Loblolly Pine Survival and Growth on a Reclaimed Mineral Sands Mine in Southeastern Virginia

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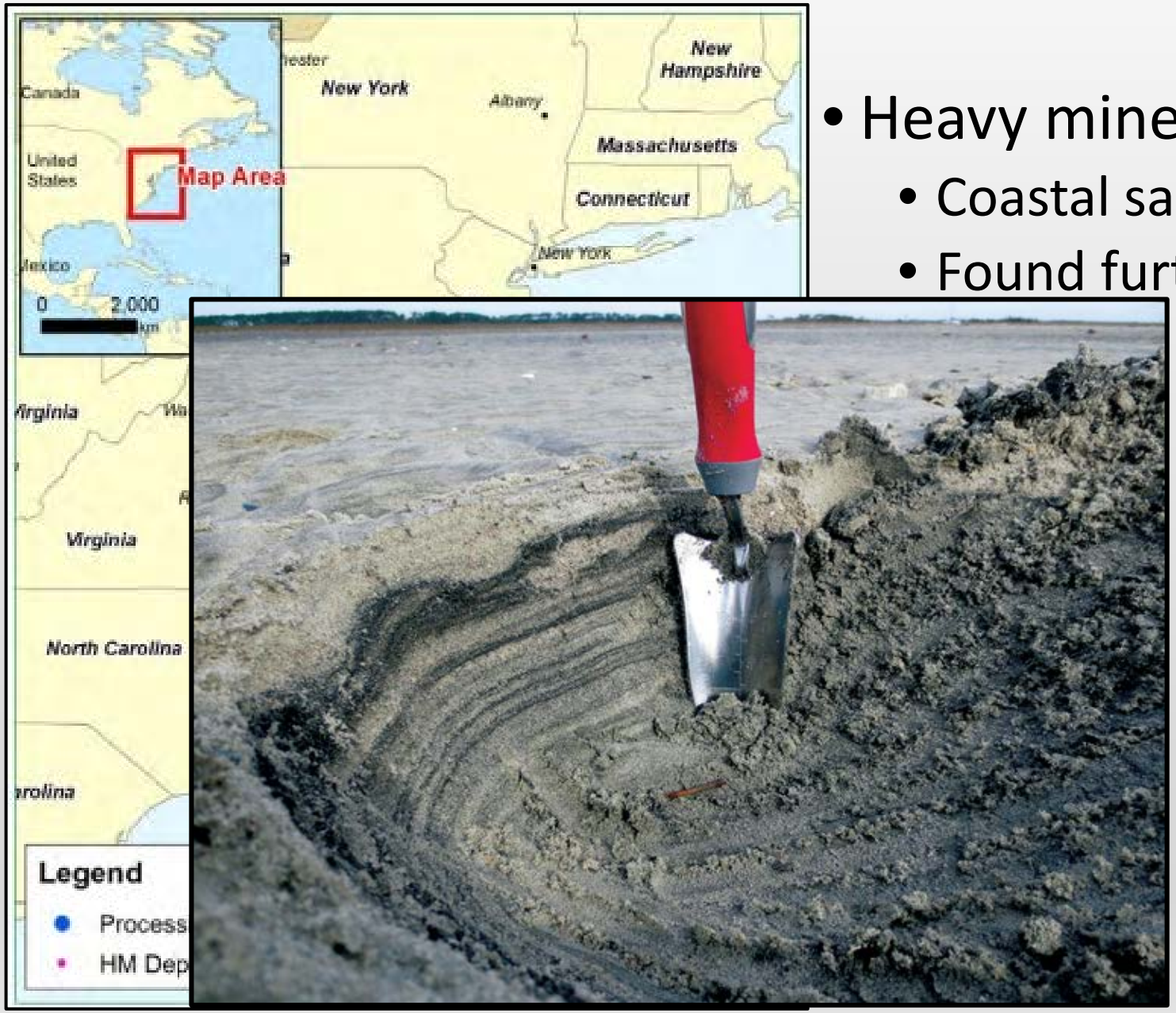
Mineral sands mining in Virginia



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

Photo credit: USGS

Mineral sands mining products

- Virginia products
  - Chloride 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

- Gravity separation 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 with pockets 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 compacted, infertile soils

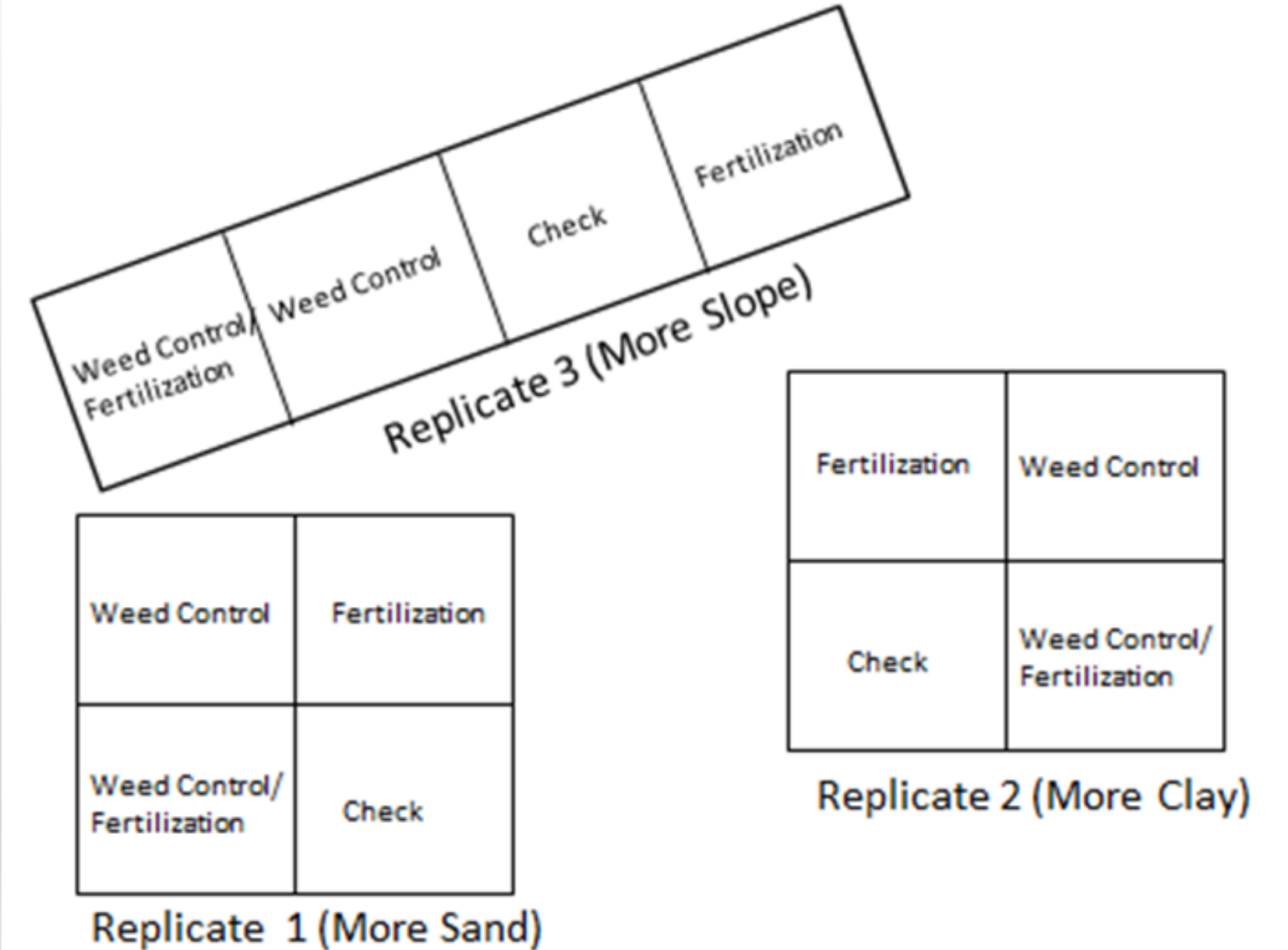
Photo credit: S.K. Klopf

Mineral sands mine pine trials

Overall site preparation

- Site preparation completed in 2011
  - Subsoil received 11.2 t/ha lime and 280 kg/ha of DAP
  - Topsoil placed
  - 2.2 t/ha lime and 336 kg/ha 15-30-15
  - Seeded with tall fescue, orchardgrass, crimson clover, ladino clover, and cereal rye as a cover crop

Methods: plot layout



February 2013

- 1 year old loblolly pine seedlings from VDOF planted in grid with 3 m spacing
- 7 x 7 seedlings per treatment per block
  - Border trees around all treatments

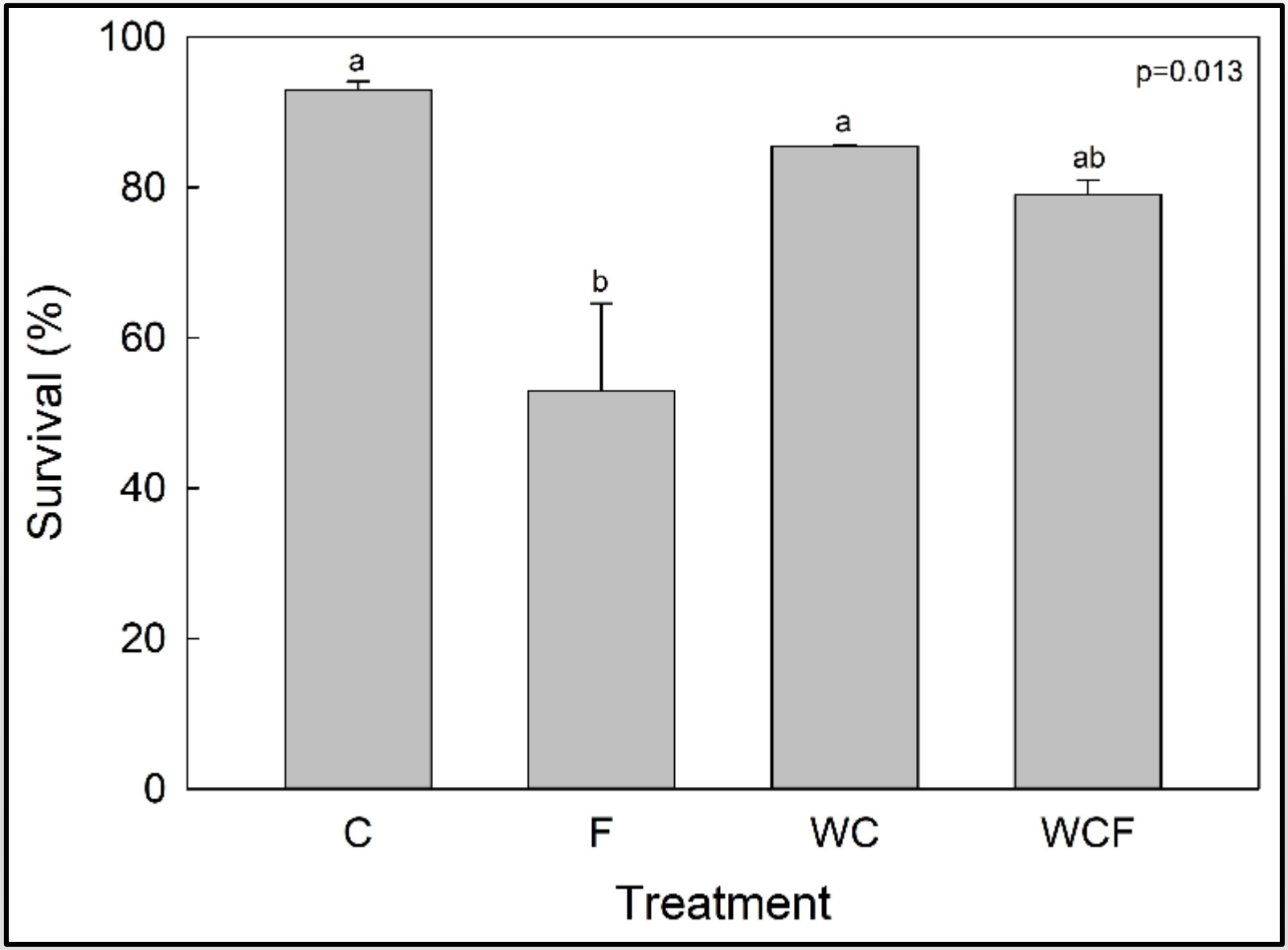
Methods: silvicultural treatments

- 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 Laboratory)
- Weed control + fertilizer (WCF)

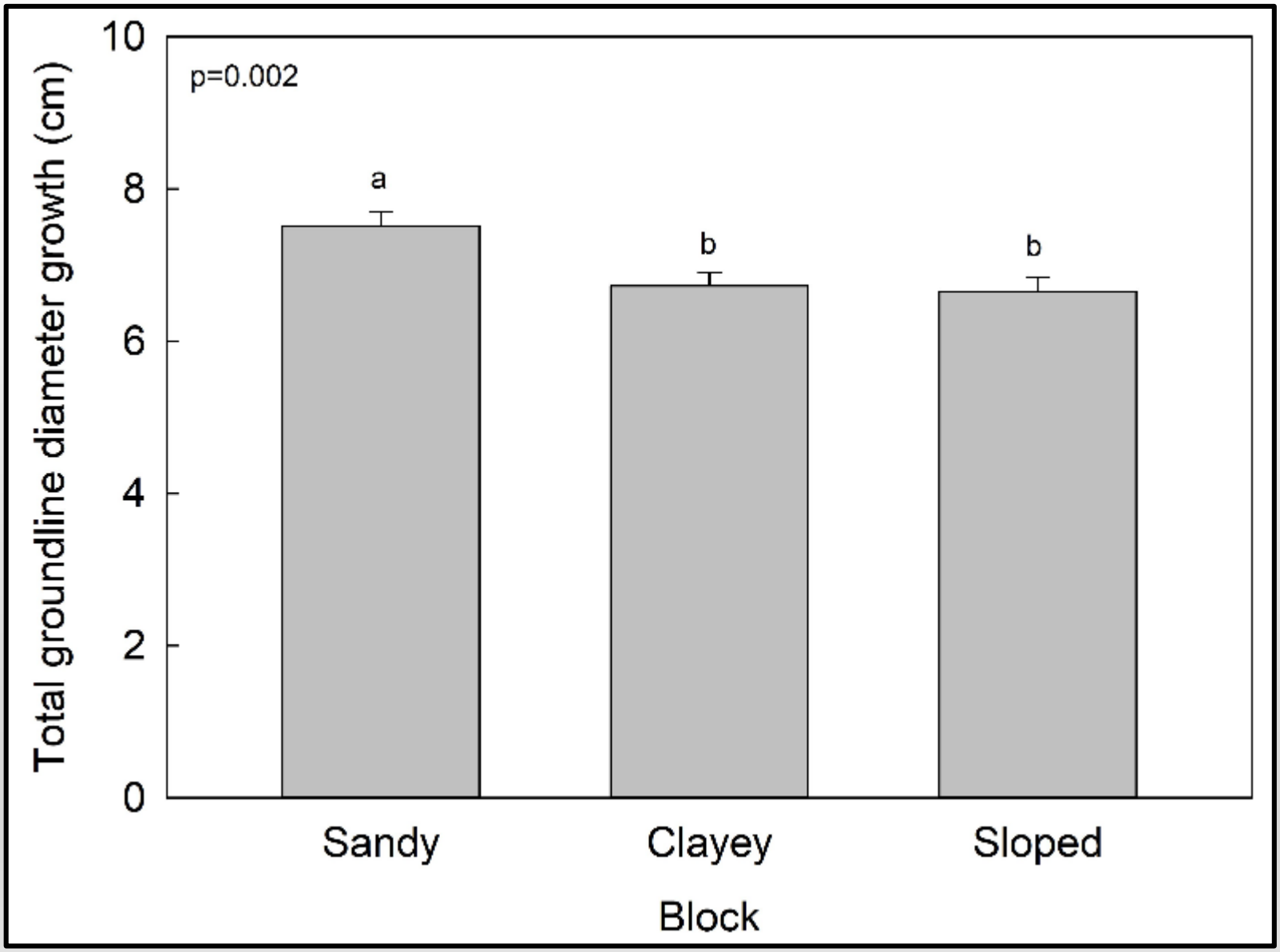
Methods: tree measurement

- Initial height and ground-line diameter (GLD) measured after planting
- Height and GLD measured every winter
- DBH measured in winter 2017/2018

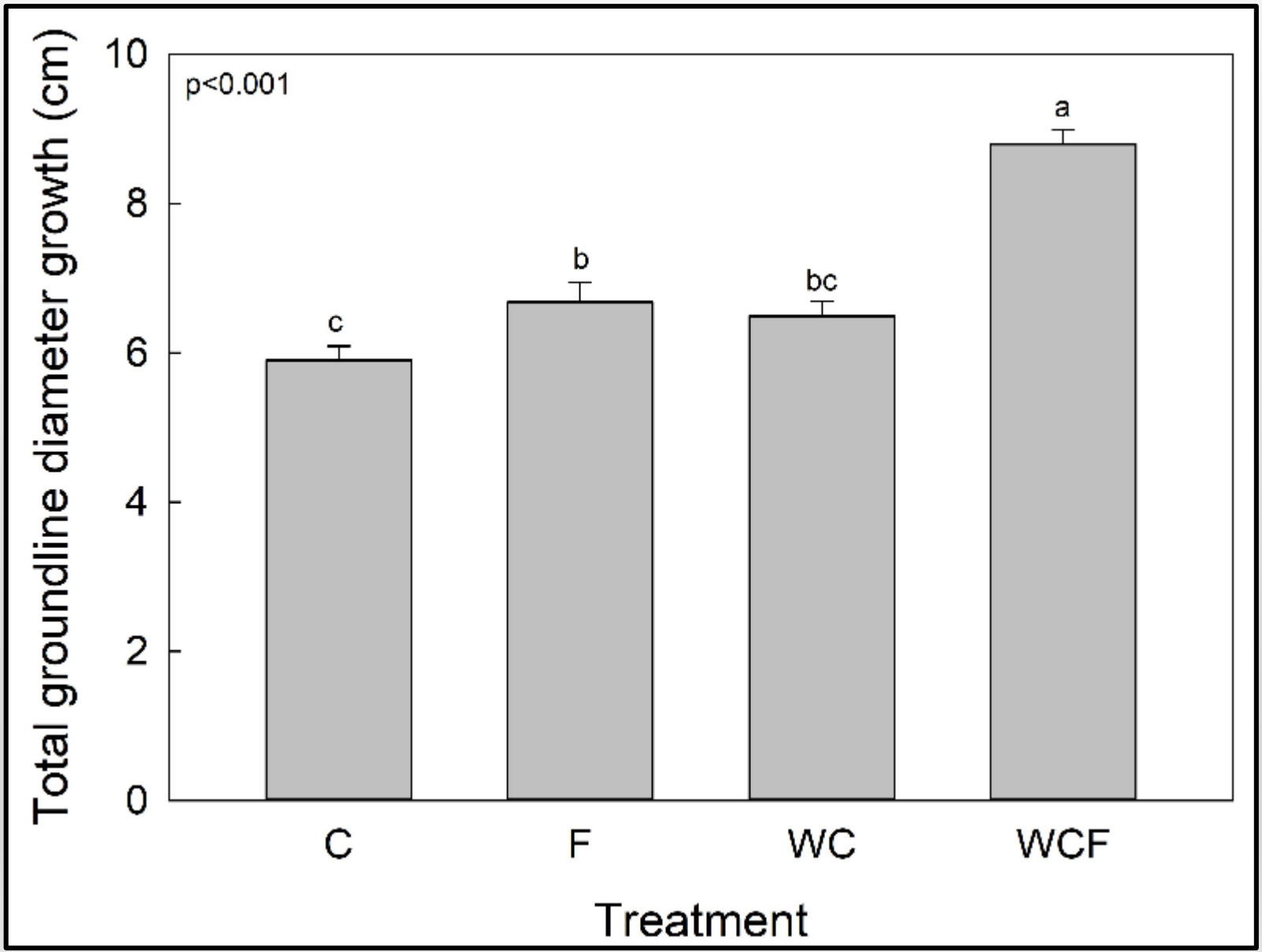
Results: Survival



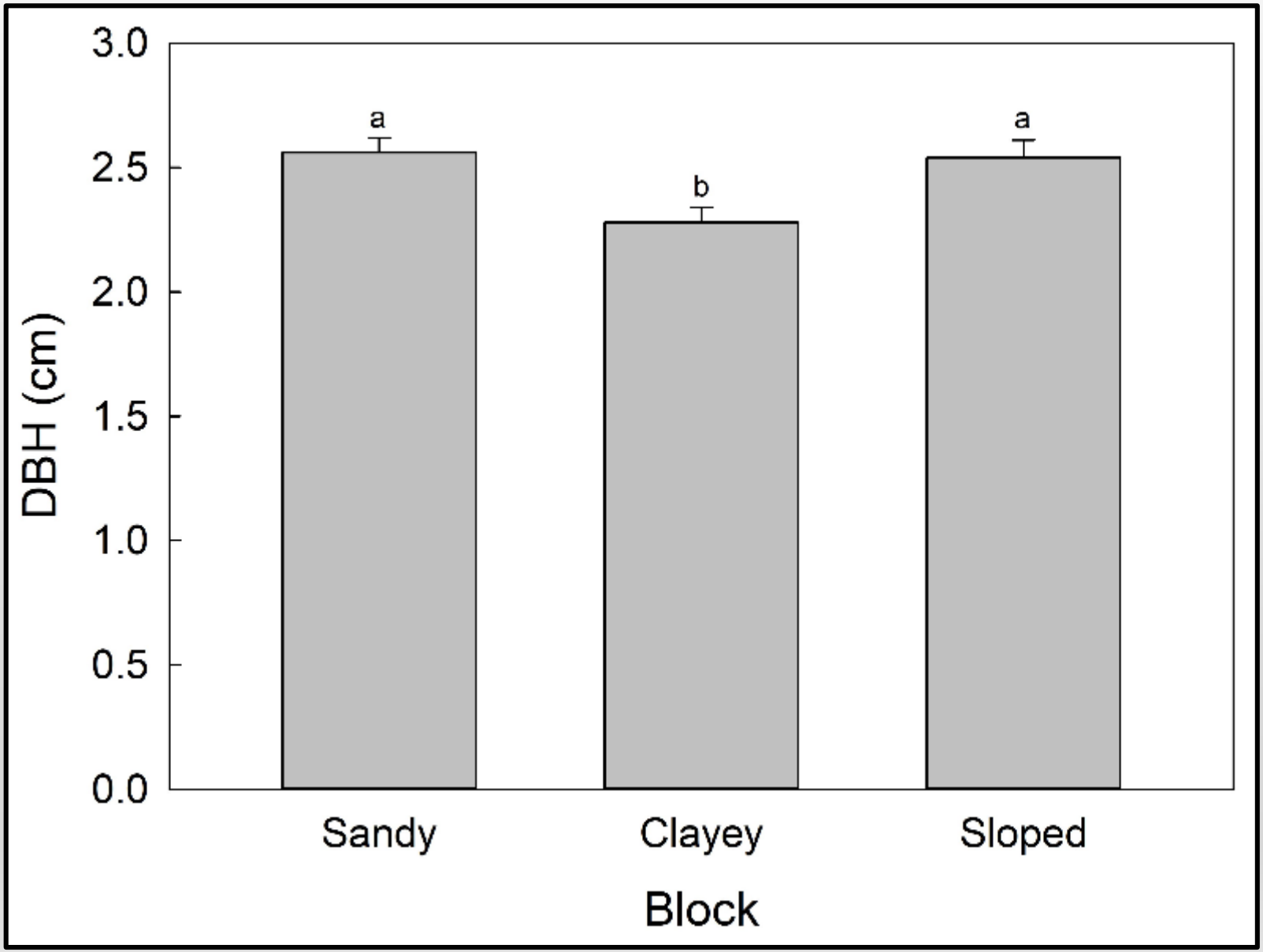
Results: Ground-line diameter growth



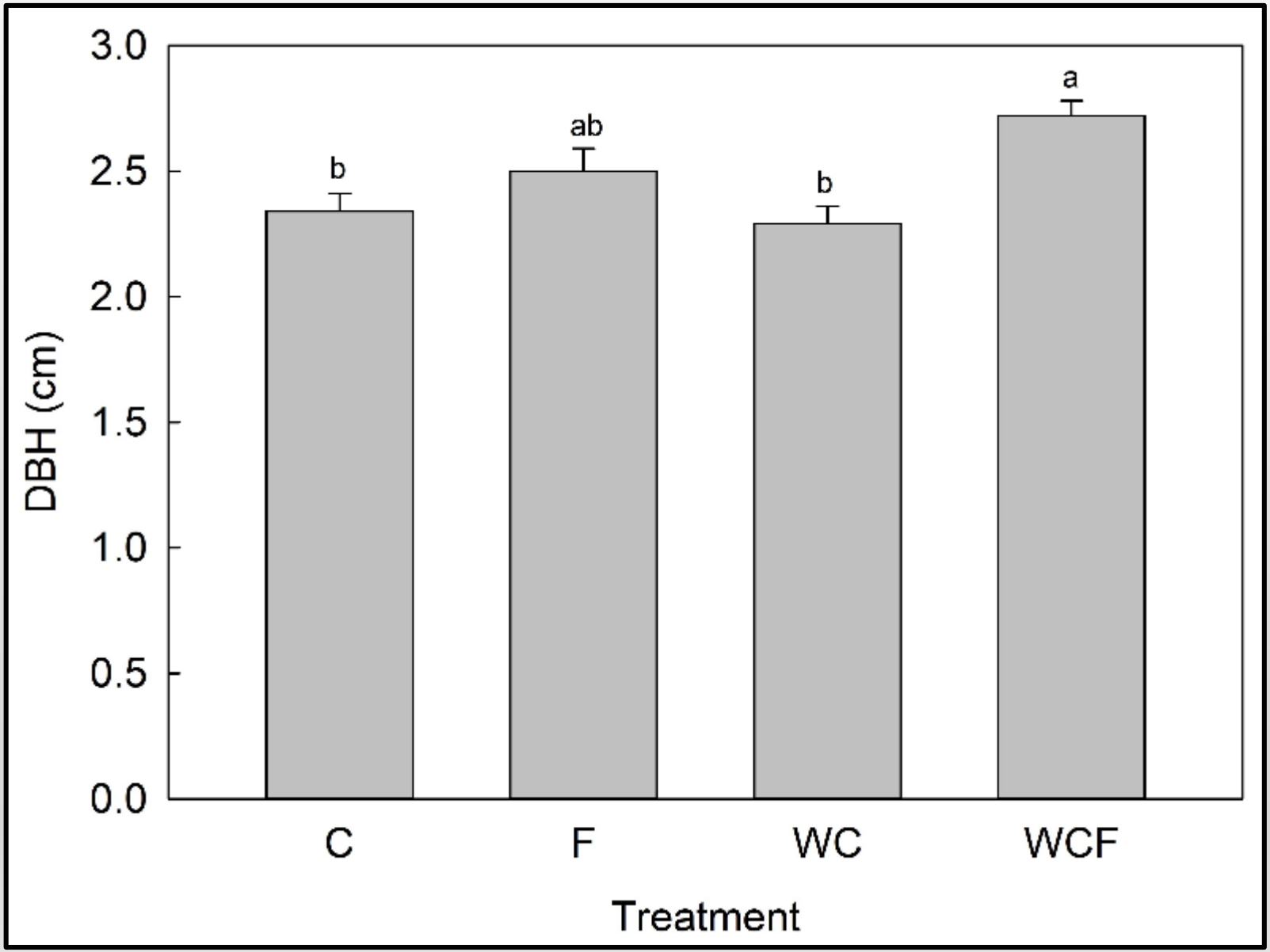
Results: Ground-line diameter growth



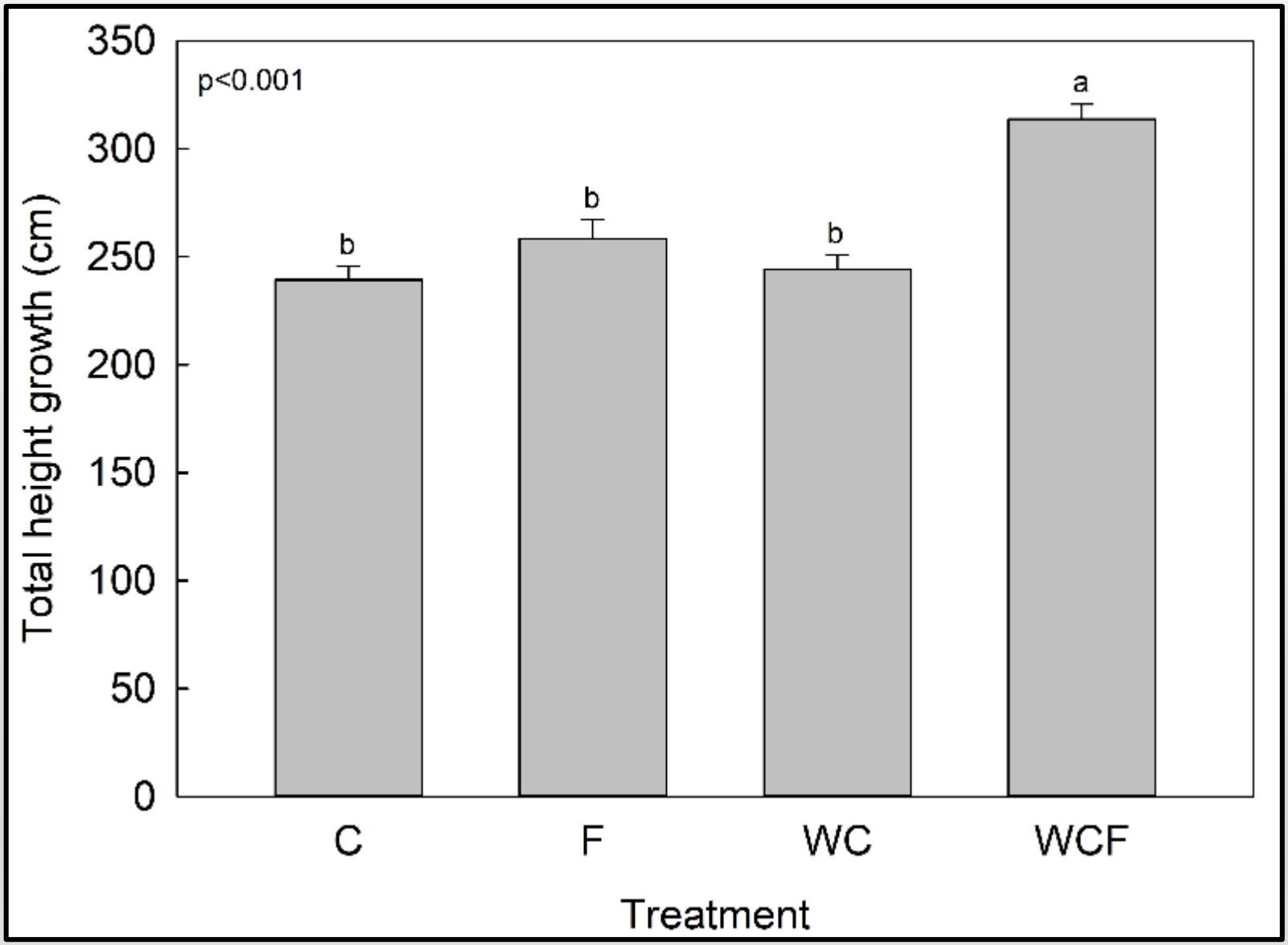
Results: DBH



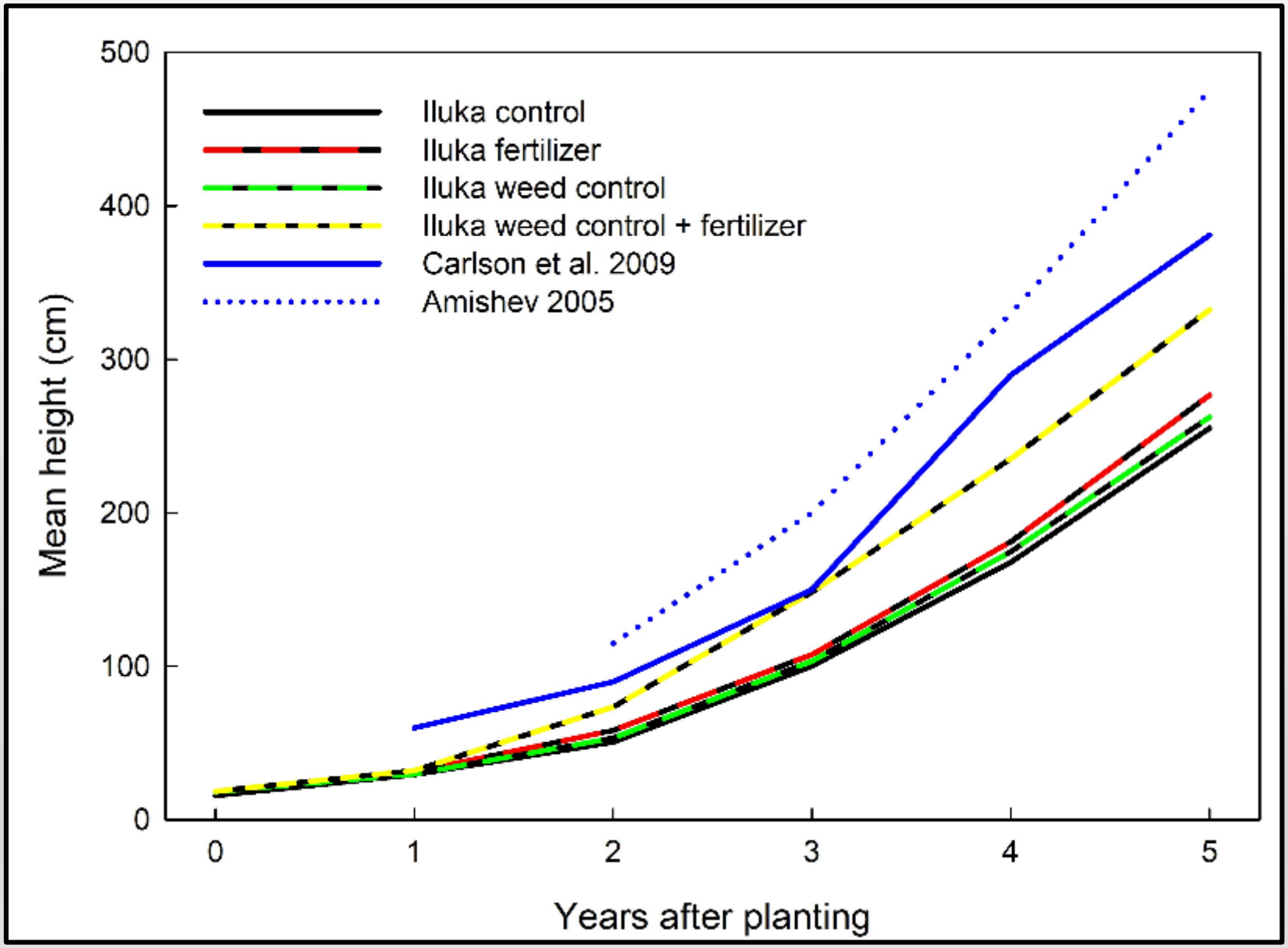
Results: DBH



Results: height growth



Growth comparison



Root excavations- more next year!

- How does mine soil morphology affect loblolly pine root growth?
- Excavating roots from a selection of representative trees to better understand how mine soils affect root morphology
  - Stay tuned!!

Weed control, sloped block
Clayey soil
Mean Db = 1.36 just above max root depth
Mean Db = 1.42 where most roots stop (~20 cm)

Summary

- Block effects
  - No differences in survival or height growth
  - GLD highest in sandy block
  - DBH higher in sandy and sloped blocks

Summary

- Treatment effects
  - Survival lowest in F, highest in C and WC
  - GLD and height growth highest in WCF
  - DBH highest in WCF

Discussion

- Few differences among blocks
  - Any differences among blocks masked by treatments (and possibly spatial differences within blocks)

Discussion

- Trees in F treatment had average growth, much lower survival
  - Fertilizer increased weed competition

Discussion

- Lower survival in WC and WCF, WCF had better growth
  - Herbicide drift?
- Trees in C treatment were smaller, but had better survival

Discussion

- Trees on unmined soils grow faster than trees on reclaimed mine soils
- Compared to unmined soils, C, WC, and F treatments all similar in size
- WCF trees approaching growth rates of trees on unmined soils

Recommendations

- Trees grown without any weed control or additional fertilizer still perform well
- If fertilizer is applied, weed control is critical to minimize weed competition
- If only weed control is applied, survival will likely be decreased without any benefits in terms of growth, so fertilizer should be added

Thanks!

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