



Pruning Automation

AUTOMATION OF DORMANT PRUNING OF SPECIALTY CROPS

Pruning by the Numbers

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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 Std.
- ⦿ Productive, quality
- ⦿ Common canopy features
- ⦿ Minimal branching
- ⦿ One simple target



Pruning Studies PSU, 2013 - 2015:

- ◎ Establish and confirm pruning rules
- ◎ **Pruning Severity**
- ◎ Pruning rule orders
- ◎ Outcomes
 - Define target(s) for Engineers
 - Refine manual pruning



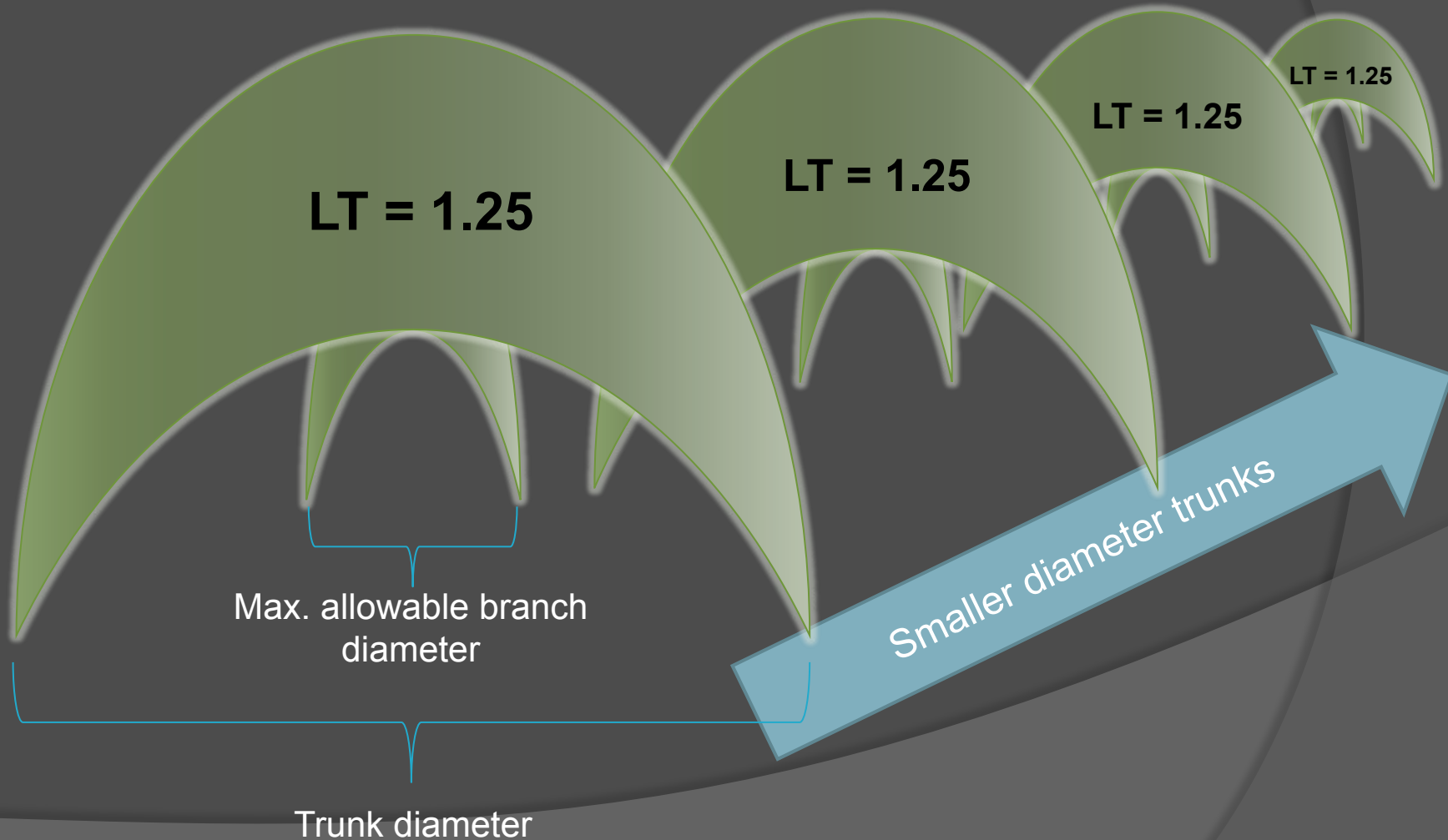
Severity: LT Ratio Approach

- Measure diameter of each limb on tree
- Measure the trunk diameter at 30 cm
- Calculate sum [LCSA] and TCSA.
- Choose desired LT ratio.
- Prune largest successive limbs to desired LT ratio.

Severity: Max Limb Diameter Approach

- 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



2013 Fuji Trial 5th leaf 'Brak'

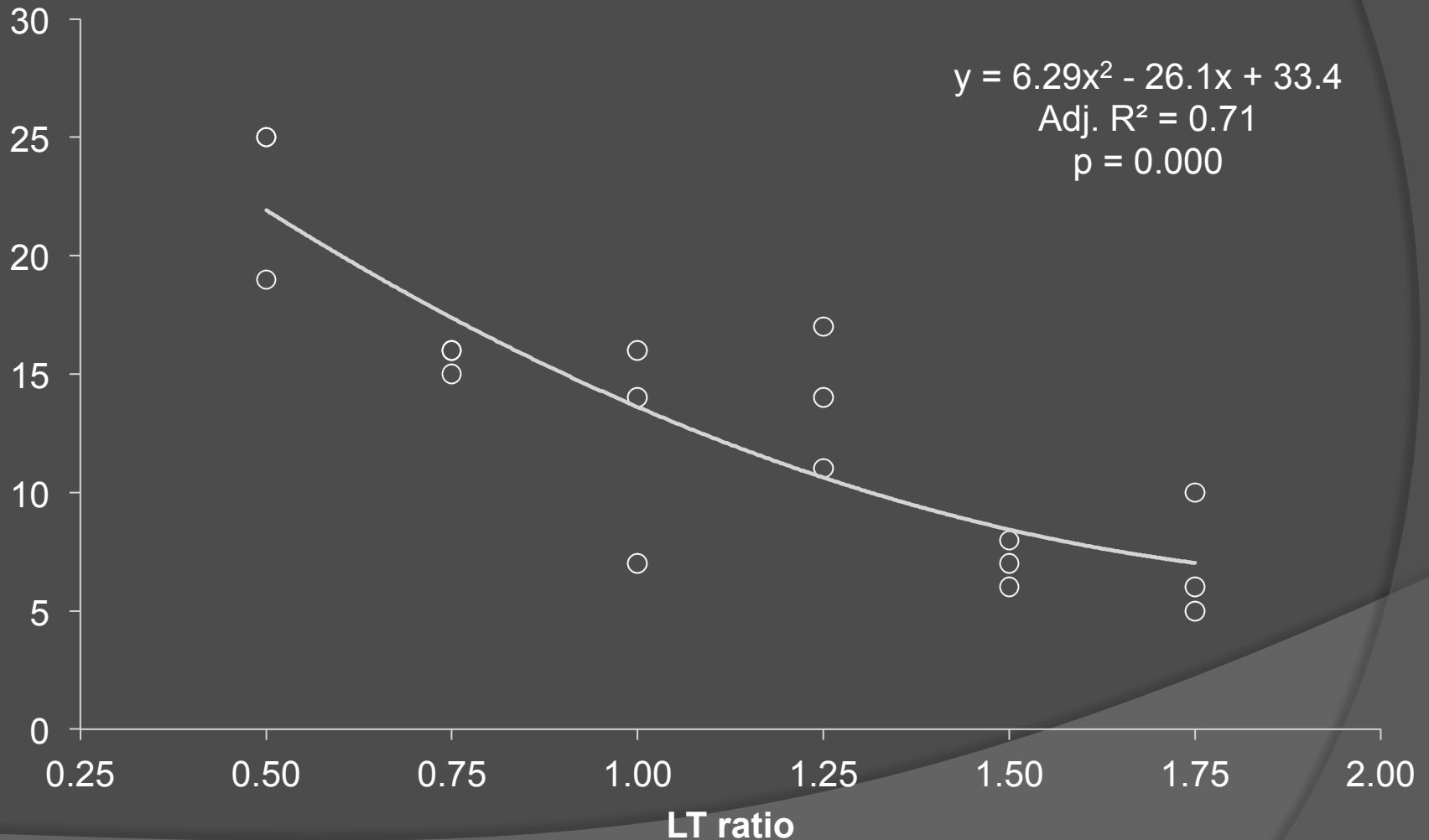


UNPRUNED

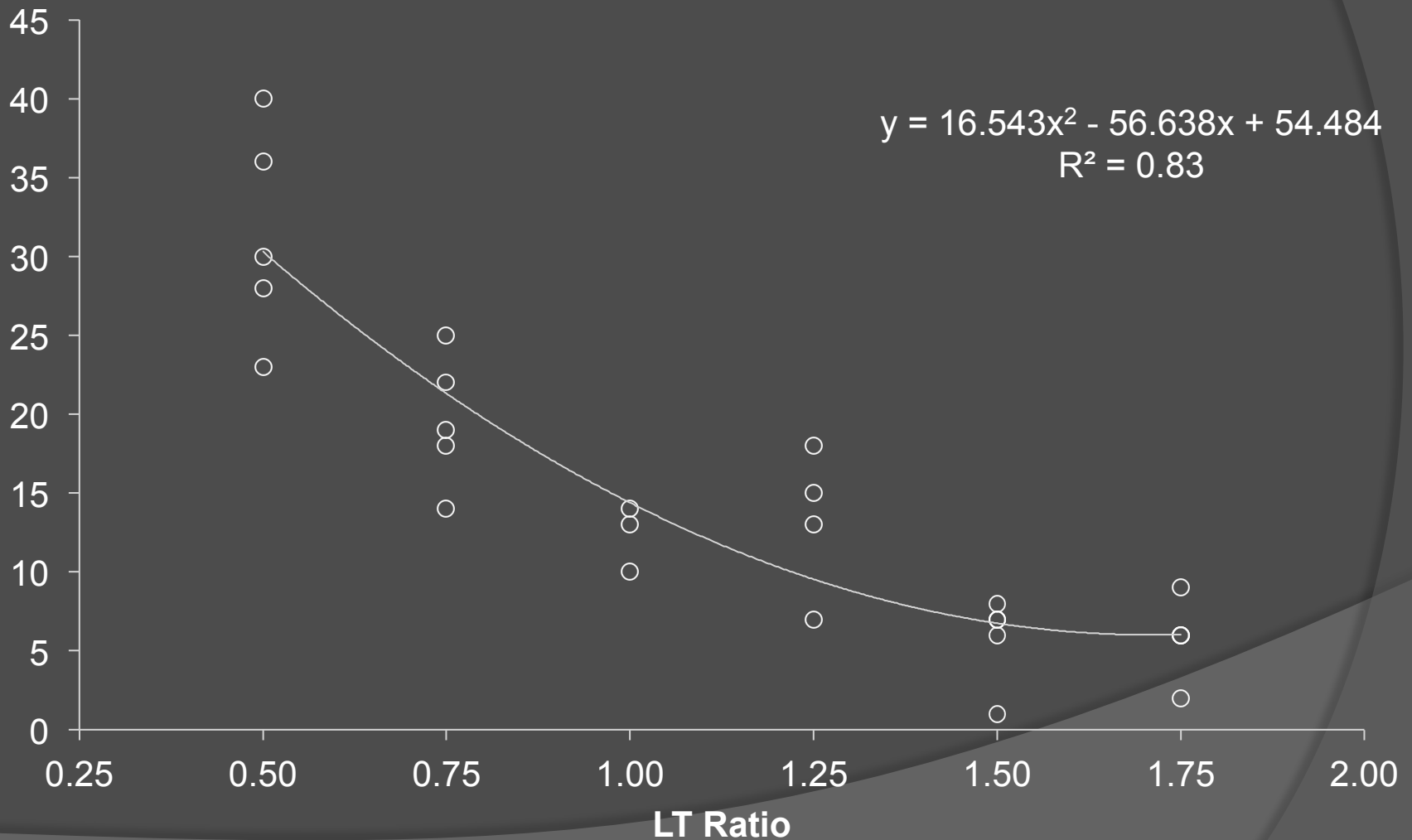


PRUNED TO 1.25 LT RATIO

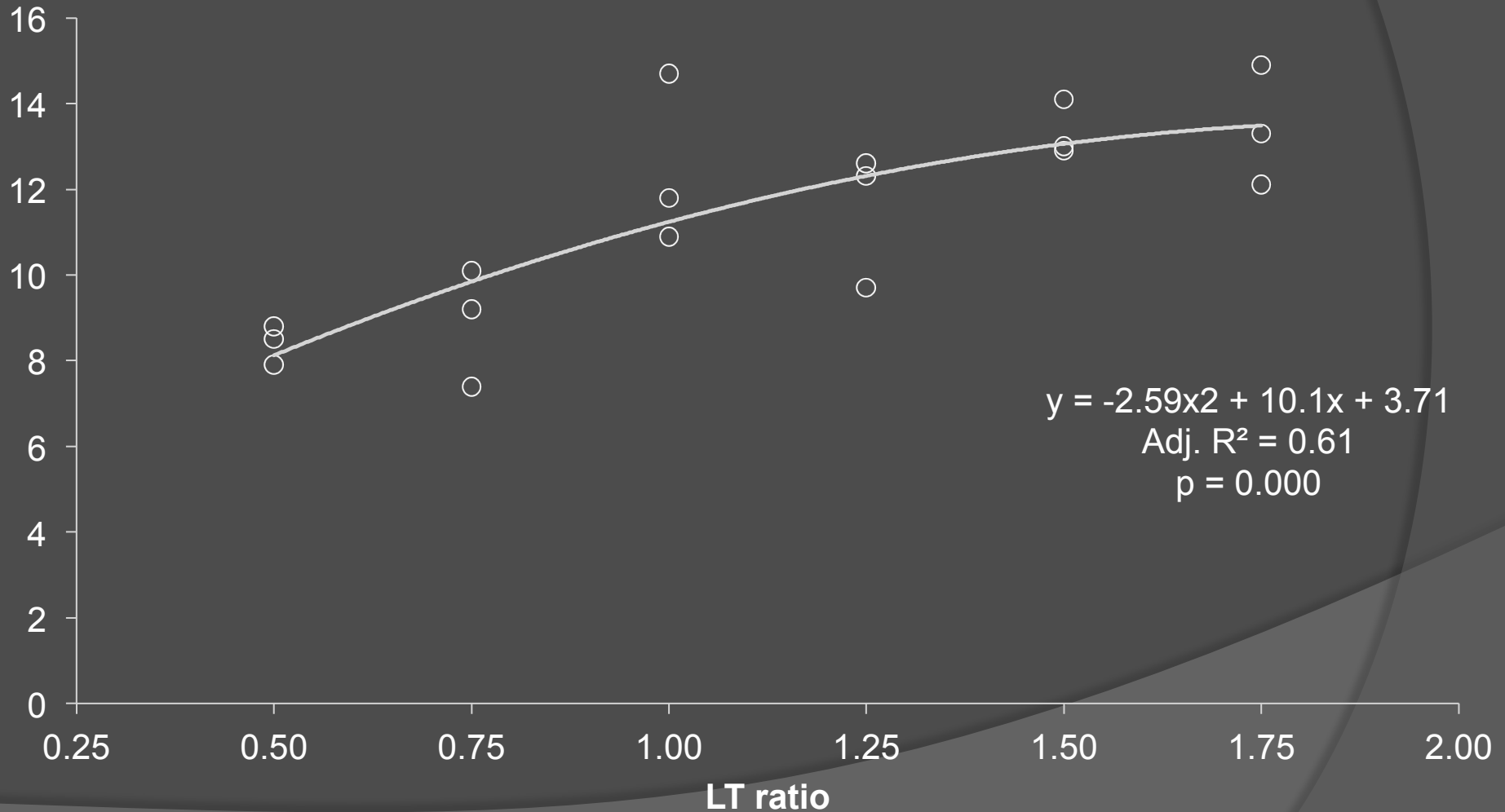
No. Limbs Removed / Tree, 2013



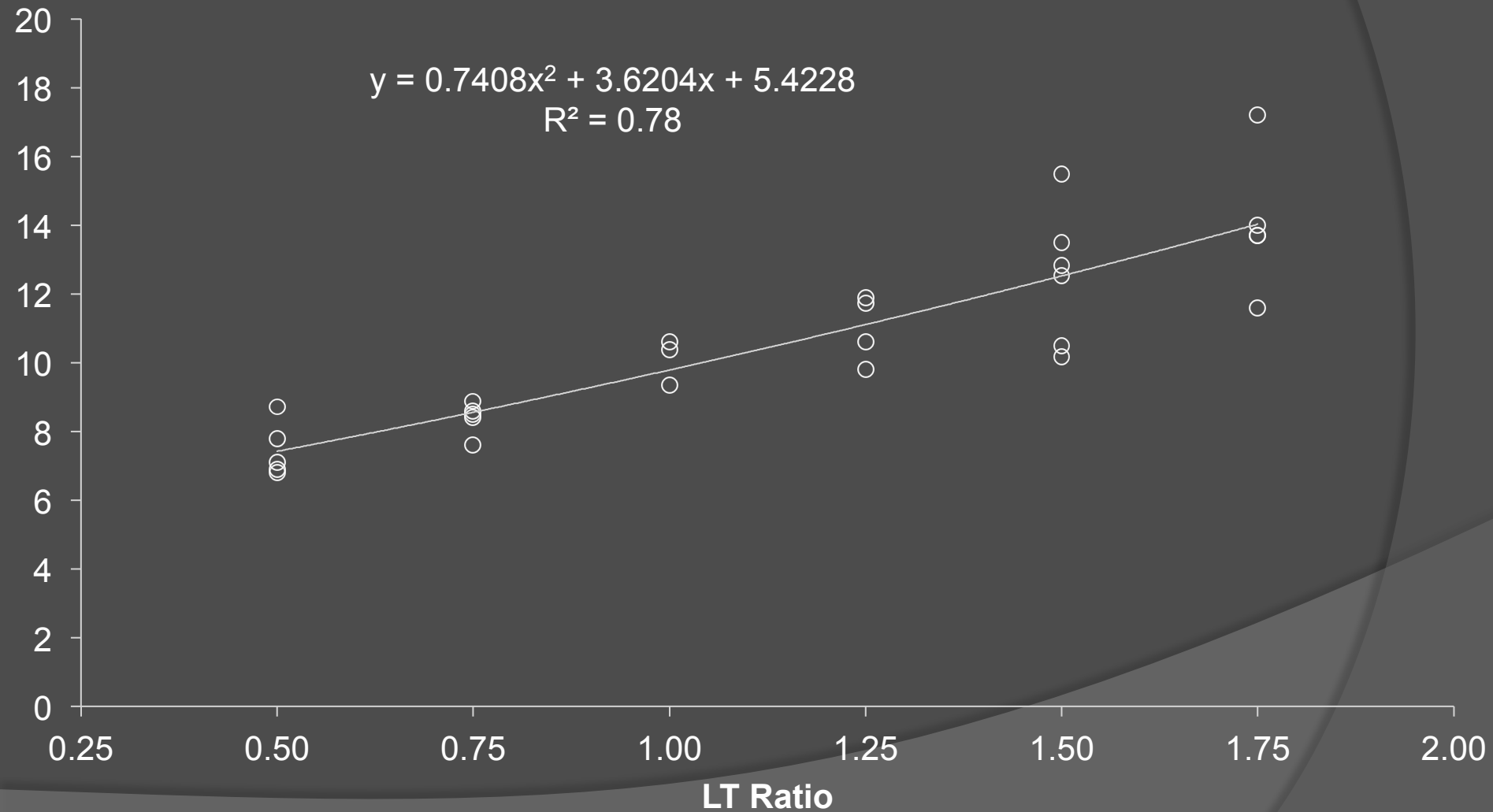
No. Limbs Removed / Tree, 2014



Maximum Remaining Limb Dia., 2013



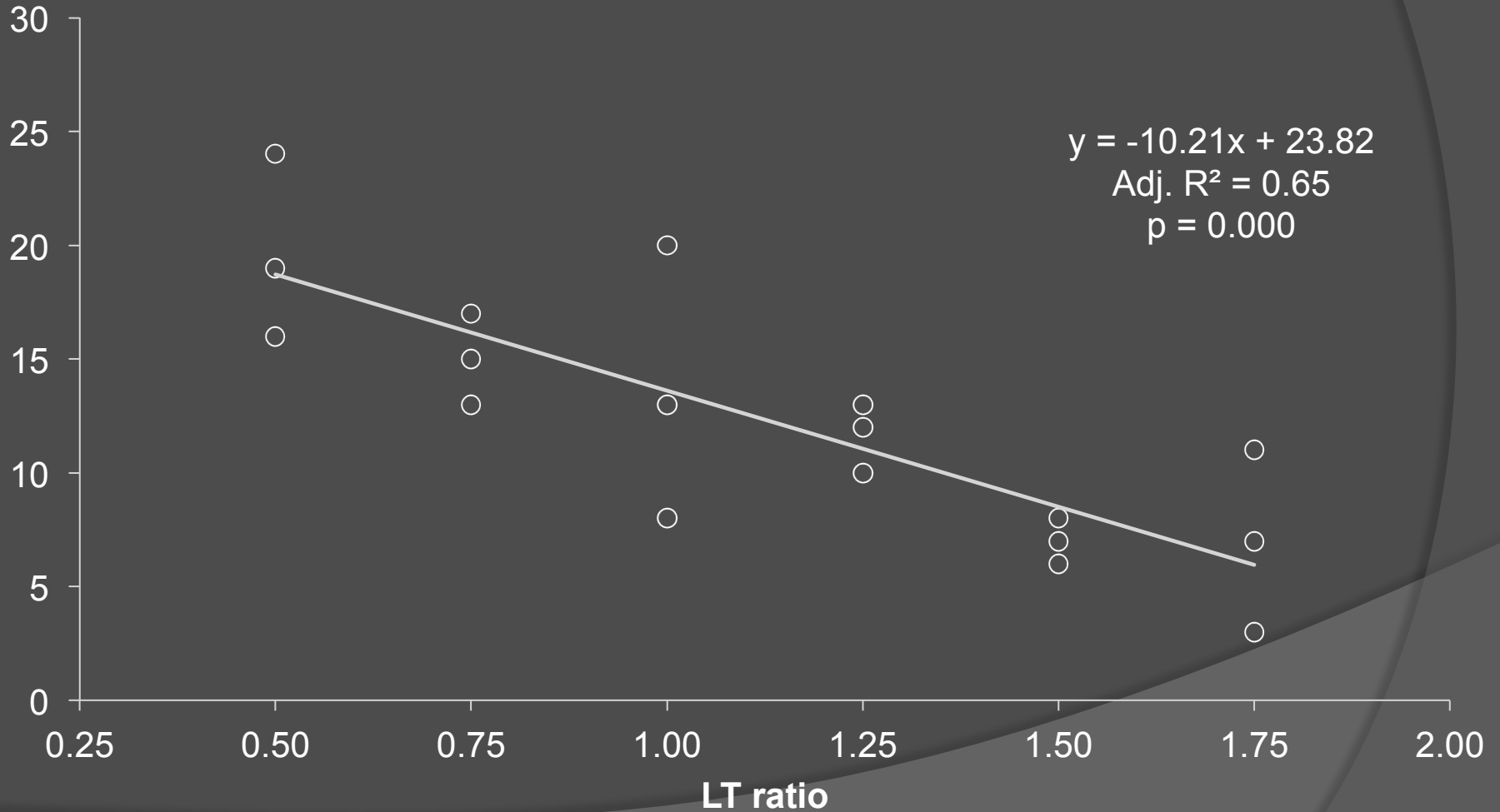
Maximum Remaining Limb Dia., 2014



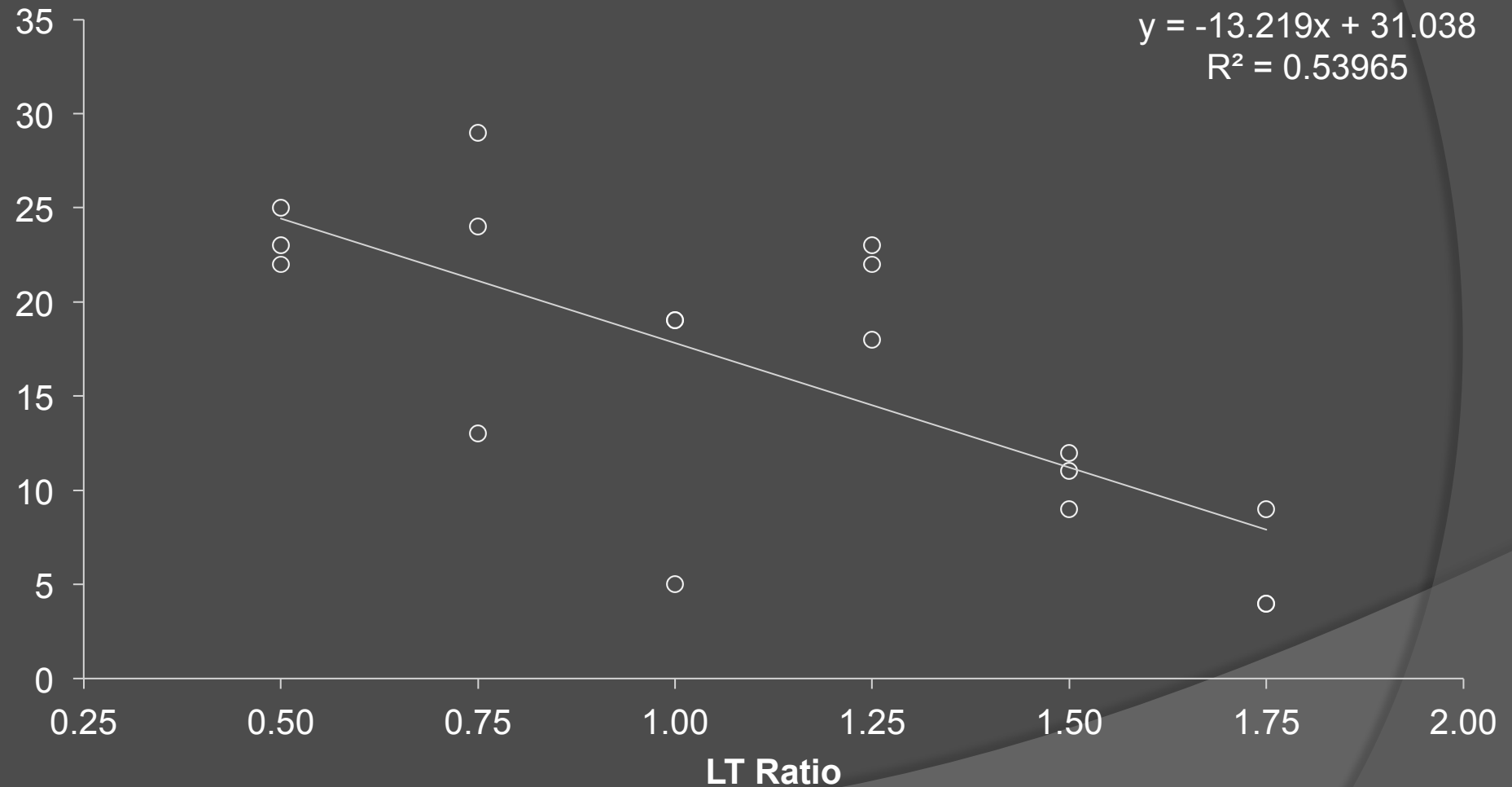
Renewal Cut / Shoot



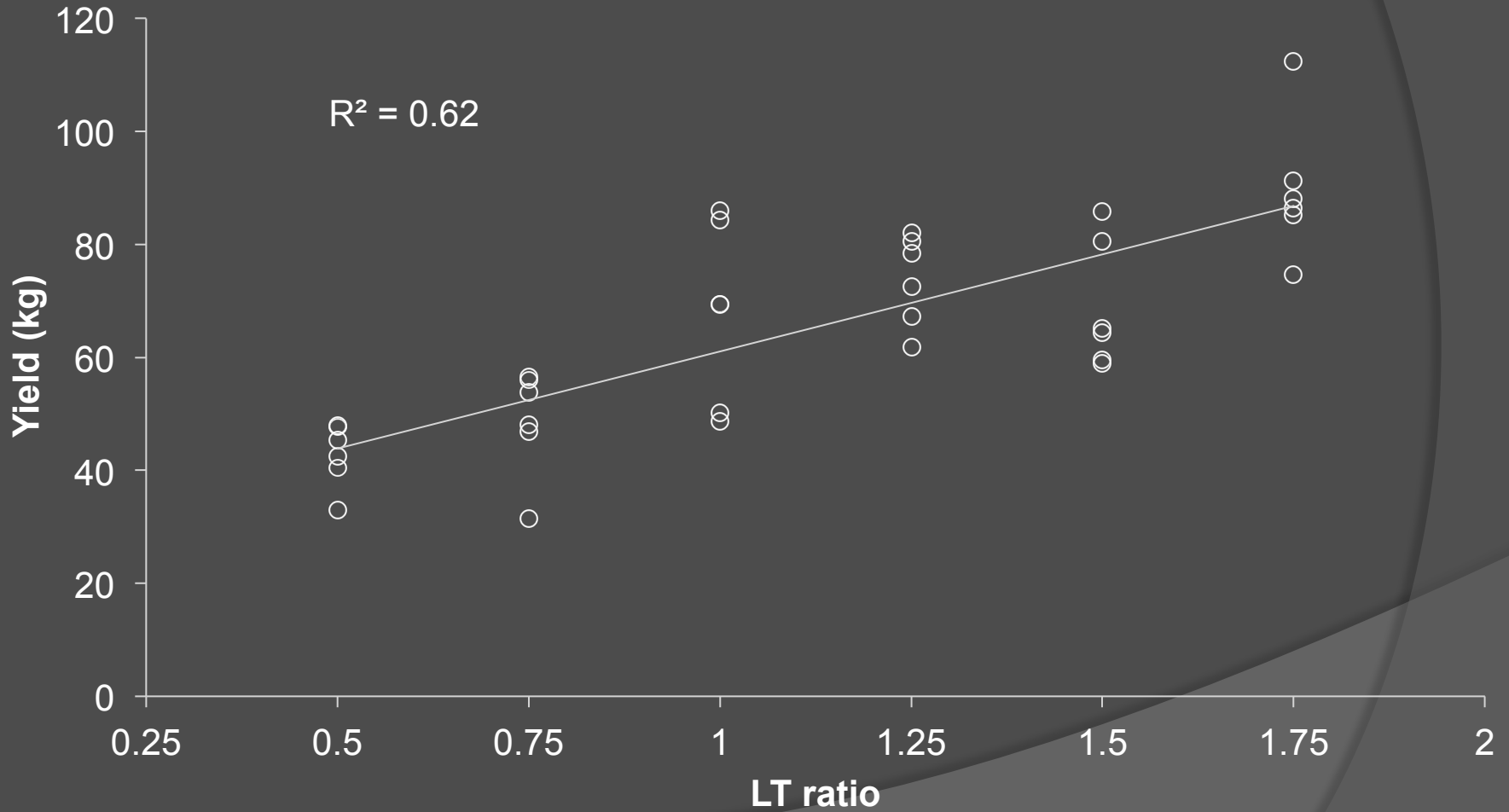
Renewal Shoots / Tree, 2013



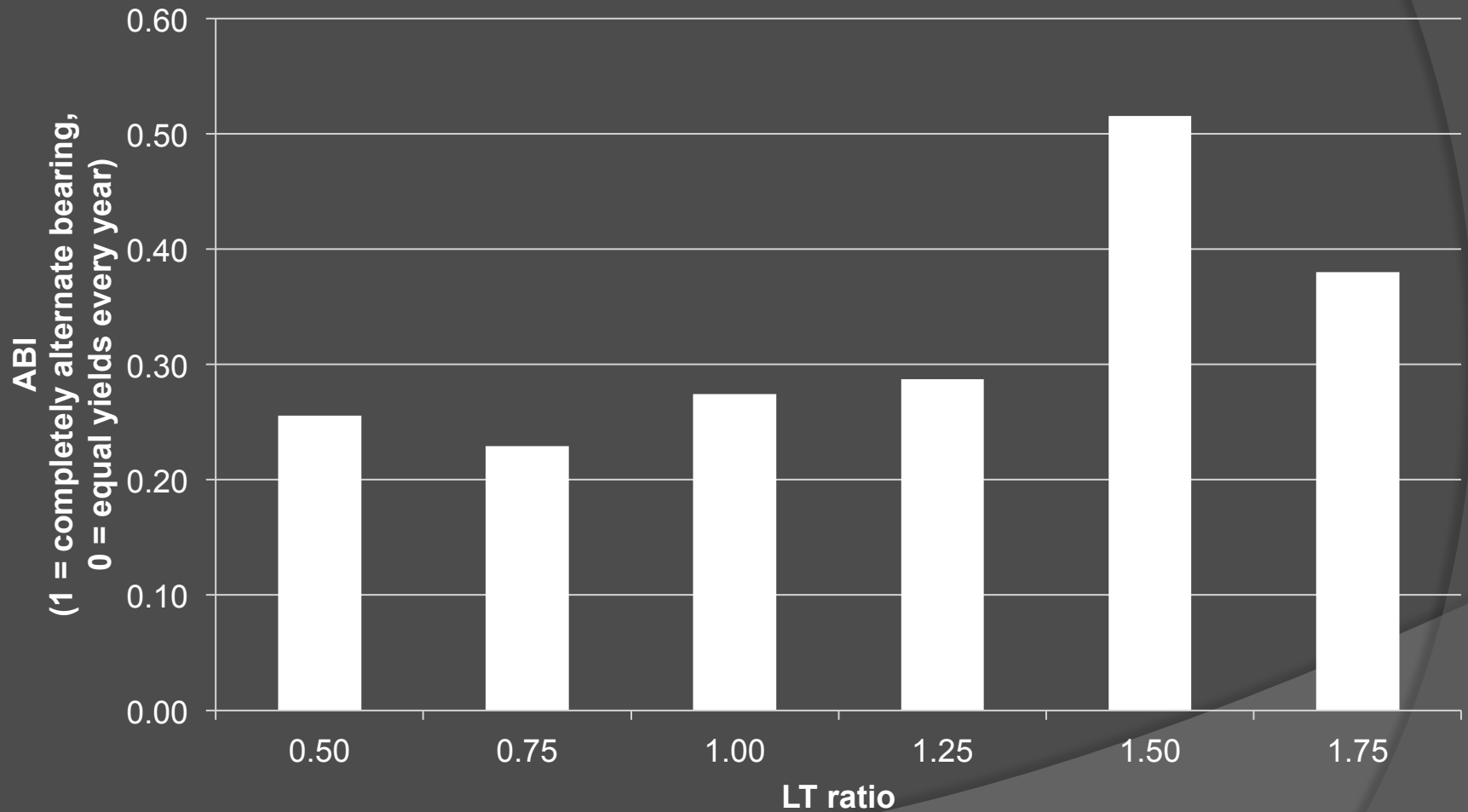
Renewal Shoots / Tree, 2014



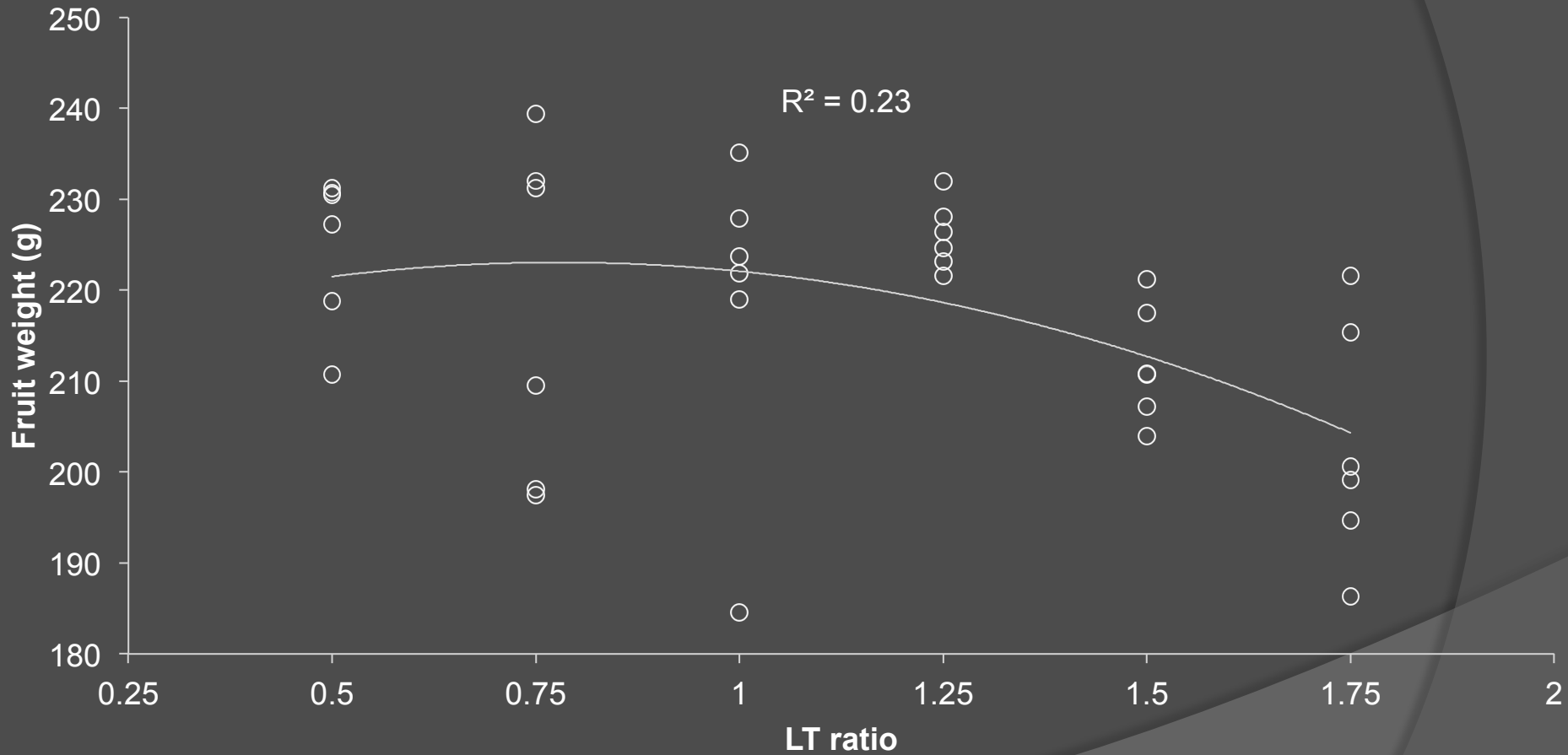
Yield per tree, cumulative 3-year



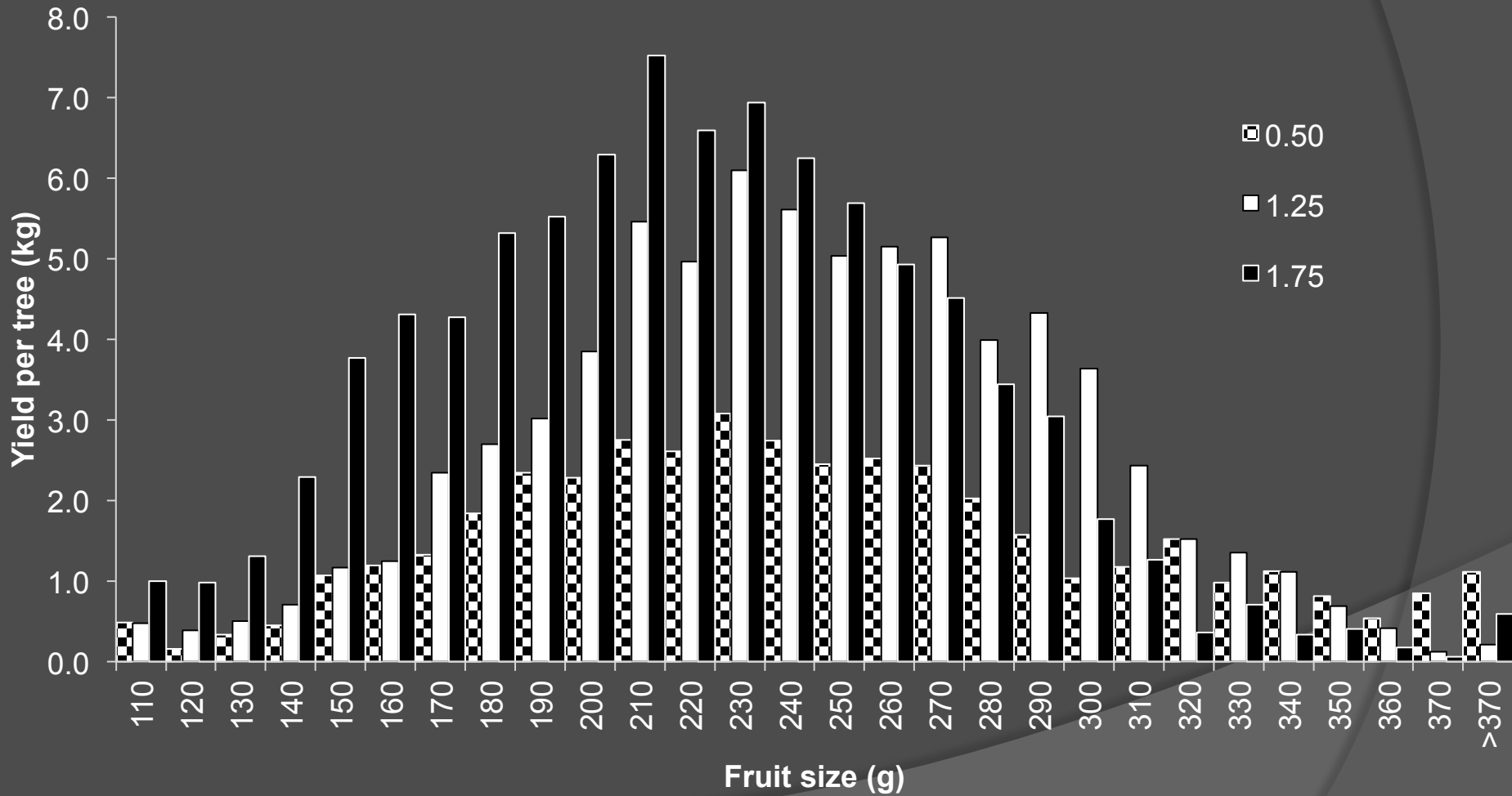
Alternate bearing index



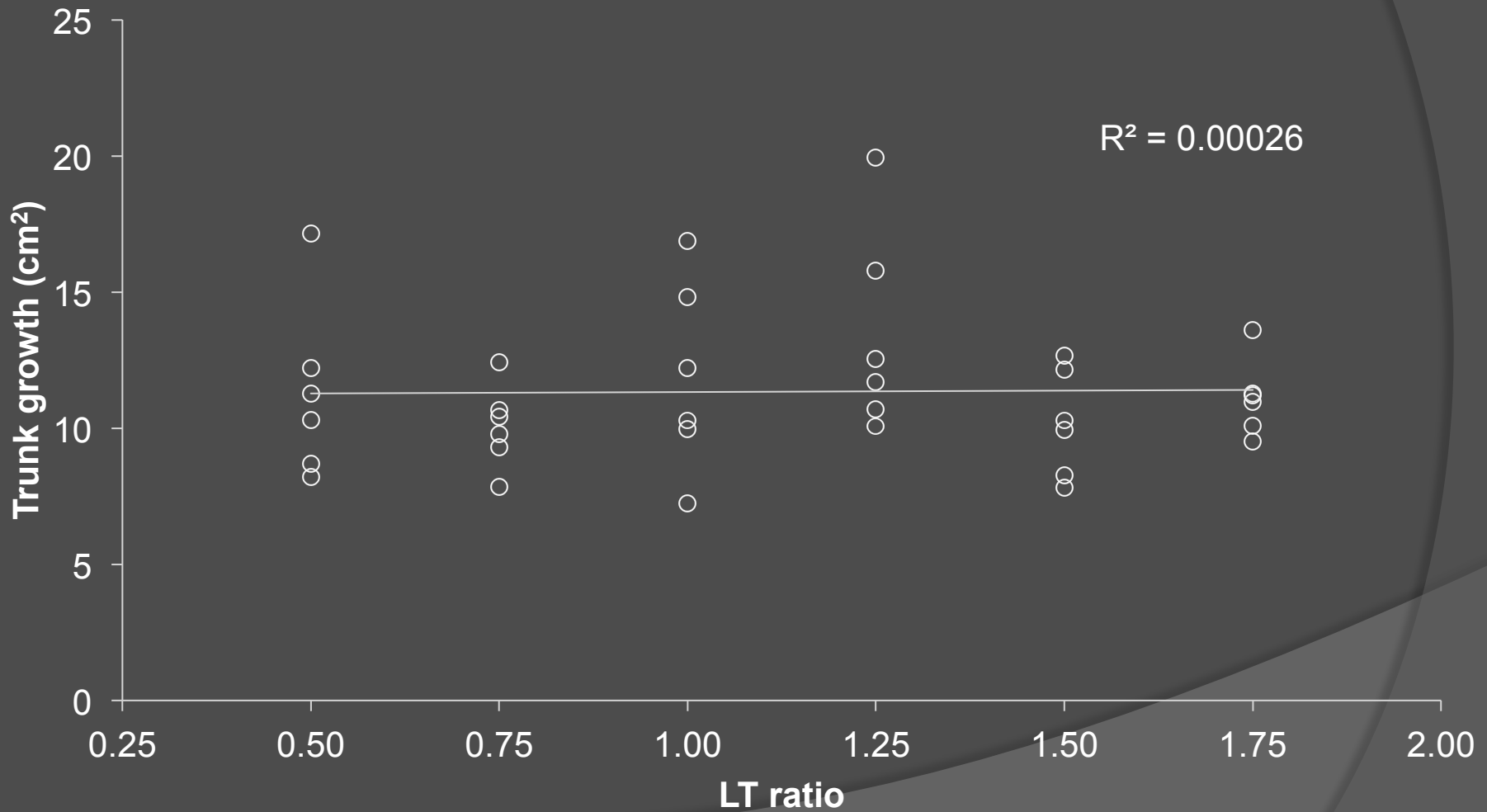
Average fruit weight, cumulative



Fruit Size Distribution, Cum.



Trunk growth, cumulative 2013-2015



Summary

- ⦿ **LT ratio worked well for setting severity**
- ⦿ **Removing next largest branch to threshold is $\sim 3/4$ of the required pruning**
- ⦿ **Max L diameter worked better!**
 - “Smoothing” the input data?
 - Easily taught to laborers
- ⦿ **Simple Severity Rule for Engineers**

MD Method:

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

MD Method of Pruning Severity

- ◎ Note: LT ratio will change with tree age
 - After full canopy is achieved, target LCSA will remain static (renewal pruning)
 - TCSA will continue to increase
 - calculate target LCSA per acre
 - Measure trunk of each tree to determine that tree's share of LCSA.



Mature Tree MD Example



- Goal: 150,000 fruits/ A on 1210 TPA
- 6 fruits / LCSA = 25k LCSA / A
- ~21 cm² LCSA / tree
 - Adjust LCSA + / - based upon TCSA(?)
- Goal can be adjusted
 - Mgt. goals
 - Site capability
 - Cultivar, etc.

Pruning Rule Orders

1. Remove all >MD limbs with renewal cut
2. Remove all pendant / upright limbs
3. Thin out horizontal limbs to 8-9 per m
4. Prune each remaining limb to a single horizontal axis.



Summary: Size Matters

- Goal: to do 70% pruning = 90% benefit
- Can we reach this goal with one rule?



Pruning Automation

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Thank You!

USDA-NIFA SCRI

State Hort Assoc of PA

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