Almond production in California- how to apply best practices in Georgia?

Bruce Lampinen
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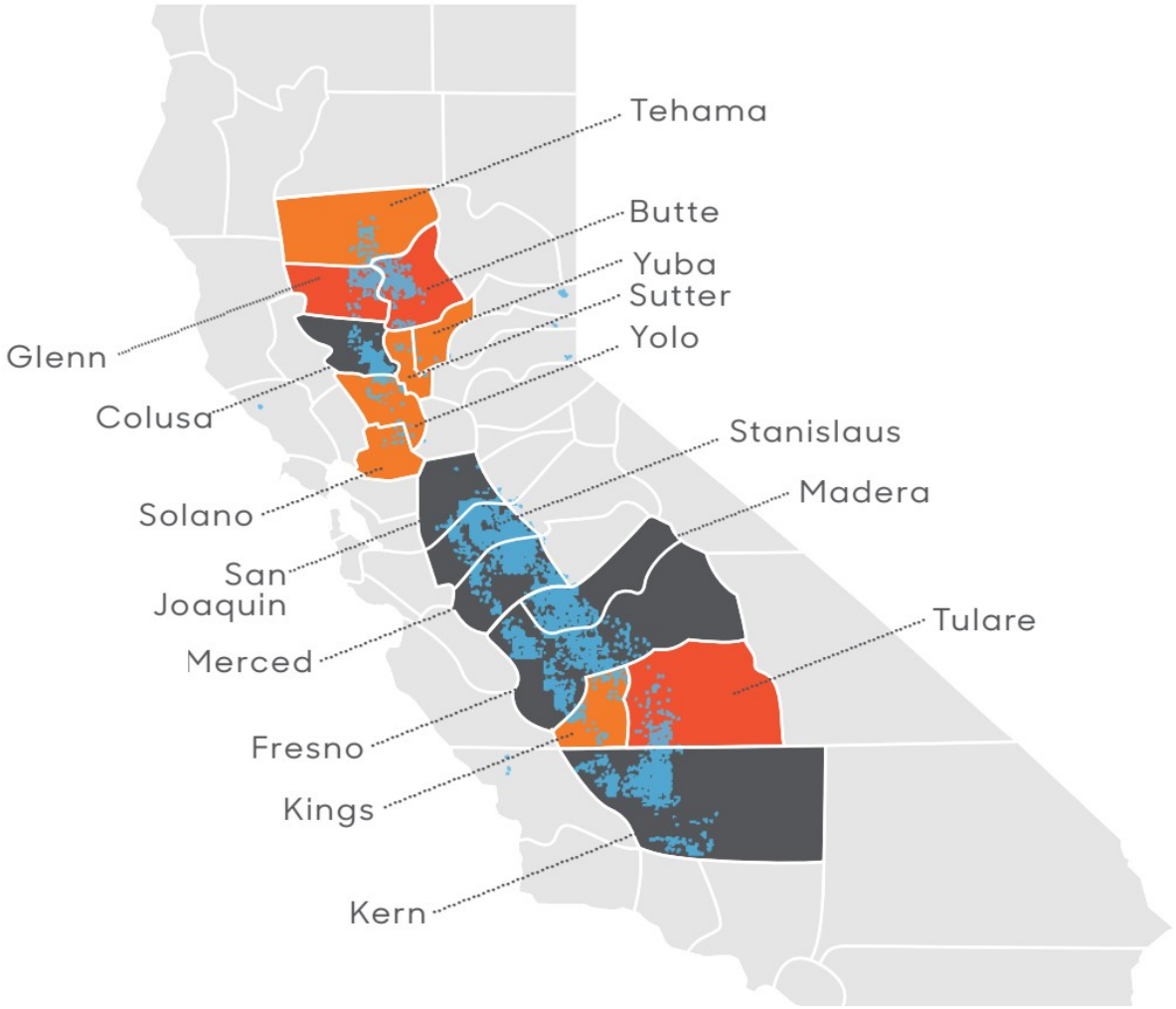
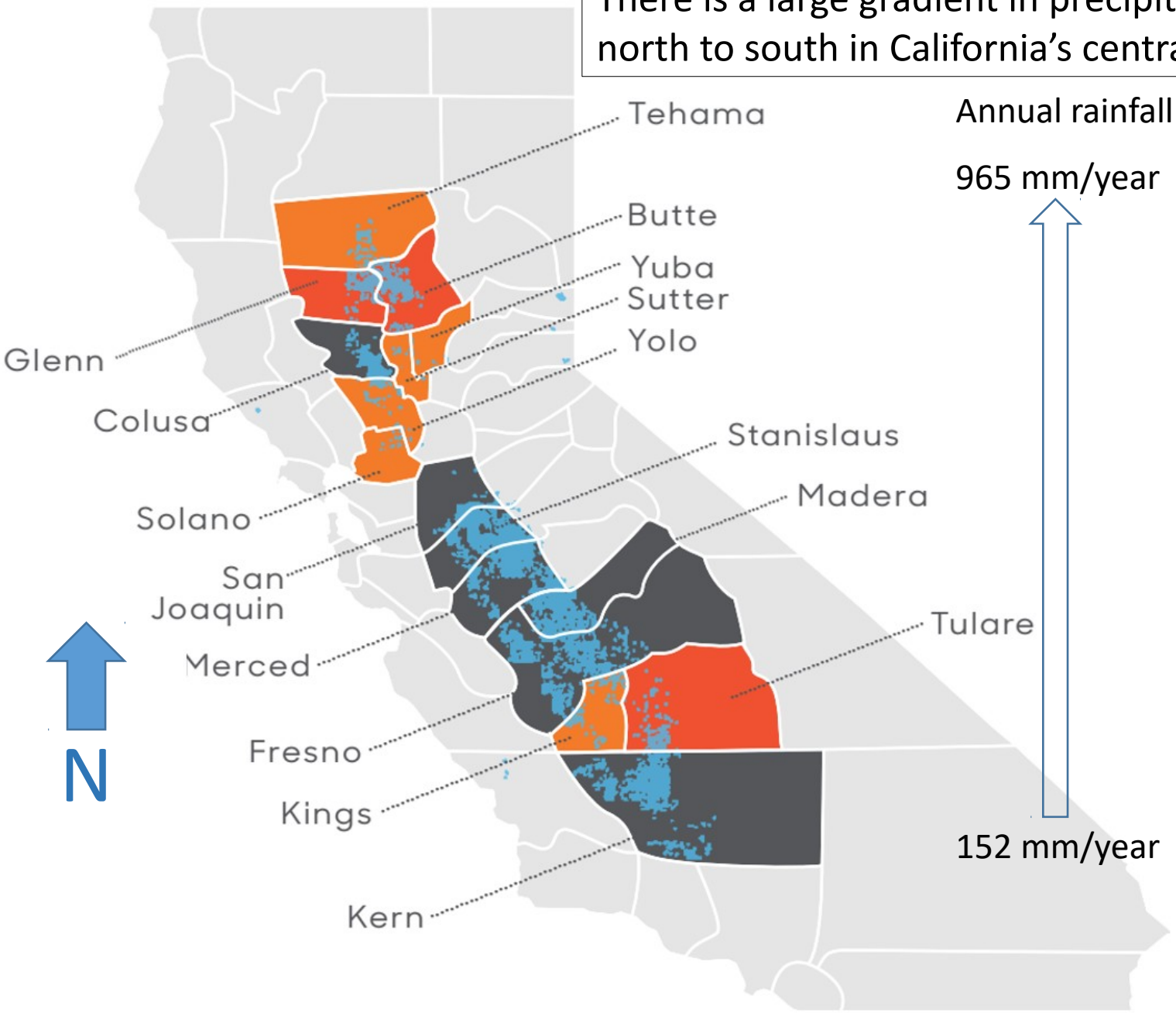
Almond and Walnut Specialist
University of California at Davis

Where Almonds Are Grown

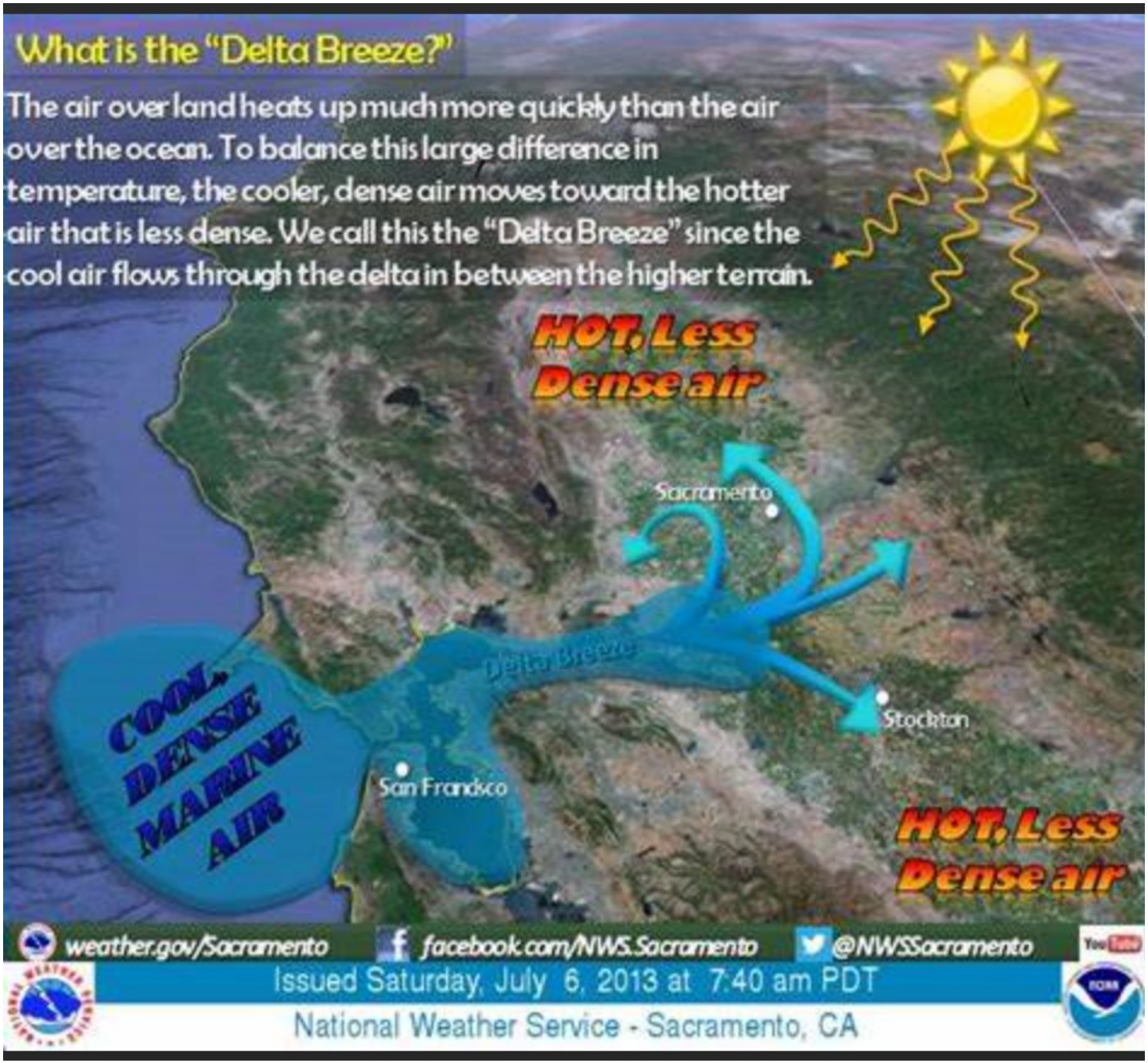
production by county | crop year 2017/18

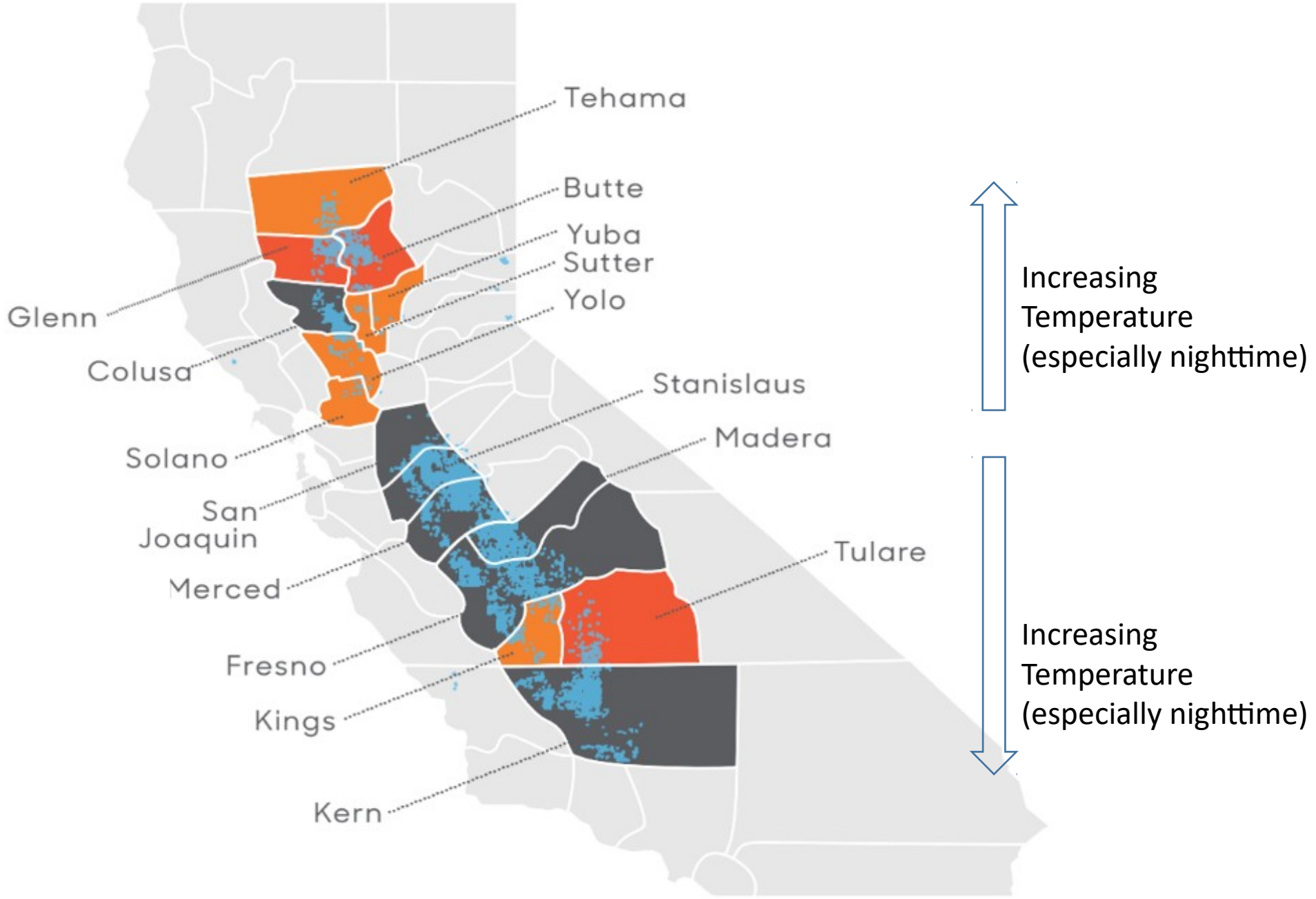


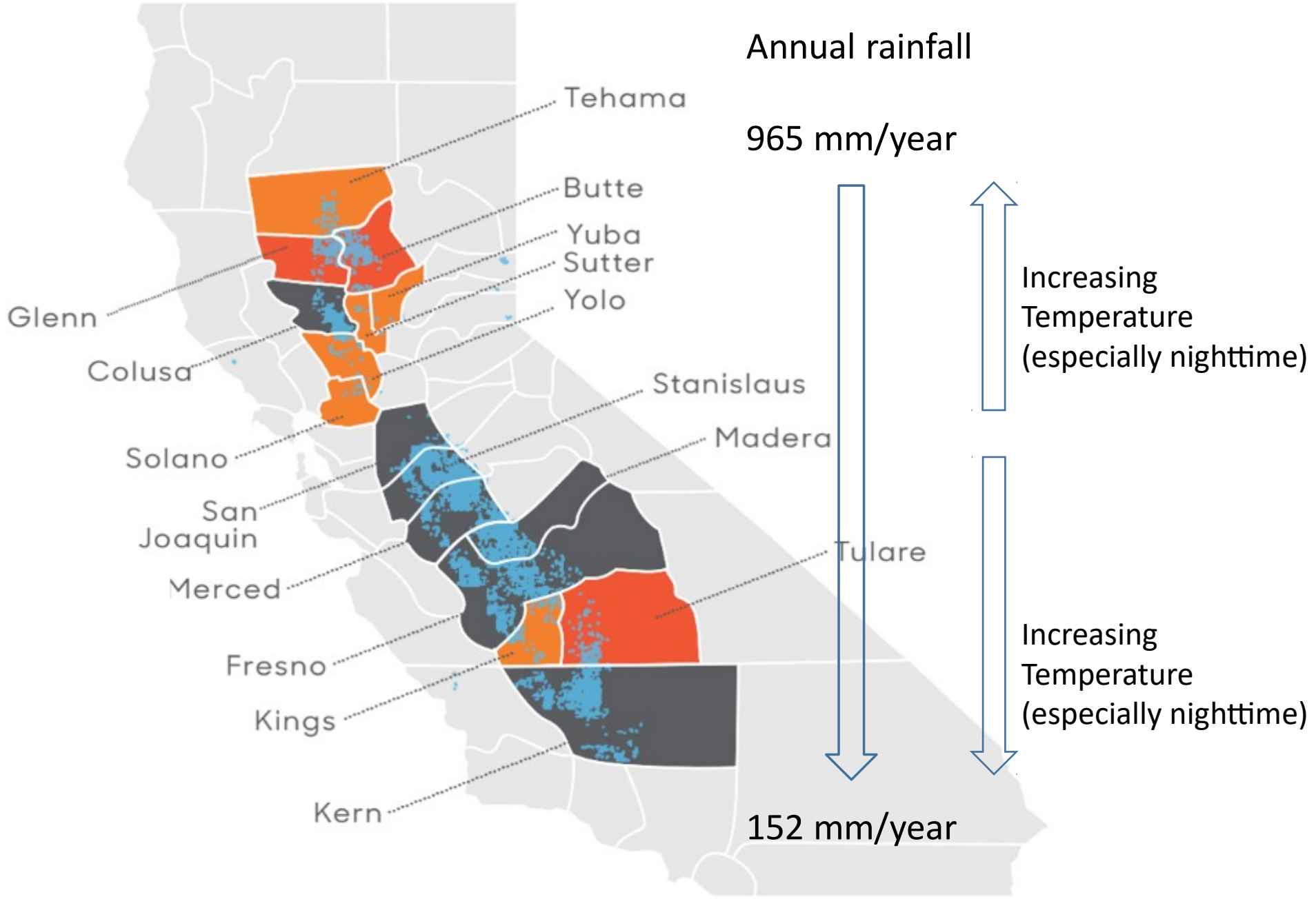
There is a large gradient in precipitation from north to south in California's central valleys



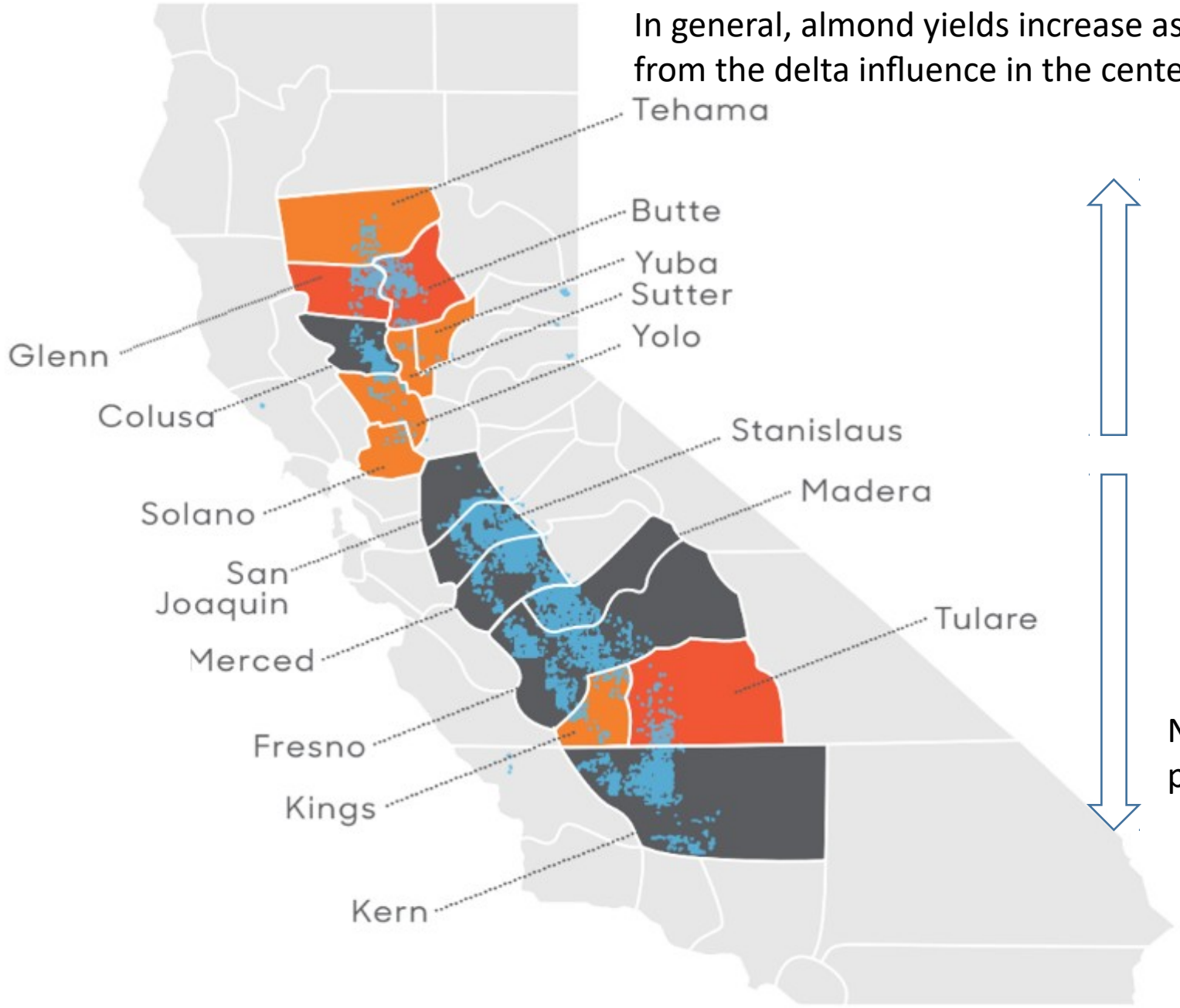

Chico
Alder Springs
Oroville
Stonyford
Truckee
Blue Canyon
Ukiah
Marysville
Beale AFB
Lake Tahoe
Clearlake
Lincoln
Tahoe Valley
Pilot Hill
Sacramento
Santa Rosa
Mather AFB
Vacaville
Napa
Camanche
Bridgeport
Mount Elizabeth
Concord
Stockton
Delta Breeze
Livermore
Modesto
San Jose
Merced
Los Gatos
Cool Ocean Currents
from Gulf of Alaska
Los Banos
Madera
Watsonville


What is the "Delta Breeze?"
The air over land heats up much more quickly than the air over the ocean. To balance this large difference in temperature, the cooler, dense air moves toward the hotter air that is less dense. We call this the "Delta Breeze" since the cool air flows through the delta in between the higher terrain.
HOT, Less Dense air
Sacramento
Delta Breeze
Stockton
COOL, DENSE MARINE AIR
San Francisco
HOT, Less Dense air
weather.gov/Sacramento
facebook.com/NWS.Sacramento
@NWSSacramento
Issued Saturday, July 6, 2013 at 7:40 am PDT
National Weather Service - Sacramento, CA


Tehama
Butte
Yuba
Sutter
Glenn
Yolo
Colusa
Stanislaus
Madera
Solano
San
Joaquin
Tulare
Merced
Fresno
Kings
Kern
Increasing
Temperature
(especially nighttime)
Increasing
Temperature
(especially nighttime)


Annual rainfall
965 mm/year
Tehama
Butte
Yuba
Sutter
Yolo
Glenn
Colusa
Stanislaus
Madera
Solano
San Joaquin
Tulare
Merced
Fresno
Kings
Kern
Increasing Temperature (especially nighttime)
Increasing Temperature (especially nighttime)
152 mm/year

In general, almond yields increase as you go away from the delta influence in the center of the state



Nonpareil plus 2-3 pollenizers

Nonpareil plus 1 pollenizer

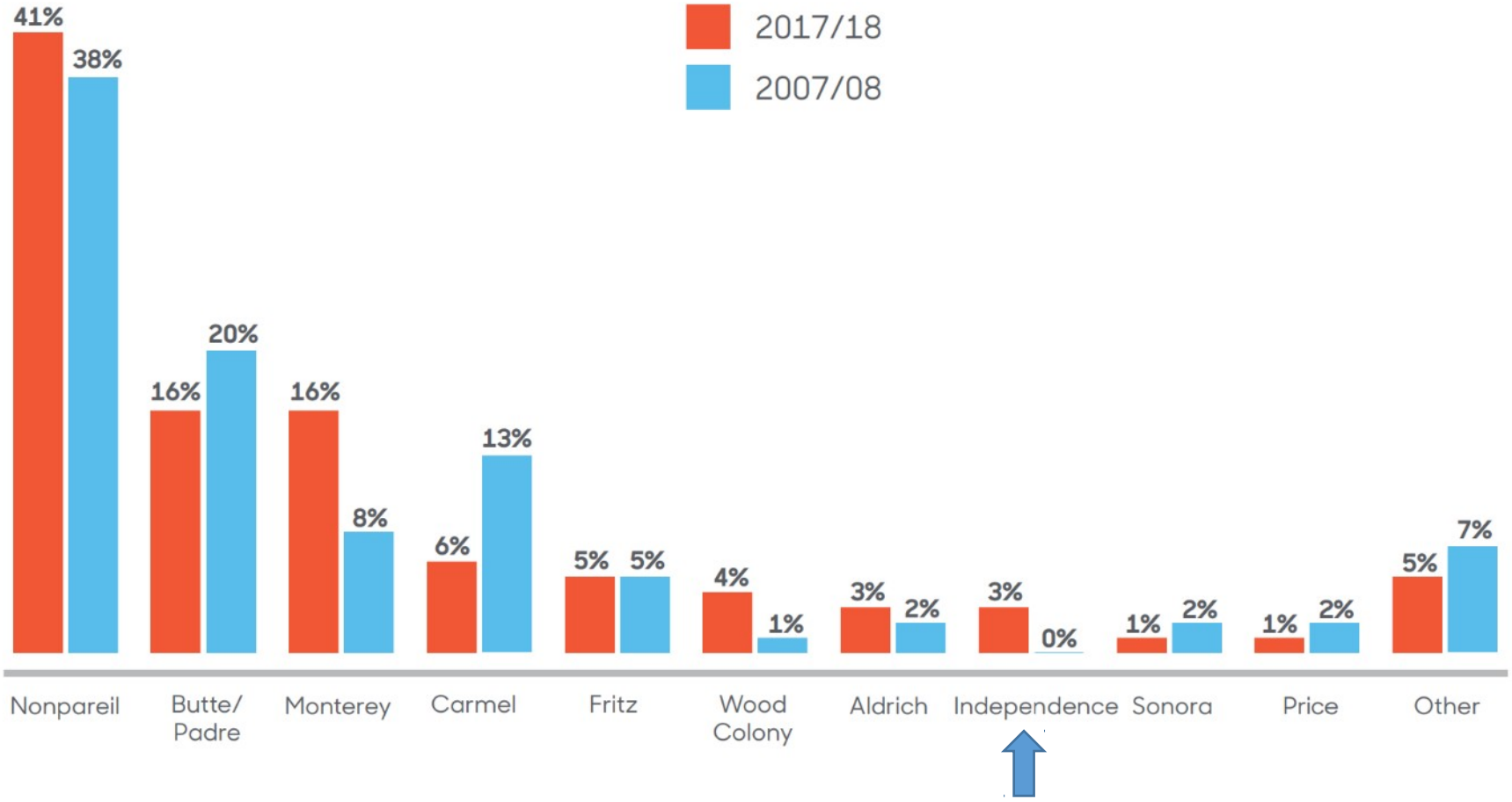
COUNTY GROWING REGIONS

	NORTHERN							CENTRAL			SOUTHERN						
CROP YEAR	BUTTE	COLUSA	GLENN	SOLANO	SUTTER	TEHAMA	YOLO	MERCED	SAN JOAQUIN	STANISLAUS	FRESNO	KERN	KINGS	MADERA	TULARE	ALL OTHERS	TOTAL
2007/08	66.7	66.2	51.8	4.3	5.6	11.4	10.0	172.9	75.2	223.3	253.8	271.0	17.9	125.3	26.7	1.4	**1,383.6**
2008/09	56.9	86.0	48.6	4.1	5.3	9.7	10.4	187.3	82.1	240.6	322.2	354.3	23.4	142.7	36.2	1.0	**1,611.0**
2009/10	49.2	75.7	52.7	3.7	5.2	10.9	12.4	156.7	70.7	198.8	281.9	317.9	20.6	112.3	32.6	1.2	**1,402.6**
2010/11	47.1	83.0	55.8	4.4	4.9	11.7	13.6	164.2	68.0	202.5	344.2	403.5	29.9	149.7	42.4	1.6	**1,626.6**
2011/12	49.0	85.5	59.7	5.1	6.9	11.9	17.9	216.7	87.9	269.7	443.0	472.6	39.0	206.1	44.5	1.6	**2,017.2**
2012/13	50.9	85.1	57.9	5.4	7.0	12.5	18.1	201.4	91.5	261.8	413.6	393.4	30.7	203.5	49.1	2.1	**1,884.1**
2013/14	56.0	103.6	69.7	6.0	7.3	14.7	22.5	213.8	95.9	284.9	398.1	427.2	32.6	216.9	55.8	1.9	**2,006.9**
2014/15	55.2	90.2	58.7	5.1	7.7	13.3	18.1	198.2	94.3	274.4	370.5	390.3	31.9	202.9	57.0	1.9	**1,869.7**
2015/16	57.4	109.7	75.4	6.0	7.4	16.0	27.3	188.7	97.2	260.7	376.5	366.1	32.4	215.2	53.9	2.3	**1,892.1**
2016/17	54.3	104.0	68.9	6.2	8.3	17.4	28.0	222.3	104.9	291.0	433.2	433.2	40.3	242.6	73.9	2.1	**2,130.6**
2017/18	52.1	112.9	72.6	8.4	8.7	18.6	39.7	223.7	108.7	303.2	494.4	429.5	43.6	264.0	80.9	2.4	**2,263.7**

California

Top Ten Almond-Producing Varieties

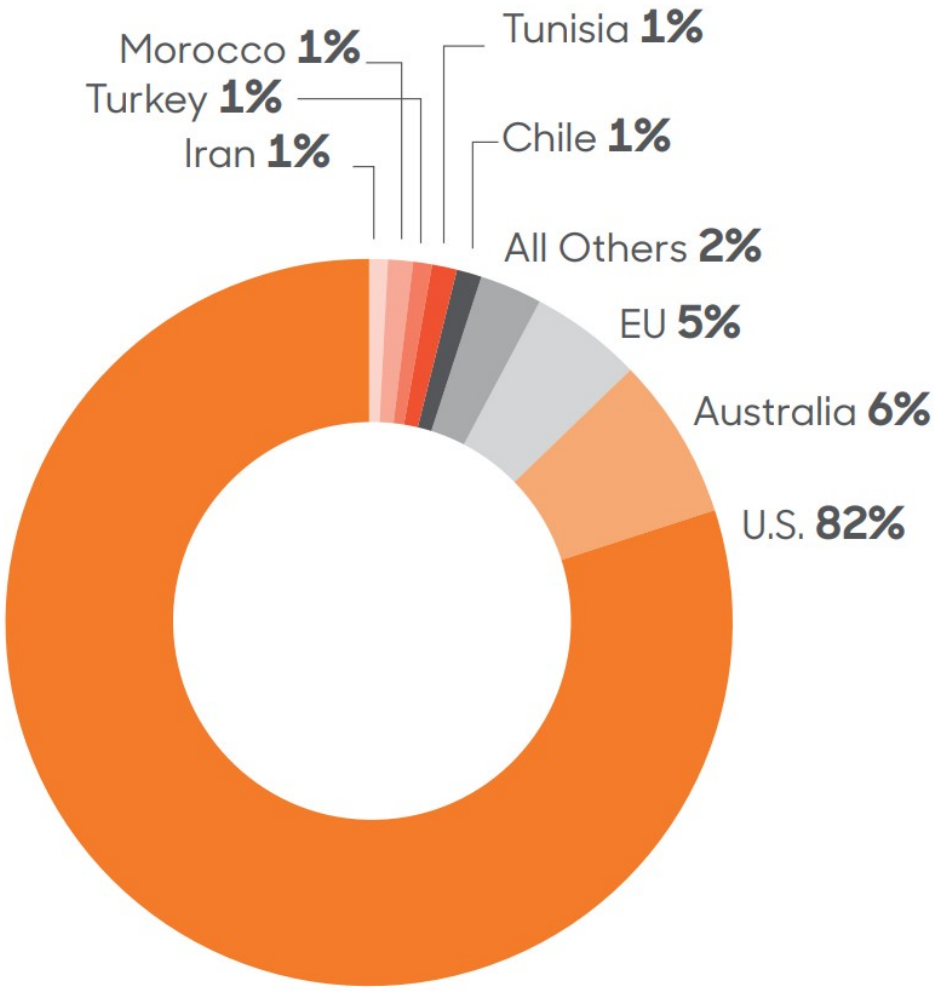
crop years 2007/08 vs. 2017/18



Self fertile

World Almond Production

crop year 2017/18



Source: Almond Board of California, Almond Board of Australia and International Dried Fruit Council.

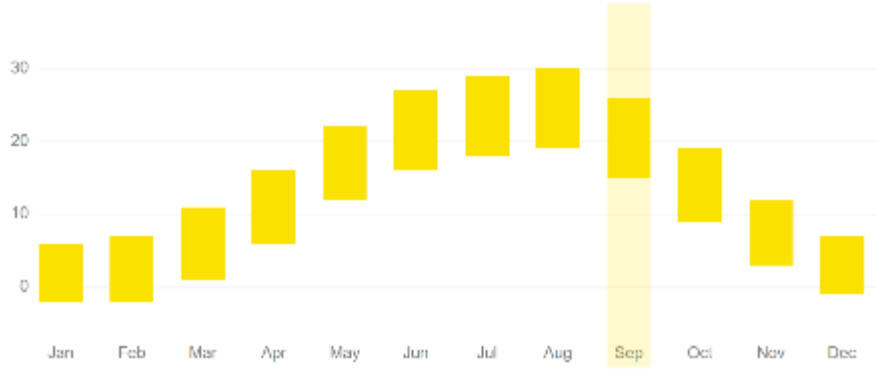
Weather history for Tbilisi, K'alak'i T'bilisi, Georgia

Average temperature

September

26 / 15 °C | F

Record temps	36° / 4° C
Avg rainfall	11.1 cm
Snow	0 days



Temperature | Rain | Snow

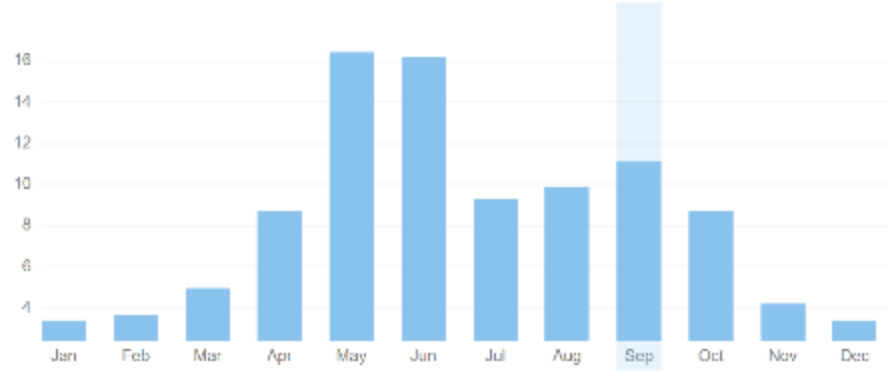
Weather history for Tbilisi, K'alak'i T'bilisi, Georgia

Average rainfall

September

11.1 cm in

Rain	23 days
Snow	0 days
Avg temps	26° / 15° C



Temperature | Rain | Snow

Weather history for Tbilisi, K'alak'i T'bilisi, Georgia

Average snowfall

September

0 days

Avg snowfall	0 cm
Avg rainfall	11.1 cm
Avg temps	26° / 15° C

Temperature | Rain | Snow

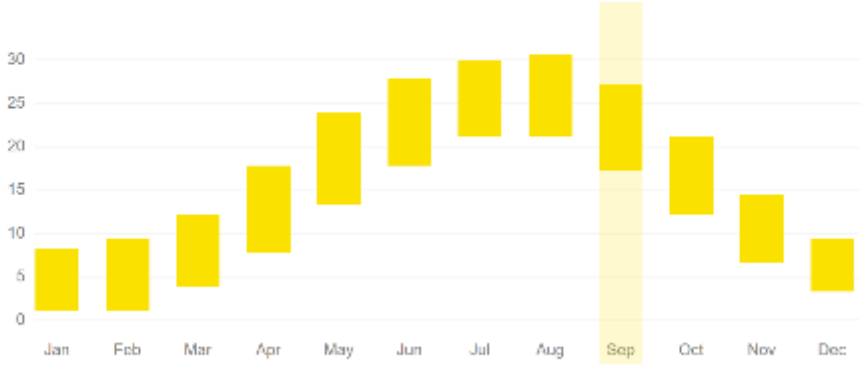
Weather history for Udabno, Georgia

Average temperature

September

27 / 17 °C | F

Record temps	39° / 6° C
Avg rainfall	11.71 cm
Snow	0 days



Temperature | Rain | Snow

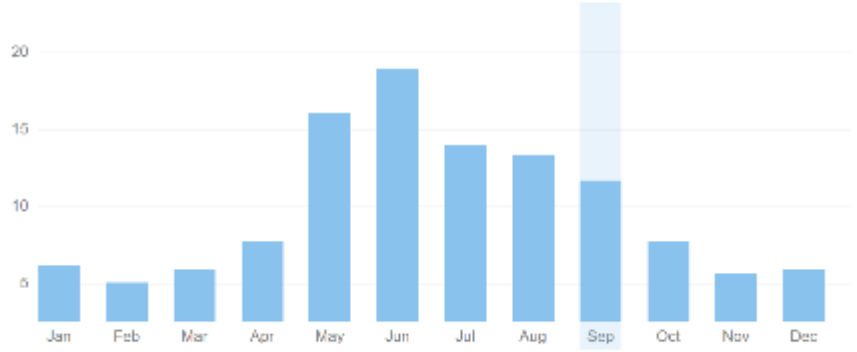
Weather history for Udabno, Georgia

Average rainfall

September

11.71 cm | in

Rain	23 days
Snow	0 days
Avg temps	27° / 17° C



Temperature | Rain | Snow

Weather history for Udabno, Georgia

Average snowfall

September

0 days

Avg snowfall	0 cm
Avg rainfall	11.7 cm
Avg temps	27° / 17° C

Temperature | Rain | Snow

Weather history for Sagarejo, Georgia

Average temperature

September

28 / 18 °C | F

Record temps	38° / 7° C
Avg rainfall	11.4 cm
Snow	0 days

Temperature | Rain | Snow

Weather history for Sagarejo, Georgia

Average snowfall

September

0 days

Avg snowfall	0 cm
Avg rainfall	11.4 cm
Avg temps	28° / 18° C

Temperature | Rain | Snow

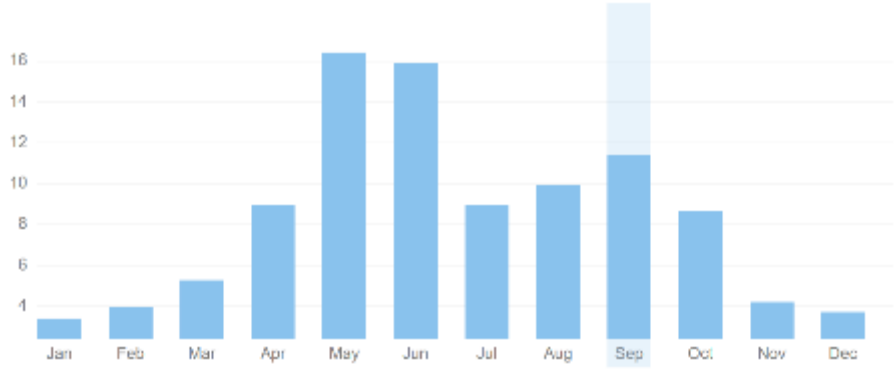
Weather history for Sagarejo, Georgia

Average rainfall

September

11.4 cm | in

Rain	22 days
Snow	0 days
Avg temps	28° / 18° C



Temperature | Rain | Snow

Weather history for Kakheti, Georgia

Average temperature

September

28 / 18 °C | F

Record temps	38° / 7° C
Avg rainfall	11.4 cm
Snow	0 days

Temperature | Rain | Snow

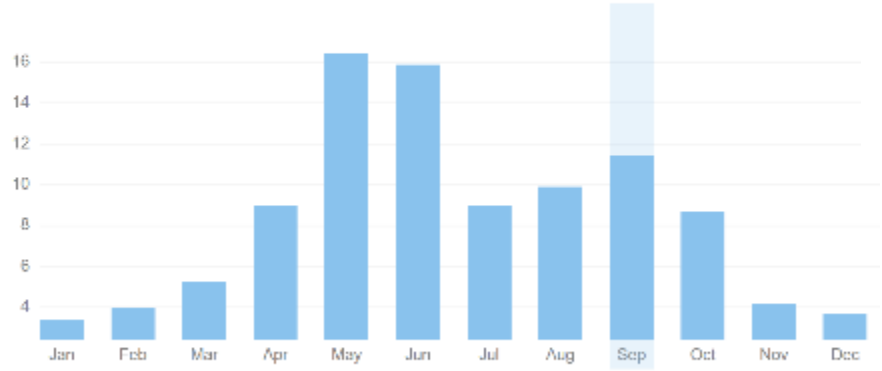
Weather history for Kakheti, Georgia

Average rainfall

September

11.4 cm | in

Rain	22 days
Snow	0 days
Avg temps	28° / 18° C



Temperature | Rain | Snow

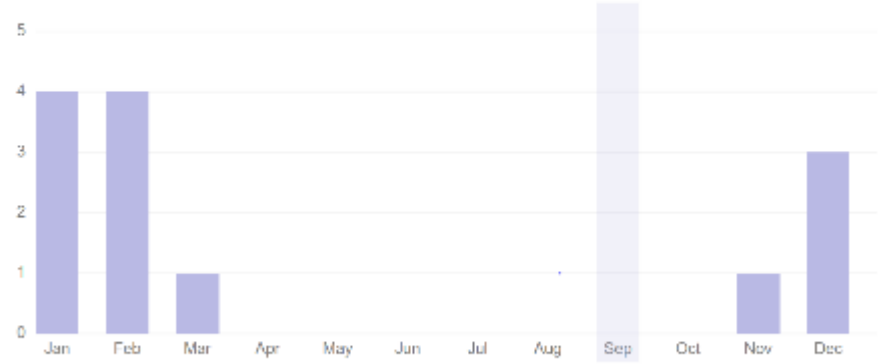
Weather history for Kakheti, Georgia

Average snowfall

September

0 days

Avg snowfall	0 cm
Avg rainfall	11.4 cm
Avg temps	28° / 18° C



Temperature | Rain | Snow

The climate of Georgia is mild and rainy on the coast and in the western plain, while it is more continental and arid in the central and eastern inland areas. In the mountains, it is obviously colder.

INDEX

THE COAST

Along the **coast** of the Black Sea and in the western plain (zone 1 on the map), **rainfall** is abundant, since it amounts to 1,500 millimeters (60 inches) per year or more, and it's distributed fairly evenly over the seasons, albeit with a maximum in autumn and winter. Winter along the coast is fairly mild, since the average temperature in January is about 7 °C (45 °F). The sea moderates the climate, while the Caucasus Mountains in the north partially protect this area from cold winds. However, beyond the Caucasus, we find the freezing Russian plains, and a bit of cold air can sometimes surpass the mountains and reach the coast: there are on average about ten days with snowfall per year. Summer is warm or even a bit hot, with a daily average around 23 °C (73 °F) in July and August; the sun often shines, but as we mentioned, there can be rainfall as well, which in summer occurs mainly in the form of downpours or thunderstorms.

Sukhumi

Here is the average precipitation in Sukhumi, in the northern part of the coast.

Sukhumi - Average precipitation

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Prec.(mm)	115	120	110	120	100	100	110	115	135	110	130	135	1400
Prec.(in)	4.5	4.7	4.3	4.7	3.9	3.9	4.3	4.5	5.3	4.3	5.1	5.3	55.1
Days	13	13	13	13	13	10	10	9	9	9	10	11	133

Despite the frequent rains, the amount of sunshine becomes good in summer, while in winter, there's not much sun. Here are the average sunshine hours per day.

Sukhumi - Sunshine

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hours	3	3	4	5	7	8	9	9	8	6	4	3

Batumi

In Batumi, in the southern part of the coast, precipitation reaches as high as 2,500 mm (99 in) per year, with a peak in autumn. Here is the average precipitation.

Batumi - Average precipitation

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Prec.(mm)	240	205	135	110	80	165	180	235	315	260	300	260	2,335
Prec.(in)	9.4	8.1	5.3	5.5	3.1	6.5	7.1	9.3	12.4	10.2	11.8	10.2	99
Days	13	14	14	14	13	13	14	14	13	11	13	14	160

Owing to the more frequent rains, in the southern part of the coast, the sun shines less often in the summer.

Batumi - Sunshine

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hours	3	4	4	5	7	8	7	7	7	6	4	3

Here are the average temperatures in Batumi.

Batumi - Average temperatures

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min (°C)	4	4	6	9	13	17	20	20	17	13	9	6
Max (°C)	10	11	12	16	20	24	26	26	24	20	16	13
Min (°F)	39	39	43	48	55	63	68	68	63	55	48	43
Max (°F)	50	52	54	61	68	75	79	79	75	68	61	55

The **sea** in Georgia is warm enough for swimming from July to September, and reaches 25 °C (77 °F) in July and August.

Batumi - Sea temperature

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp (°C)	10	9	9	11	16	22	25	25	24	20	16	12
Temp (°F)	50	48	48	52	61	72	77	77	75	68	61	54

This type of climate is also found in the plain near the coast, in cities like Kutaisi and Senaki, even though the summer gets a little warmer because of the distance from the sea. In ancient times, this area comprising the coast and the western plain was called Colchis.

Inland areas

In the **interior** (zone 2 on the map), separated from the western plains by secondary mountain ranges such as the Likhi Mountains, we find valleys and plateaus lying at an altitude between 400 and 1,000 meters (1,300 and 3,300 feet).

Tbilisi

In the capital, **Tbilisi**, located in the valley of the Kura, at 450 meters (1,450 ft) above sea level, the climate is slightly continental, and it's much more arid than on the coast. The monthly average temperature ranges from 3 °C (37 °F) in January to 25 °C (77 °F) in July. Here is the average temperature.

Tbilisi - Average temperatures

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min (°C)	-1	0	3	8	12	16	20	20	15	10	5	1
Max (°C)	7	8	13	19	23	28	31	31	26	20	13	8
Min (°F)	30	32	37	46	54	61	68	68	59	50	41	34
Max (°F)	45	46	55	66	73	82	88	88	79	68	55	46

The rainfall amounts to 500 mm (20 in) per year, with a minimum in winter, even though the sky is often cloudy, and a maximum in late spring, in May and June, mainly because of afternoon instability, which can cause showers and thunderstorms and partly continues in summer. During winter, snowfall is quite frequent (although it's not abundant because of the low level of precipitation), and so are cold spells, during which the temperature can drop to about -15 °C (5 °F). Summer is sunny, despite a few afternoon downpours or thunderstorms; there can also be hot days, with maximum temperatures around 36/38 °C (97/100 °F).
Here is the average precipitation.

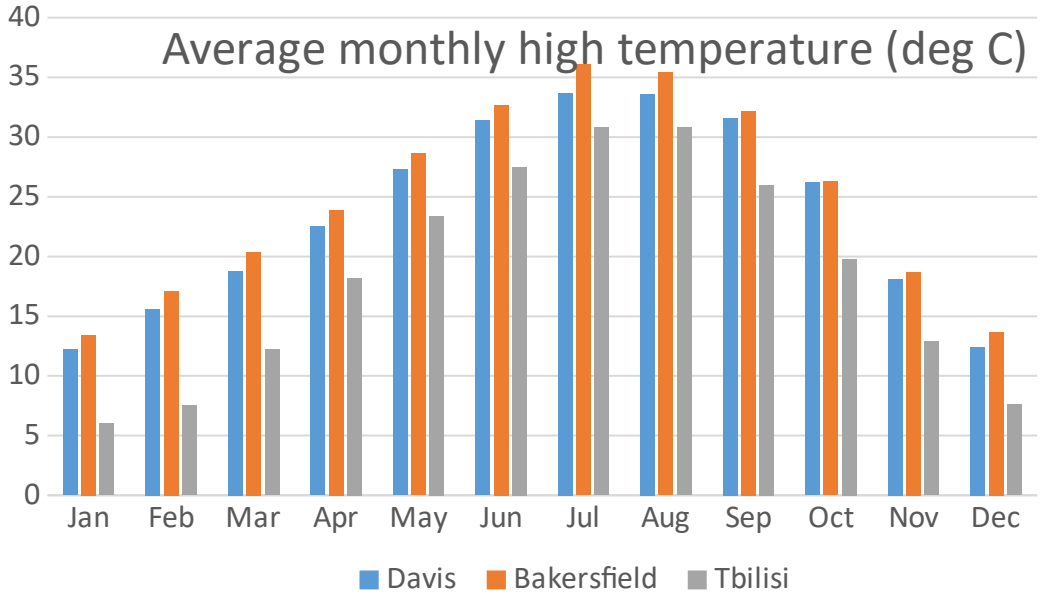
Tbilisi - Average precipitation

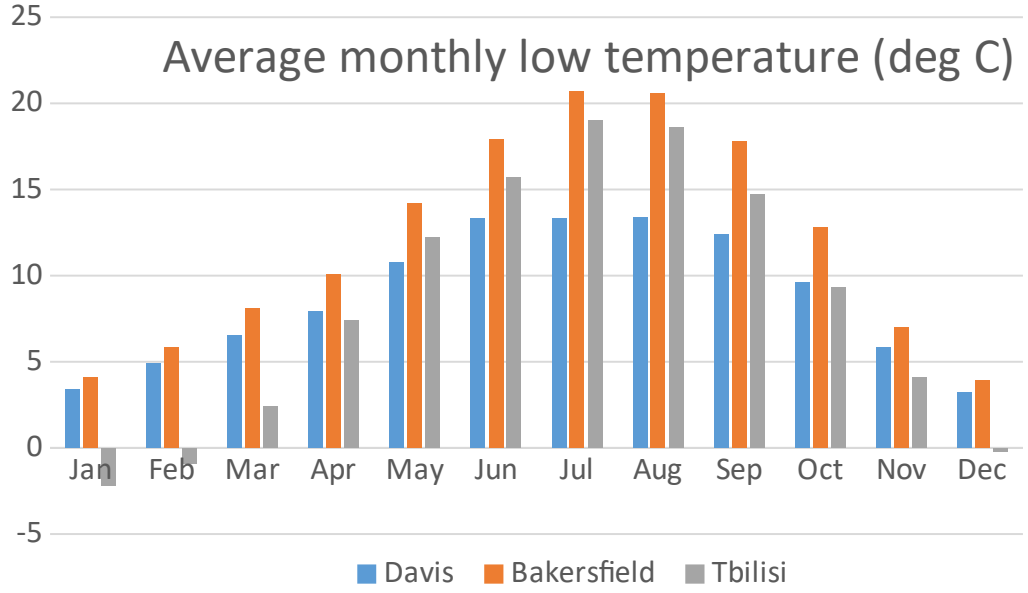
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Prec.(mm)	20	25	30	50	80	75	45	50	35	40	30	20	495
Prec.(in)	0.8	1	1.2	2	3.1	3	1.8	2	1.4	1.6	1.2	0.8	19.5
Days	4	5	6	8	10	9	6	6	5	6	4	4	71

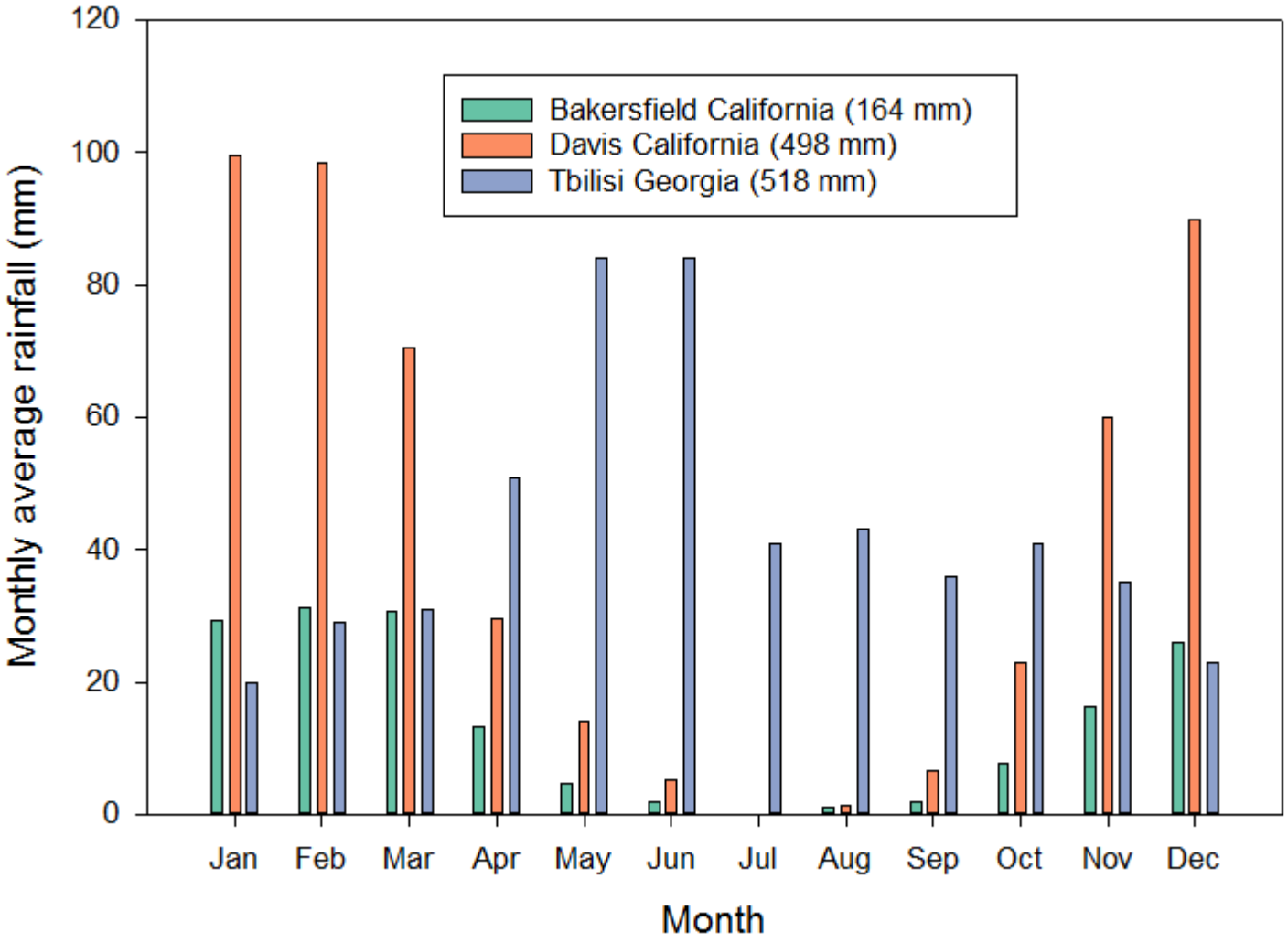
As mentioned, the sun in Tbilisi often shines in summer, apart from afternoon thunderstorms, while in winter, it is not very frequent.

Tbilisi - Sunshine

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hours	3	4	5	5	7	9	9	8	7	6	3	3


Average monthly high temperature (deg C)
40
35
30
25
20
15
10
5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Davis
Bakersfield
Tbilisi


Average monthly low temperature (deg C)
25
20
15
10
5
0
-5
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Davis
Bakersfield
Tbilisi


Bakersfield California (164 mm)
Davis California (498 mm)
Tbilisi Georgia (518 mm)
Monthly average rainfall (mm)
120
100
80
60
40
20
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

5 metric tons of kernel per ha (4500 kernel lbs/ac)

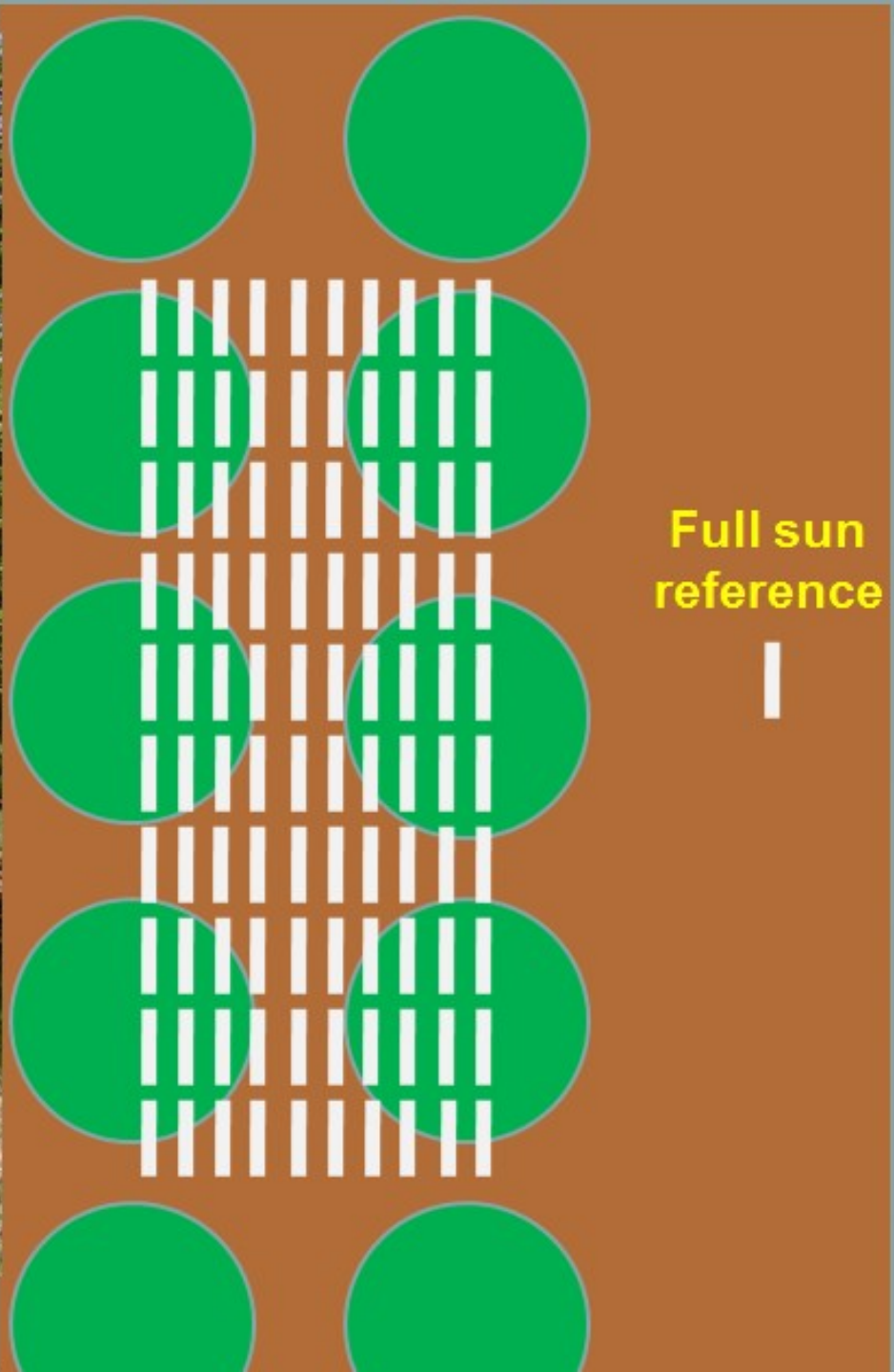
Factors influencing yield potential in a developing orchard

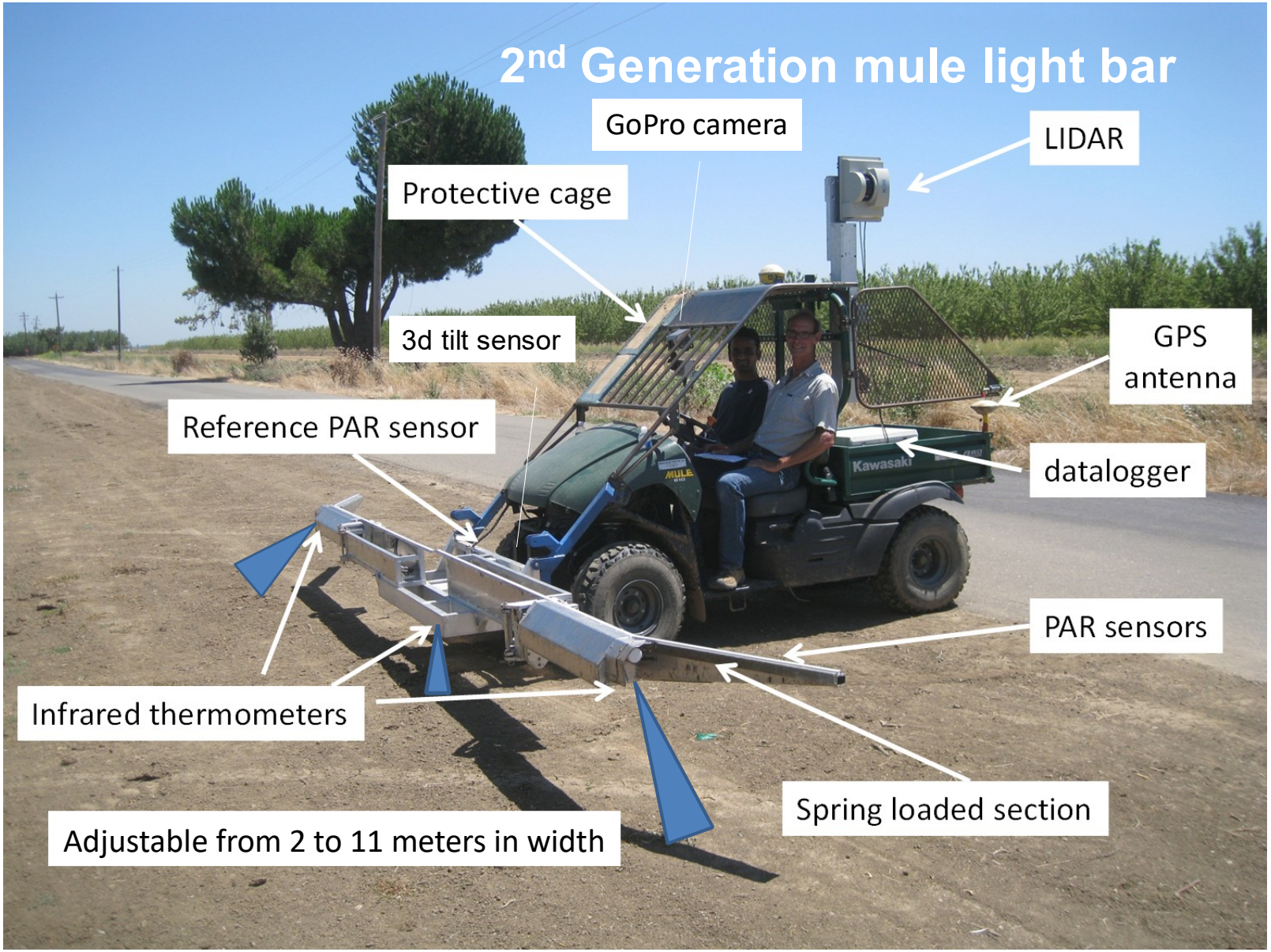
- Canopy size as influenced by
  - Variety
  - Rootstock
  - Tree spacing
  - Irrigation management
  - Nutrition management
  - Pruning

Yield and irrigation needs are driven by canopy size

- Important to have a means to assess canopy size
- We use photosynthetically active radiation (PAR) interception under the tree canopy to assess canopy size
- This is better than shaded area since it also account for light coming through in the shade

Decagon Sunfleck Ceptometer




2nd Generation mule light bar
GoPro camera
LIDAR
Protective cage
3d tilt sensor
GPS antenna
Reference PAR sensor
datalogger
PAR sensors
Infrared thermometers
Spring loaded section
Adjustable from 2 to 11 meters in width

We set up a portable weather station with temp, RH, windspeed and PAR sensors outside orchard

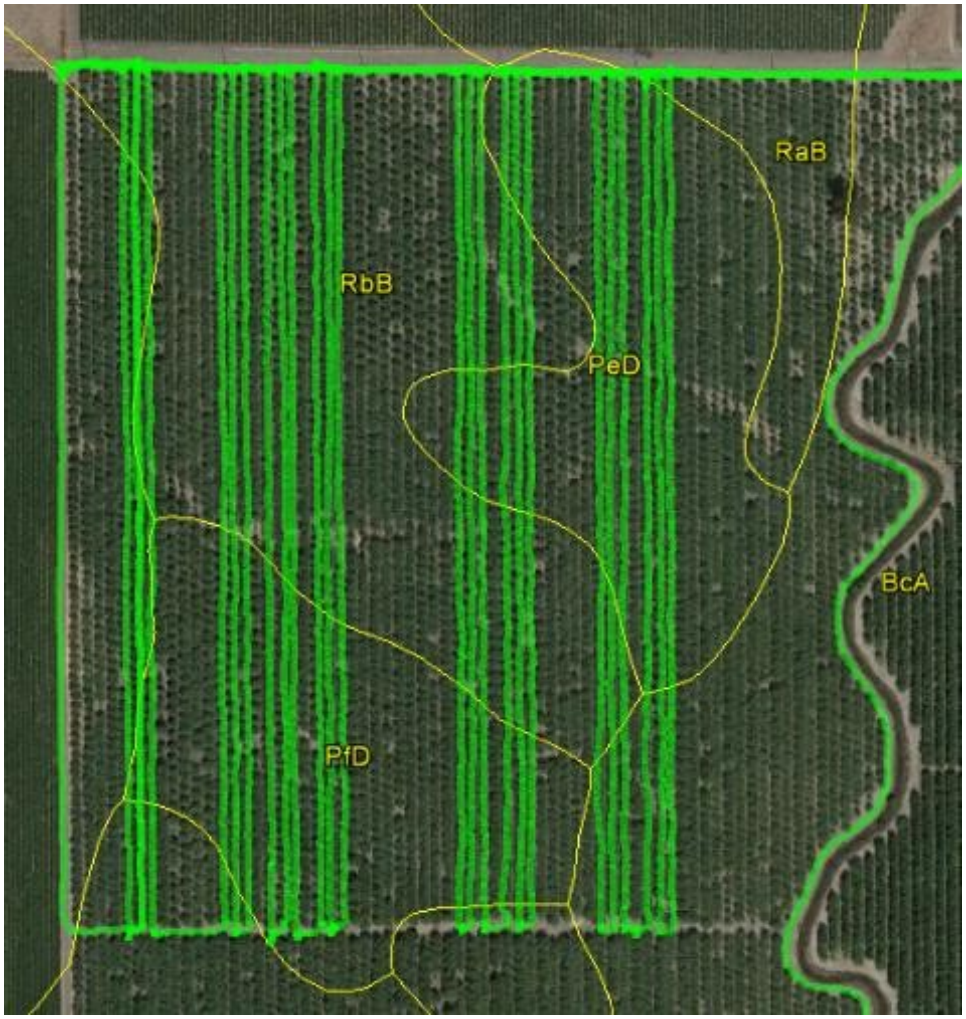
Normal speed of travel is 10 km/hr so we can map about 20 km within 1 hour of midday

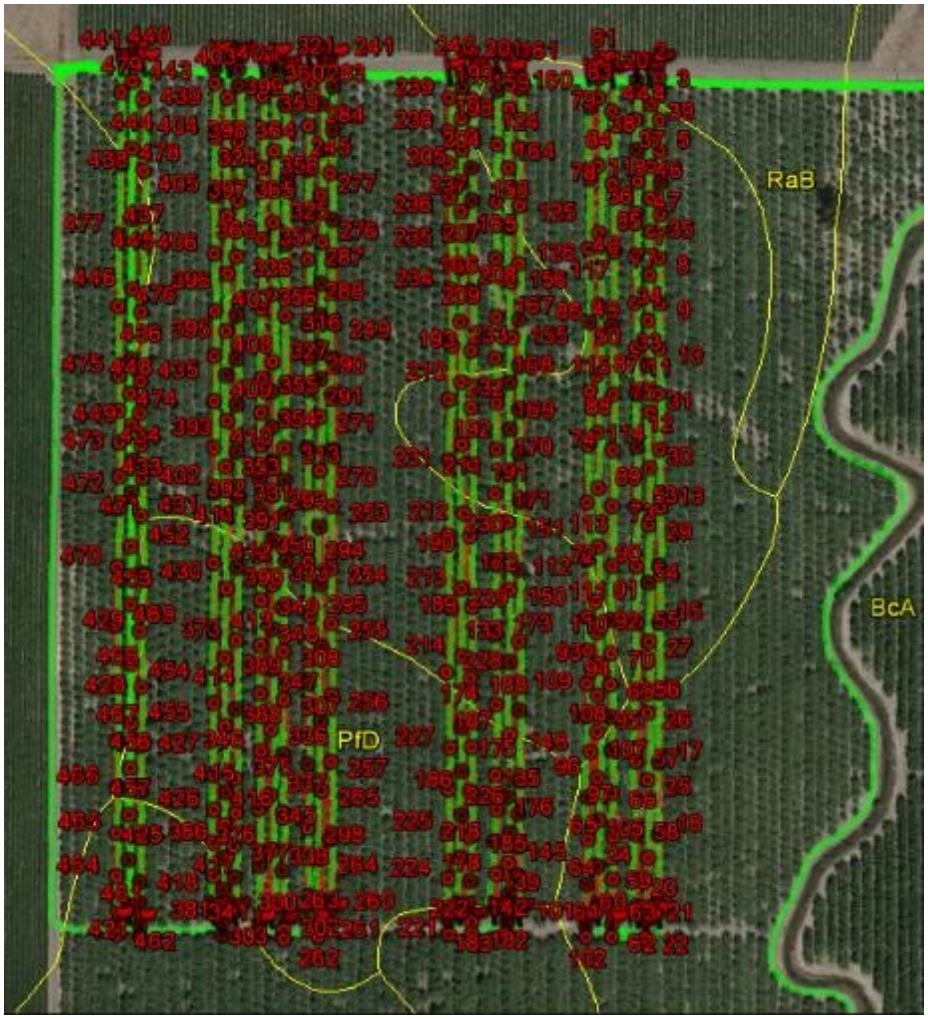
Self contained hydraulic system for operating augers, autosampler and elevator

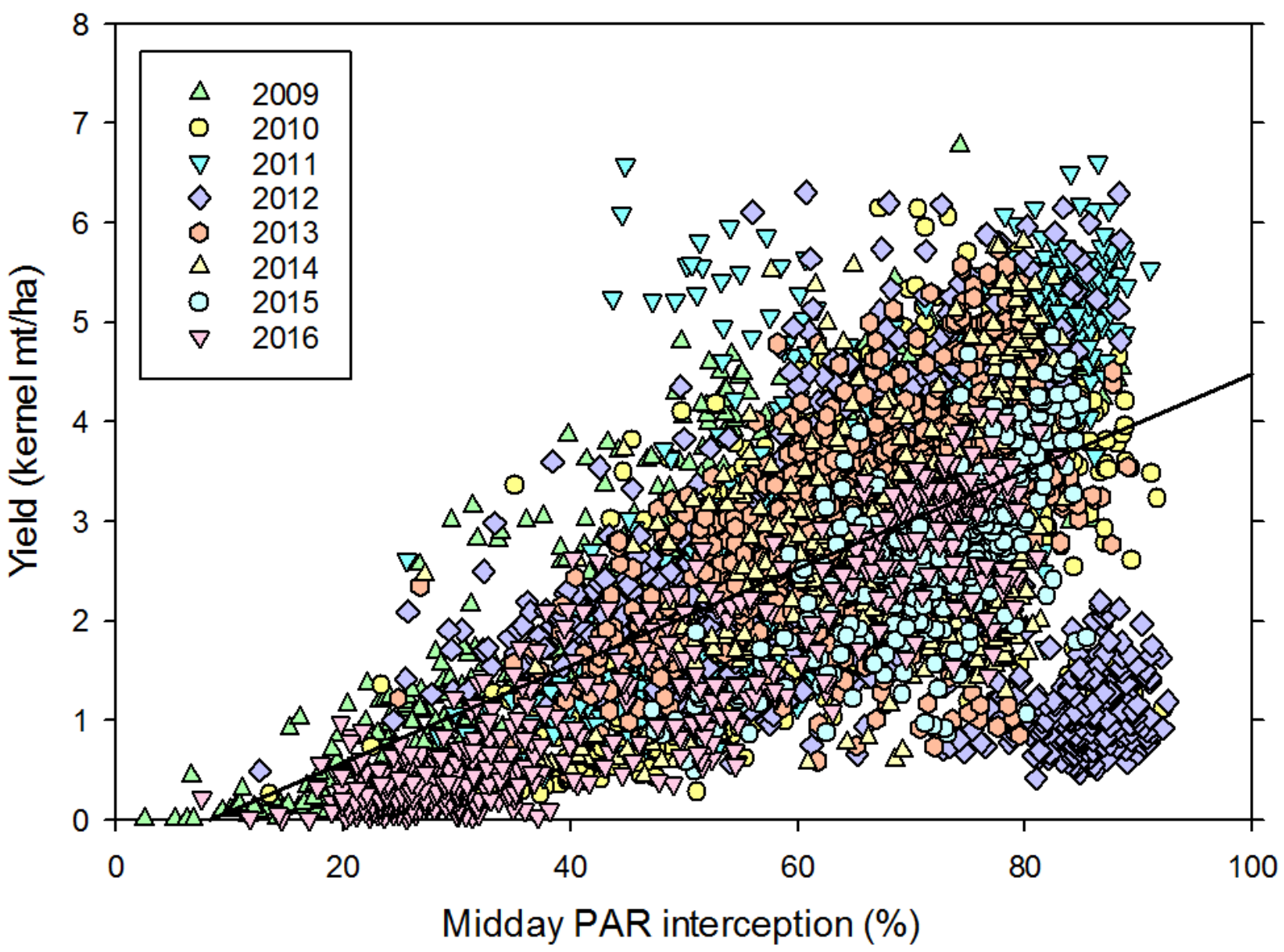
Trimble GPS acts as datalogger to collect continuous yield data

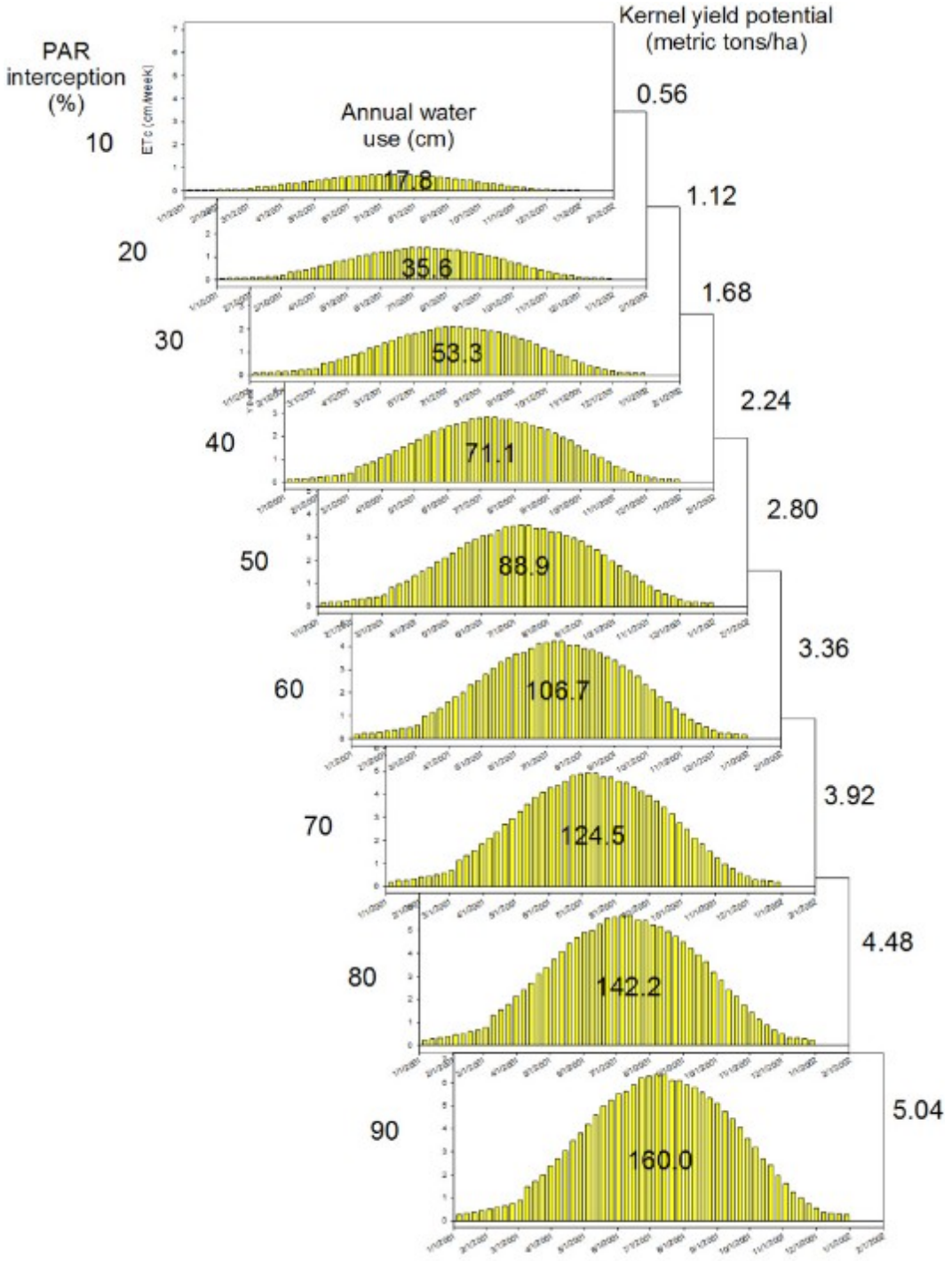
Autosampler delivers nuts to right rear of cart

Wireless controller for hydraulically operated auto sampler


RaB
RbB
PeD
BcA
PfD


RaB
BcA
PfD


Average of all data- 0.045 kernel mt/ha per 1% PAR intercepted
2009
2010
2011
2012
2013
2014
2015
2016
Yield (kernel mt/ha)
Midday PAR interception (%)
0
1
2
3
4
5
6
7
8
0
20
40
60
80
100


PAR interception (%)
Annual water use (cm)
Kernel yield potential (metric tons/ha)
ETc (cm/week)
10
17.8
0.56
20
35.6
1.12
30
53.3
1.68
40
71.1
2.24
50
88.9
2.80
60
106.7
3.36
70
124.5
3.92
80
142.2
4.48
90
160.0
5.04

Summary of available yield versus applied water trials in California and Australia suggest that production potential is 0.00315 MT/mm water applied so yield potential is about 2 MT/ha with 650mm rainfall under rain-fed conditions

PAR interception	Applied water (mm)	Yield potential (MT/ha)
10	178	0.560
20	356	1.121
30	533	1.681
40	711	2.242
50	889	2.802
60	1067	3.363
70	1245	3.923
80	1422	4.483
90	1600	5.044

How do we produce 4.5 mt/ha?- This will be the subject of my afternoon talk.

PAR interception	Applied water (mm)	Yield potential (MT/ha)
10	178	0.560
20	356	1.121
30	533	1.681
40	711	2.242
50	889	2.802
60	1067	3.363
70	1245	3.923
80	1422	4.483
90	1600	5.044

Maximum recommended canopy cover to minimize food safety risk


Questions?