Pruning Studies to Manage Crop Load in Pennsylvania

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Outline

- Pruning for crop load potential: Getting crop “in the ballpark”
- Tall Spindle pruning severity studies: Gala and Fuji
- Artificial Spur Extinction: spur pruning Gala and Golden Delicious

Crop Load Terms

- Yield: Weight or volume (Bu) fruit / tree or / land unit (acre)
- Crop load: Fruit number per unit of bearing surface
  - trunk or limb size: No. / TCSA; No. / LCSA
  - Crop *density*
  - “Supply-Demand” ratio

Crop Load Mgt Options:

- Pruning: Adjust crop potential
- Blossom thinning
  - Chemical
  - Mechanical
- Post-bloom chemical thinning
  - Rescue chemical thinning at 20 mm
- Hand thinning: Corrective measure when all else fails
- Return bloom sprays

Pruning Goals: Fruit Size and Quality
Sunlight and Crop Density

- Pruning reduces yield and increases fruit size & quality
- Space fruiting laterals vertically & radially
- Reduce shading by reducing excess branching
- Reduce crop density to promote higher Leaf : Fruit ratio
- Can we quantify this?

Pruning for Peach Crop Load Goal

Quad V orchard

600 bushel / A of large (3”) fruit

= 60,000 peaches per A

345 trees/A = 174 peaches/ tree

4 scaffolds / tree = 44 peaches/ scaffold

At 2 peaches per fruiting lateral = 22 laterals

Ballpark: Prune to 22 fruiting laterals / scaffold

Spurs & Terminals on 2+ Year Limbs

6 spurs / lcsa

Equilifruit Disk

Pruning for Apple Crop Load Goal:

1210 bushel / A of 3” fruit

= 121,000 apples per A

1210 trees/A = 100 apples/ tree

100 apples @ 6 fruits / lcsa = 16.7 cm^2 lcsa per tree (2.6 in^2 lcsa)

If limbs are ~1 cm (0.4”) in diameter, 22/ tree are needed for a full crop

Estimated Limb No. for Target Yield / A
1210 Trees / A (3’ x 12’ spacing)

Yield Goal (Bu / A)	Fruit no. / tree	Limb csa / tree	Limbs / tree (est)
1000	83	14	18
1210	100	17	22
1500	124	21	27
1800	149	25	32

Pruning Automation

USDA-NIFA SCRI

AUTOMATION OF DORMANT PRUNING OF SPECIALTY CROPS

Pruning by the Numbers

Pruning Severity Treatments

Unpruned | LTR = 1.25 | LTR= 1.00 | LTR = 0.50

Remove a sequence of limbs, always removing the largest remaining limb until the level of severity meets the target value

The Numbers?

- Need measurable benchmark

1. To develop robotic pruning
   - What limbs to cut?
   - Threshold (when to stop?)
   - What & how much data needed?
2. To evaluate: how did we do?
3. Need for manual pruning too

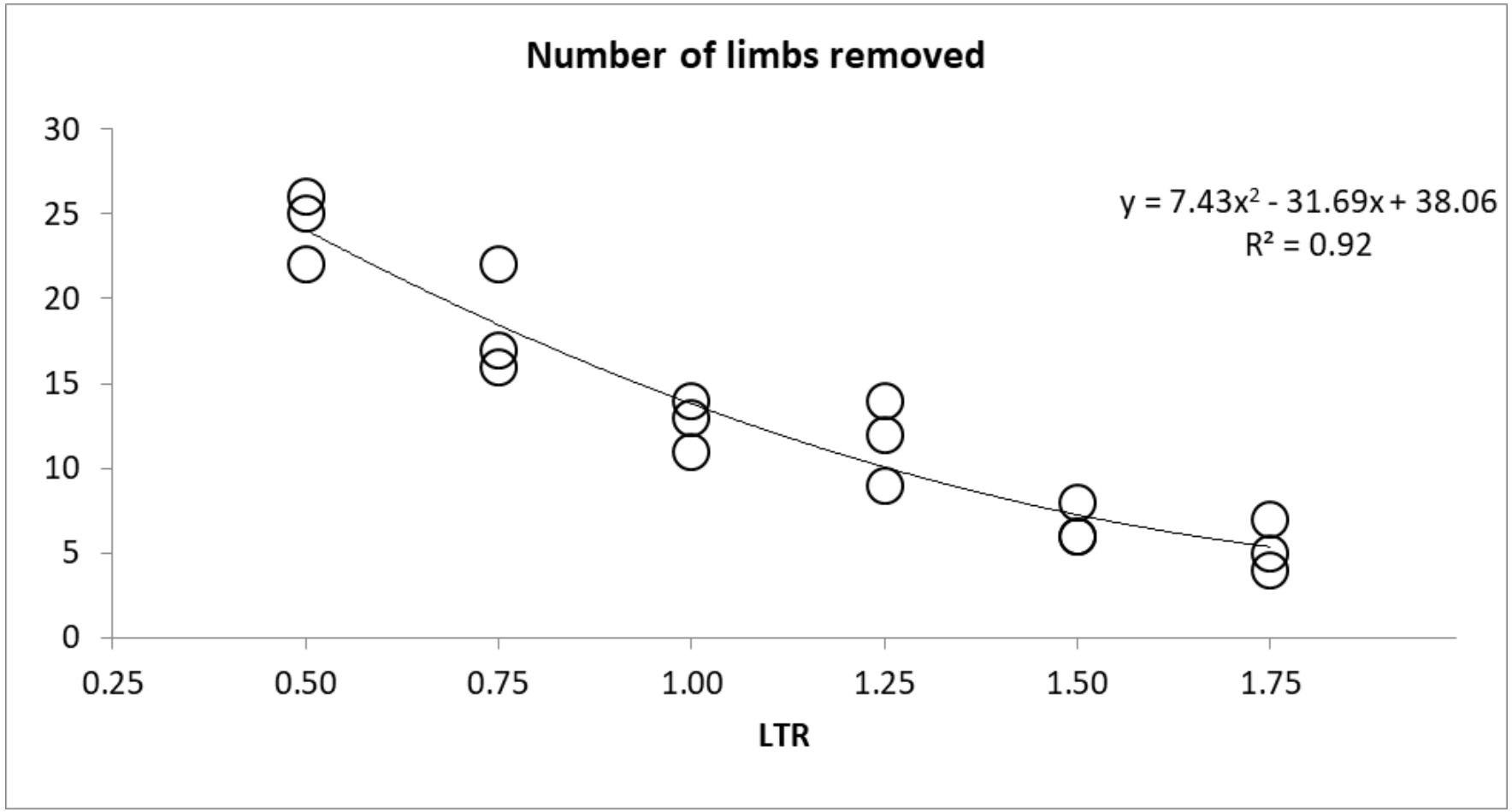
Tall Spindle

- World standard
- Productive, quality
- Common canopy features
- Minimal branching
- One simple target

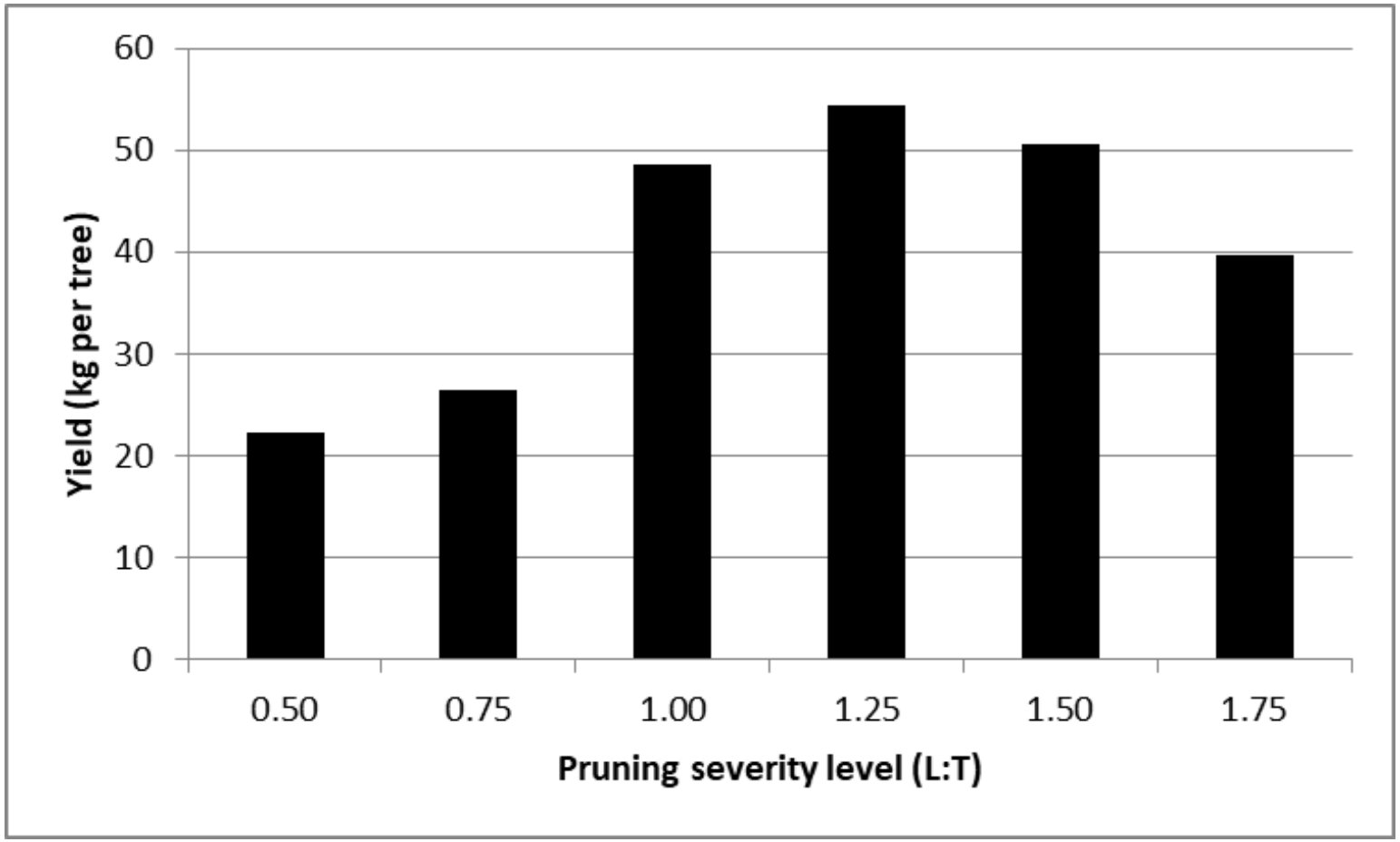
Severity: Limb - Trunk Ratio

- Measure diameter of each limb on 4 trees
- Measure the trunk diameter at 12 inches
- Calculate sum [LCSA] and TCSA.
- Choose desired LT ratio.
- Prune **largest successive limbs** to desired LT ratio.

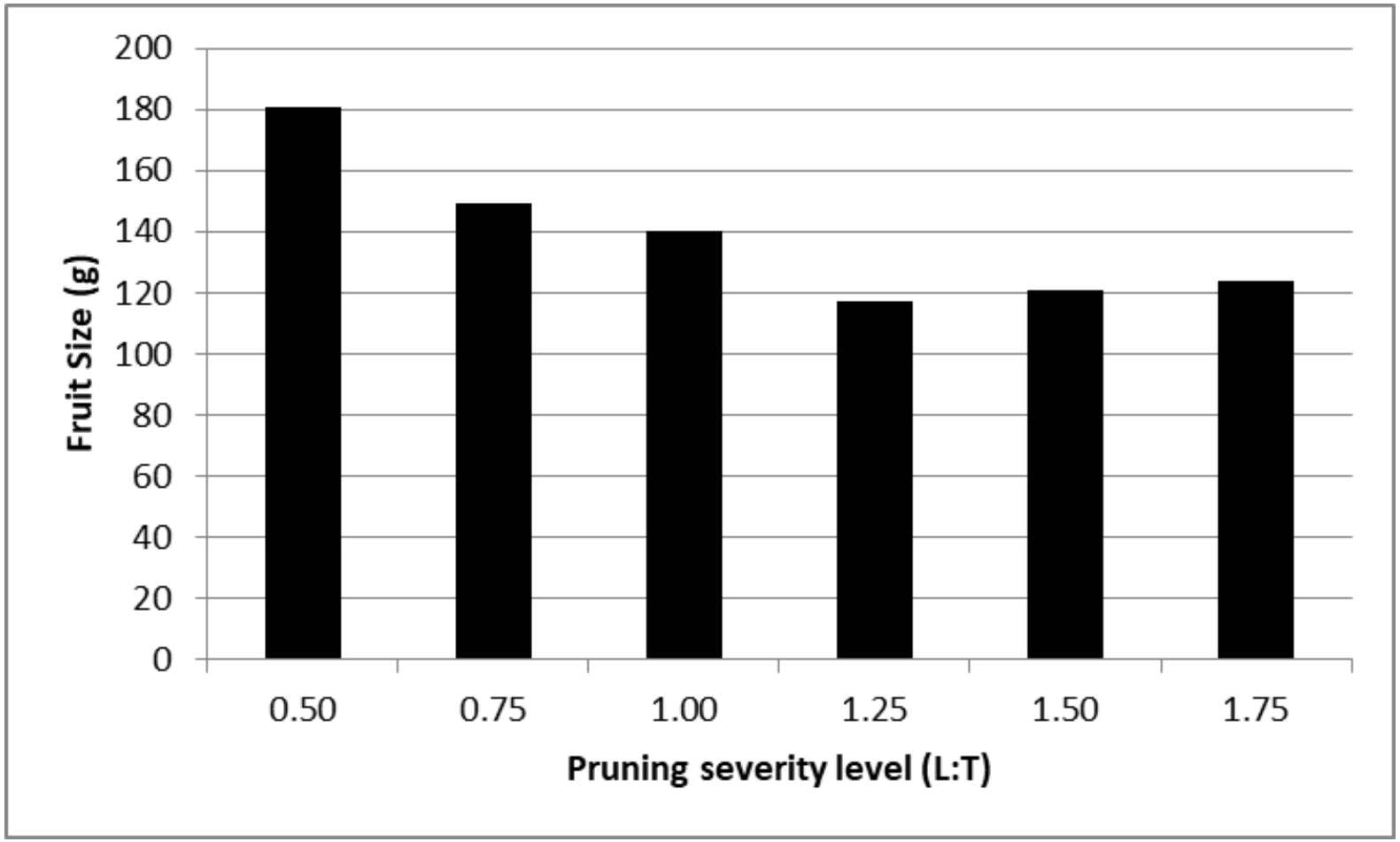
Pruning Severity: Gala/ M.9


Number of limbs removed
30
25
20
15
10
5
0
0.25
0.50
0.75
1.00
1.25
1.50
1.75
LTR
y = 7.43x² - 31.69x + 38.06
R² = 0.92

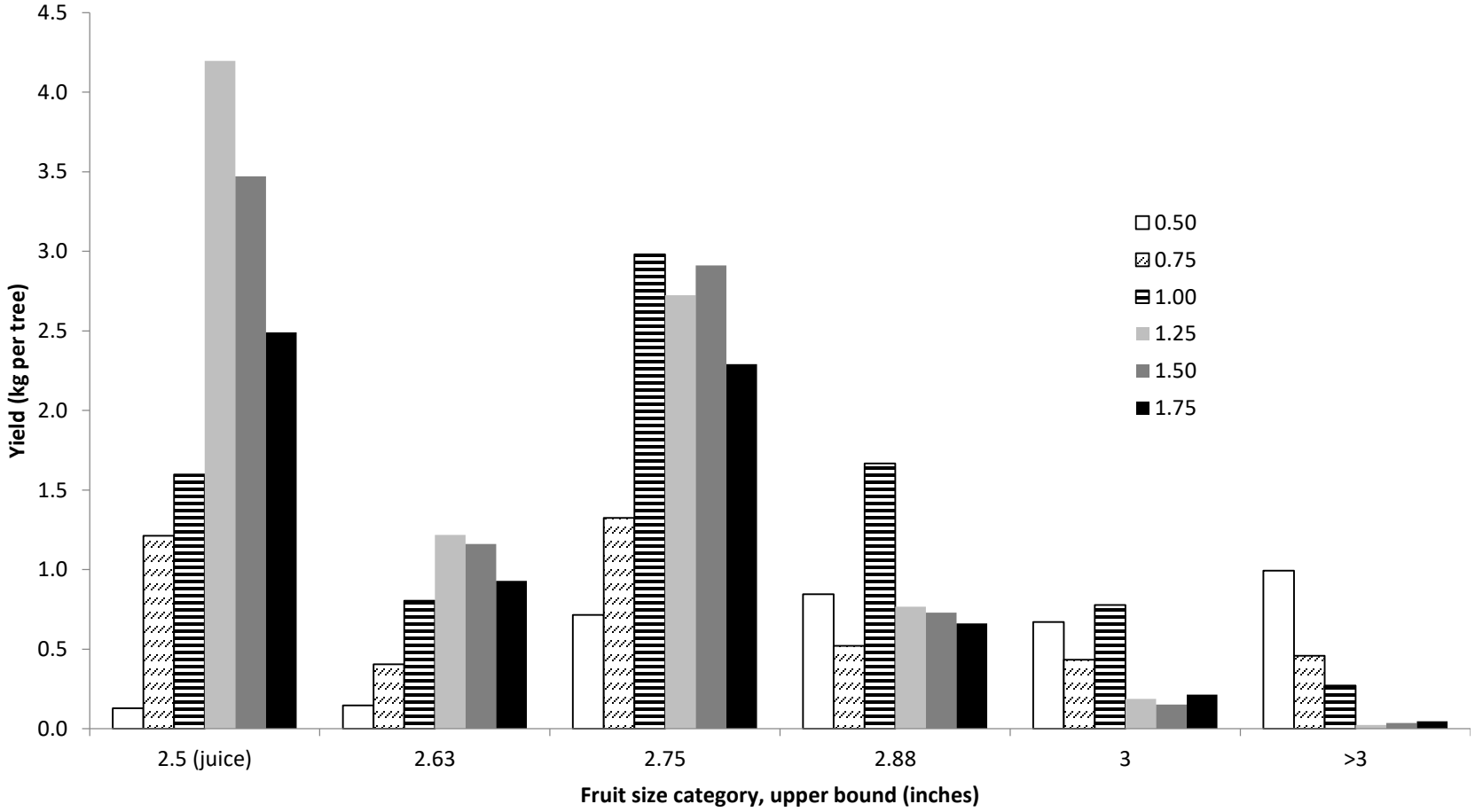
Gala Yield per Tree

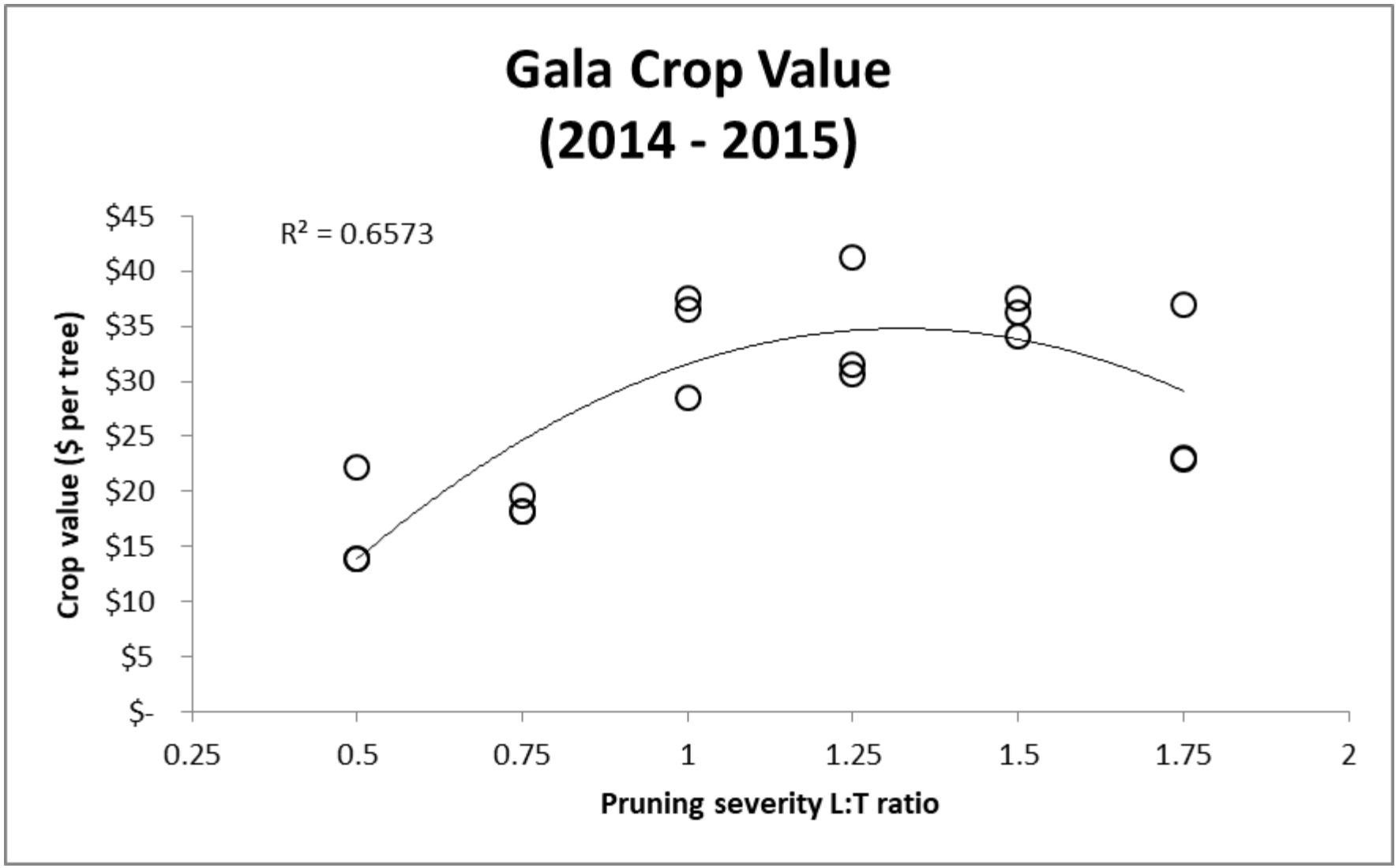


Gala Fruit Size

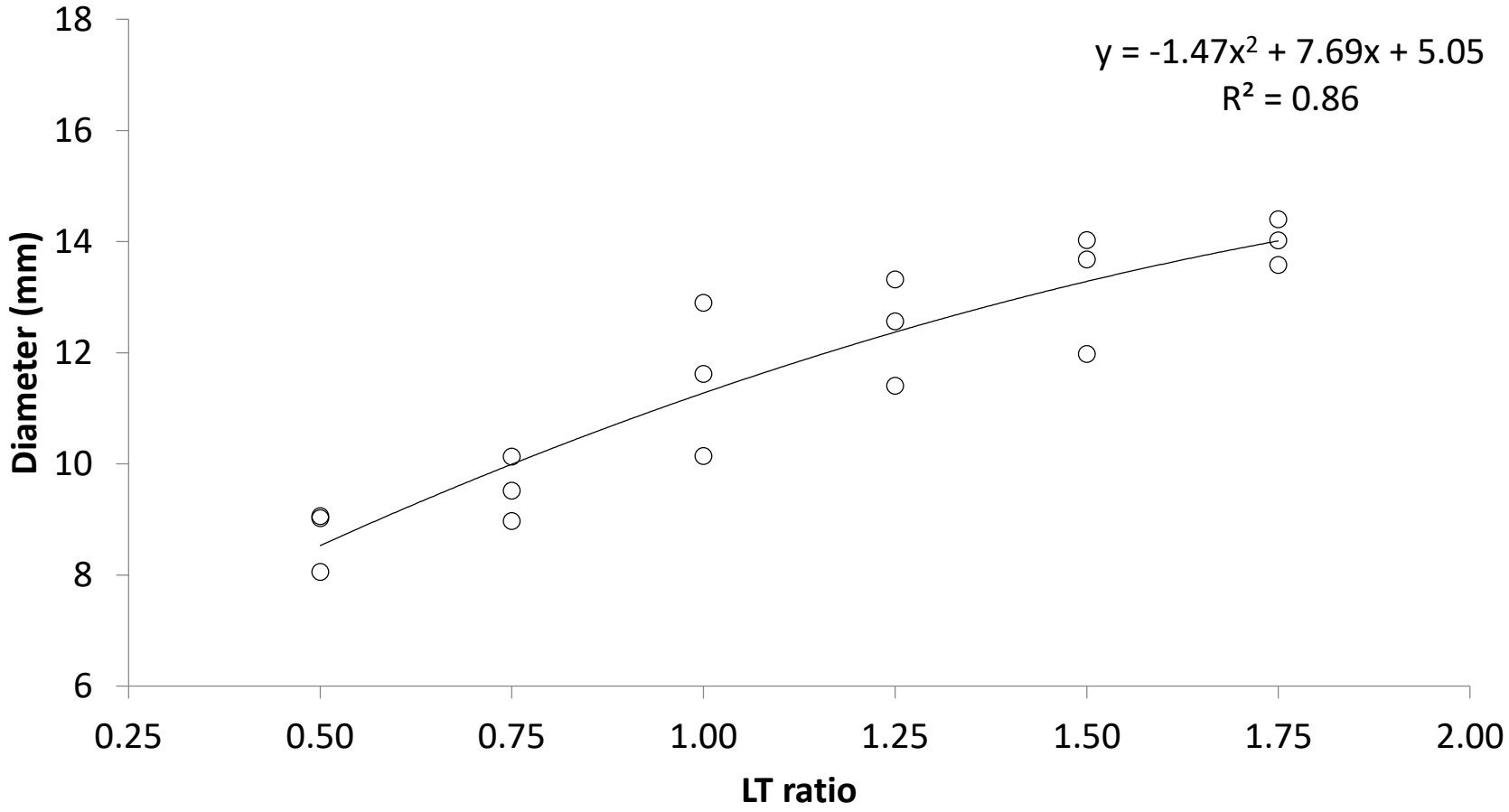


Gala Fruit Size Distribution




Gala Crop Value
(2014 - 2015)
R² = 0.6573
Crop value ($ per tree)
$45
$40
$35
$30
$25
$20
$15
$10
$5
$-
0.25
0.5
0.75
1
1.25
1.5
1.75
2
Pruning severity L:T ratio

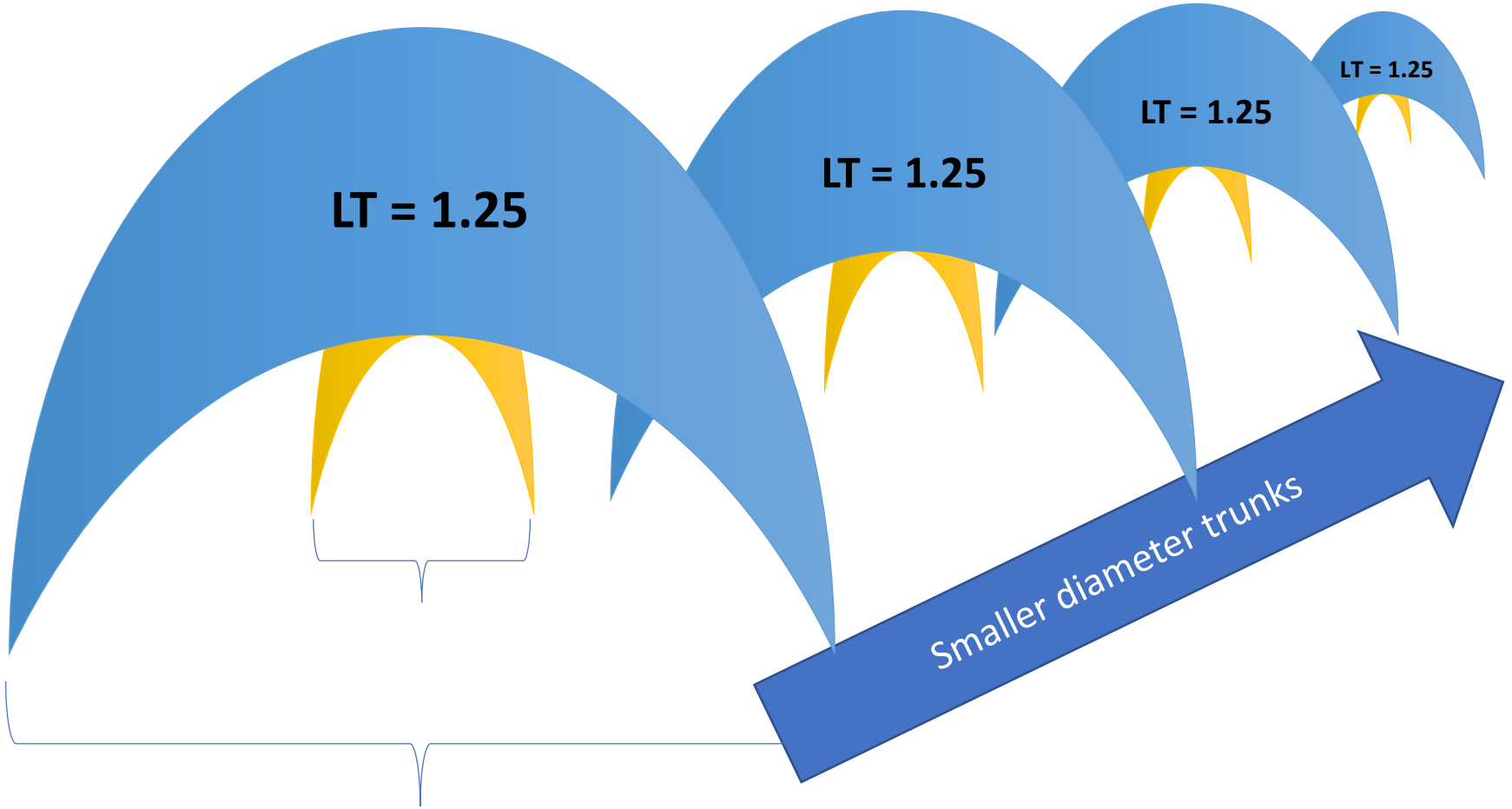
Max remaining limb diameter after pruning



Severity: Max Limb Diameter

- Measure sum[LCSA] / tree and TCSA on ~4 representative trees
- Establish target severity (LT ratio)
- Regression to establish max remaining limb diameter (MD)
- *MD (2013) = -0.87 +0.553 TC + 4.29 LT*
- Then need only measure TC to determine the maximum allowable branch diameter from LT ratio data. Cut off all larger limbs.

MD: Maximum Allowable Branch Diameter

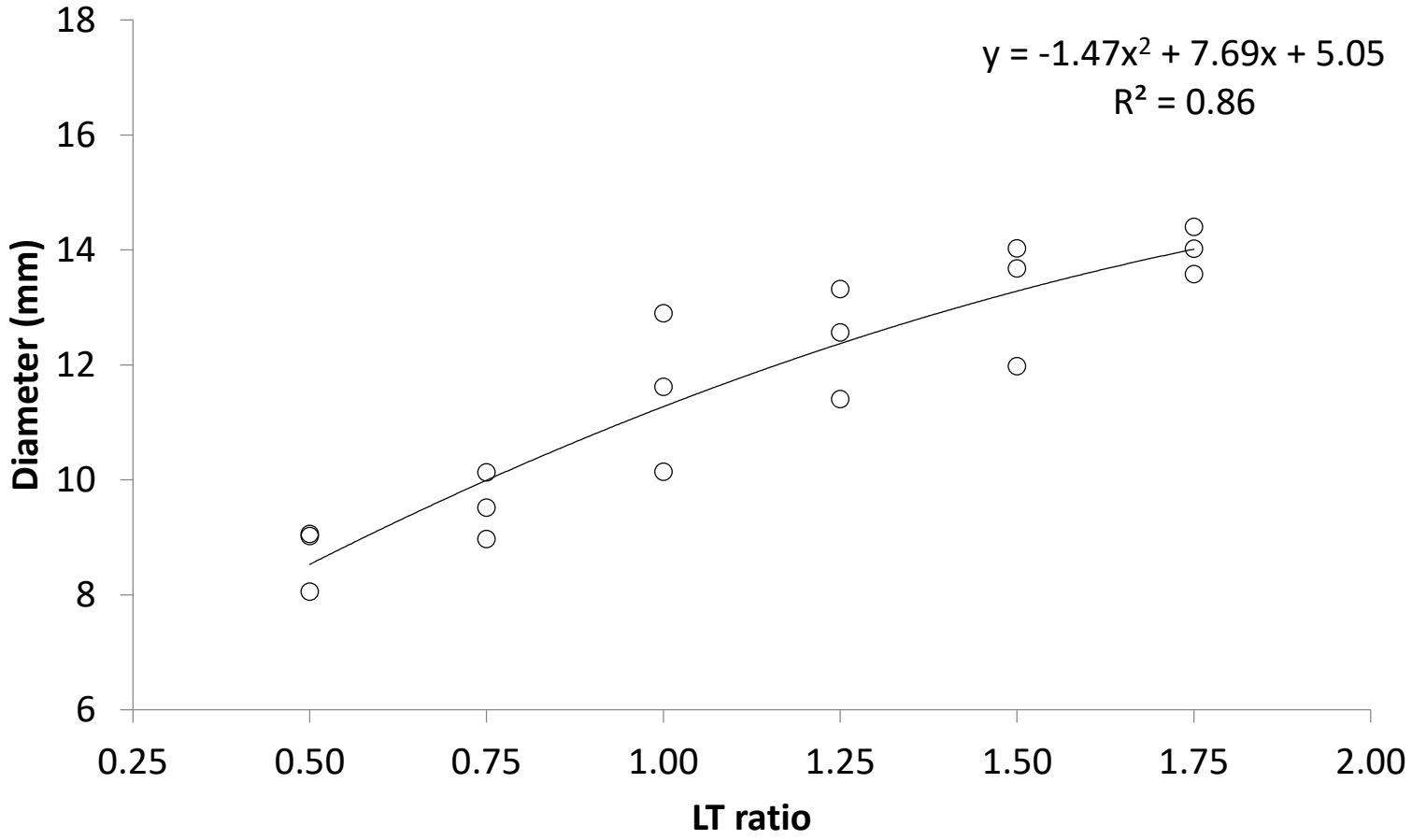


Fuji Pruning Severity Trial

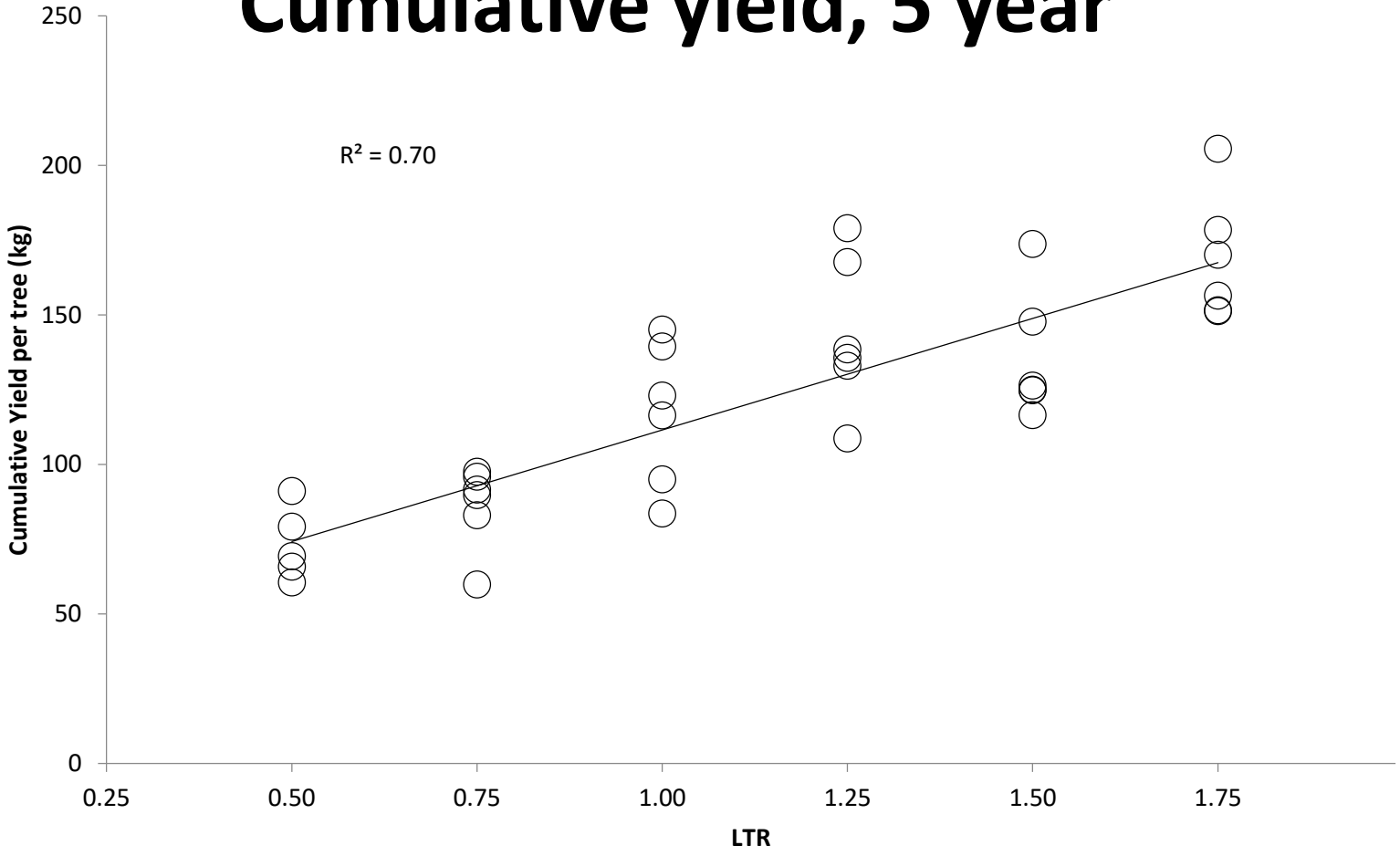
UNPRUNED

PRUNED TO 1.25 LT RATIO

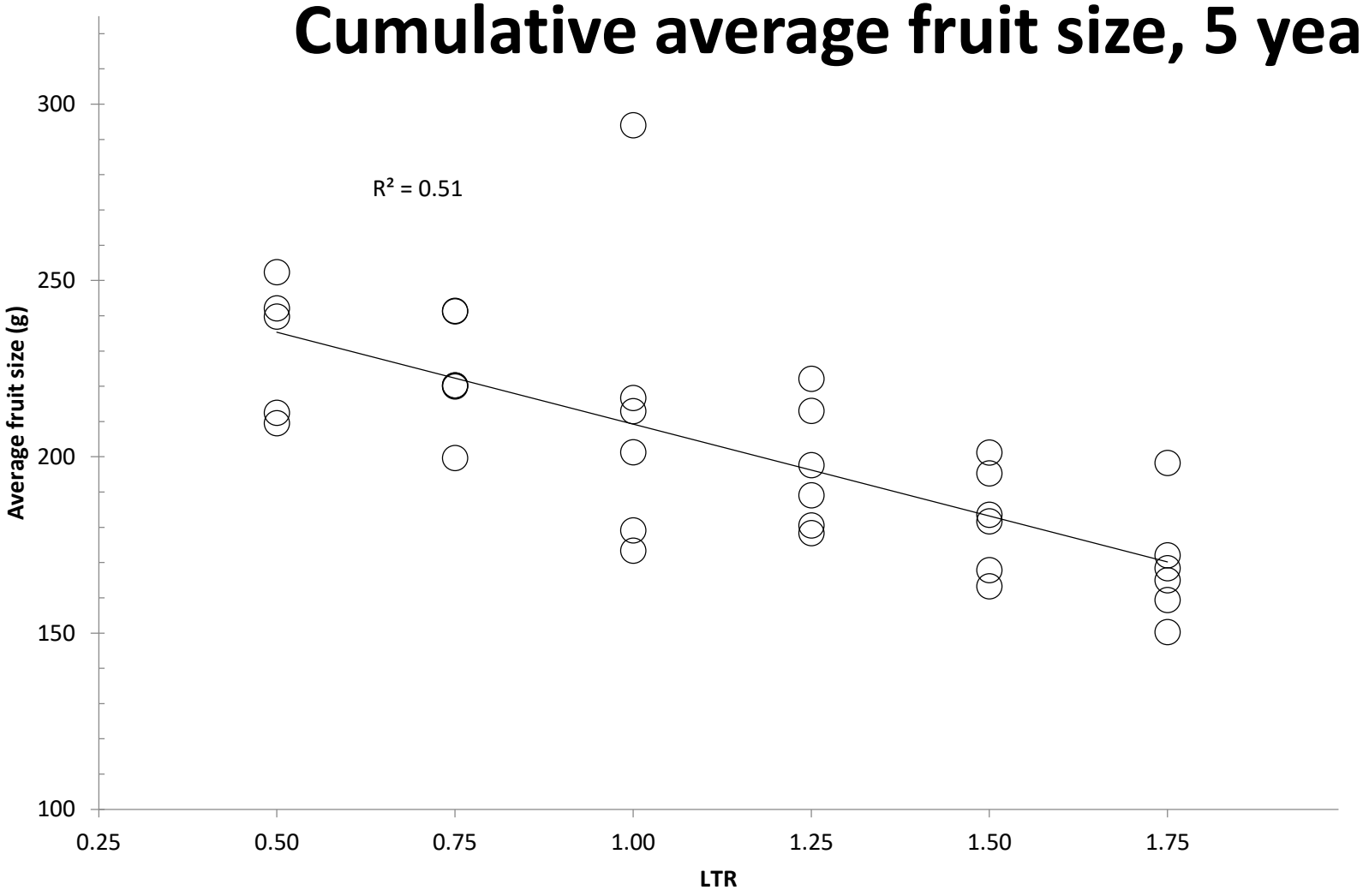
Maximum remaining limb diameter after pruning, 4 year average



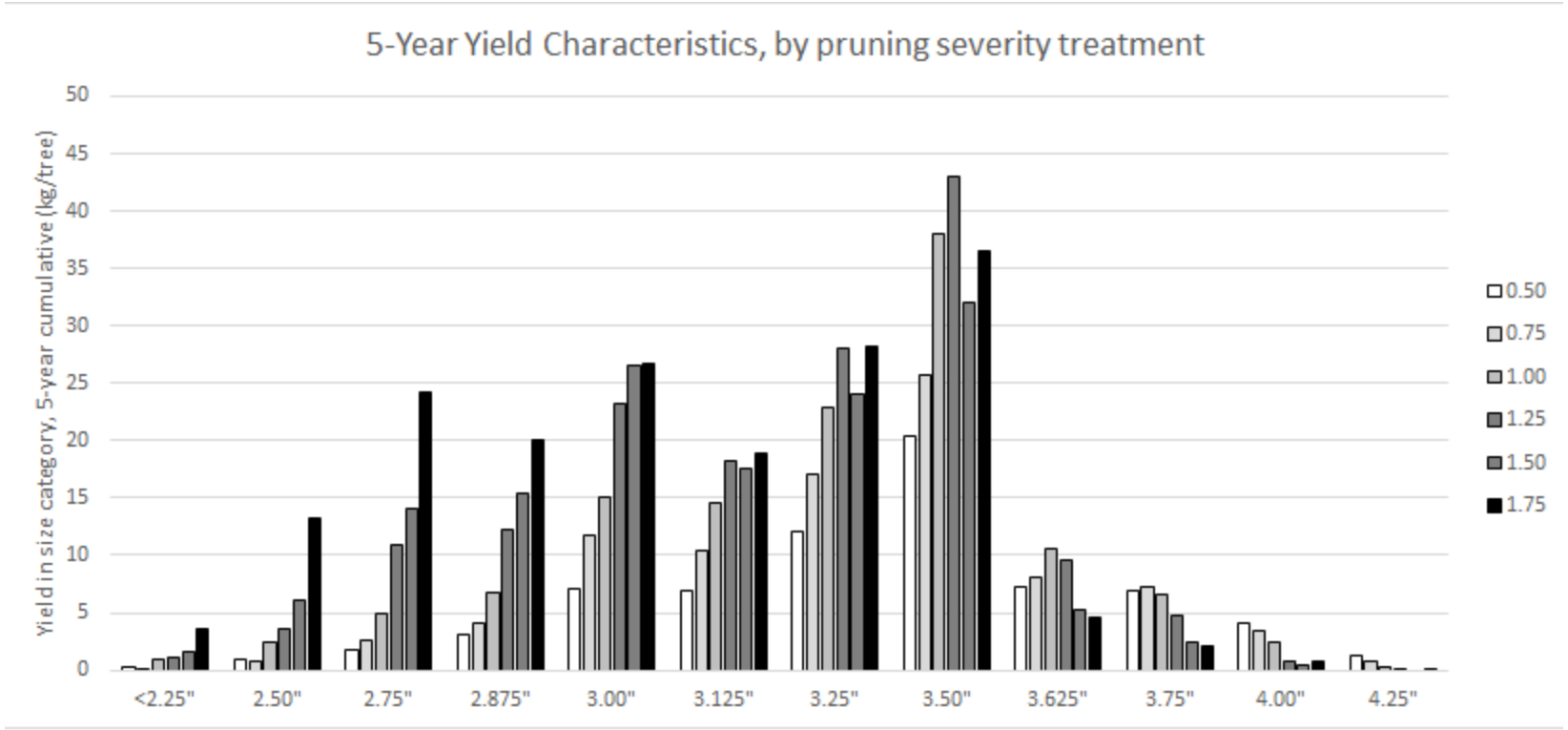
Cumulative yield, 5 year



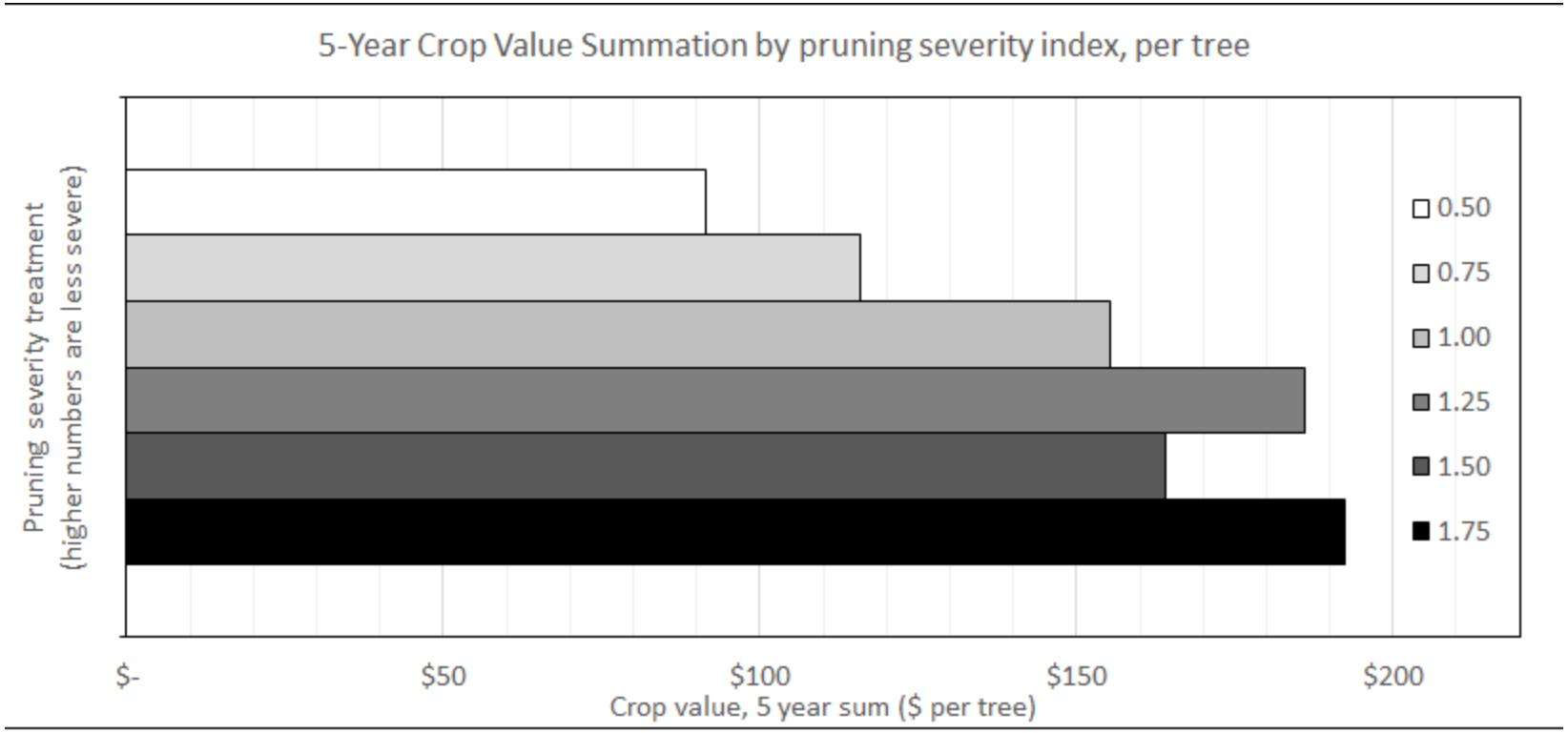
Cumulative average fruit size, 5 year



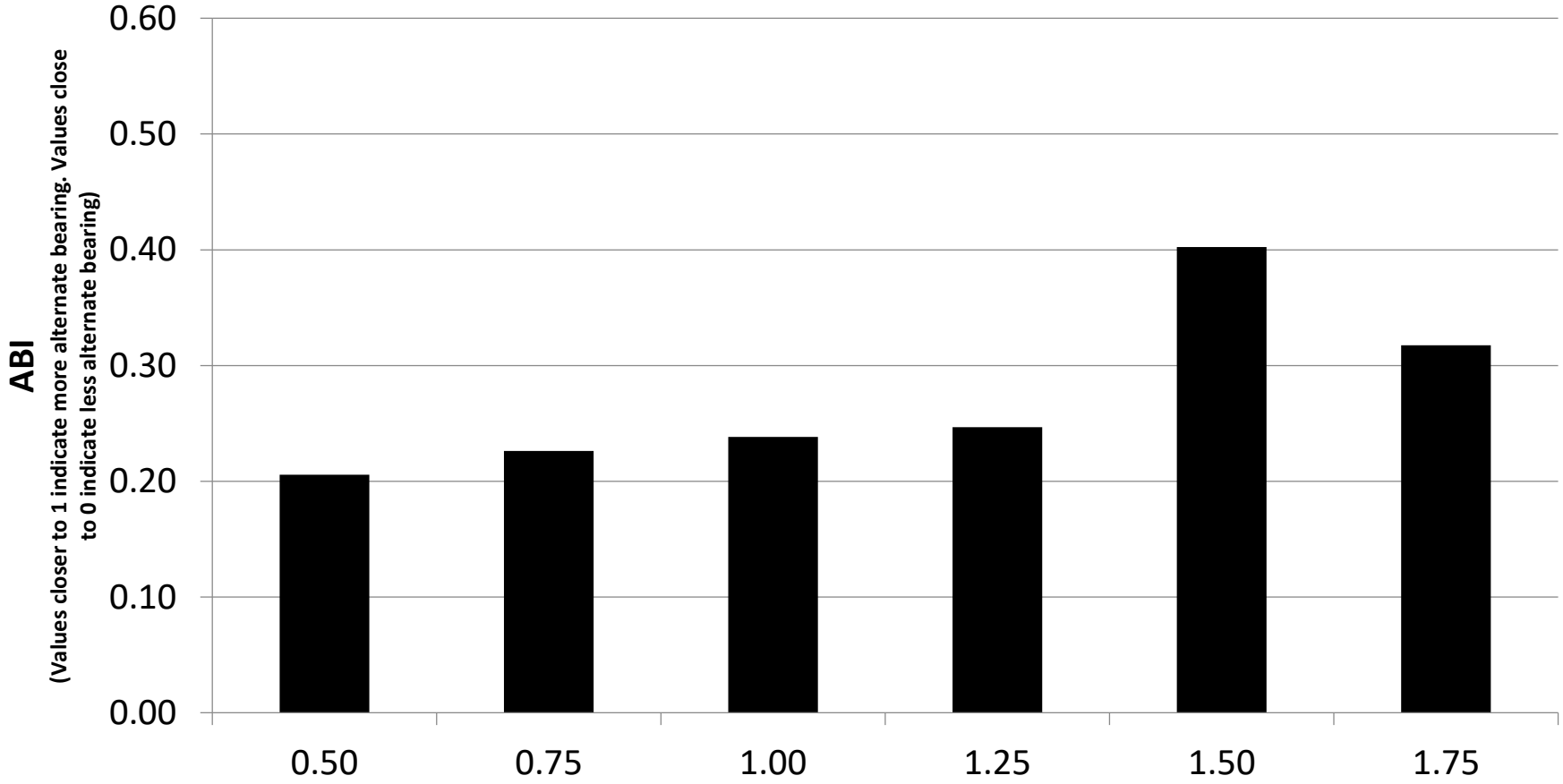
Fuji Fruit Size, 5 Year Average



Fuji Crop Value



Alternate bearing index



MD Method:

- Scan LCSA and TCSA in 4 trees / block
- Set desired severity level (LT)
  - 1.25 produced best yield / large fruit for Gala
- Calculate threshold diameter for largest remaining branch (MD)
  - 12.5 mm = ½ inch
- Prune off everything larger!

On-going Studies: MD Method for Pruning Severity

- LT ratio will change with tree age
  - After full canopy is achieved, does target LCSA become static?
  - TCSA will continue to increase
  - If so: calculate target LCSA per acre
  - Measure trunk of each tree to determine that tree's share of LCSA.

MD Method

- Goal can be adjusted
  - Mgt. goals
  - Site capability
  - Cultivar, etc.
- Simple severity rule for engineers to design automated pruning

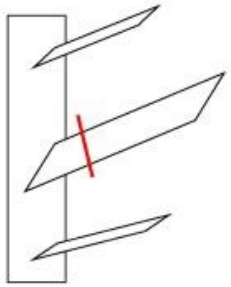
Pruning Rule Orders

1. Remove all >MD limbs with renewal cut
2. Remove all pendant / upright limbs
3. Thin out horizontal limbs to 8 per m
4. Prune each remaining limb to a single axis

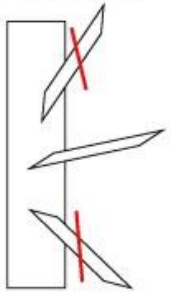
Experimental Pocket Guide

Sequential Pruning Procedures

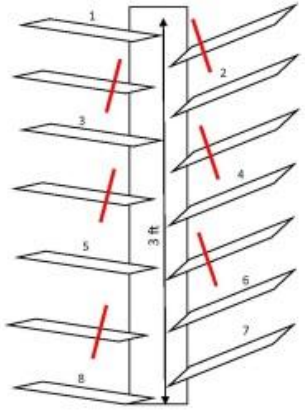
1 Remove all limbs > 1/2 inch diameter with renewal cut



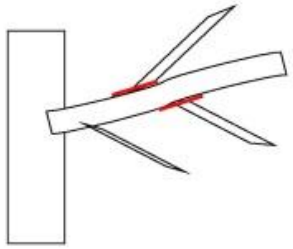
2 Remove all pendant ("hangers") and upright limbs ("risers")



3 Thin out remaining limbs to 8 per 3 ft of leader length

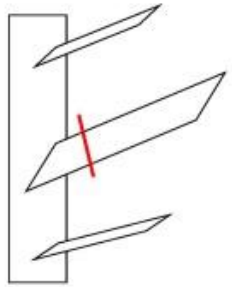


4 Thin out secondary branches on each remaining limb to create a single axis

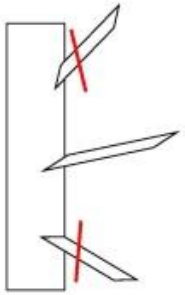


Orden de los Pasos para la Poda

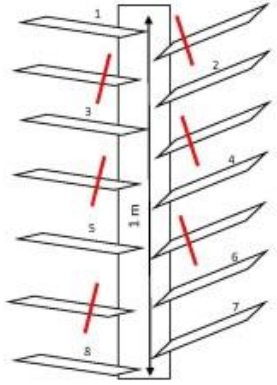
1 Remover todos las ramas de más de 1.25 cm de diámetro con un corte de renovación



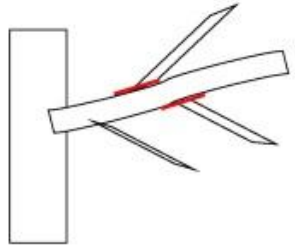
2 Remover todas las ramas colgantes (que crecen hacia abajo) o verticales



3 Entresacar la cantidad de ramas que quedan hasta 8 por cada 1 m de la altura del tronco



4 Entresacar las ramitas secundarias en cada rama que queda para formar un solo eje



Summary: Size Matters

- Goal: to do 70% pruning = 90% benefit
- We can reach this goal with one rule

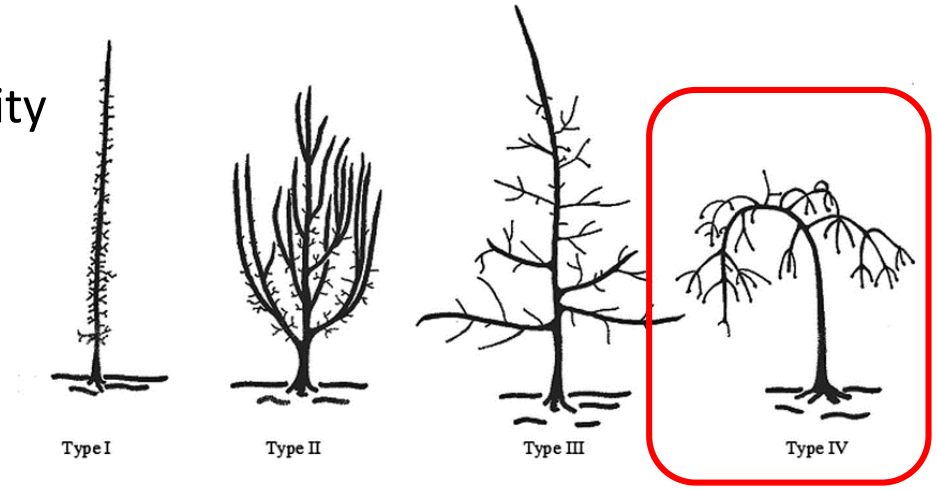
Artificial Spur Extinction (ASE)

- Early season decrease in potential crop load
    - Branch level manipulation
    - Used widely in New Zealand and Australia
        - Followed with hand thinning

1. Early in the season excess fruiting buds (spurs) are removed
    - Around tight cluster or green tip
    - Standard: 6 buds per cm^2 limb cross sectional area (lcsa)
2. All lateral buds stripped from one year old wood

Previous Research on ASE

- Designed to mimic reproductive strategies of type IV apple trees
  - Developed in France
- Currently widely practiced in New Zealand and Australia
  - Examined impacts on multiple varieties
    - Preventing early bearing
    - Decreasing bienniality
    - Fruit quality and storability
  - Follow up hand thinning



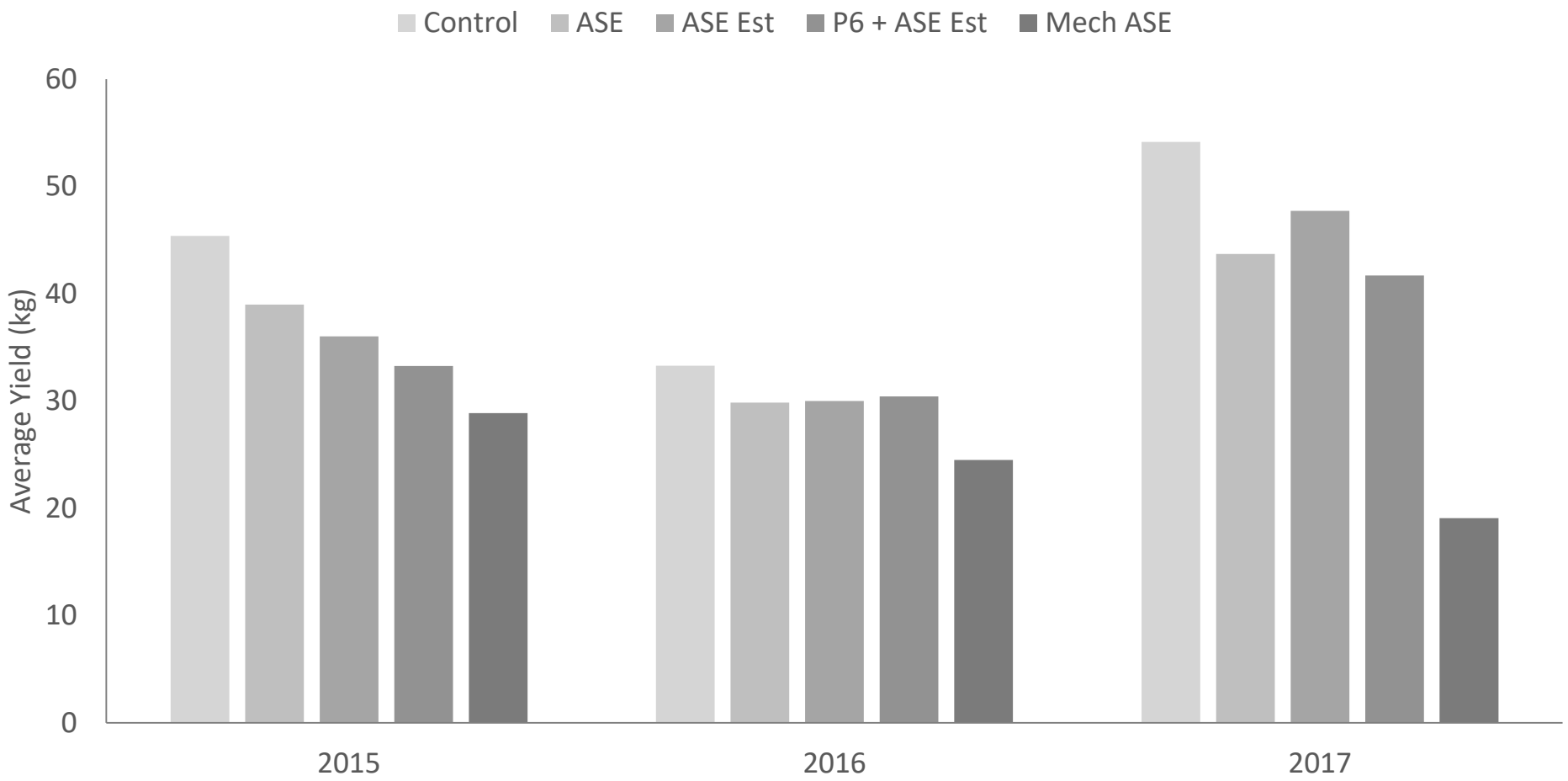
PA Research on ASE

Pennsylvania: focused on implementation methods

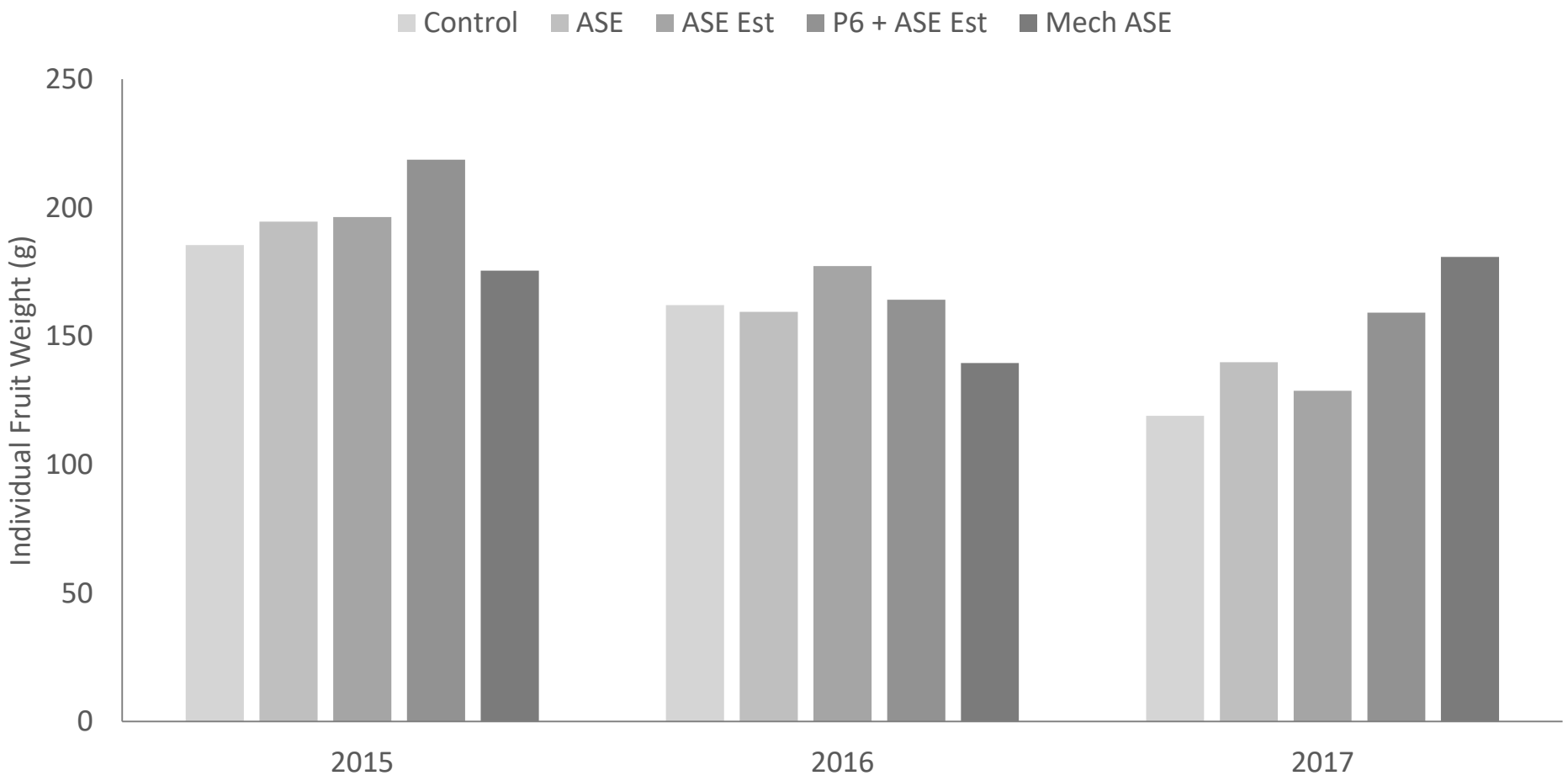
- Traditional ASE using the Equili-fruit disc
- Estimated ASE
- ASE in combination with pruning to 6 limbs/m canopy
  - New Zealand
- Mechanical ASE using string thinner

Kon, T.M.

Golden Delicious: Yield



Golden Delicious: Fruit Size

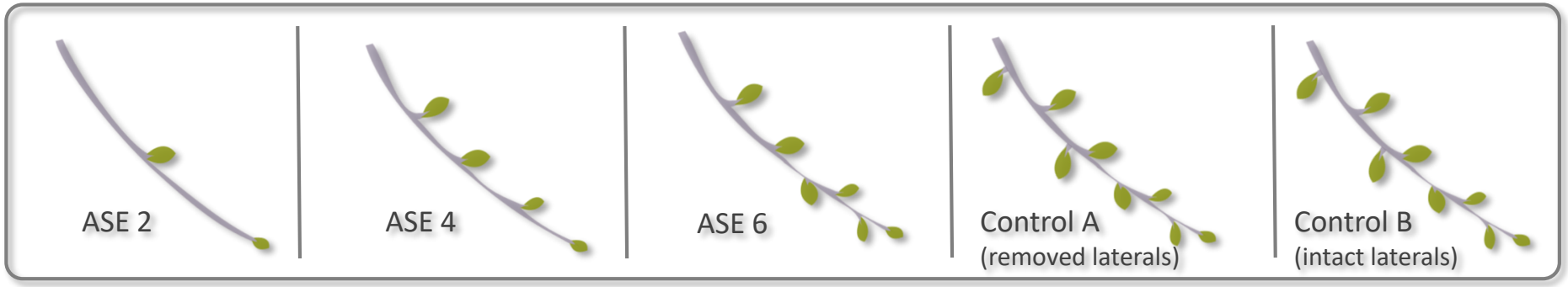


Golden Delicious: Conclusions and next steps

- No discernible trend
  - Fruit size and yield weren't improved reliably by any treatment
- Standard (6 buds/cm^2 lcsa) is not low enough for Pennsylvania climates
- Determine if a level of spur extinction can produce ideal fruit size and quality in Pennsylvania Orchards
  - Achieving ideal crop load
  - Maximizing crop value
  - 'Gala'

Artificial Spur Extinction: Intensity

- Mature ‘Crimson Gala’ apple trees
  - Trained to tall spindle
- Thinned in mid march
  - At or before green tip
  - 5 treatment groups
    - ASE2, ASE4, ASE6
    - Control A (removed laterals), Control B (intact laterals)



ASE 2

ASE 4

ASE 6

Control

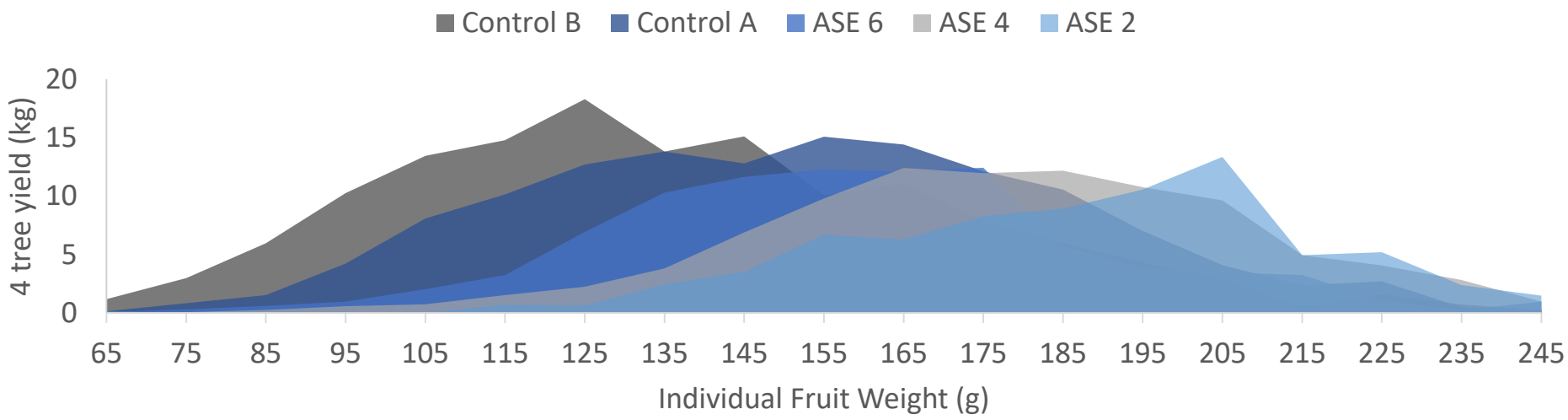
(4 trees per treatment)
Two seasons of data

Environmental Variability

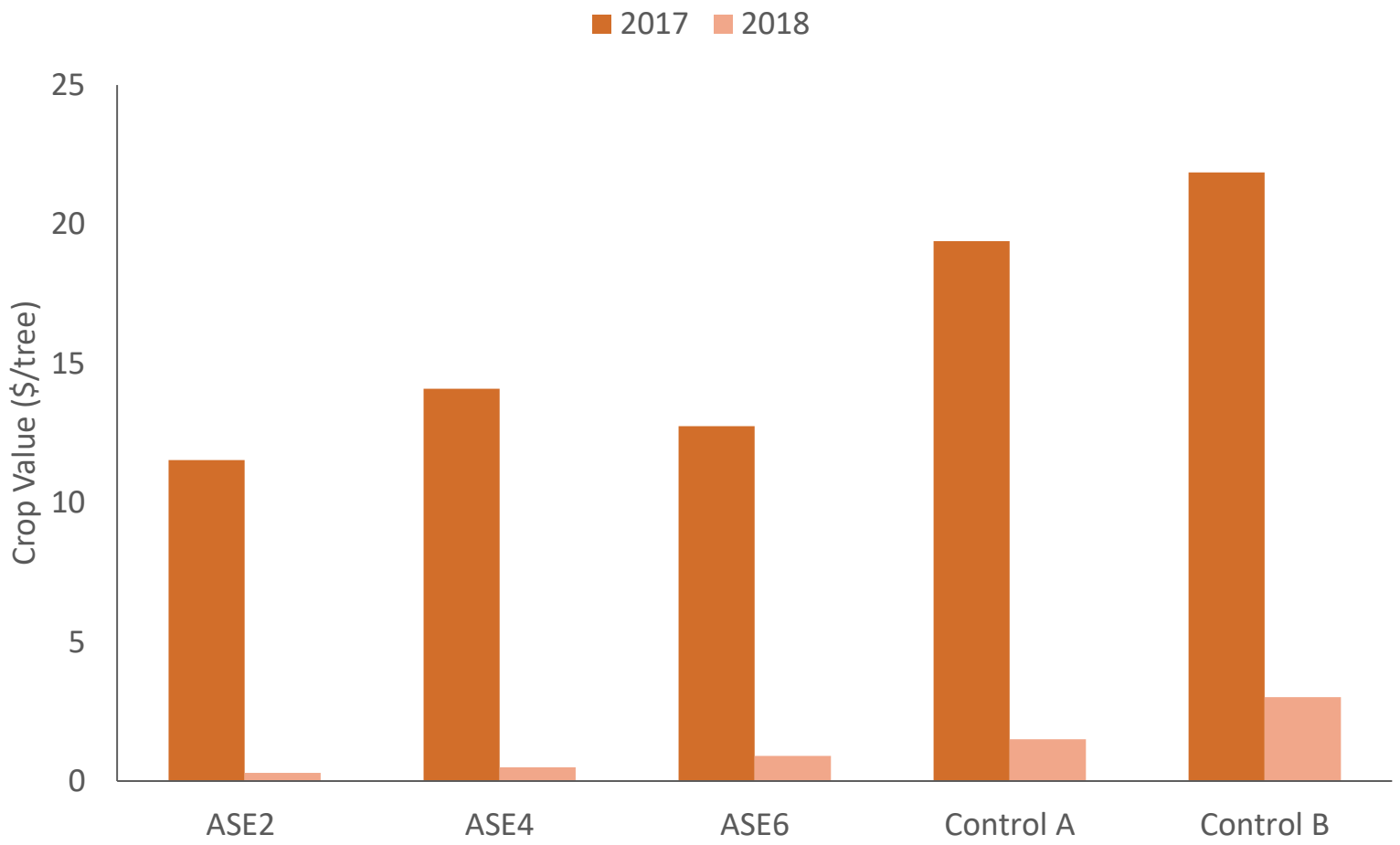
Hail event in 2018

- Petal fall
- Physical damage caused low fruit set

Yield Distribution:



Crop Value


2017
2018
25
20
15
10
5
0
Crop Value ($/tree)
ASE2
ASE4
ASE6
Control A
Control B

ASE Conclusions

- Current results
  - Not as promising as in the southern hemisphere
    - Lack of follow-up thinning?
    - Climate Differences
  - Risk associated with early thinning
  - Not recommended for Mid-Atlantic growers

Thank you
- State Horticultural Association of Pennsylvania
- Penn State FREC