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A rapid prototyping design tool for pear harvest-aid platforms utilizing 3D fruit reachability and kinematic modeling

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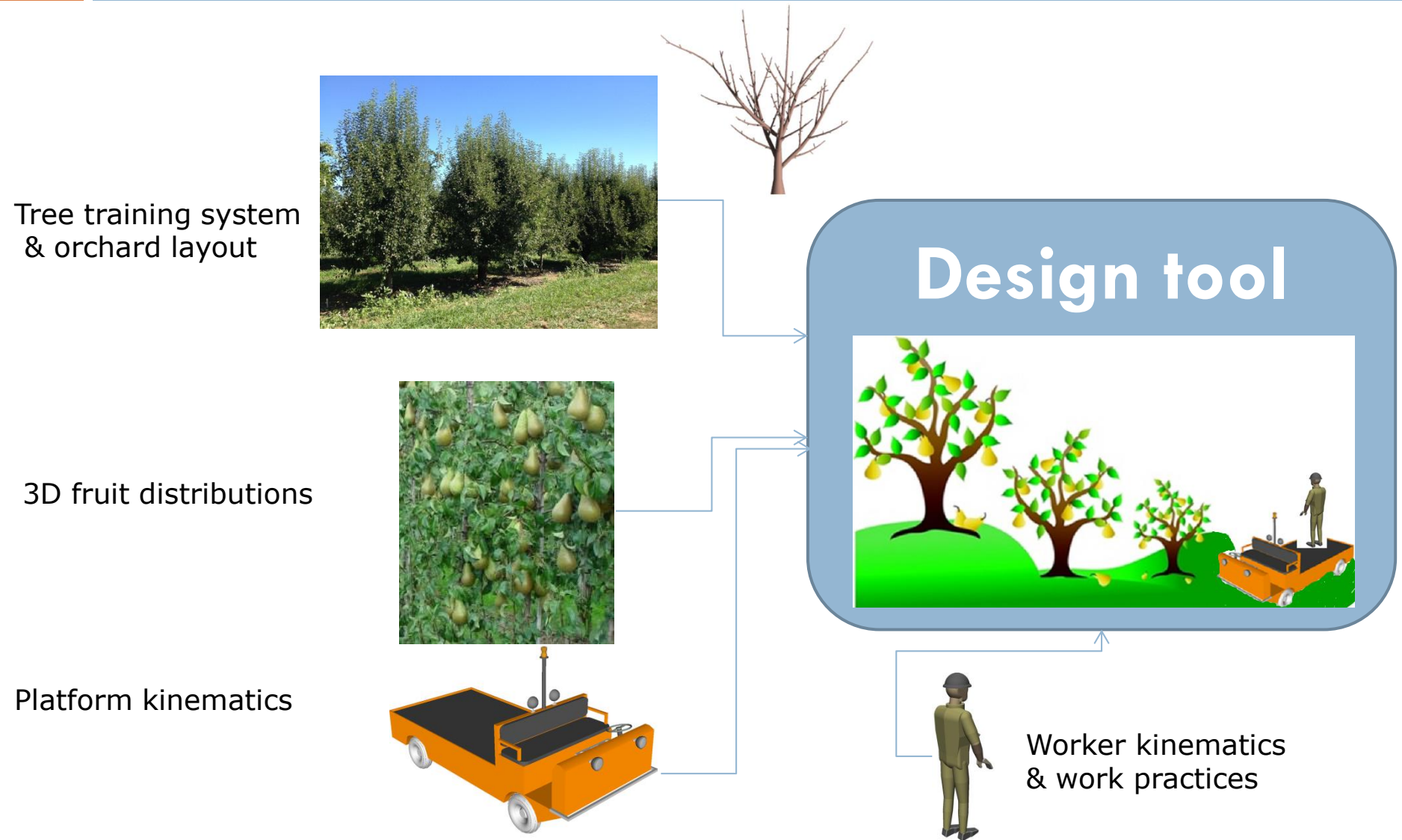
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<sup>2</sup>University of California Cooperative Extension, Lake and Mendocino Counties.

<sup>3</sup>University of California Cooperative Extension, Sacramento County.

# Goal: Harvesting machine design tool

2





# Mechanical pear harvesting

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## Four possibilities for pear picking

1. Branch hitting
  - ▣ Impractical for pears.
2. Limb shaking
  - ▣ Inefficient.



# Mechanical pear harvesting

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## 3. Trunk shaking

- ▣ Too much bruising.



- ▣ What if fruits could decelerate somehow?

## Mehlschau 1974



# Design issues

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- How many times?
- What configuration?
- What sizes?
- Branch interference?
- Fruit drop distances?
- ...
- How can we evaluate different designs?

**Mehlschau 1974**





# Mechanical pear harvesting

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## 4. Robotic picking

- ▣ Technical problems
- ▣ Design / efficiency problems.



# Design Issues

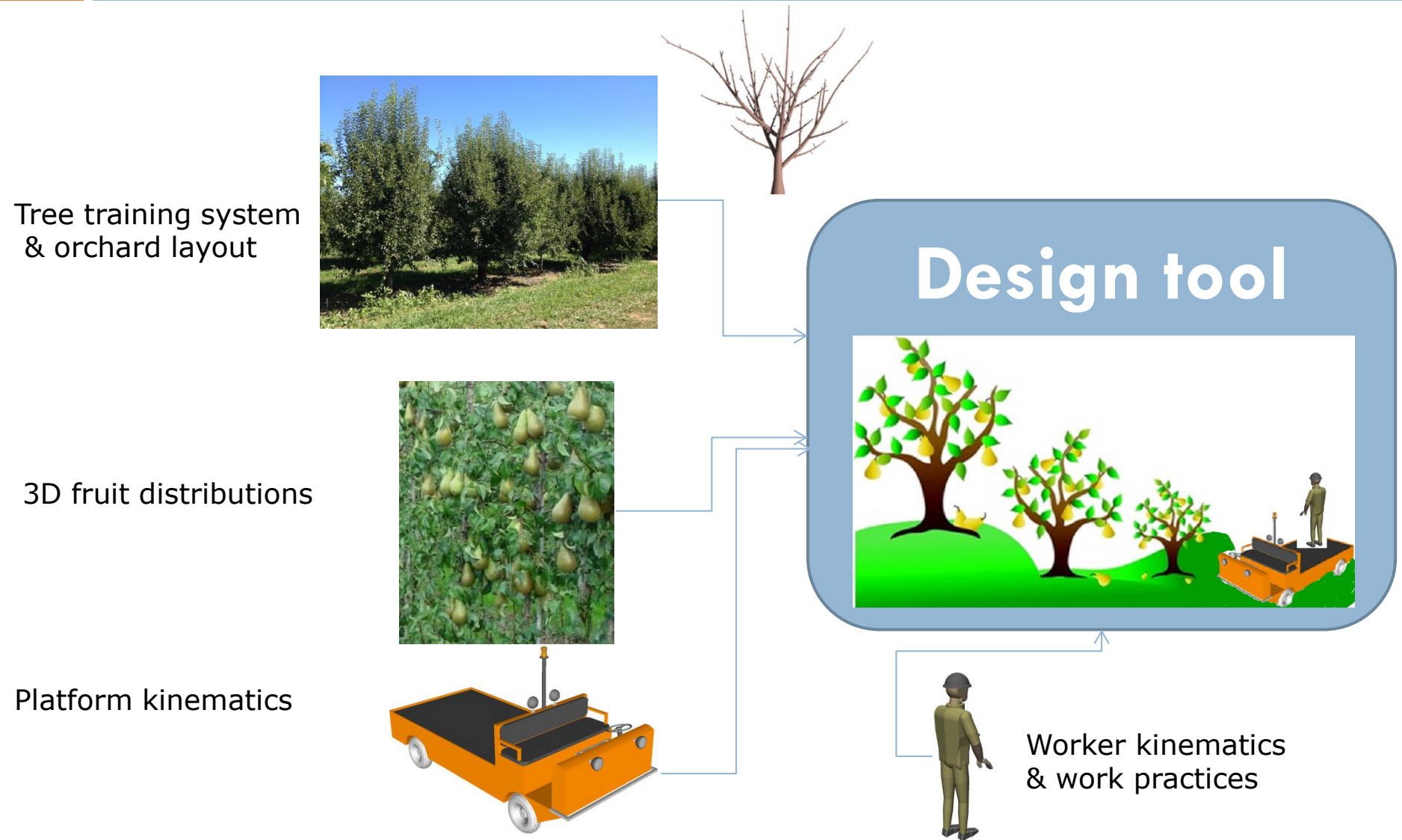
7

- ▣ Could actuator arrays achieve high picking efficiency and speed?
- ▣ How many arms?
- ▣ What configuration?
- ▣ What sizes/envelopes?
- ▣ How do branches interfere?
- ▣ ...
- ▣ How can we evaluate different designs?



# Goal: Harvesting machine design tool

8





# Year 2 of project; ends March 2014

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## Funding sources for 2013-14

**Canning Peach Mechanization  
Research Fund**

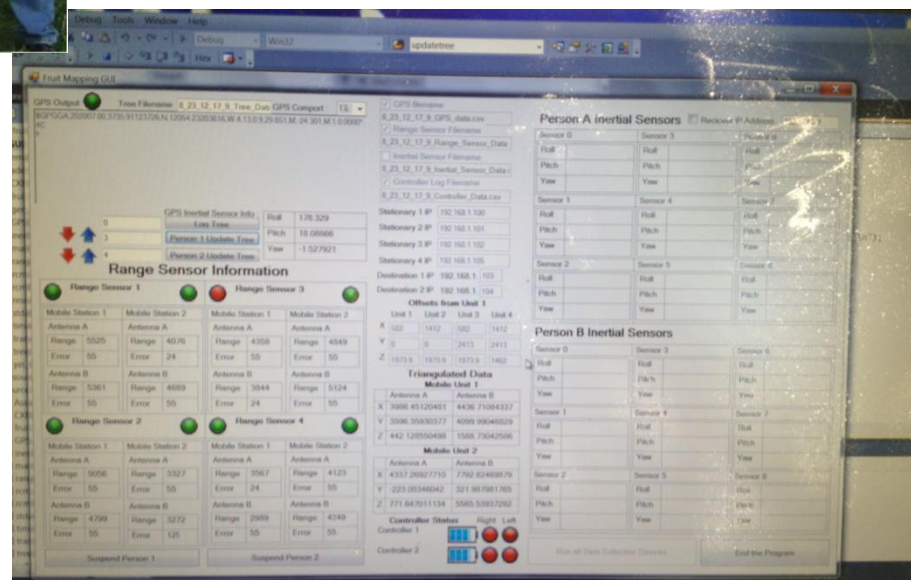
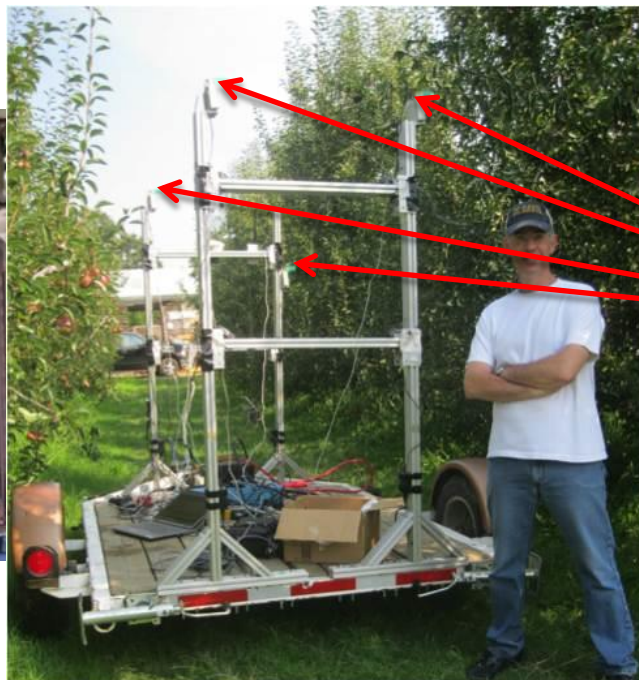


**California Pear Advisory Board**





# Methodology



# Data collection

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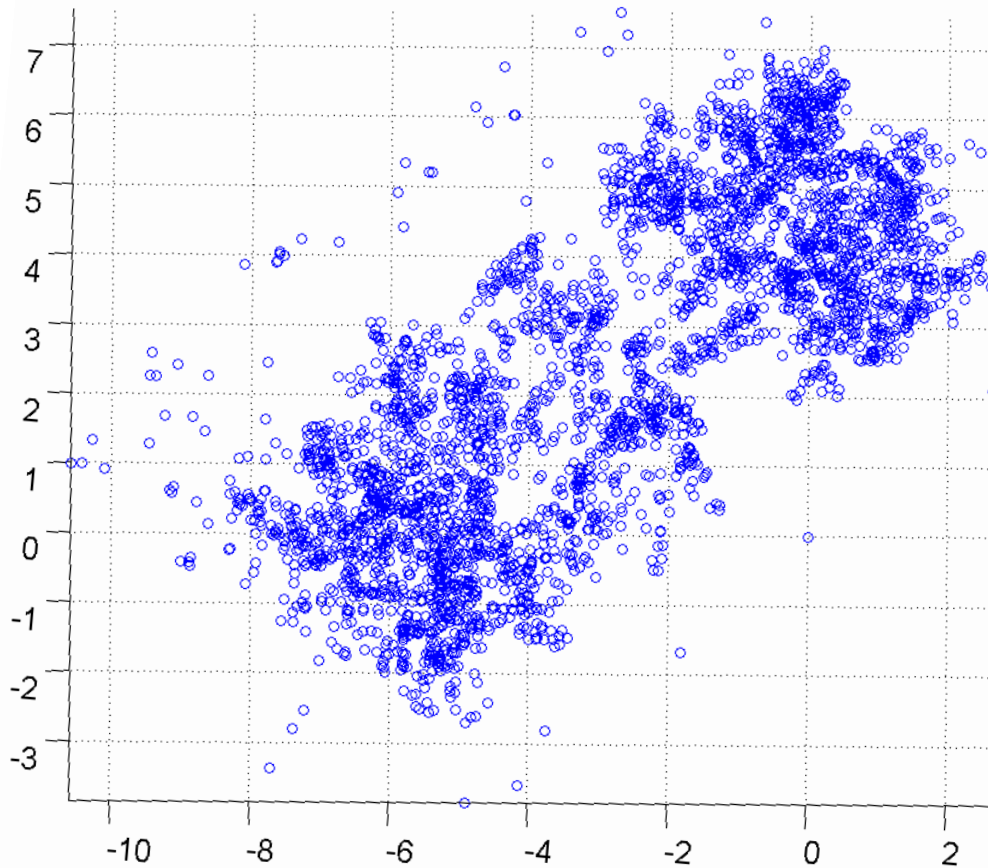
- 7/24/13: Joe Green Ranch, Courtland
  - ▣ Trees: Open-vase, ~33 yrs old; Bosc.
- 8/12/13: Dan Family Ranch, Lakeport
  - ▣ Trees: Hedged, ~12 yrs old; Red Bartlett.
- 8/13/13: Ruddick Ranch, Ukiah
  - ▣ Trees: Open-vase, ~15 yrs; Yellow Bartlett.
- 8/14/13: Ruddick Ranch, Ukiah
  - ▣ Trees: High Density Trellis, ~3 yrs; Yellow Bartlett.



# Joe Green Ranch

DATE: 7/24/2013  
WHAT: Pear trees, standard open-vase  
AGE: ~33 yrs  
TREE HEIGHT: ~14ft  
VARIETY: Bosc

12



# Joe Green Ranch

DATE: 7/24/2013

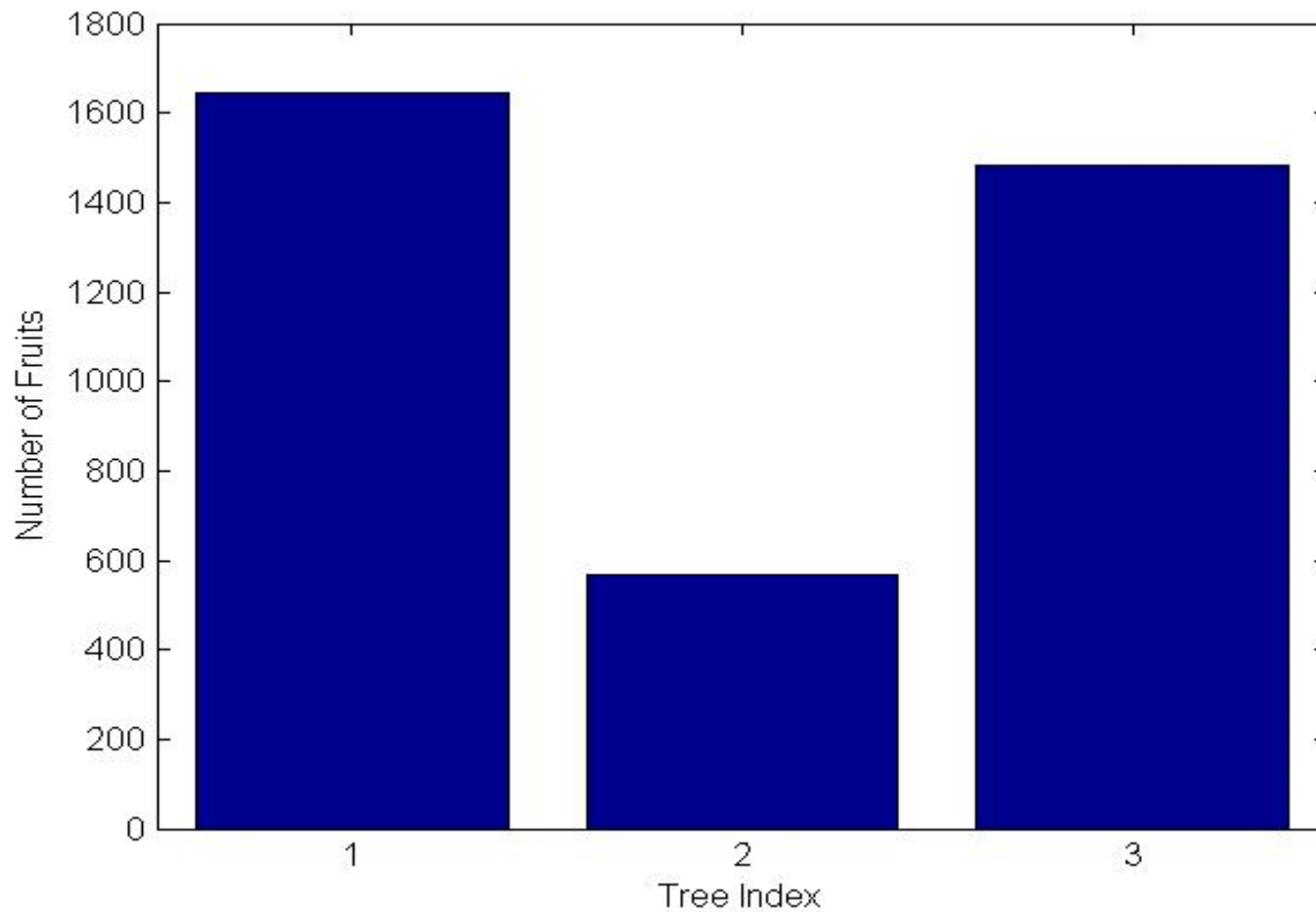
WHAT: Pear trees, standard open-vase

AGE: ~33 yrs

TREE HEIGHT: ~14ft

VARIETY: Bosc

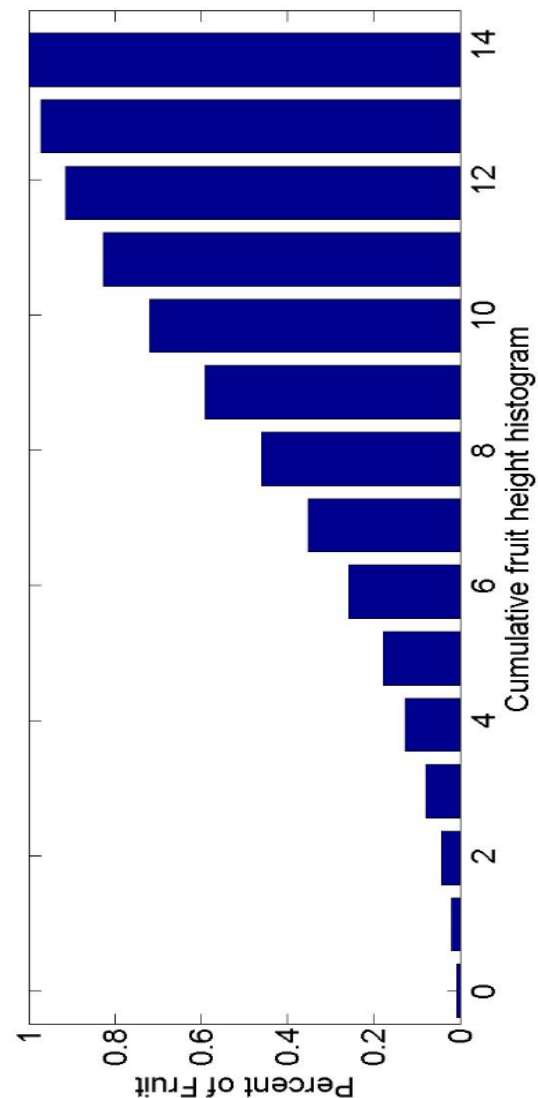
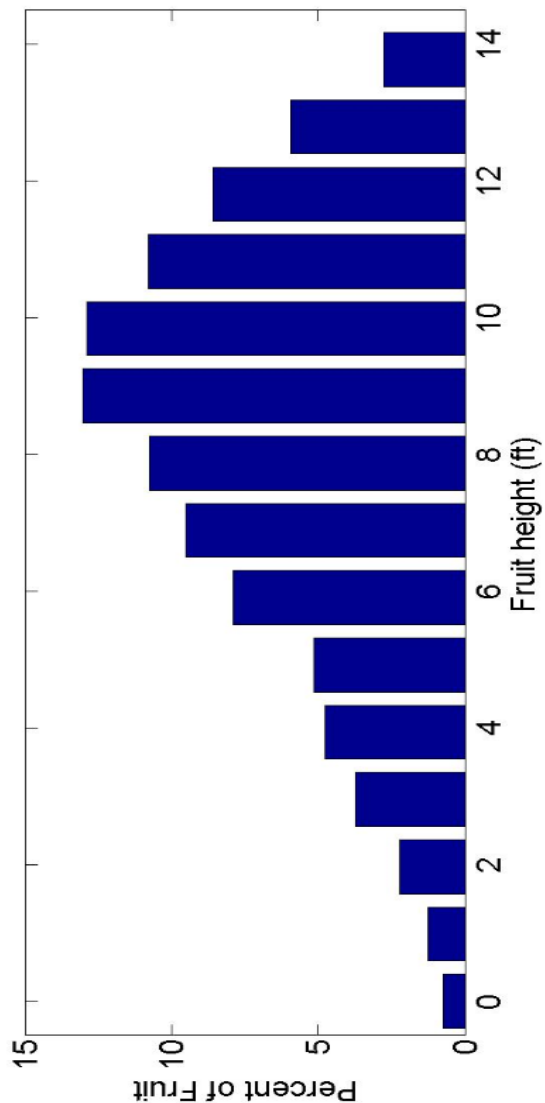
13



# Joe Green Ranch

DATE: 7/24/2013  
WHAT: Pear trees, standard open-vase  
AGE: ~33 yrs  
TREE HEIGHT: ~14ft  
VARIETY: Bosc

14





# Joe Green Ranch

DATE: 7/24/2013

WHAT: Pear trees, standard open-vase

AGE: ~33 yrs

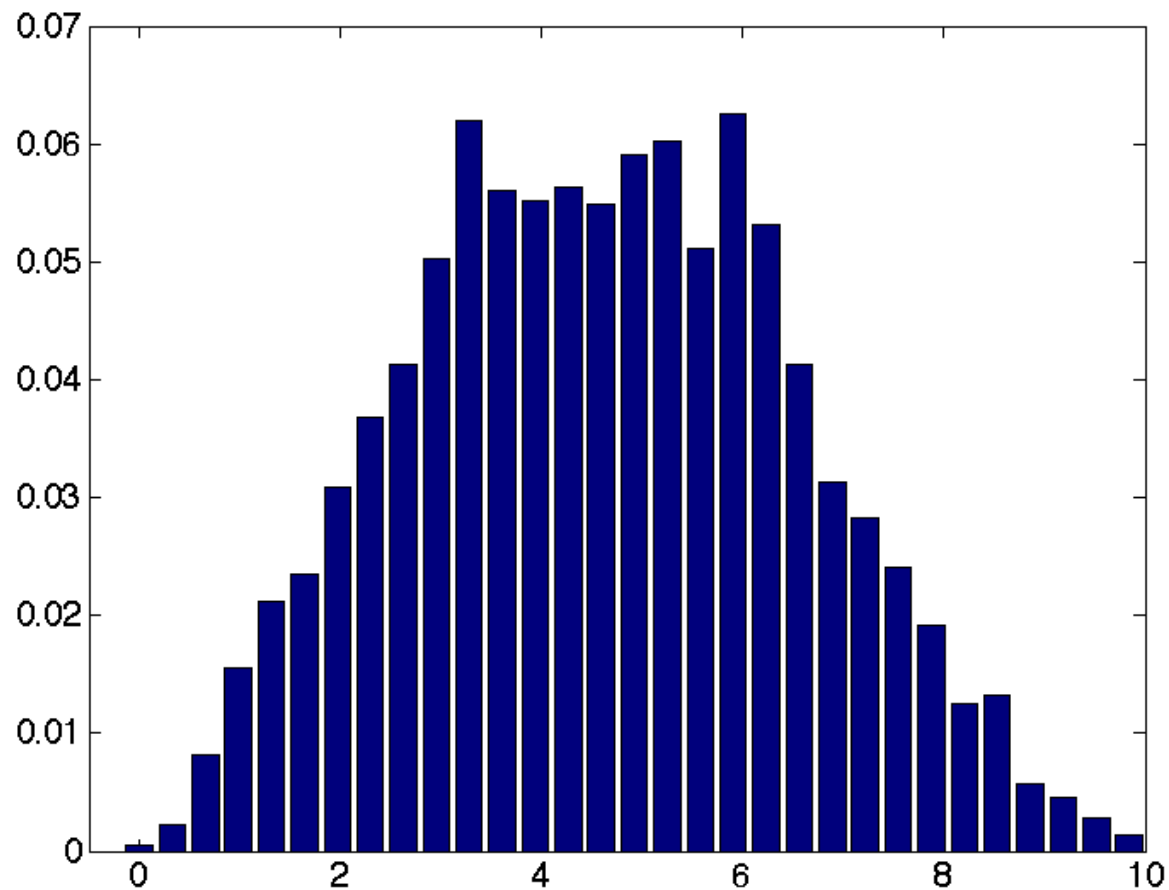
TREE HEIGHT: ~14ft

VARIETY: Bosc

15



**Radial distance of fruits from trunk**



# Joe Green Ranch

DATE: 7/24/2013

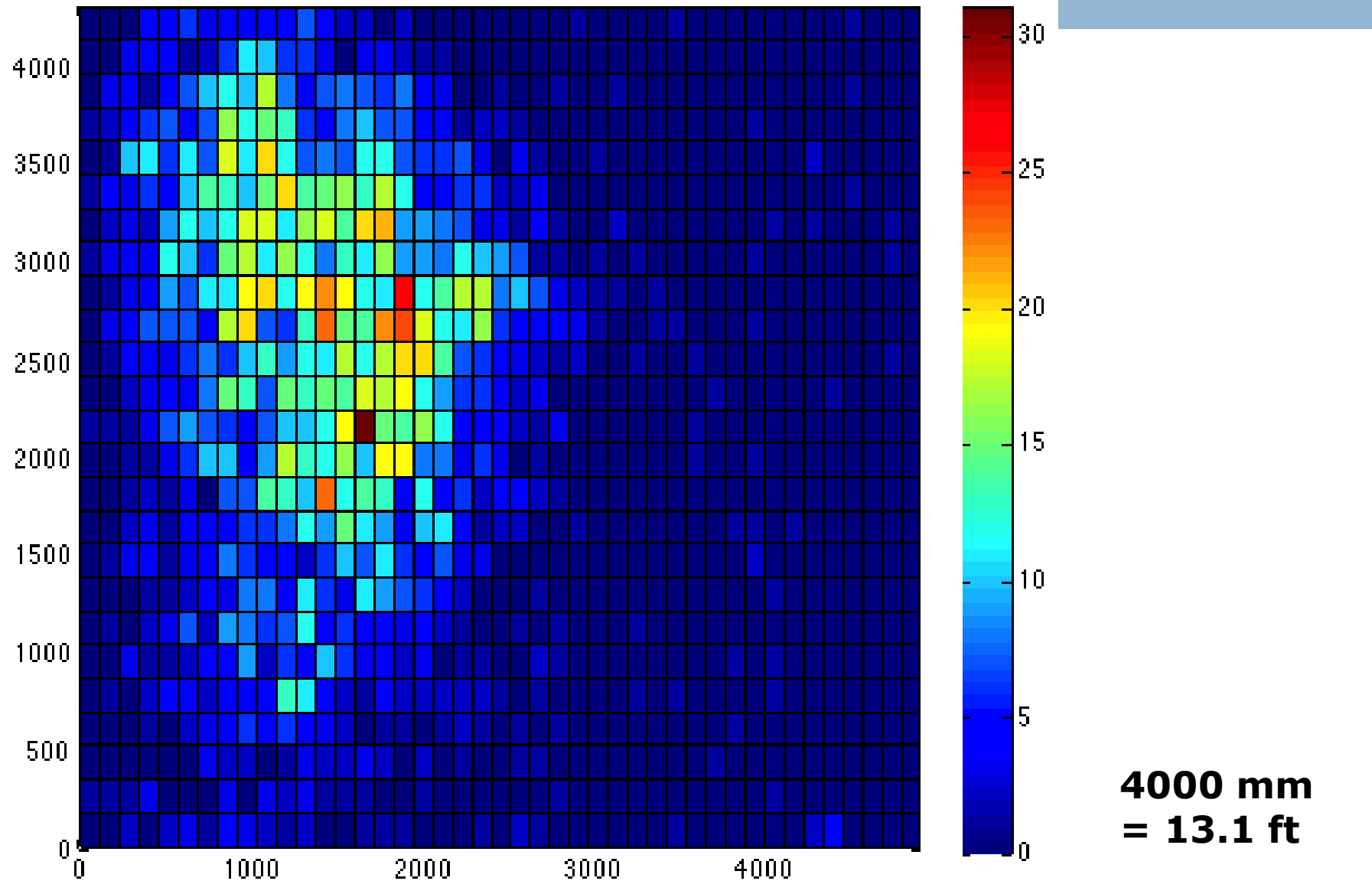
WHAT: Pear trees, standard open-vase

AGE: ~33 yrs

TREE HEIGHT: ~14ft

VARIETY: Bosc

16





# Dan Family Ranch

## Lakeport

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DATE: 8/12/2013  
WHAT: Pear trees, Hedged  
AGE: ~12 yrs  
TREE HEIGHT: ~16ft  
VARIETY: Bartlett

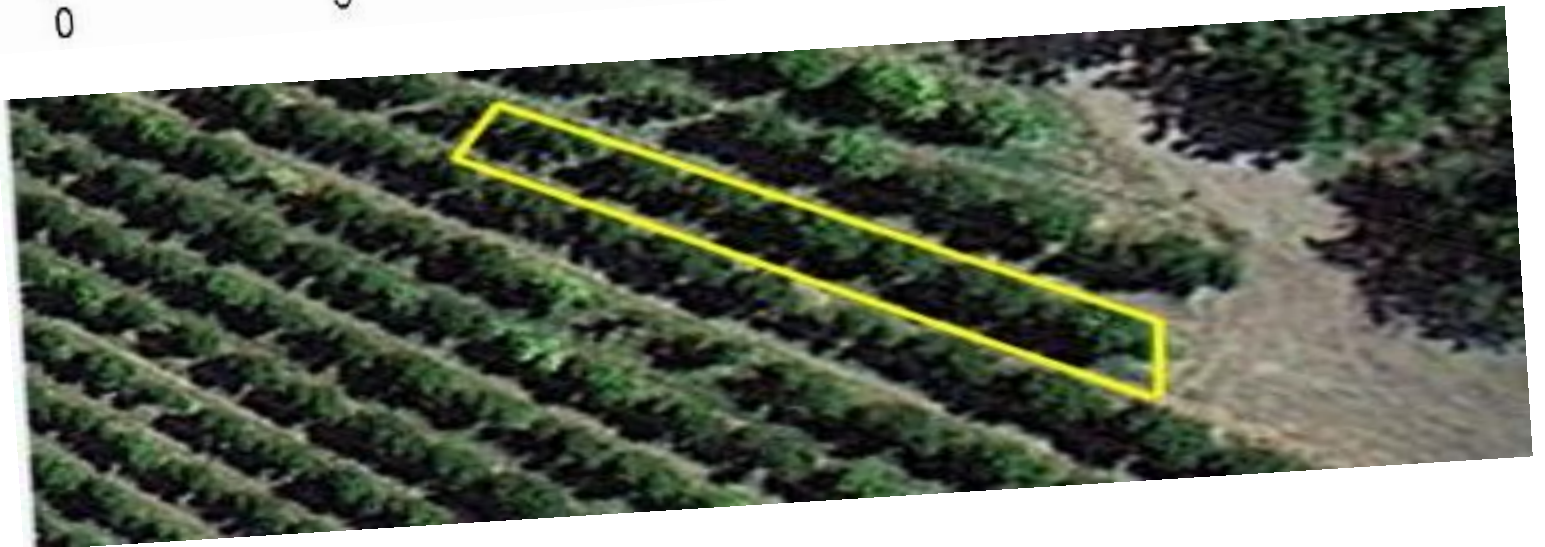
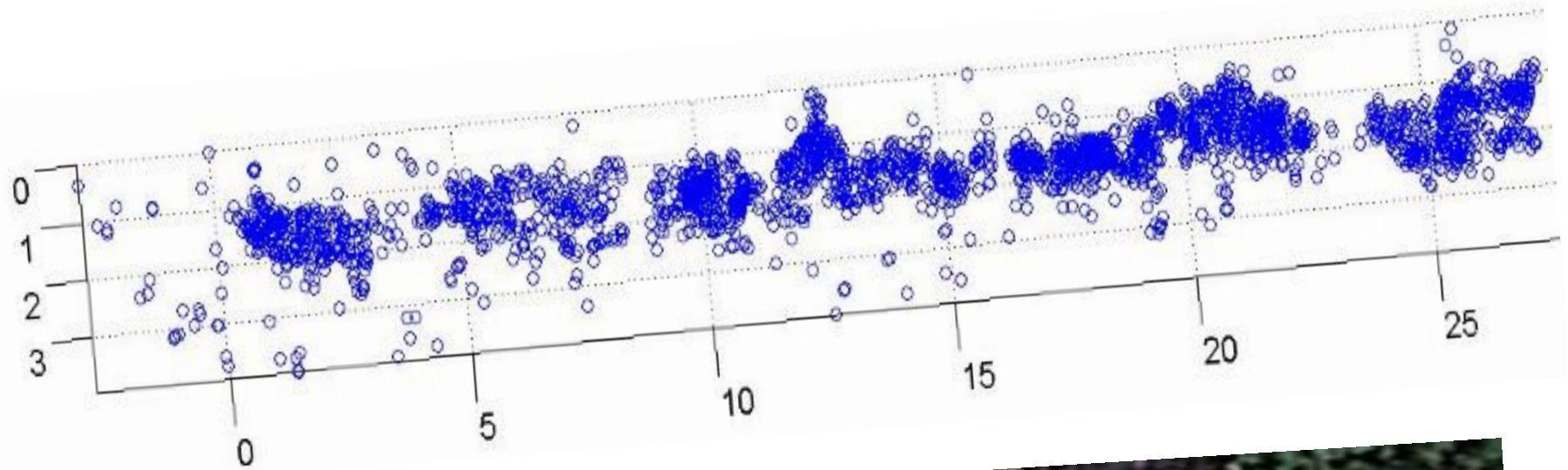




# Dan Family Ranch

DATE: 8/12/2013  
WHAT: Pear trees, Hedged  
AGE: ~12 yrs  
TREE HEIGHT: ~16ft  
VARIETY: Bartlett

18



# Dan Family Ranch

DATE: 8/12/2013

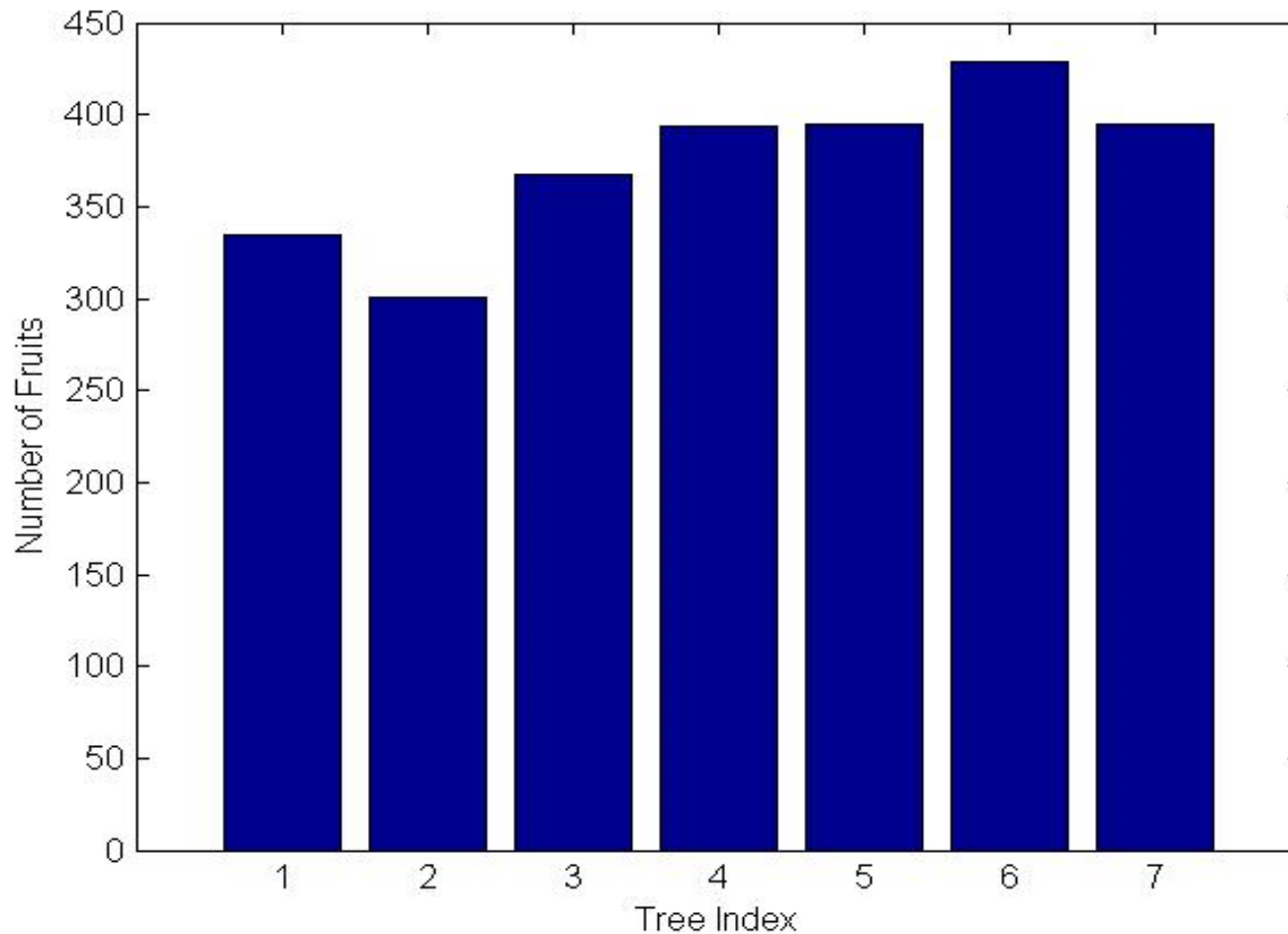
WHAT: Pear trees, Hedged

AGE: ~12 yrs

TREE HEIGHT: ~16ft

VARIETY: Bartlett

19



# Dan Family Ranch

DATE: 8/12/2013

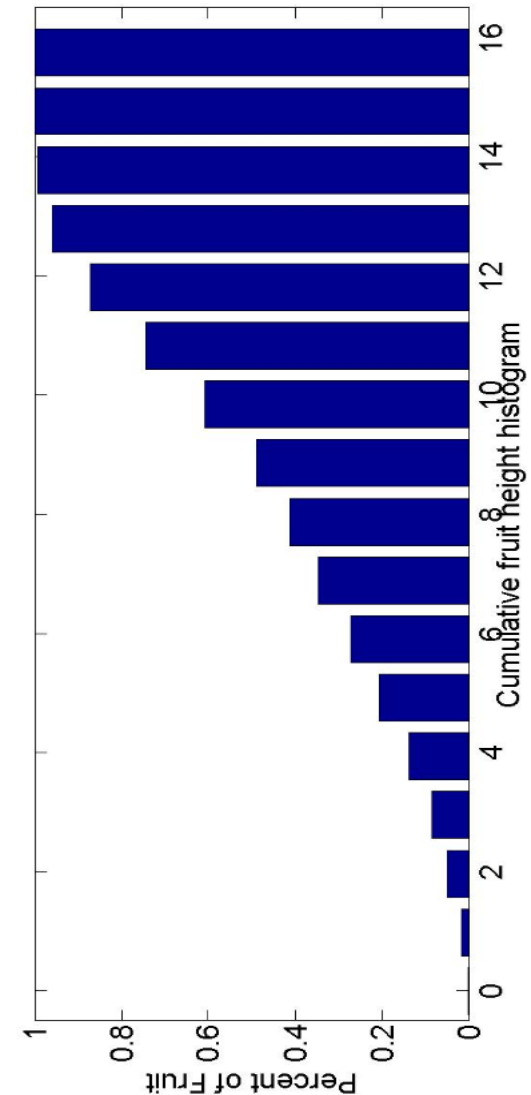
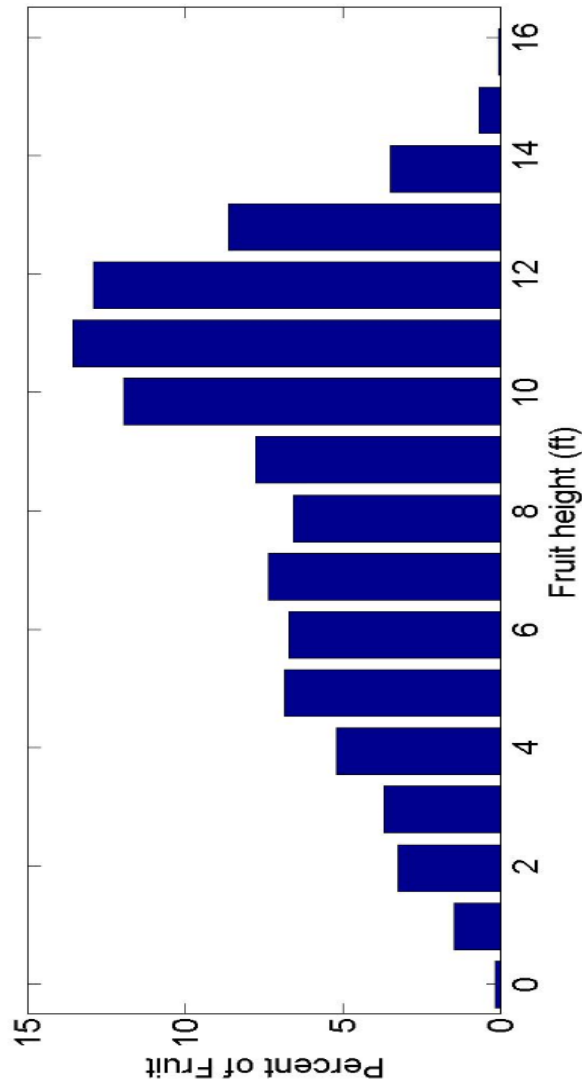
WHAT: Pear trees, Hedged

AGE: ~12 yrs

TREE HEIGHT: ~16ft

VARIETY: Bartlett

20





# Dan Family Ranch

DATE: 8/12/2013

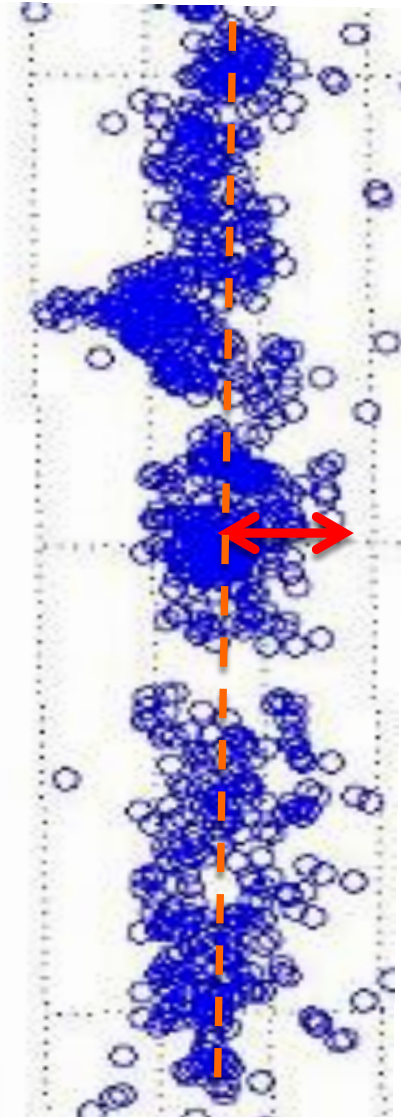
WHAT: Pear trees, Hedged

AGE: ~12 yrs

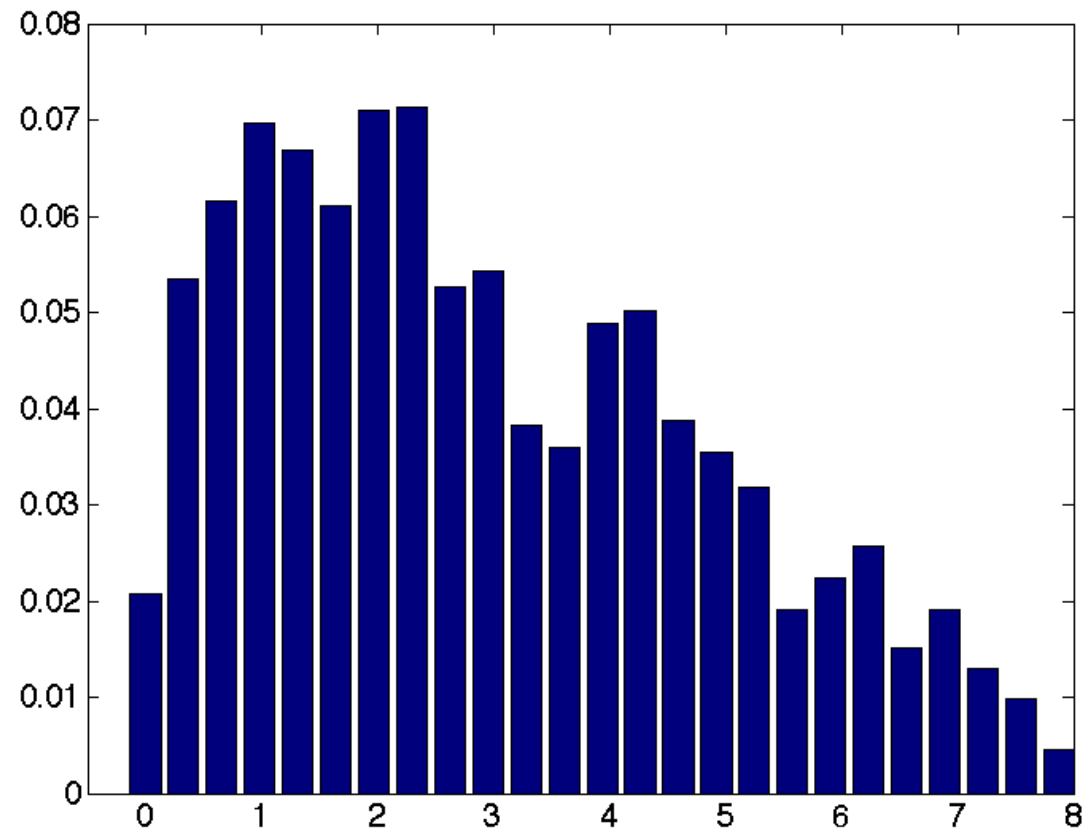
TREE HEIGHT: ~16ft

VARIETY: Bartlett

21



**Distance of fruits from tree-row**



# Ruddick Ranch, Ukiah

DATE: 8/13/2013

WHAT: Pear trees, standard open-vase

AGE: ~15 yrs

TREE HEIGHT: ~13.5ft

VARIETY: Bartlett

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# Ruddick Ranch

DATE: 8/13/2013

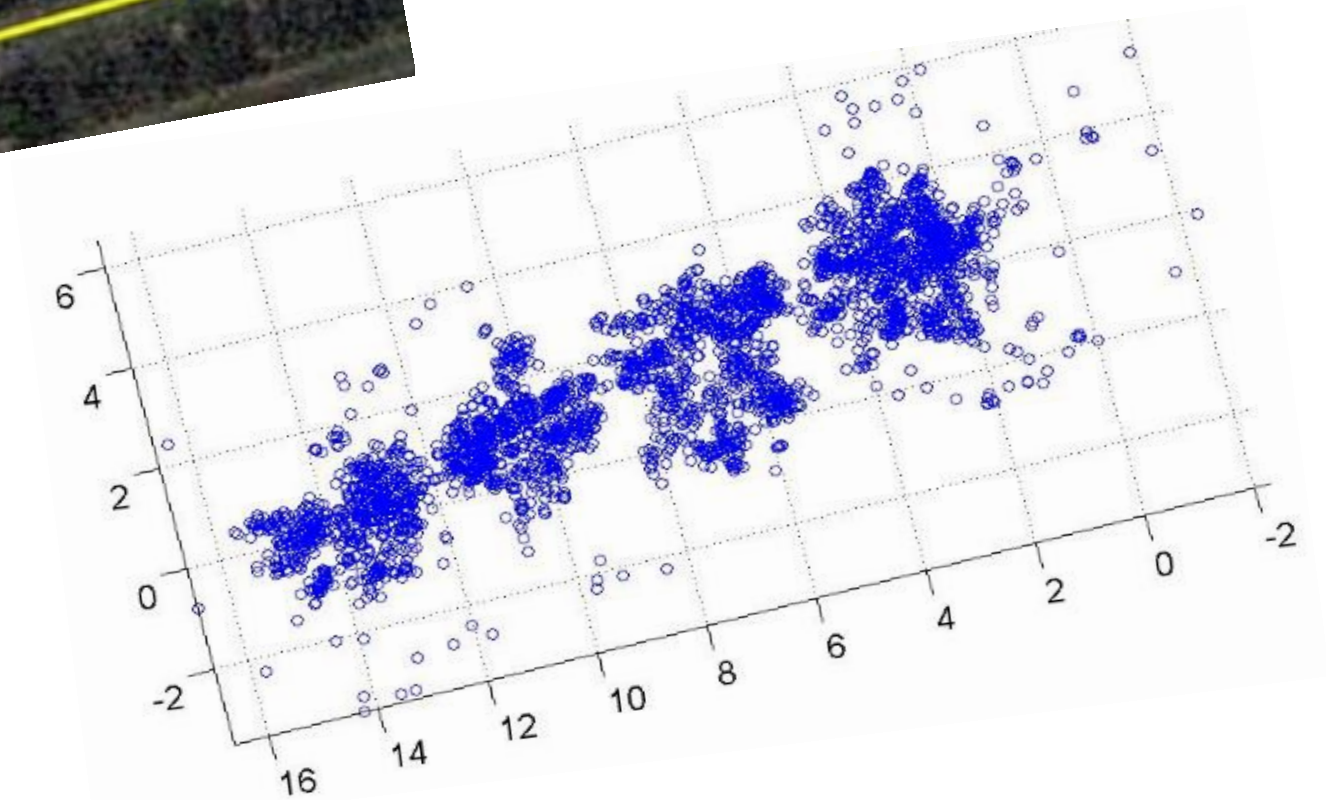
WHAT: Pear trees, standard open-vase

AGE: ~15 yrs

TREE HEIGHT: ~13.5ft

VARIETY: Bartlett

23

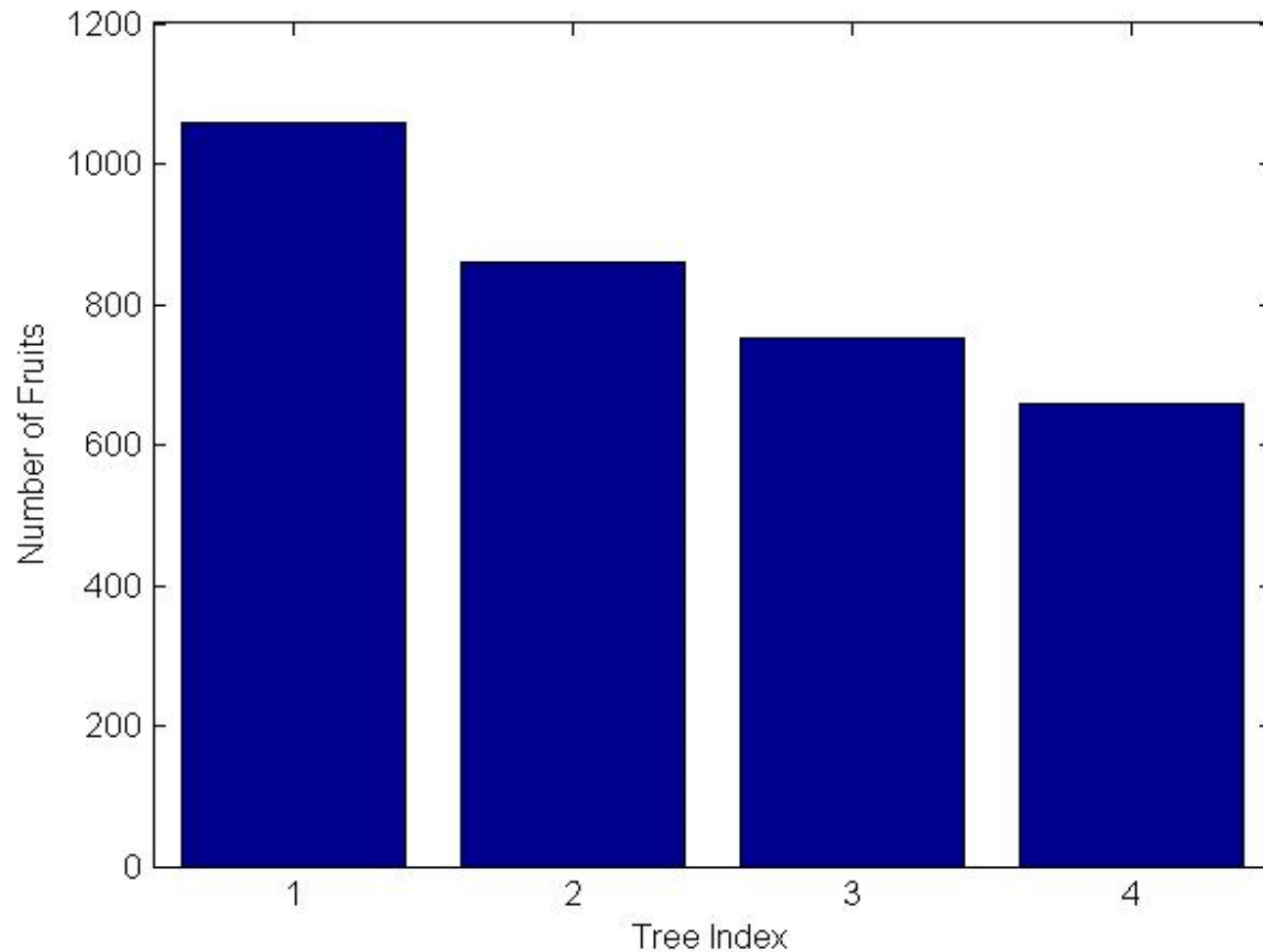




# Ruddick Ranch

DATE: 8/13/2013  
WHAT: Pear trees, standard open-vase  
AGE: ~15 yrs  
TREE HEIGHT: ~13.5ft  
VARIETY: Bartlett

24



# Ruddick Ranch

DATE: 8/13/2013

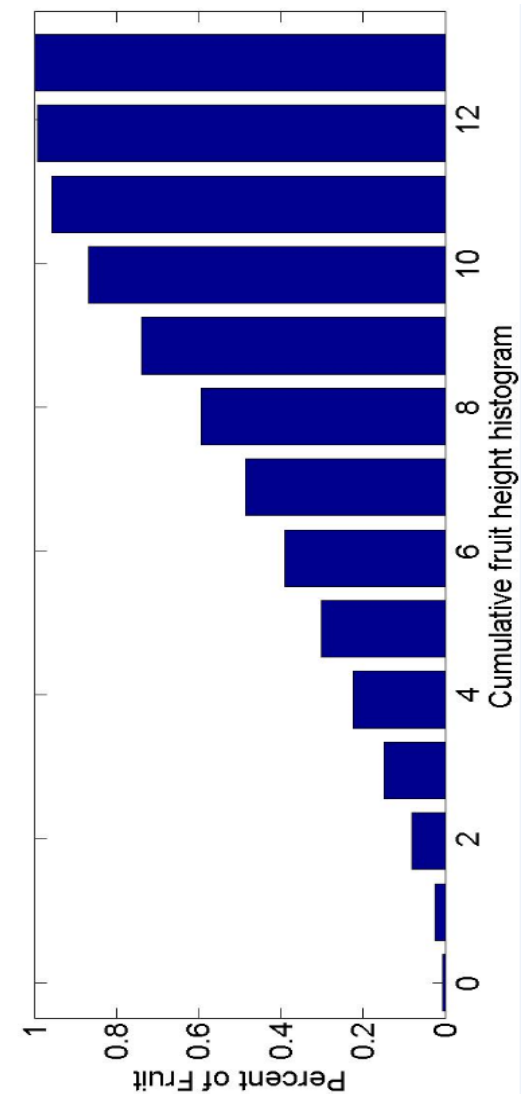
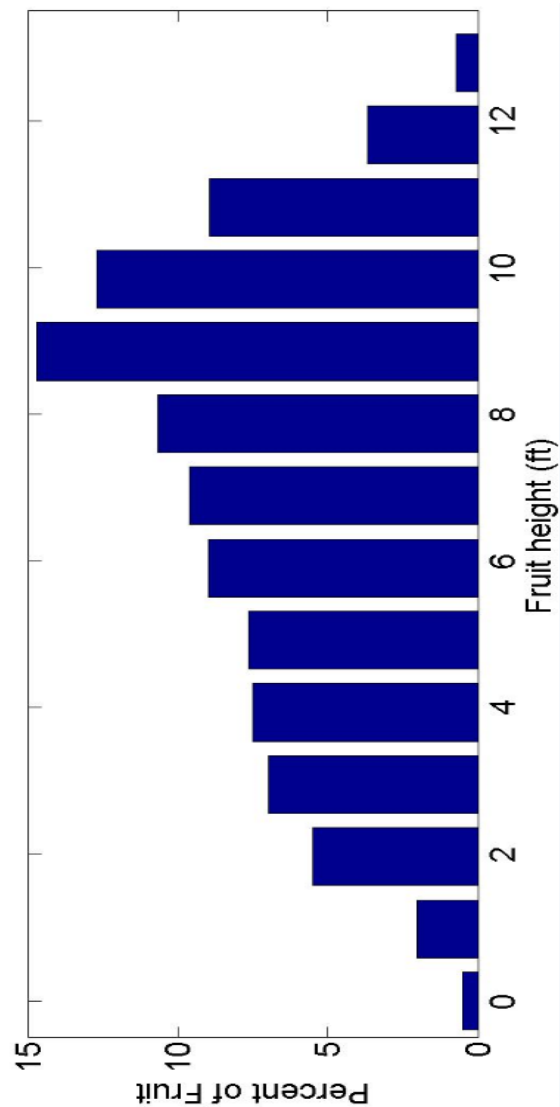
WHAT: Pear trees, standard open-vase

AGE: ~15 yrs

TREE HEIGHT: ~13.5ft

VARIETY: Bartlett

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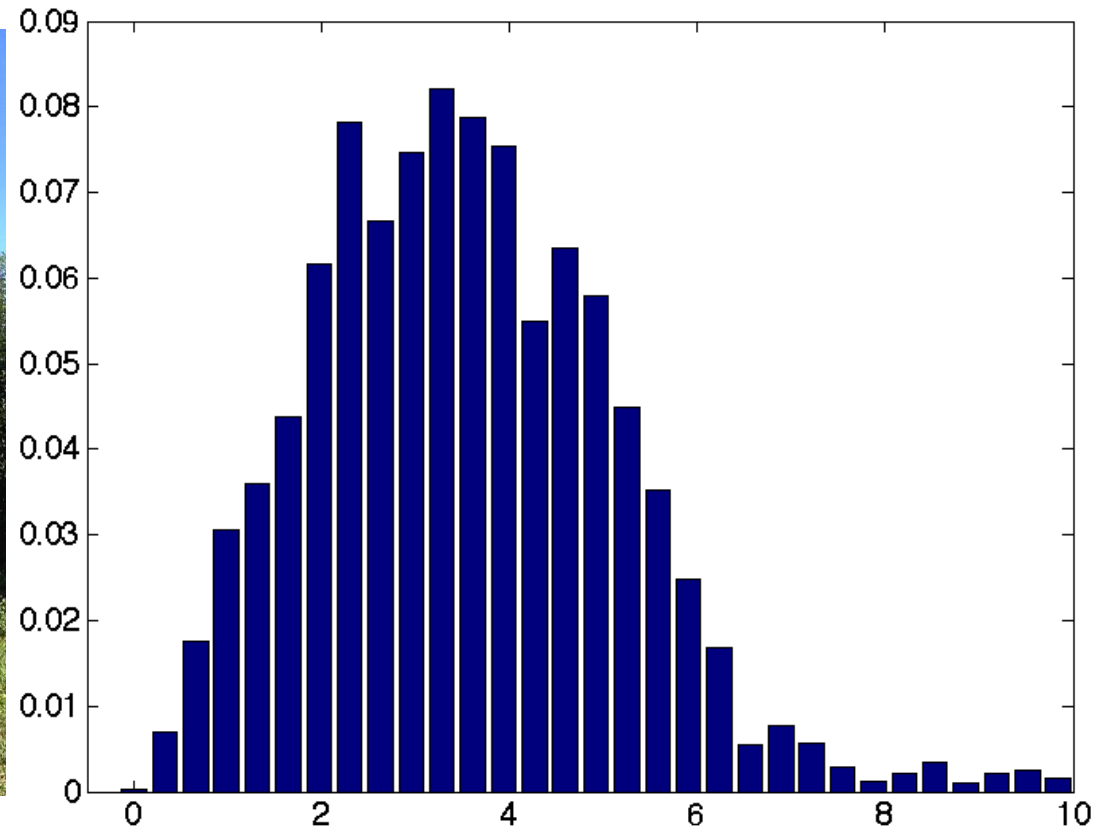


# Ruddick Ranch

DATE: 8/13/2013  
WHAT: Pear trees, standard open-vase  
AGE: ~15 yrs  
TREE HEIGHT: ~13.5ft  
VARIETY: Bartlett

26

## Radial distance of fruits from trunk





# Ruddick Ranch

DATE: 8/13/2013

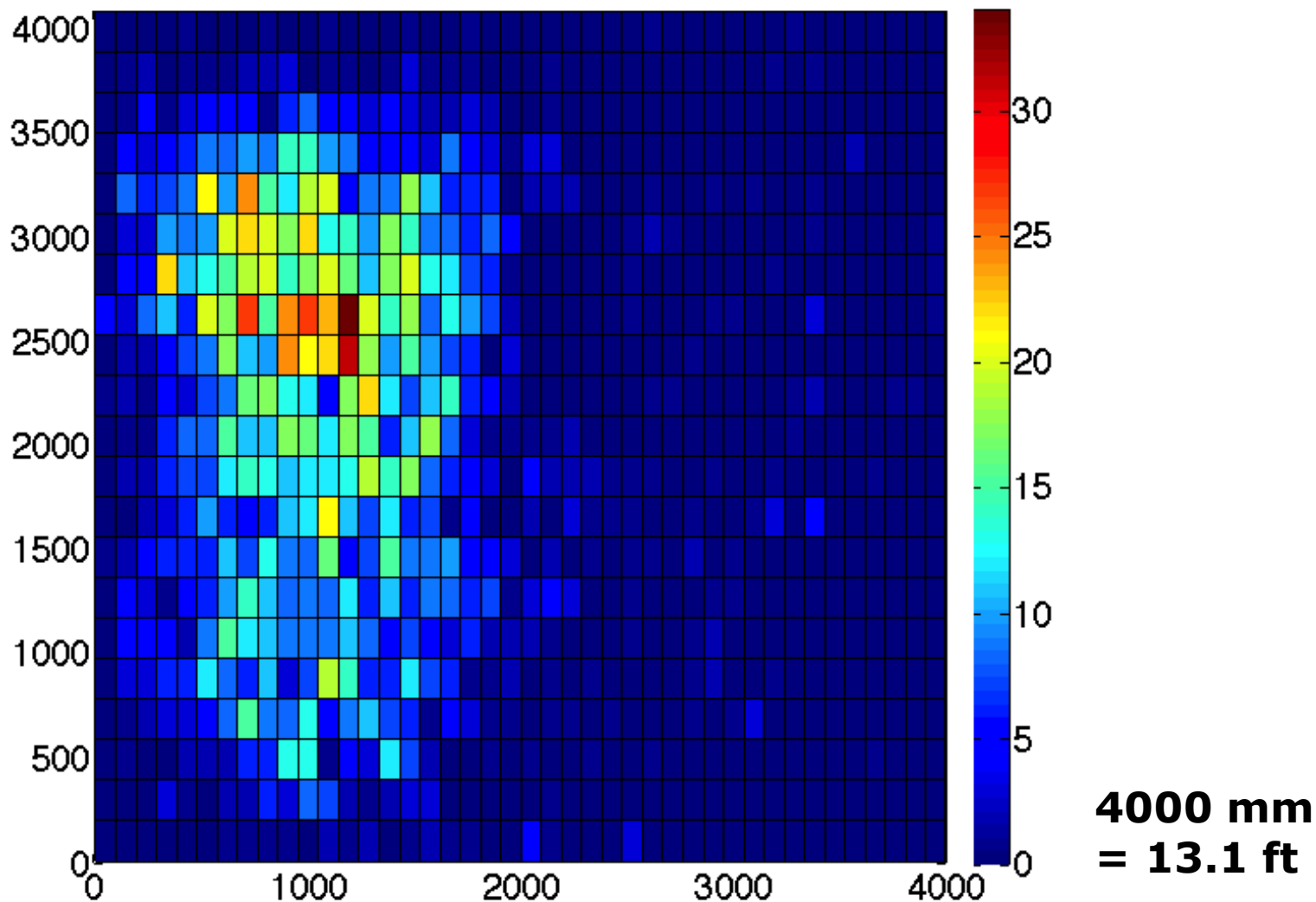
WHAT: Pear trees, standard open-vase

AGE: ~15 yrs

TREE HEIGHT: ~13.5ft

VARIETY: Bartlett

27



# Ruddick Ranch

DATE: 8/14/2013

WHAT: Pear trees, High Density Trellis

AGE: ~ 3 yrs

TREE HEIGHT: ~9ft

VARIETY: Bartlett

28





# Ruddick Ranch

DATE: 8/14/2013

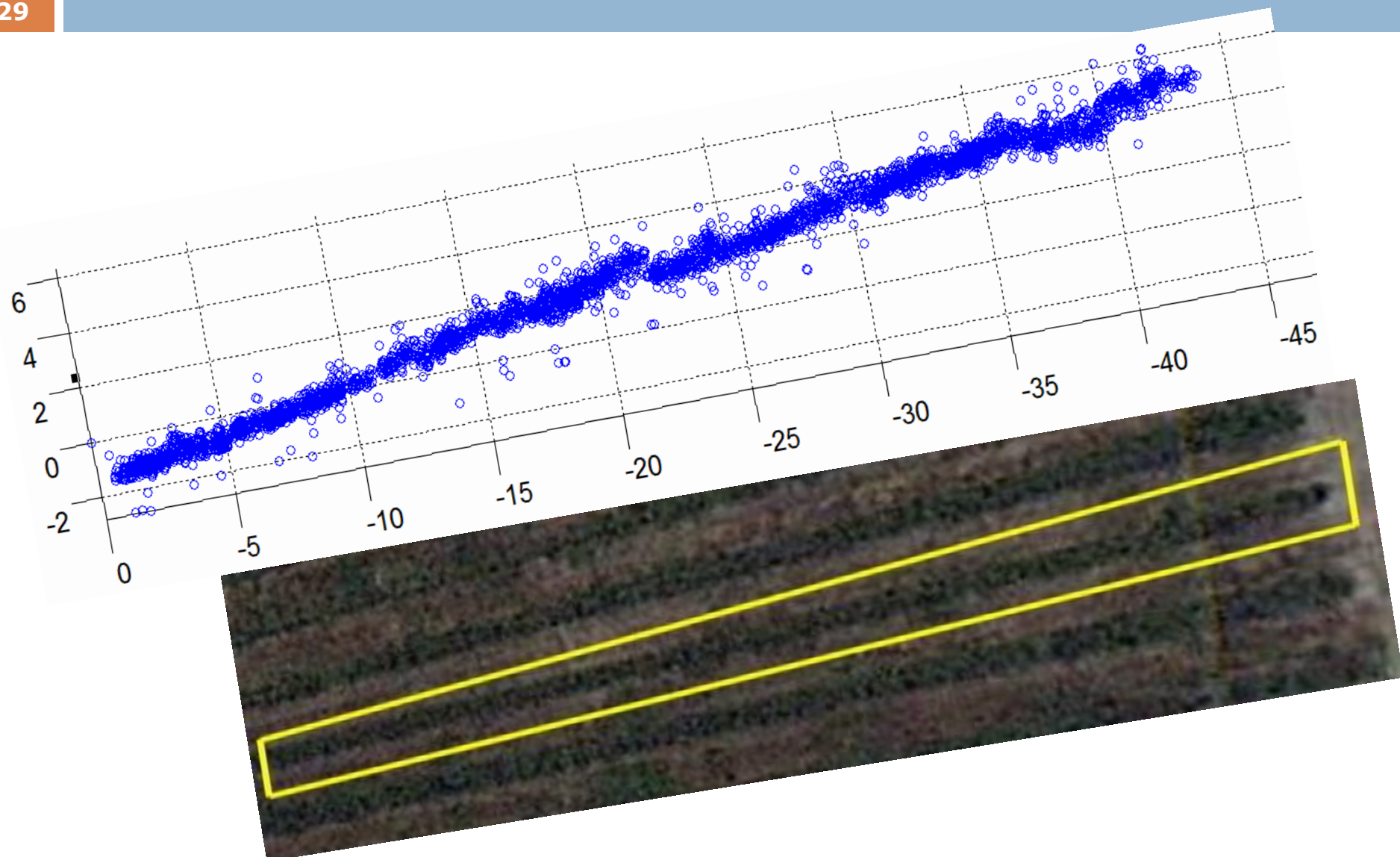
WHAT: Pear trees, High Density Trellis

AGE: ~ 3 yrs

TREE HEIGHT: ~9ft

VARIETY: Bartlett

29





# Ruddick Ranch

DATE: 8/14/2013

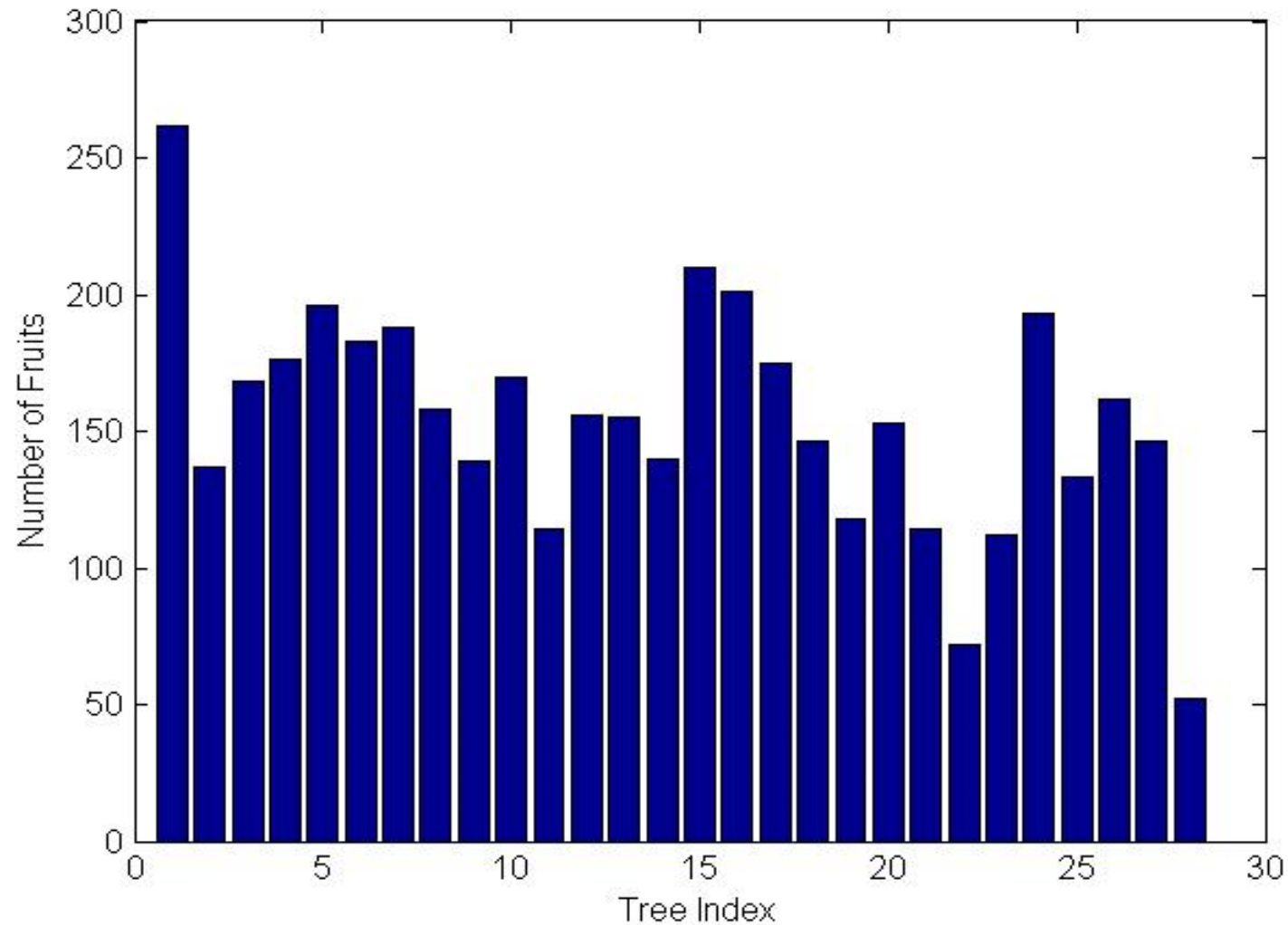
WHAT: Pear trees, High Density Trellis

AGE: ~ 3 yrs

TREE HEIGHT: ~9ft

VARIETY: Bartlett

30



# Ruddick Ranch

DATE: 8/14/2013

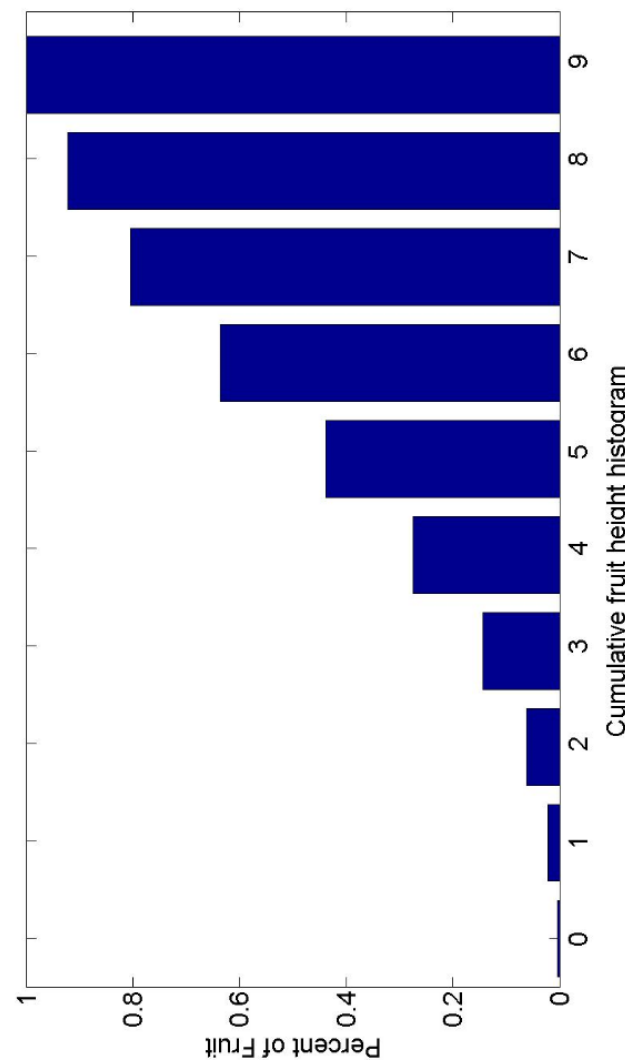
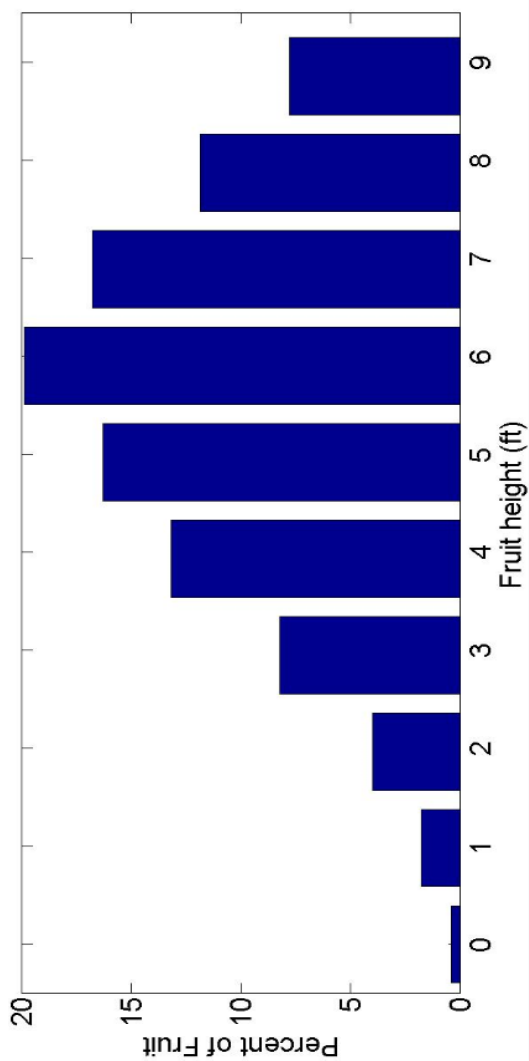
WHAT: Pear trees, High Density Trellis

AGE: ~ 3 yrs

TREE HEIGHT: ~9ft

VARIETY: Bartlett

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# Ruddick Ranch

DATE: 8/14/2013

WHAT: Pear trees, High Density Trellis

AGE: ~ 3 yrs

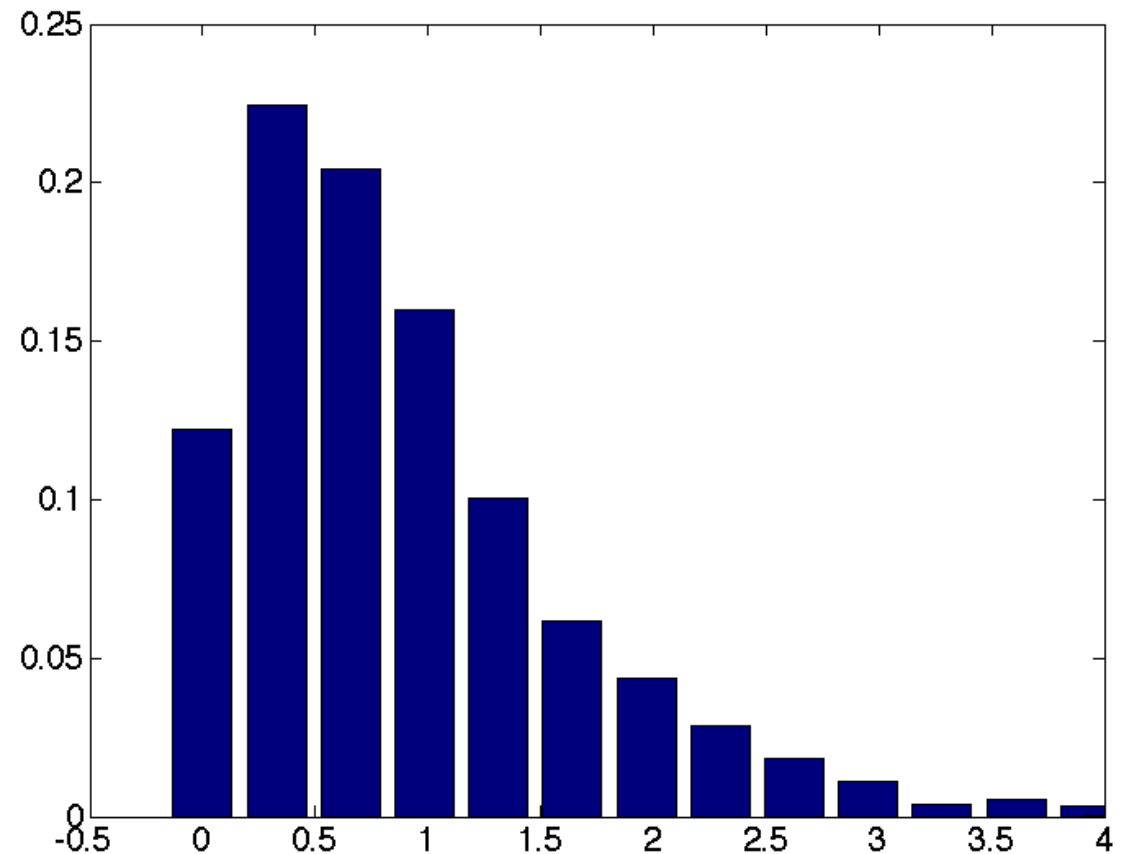
TREE HEIGHT: ~9ft

VARIETY: Bartlett

32



**Distance of fruits from trellis**





# Ruddick Ranch

DATE: 8/14/2013

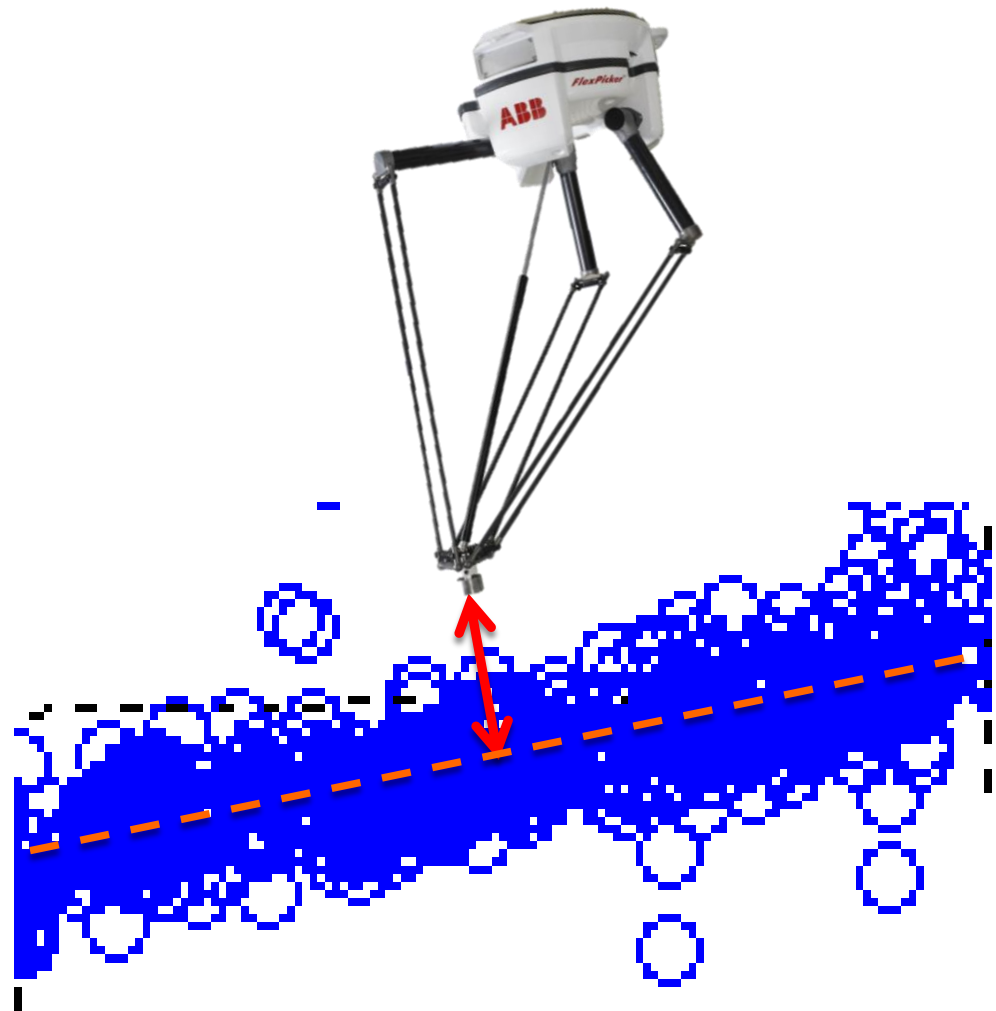
WHAT: Pear trees, High Density Trellis

AGE: ~ 3 yrs

TREE HEIGHT: ~9ft

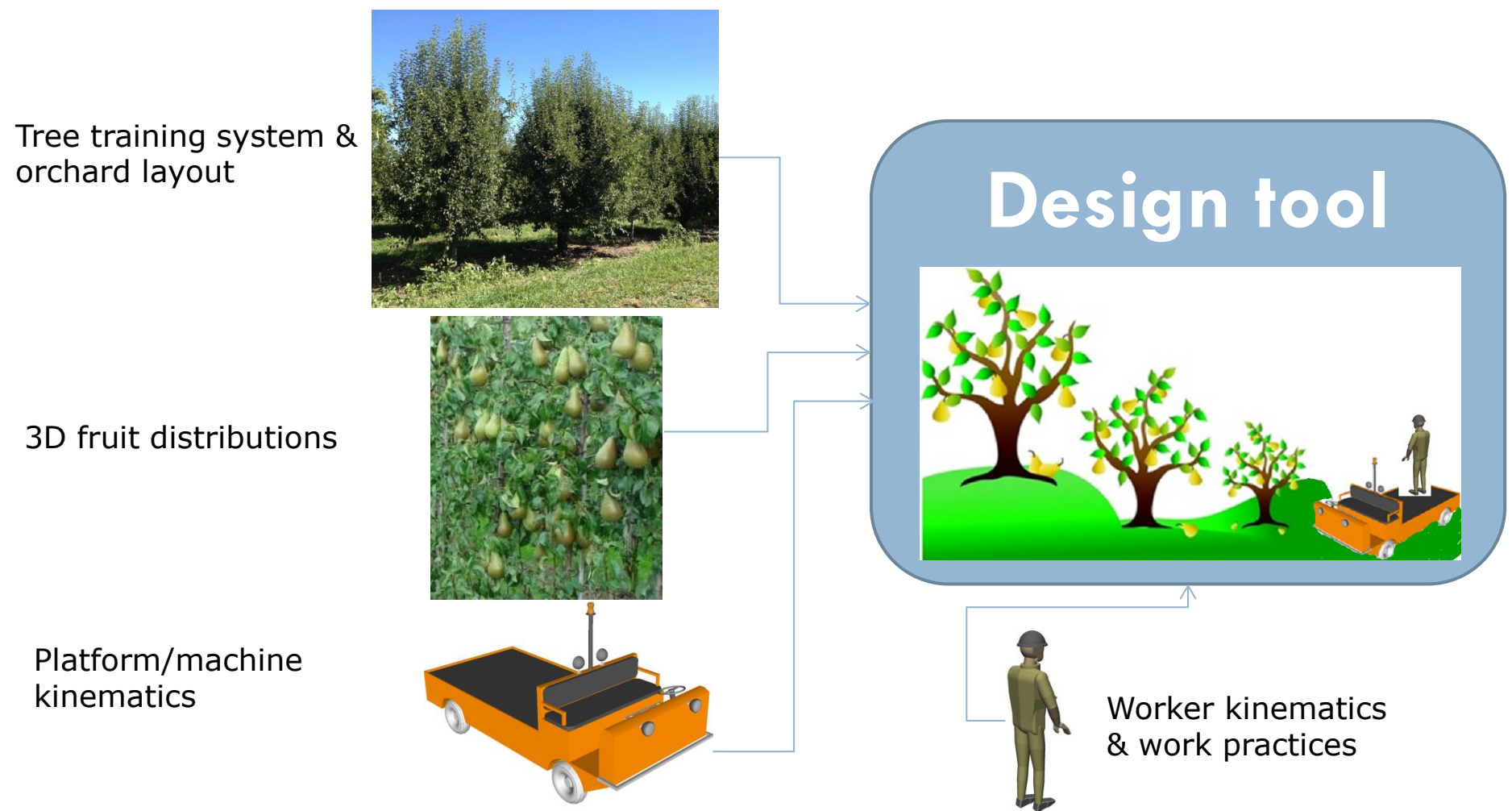
VARIETY: Bartlett

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# Work in progress

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# THANK YOU!

## Acknowledgements:

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Chuck Ingels, UCANR Extension, Sacramento County

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