Native Tree Survival and Herbaceous Establishment on an Experimentally Reclaimed Appalachian Coal Mine

S.C. Koropchak, C.E. Zipper, J.A. Burger and D. M. Evans
Virginia Tech, Blacksburg, VA

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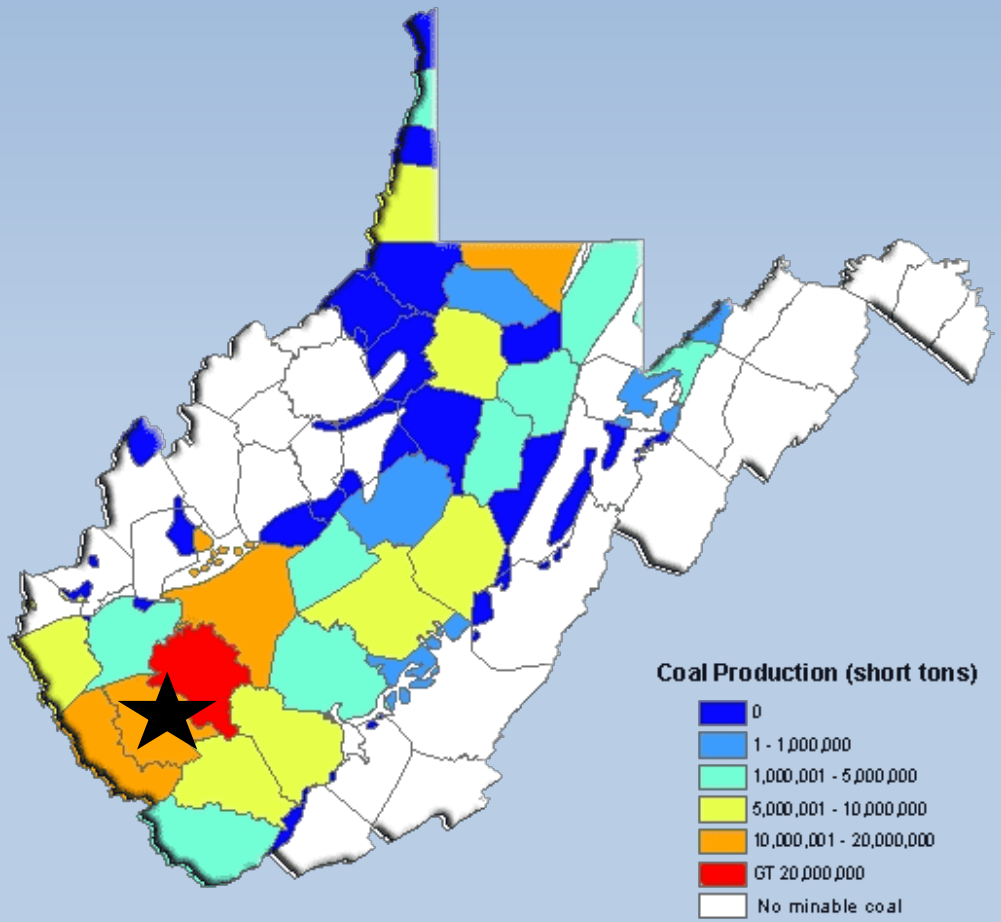
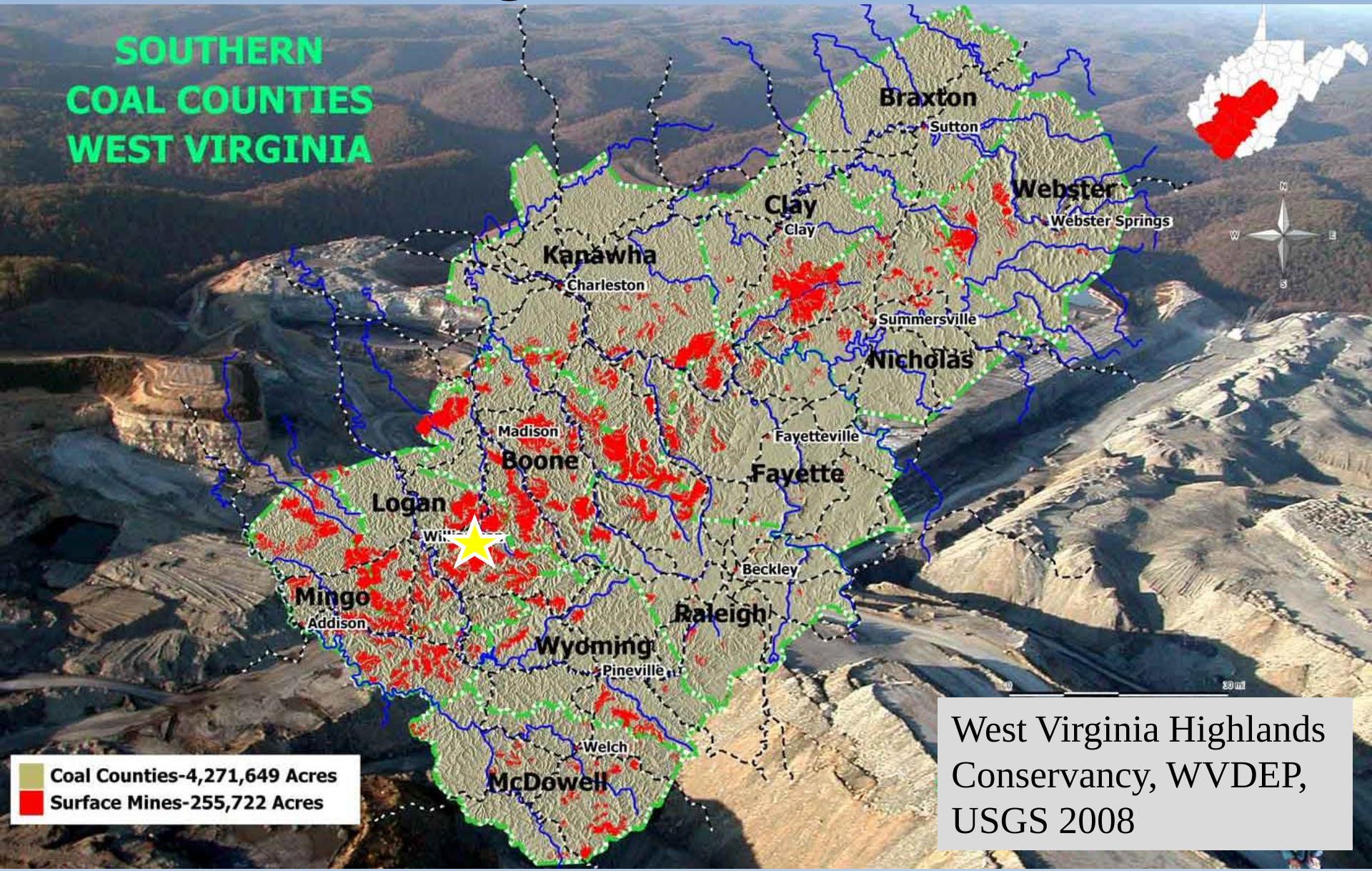
West Virginia Coal Production



- ~8.5 % of US coal production (GAO 2009)

West Virginia Geologic and Economic Survey 2012

West Virginia Coal Production



West Virginia Highlands Conservancy, WVDEP, USGS 2008

Coal Surface Mine Reclamation

- Reclamation goals: To reestablish economically and ecologically valuable land cover
  - Can be achieved with reforestation
- Methods to achieve reforestation known as the Forestry Reclamation Approach (FRA) (Burger et al. 2005)

Forestry Reclamation Approach

1) 4 ft of rooting medium: topsoil, brown sandstone, or best available

2) Loosely grade material during placement
   - Minimize compaction to allow tree roots to grow

3) Tree compatible herbaceous groundcover
   - Hold on to soil but don’t compete with tree saplings

4) Plant mix of trees including early succession species for value to wildlife and soil stabilization (e.g. dogwood) and commercially valuable crop species (e.g. oaks)

5) Use proper tree planting techniques
   - Store trees properly, keep roots moist before planting, plant to appropriate depth, etc.

Substrate Selection

- Evidence that native salvaged topsoil and/or brown (weathered) rocks can be beneficial to the success of a reclamation (Skousen et al. 2011)
  - Better quality planting media for trees
  - Topsoil serves as a source of native forest understory plant propagules (e.g. seeds, rhizomes)

Seeding Treatment

- Evidence that even tree-compatible species have been found to persist and compete with trees
- Tree survival and growth improve as competition from groundcover decreases (Fields-Johnson et al. 2012)
- No known studies comparing an unseeded treatment with tree-compatible seeding treatment

Main Questions

1) How does seeding an herbaceous cover crop affect tree survival after one growing season (GS)?

2) How do various substrates affect the survival of planted trees after one GS?

3) How does seeding an herbaceous cover crop affect the understory community after one GS?

4) How do various substrates affect the understory community after one GS?

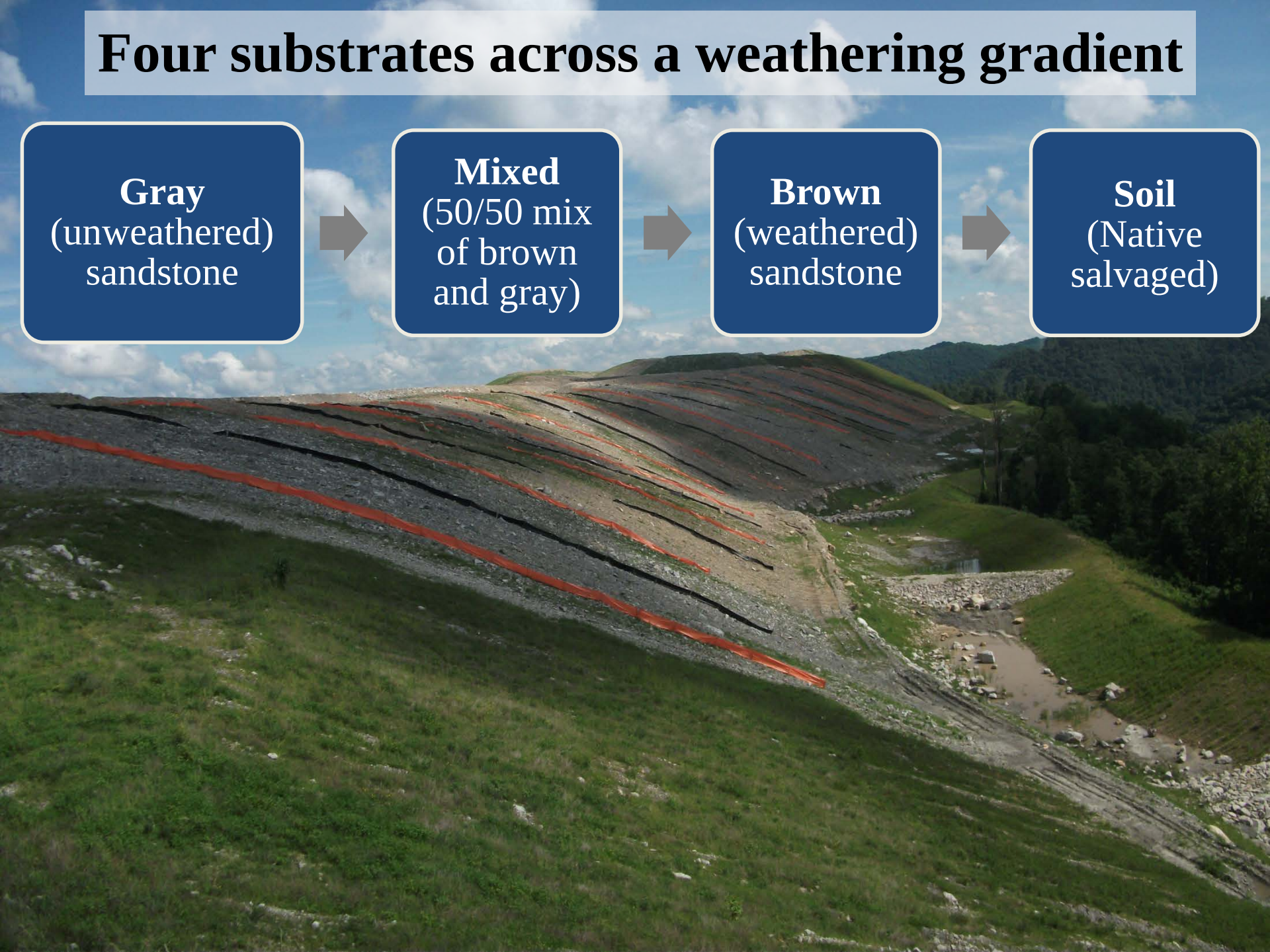
Four substrates across a weathering gradient

Gray (unweathered) sandstone

Mixed (50/50 mix of brown and gray)

Brown (weathered) sandstone

Soil (Native salvaged)



Seeding Prescription

- Seeded plots: mix of tree-compatible herbaceous species
  - Perennial rye, Timothy grass, Annual rye, Birdsfoot trefoil, white clover
- Unseeded plots: no seed
- All plots: 19-19-19 N-P-K fertilizer, mulch

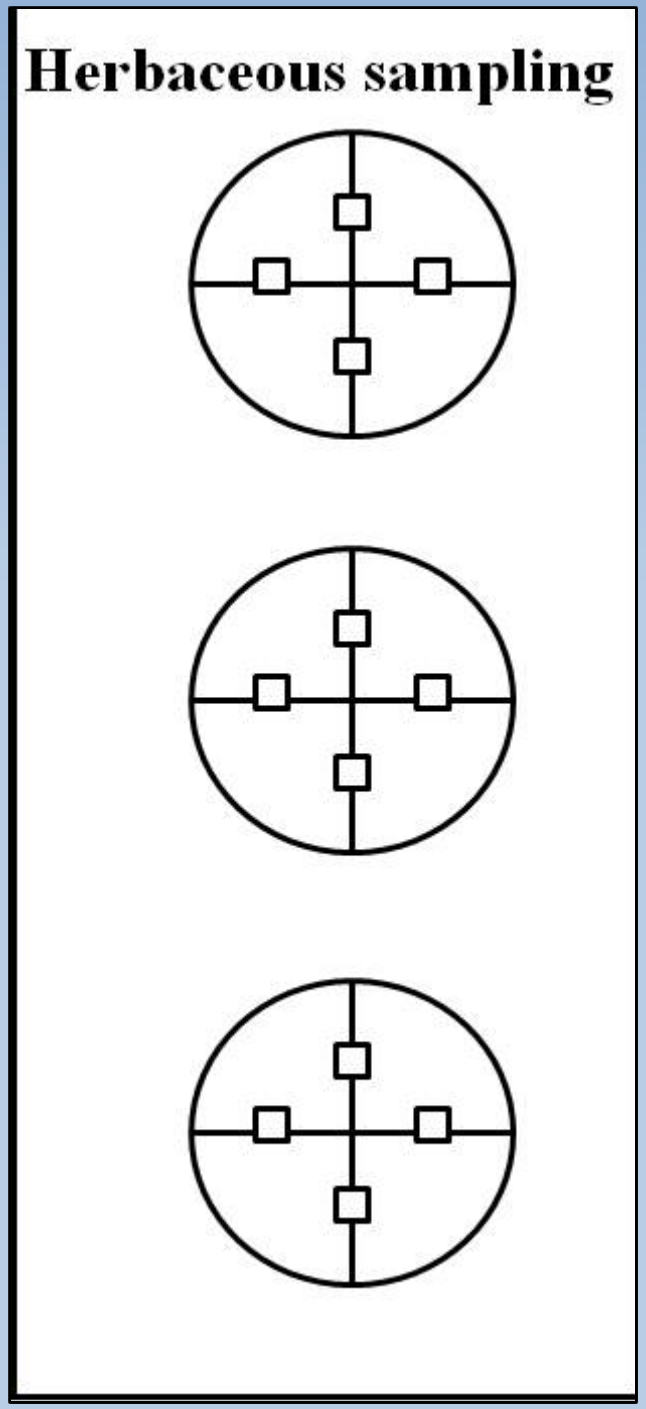
Tree Planting Prescription

Succession Stage	Species	Trees/hectare
Early	Sugar Maple (SM)	247
	Black Cherry (BC)	247
	Tulip Poplar (TP)	124
	Hawthorn (H)	62
	Eastern Redbud (RB)	62
	Gray Dogwood (GD)	62
	Eastern White Pine (EWP)	62
Late	White Oak (WO)	247
	Northern Red Oak (RO)	247
	Chestnut Oak (CO)	247
	Shagbark Hickory (SH)	124


Experimental Block 3
Experimental Block 2
Experimental Block 1
Area 6
Area 5
Area 4
Area 3
Area 2
Area 1
Area 7
Area 8
Experimental Block 4
S
N
Soil
Bm
Gray
Mix

Vegetation Sampling Methods

- Substrate plots = 0.4 ha
  - Seeded/unseeded subplots = 0.2 ha
- Tree sampling plots
  - 1/50 ha
- Herbaceous sampling plots
  - 1 m^2

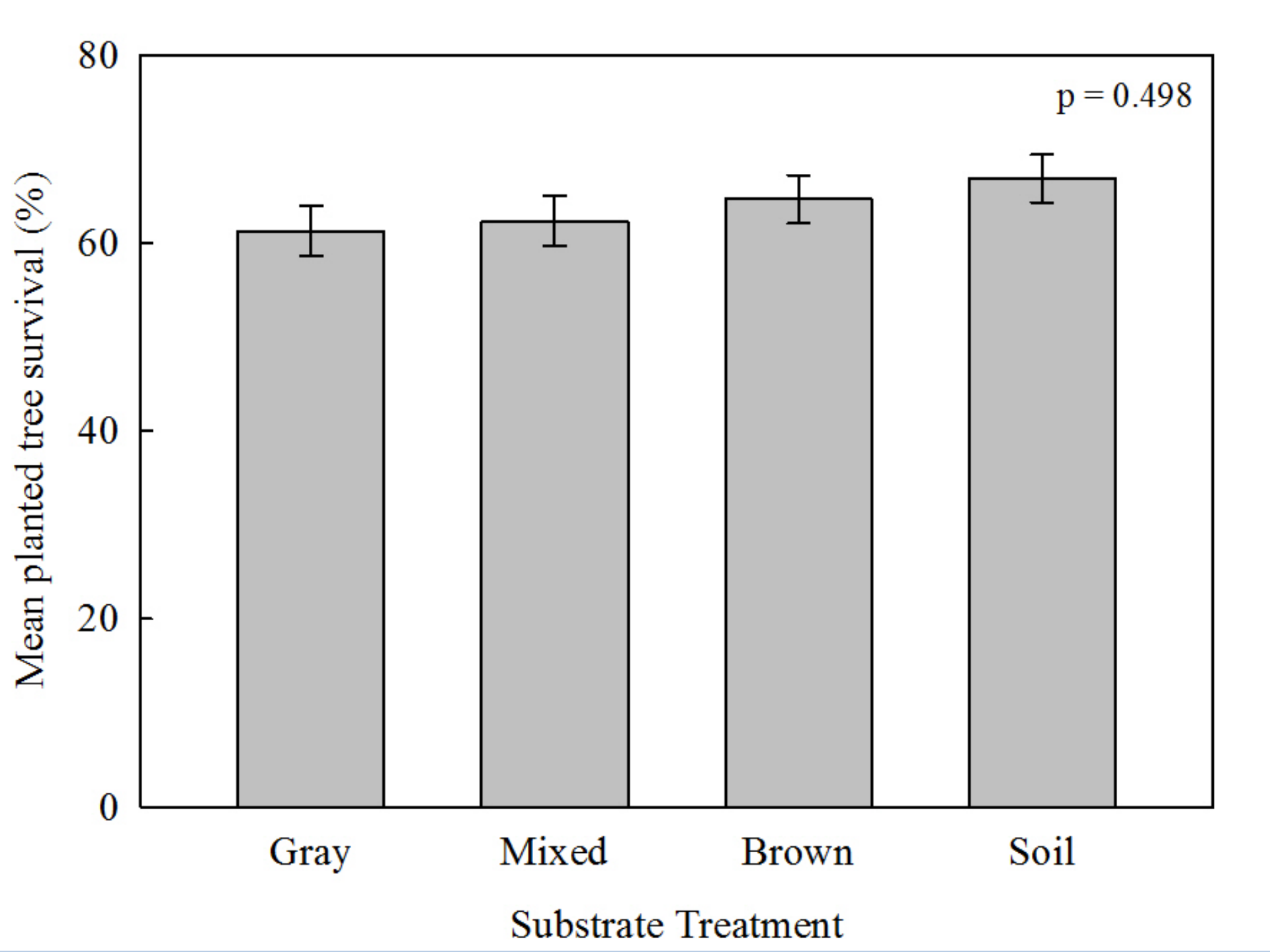


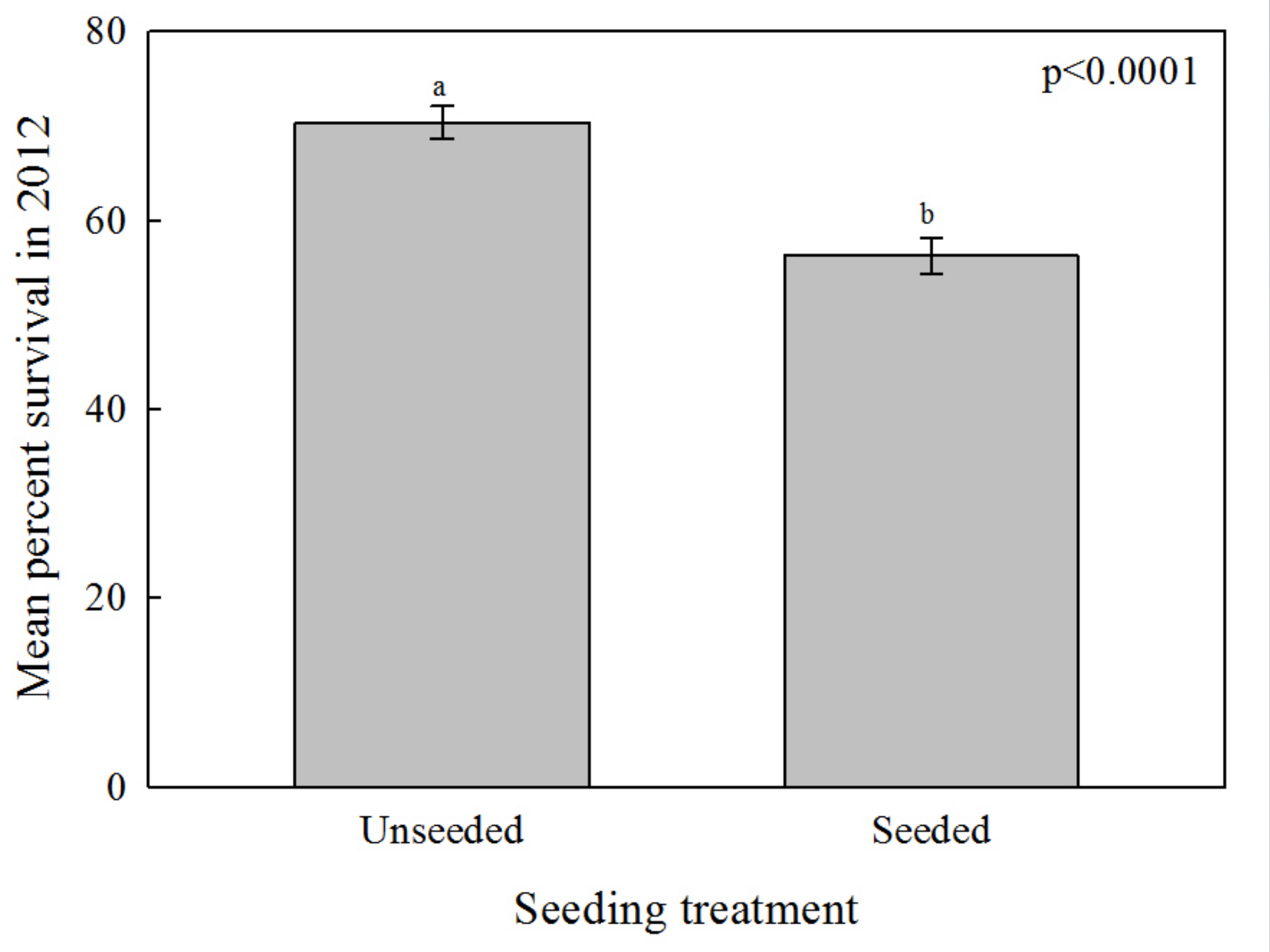
Data Collection

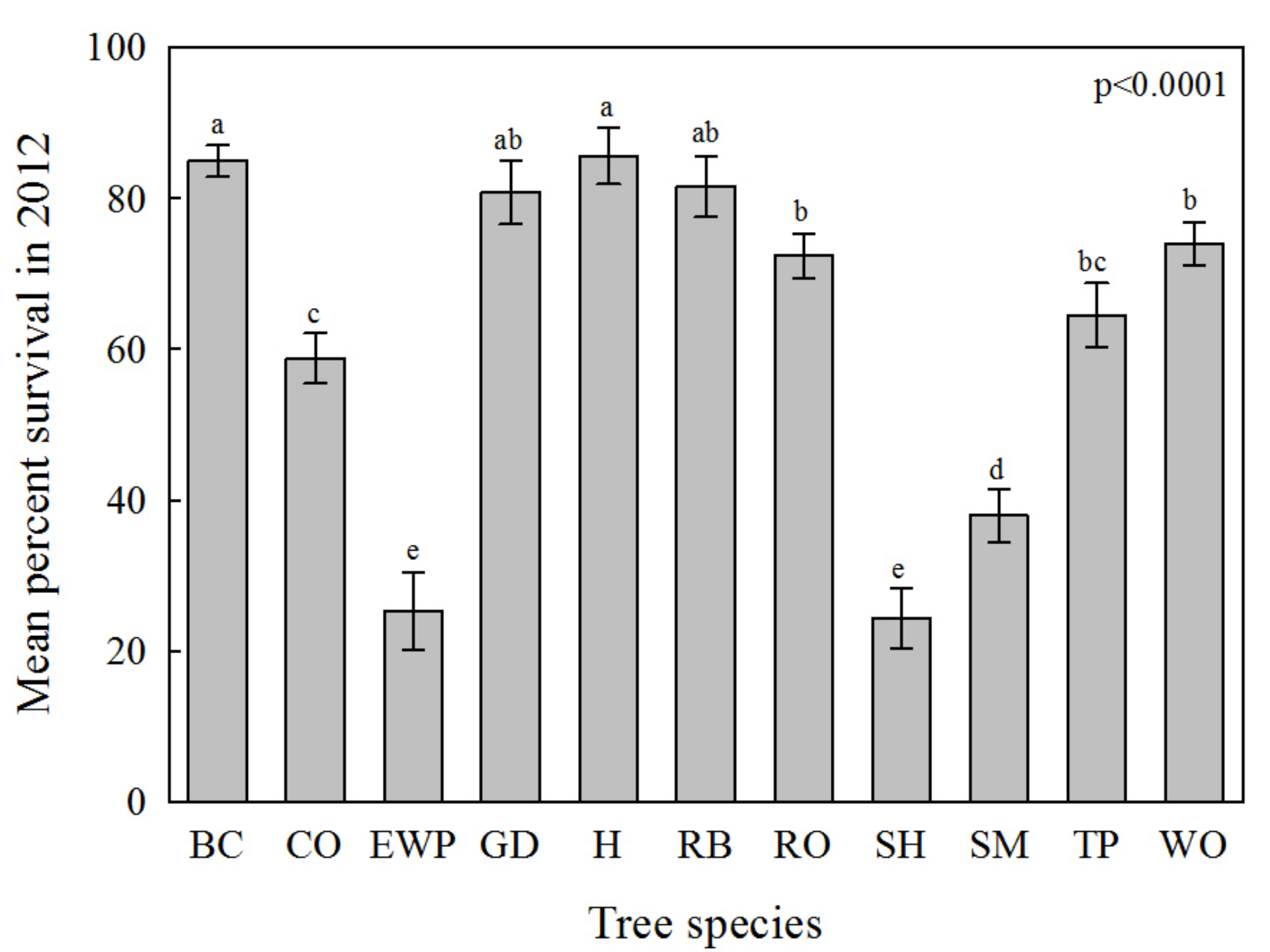
- Trees
  - Height, survival, basal diameter
- Herbaceous community
  - All plants and their percent covers recorded
    - Total percent cover
    - Volunteer (unplanted) and total (planted + unplanted) species richness
    - Diversity
- Substrate characterization
  - Structural (e.g. coarse fragment content) and chemical properties (e.g. pH, organic matter)

Results: First Growing Season

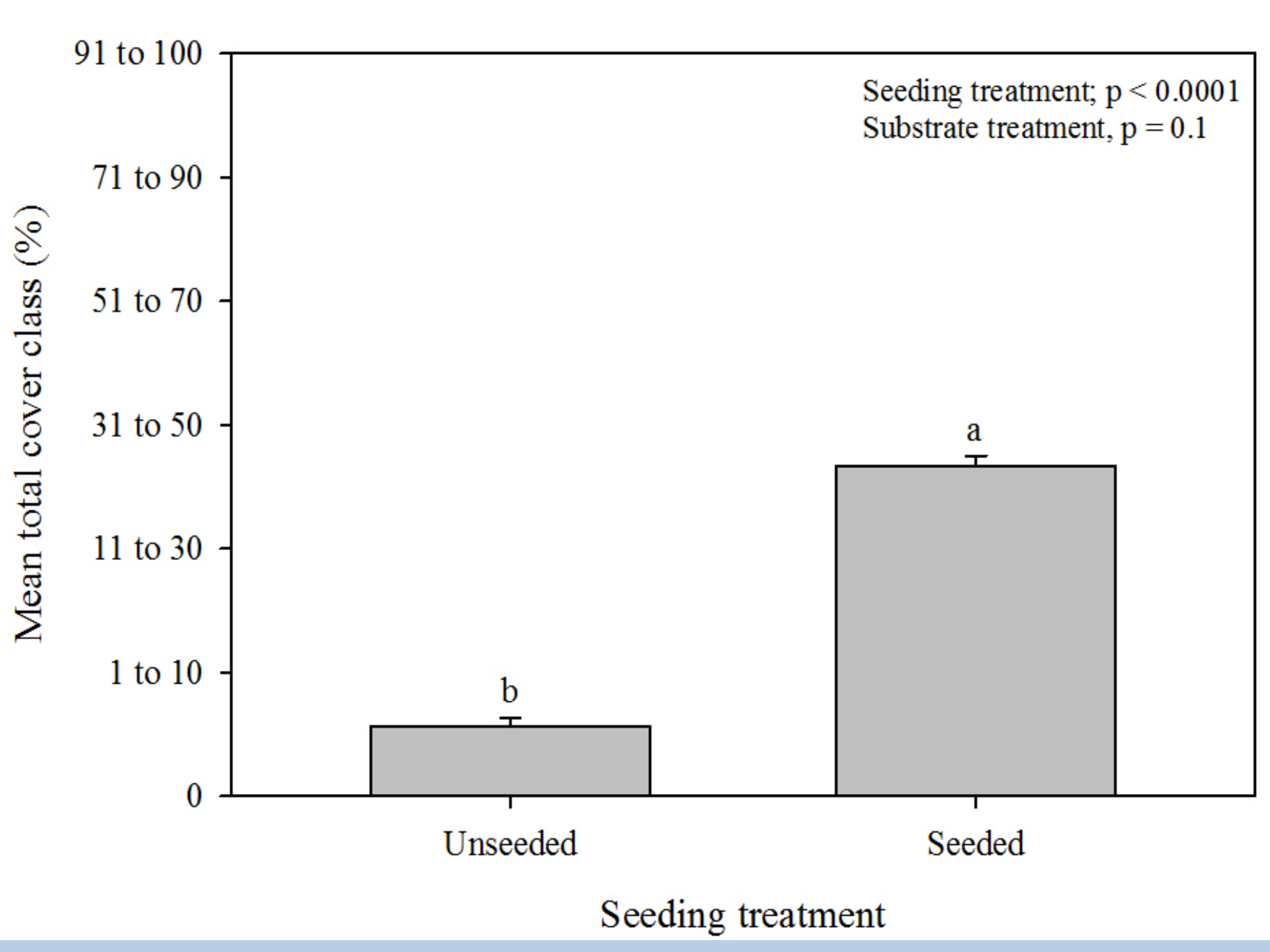
Tree Survival


80
60
40
20
0
p = 0.498
Mean planted tree survival (%)
Gray
Mixed
Brown
Soil
Substrate Treatment

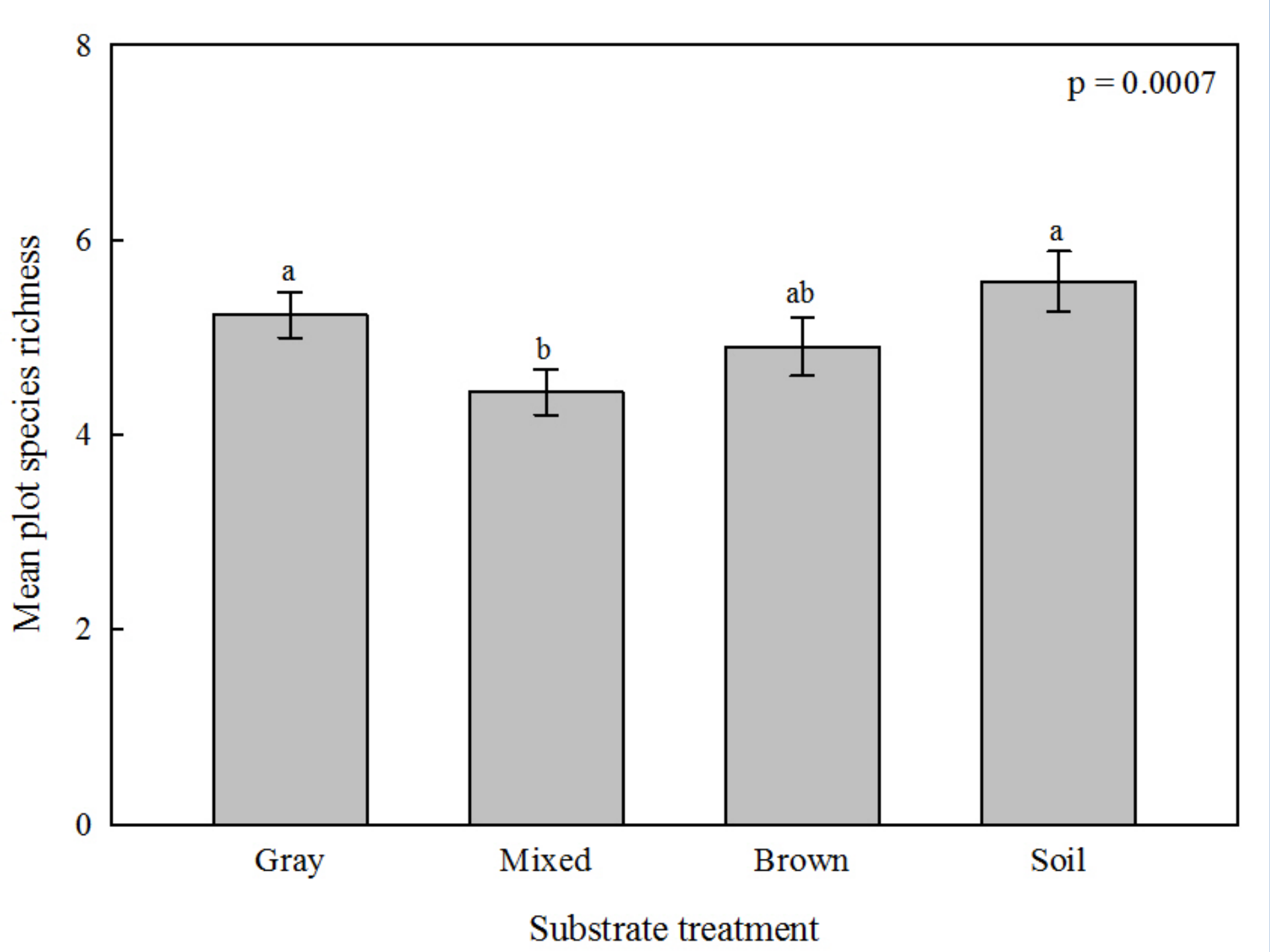

80
60
40
20
0
Mean percent survival in 2012
p<0.0001
a
b
Unseeded
Seeded
Seeding treatment

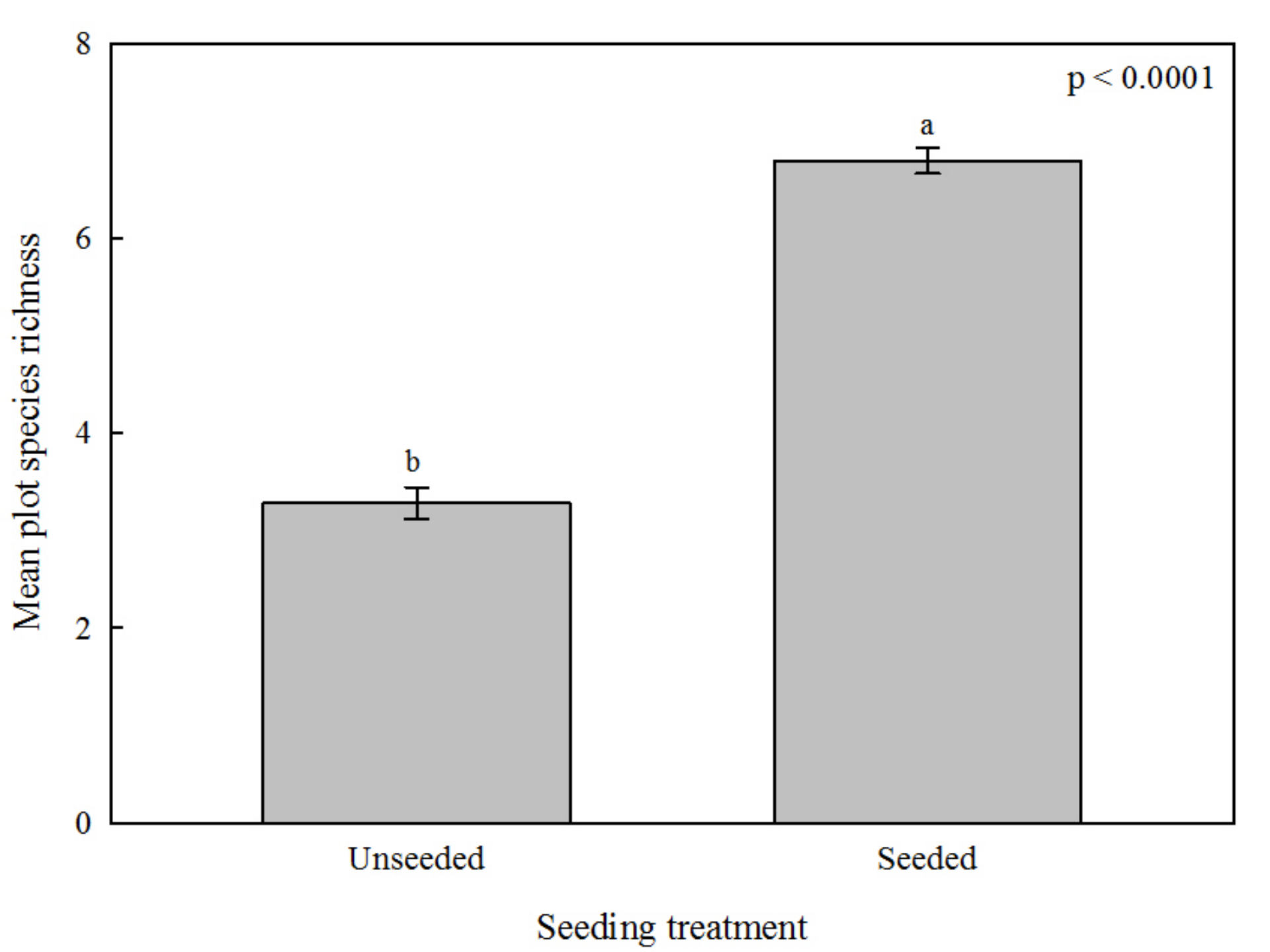

100
80
60
40
20
0
Mean percent survival in 2012
p<0.0001
a
c
e
ab
a
ab
b
e
d
bc
b
BC
CO
EWP
GD
H
RB
RO
SH
SM
TP
WO
Tree species

Total Herbaceous Cover

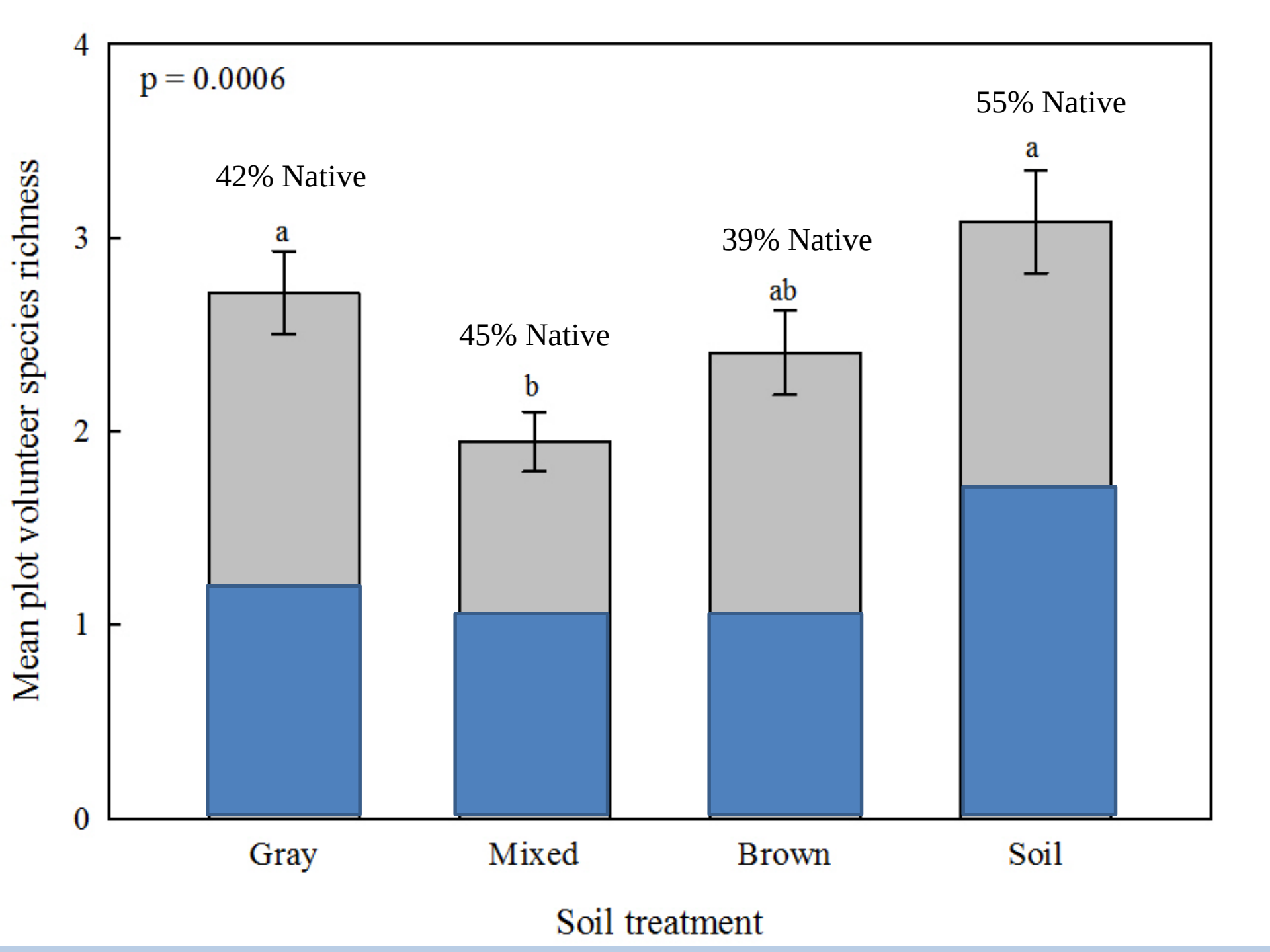

91 to 100
71 to 90
51 to 70
31 to 50
11 to 30
1 to 10
0
Mean total cover class (%)
Seeding treatment; p < 0.0001
Substrate treatment, p = 0.1
a
b
Unseeded
Seeded
Seeding treatment

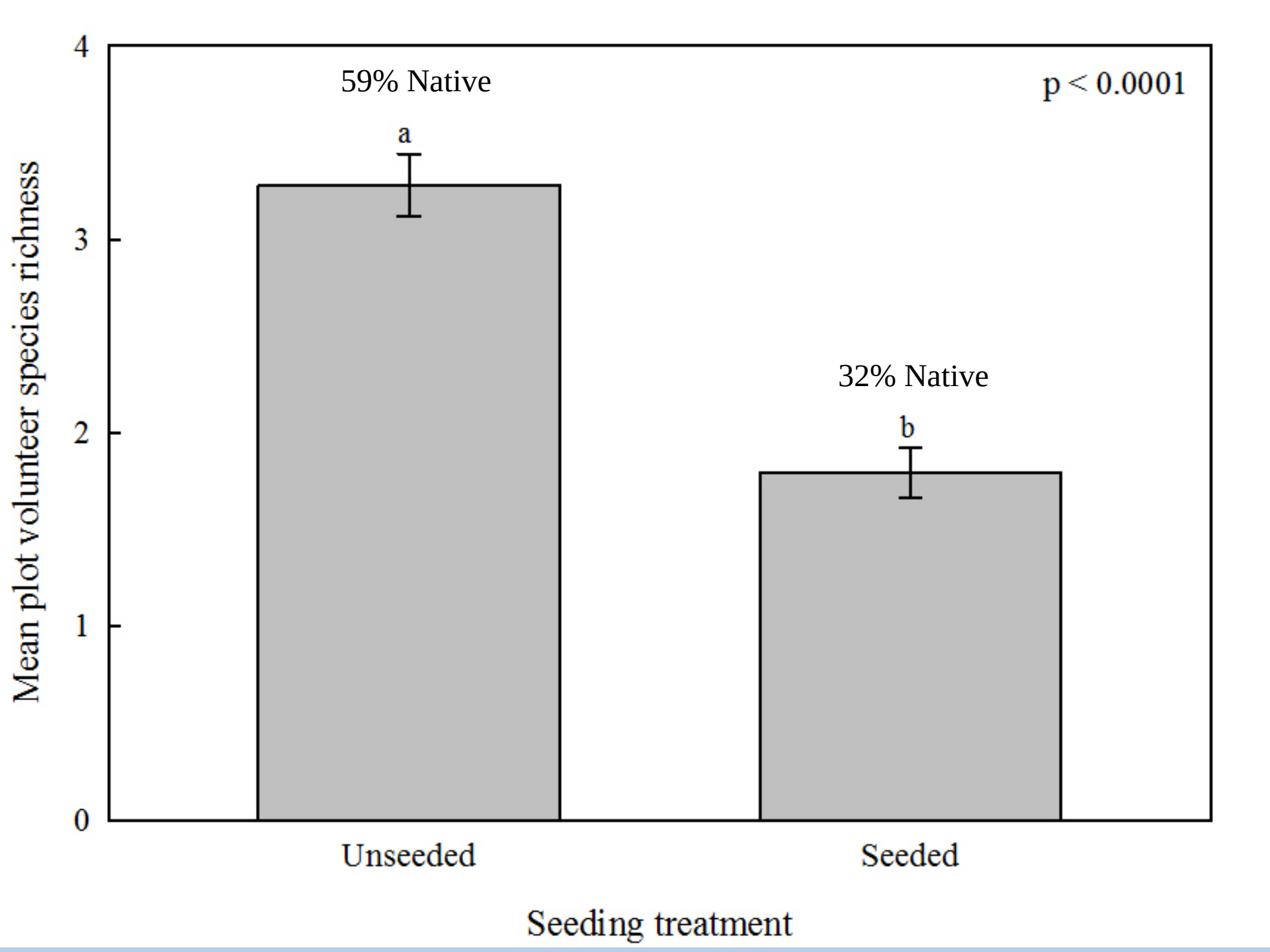
Total Species Richness


p = 0.0007
Mean plot species richness
8
6
4
2
0
a
b
ab
a
Gray
Mixed
Brown
Soil
Substrate treatment

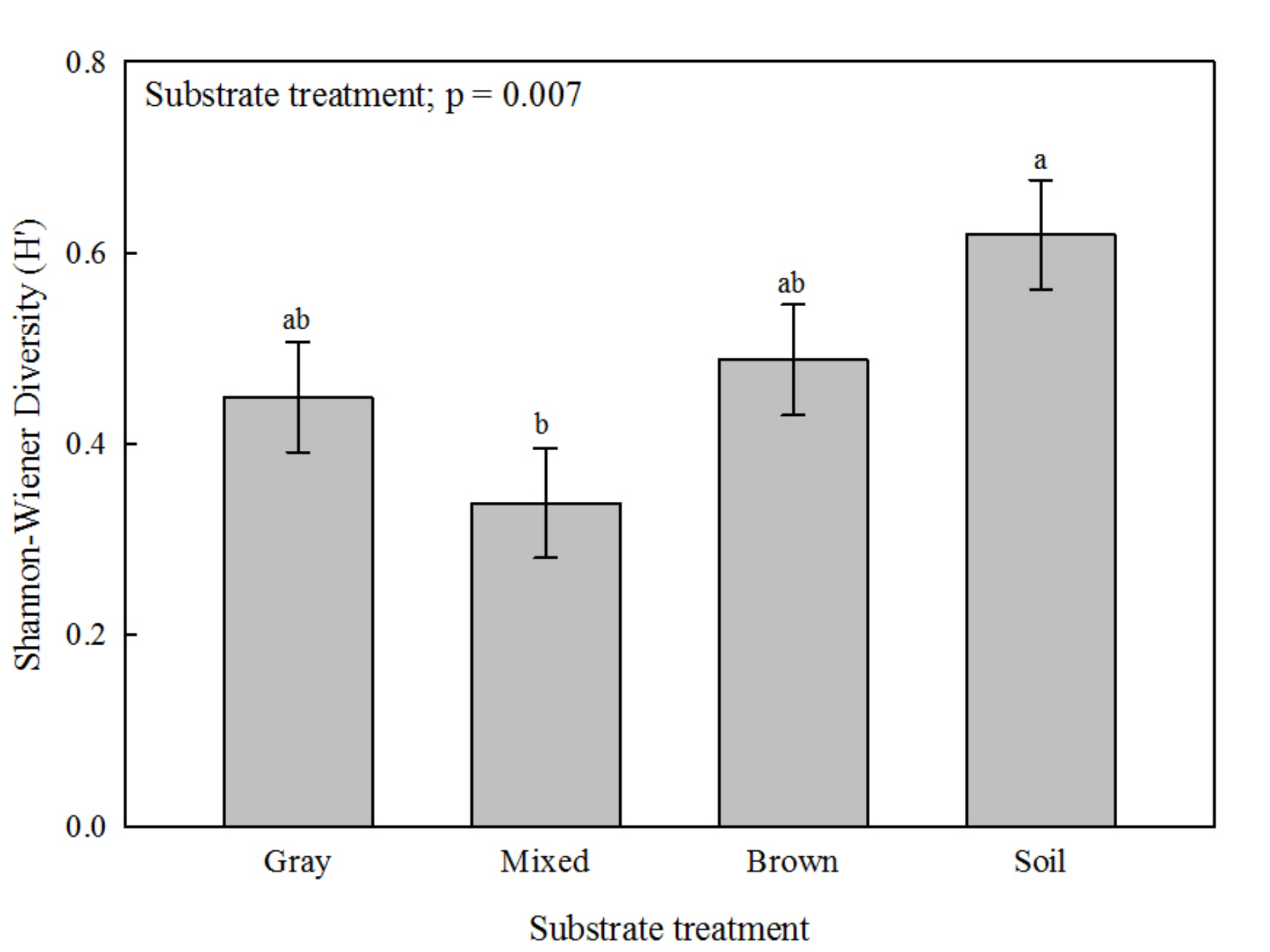

8
6
4
2
0
p < 0.0001
a
b
Mean plot species richness
Unseeded
Seeded
Seeding treatment

Volunteer Species Richness


p = 0.0006
42% Native
45% Native
39% Native
55% Native
a
b
ab
a
Mean plot volunteer species richness
0
1
2
3
4
Gray
Mixed
Brown
Soil
Soil treatment


4
3
2
1
0
Mean plot volunteer species richness
59% Native
a
p < 0.0001
32% Native
b
Unseeded
Seeded
Seeding treatment

Diversity (H’)


Substrate treatment; p = 0.007
Shannon-Wiener Diversity (H')
0.0
0.2
0.4
0.6
0.8
ab
b
ab
a
Gray
Mixed
Brown
Soil
Substrate treatment

Substrate Treatment Effects

- No observed differences (yet) in tree survival among substrate treatments
  - Environmental factors mask effects of substrate?
  - Species differences: poor tree stocks?

- Richness highest in substrates at ends of weathering gradient (gray sandstone and salvaged soil)
  - Higher proportion of native species in soil

- Diversity (measure of richness and evenness) highest in salvaged soil treatment

Seeding Treatment Effects

- Tree survival higher in unseeded treatment
  - Competition for resources? "Lost" trees?
- Cover and total richness higher in seeded treatment
  - Seeded plots include a base suite of species
- Volunteer richness higher in unseeded treatment
  - All species in unseeded treatment are volunteers
  - More space available for volunteers to establish

Main Conclusions

- Differences in tree survival and herbaceous community present after one growing season
- Differences expected to become more pronounced in future growing seasons
  - Transplant stress no longer a factor
  - Influx of additional propagules
- Future research essential to understand the importance of substrate selection and seeding prescription in rebuilding of forest communities

Proposed Future Work

- Quantify volunteer tree establishment
- Perform 3D scan of site to assess site topography and quantify gully erosion
- Gain at least one more year of data to better understand treatment effects

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