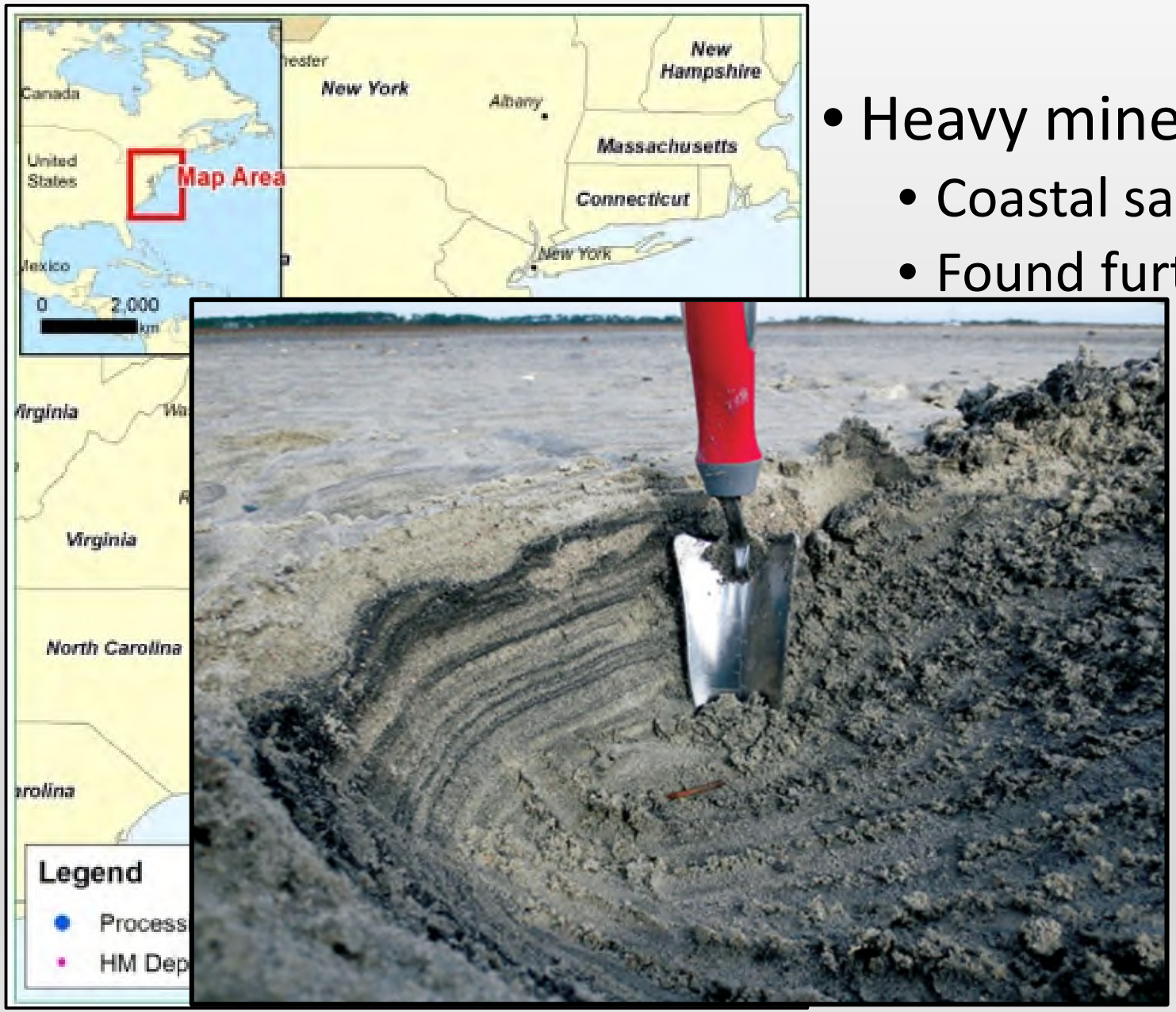
Loblolly Pine Survival, Growth, and Root Morphology on a Reclaimed Mineral Sands Mine in Southwestern VA

Sara Klopf, W.L. Daniels, & R. Stewart
Virginia Tech
7 June 2023

Mineral sands mining in Virginia



- Heavy mineral sands
  - Coastal sand deposits
  - Found further inland

Photo credit: USGS

Mineral sands mining products

- Virginia products
  - Ilmenite ($FeTiO_3$)
    - Mostly sold for TiO_2 pigment
  - Zircon ($ZrSiO_4$)
    - High quality ceramics (opacifier)

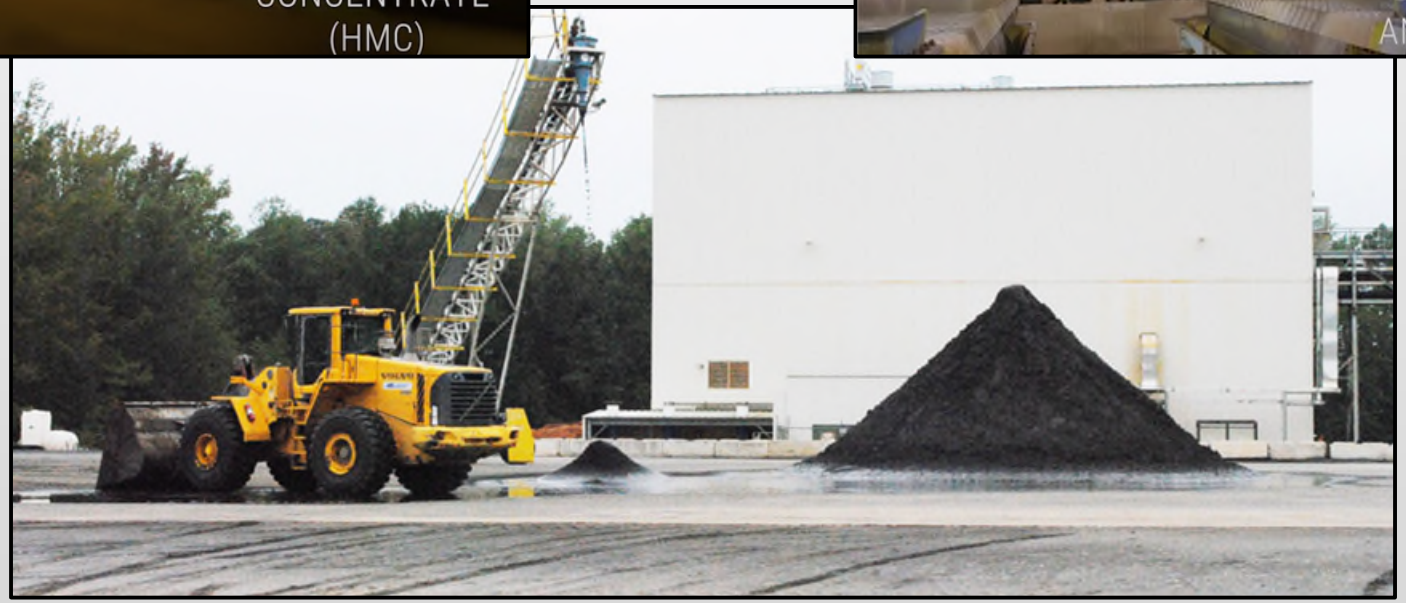
Iluka Resources 2014, 2015

Mineral sands mining process

- Excavate ore (clay, sand, and heavy minerals)

Photo credits: Iluka Resources

Mineral sands mining process



- Series of screening, concentrating, and refining steps to obtain heavy minerals

Photo credits: Iluka Resources

Mineral sands mining process

- Clay and sand pumped into mine cells as a slurry

Photo credits: Iluka Resources, S.K. Klopf

Mineral sands mine reclamation

- Goal: return landscape to productive agriculture
- Primary reclamation constraints
  - Soils with low fertility and pH
  - Soil texture often variable (vertical and lateral) with layers of “slimes” and sands
  - Compacted soils with high D_b

Schroeder, Daniels, & Alley 2010

Photo credits: S.K. Klopf, Z. Orndorff

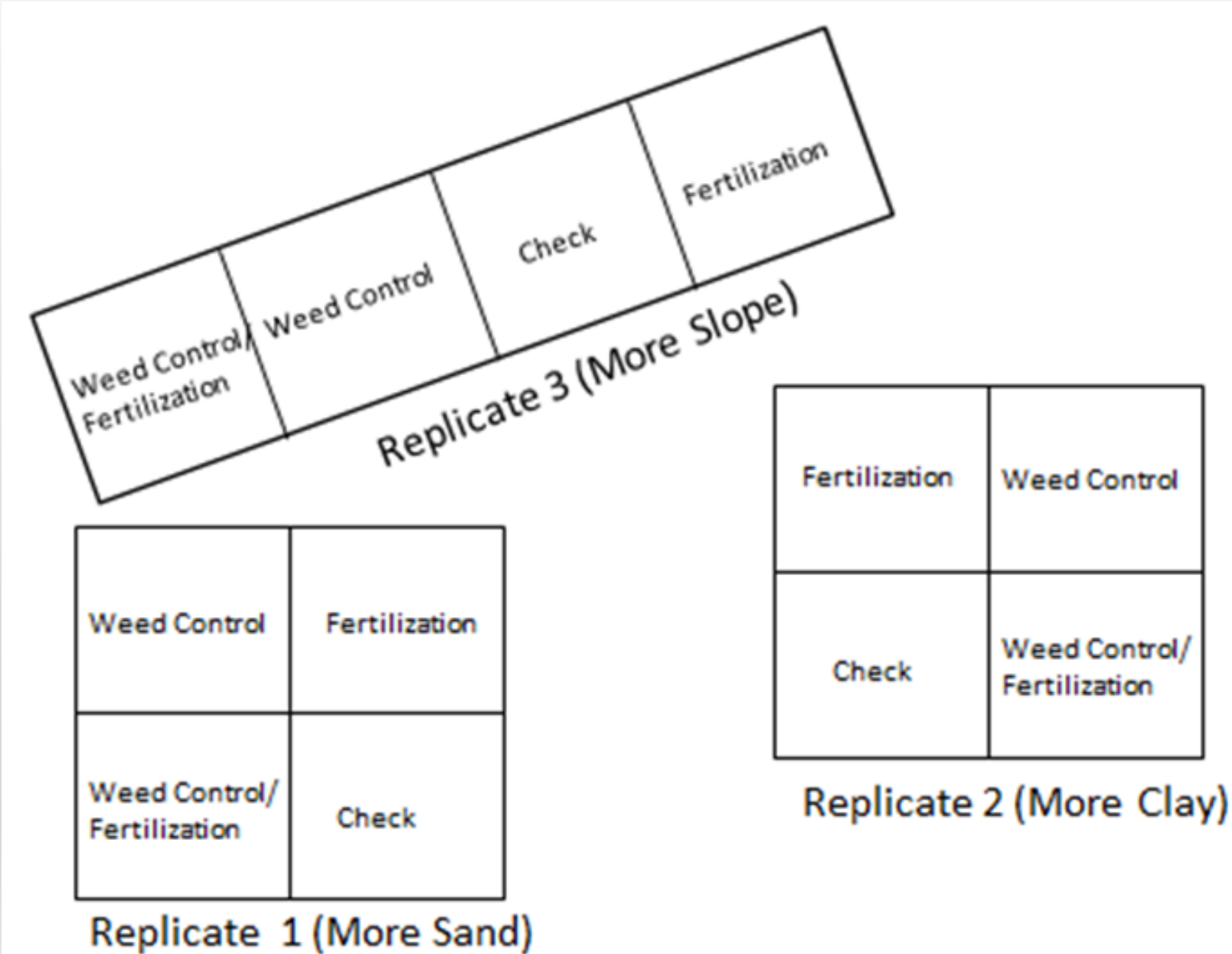
Post-mining land use

- Upland pasture or farmland
- Alternative crops, such as loblolly pines
  - Low maintenance, tolerant of infertile soils, popular crop in region

Photo credit: S.K. Klopf

Mineral sands mine pine trials

Methods: plot layout



February 2013

- Planted in grid with 2.8 m spacing (1238 trees/ha)
- 7 x 7 trees per treatment per block
  - Border trees around all treatments

Methods: silvicultural treatments

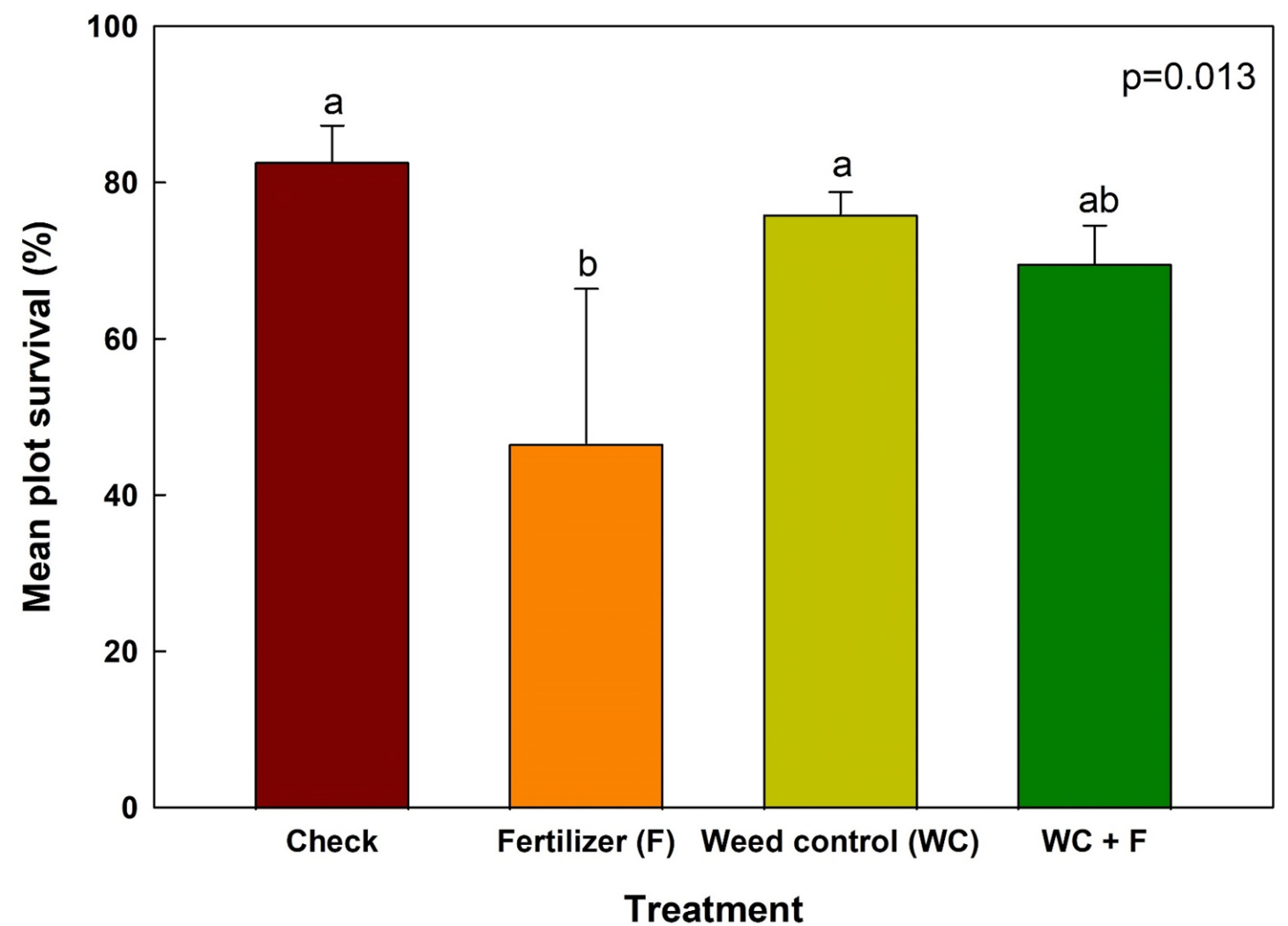
- Check (C)
- Weed control (WC)
  - Backpack spray 1% glyphosate in 1.5 m circle around tree
  - March and June during first two growing seasons
- Fertilizer (F)
  - March 2013 (56-28-56 kg ha^{-1} NPK)
  - June 2014 (67-33-67 kg ha^{-1} NPK and 114 kg ha^{-1} trace minerals)
    - Tissue analysis to determine rates (Waters Agricultural Lab)
- Weed control + fertilizer (WCF)

Methods: tree measurement

- Initial height and gro
  line diameter (GLD)
  measured after plant
- Height and GLD mea
  every winter (DBH by v
  2017/2018)
  - Height pole; began u
    clinometer in 2019 (
- Trees thinned winter 2023
  - 2023 post-thin BA 9.5 m^2/ha
    (41.6 ft^2/ac)

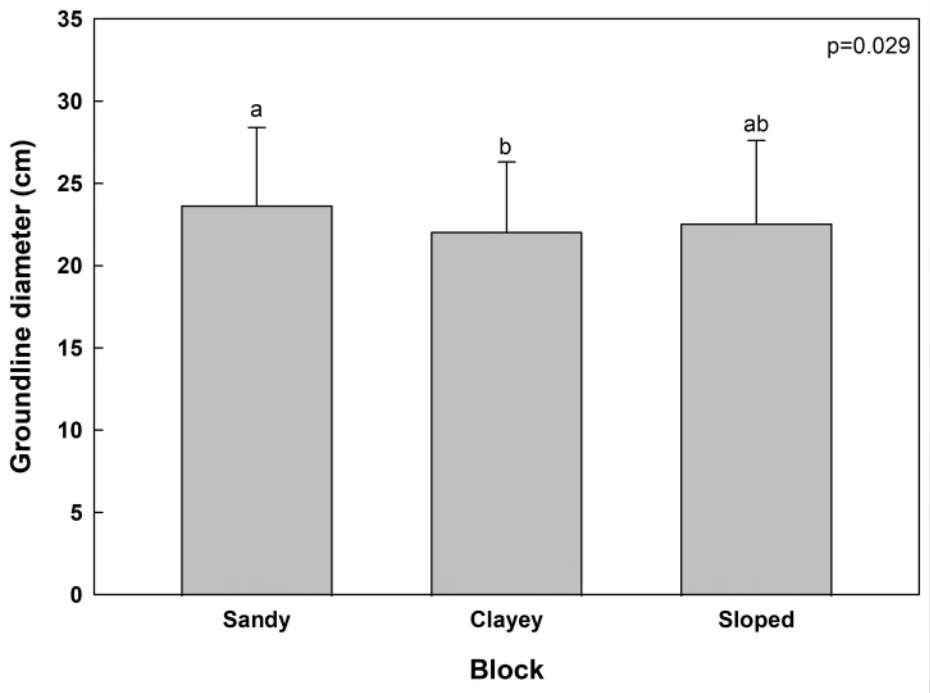
Photo credit: Sara Klopf Jan. 2020, Dec. 2022

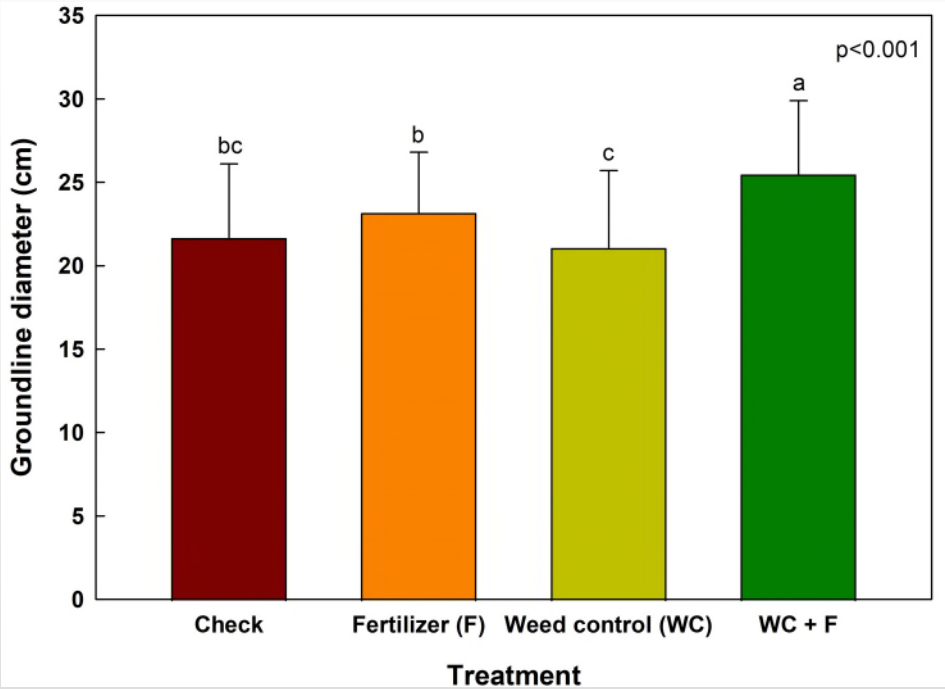
Results: Survival



- Survival did not differ among blocks (63.7-75.8%, mean 68.3%)
- Highest survival in Check and WC plots, lowest in F plot

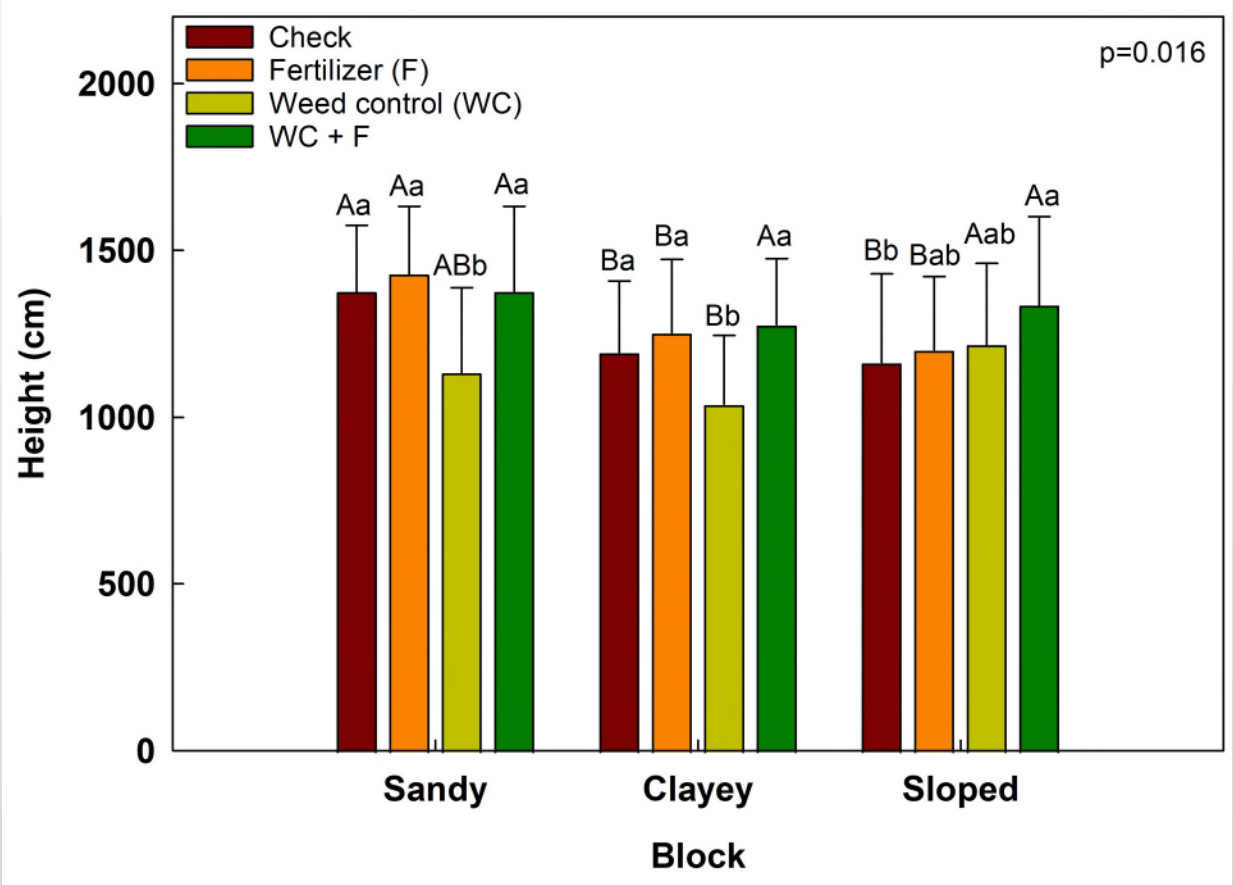
Results: Ground-line diameter





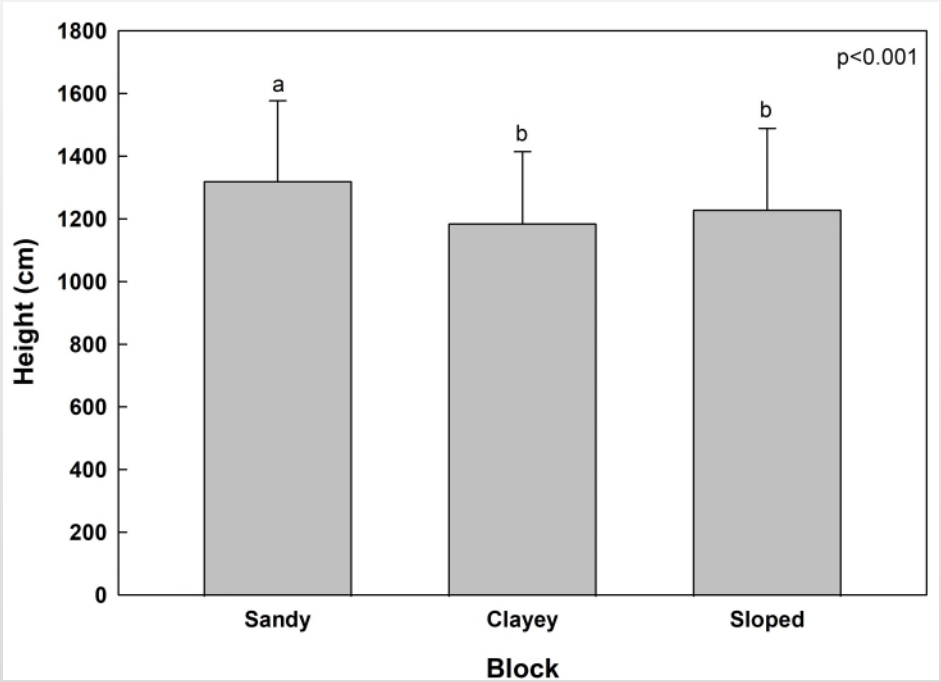
- Site mean 22.8 ± 4.7 cm
- GLD highest in Sandy Block (Sloped Block did not differ)
- GLD largest in WC + F treatment, lowest in WC treatment (didn't differ from check)
- Similar relationships among blocks/treatments for DBH

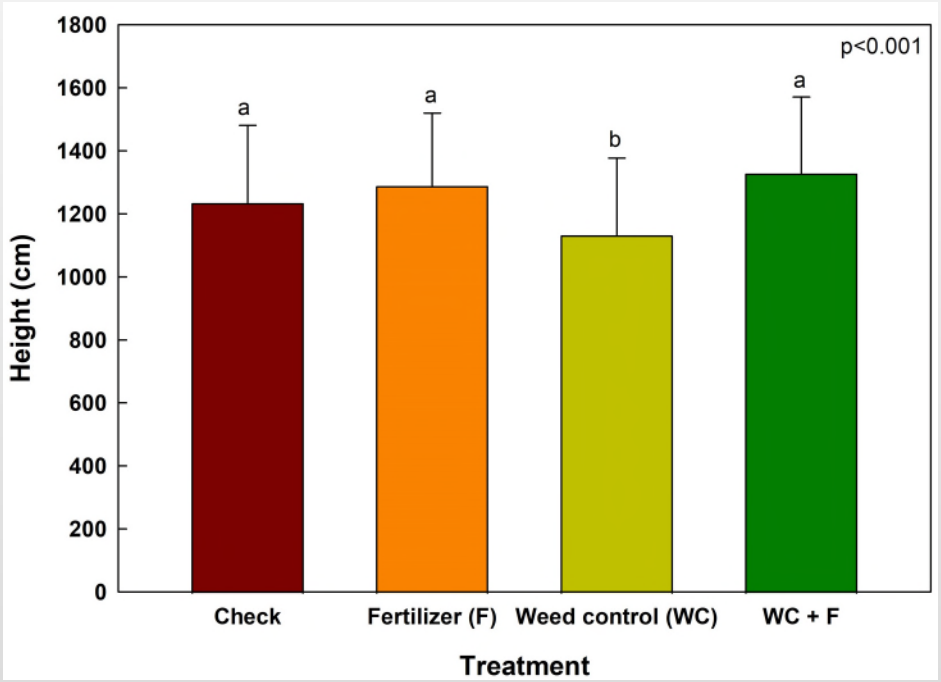
Results: Height



- Site mean 1242.4 ± 250.9 cm
- Sandy and Clayey Blocks, trees shortest in WC, tallest in Check, F, and WC+F treatments.
- Sloped Block, trees shortest in Check treatment, tallest in WC+F treatments

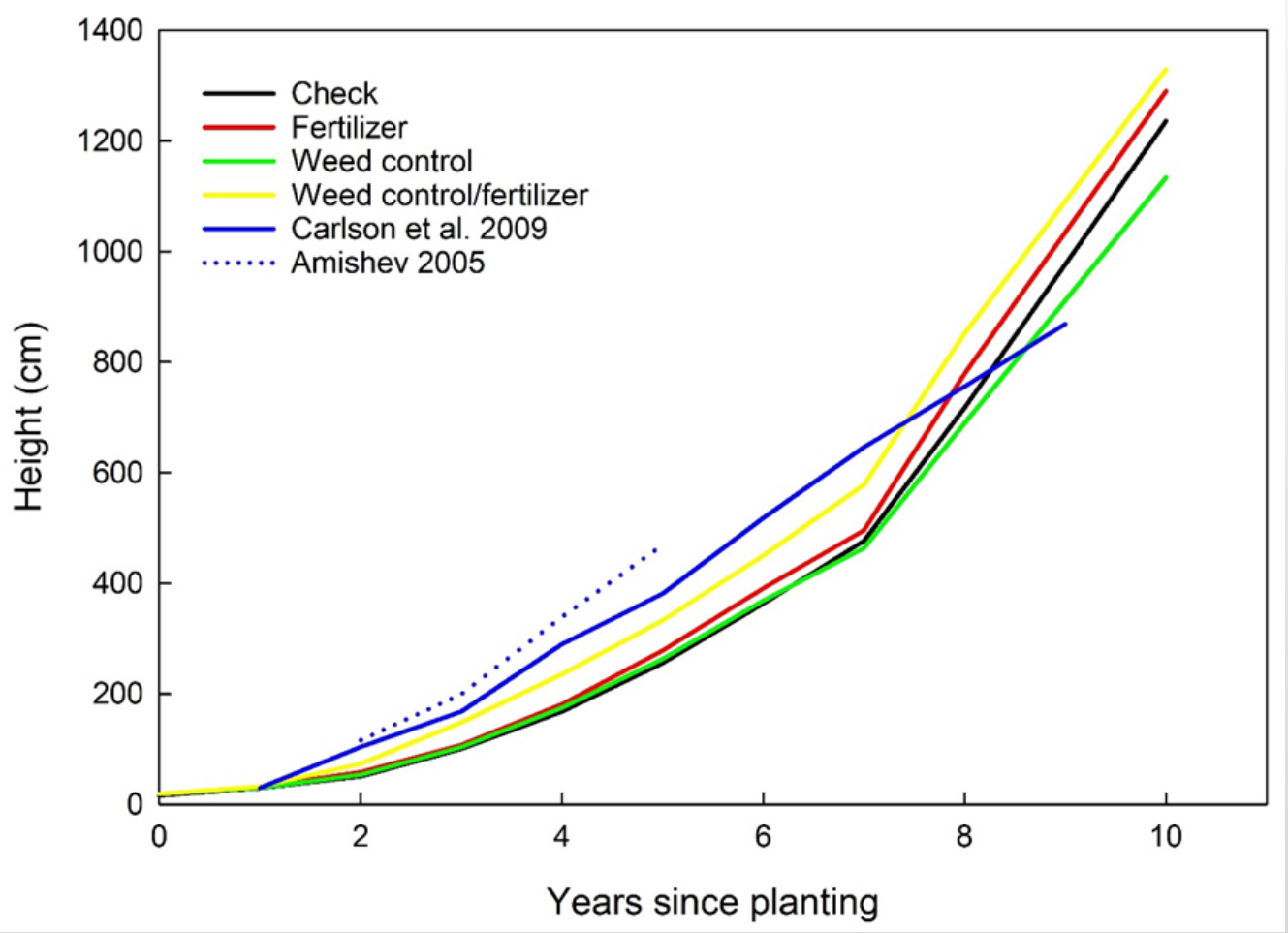
Results: Height





- Trees tallest in Sandy Block
- Trees shorter in WC than all other treatments

Height comparison



- Two studies on unmined soils in VA coastal plain – similar WC + F treatment
- Initially, trees on unmined soils grew faster than trees on reclaimed mine soils
  - Typical – trees on mined lands “sit” for first few years
- All trees on reclaimed mine soils were taller in GS 9 than trees on unmined soils

Discussion

- Few overall differences in survival/height/diameter among blocks
  - Any differences among blocks possibly masked by treatments (and possibly spatial differences within blocks, e.g. interactions)

Discussion

- Trees in F treatment had average growth, much lower survival (most mortality in first few years)
  - Fertilizer increased weed competition (Burger et al. 2013)

Photo credit: Sara Klopf, April 2017

Discussion

- Lower survival in WC and WCF, WCF had better growth
  - Herbicide drift?
- Trees in C treatment were smaller, but had better survival (not presented, but C growth rates catching up)

Photo credit: S. Klopf 2017

Recommendations

- Adding nothing is just fine
  - By 10 years, differences in growth rates insignificant with higher survival
- If you want to fertilize, weed control is critical
- Weed control alone may decrease survival without any benefit in terms of growth

Root Morphology

Root morphology

- Two trees (Good/Bad) excavated per treatment, per block – trees from thinning
- Good/Bad selected based on GLD of stump

Root morphology

- Initial excavation around roots, soil pit dug by excavator
- Manual excavation of roots
- Soil profile descriptions, Db sampling
- Root ball pulled out by excavator

Root morphology

Root morphology

Thanks!

- Field/lab/GIS assistance: Steve Nagle, Zenah Orndorff, Athena Tilley, Pat Donovan
- Funding and field support: Iluka Resources
  - Logistics: Adam Haywood, Jason Weir, Scott Powell