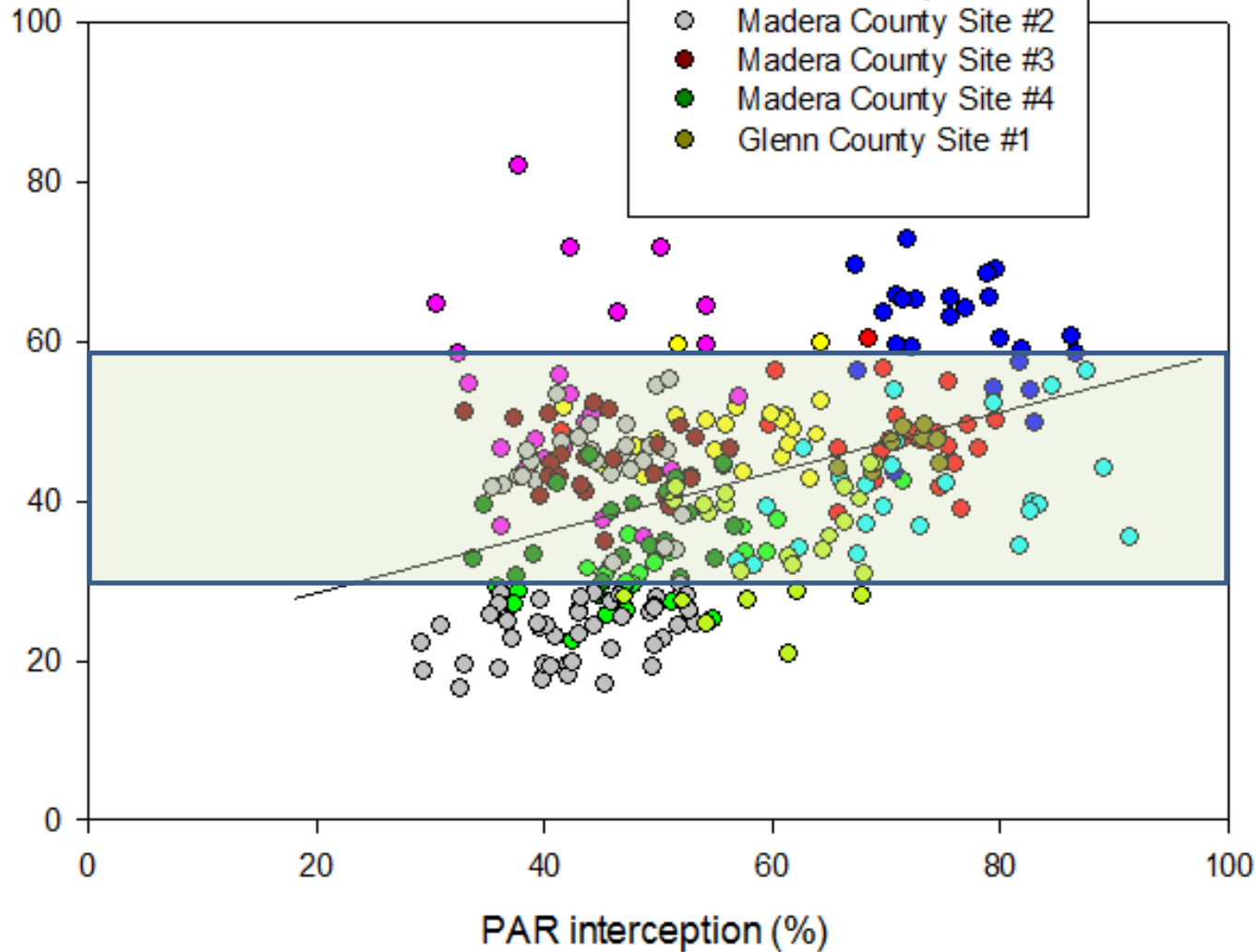
Nut drying on orchard floor can vary depending on canopy size-
be sure to sample across canopy size gradients



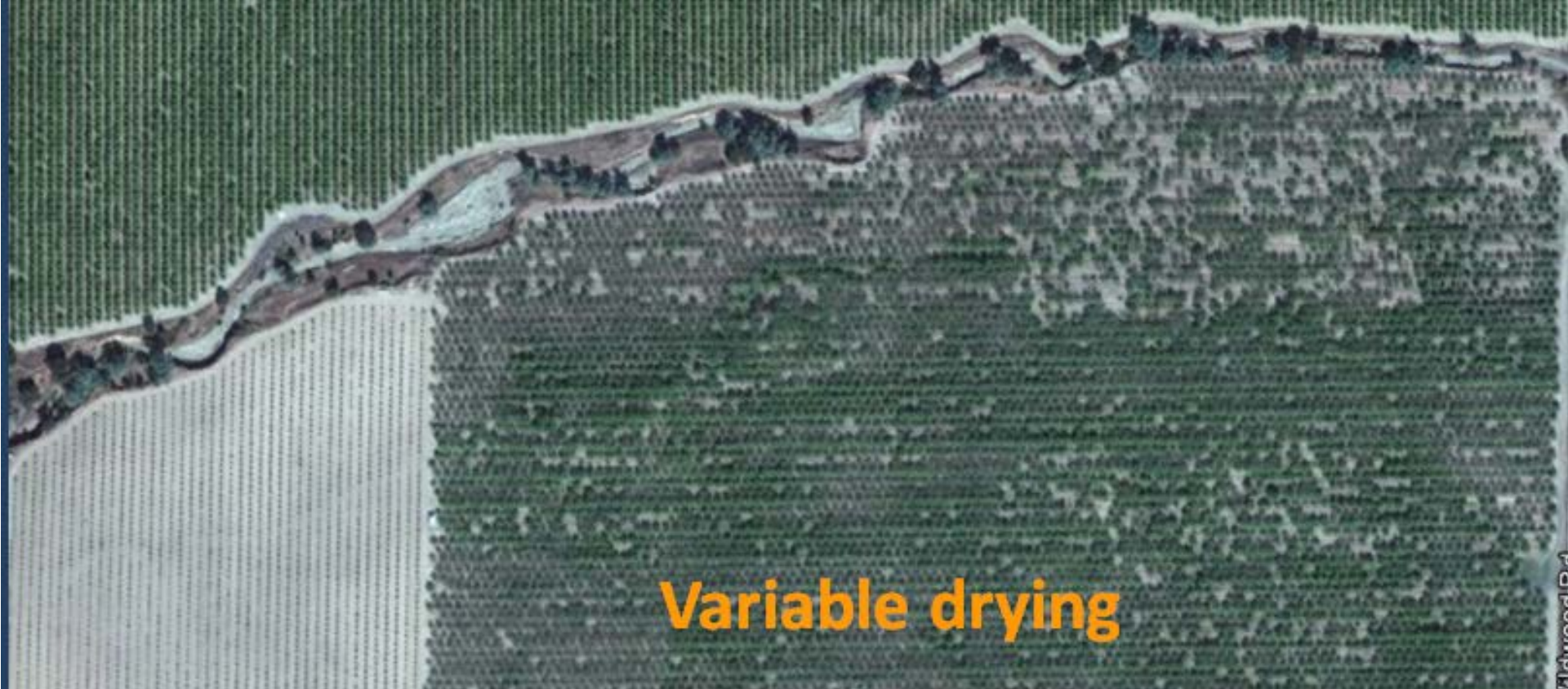
Nuts in lower light interception parts of orchard dried more rapidly than those in high light interception parts of orchard



% Relative Humidity



More uniform drying



Variable drying



King Rd

N

N/S hedgerow

Orchard orientation

Maier Rd

E/W hedgerow

Image U.S. Geological Survey
© 2013 Google

Google earth

1998

Imagery Date: 5/31/2007 39°08'55.08" N 122°16'57.94" W elev. 175 ft eye alt. 2166 ft



5 MINUTES

AUG.09,11 06:01 AM



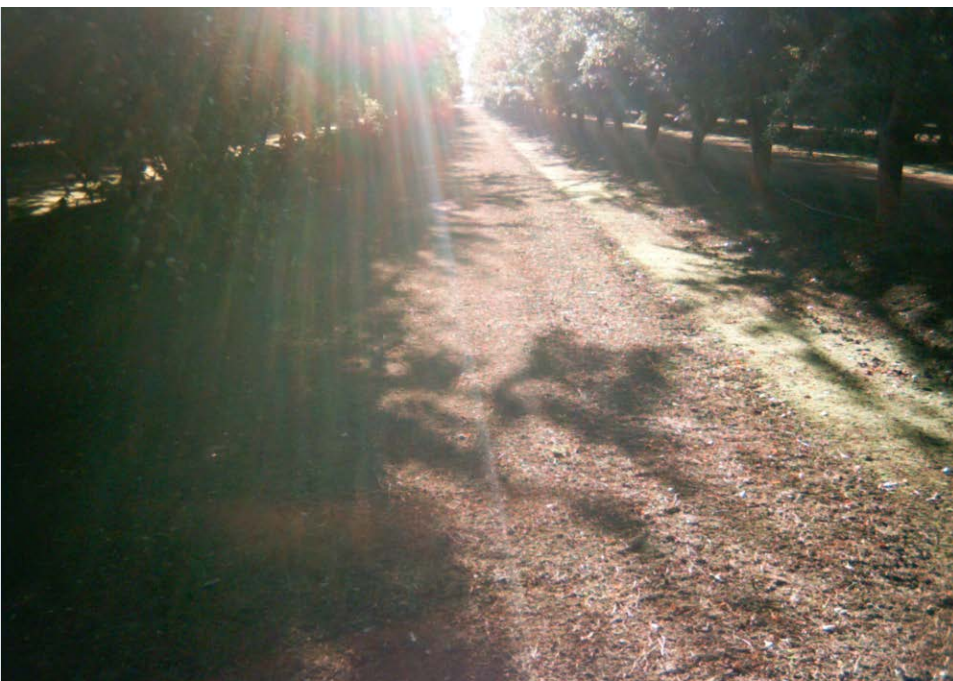
5 MINUTES

AUG.09,11 06:02 AM

east/west

6:00AM

north/south



5 MINUTES

AUG.09,11 07:01 AM



5 MINUTES

AUG.09,11 07:02 AM

east/west

7:00AM

north/south



5 MINUTES

AUG.09,11 08:01 AM

east/west



5 MINUTES

AUG.09,11 08:02 AM

north/south

8:00AM



5 MINUTES

AUG.09,11 09:01 AM



5 MINUTES

AUG.09,11 09:02 AM

east/west

9:00AM

north/south



5 MINUTES

AUG.09,11 10:01 AM



5 MINUTES

AUG.09,11 10:02 AM

east/west

10:00AM

north/south



east/west

11:00AM



north/south



5 MINUTES

AUG.09,11 12:01PM

east/west

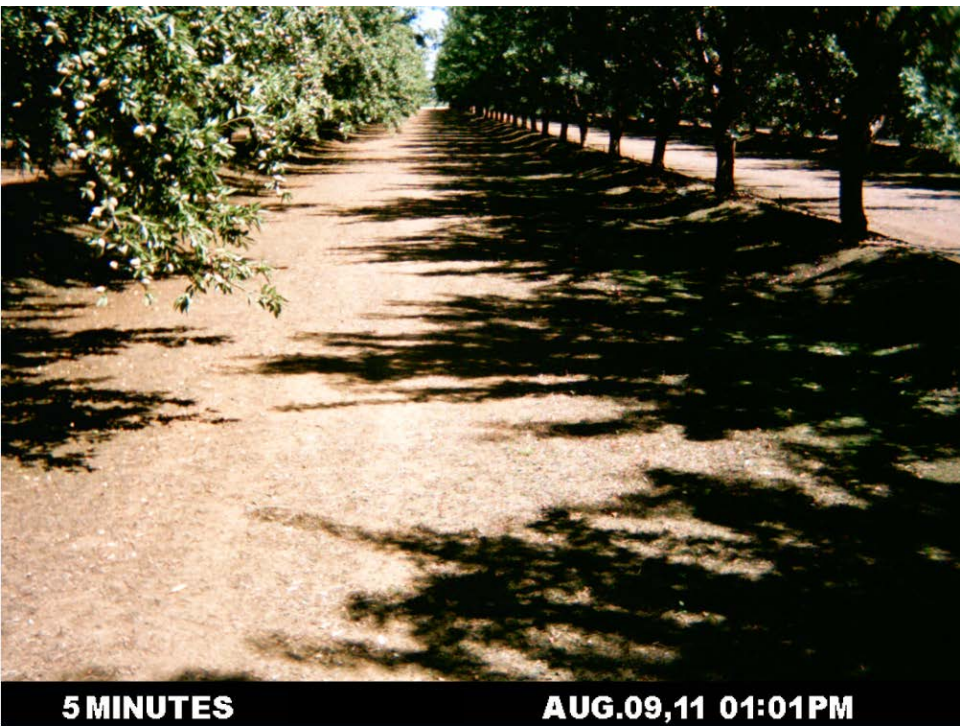


5 MINUTES

AUG.09,11 12:00 PM

north/south

12:00PM



5 MINUTES

AUG.09,11 01:01PM



5 MINUTES

AUG.09,11 01:00 PM

east/west

1:00PM

north/south



east/west



north/south

2:00PM



5 MINUTES

AUG.09,11 03:01PM



5 MINUTES

AUG.09,11 03:00 PM

east/west

3:00PM

north/south



5 MINUTES

AUG.09,11 04:01PM

east/west

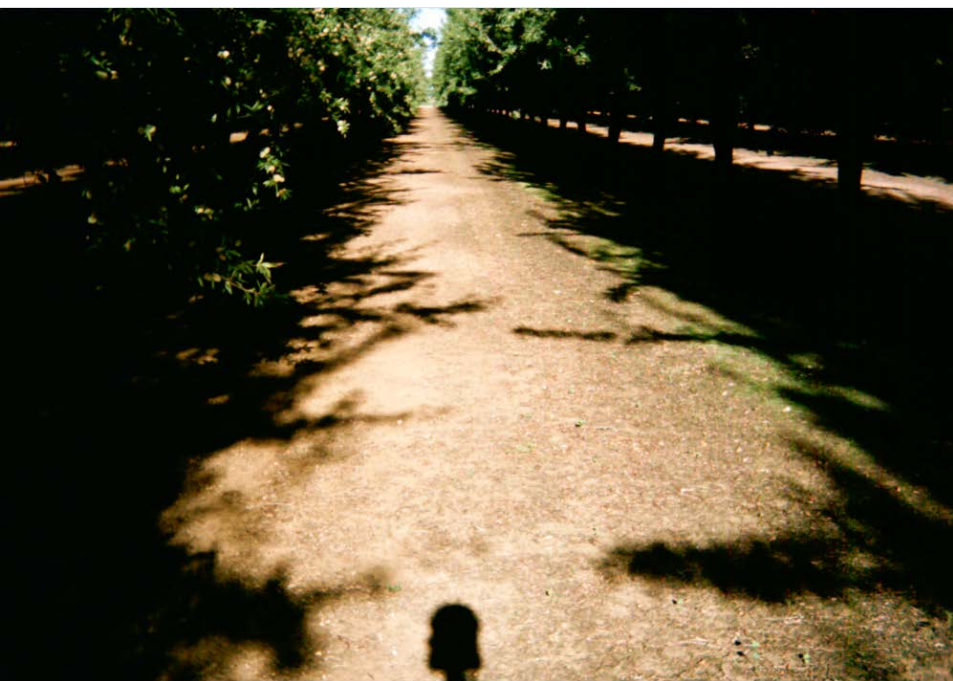


5 MINUTES

AUG.09,11 04:00 PM

north/south

4:00PM



5 MINUTES

AUG.09,11 05:01PM



5 MINUTES

AUG.09,11 05:00 PM

east/west

5:00PM

north/south



5 MINUTES

AUG.09,11 05:41PM



5 MINUTES

AUG.09,11 05:45 PM

east/west

5:45PM

north/south

North south oriented rows have better light distribution over the course of the day

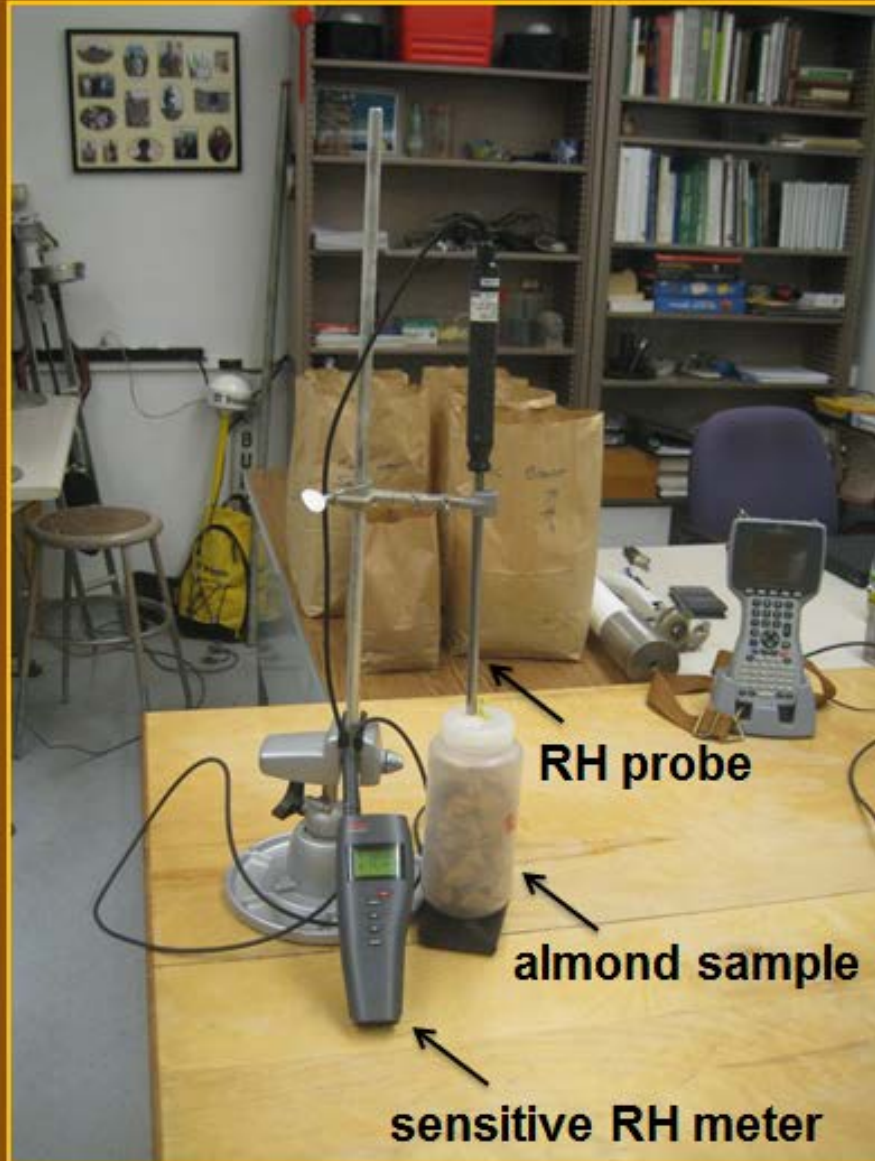
It can be difficult to dry nuts in east west oriented rows, particularly for late varieties

Water activity definition

Water activity - a measure of the availability of water in the food product which is available for bacterial or fungal growth

- It is water activity rather than water content that determines the potential for bacterial or fungal growth
- For almonds, a water activity of less than 0.7 is best
- A water activity of 0.7 is equivalent to a relative humidity of 70%

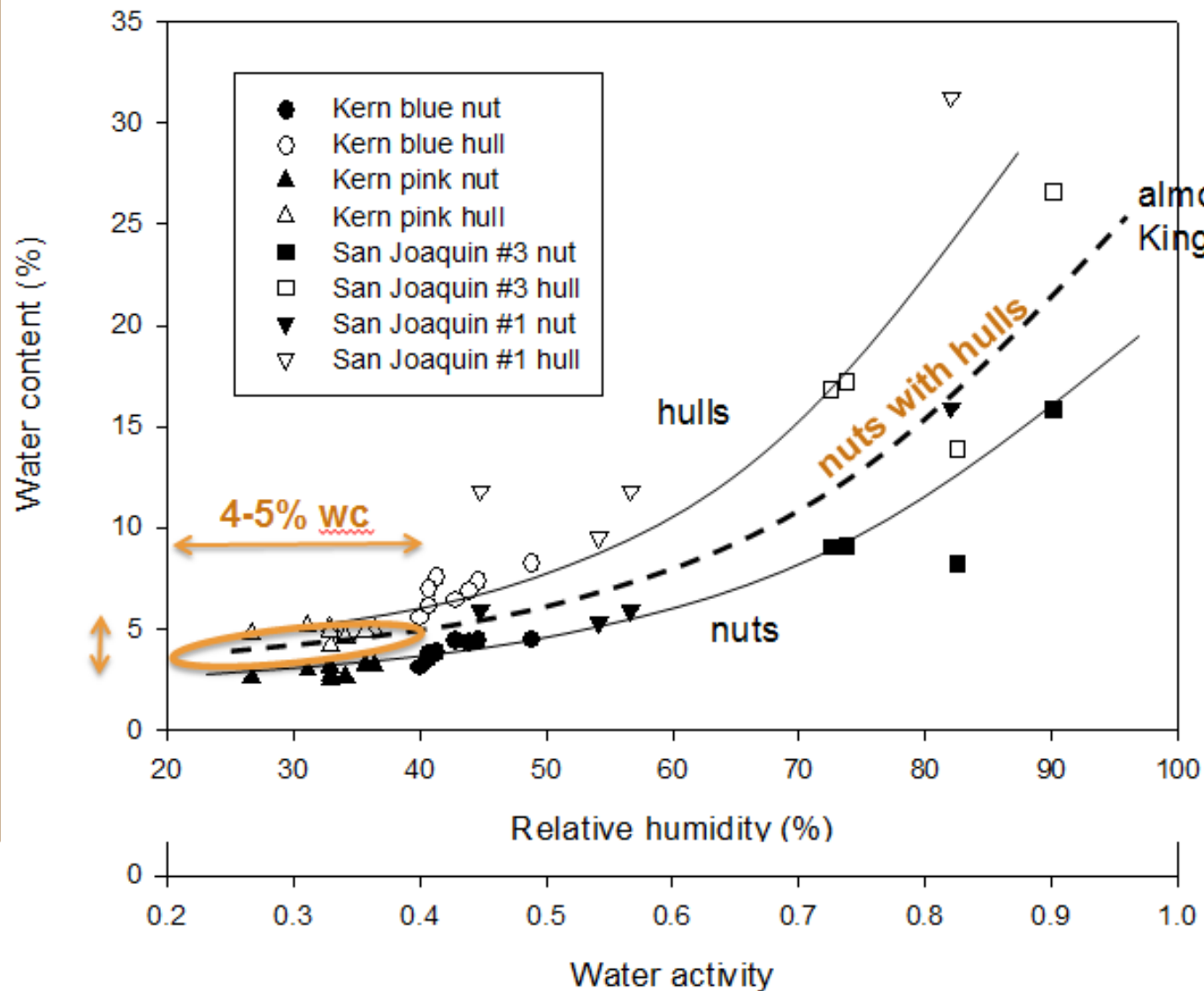
Measuring water activity (relative humidity) in an almond sample that has been allowed to equilibrate to room temperature



At end of drying period, ~2% higher moisture content under tree compared to in drive row



Relationship between relative humidity and water content for almond kernels with shell, hulls, and nuts with shells and hulls



Relationship between RH, water activity (at room temperature), and water content (kernels and hulls, hulls, and kernels)

Relative humidity	Water activity	water content		
		kernels+hulls	hulls	kernels
30	0.30	3.80	4.43	2.73
31	0.31	3.89	4.59	2.79
32	0.32	4.00	4.76	2.85
33	0.33	4.11	4.94	2.92
34	0.34	4.22	5.12	2.99
35	0.35	4.34	5.31	3.06
36	0.36	4.47	5.50	3.14
37	0.37	4.61	5.71	3.22
38	0.38	4.75	5.92	3.31
39	0.39	4.89	6.13	3.40
40	0.40	5.05	6.36	3.50
41	0.41	5.20	6.59	3.60
42	0.42	5.37	6.83	3.71
43	0.43	5.54	7.07	3.82
44	0.44	5.72	7.32	3.94
45	0.45	5.90	7.58	4.06
46	0.46	6.09	7.85	4.18
47	0.47	6.29	8.12	4.31
48	0.48	6.49	8.40	4.45
49	0.49	6.70	8.69	4.59
50	0.50	6.92	8.98	4.73
51	0.51	7.14	9.28	4.88
52	0.52	7.37	9.59	5.03
53	0.53	7.60	9.90	5.19
54	0.54	7.84	10.22	5.35
55	0.55	8.09	10.55	5.51
56	0.56	8.34	10.89	5.69
57	0.57	8.60	11.23	5.86
58	0.58	8.87	11.58	6.04
59	0.59	9.14	11.94	6.23
60	0.60	9.42	12.30	6.42
61	0.61	9.70	12.67	6.61
62	0.62	9.99	13.05	6.81
63	0.63	10.29	13.43	7.01
64	0.64	10.59	13.82	7.22
65	0.65	10.90	14.22	7.43
66	0.66	11.22	14.62	7.65
67	0.67	11.54	15.04	7.87
68	0.68	11.87	15.45	8.10
69	0.69	12.20	15.88	8.33
70	0.70	12.55	16.31	8.56
71	0.71	12.89	16.75	8.80
72	0.72	13.25	17.20	9.05

Relative humidity	Water activity	water content		
		kernels+hulls	hulls	kernels
73	0.73	13.61	17.65	9.30
74	0.74	13.97	18.11	9.55
75	0.75	14.34	18.58	9.81
76	0.76	14.72	19.06	10.07
77	0.77	15.11	19.54	10.34
78	0.78	15.50	20.03	10.61
79	0.79	15.89	20.52	10.89
80	0.80	16.30	21.02	11.17
81	0.81	16.71	21.53	11.45
82	0.82	17.12	22.05	11.75
83	0.83	17.55	22.57	12.04
84	0.84	17.97	23.10	12.34
85	0.85	18.41	23.64	12.64
86	0.86	18.85	24.18	12.95
87	0.87	19.30	24.74	13.27
88	0.88	19.75	25.29	13.59
89	0.89	20.21	25.86	13.91
90	0.90	20.68	26.43	14.24
91	0.91	21.15	27.01	14.57
92	0.92	21.63	27.60	14.90
93	0.93	22.11	28.19	15.25
94	0.94	22.60	28.79	15.59
95	0.95	23.10	29.39	15.94
96	0.96	23.60	30.01	16.30
97	0.97	24.11	30.63	16.66
98	0.98	24.63	31.26	17.02
99	0.99	25.15	31.89	17.39
100	1.00	25.68	32.53	17.76

Impact of different tarp materials on stockpile conditions



White on black



White



Clear



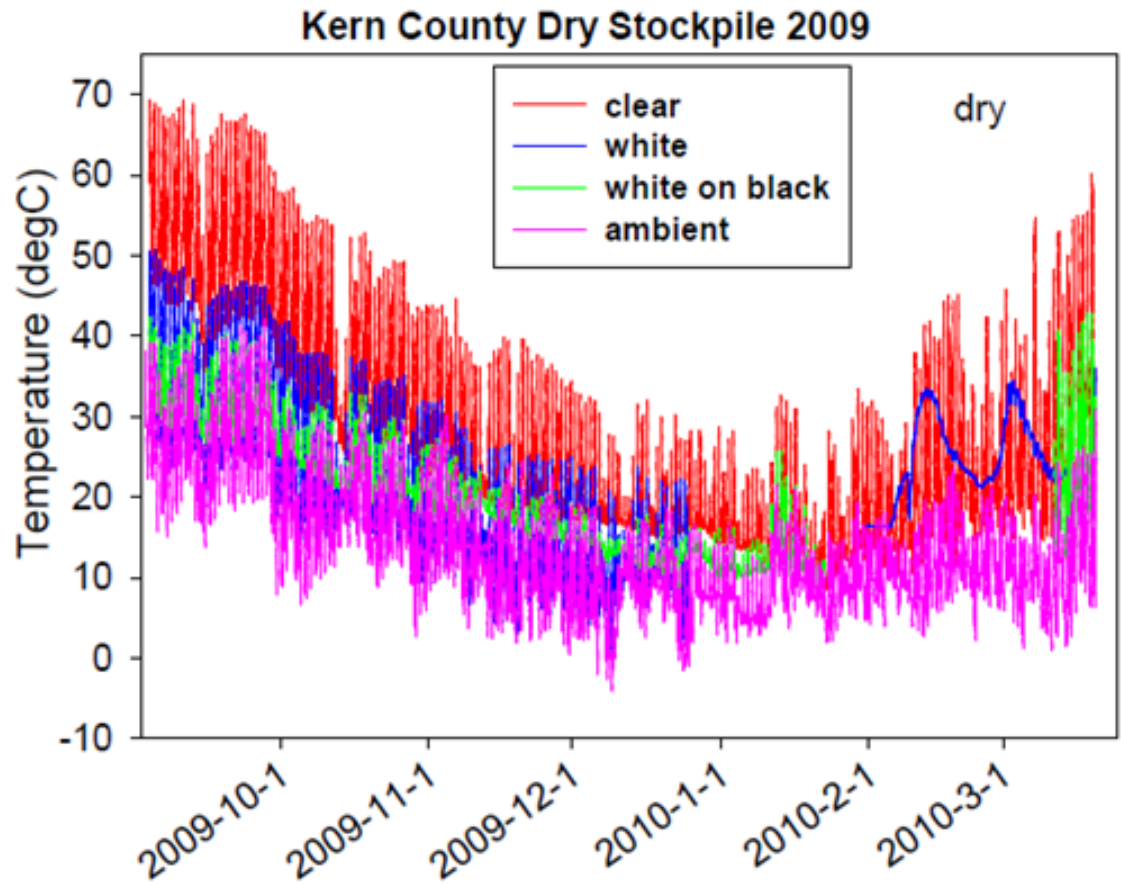


Temperature and relative humidity sensor placement in stockpiles. Sensors were approximately in the middle of the stockpiles long dimension in line with the yellow measuring tapes.

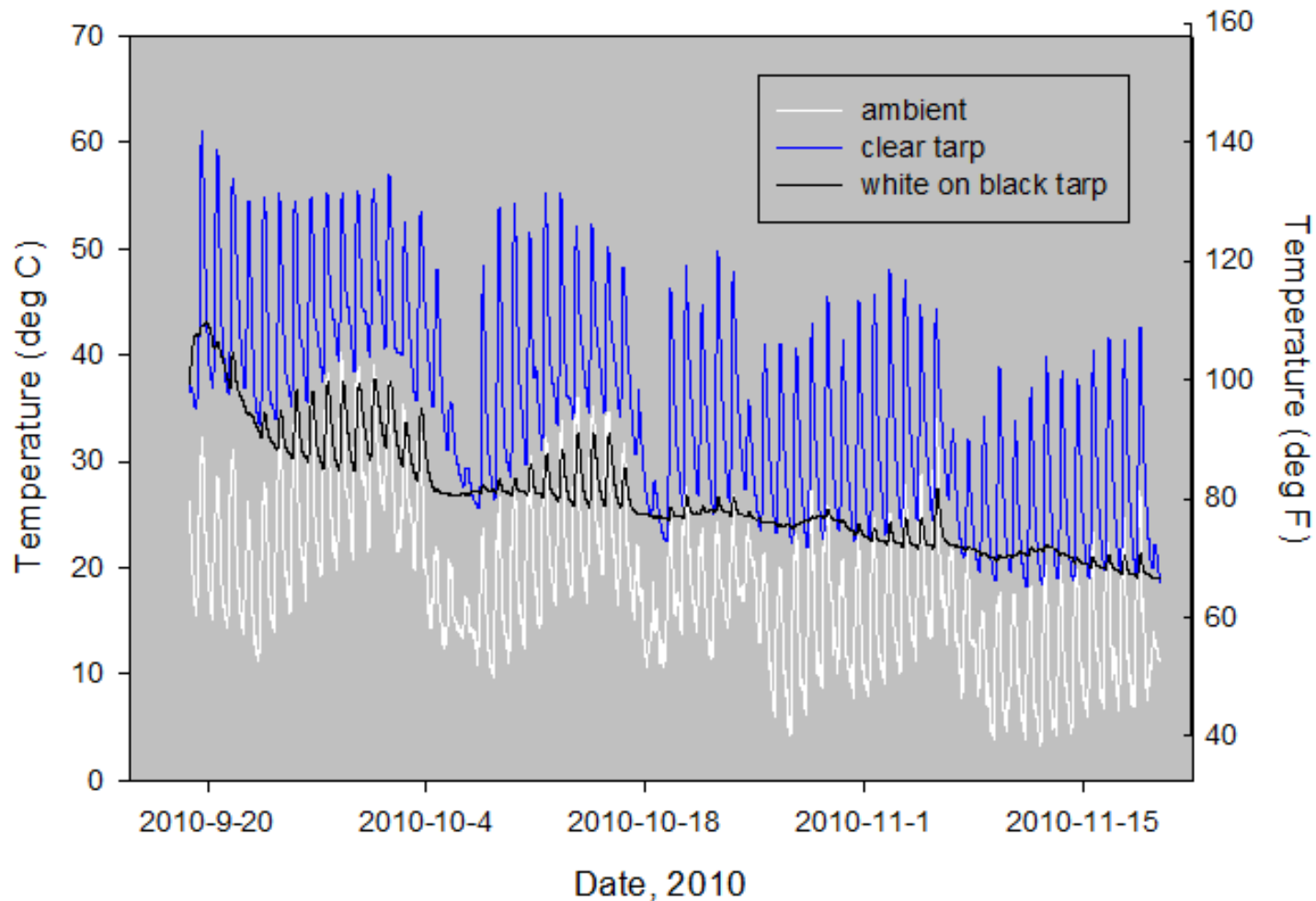
Impact of different tarp materials on stockpile conditions

Temp. top of pile

- White better and white on black tarps much better than clear
- less day-to-night temperature fluctuations
- Less condensation



Impact of different tarp materials on stockpile conditions



White on black tarp ran up to 68F cooler than the commonly used clear tarp and had much smaller day to night temperature fluctuations

Table 1. Starting and ending moisture content for in hull nuts from dry and wet stockpiles covered with either clear or white on black tarp in 2010-11. Samples taken from location labeled 3' down are from 3' down from the top/center of pile (indicated with arrows) are the most representative of conditions in the overall pile. Samples labeled top and side are taken on outer surface of pile where condensation is most likely. Note that moisture content increased during storage period in all stockpiles at all locations.

Dry stockpile

	Location	Starting % moisture	Ending moisture	Change in % moisture
clear	Top	4.9	31.6	+26.7
	3' down	3.7	9.9	+6.2
	Side	4.3	6.3	+2.0
white on black	Top	4.1	9.2	+5.0
	3' down	5.2	7.2	+2.0
	Side	4.7	9.9	+5.2

Wet stockpile

	Location	Starting % moisture	Ending moisture	Change in moisture
clear	Top	7.8	27.7	+19.9
	3' down	8.0	11.5	+3.5
	Side	7.5	8.1	+0.6
white on black	Top	6.2	23.0	+16.8
	3' down	7.1	10.9	+3.8
	Side	6.8	21.0	+14.2

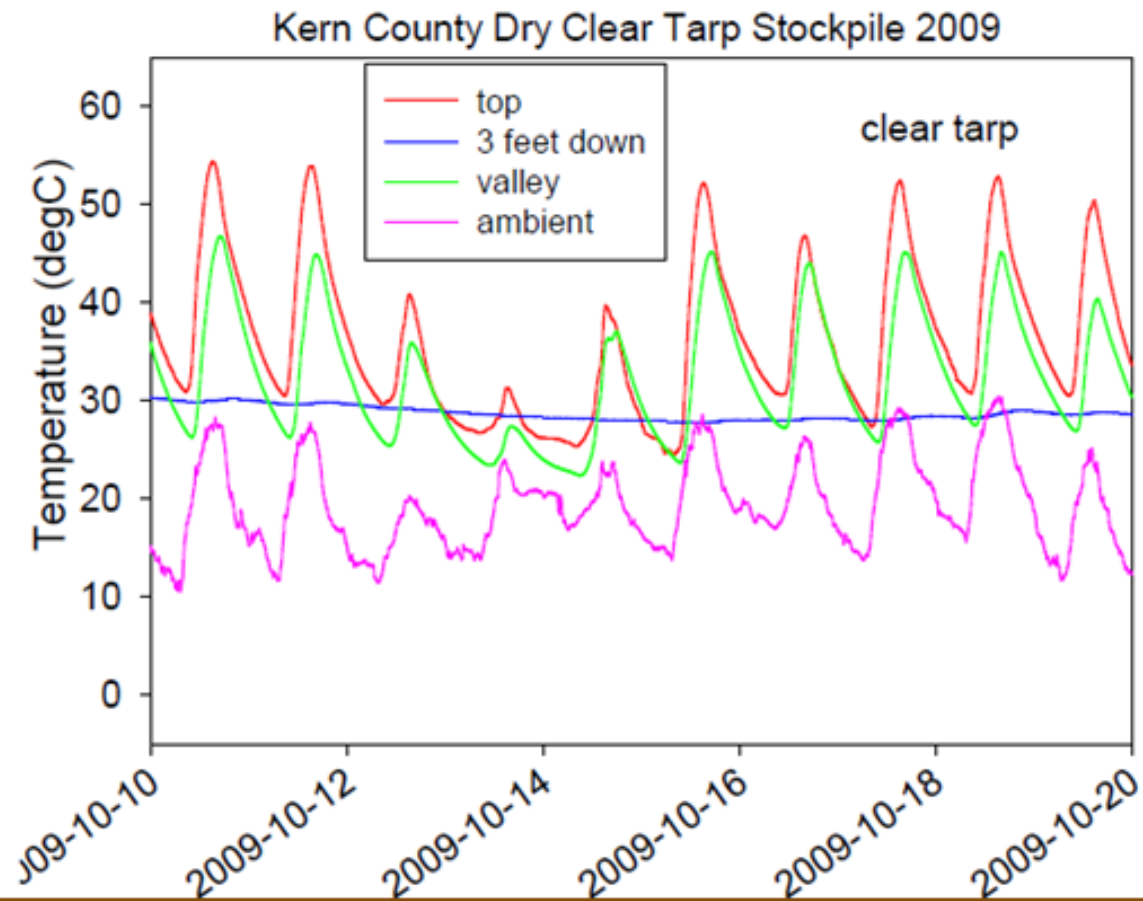
Table 2. Starting and ending moisture content for in hull nuts from stockpiles covered with either clear or white on black tarp in 2011-12. Samples taken from location labeled 3' down are from 3' down from the top/center of pile (indicated with arrows) and those labeled top are from the outer surface at the top of the pile.

	Location	Starting % moisture	Ending moisture	Change in % moisture
clear	Top	7.2	22.4	+15.2
	3' down	7.2	7.7	+0.5
White on black	Top	6.8	9.1	+2.3
	3' down	6.8	5.6	-1.2

Table 3. Results from inoculation studies with atoxigenic isolate of *Aspergillus flavus* (i.e. AF36 strain). The inoculated samples were placed at 1 meter depth in mesh bags within the clear and white on black tarp covered stockpiles. Samples 1-8 were taken at installation in the first week of December at depth of 1 meter in the piles at the depth where AF36 inoculated sample bags were to be installed. Samples 9-16 were taken at the time of removal of sensors and inoculated bags in mid-March at 1 meter depth near inoculated bags. Samples 17-24 represent the contents of the bag containing the sensors and the AF36 inoculated samples.

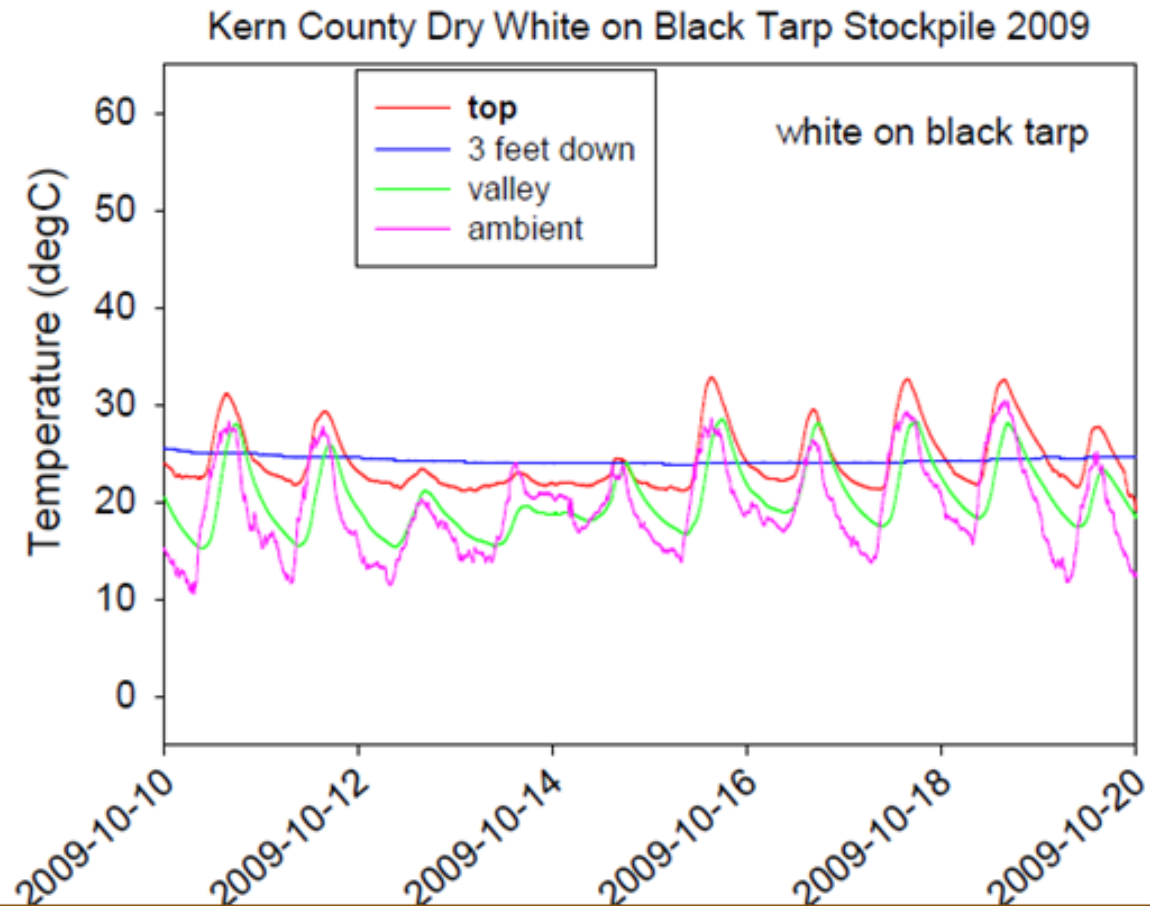
Sample #	Timing	Pile #	stockpile info	mass(g)	B1 Aflatoxin (ppb)
1	Install	1	Clear	370	0
2	Install	2	Clear	455	0
3	Install	3	Clear	405	0
4	Install	4	Clear	410	0
5	Install	5	white/black	510	0
6	Install	6	white/black	510	0
7	Install	7	white/black	470	0
8	Install	8	white/black	360	0
9	Post-stockpile	1&2 -A	Clear	400	0
10	Post-stockpile	1&2 - B	Clear	400	2.7
11	Post-stockpile	3&4 - A	Clear	480	0
12	Post-stockpile	3&4 -B	Clear	380	0
13	Post-stockpile	5&6-A	white/black	375	0
14	Post-stockpile	5&6-B	white/black	355	0
15	Post-stockpile	7&8-A	white/black	425	0
16	Post-stockpile	7&8-B	white/black	480	0
17	Post-inoculated	1	Clear	390	0
18	Post-inoculated	2	Clear	385	0
19	Post-inoculated	3	Clear	490	0
20	Post-inoculated	4	Clear	410	0
21	Post-inoculated	5	white/black	460	0
22	Post-inoculated	6	white/black	580	0
23	Post-inoculated	7	white/black	440	0
24	Post-inoculated	8	white/black	505	0

Impact of Different Tarps - Clear



Impact of Different Tarps – White on Black

Conditions in pile much more uniform with white on black tarp



Impact of different tarp materials on stockpile conditions



Clear tarp north end



White on black tarp north end

Smaller temperature fluctuations under white on black tarp led to less condensation problems and correspondingly less mold growth



Large humps on top of piles leads to valleys where condensed water can collect and contact nuts leading to mold growth



Flattening tops of piles leads to less concentration of condensate. Orienting piles with long axis in north/south direction is also beneficial



Long axis east/west

Area with most problems



Long axis north/south



N

Stockpiling Guidelines

Do not stockpile if either the hull moisture content exceeds 13%
or the kernel moisture content exceeds 6%

This is equivalent to a sample water activity of 0.7 or a relative humidity of 70% (at room temperature)

Hull moisture content

11-12% Acceptable (the hull snaps)

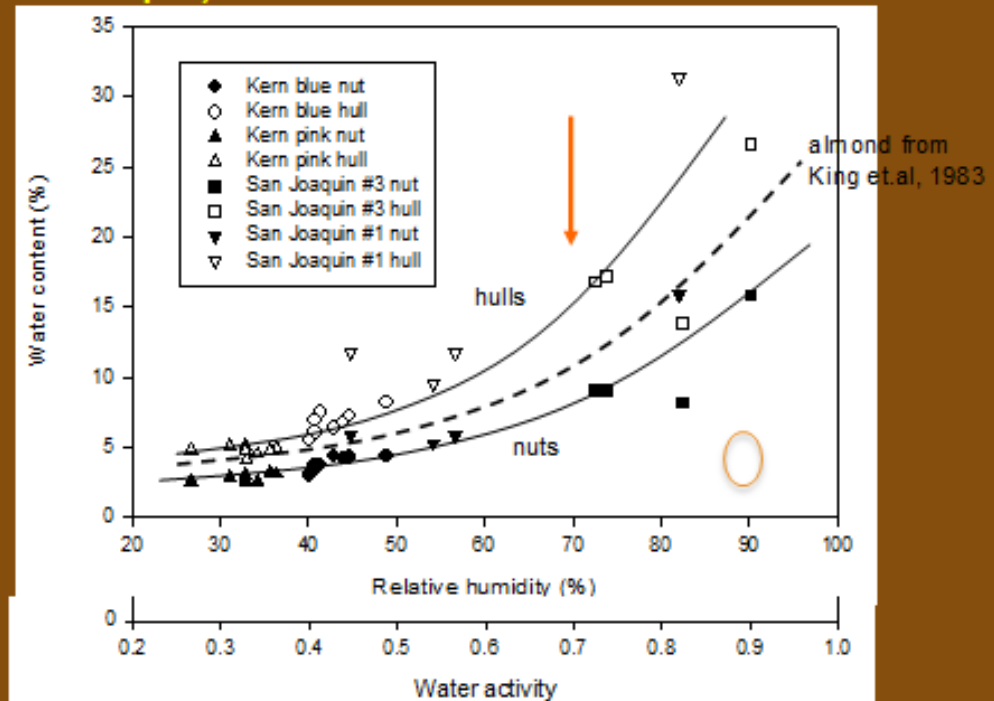
>13% Too high

Kernel moisture content

4-5% Excellent

< 6% Acceptable

> 6% Too high



Food safety risk should be assessed in relation to orchard planting design and canopy structure

- More uniform orchard canopy development leads to more uniform nut drying on orchard floor
 - Hedgerow planting leads to more dense shade under tree row which may increase food safety risk
 - More conventional tree spacing leads to more varied light/temperature patterns across orchard floor
 - North/south oriented rows better than east/west
 - Any orchard producing above 3500 kernel pounds per acre likely has increased potential for food safety related problems
-
- Stockpiling**
 - Make sure nuts are adequately dry before stockpiling
 - Sample nut moisture content in a systematic way across orchard before beginning harvest operation
 - Choose appropriate tarp materials to minimize condensation potential
 - Orient stockpiles with long axis north/south



Questions?



Field Quality: Concealed Damage



Franz Niederholzer

UCCE Colusa/Sutter/Yuba Counties

Bruce Lampinen

UC Davis, Plant Sciences Department





What is Concealed Damage?



- **Darkening of interior of the kernel, which develops after heating (roasting or blanching).**

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- **Extremely unpleasant flavor is present in extreme cases of Concealed Damage.**

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- Extremely unpleasant flavor is present in extreme cases of Concealed Damage.
- **The result of wet and warm post-shake conditions/storage. The wetness and high temps don't necessarily need to occur together.**

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- **The exact biochemical mechanism(s) are not known, but are being studied.**

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- Darkening of interior of the kernel, which develops after heating (roasting or blanching).
- Extremely unpleasant flavor is present in extreme cases of Concealed Damage.
- The result of wet and warm post-shake conditions/storage. The wetness and high temps don't necessarily need to occur together.
- The exact biochemical mechanism(s) are not known, but are being studied.
- **Concealed damage can't be detected by external screening.**

What can be done to limit Concealed Damage?

- **Supported by the Almond Board of CA, field work was begun in 2011 to determine field practices that can limit the development of Concealed Damage.**
- **This work complements Concealed Damage research under controlled conditions in Dr. Alyson Mitchell's lab at UC Davis.**

2011

- **Wet, windrowed nuts are wet again, then conditioned or not conditioned, and delivered to UCD for lab analysis.**

2012

- **Controlled studies using small “windrows” with different conditioning practices, then storage and CD assessment in Jan/Feb.**

2013

- **Nuts wetted 3+ times, windrowed, stockpiled.**

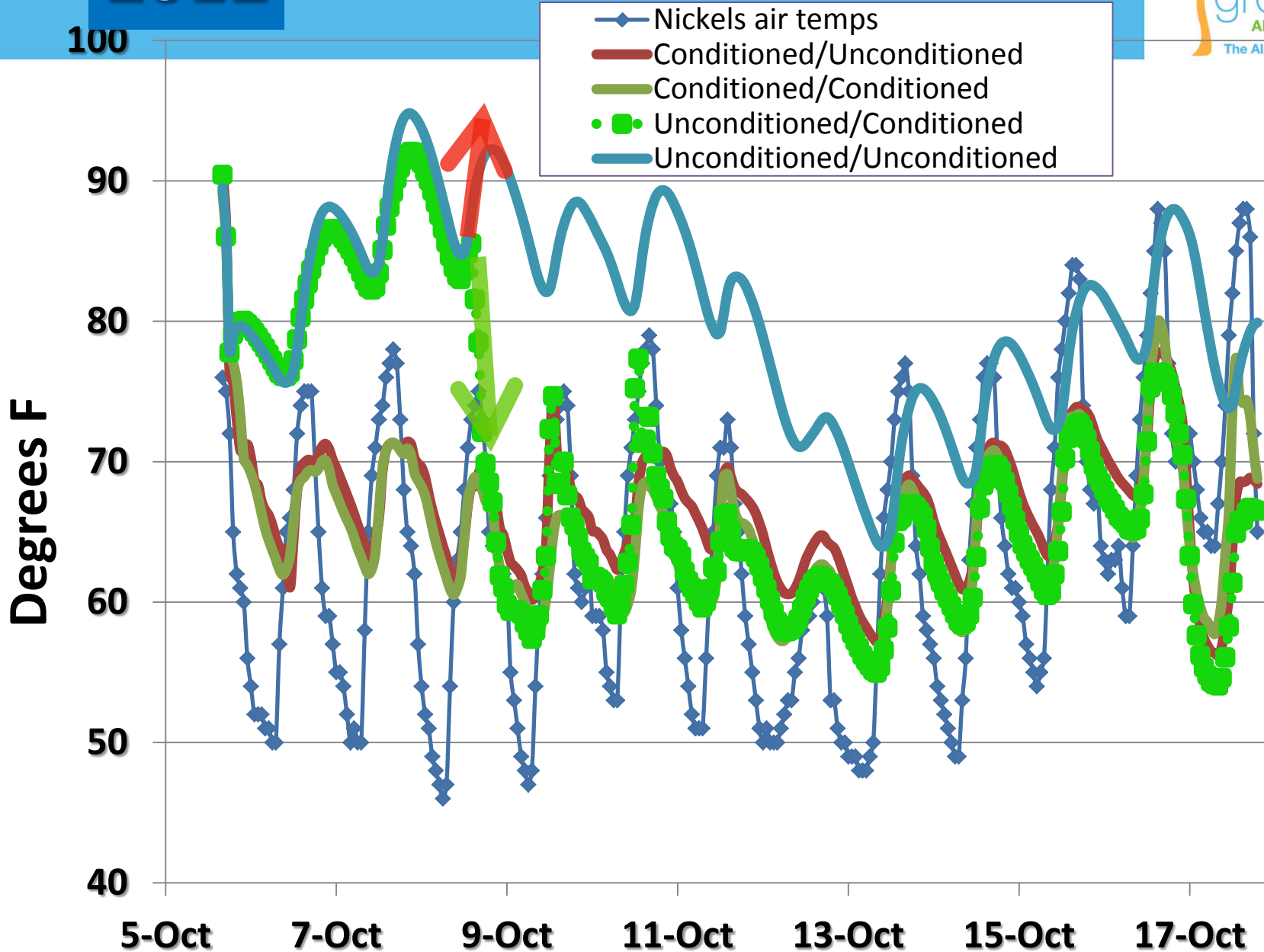
2011



<i>Treatments</i>	% Moisture on Oct 28	% Discoloration 1 WAPU*	% Discoloration 4 WAPU*
Dry, conditioned	11.9	1.7 ± 2.9	2.3 ± 4.2
Wet nuts, conditioned	12.9	5.0 ± 5.8	1.9 ± 4.2
Dry, unconditioned	17.1	10.8 ± 7.9	4.2 ± 3.4
Wet nuts, unconditioned	19.8	23.8 ± 10.6	---

*WAPU = weeks after pickup

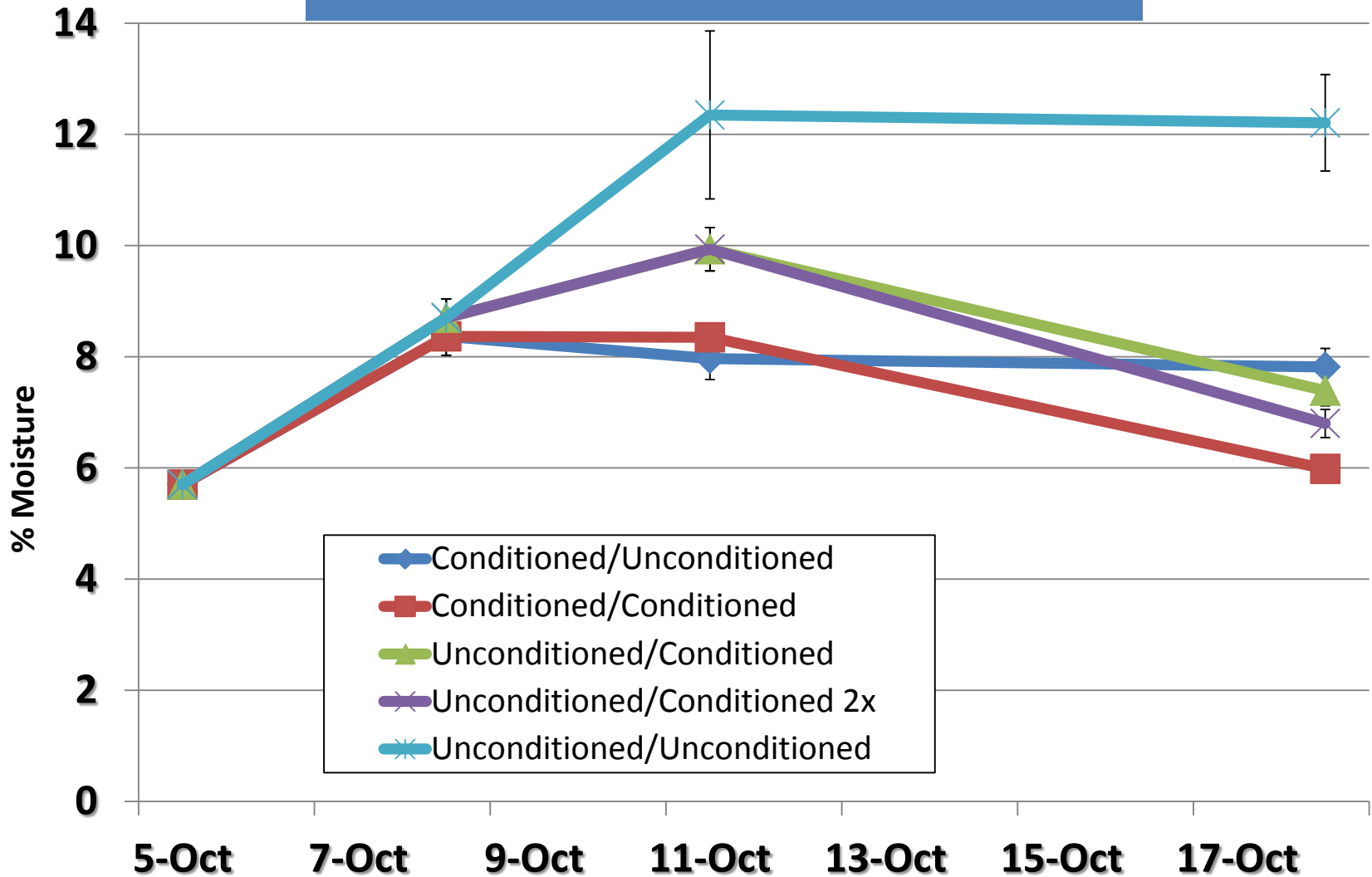
2012



2012

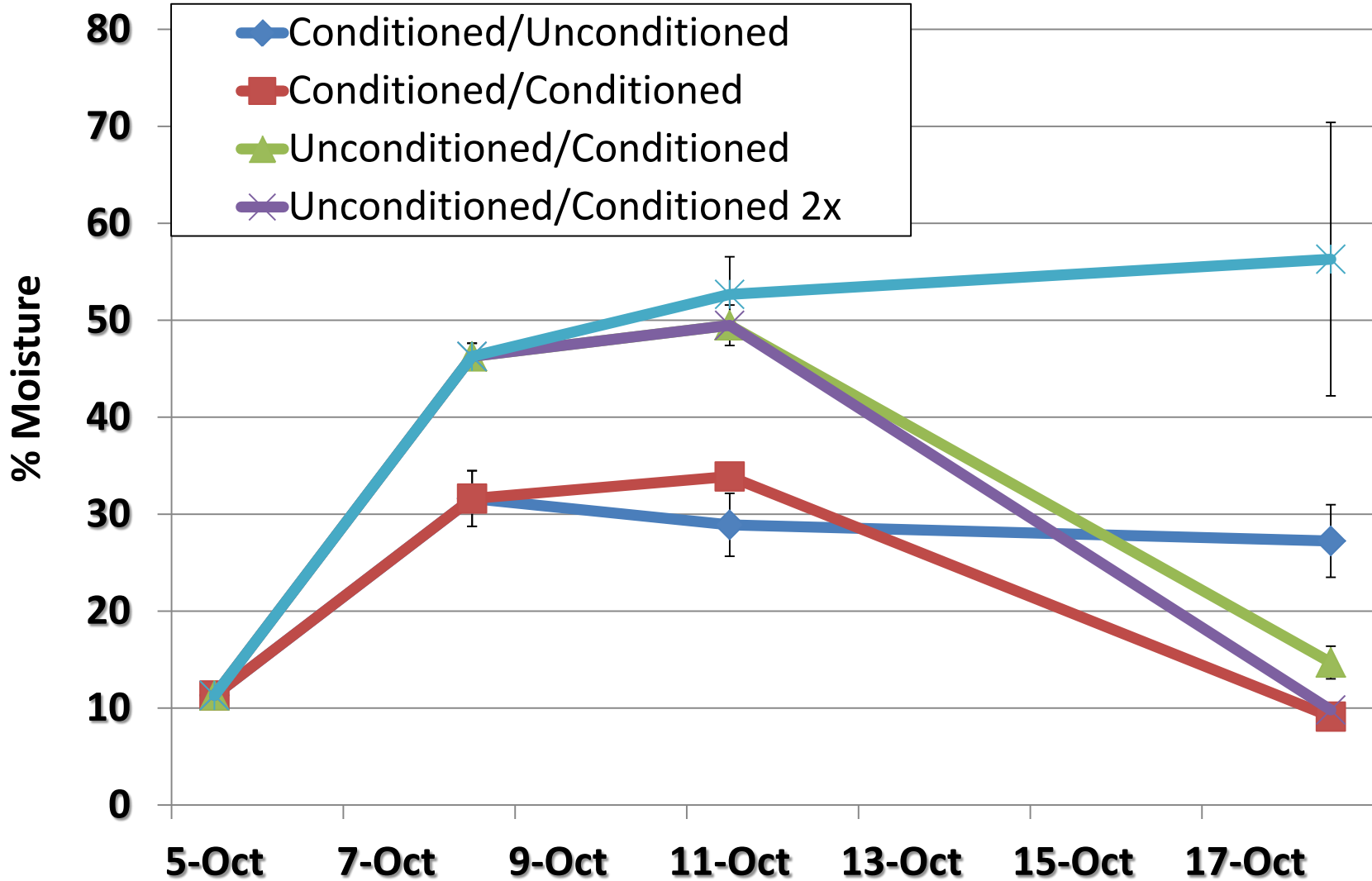


Kernel Moisture Data



2012

Hull Moisture Data



2012 REVIEW



- **Started with very dry nuts**
- **Wetted and let sit for 12 days under good drying conditions**
- **Hulling soon after pickup**
- **Stored until mid-January**
- **Commercially roasted**
- **NO Differences in Concealed Damage**

2013



Treatments	0.5" water	Roll nuts	0.5" water	Condition	1.0" water	Condition	Condition
1	X						
2	X						
3	X						
4	X						
5	X						
6	X						

2013



2013

Treatments	0.5" water	Roll nuts	0.5" water	Condition	1.0" water	Condition	Condition
1	X	X					
2	X	X					
3	X						
4	X	X					
5	X						
6	X						



2013



Treatments	0.5" water	Roll nuts	0.5" water	Condition	1.0" water	Condition	Condition
1	X	X	X				
2	X	X	X				
3	X		X				
4	X	X	X				
5	X		X				
6	X		X				

2013



2013



2013



Treatments	0.5" water	Roll nuts	0.5" water	Condition	1.0" water	Condition	Condition
1	X	X	X	X			
2	X	X	X	X			
3	X		X	X			
4	X	X	X				
5	X		X				
6	X		X				

2013



Treatments	0.5" water	Roll nuts	0.5" water	Condition	1.0" water	Condition	Condition
1	X	X	X	X	X		
2	X	X	X	X	X		
3	X		X	X	X		
4	X	X	X		X		
5	X		X		X		
6	X		X		X		

2013



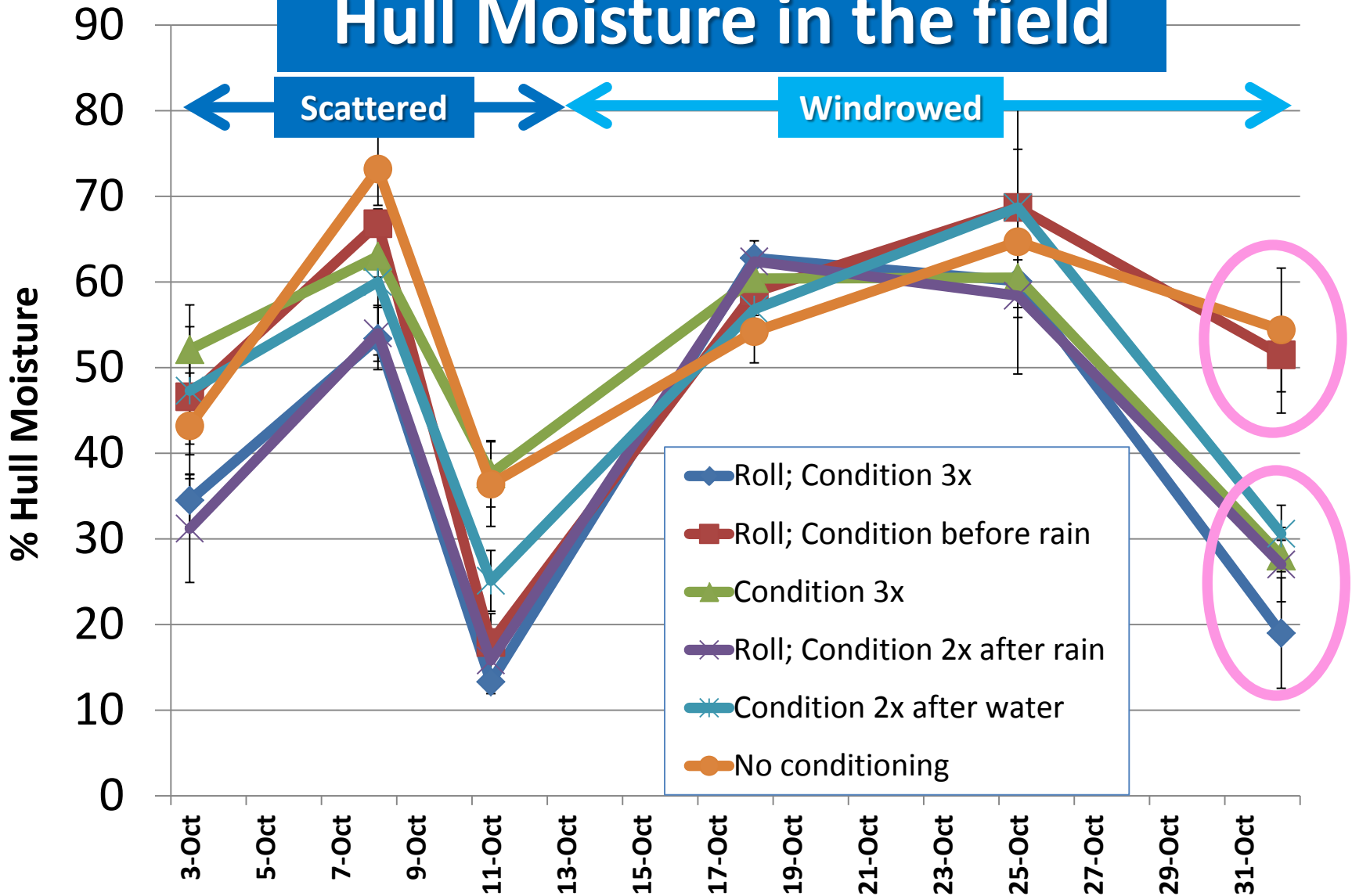
2013



Treatments	0.5" water	Roll nuts	0.5" water	Condition	1.0" water	Condition	Condition
1	X	X	X	X	X	X	X
2	X	X	X	X	X		
3	X		X	X	X	X	X
4	X	X	X		X	X	X
5	X		X		X	X	X
6	X		X		X		

2013

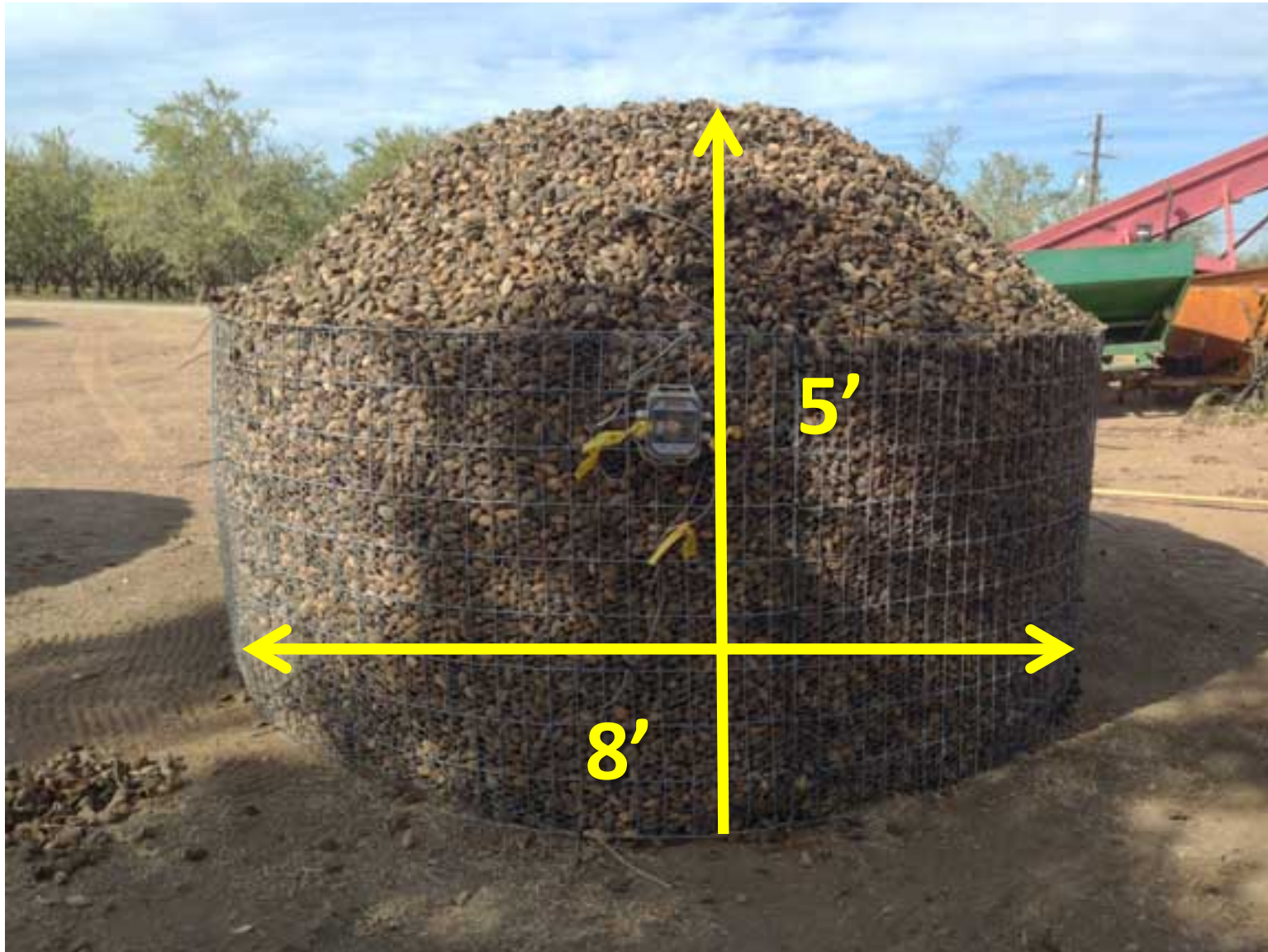
Hull Moisture in the field



2013



2013



Take Home, so far



- **Don't pile wet nuts.**
- **Condition windrowed nuts after rain for fastest drying potential.**
- **Every orchard, every year is a case study. Current weather & orchard conditions determine how fast/well nuts dry.**
- **Nut moisture can vary across the block.**

Thanks to:



Stan Cutter, Nickels Soil Lab

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Dave Baker, Blue Diamond Growers

Mel Machado, Blue Diamond Growers

Rob Kriss, Blue Diamond Growers

Almond Board of California



**Tomorrow Begins at
7:30 with a Continental
Breakfast in the
Tradeshow Hall Followed
by a Presentation Titled
Pest in the Orchard**



Presented by
Syngenta



Thank you!

