Survival, Growth, and Blight Incidence of Chestnuts on an FRA-Reclaimed Coal Mine in Southwestern Virginia

S.K. KLOPF, C.E. ZIPPER, & J. HOLLIDAY

SCHOOL OF PLANT AND ENVIRONMENTAL SCIENCES, VIRGINIA TECH

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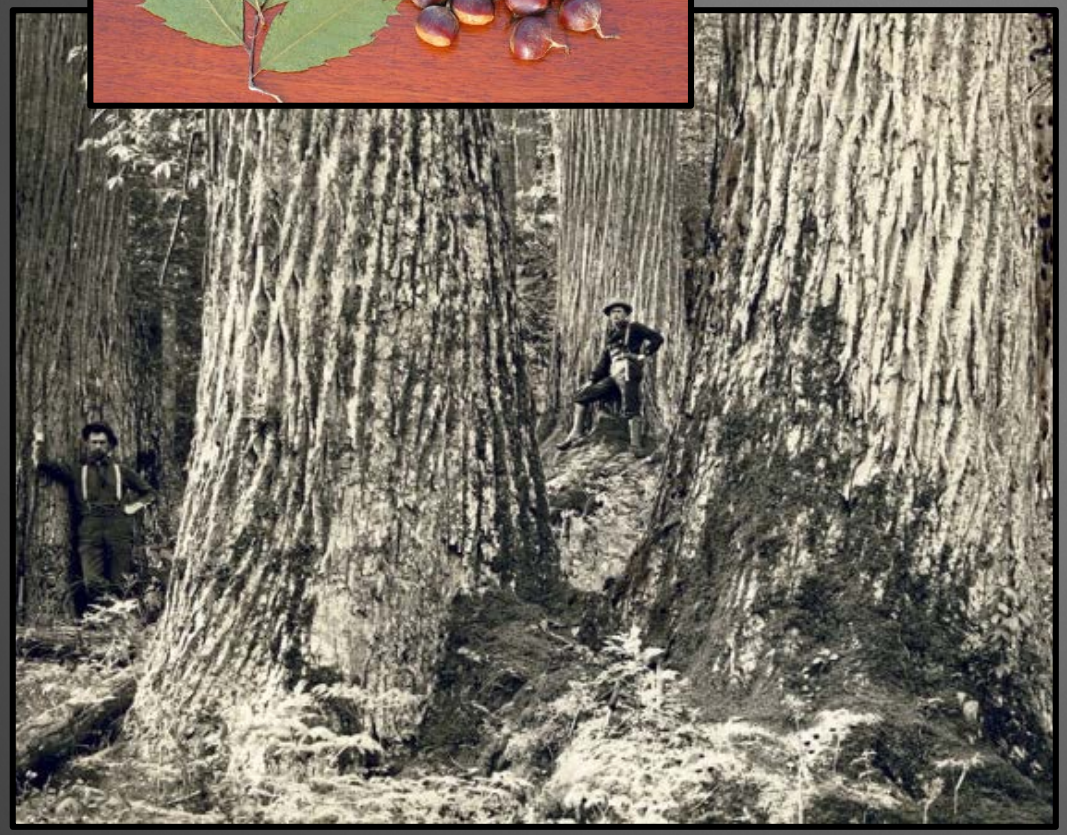
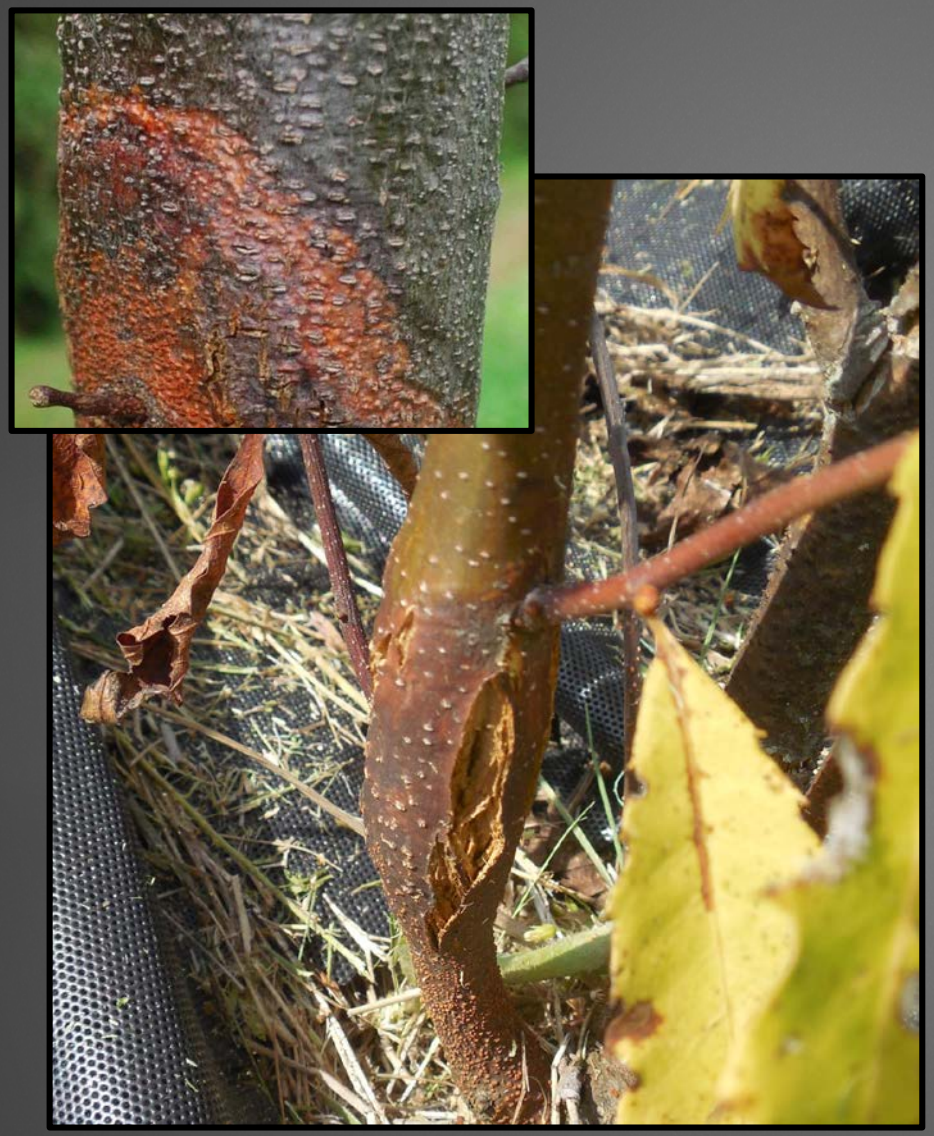
A Former Giant



Forest History Society, Durham, NC

- *Castanea dentata*
- Historically 25% of forest
- Range of 800,000 km^2
- The ‘sequoia of the East’ (French et al. 2007, Money 2007, Ronderos 2000)
  - Maybe not QUITE as big as remembered (Collins et al. 2018)
- Tree used ‘from cradle to the grave’

‘Felled by a Fungus’

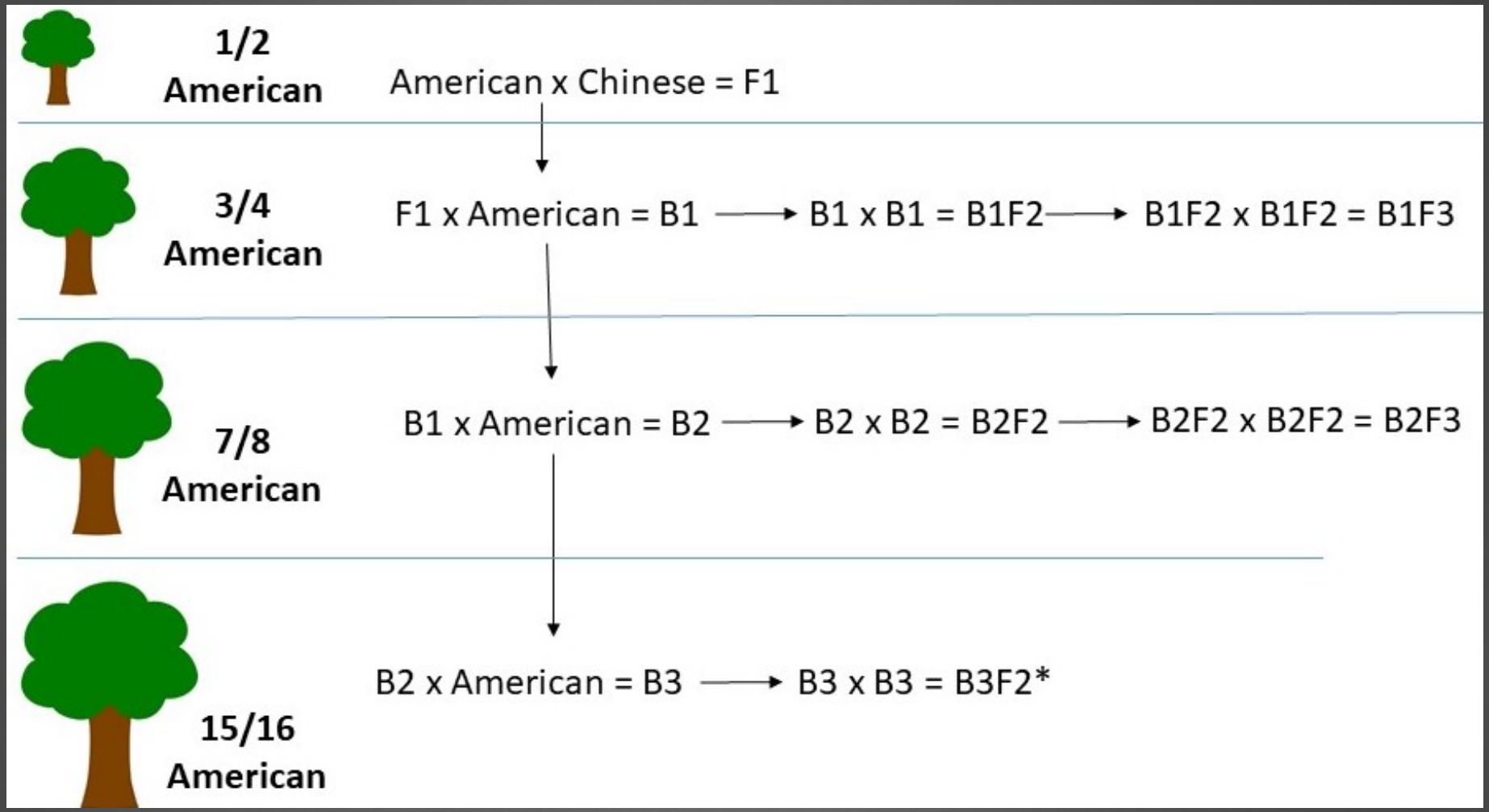


- Fungal blight – 1904 Bronx Zoo
  - Rapidly spread by ‘Japanese Giant’ cultivar (Tallamy 2007)
- Cankers damage vascular tissues, top-kill tree
- American chestnut functionally extinct in majority of forest
- Chinese chestnuts (*C. mollissima*) somewhat blight resistant

Photo Credits: S. Klopf, W. Powell

Orwig 2002, Thompson 2012, Dagleish et al 2015

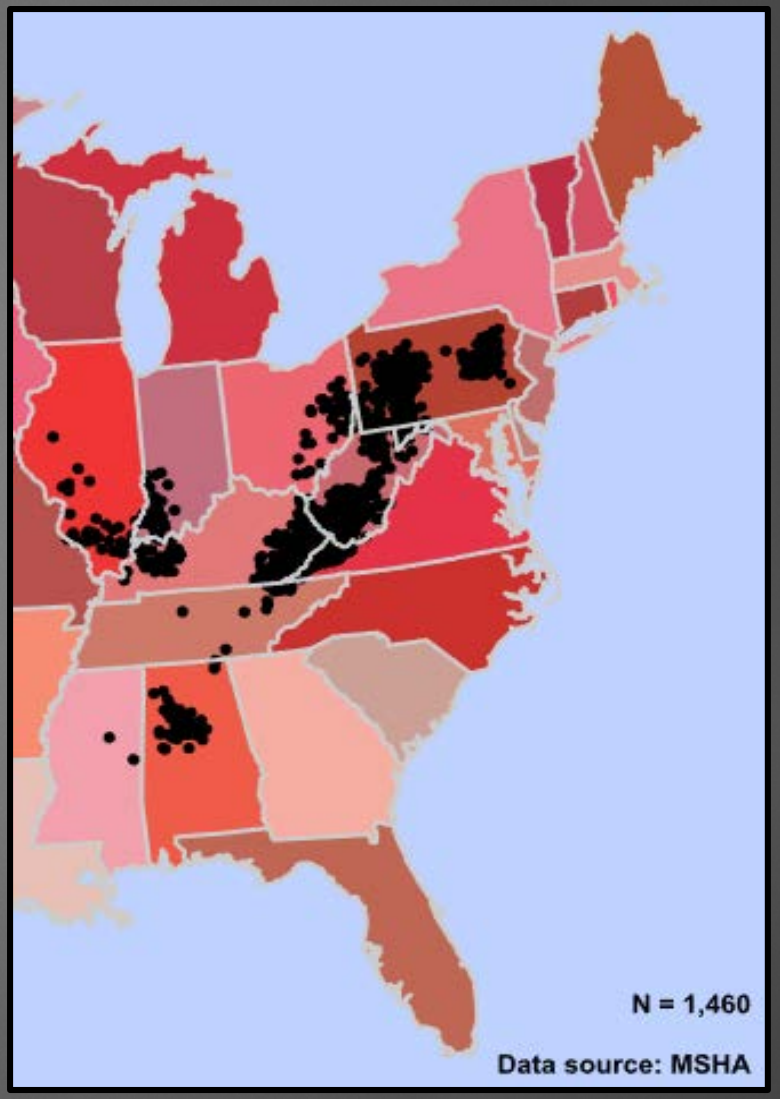
Breeding Blight-resistant Trees



(Clapper 1954, Jaynes and Graves 1963, Hebard 2001)

Chestnuts & Coal Mine Reforestation

American Chestnut Foundation



CDC 2015

Coal Mine Reforestation: The FRA

- 5 Step process to improve reforestation success (Burger et al. 2005)
  1) Suitable growth medium: 1.2 m topsoil, weathered sandstone, or best available
  2) Loosely grade
  3) Tree compatible groundcover
  4) Mix of fast and slow establishing native trees
  5) Plant trees properly

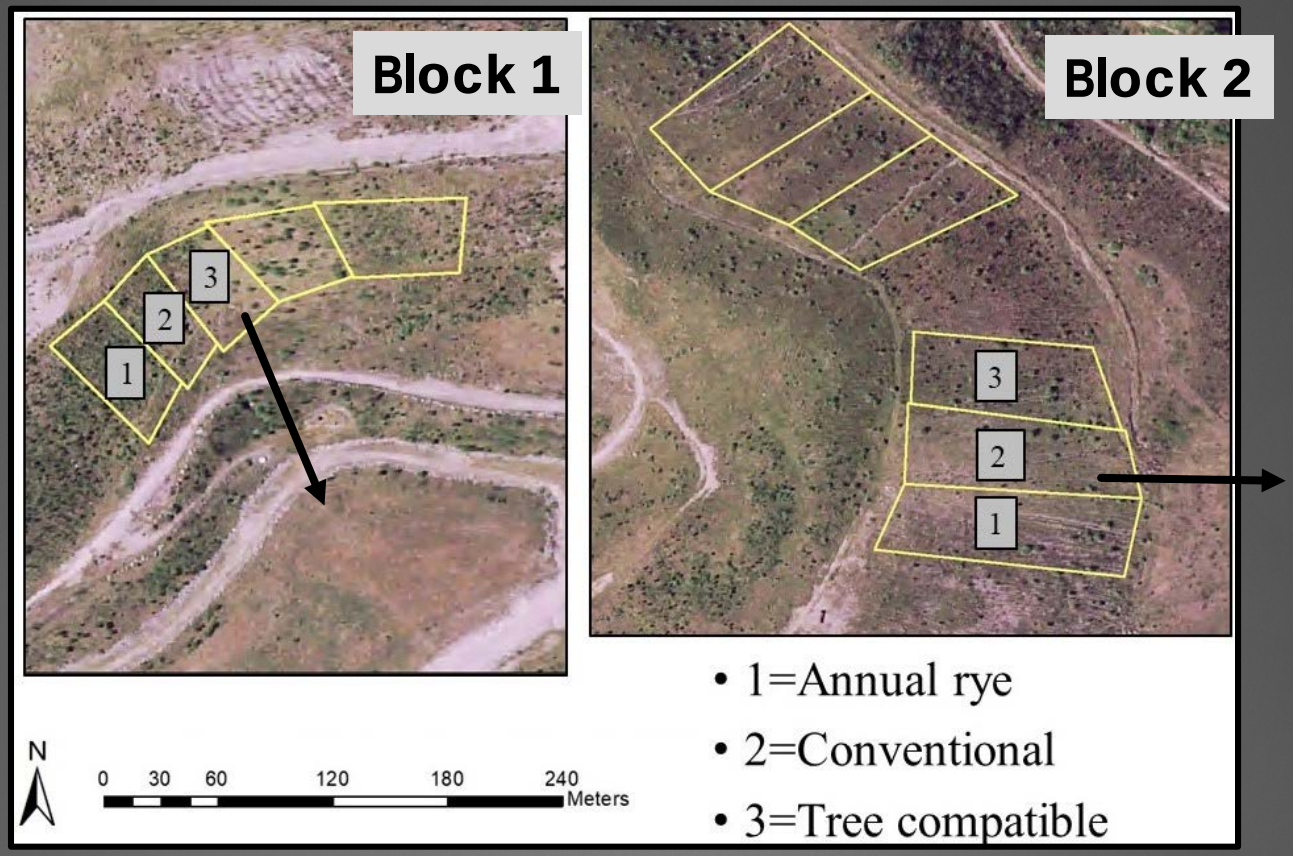
Chestnut Growth on Mines

- Chestnuts typically have lower survival and growth on mine soils (Fields-Johnson 2011, Clark et al. 2012, Gilland and McCarthy 2014, Skousen 2016)
  - Why???
    - Historically on dry, south-facing ridges with sandy soil, BUT, decreased survival and increased blight observed with higher sand content (Braun 1935, McEwan et al. 2005, Rhoades et al. 2009)
    - Cited slower growth in poorly drained or extremely dry soils with high pH, BUT observed poor growth on former mines with mesic, acidic soil (Gilland and McCarthy 2012)
    - Some hardwood competition improves survival and growth, reduces blight – but not always (Griffin et al. 1991, Clark et al. 2012)

Study Goals

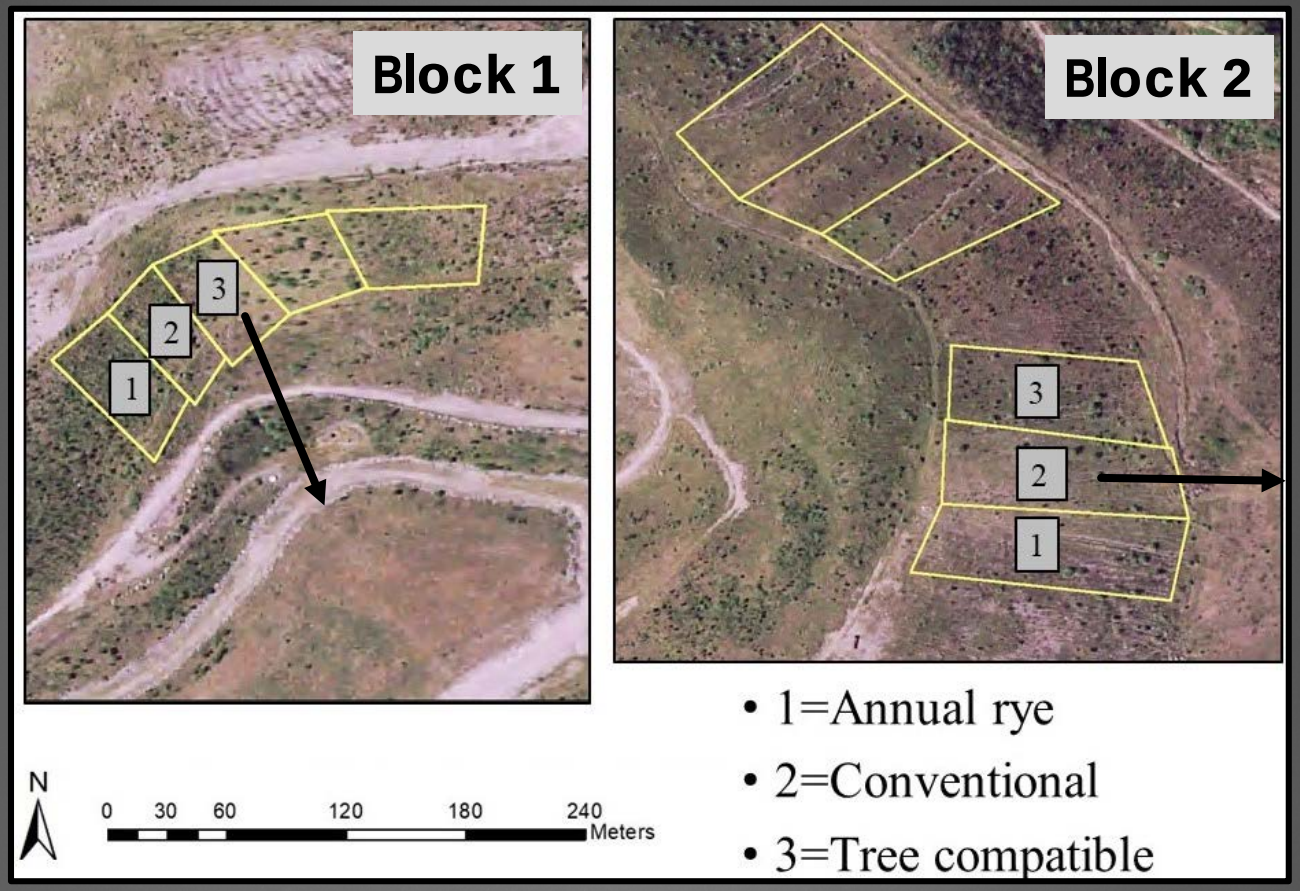
- To quantify survival, growth, and blight incidence of chestnuts after 9 growing seasons on an FRA-reclaimed coal mine

Study Setup



- Loose-graded and seeded by winter 2007/2008
  - Block 1 weathered and unweathered SS
    - pH 5.51 to 5.96 in 2008, and 6.52 to 6.98 in 2016
  - Block 2 unweathered SS, SiS, and Sh
    - pH 7.46 to 8.10 in 2008, and 7.3 to 7.89 in 2016

Study Setup



- Three seed mixes
  - AR: Annual rye
  - CON: Conventional mix (including orchardgrass, Korean lespedeza)
  - TC: Tree compatible mix (lower SR, non-competitive species)

Tree Planting

- Mix of native trees professionally planted as bare-root seedlings (1,845 trees/ha) in winter 2007/2008
  - Crop trees including chestnut oak and black oak
  - Wildlife trees including white pine and redbud

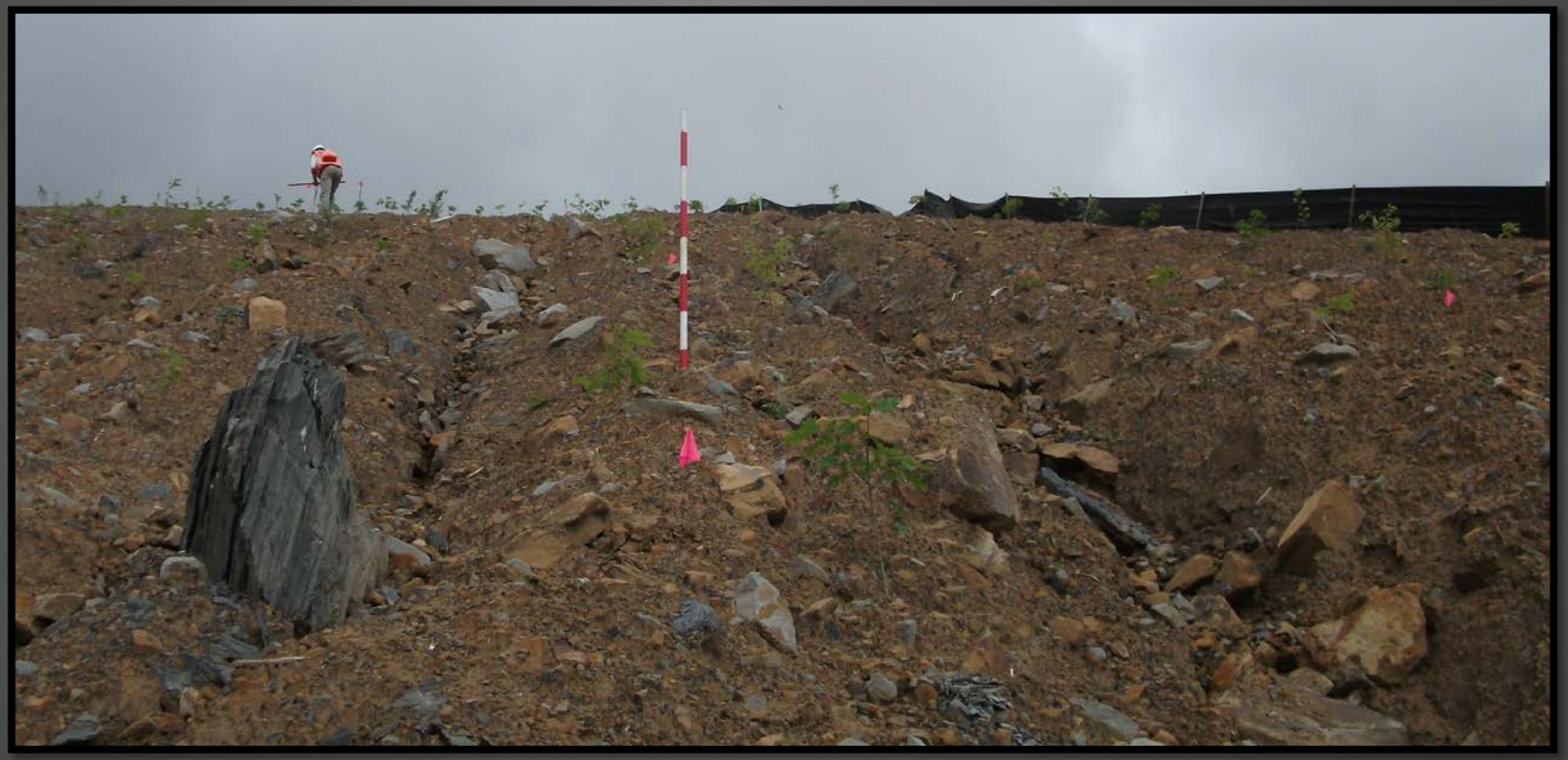


Photo credit: S. Klopf

American chestnut Planting

- Mix of chestnuts (ACF) planted as nuts among planted tree seedlings in March 2008
  1) Pure American
  2) Pure Chinese
  3) B1F3
     - 3/4 American
  4) B2F3
     - 7/8 American
  5) B3F2
     - 15/16 American
- Tree tubes installed and labeled with genotypes
  - Unique tree tags added after germination

Data Collection

- Fall 2016 – Spring 2017
  - Tree health/growth
    - Height, ground-line diameter (GLD)
    - Blight incidence
  - Site characteristics
    - Downhill aspect, slope
    - Landscape position
    - Vegetation competition
    - Soil sample collected: pH, EC, field texture

Quantifying Blight Symptoms

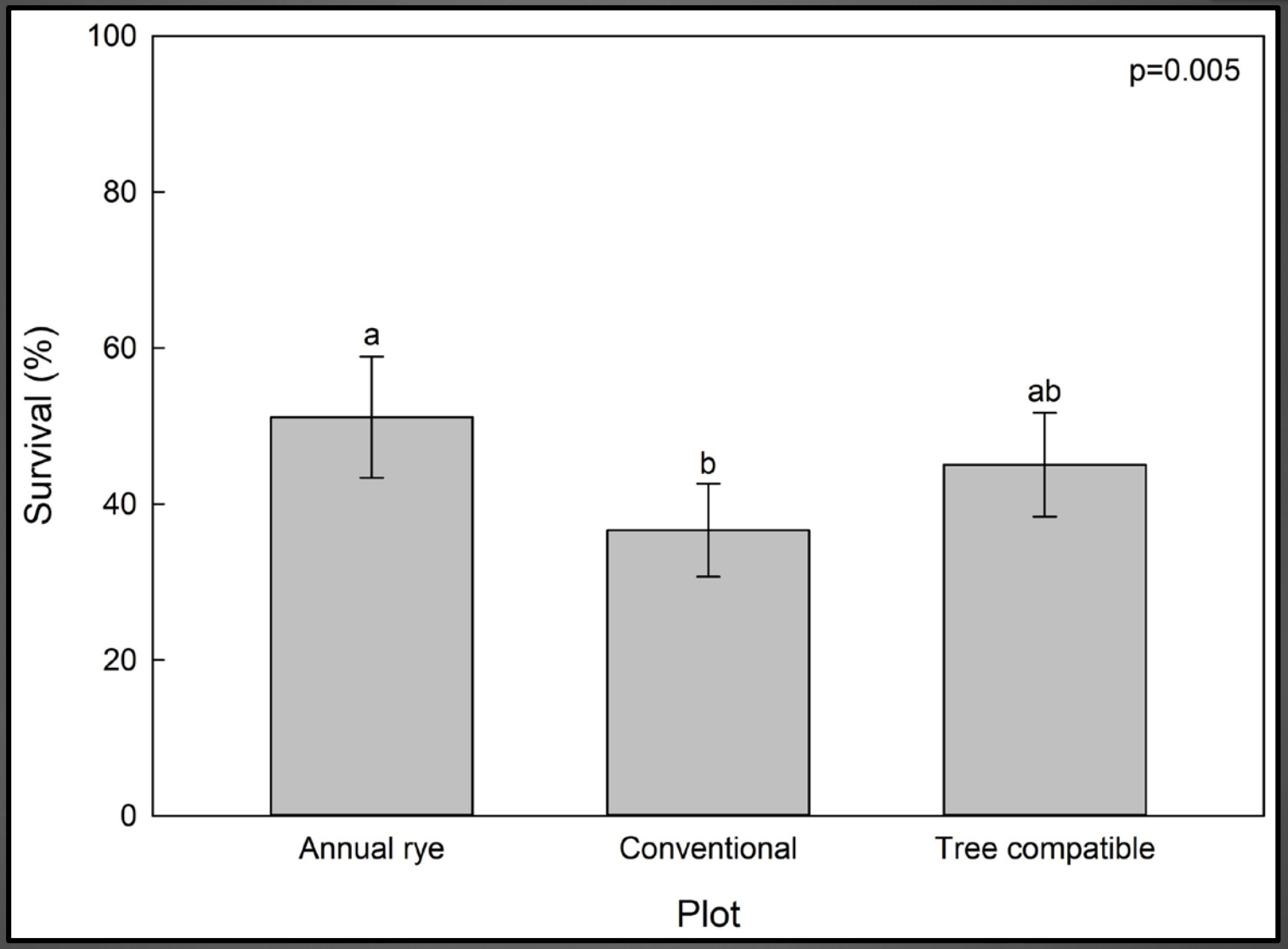
- Blight symptom index
  (Tizado et al. 2012)
  - Range from 0 to 5
    - Recorded for trunk, lower crown, middle crown, upper crown, and overall
    - 0 = no visible symptoms
    - 5 = visible symptoms on 81%+ of tree/tree part

Photo Credit: S. Klopf

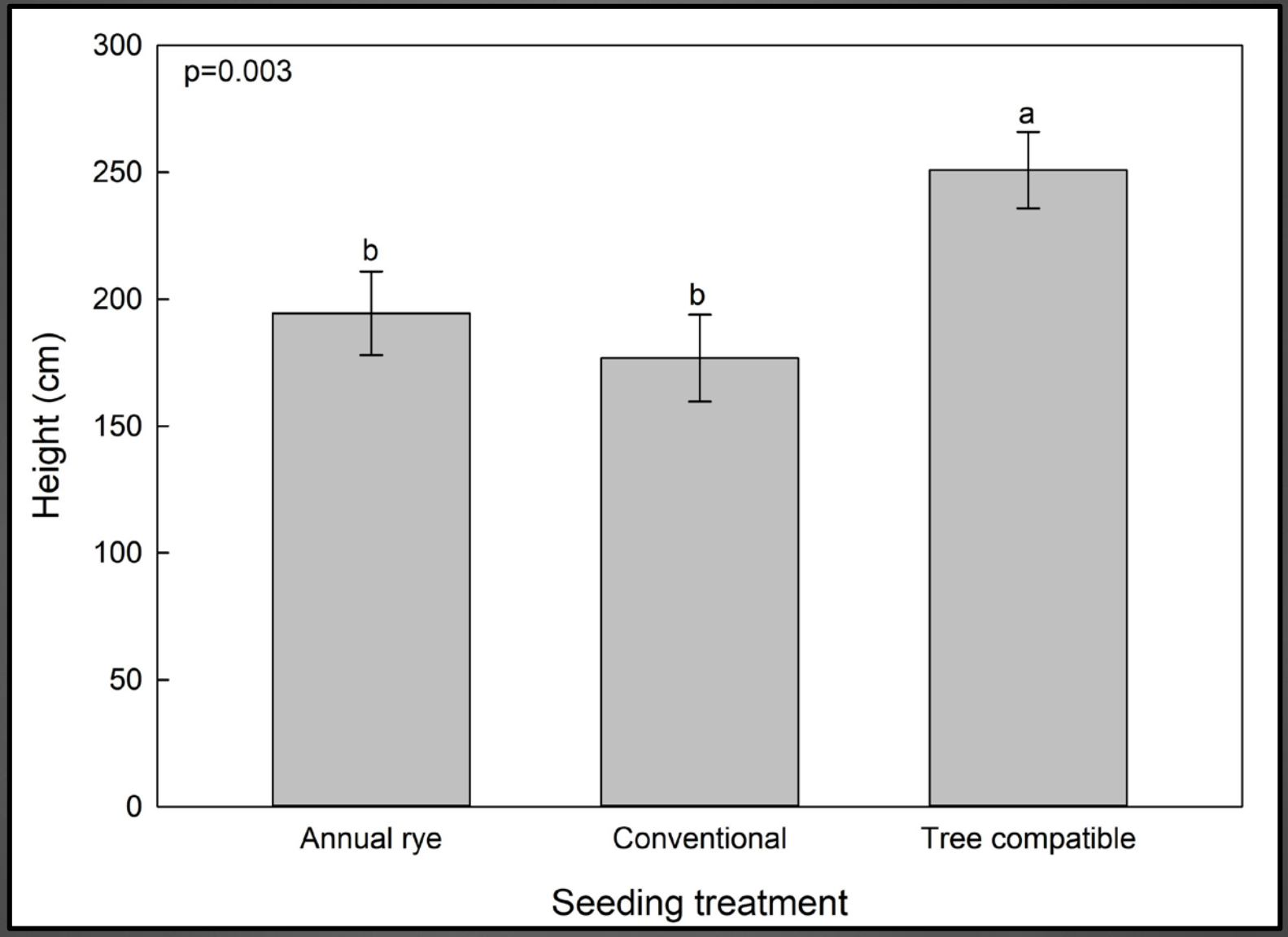
Measuring Vegetation Competition

- Cover (%) of competing vegetation relative to tree size
- Vegetation competition index (Evans et al. 2013)
  - Rank from 1 to 5
  - 1=no vegetation
  - 3=vegetation ½ to ¾ tree height
  - 5=Vegetation taller than tree

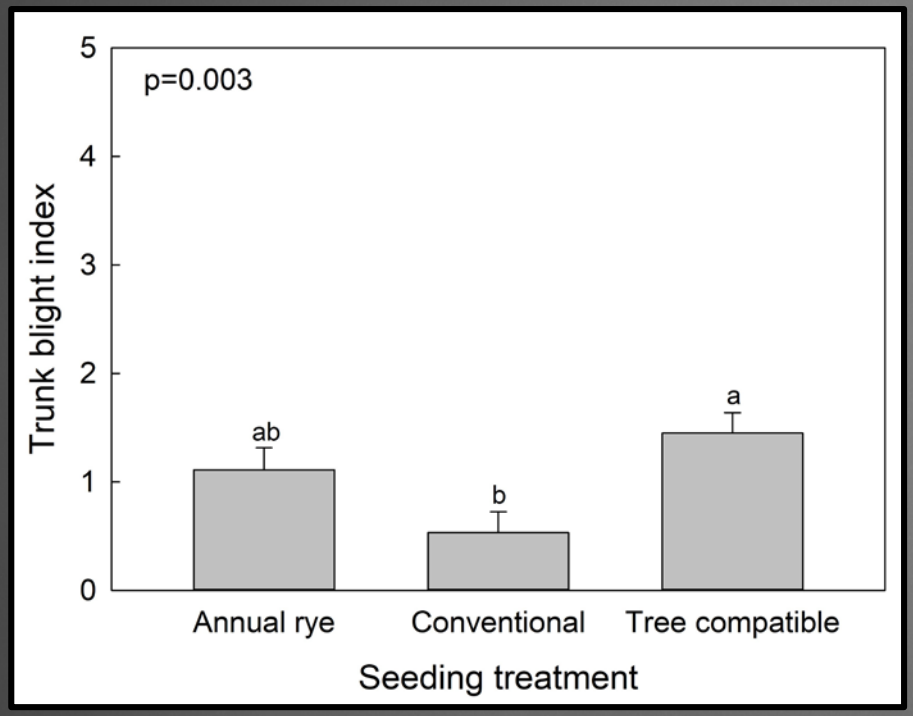
Results: Survival and seed mix

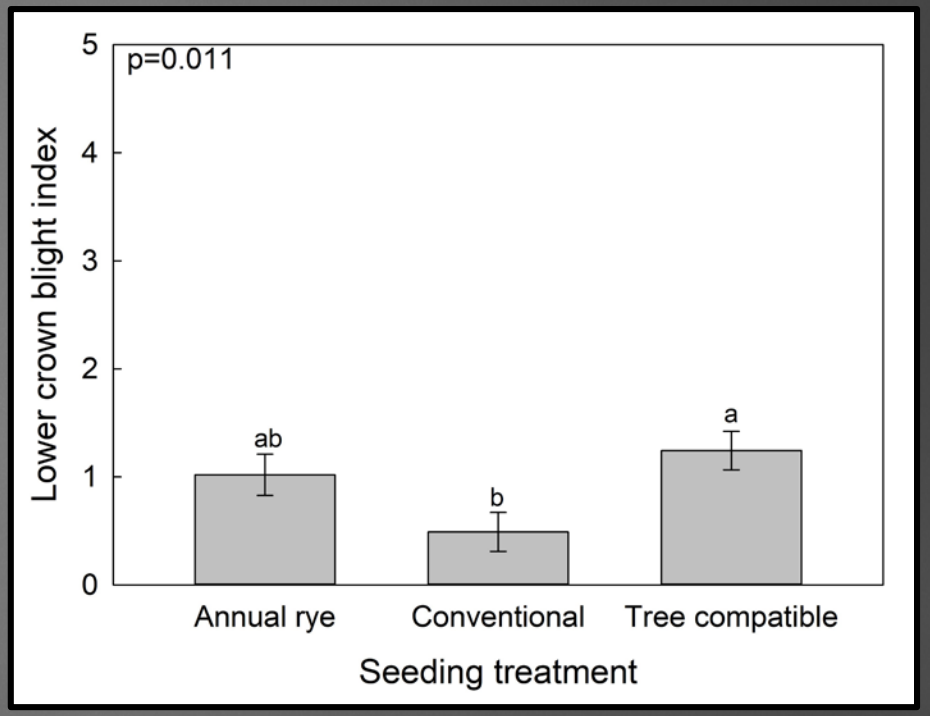


Results: Height and seed mix

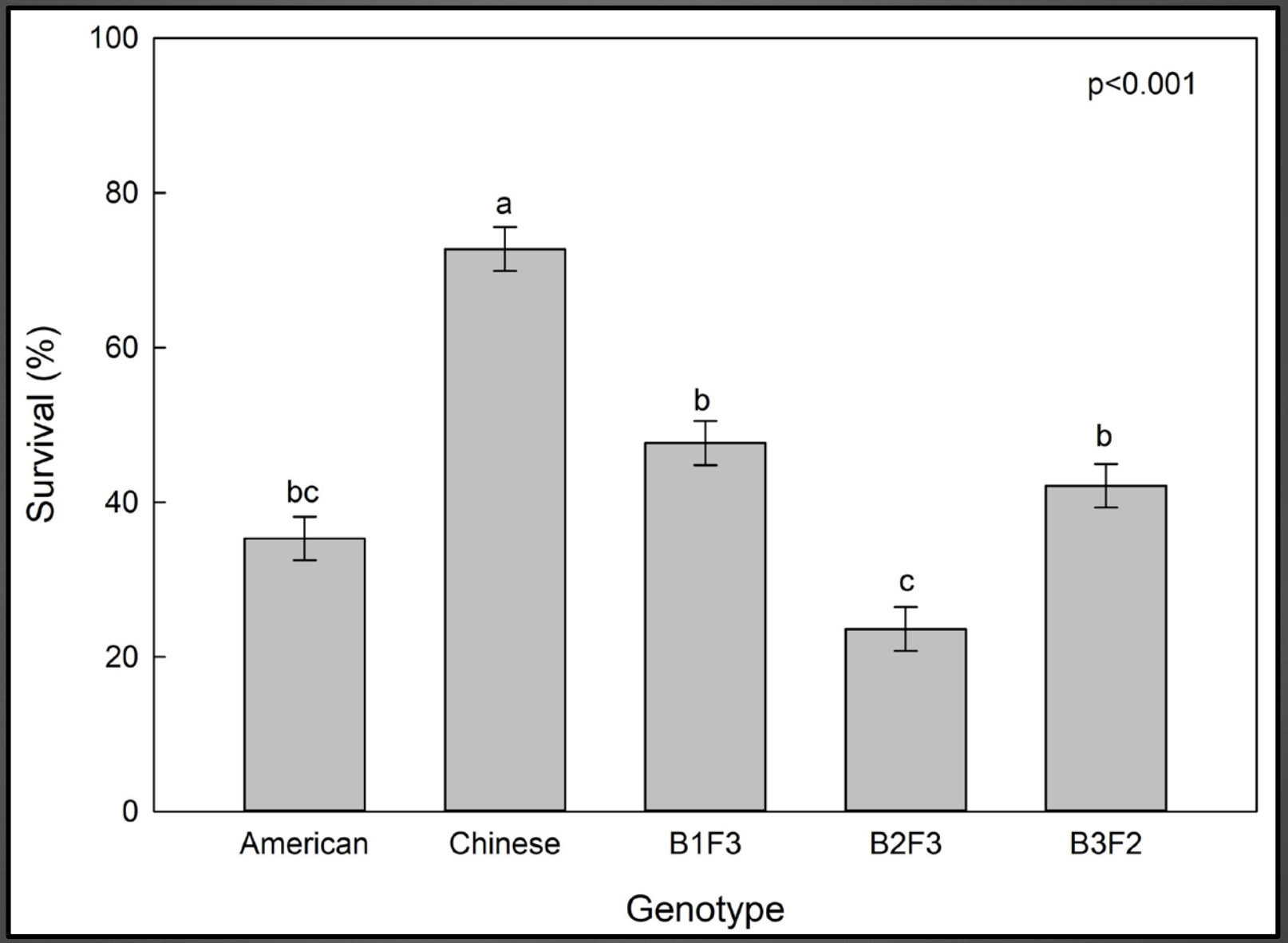


Blight and seed mix

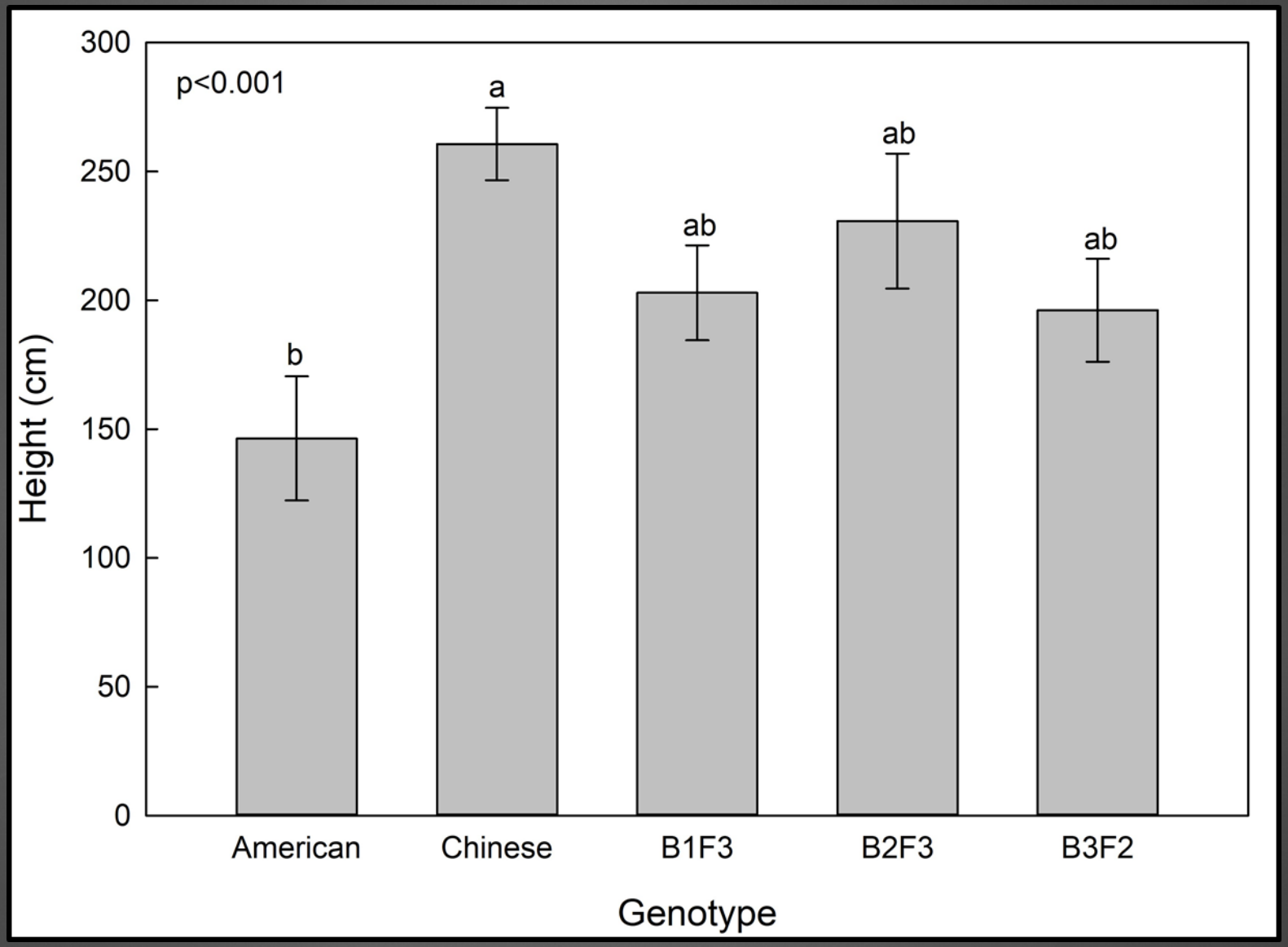




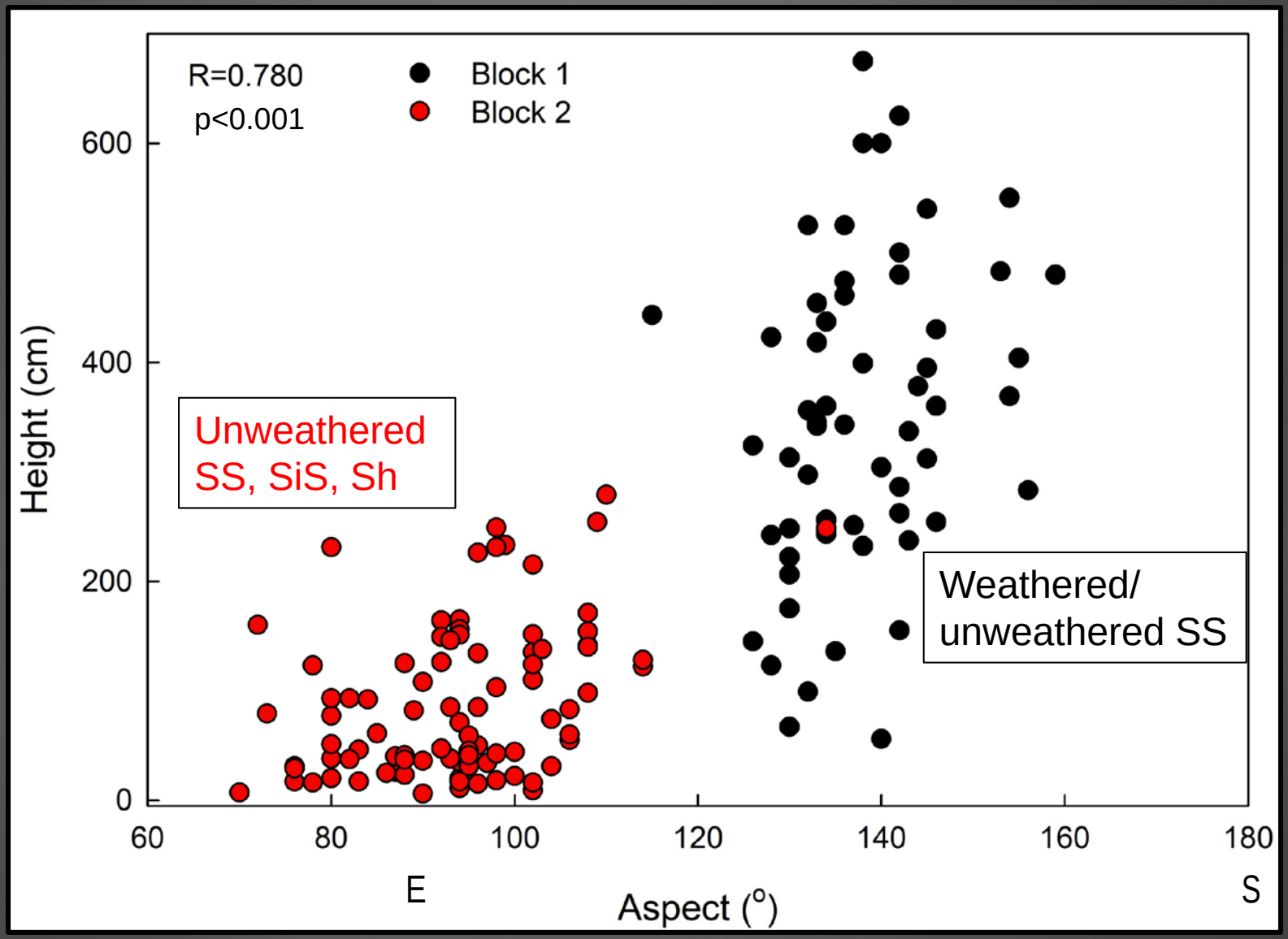
Results: Survival and genotype



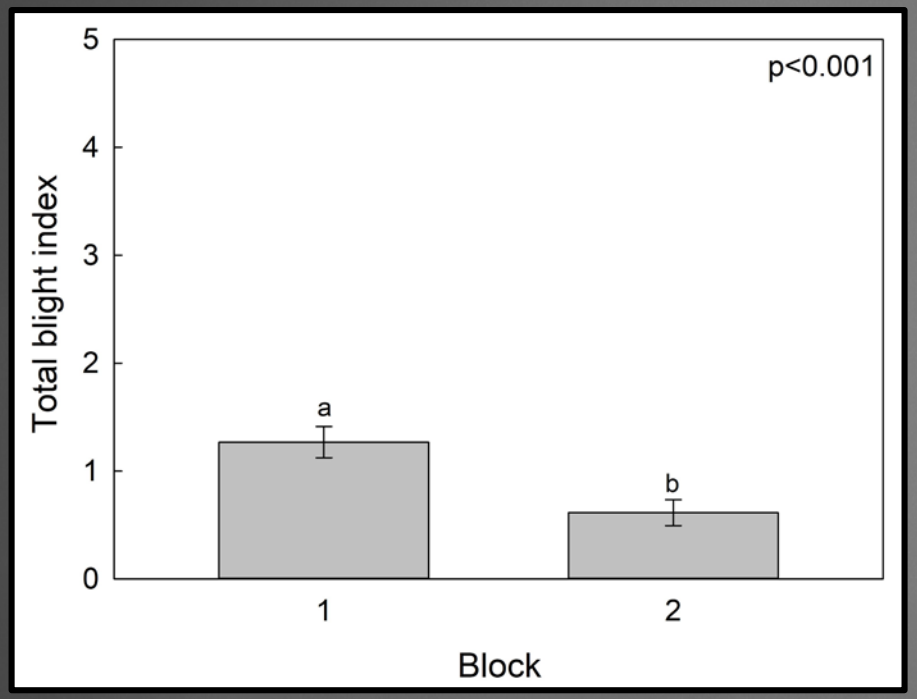
Results: Height and genotype

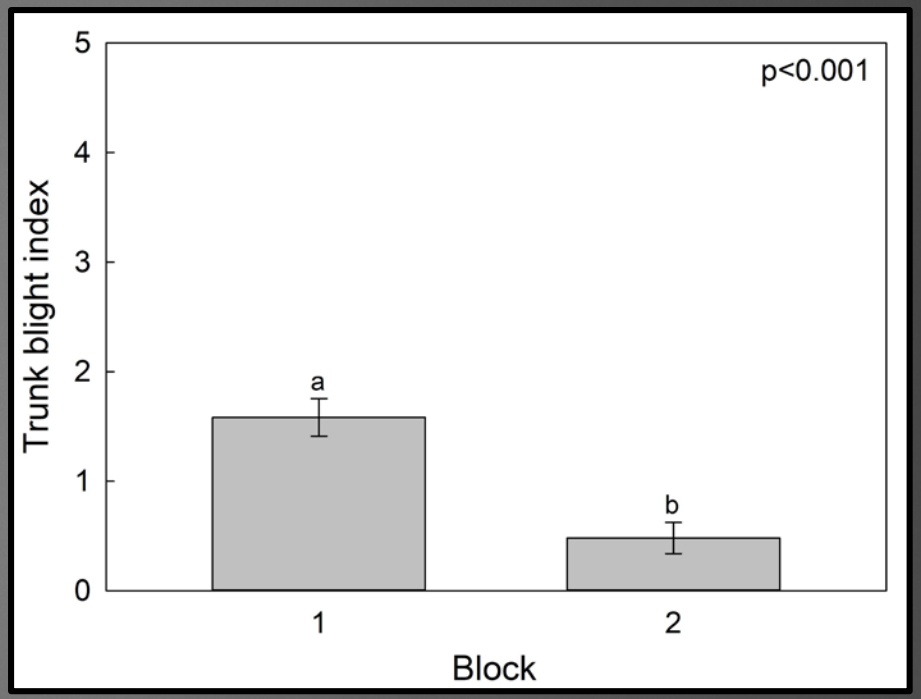


Results: Height and aspect



Results: Block and blight incidence

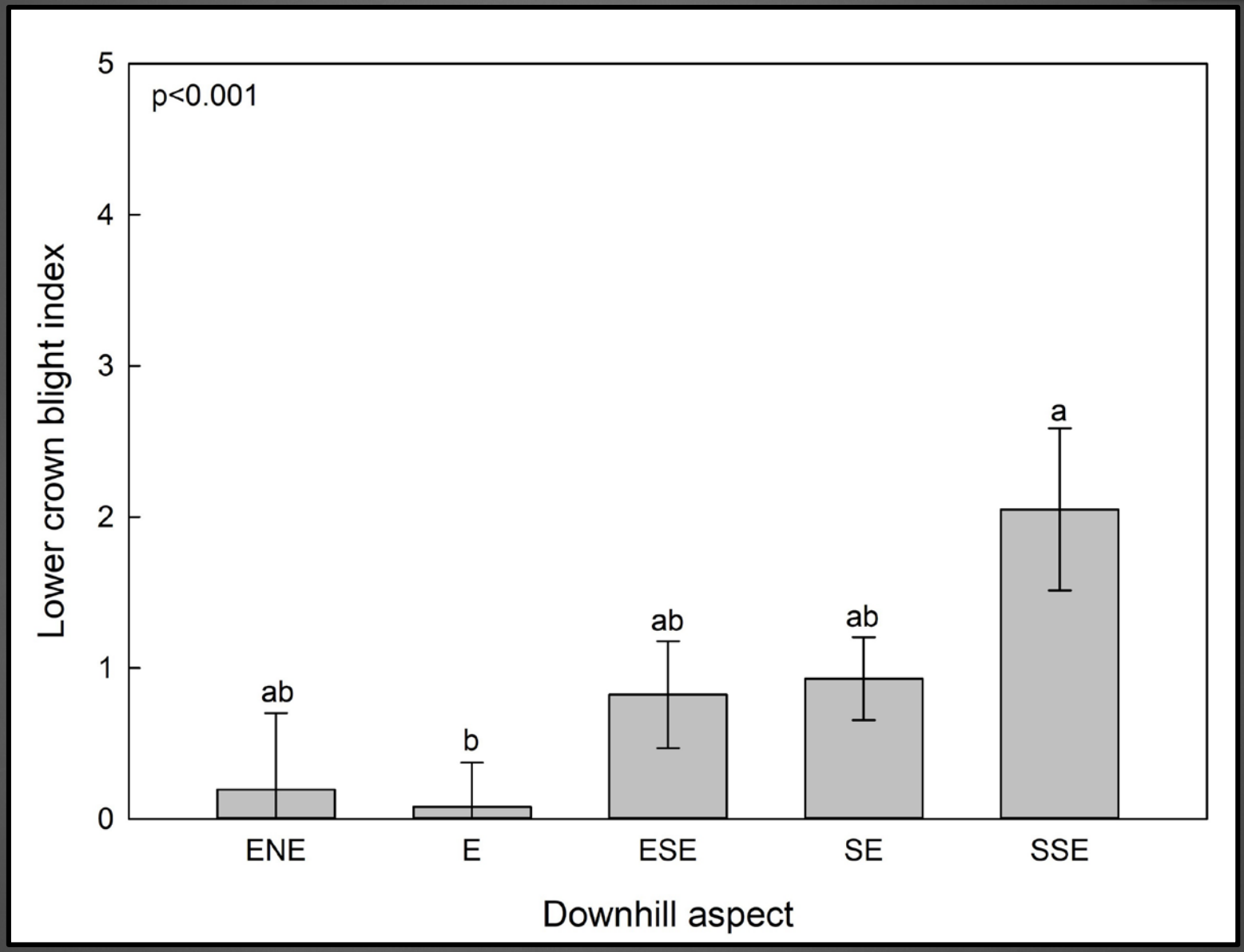




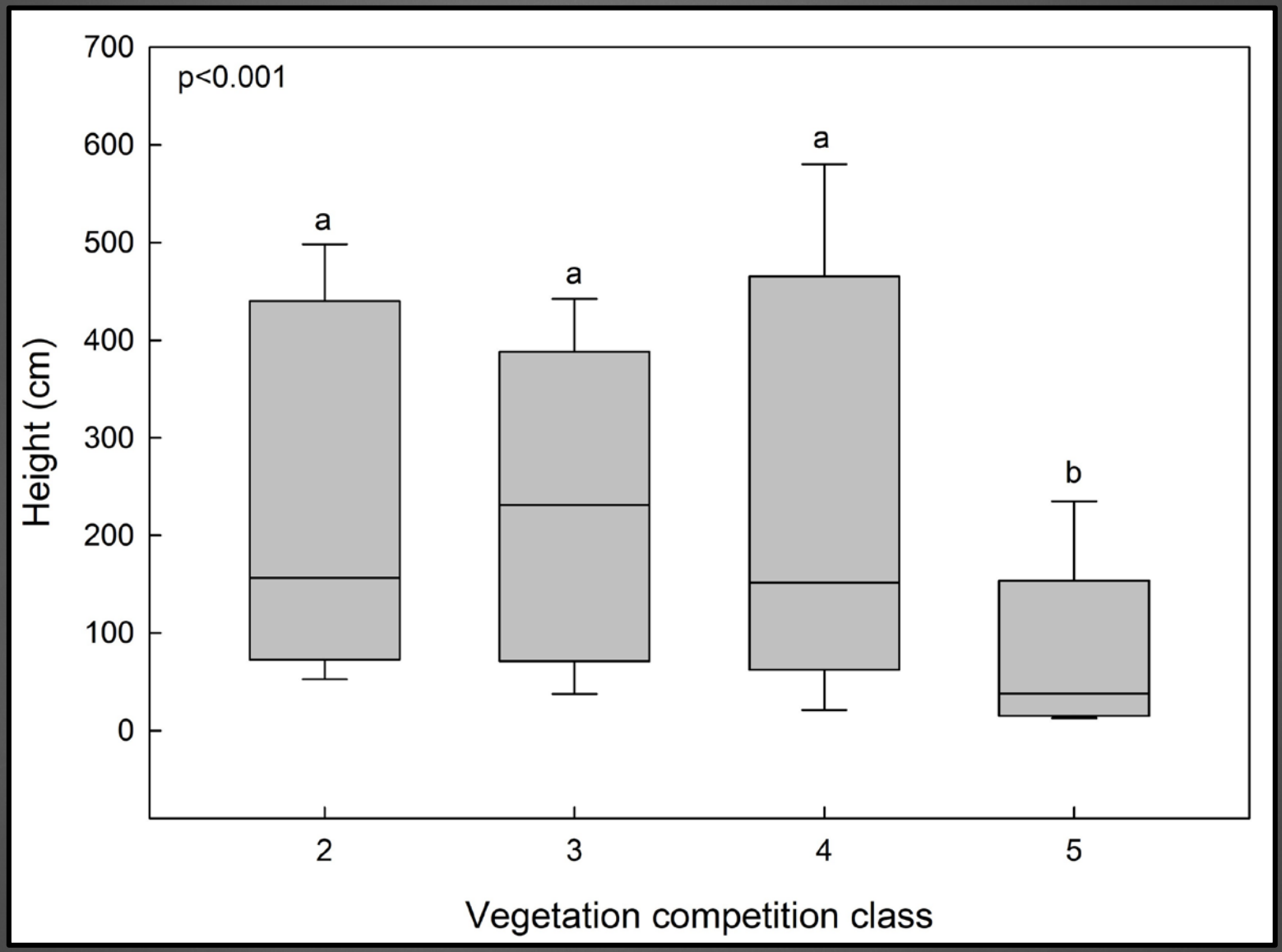
Block 1: South aspect, weathered/unweathered SS

Block 2: East aspect, unweathered SS, SiS, Sh

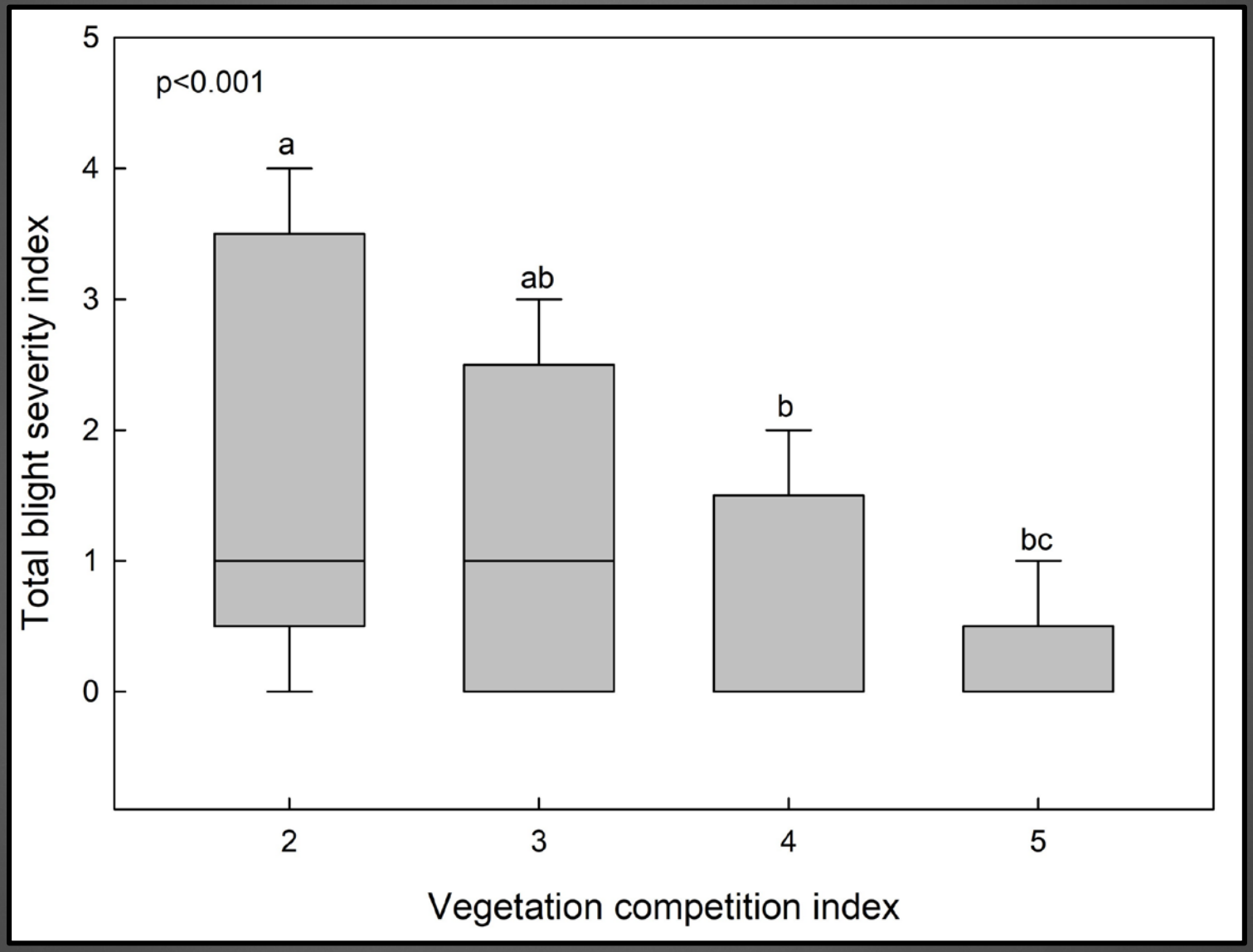
Results: Blight and aspect



Results: Height and vegetation competition



Results: Blight and vegetation competition



Summary and conclusions

- Survival
  - Similar between blocks, highest in AR
    - Seeding treatments can have long-term effect on reclamation success (Burger et al. 2008, Burger et al. 2009)
  - Chinese chestnut had highest survival, B2F3 lowest
    - Chinese chestnuts do well on sandy/gravelly soils, maybe well-suited for mine soils (Strang 2012)
    - Similar survival to hybrids on fine-textured soil (Gilland and McCarthy 2014)

Summary and conclusions

- Height
  - Trees taller in Block 1
    - Height differences between blocks similar among other native tree species planted in this study
  - Trees taller with less competitive vegetation (TC, shorter vegetation
    - Many dead or missing trees where vegetation was particularly thick and aggressive
    - Trees absent in every location with no herbaceous vegetation
    - Seeding treatment important!! (Burger et al. 2008, Burger et al. 2009)
  - Chinese chestnuts tallest
    - Tend to perform well on mine soils (Bauman et al. 2014, Gilland and McCarthy 2014)
  - Trees taller at more southerly aspect
    - Historically on S facing ridges (Braun 1935)

Summary and conclusions

- Blight
  - More total and trunk blight symptoms in block 1
  - More trunk and lower crown blight in TC than CON
  - No blight differences among genotypes
  - More lower crown blight at SSE aspect, less at more easterly aspects
  - Less total blight with more vegetation competition

Summary and conclusions

- Better execution of FRA (higher quality growth medium and less aggressive herbaceous layer) led to better chestnut survival and growth – but more blight
  - Higher stem density (including blight carrier species), faster disease transmission?
  - Larger trees more likely to have blight symptoms?

More studies needed!

- Limitations in this study due to many autocorrelated factors (block, substrate, aspect)
  - Need studies isolating these variables

Other thoughts

- What we know
  - More blight on sandy, xeric sites (vs. mesic) (Rhoades et al. 2009)
  - Can perform well with competition (Griffin et al. 1991)
  - Share ectomycorrhizal (ECM) symbionts with other tree species that can improve growth and survival (Bauman et al. 2012)
- Beneficial to allow understory and native seedlings to establish before planting chestnuts?
  - Build up OM in soil – improve water holding capacity
  - Chestnuts can grow in understory, take advantage of light gaps
  - Older trees function as nurse plants/facilitate ECM colonization (Bauman et al. 2012)

Thanks!

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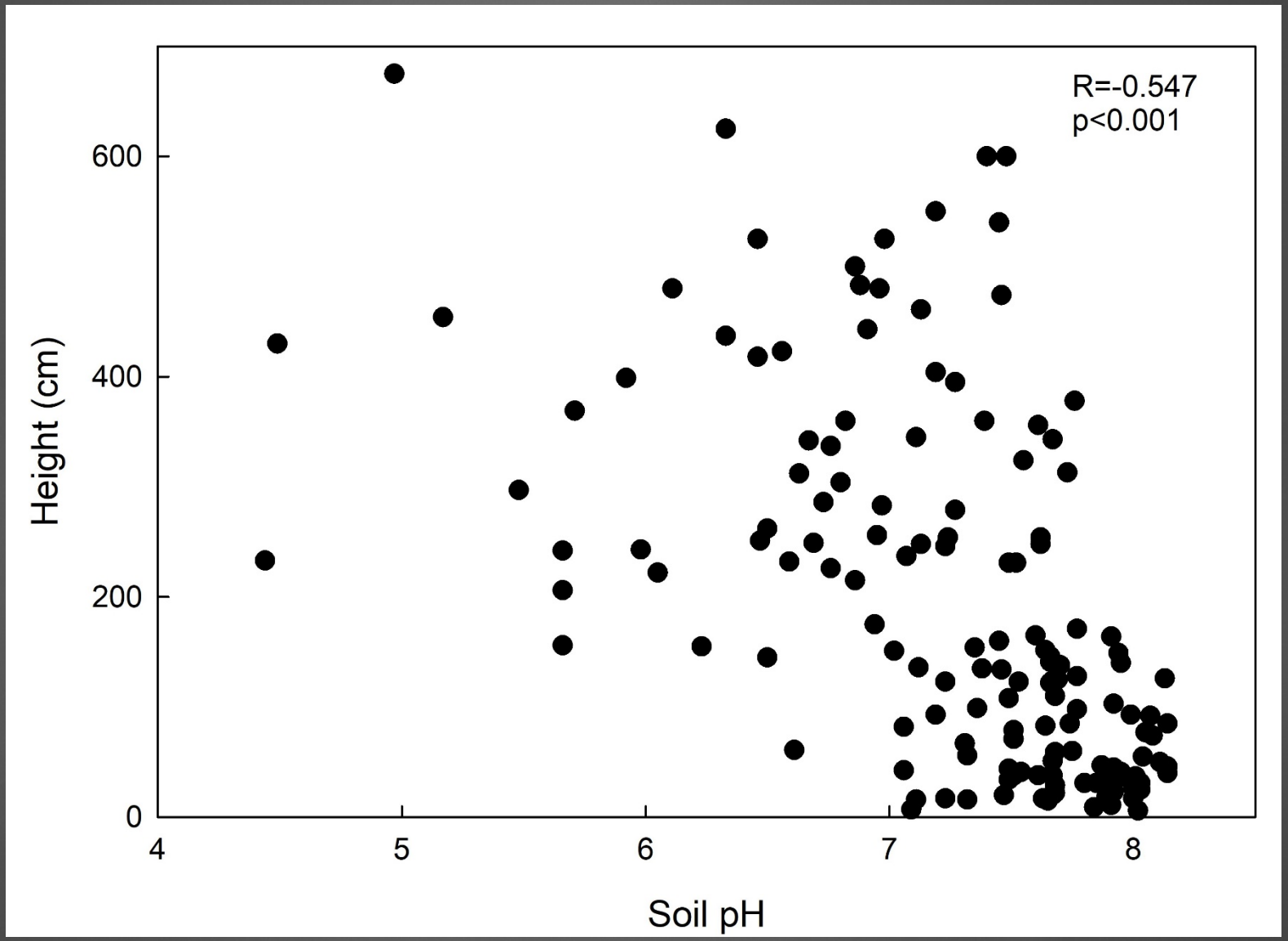
Height and pH



Height and directional aspect