

# Leaf Nutrients: Tree to Tree Variability

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# Sources of variability in the orchard

- Soil
- Trees
  - Rootstock genetics
  - Cultivars (main cultivar, pollinizer, seedlings, mistakes)
  - Missing trees, replacements
- Climate
  - Temperature
  - Air flow
  - Wind
  - Sunlight
  - Irrigation
- Pests
  - Disease
  - Insects





Soils exhibit high variability, even within very short distances





Soils are variability affects tree performance over the lifetime of an orchard





- Pecans have separate male and female flowers.
- Rootstocks are named for the mother cultivar. The father may vary.
- In a population of pecan rootstocks each plant is genetically unique.



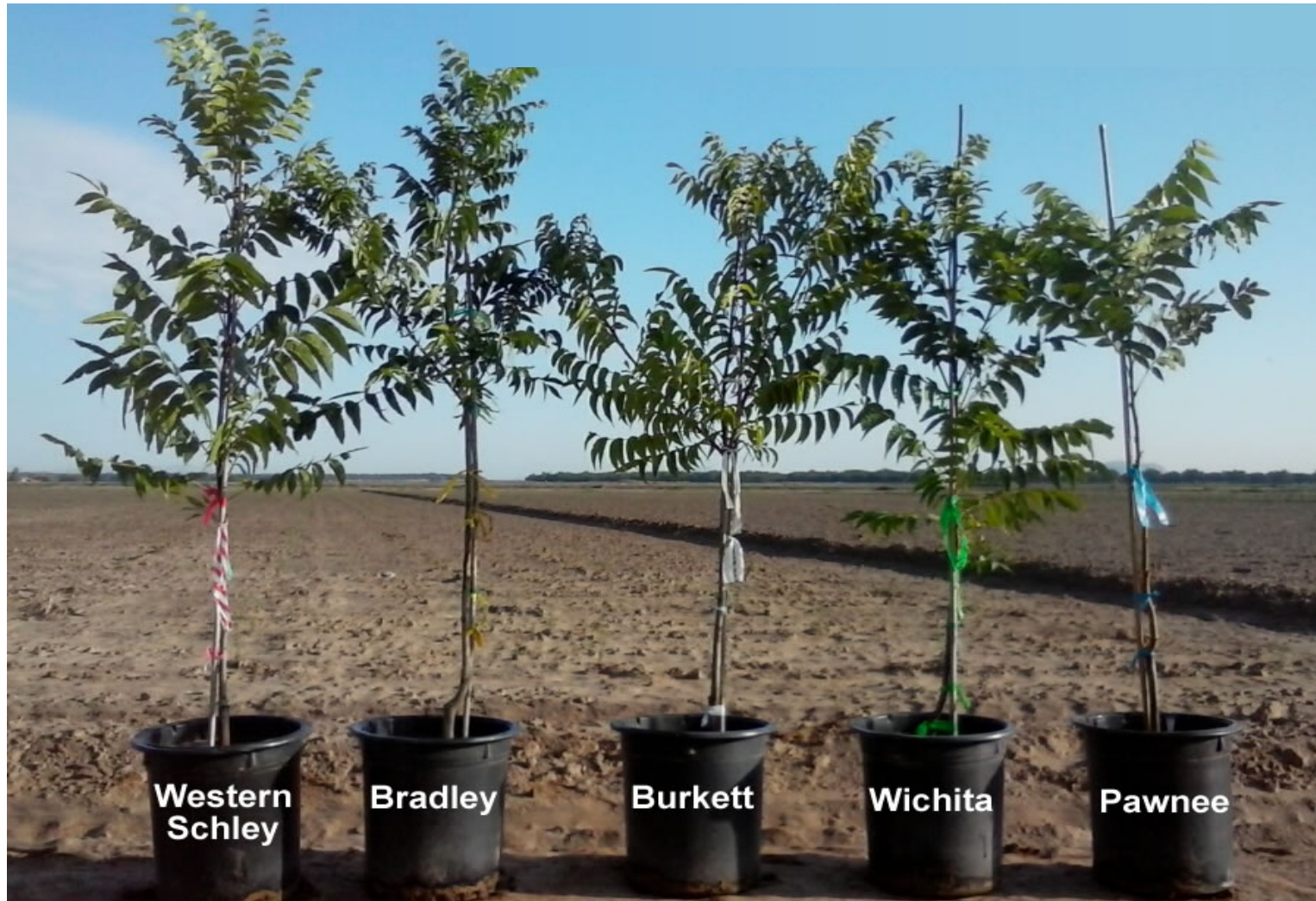


A root stock cultivar in a nursery consists of half-siblings from a known mother





Scions grafted onto rootstock are taken from a specific cultivar, and the resulting rootstock/scion tree takes the name of the scion. The scions should all be genetically identical.



## Irrigation non-uniformity contributes to orchard variability



Photo from Irrigation Evaluation and Saving Water – Modesto Junior College Irrigation Technology



# Potential Distribution Uniformity

(actual values are typically lower)

- |                                   |     |
|-----------------------------------|-----|
| • Permanent under tree sprinklers | 95% |
| • Orchard Drip                    | 90% |
| • Border Flood                    | 85% |
| • Level Furrow                    | 85% |
| • Sloping Furrow                  | 90% |

If ET = 50"  
and Distribution Uniformity = 85%

$$\frac{50''}{0.85} = 59'' \text{ needs to be applied to insure the driest areas receive } 50''$$

To make sure all parts of the orchard block receives 50", some areas will receive considerable more water than others



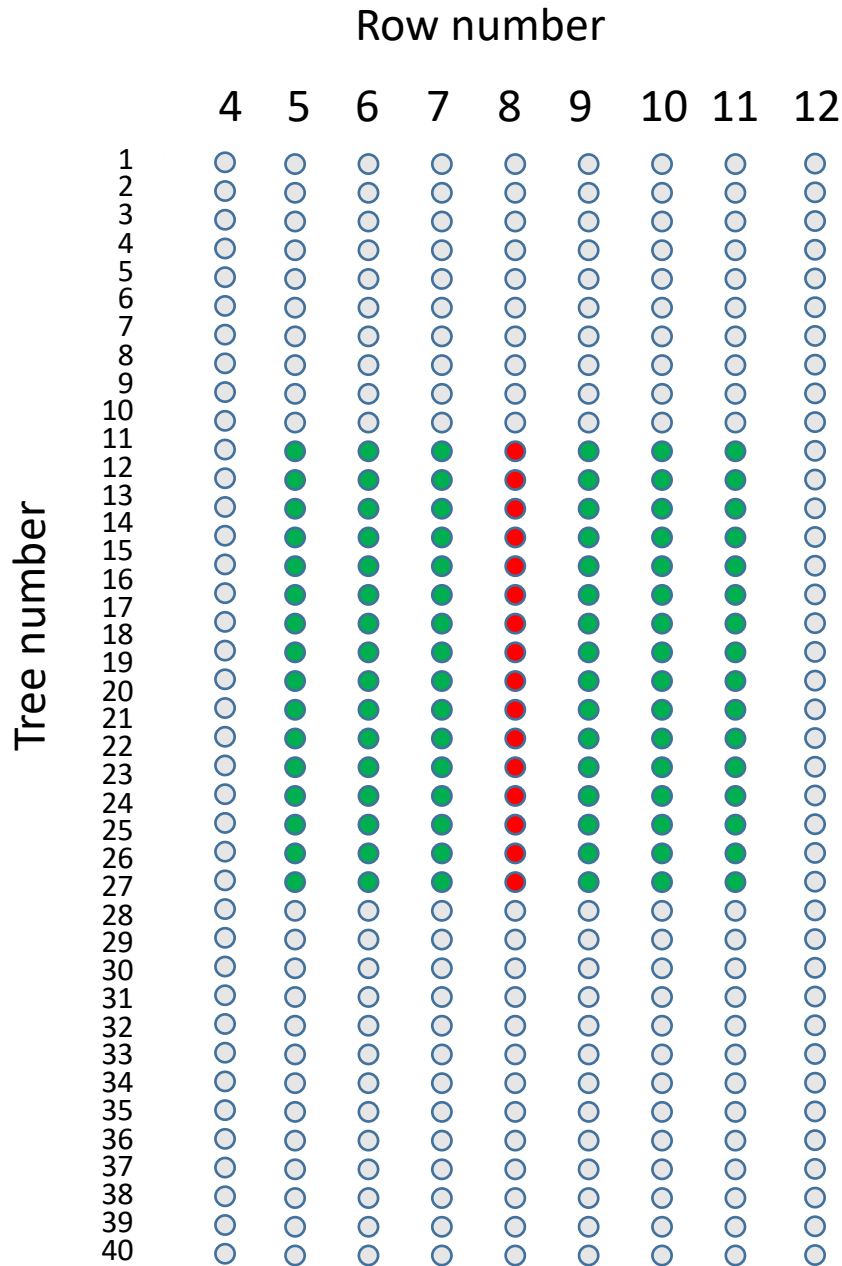
Gaps from missing trees gives adjacent trees more sunlight, water, nutrients



Replacement trees provide  
reduced competition to  
adjacent trees

Photo: Lenny Wells





## Field study to evaluate tree-to-tree nutrient variability

- Wichita
- Western

Trees all receive identical irrigation and fertilization

- ZnEDTA fertigated at 6 lbs/ac of Zn
- No foliar Zn

Sample 119 trees separately

- Leaf samples
- Soil samples
- Trunk diameter

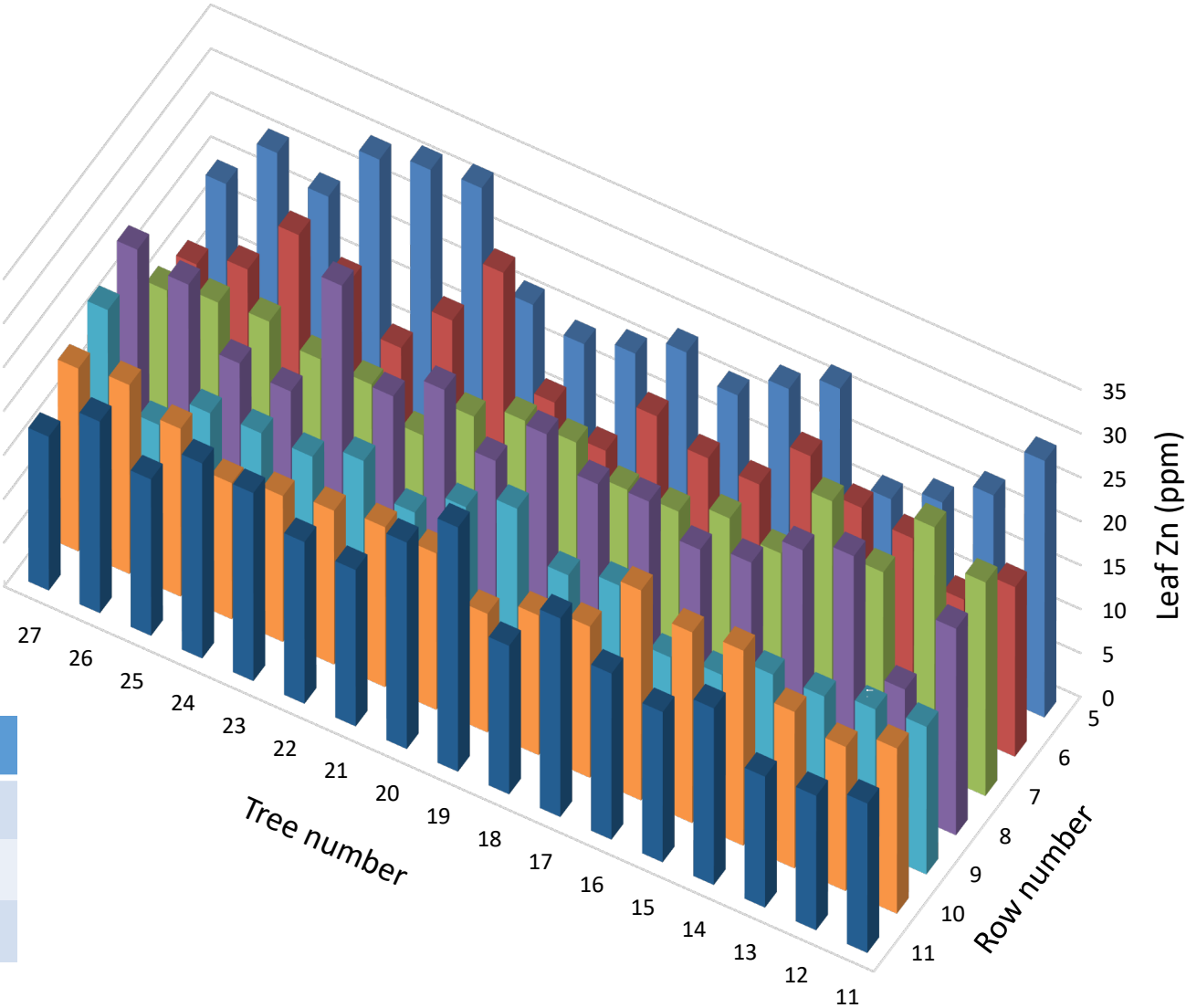
# Leaf zinc analysis

- Lowest value 12 ppm
- Highest value 32 ppm
- Average value 20 ppm

Trees showed no visible  
zinc deficiency



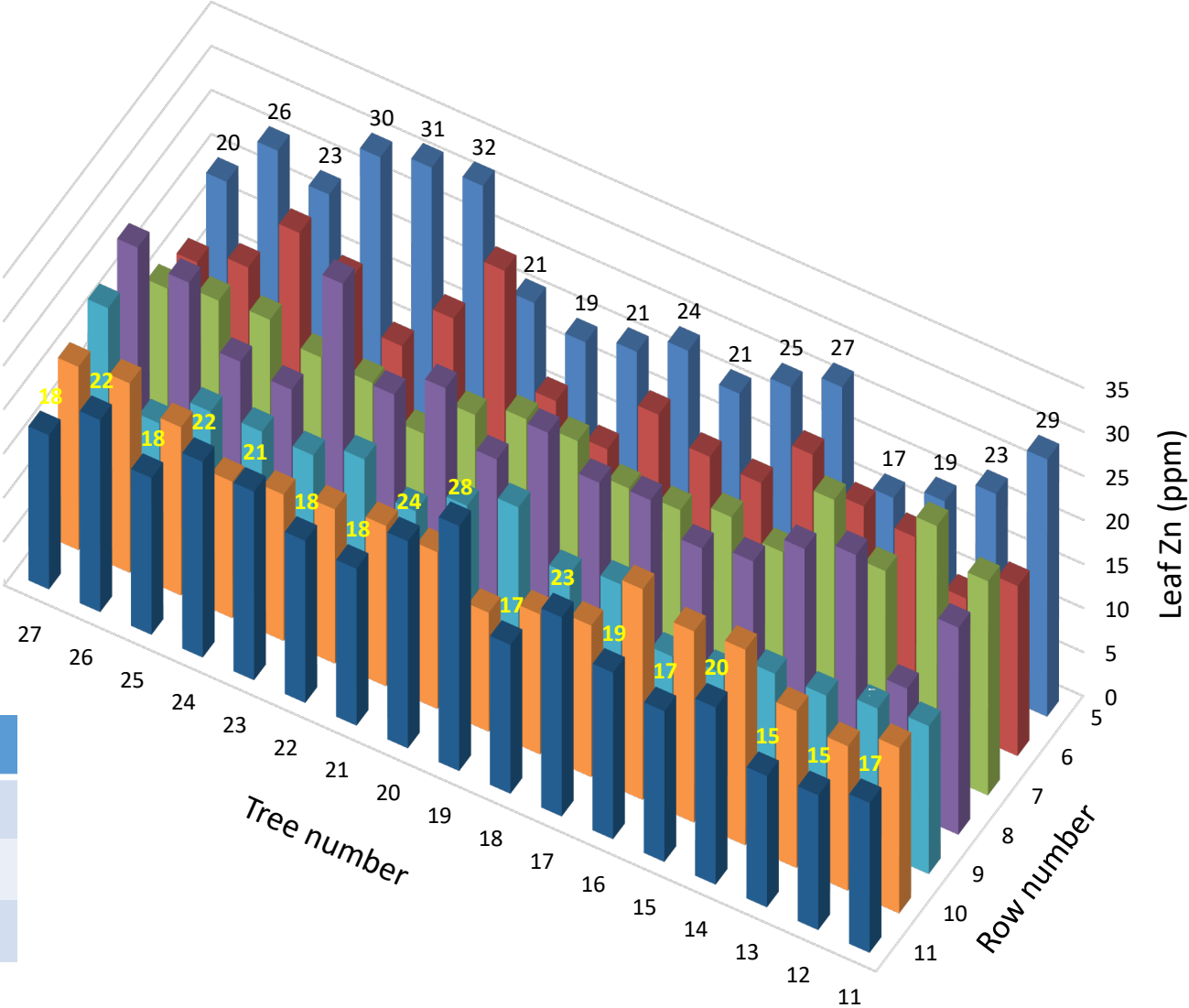
Leaf Zinc Concentration (ppm)



Leaf Zn	ppm
Low	12
High	32
Average	20



Leaf Zinc Concentration (ppm)

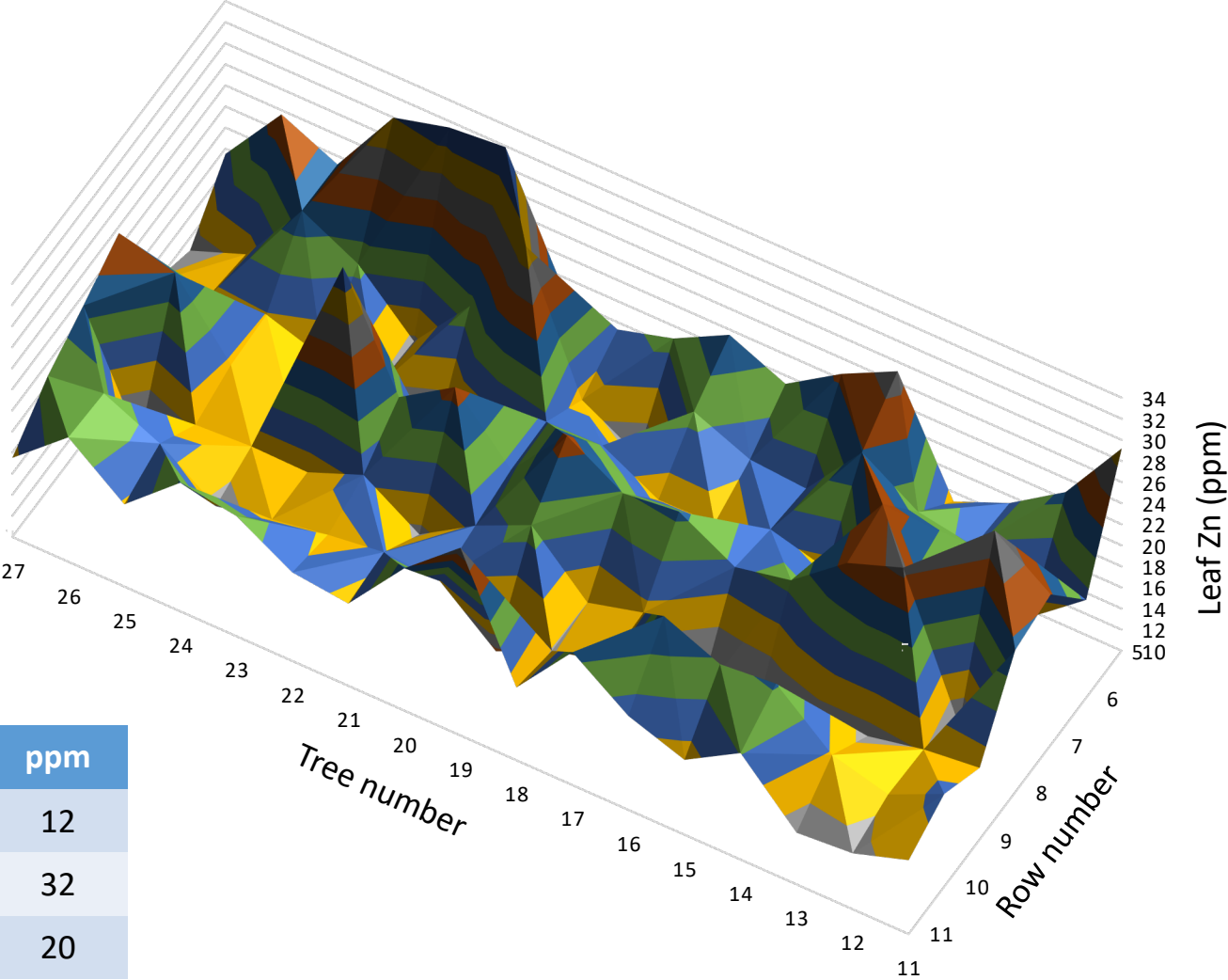


Leaf Zn	ppm
Low	12
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# Leaf Zinc Concentration (ppm)

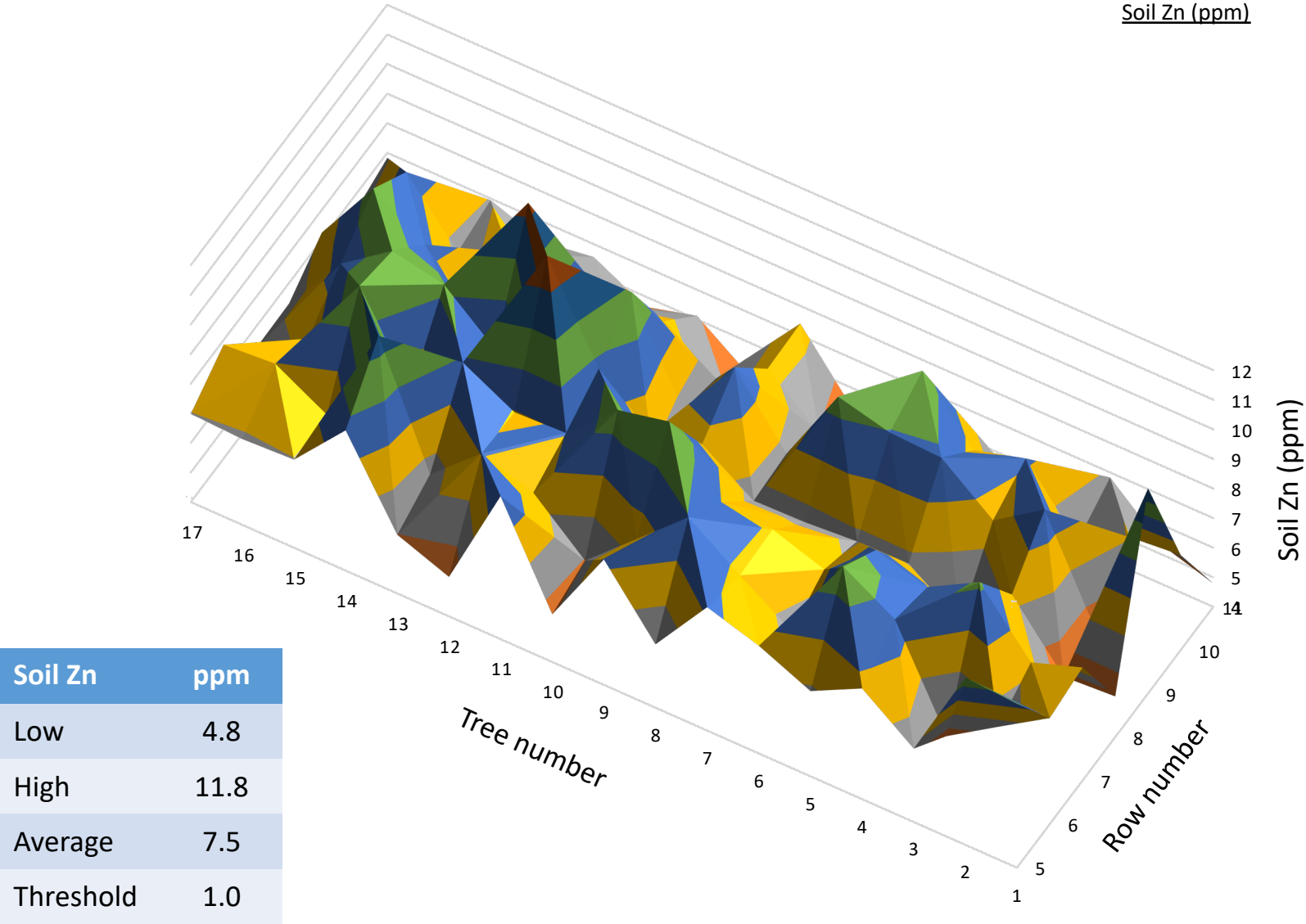
Leaf Zn (ppm)

- 10-12
- 12-14
- 14-16
- 16-18
- 18-20
- 20-22
- 22-24
- 24-26
- 26-28
- 28-30
- 30-32
- 32-34



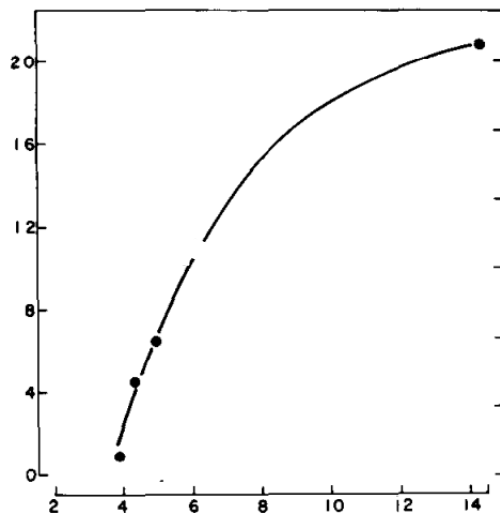
Leaf Zn	ppm
Low	12
High	32
Average	20

DTPA-Extractable Soil Zinc (ppm)



# How much zinc is enough?

Authors	Year	Zinc threshold determination	Leaf Zn (ppm)
Kim et al.	2002	Eliminated symptoms in individual greenhouse trees	>11
Hu and Sparks	1991	Maximized photosynthesis in individual orchard trees	> 14



HORTSCIENCE 26(3):267-268. 1991.

## **Zinc Deficiency Inhibits Chlorophyll Synthesis and Gas Exchange in 'Stuart' Pecan**

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*Department of Horticulture, University of Georgia, Athens, GA 30602*

# LI-COR photosynthesis meter used to measure individual leaf photosynthesis rates

- Multiple measurements give us individual tree photosynthesis rates
- Leaf samples from the measured trees provide nutrient concentrations



# Individual tree zinc threshold

- Heerema et al (2017) determined the leaf Zn level required to maximize individual tree photosynthesis
  - Orchard-grown Wichita trees
  - Single tree threshold Zn concentration = 15 ppm
  - How does this compare to an orchard block threshold?

J. AMER. SOC. HORT. SCI. 142(1):27–35. 2017. doi: 10.21273/JASHS03938-16

## Soil-application of Zinc-EDTA Increases Leaf Photosynthesis of Immature ‘Wichita’ Pecan Trees

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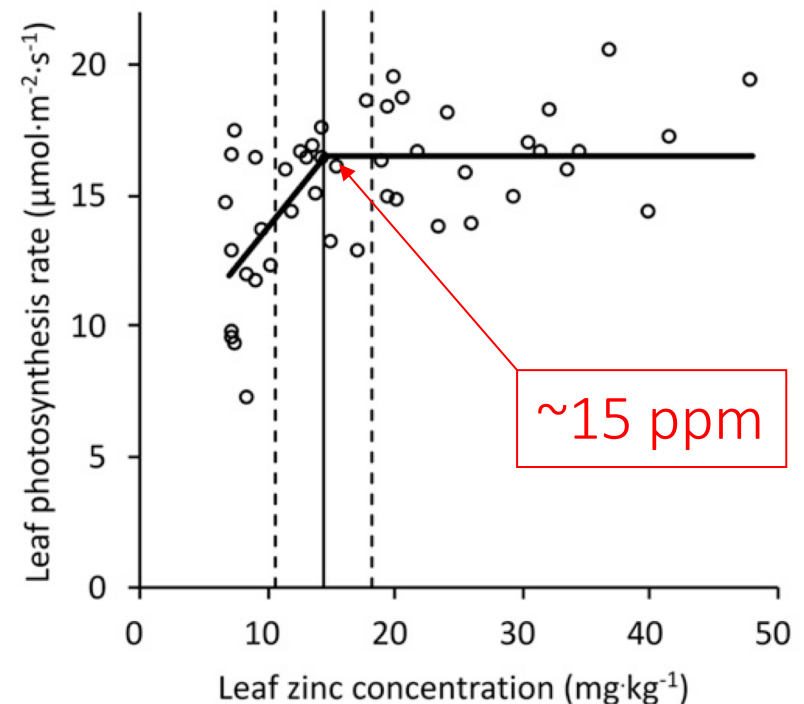
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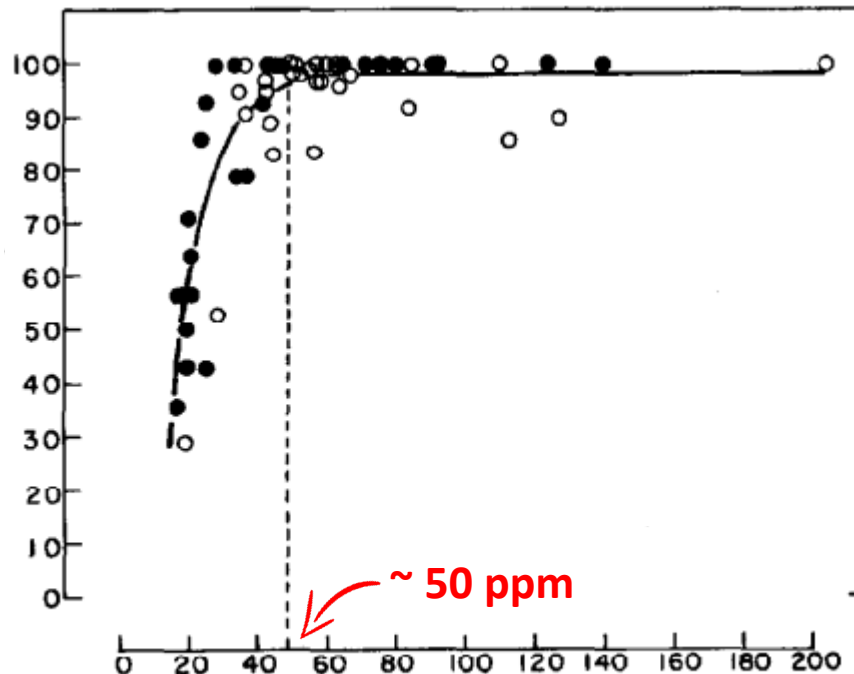
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Sparks (1993) identified 50 ppm as an **orchard threshold Zn concentration** based on a combination of deficiency symptoms and nut yield



Based on data from

Brooks (1964)

Hunter (1965)

Malstrom et al (1984)

Smith and Storey (1979)

Sparks and Payne, (1982)

Worley et al (1981)

# Single tree versus orchard block

- Orchard block sampling

- Should provide a block average, not highs and lows
  - Randomly selected trees from < 10 acres
  - 60 leaflets from all sides (N-W-S-E) sides
  - Collect samples from ~ 30 trees

- Individual tree sampling

- Indicates nutrient status of each tree
  - All samples collected from a single tree
  - Leaflets collected from all sides of the tree
  - Leaflets were collected from non-fruiting branches

- If minimum zinc acceptable concentration is 15 ppm
  - Average zinc concentration was 20 ppm
    - This is above the 15 ppm threshold, but well below published orchard values (40 – 50 ppm)
    - Of 119 trees we sampled
      - 10 trees (8½ %) had  $\leq 15$  ppm of zinc
      - 59 trees had between 15 and 20 ppm
      - 46 trees had between 20 and 30 ppm
      - 4 trees had  $> 30$  ppm
  - How high does the average need to be so that  $< 1\%$  of trees fall below 15 ppm of zinc?
    - Preliminary data analyses indicate that the orchard block threshold value is between 24 and 28 ppm

# Individual tree manganese threshold

- Sherman et al (2017) determined the leaf Mn level required to maximize individual tree photosynthesis
  - Orchard-grown Pawnee, Western
  - Single tree threshold Mn concentration = 150 ppm
  - How does this compare to an orchard block threshold?

HORTSCIENCE 52(4):634–640. 2017. doi: 10.21273/HORTSCI11252-16

## Optimal Manganese Nutrition Increases Photosynthesis of Immature Pecan Trees

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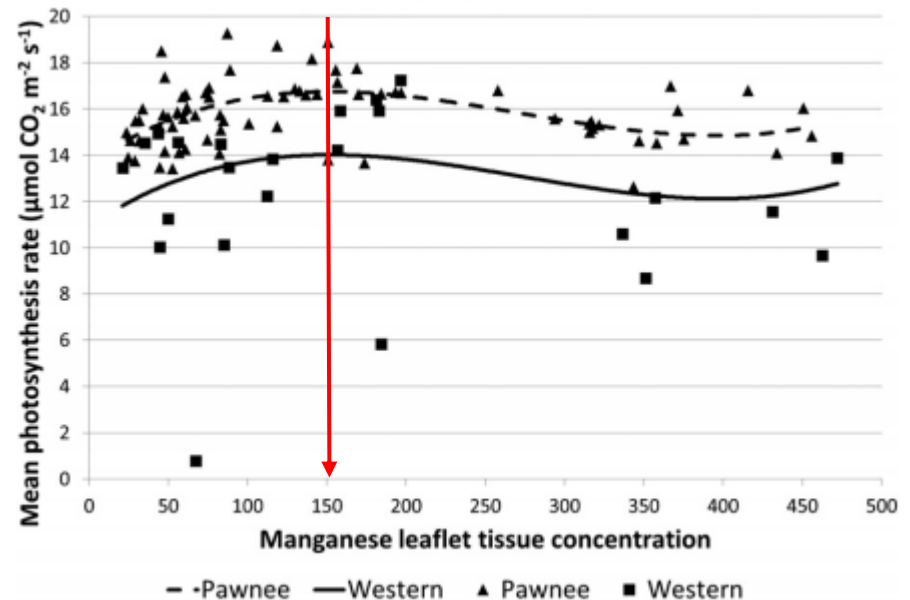
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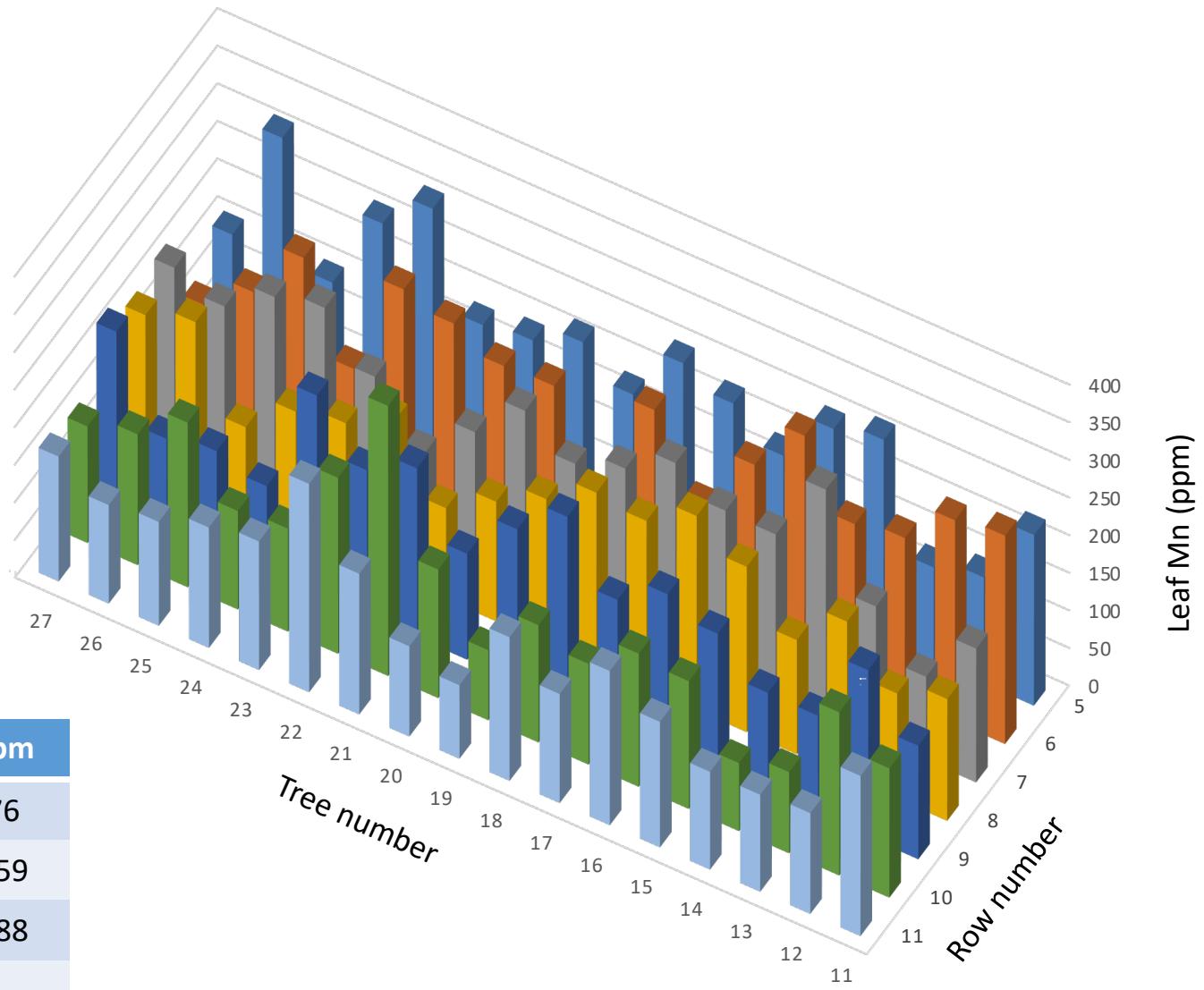
Economics, Applied Statistics, and International Business Department, New Mexico State University, MSC 3Q Box 30003, Las Cruces, NM 88003

Rolston St. Hilaire

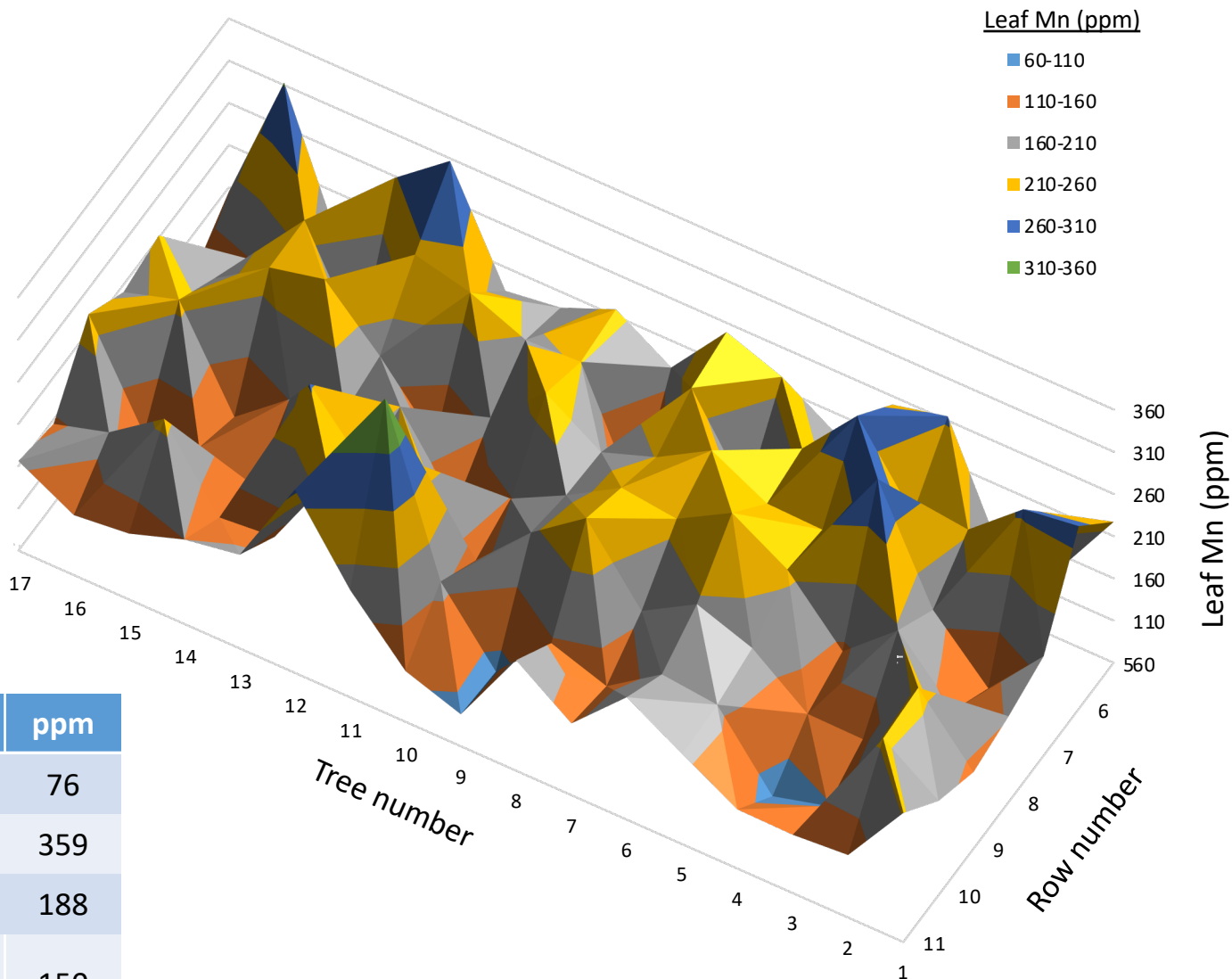
Department of Plant and Environmental Sciences, New Mexico State University, MSC 3Q Box 30003, Las Cruces, NM 88003



## Leaf Mn



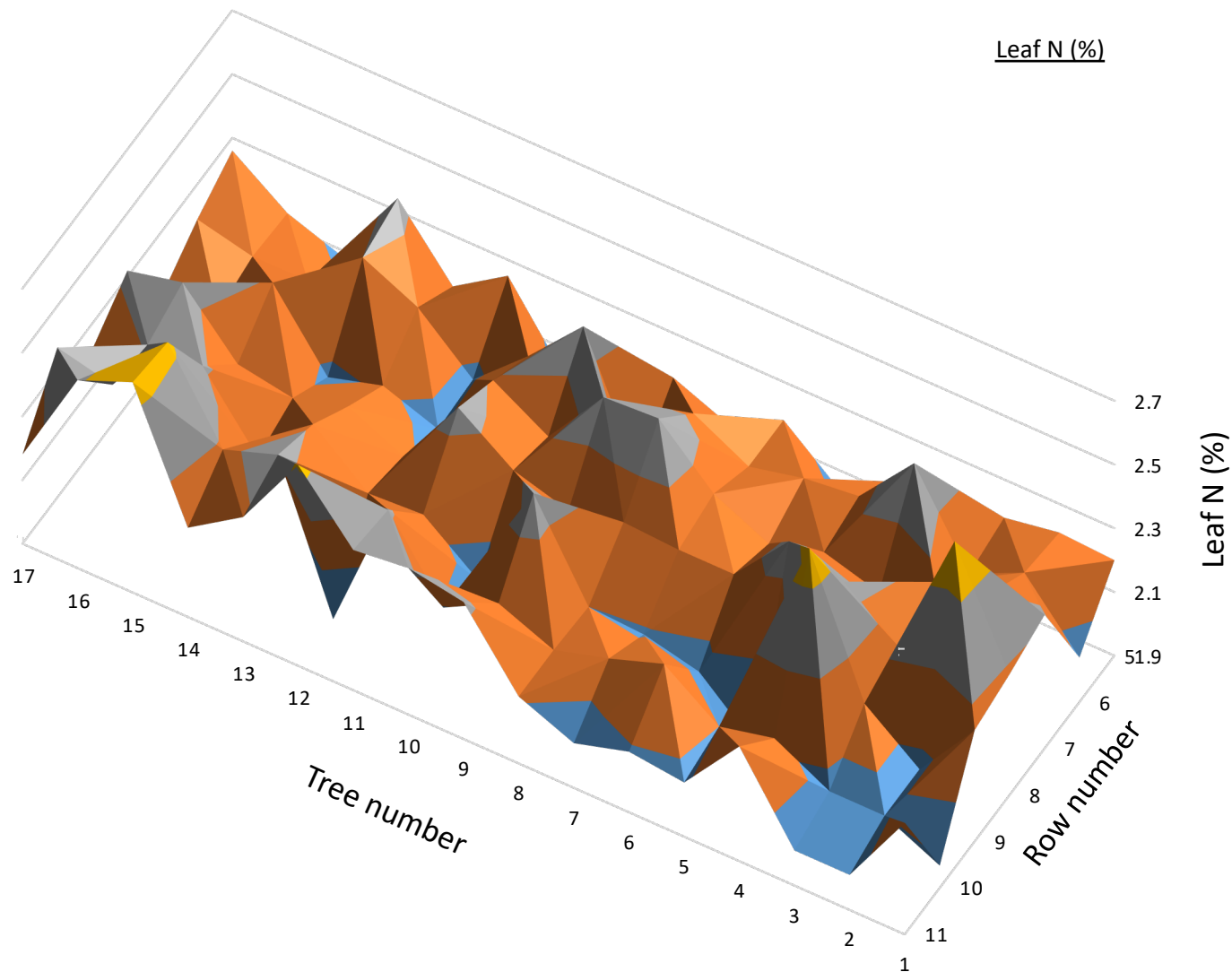
# Leaf Mn (ppm)



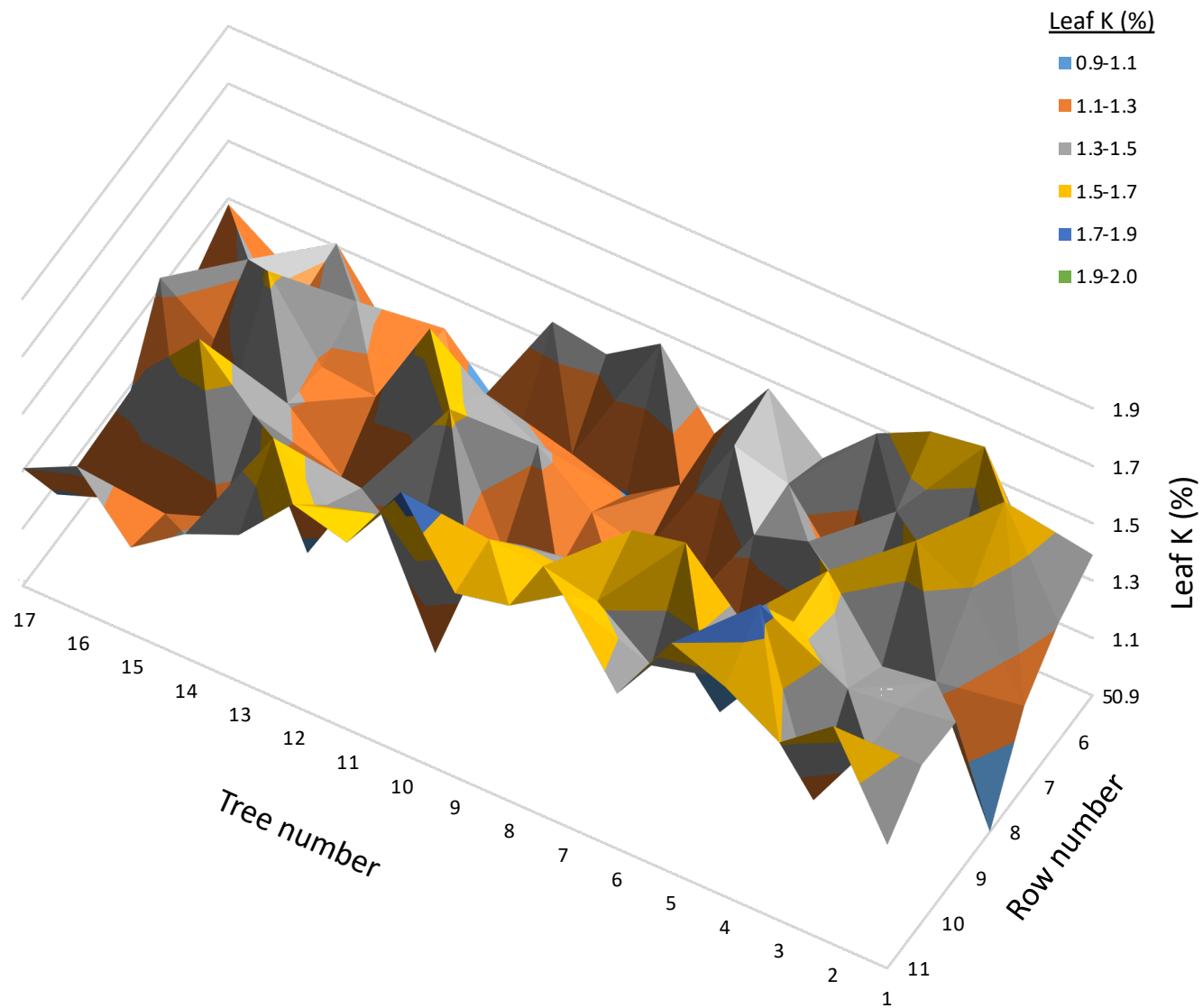
Leaf Mn	ppm
Low	76
High	359
Average	188
Single tree threshold	150
Orchard threshold	??



# Leaf Nitrogen (%)



# Leaf K (%)



# Single tree versus orchard thresholds

- Standards developed for individual trees cannot be directly transferred to whole orchard samples
  - Standards based on individual tree measurements:  
growth, photosynthesis, yield
- Most nutrient standards have been developed from whole orchard block measurements
  - The whole block standards should be high enough to insure that individual trees have adequate nutrition to maximize photosynthesis, growth, nut yield
- Orchard block thresholds will be higher than individual tree thresholds

# Goals

- What is the source of tree-to-tree variation?
  - We're evaluating the spatial distribution of leaf nutrient concentrations
    - If genetic variability is responsible, the variation should be randomly distributed within the orchard block
    - If there are patterns in the variation (clusters of high or low zinc trees) then non-genetic factors are likely responsible.
      - If variation in soil properties matches tree variation, then we can attribute tree-to-tree differences to soil variability
- Translate individual tree thresholds to orchard block values
  - Based on tree-to-tree variability
  - Insure that all trees are above the individual tree thresholds

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Questions?