# Botany and Physiology of the Pistachio Tree

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8th Advances in PISTACHIO PRODUCTION
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# Outline

- Botany
- Pollination
- Fruit Development
- Dormancy and Chilling
- Drought Tolerance
- Salt Tolerance
- Nutrient Uptake and Demand
- Physiological Issues
- Effect of Rootstock on Scion Growth

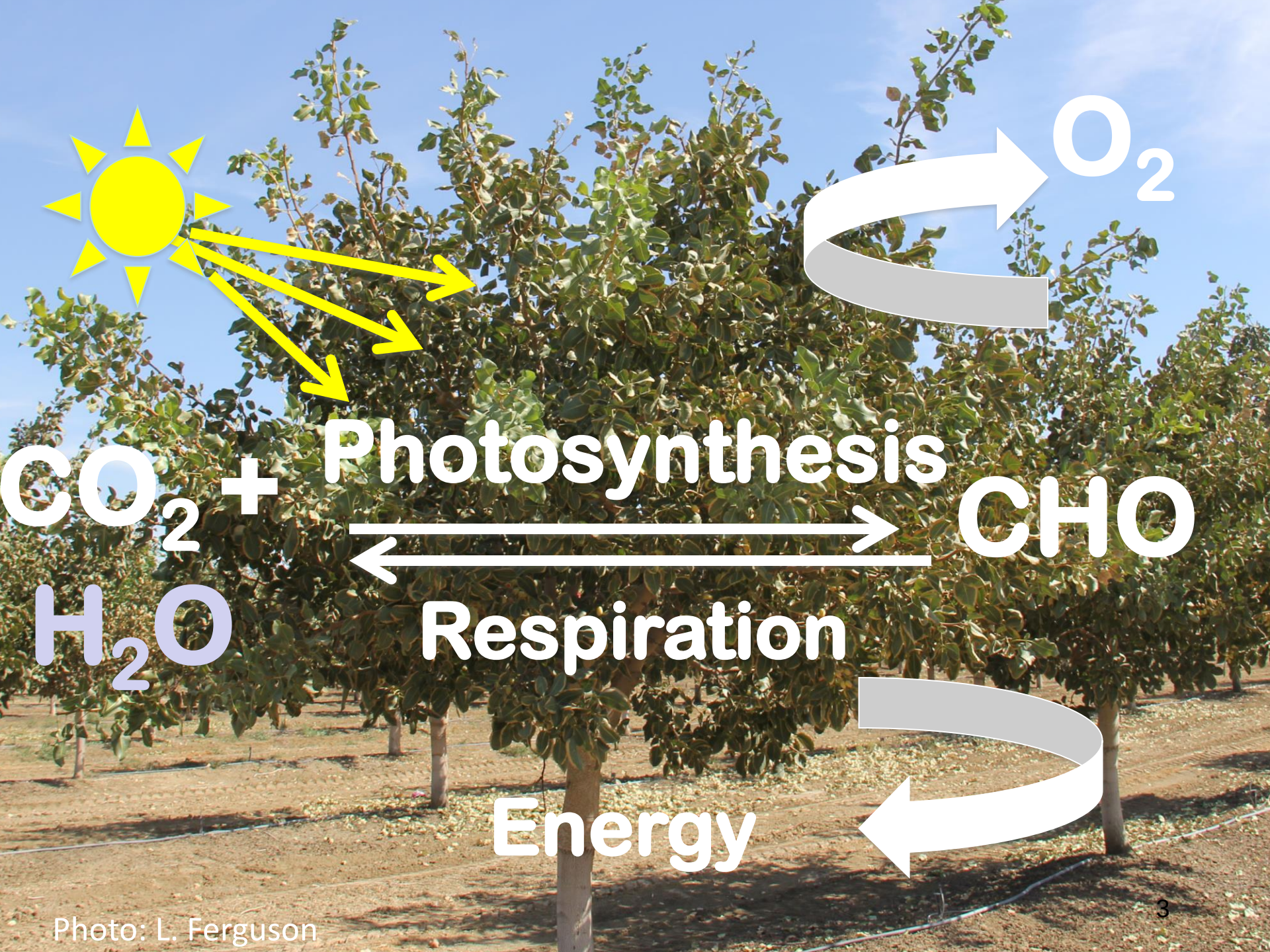



Photo: L. Ferguson

# Botany

- Order: Sapindales
- Family: Anacardiaceae
- Genus: Pistacia
- Species: vera

# Botany

# San Juan, Argentina: October 1, 2012

Photo: L. Ferguson

# Botany

- Temperature deciduous
- *Pistacia* species native to areas from $40^{o}$ to $70^{o}$ latitude
- *P. vera* is from Western Asia and Asia Minor
- Introduced to California in early $20^{th}$ century
  - Didn't become economically important until later $20^{th}$ century

# Botany

- 25-35 feet (7.6-10.6 meters) in height
- Apically dominant
- Long juvenility
- Bears crop on one-year-old wood
- Alternate bearing scion

# Dioecious

- Definition: Separate houses
- Bloom overlap critical

Male

Female

Photo: L. Ferguson

Photo: L. Ferguson


Photo: L. Ferguson

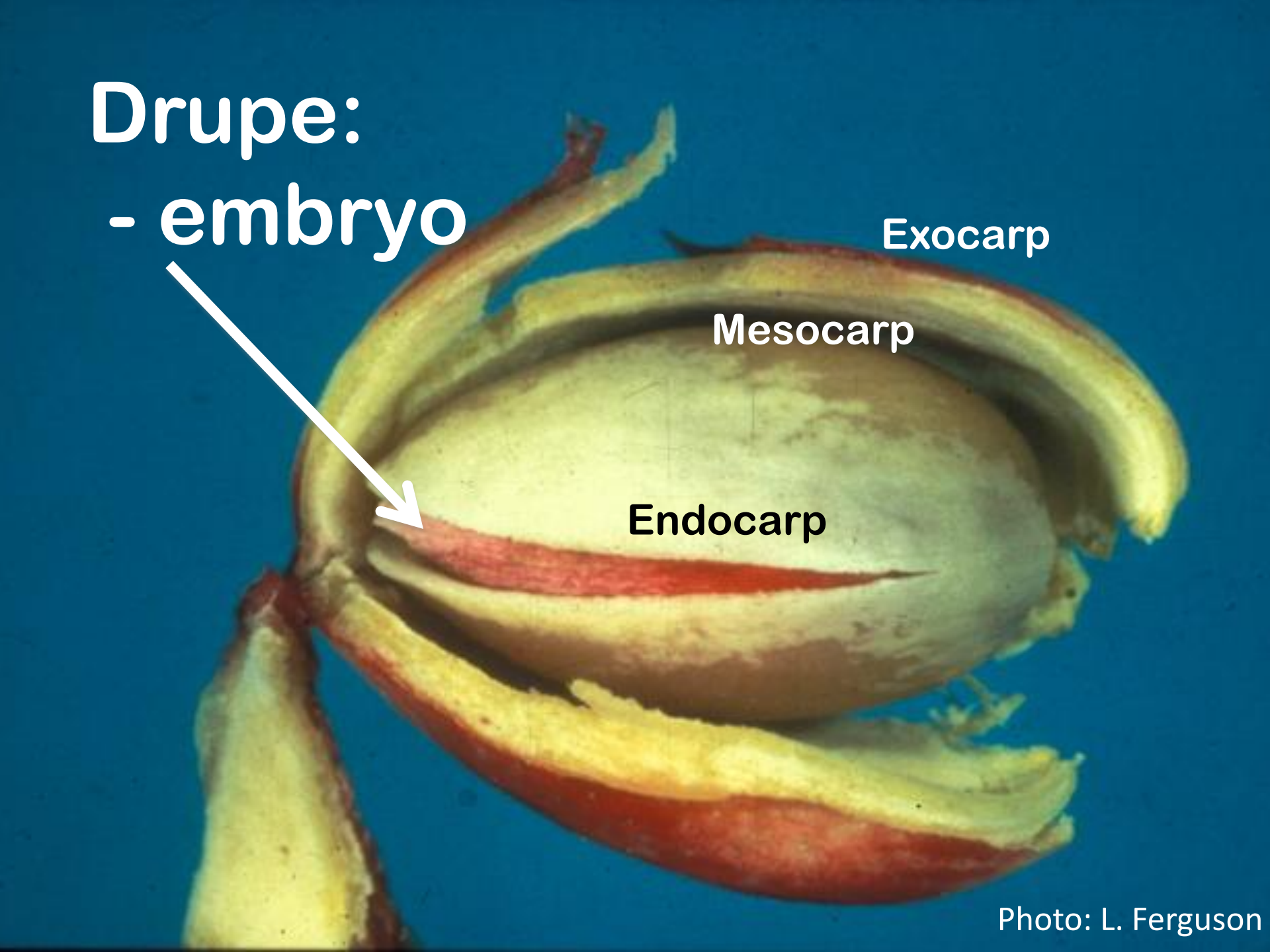

Photo: C. E. Kallsen

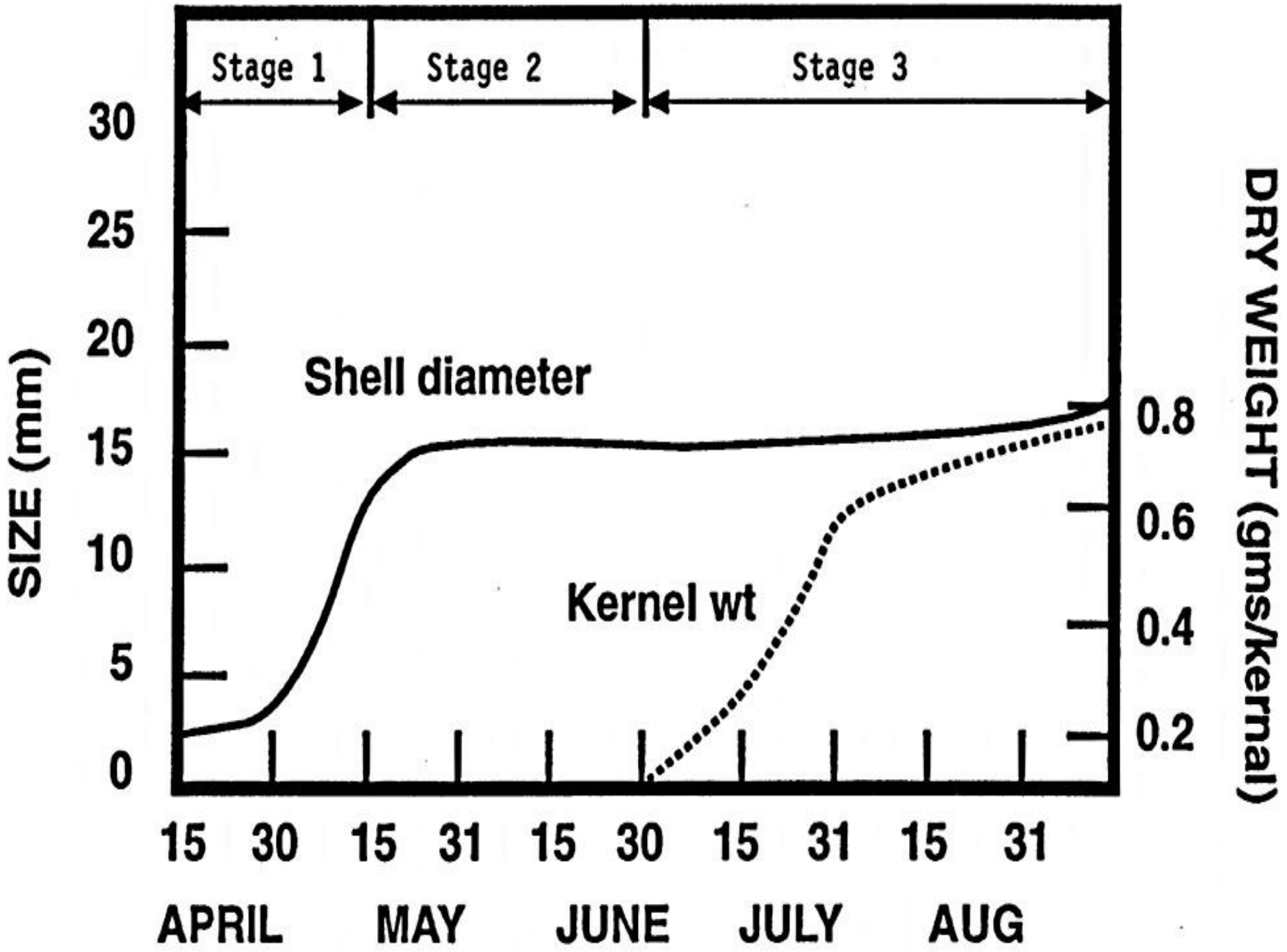
# Pistachio Flowers

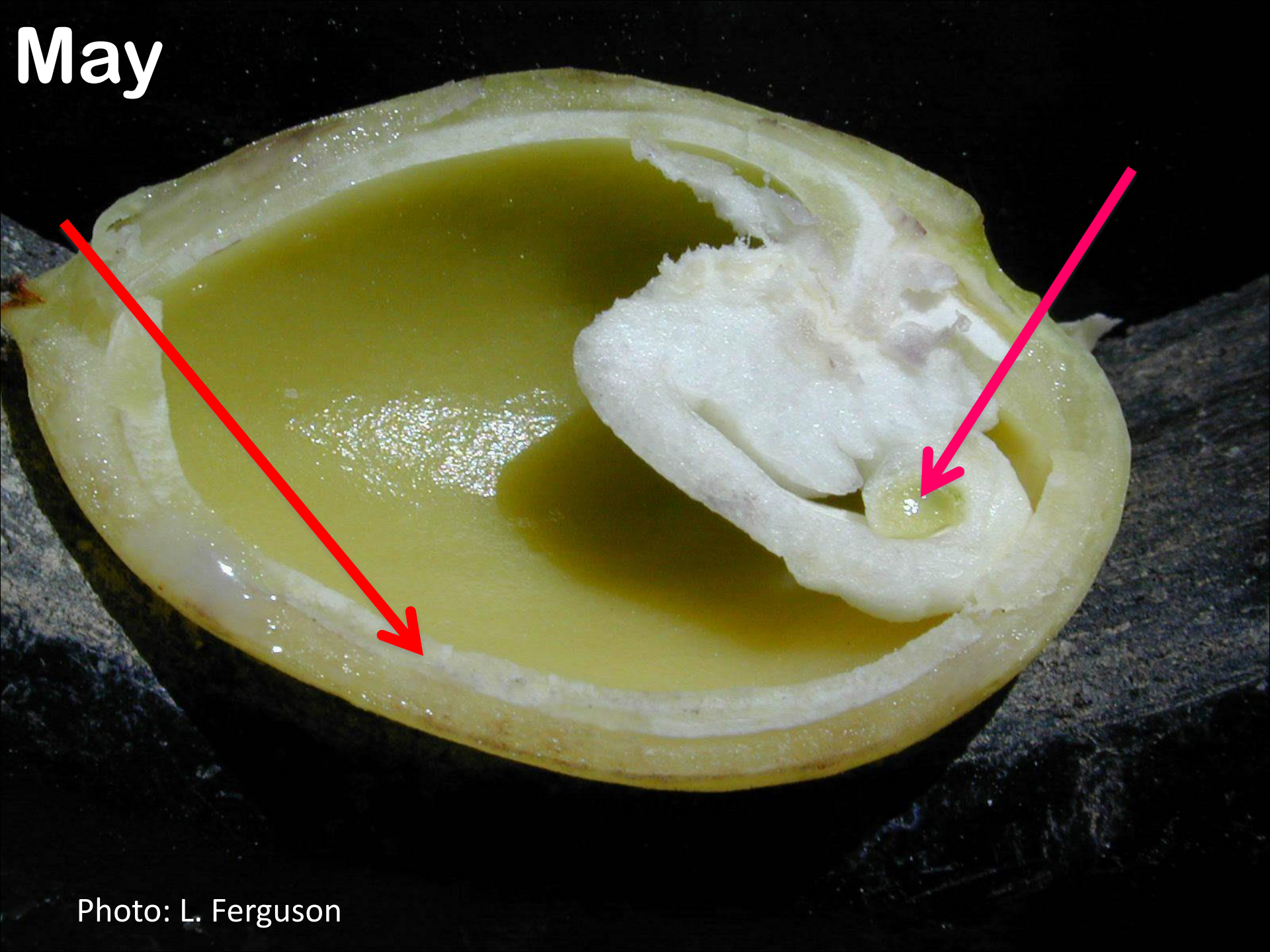
- 100-200 flowers

  <4% set, resulting in an average of 14 fruit

  5-30% blanks
- Apically dominant
  - Most nuts are at the terminus (8% of total flowers)
- Capable of parthenocarpy


Drupe:
- embryo
Exocarp
Mesocarp
Endocarp
Photo: L. Ferguson


Stage 1
Stage 2
Stage 3
30
25
20
15
10
5
0
SIZE (mm)
Shell diameter
Kernel wt
0.8
0.6
0.4
0.2
DRY WEIGHT (gms/kernal)
15
30
15
31
15
30
15
31
15
31
APRIL
MAY
JUNE
JULY
AUG


May
Photo: L. Ferguson


June
Photo: L. Ferguson


Photo: L. Ferguson


August
Photo: L. Ferguson


Photo: L. Ferguson

# September

Photo: L. Ferguson


Photo: L. Ferguson

# Growing Degree Day Requirements

## High heat needed in summer

| | Kerman | Golden Hills | Lost Hills |
|---|---|---|---|
| Stage I | 756 | 705 | 751 |
| Stage II | 2583 | 2830 | 3157 |
| Stage III | Starts at 1000, ends at 2111 | Starts at 931, ends at 1904 | Starts at 982, ends at 2021 |

# Temperature Requirements

- Cool winters with temperatures in the 40s
  - No hard freezes
  - No late or early freezing temperatures
- Chill hours
  - Kerman: > 750 hours @ < 32-45 $^{o}$ F (0 - 7.2 $^{o}$ C)
  - Peters: > 900 hours @ < 32-45 $^{o}$ F (0 - 7.2 $^{o}$ C)

# Dormancy


- Dormancy: when growth does not occur in living plants
  - Endodormancy: when growth does not occur due to conditions within the plant
  - Ecodormancy: when growth does not occur due to conditions external to the plant

# Does it matter which model is used?

## What is known about chill models

| Information from controlled experiments | Chilling Hours | Utah | Utah+ | Dynamic Model |
|---|---|---|---|---|
| Depends on temperature | + | + | + | + |
| Daily temperature cycle | + | + | + | + |
| Weighted temperatures | - | + | + | + |
| Continuous weights | - | - | - | + |
| Warm temperatures - | - | + | - | + |
| Moderate temperatures + | - | - | - | + |
| Two-phase process | - | - | - | + |

Luedeling et al. Erwerbsobstbau (submitted).

# Temperature Requirements

- Cool winters with temperatures in the 40s
  - No hard freezes
  - No late or early freezing temperatures
- Chill hours
  - Kerman: > 750 hours @ < 42-45 $^{o}$ F (5.8 - 7.2 $^{o}$ C)
  - Peters: > 900 hours @ < 42-45 $^{o}$ F (5.8 - 7.2 $^{o}$ C)
- Chill portions
  - Kerman > 59
  - Peters > 69

# Modelling Yield

- Last year's yield strongest predictor of current year's yield
- Temperatures > 65$^{o}$ F (18.3$^{o}$ C) during dormancy period (Nov 15 to Feb 15) negatively correlated with current season's yield
  - Each hour in excess of this temperature resulted in a loss of 13.1 lbs/ac (14.7 kg/ha)

# Critical Temperatures

- Critical heat temperatures unknown
  - Literature suggests 77-86$^{o}$ F (25-30$^{o}$ C)
- Critical cold temperatures largely unknown
  - Rootstock more sensitive than the scion
  - 11 nights between 4$^{o}$ and 11$^{o}$ F (-15.5 to -12$^{o}$ C)in 1990
    - *P. integerrima*: 41% mortality
    - *P. atlantica*: 0% mortality
    - *P. atlantica x P. integerrima*: 0% mortality

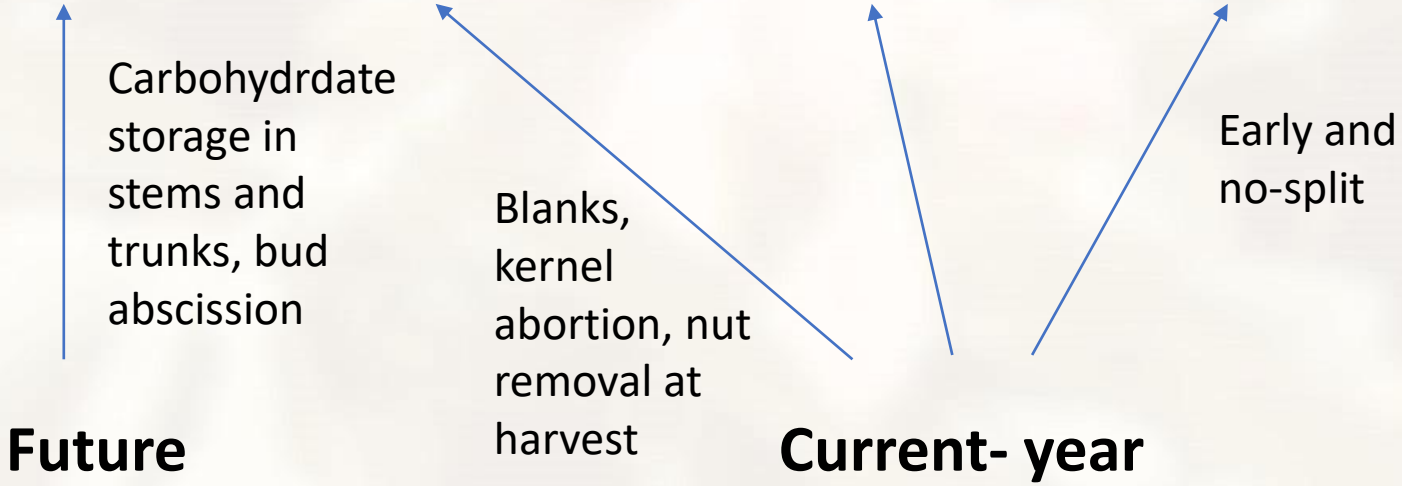

Photo: L. Ferguson

# Drought Tolerance

- Phreatophytes
  - Can exploit deep reservoirs of water
- Leaves adapted to maintain turgor in arid conditions
  - Thick cuticle
  - Xerophytic palisade mesophyll adaptation
  - More abaxial stomata than adaxial
  - Stomatal conductance higher on abaxial side
  - Stomata located near leaf veins

# Drought Tolerance

- Components of yield =
  #clusters x #nuts/cluster x nut weight x nut quality



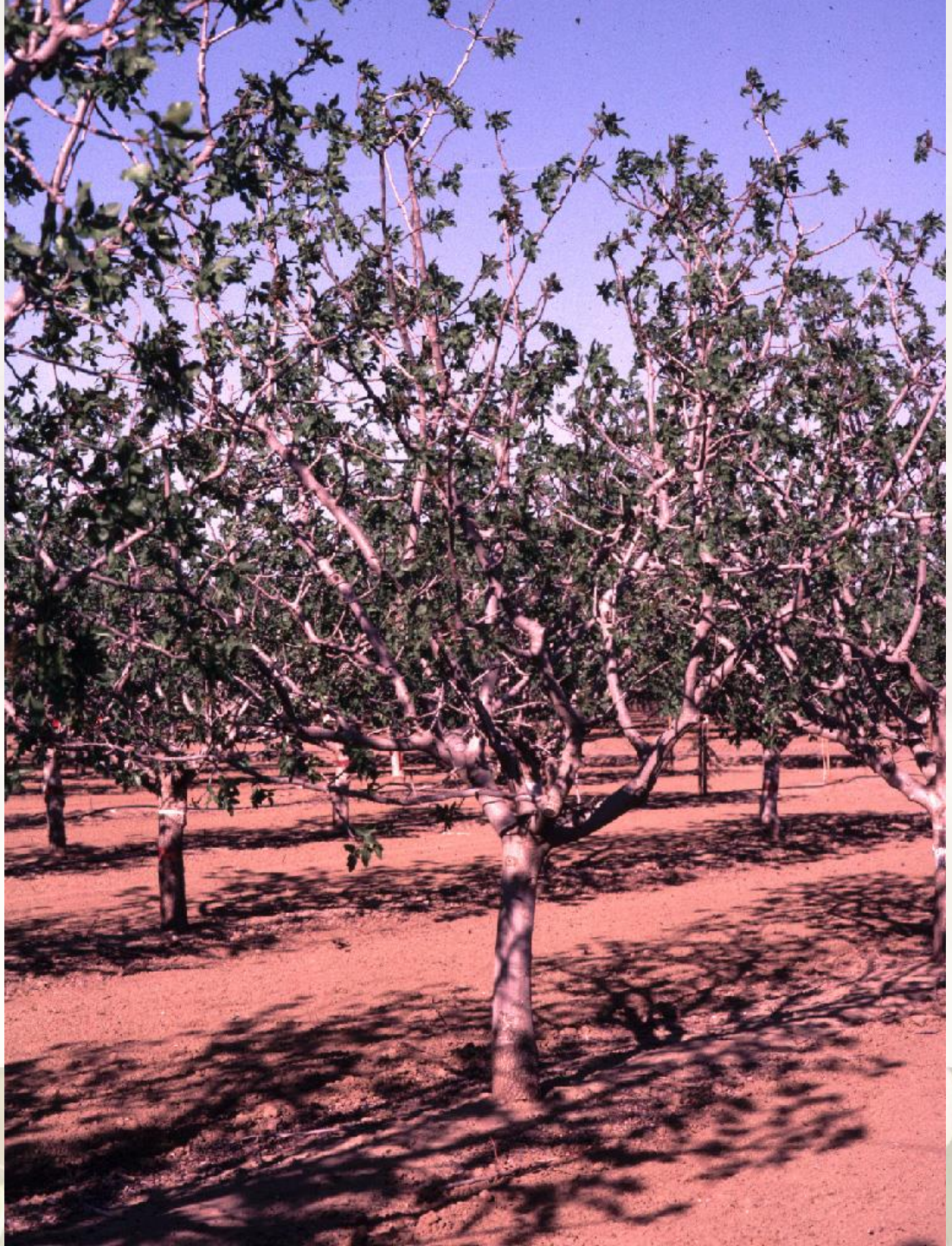
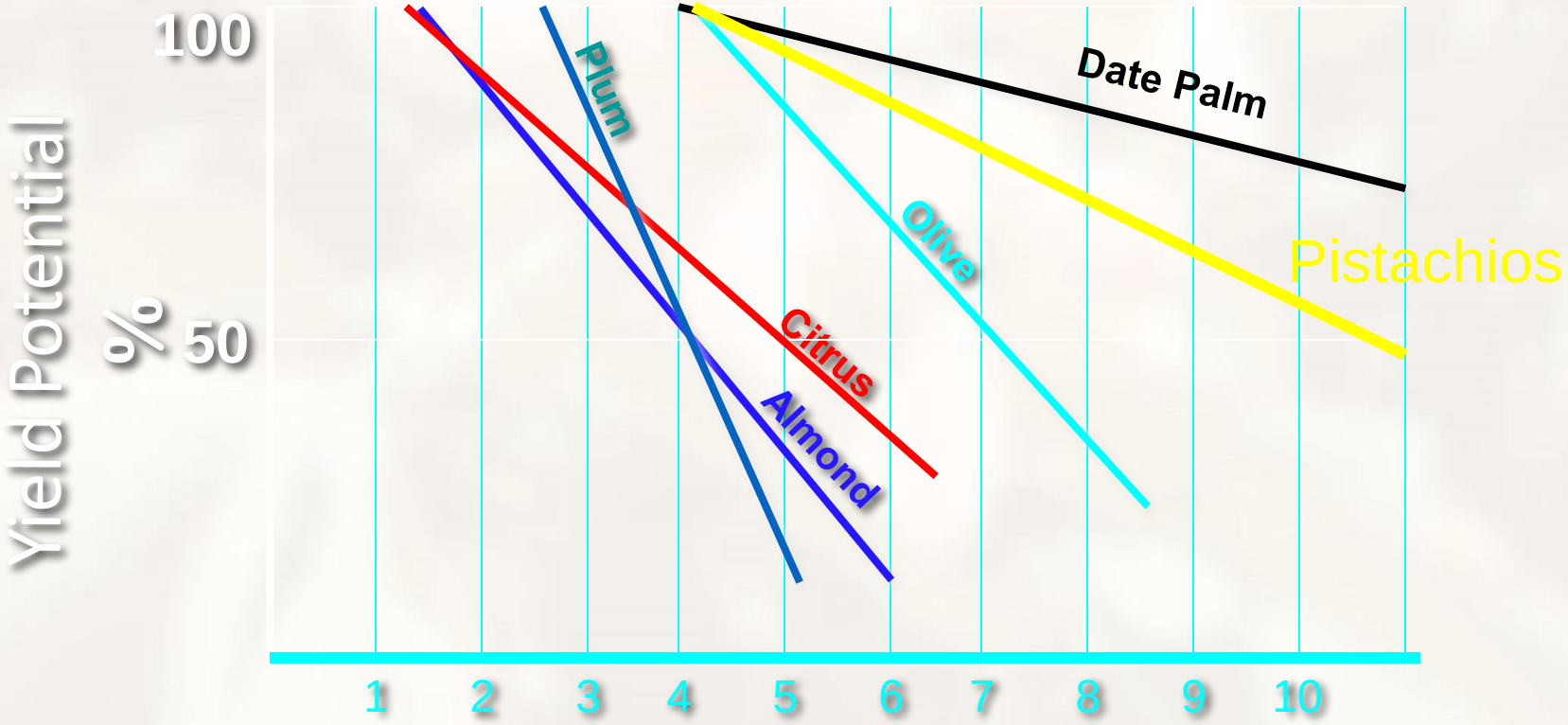


Photo: L. Ferguson

# Salt Tolerance



# Salt Tolerance

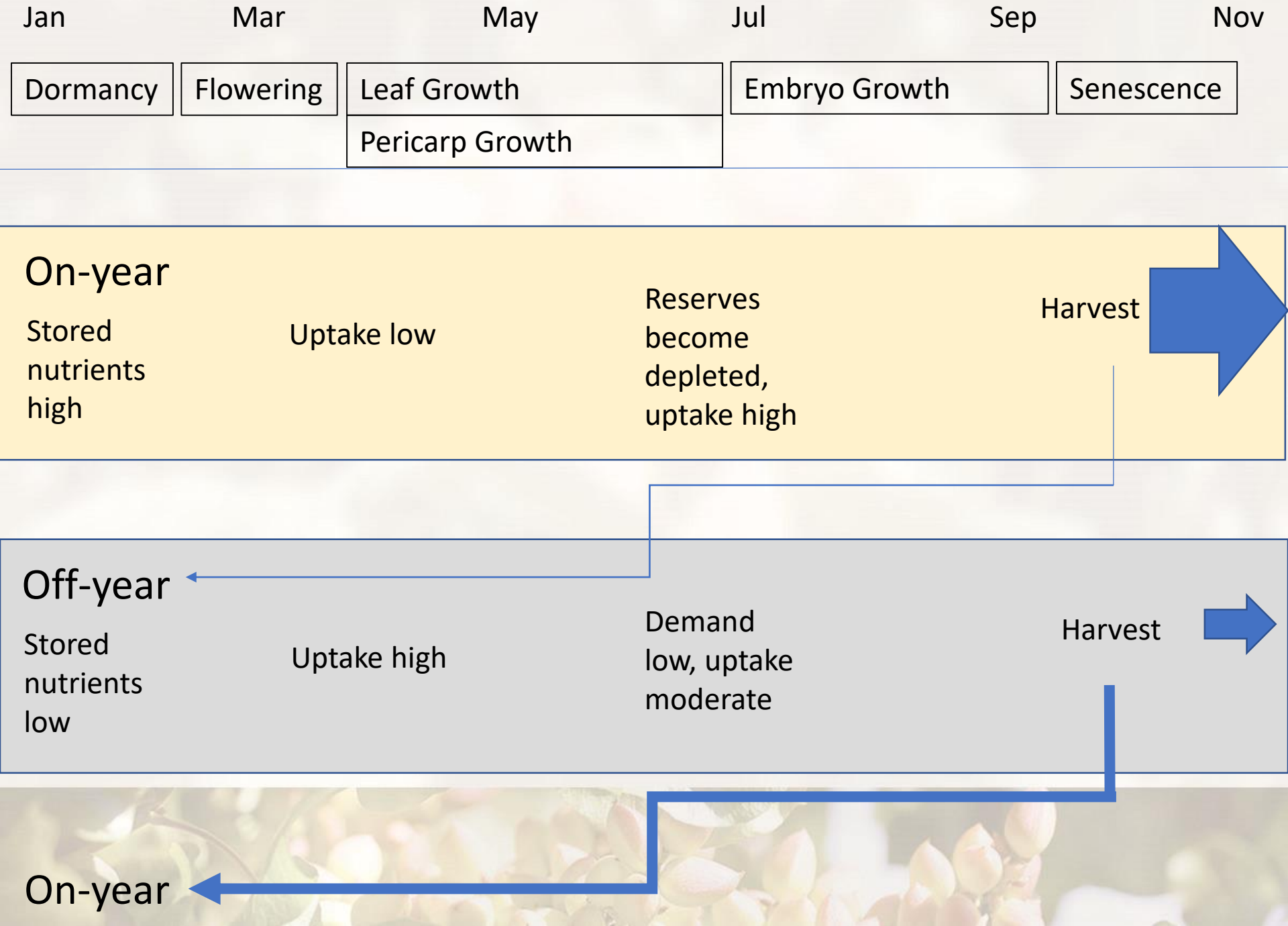
- Specific ion damage
- Osmotic effects

# Salt Tolerance

- Greenhouse study conducted by L. Ferguson (2001) shows that osmotic effects are greater than specific ion effects
  - *P. integerrima* rootstocks less tolerant of salt-affected rootzones than *P. atlantica* or the hybrids.
- Established trees can be irrigated with water up to 8 dS/m (rootzone salinity of 11.4 dS/m) without affecting yield (B. Sanden, 2004)
- Salt tolerance of establishing orchards is lower (5 dS/m) (B. Sanden, 2014)

# Pistachio Nutrient uptake

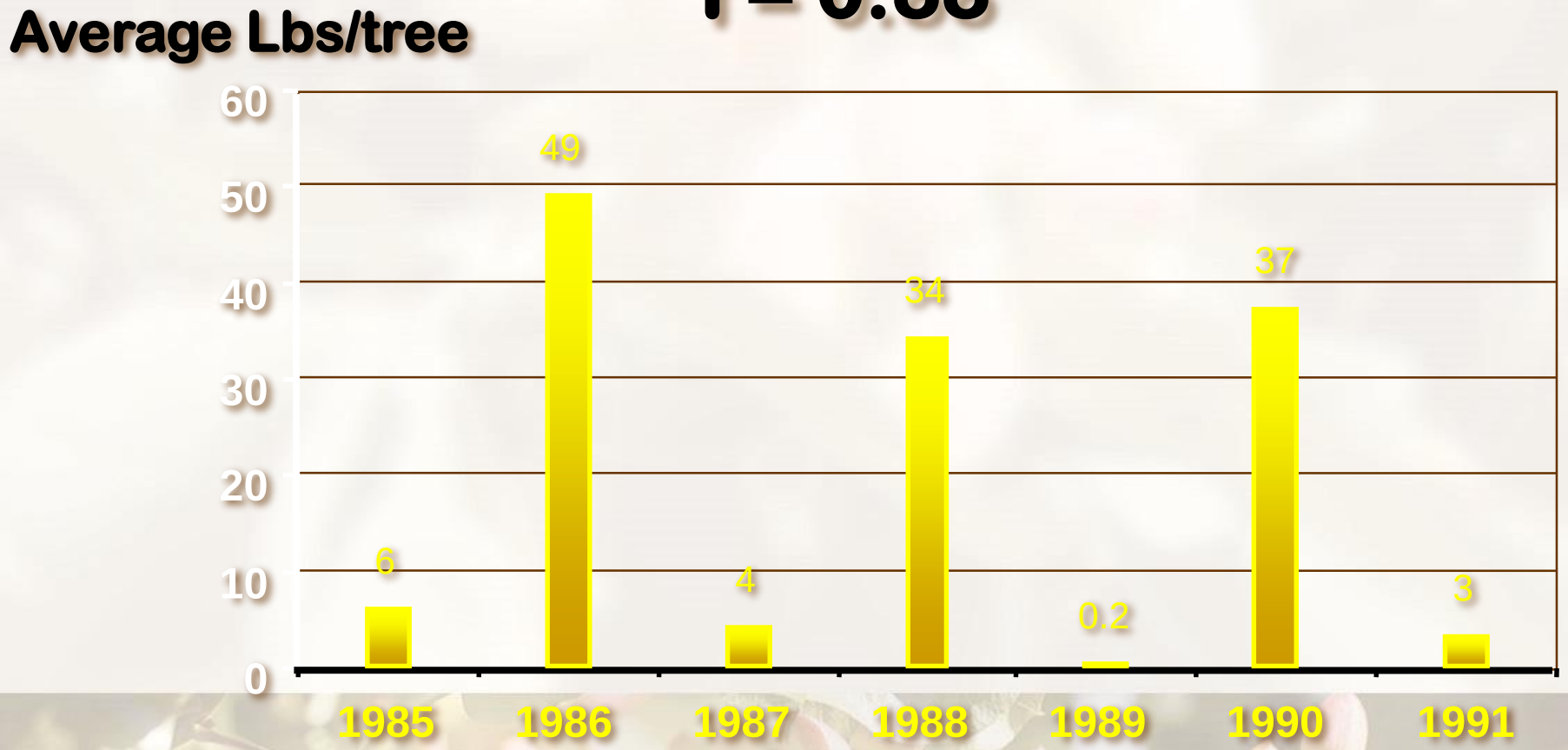
- Pistachios uptake nutrients at a rate reflecting demand
- No uptake during dormancy
- Little uptake between harvest and leaf senescence
- Fruit shows strong demand for nutrients
  - High uptake during nut fill
- Higher uptake during on years than off
  - Accumulation mostly in fruit in on-year trees, perennial tissues in off years

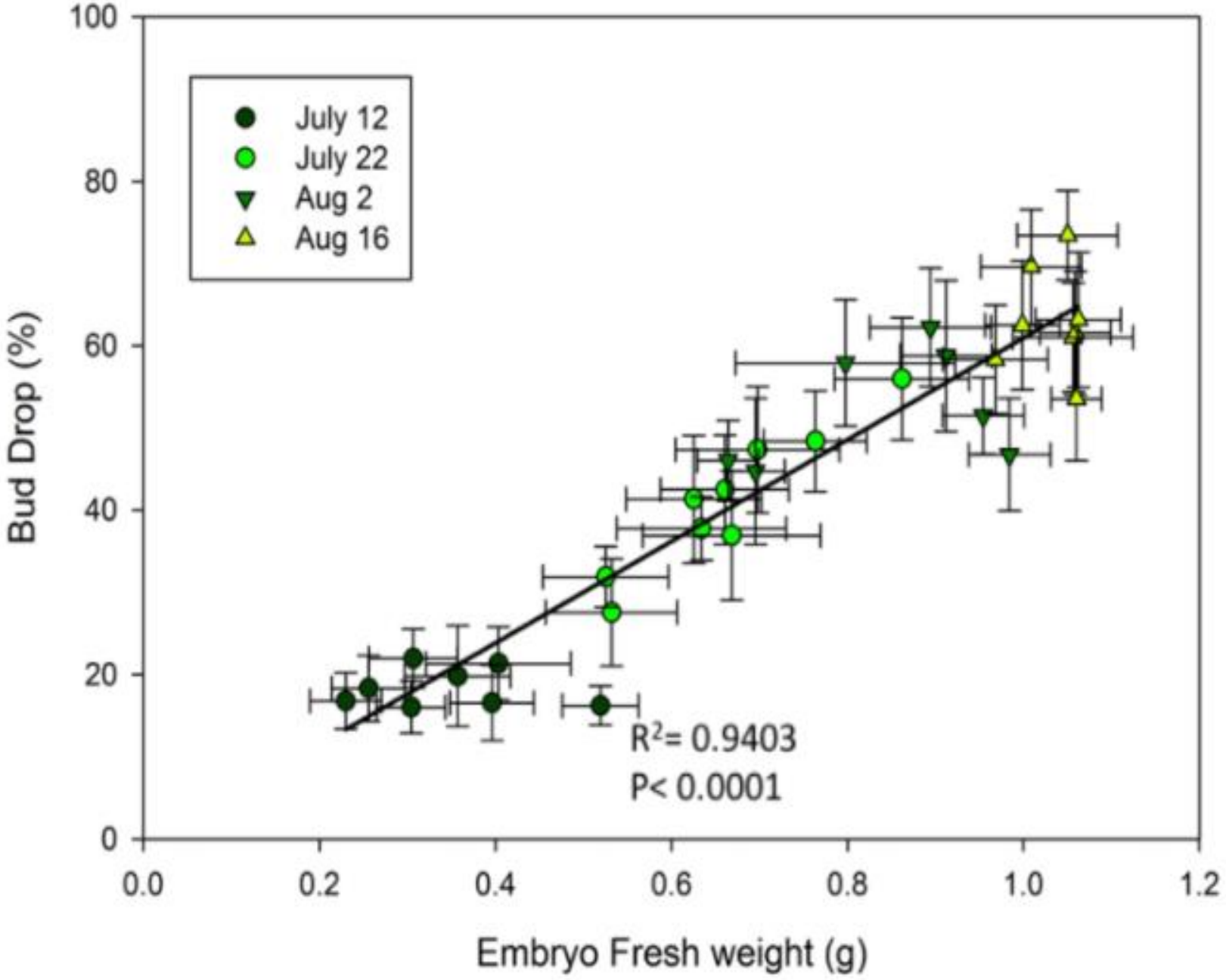

Jan
Mar
May
Jul
Sep
Nov
Dormancy
Flowering
Leaf Growth
Pericarp Growth
Embryo Growth
Senescence
On-year
Stored nutrients high
Uptake low
Reserves become depleted, uptake high
Harvest
Off-year
Stored nutrients low
Uptake high
Demand low, uptake moderate
Harvest
On-year

# Physiological Issues

- Alternate bearing
- Non-splits
- Blank nuts

# Alternate Bearing in Kern County 1985 – 1991 I = 0.88




July 12
July 22
Aug 2
Aug 16
Bud Drop (%)
Embryo Fresh weight (g)
R²= 0.9403
P< 0.0001
0
20
40
60
80
100
0.0
0.2
0.4
0.6
0.8
1.0
1.2

# 7 Year Yield Response *P. atlantica* rootstock

- Hedged and Topped
- 1985: 0.8 kg/tree
- 1986: 12.7 kg/tree ON
- 1987: 6.4 kg/tree
- 1988: 11.8/kg/tree ON
- 1989: 5.1/kg/tree
- 1990: 12.2/kg/tree ON
- 1991: 11.6/kg/tree

- 60.6/kg/tree cumulative

- Control
- 1985: 2.9 kg/tree OFF
- 1986: 22.1 kg/tree
- 1987: 1.6 kg/tree OFF
- 1988: 15.3/kg/tree
- 1989: 0.1/kg/tree OFF
- 1990: 16.7/kg/tree
- 1991: 1.4/kg/tree OFF

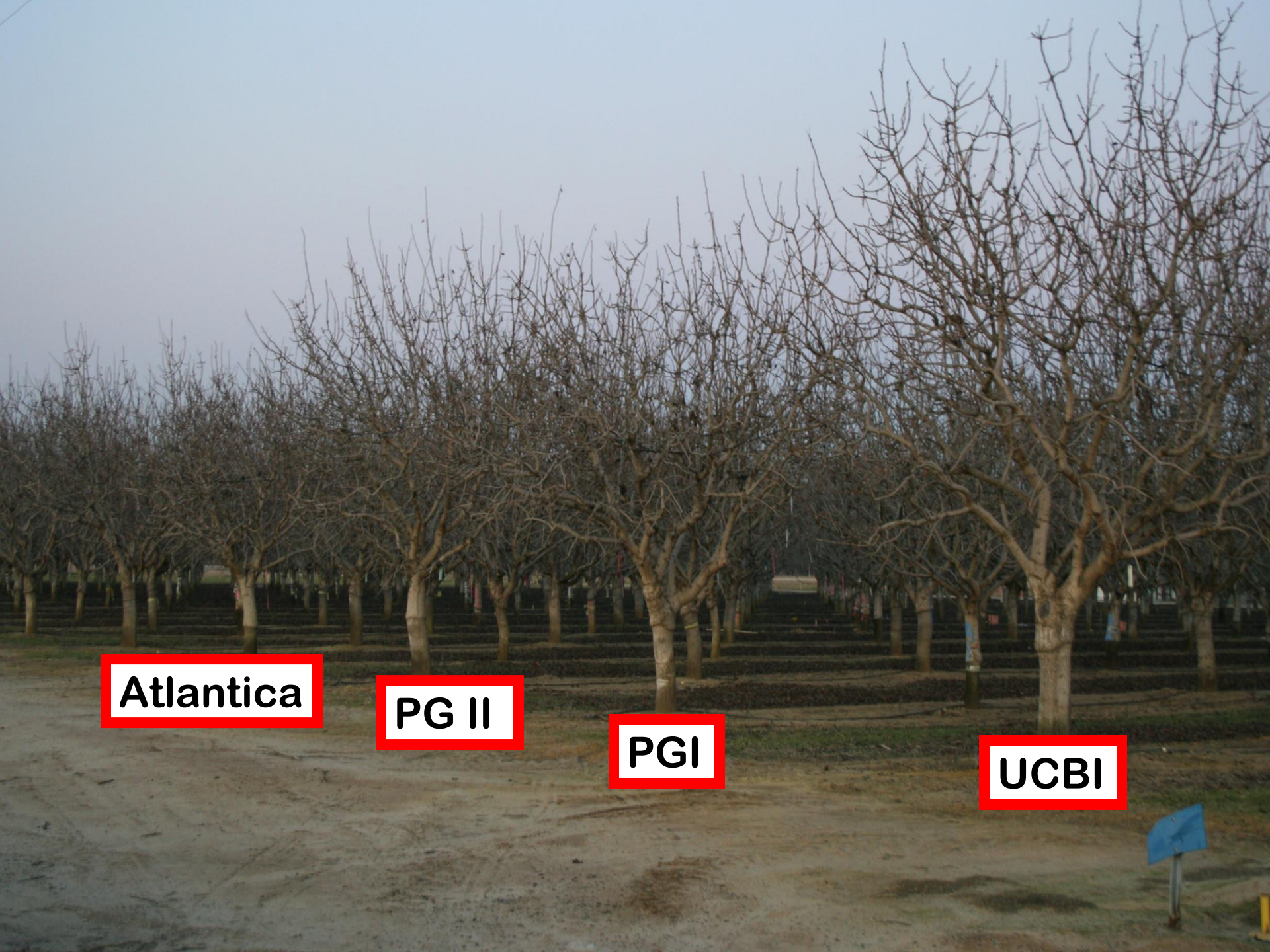
- 60.1/kg/tree cumulative


Photo: L. Ferguson

Photo: L. Ferguson

# Effect of Rootstock on Scion Growth

- Pre-formed buds are formed the previous year and all components are already developed
    - First growth flush of the season
    - No difference in leaf number between rootstocks
    - Differences in length due to internode length
- Neoformed growth is formed and grown in the same season
    - Later growth flushes
    - More likely to occur in younger trees
    - Seen in high vigor rootstocks


Atlantica
PG II
PGI
UCBI

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