

# *Reclamation Practice Influences on the Post-Mining Plant Community at a Virginia Mine Site After Six Years*

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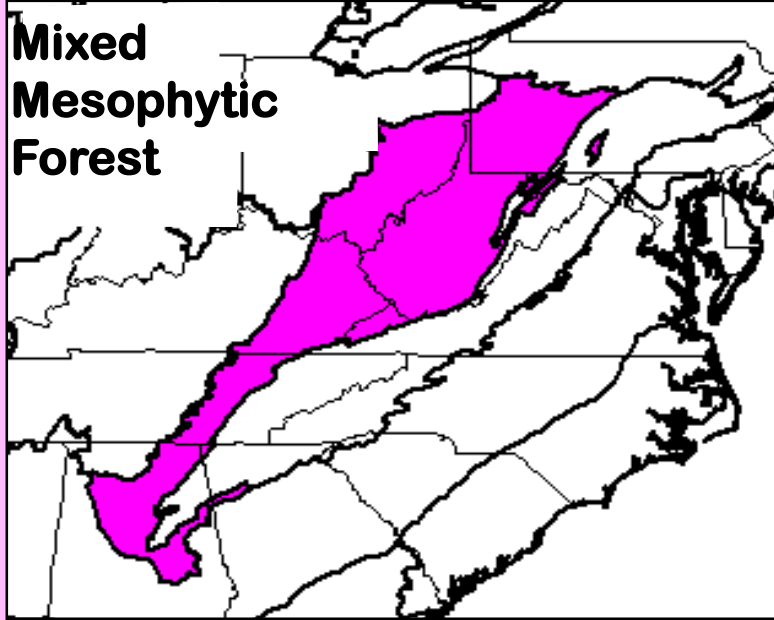
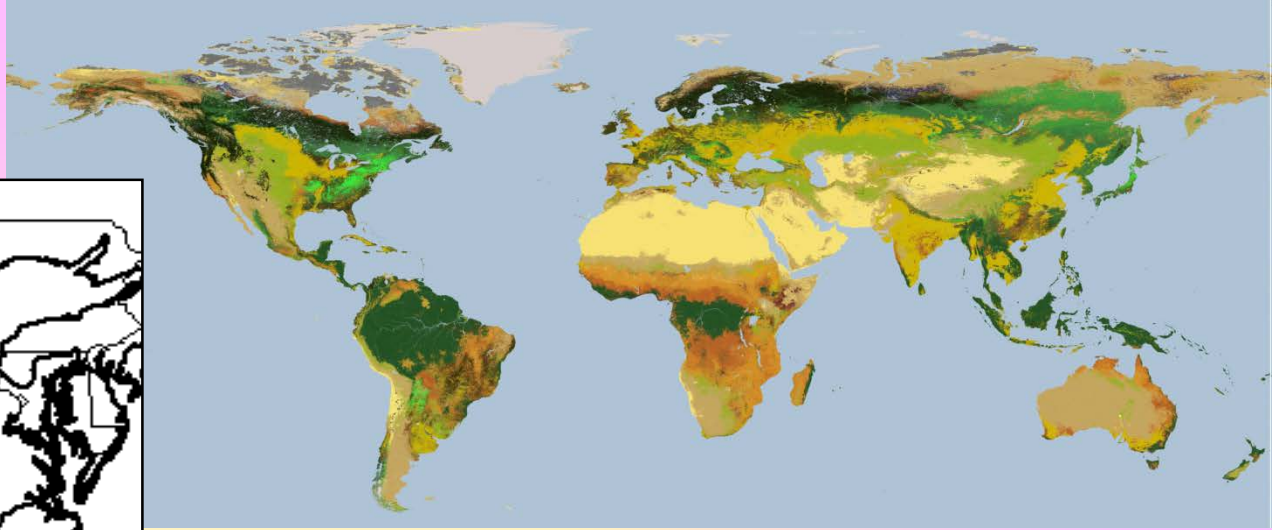
ASMR Conference  
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Spokane WA



Powell  
River  
Project



# Introduction:



- o **The Mixed Mesophytic Forest of central Appalachia: Among the most diverse non-tropical ecosystems in the world.**
- o **Appalachian surface mining has been removing it .**



# Forest Reclamation Approach (FRA):

1. Create a *suitable rooting medium* for good tree growth no less than 4 ft deep, comprised of topsoil, weathered sandstone and/or best available material.
2. Loosely grade the topsoil or topsoil substitute established in step one to create a *noncompacted growth medium*.
3. Use *ground covers* that are compatible with growing trees.
4. Plant *2 types of trees* - early successional for wildlife and soil stability, and commercially valuable crop trees.
5. Use *proper tree planting techniques*.



Photo: Chris Fields-Johnson  
on site in 2008-09.

## Research Objectives:

Determine effects of  
grading and seeding  
practices on post-mining plant communities.

- Native tree establishment and growth
- Understory vegetation

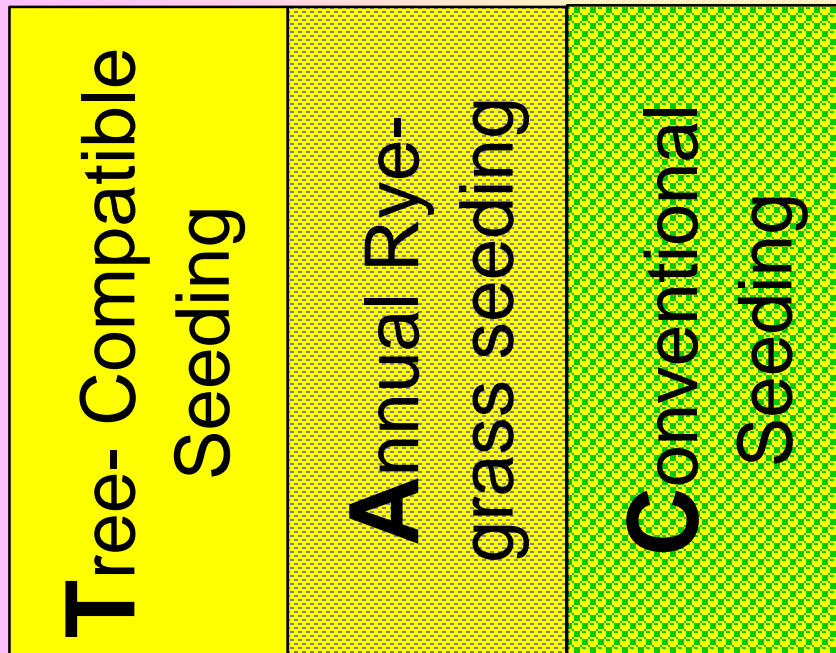


# Research Summary

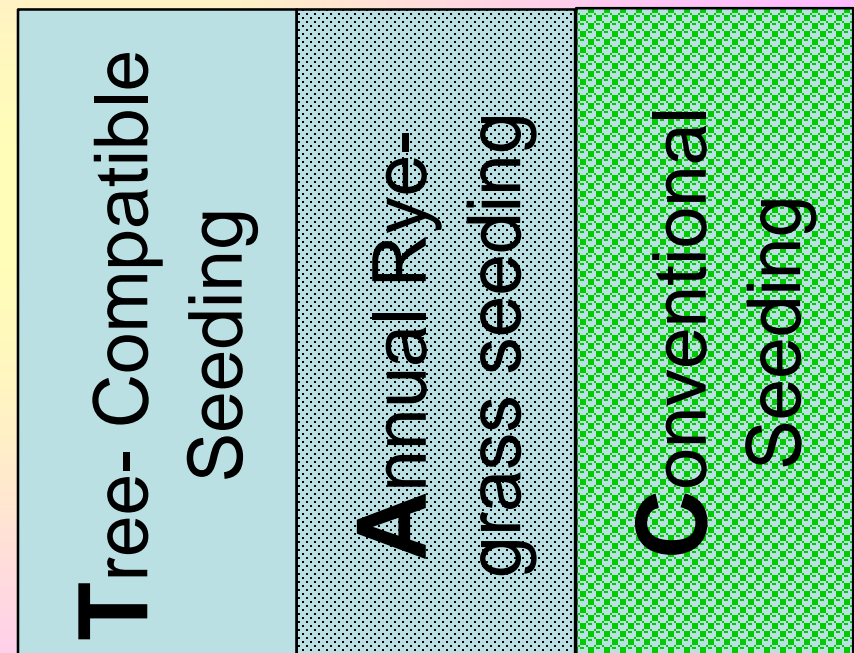
- 2006-07** Mining Co. applies reforestation practices operationally.
- 2007** Mining Co. constructs experimental plots.
- 2007-08 Winter** Seed & plant experimental plots
- 2008-09 Winter** Replant trees, experimental plots.
- 2008-09:** Measure trees & understory, sample soils in experimental plots  
(Chris Fields-Johnson M.S. thesis)
- 2014** Measure trees & understory, and sample soils: experimental & operational plots (reported here).

# Reforestation Treatments Applied

## Loose Grading



## Smooth Grading



Treatments were randomized at each location

# Seed Mixes Applied (pounds/acre)

	Con- ventional	Tree- Compatible*	Annual Ryegrass
Rye Grain	30		
Annual Ryegrass		20	20
Orchardgrass	20		
Perennial Ryegrass	10	10	
Redtop	3		
Timothy		5	
Weeping Lovegrass	2	2	
Korean lespedeza	5		
Ladino Clover	5	3	
Birdsfoot Trefoil	5	5	
<b>Total Seed</b>	<b>80</b>	<b>45</b>	<b>20</b>

\* Tree-compatible is similar to ARRI Advisory No. 6.

All areas: 1500 lbs cellulose mulch, 54 lbs N, and 140 lbs P<sub>2</sub>O<sub>5</sub> /acre

Grading:

- Smooth graded
- Loose graded

Seeding:

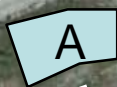
- A = Annual Ryegrass
- T = Tree-compatible
- C = Conventional

Plot aspect

200x = seeding/planting year (early).

# Layout of plots and experimental treatments

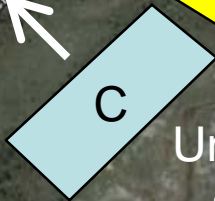
**Block 1 - Experimental:**  
Weathered/unweathered sandstone mix, 2008



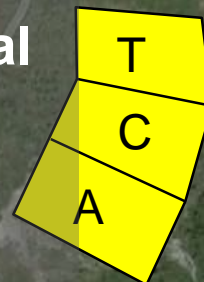
**Operational**  
Unweathered hard sandstone, 2007



**Operational**  
Unweathered hard sandstone, 2006



**Block 2 - Experimental**  
Unweathered Siltstone-dominant/spoil mix, 2008



“Block 4”

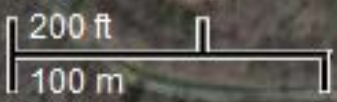
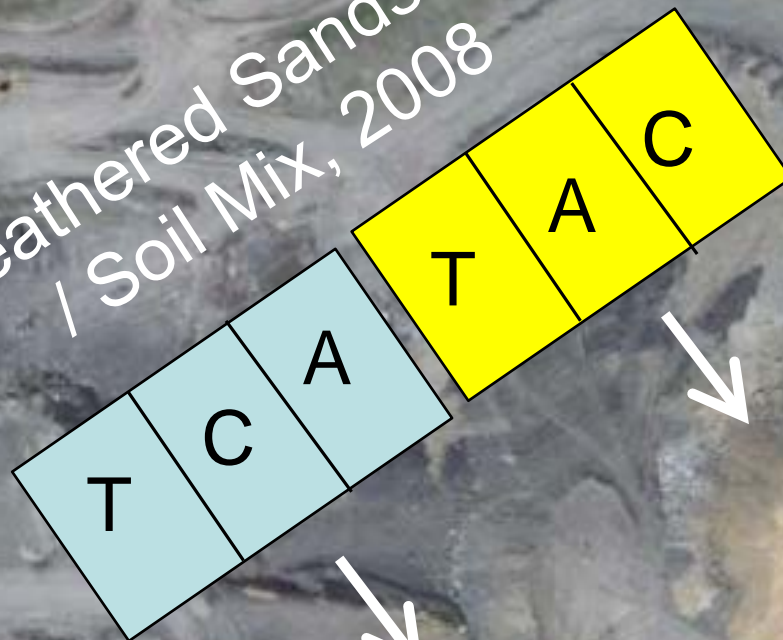




Former and Departed Block 3  
**3<sup>rd</sup> Replication**  
**of 2008 Install**  
on a different mine

***R.I.P.***

Weathered Sandstone  
/ Soil Mix, 2008



# Treatment Plot Summary

Plot Feature		Block 1	Block 2	Block 4
<b>Rock Type</b>		Weathered + Unweathered. Sandstone	Unweathered Gray Siltstone	Hard White Unweathered Sandstone
Soil pH (in 2008)		5.7 ± 0.3b	7.4 ± 0.2a	?
Plot Origin		Experi- mental	Experi- mental	Opera- tional
Treatments Represented:				
<b><u>Grading</u></b>	<b><u>Seeding:</u></b>			
Loose	Conventional	2008	2008	
Loose	Tree-Compat.	2008	2008	2007
Loose	An'l Ryegrass	2008	2008	
Smooth	Conventional	2008	2008	2006
Smooth	Tree-Compat.	2008	2008	
Smooth	An'l Ryegrass	2008	2008	

# Tree planting prescription for all 2008 plots.

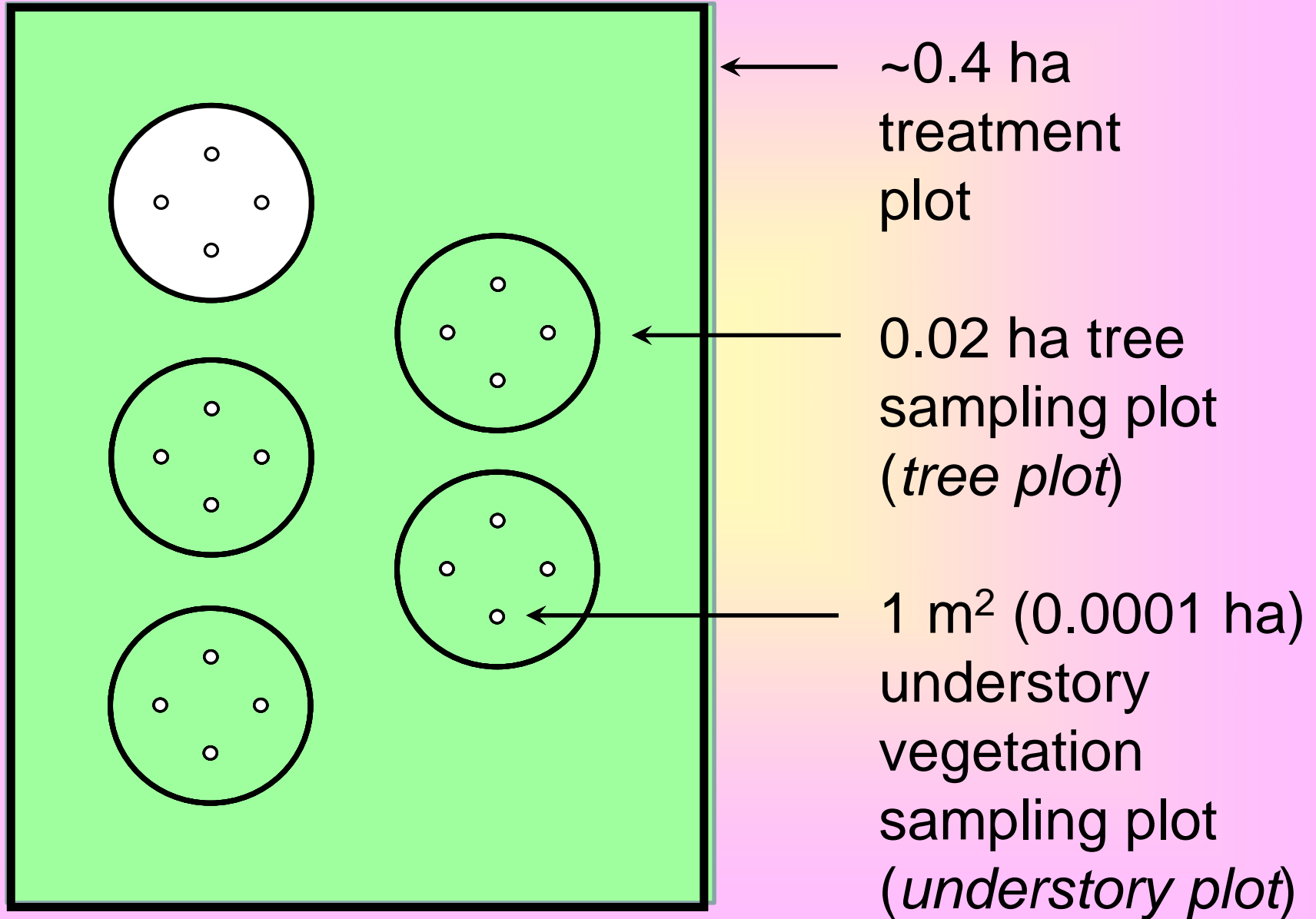
<u>Crop Trees</u>	/ acre	<u>Wildlife Trees</u> *	/ acre
Yellow Poplar	50	Shagbark Hickory	25
White Oak	83	White Pine	37
Chestnut Oak	83	Redbud	22
Black Oak	83	Gray Dogwood	22
Red Oak	83	Red Mulberry	10
Sugar Maple	83		<u>116</u>
Black Cherry	83		
White Ash	83		
	<u>631</u>	<u>Total Trees</u>	<u>747</u>

\* "Wildlife Trees" are also called "Nurse"

Sites were planted in early 2008. Because of seedling quality problems, research areas were replanted in early 2009 to restore full stocking.

2006 and 2007 planting prescriptions are not available

# Field Measurements



# Field Measurements

**Trees:** *Elaeagnus umbellata* (autumn olive) tallied as a tree

- Tally all within tree plots; ID for species, measure for height and diameter.
- Visually estimate canopy cover over understory plots

**Understory Vegetation:** Within understory plots

- ID all present to lowest lowest practical taxonomic class.
- Visually estimate canopy cover by taxon and overall.

**Soils:**

- Sample understory plots, 0-5 & 10-20 cm, <2mm.

# Data Analysis: Understory Veg

## Primary Metrics:

- ✓ Richness
- ✓ Groundcover % - by species and overall

## Analyze Richness & Groundcover % - by Type

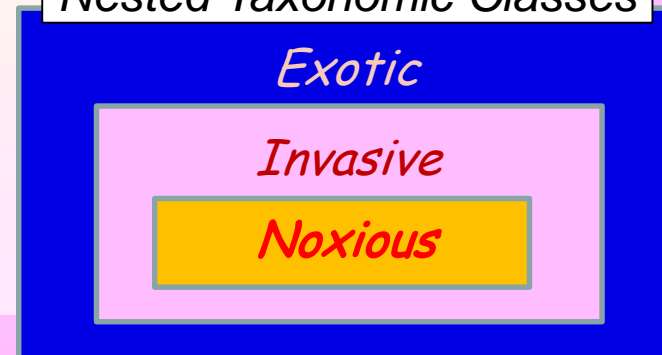
- ✓ Total
- ✓ Seeded – includes hydroseeder contaminant *Securigera varia* (crown vetch) in Block 1. All are exotic, none are noxious.
- ✓ Native
- ✓ Invasive: all are exotic (non-native)
- ✓ Noxious: all are invasive exotics

### Nested Taxonomic Classes

*Exotic*

*Invasive*

*Noxious*



# Data Analysis: Trees

## ***Native Trees:***

Richness

Density: Living trees / hectare

Mean height, basal diameter, volume index ( = height x diameter<sup>2</sup> ) : growth indicators (native tree analyses were “species normalized”).

Sum per-tree volume indices: area biomass indicator

## ***Exotic (non-native) Trees:***

Density, Volume index sum

# Data Analysis: Statistical Comparisons

Experimental Treatments within **Blocks 1 and 2** : 2-factor ANOVA / Tukey (n = 12 Treatment Plot means) [ $\alpha = 0.10$ ]

- Smooth vs. Loose Grading
- Conventional (CON) vs. Tree-Compatoble (TC) vs. Annual Rye (AR) seeding

Treatment Combinations applied operationally in **Block 4**: One-way ANOVA (n = 10 tree-plot means) [ $\alpha = 0.05$ ]

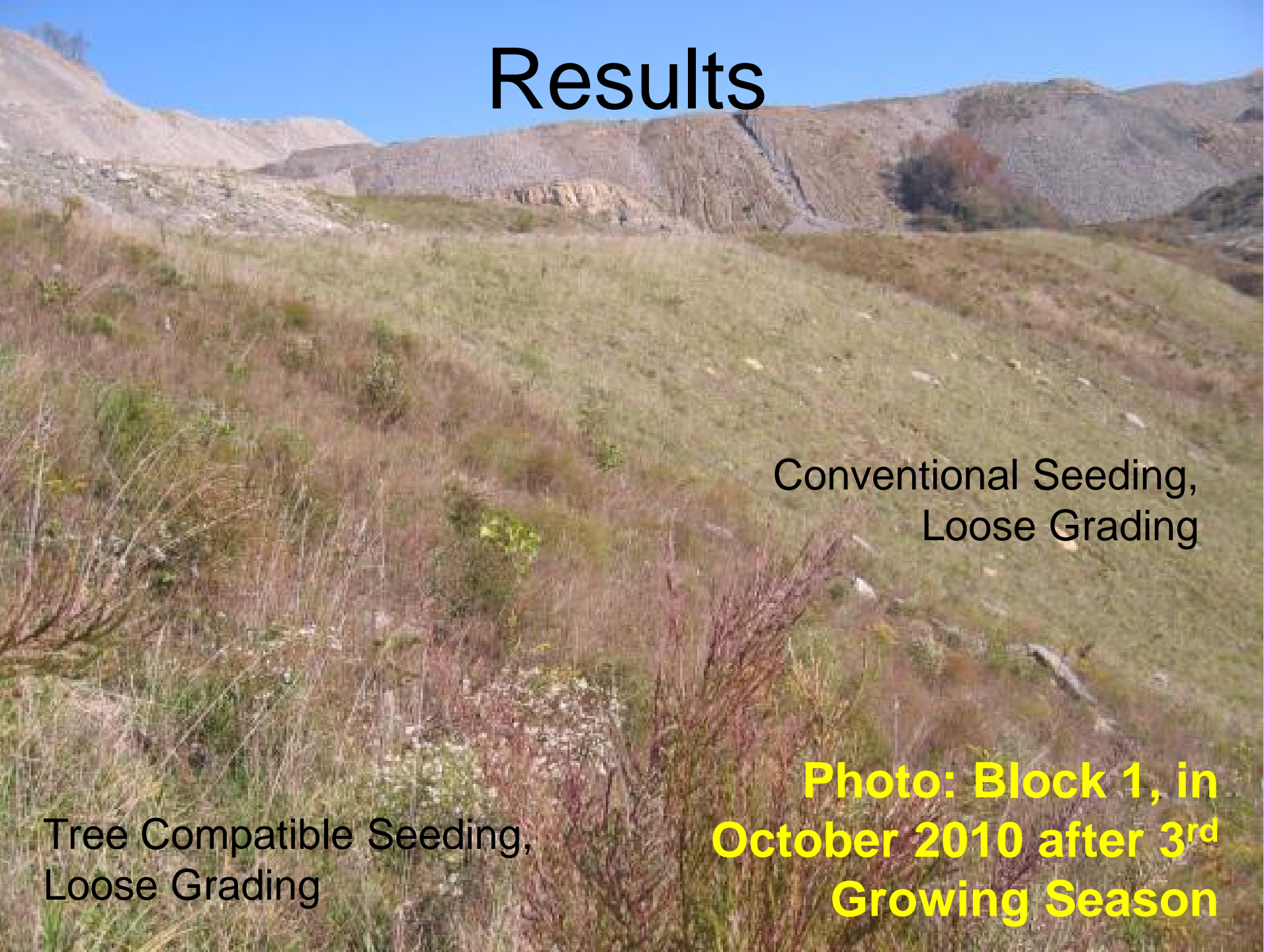
- Smooth/CON vs. Loose/TC

Block Effects: One-way ANOVA (n = 14 treatment plot means) [ $\alpha = 0.05$ ]

- Block 1: Mix weathered/unweathered sandstone
- Block 2: Unweathered high-pH siltstone
- Block 4: Unweathered siliceous sandstone:



# Results

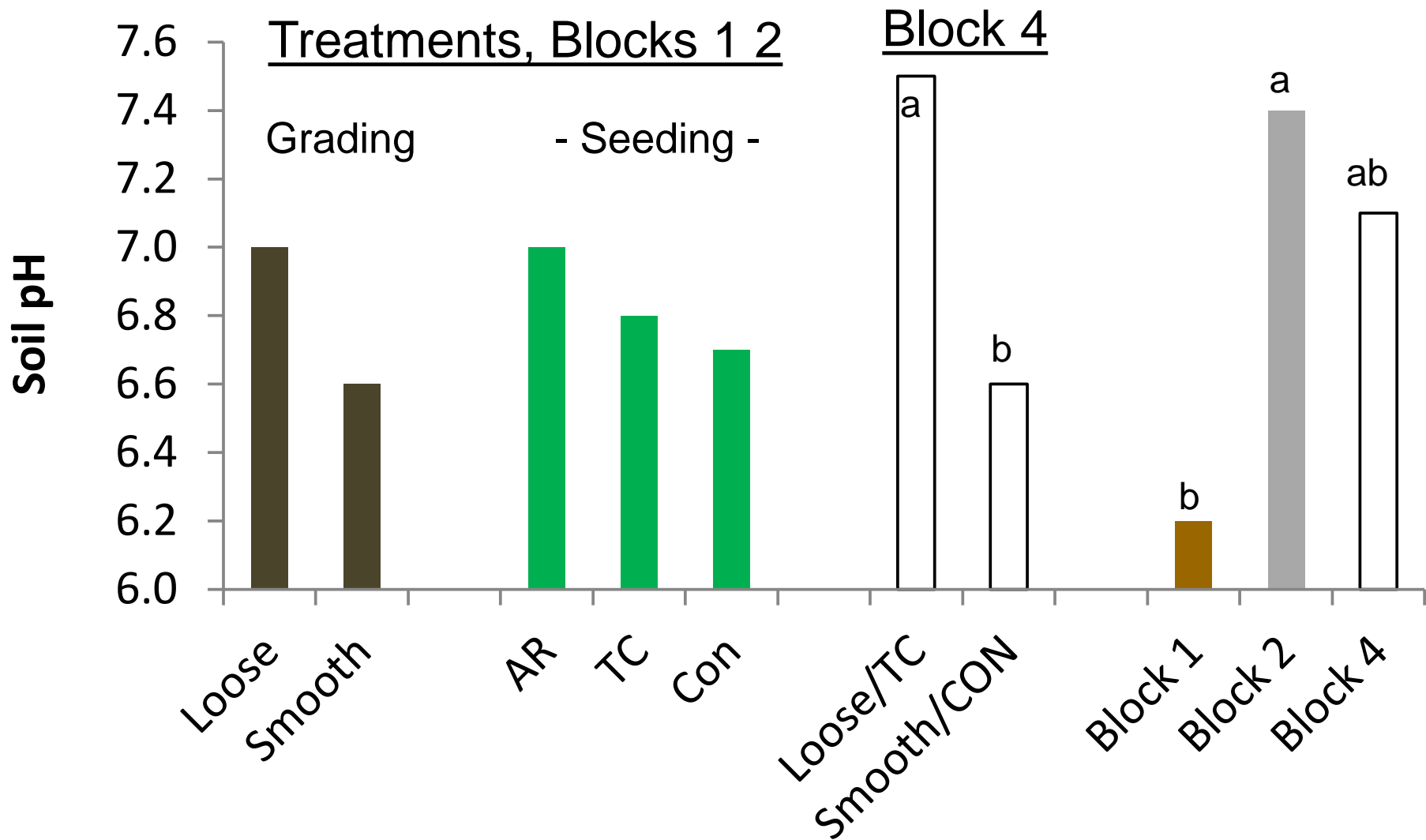


Conventional Seeding,  
Loose Grading

Tree Compatible Seeding,  
Loose Grading

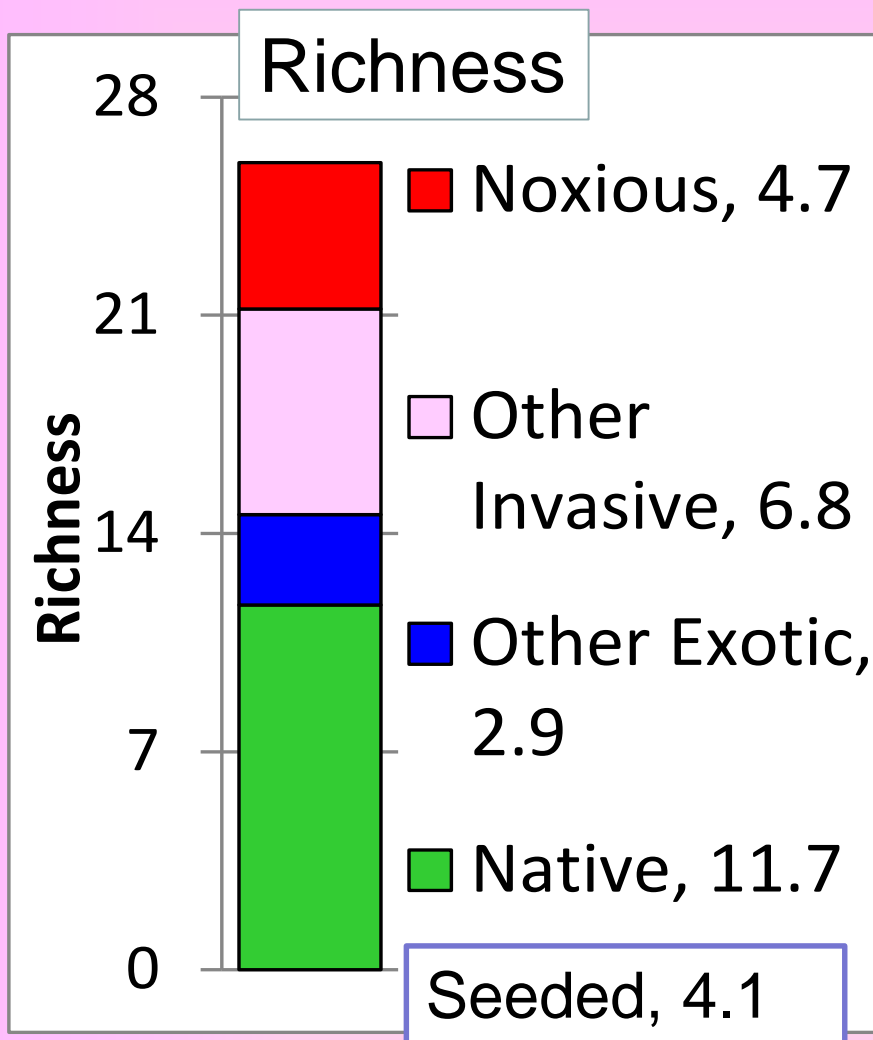
**Photo: Block 1, in  
October 2010 after 3<sup>rd</sup>  
Growing Season**

# Soils: data from VT soil testing lab

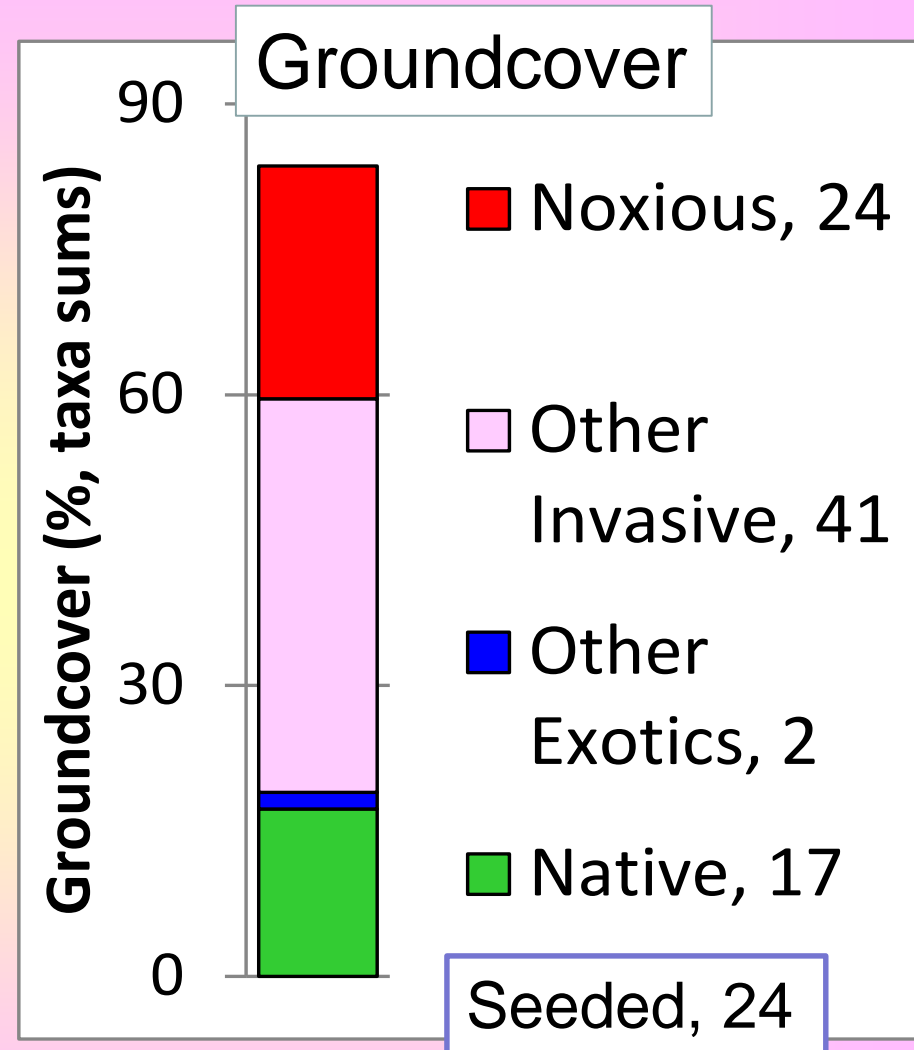


Soluble Salts: No significant differences, all < 140 mg/kg

# Understory: Overall, treatment-plot means



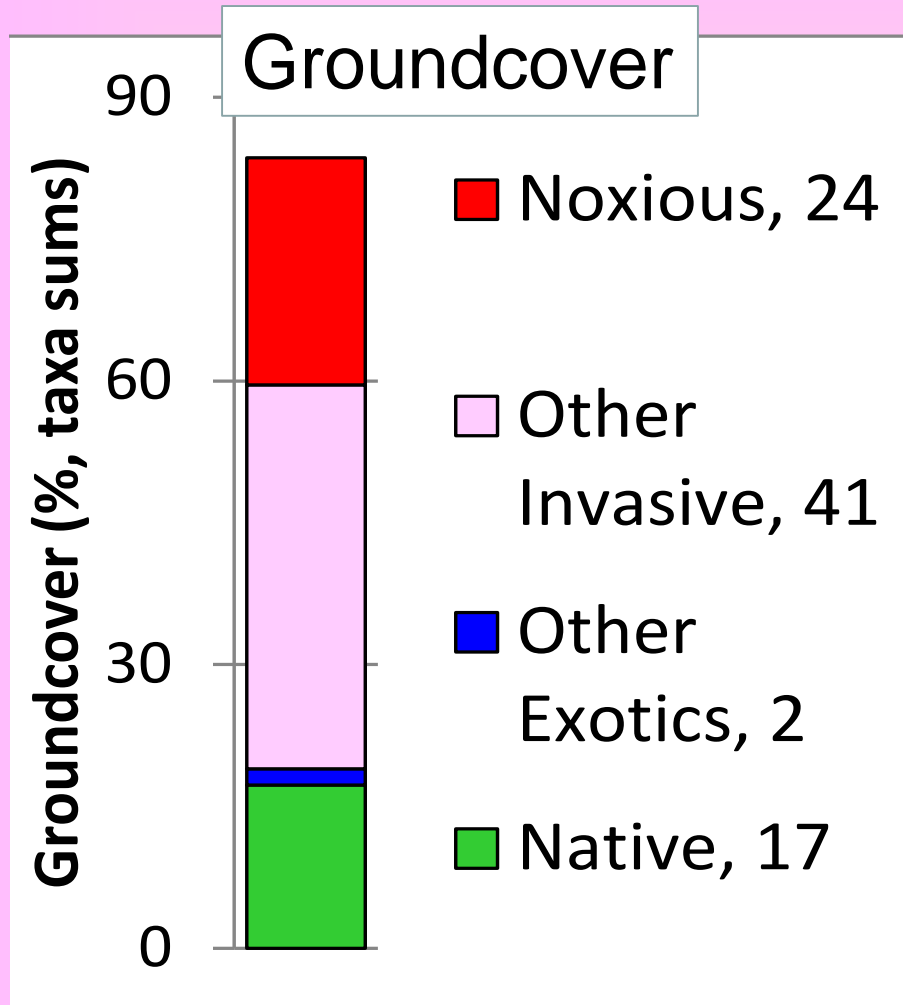
No significant differences were found.



Significant differences to be shown

All noxious are invasive, all invasive are exotic. No noxious were seeded. Seeded not plotted.

# Understory: 73 Taxa were recorded.



\* = Seeded

Most groundcover provided by:

## Noxious:

- Lespedeza cuneata (Sericea)
- Tussilago farfara (coltsfoot)
- Daucus carota (Queen Anne's lace)
- Buddleja davidii (butterflybush)

## Other Invasive:

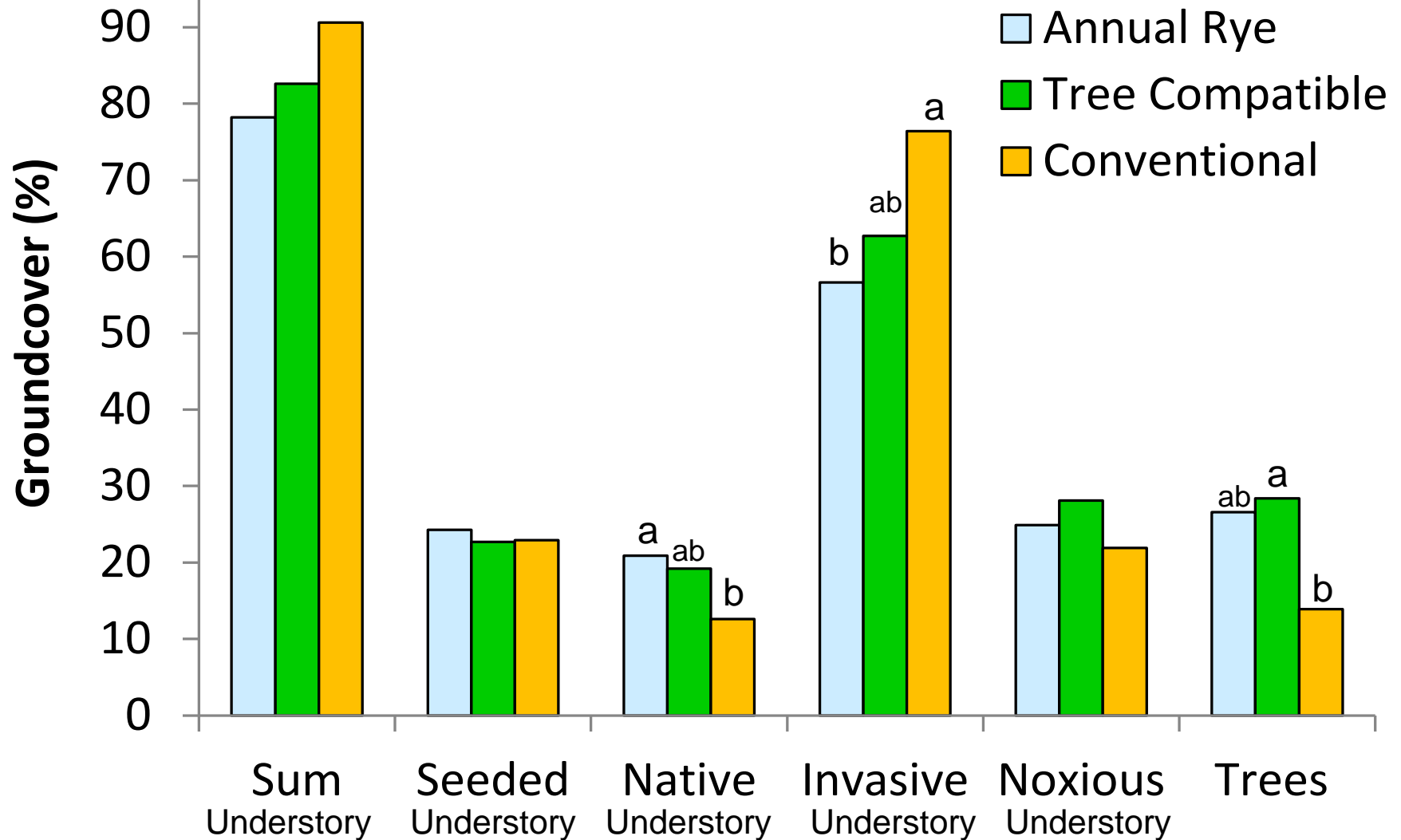
- Schedonorus arundinaceus (tall fescue)
- Securigera varia (crownvetch)\*
- Dactylis glomerata (orchardgrass)\*
- Lotus corniculatus (bird's-foot trefoil)\*
- Trifolium repens (white clover)\*
- Eragrostis curvula (weeping lovegrass)\*
- Trifolium pratense (red clover)

## Native:

- Solidago canadensis (goldenrod)
- Rubus allegheniensis (blackberry)
- Lobelia spicata (lobelia)
- Lactuca canadensis (Canada lettuce)
- Andropogon virginicus (broomsedge)

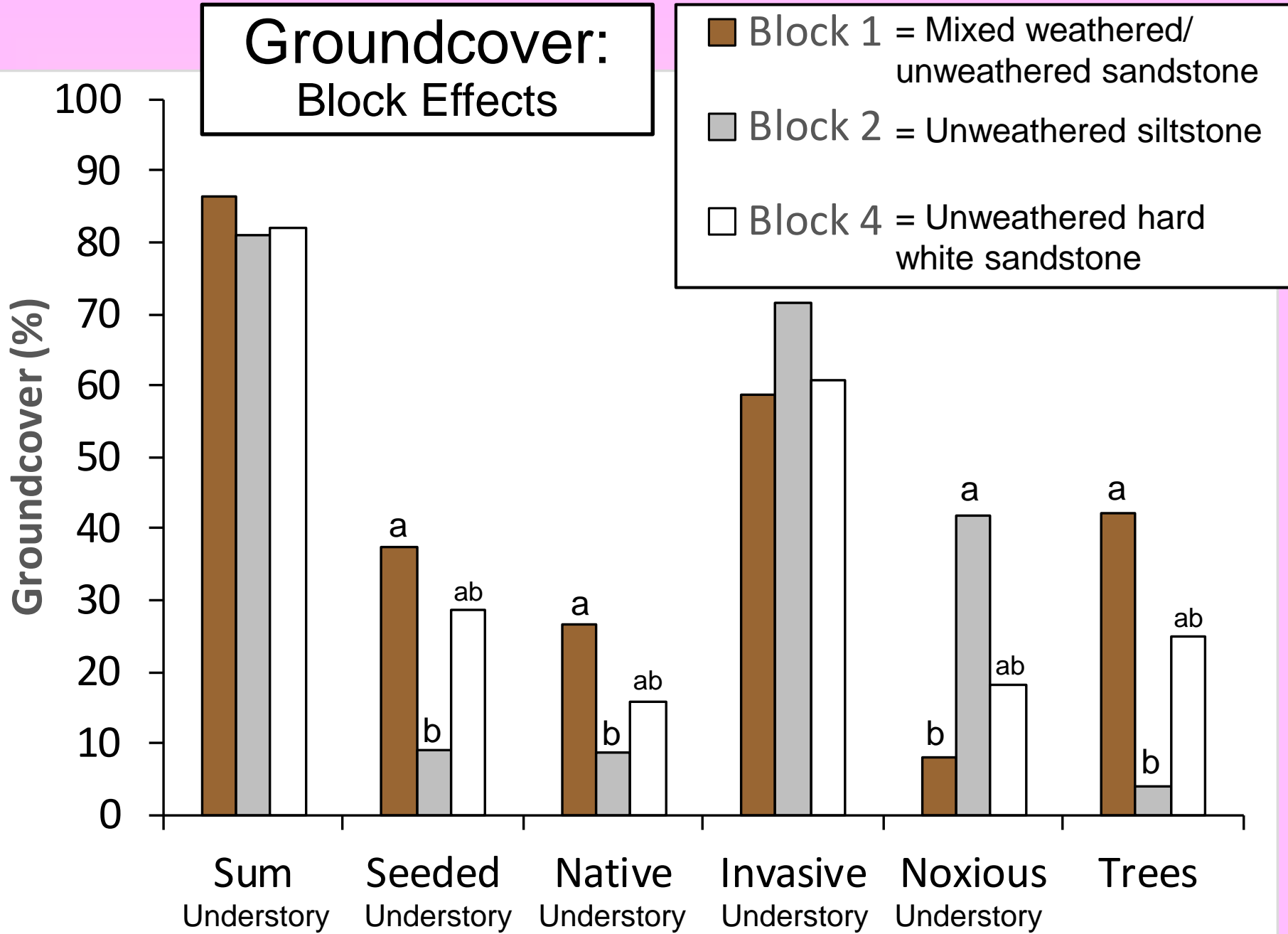
# Groundcover:

## Seeding Treatment Effects, Blocks 1 & 2



No grading treatment effects or seeding treatment effects within Block 4 were evident.

# Groundcover: Block Effects

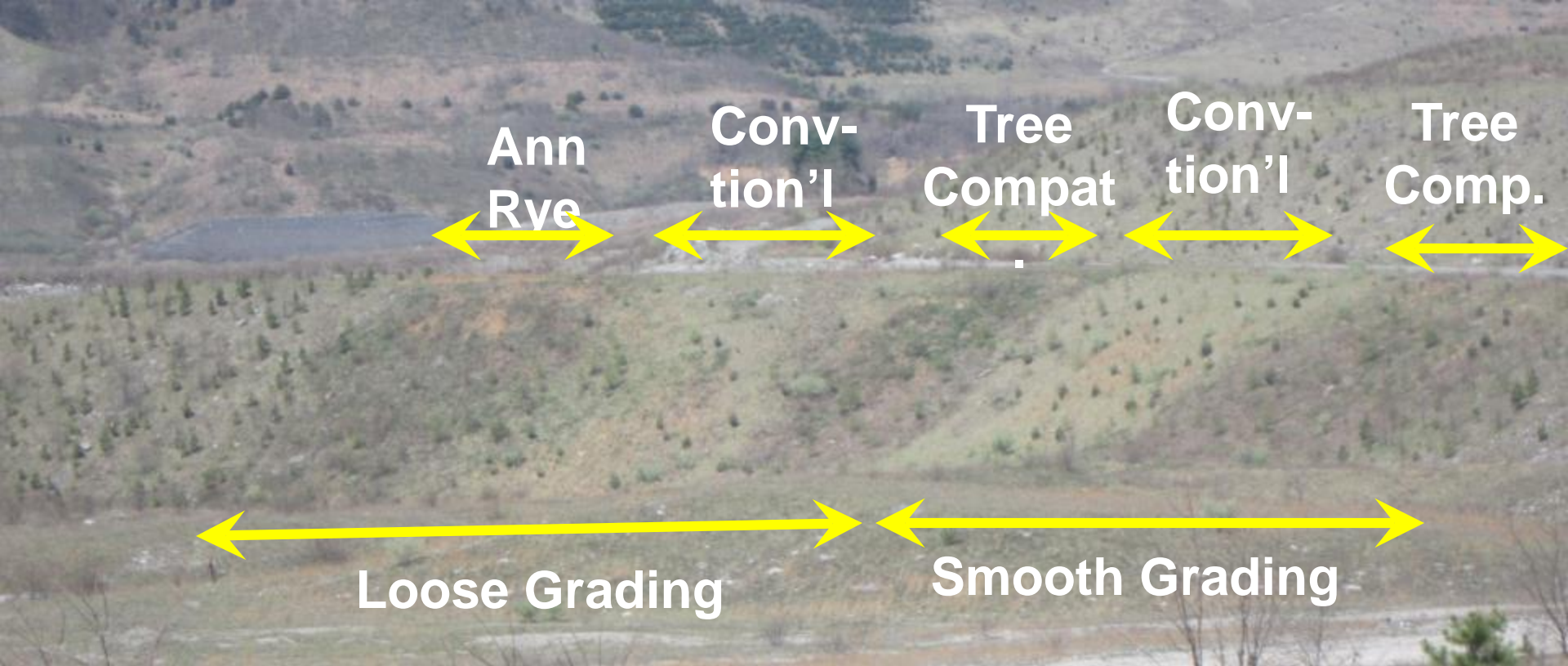


Seeded – includes hydroseeder tank contaminant *Securigera varia* (crown vetch) in Block 1.

Block 1, Loose, Tree Compatible

Block 1, Smooth, Conventional

04/24/2014 13:00



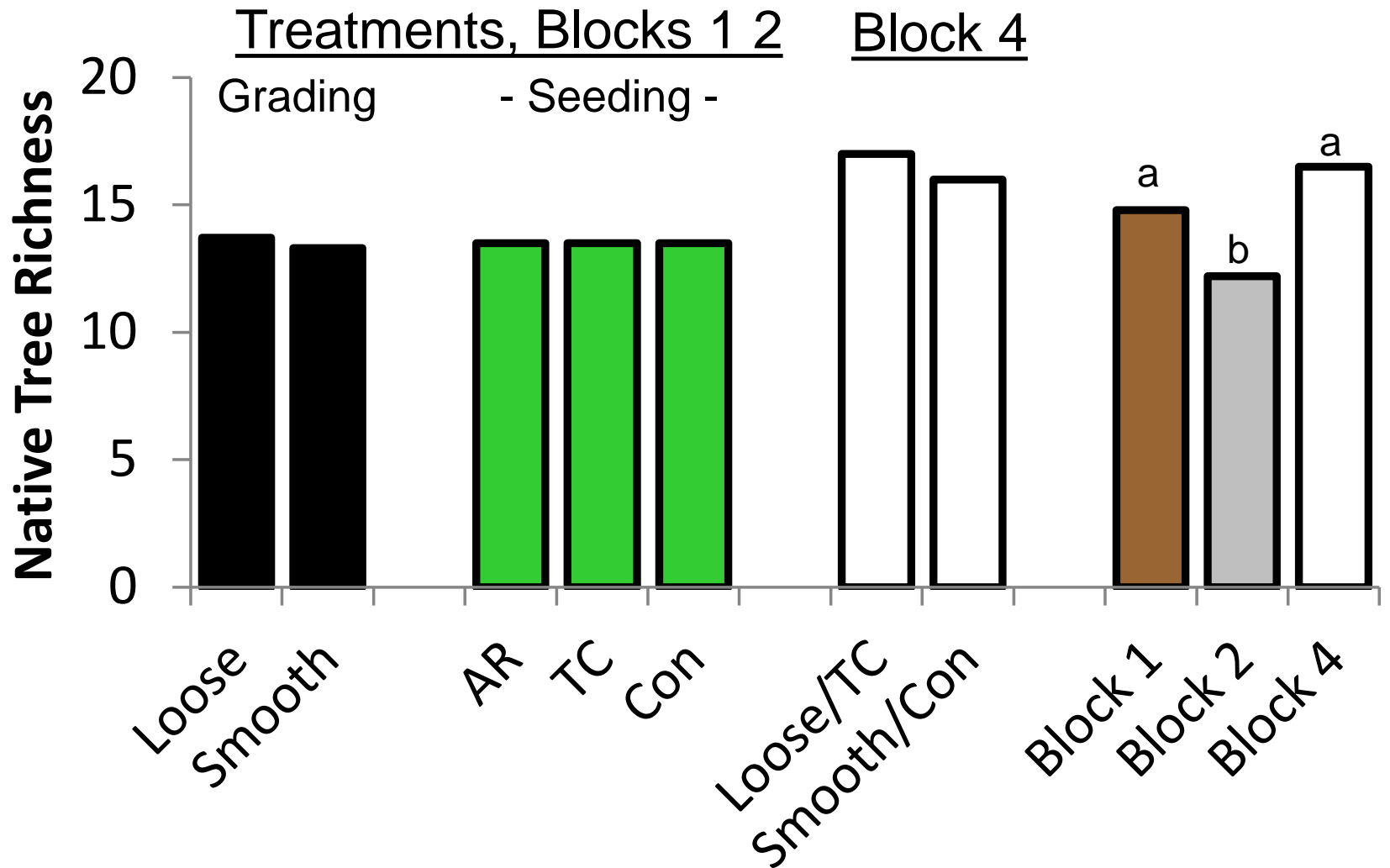
Block 1 in April, 2014.

Although vegetation was still in partial senescence, seeding treatments are clearly visible.

Smooth-graded Annual Rye is further right, not shown.

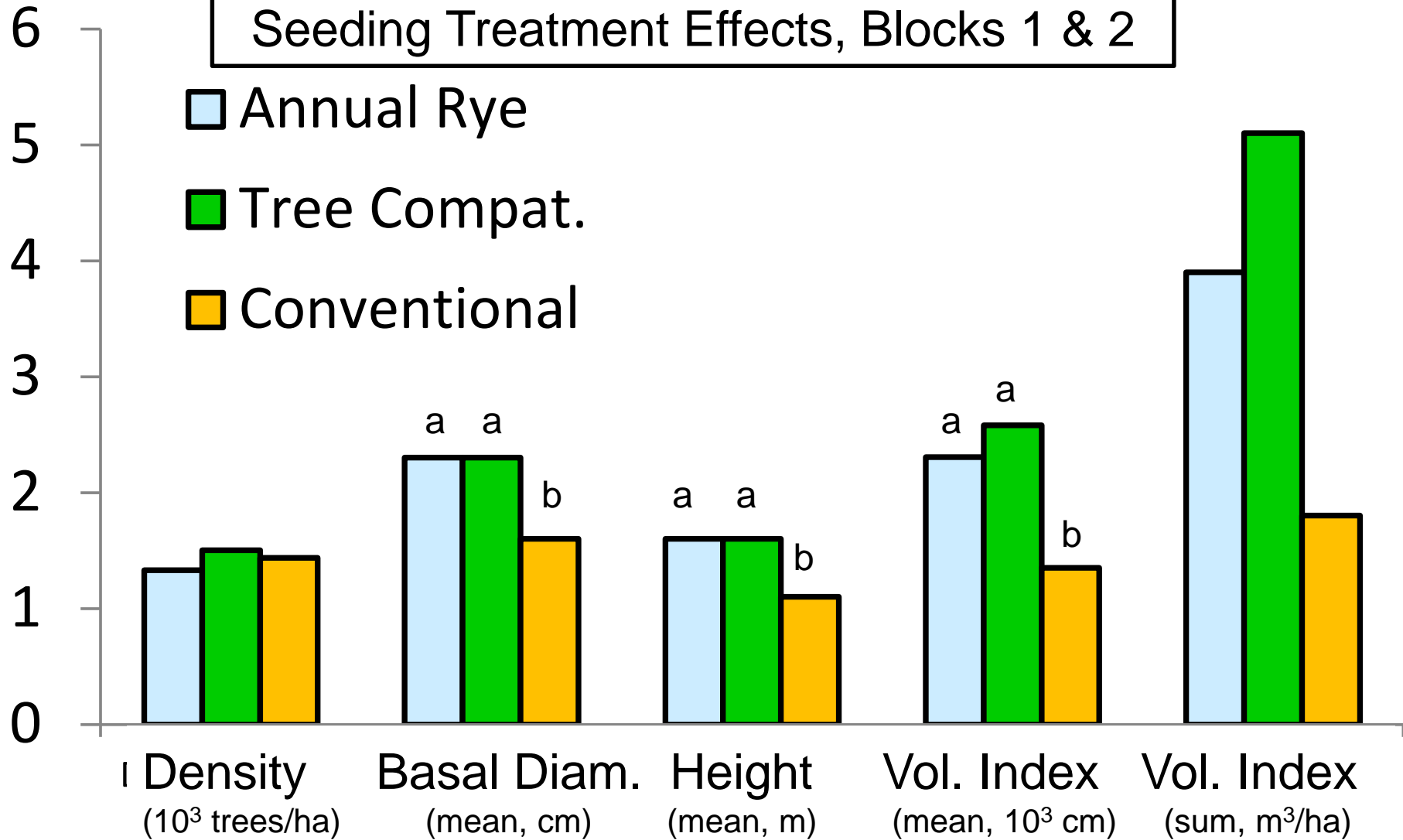


# Native Tree Species Richness



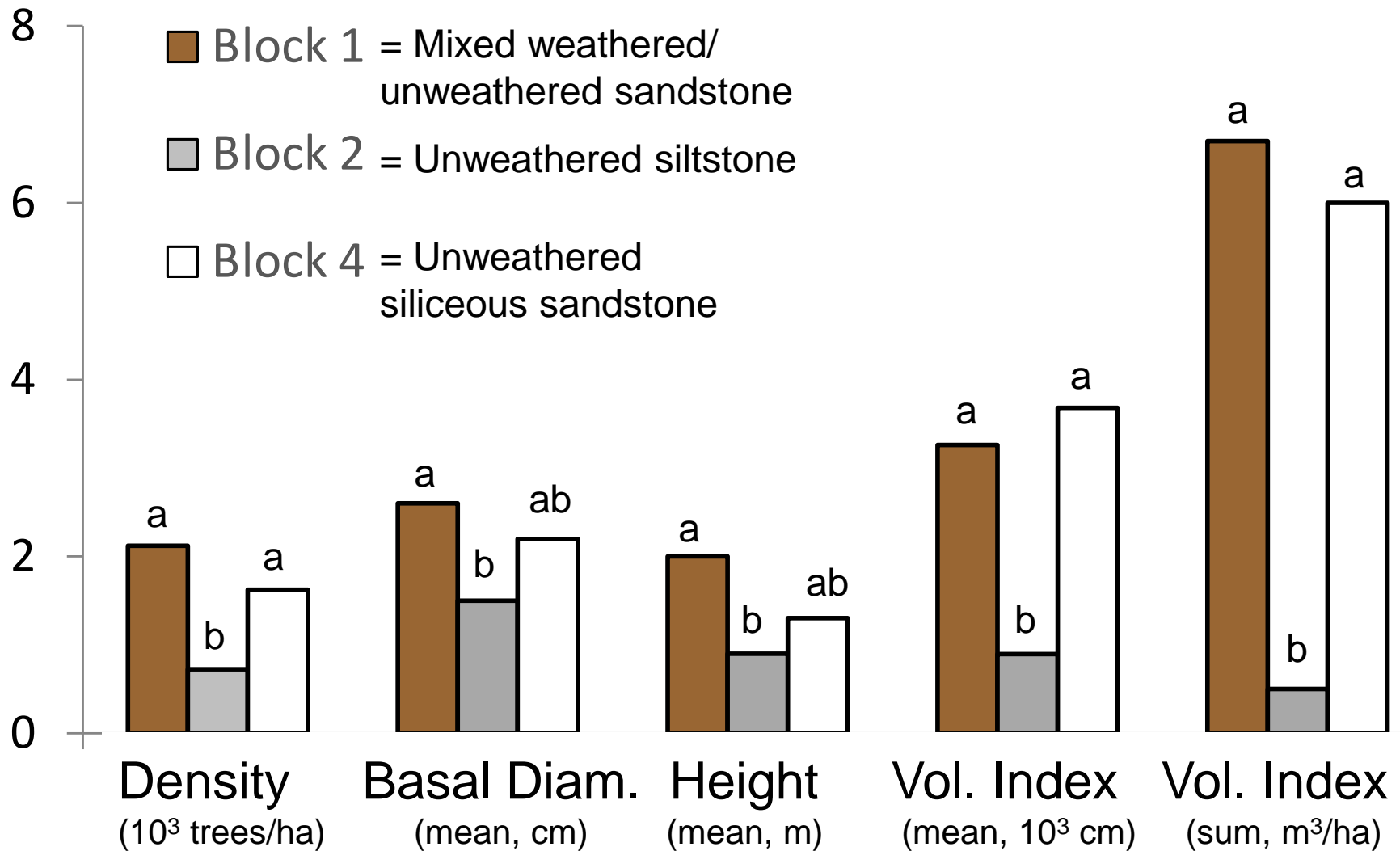
# Native Trees

Seeding Treatment Effects, Blocks 1 & 2



No grading treatment effects were evident. Block 4 treatment effects not shown.

# Native Trees: Block Effects



# Exotic Trees

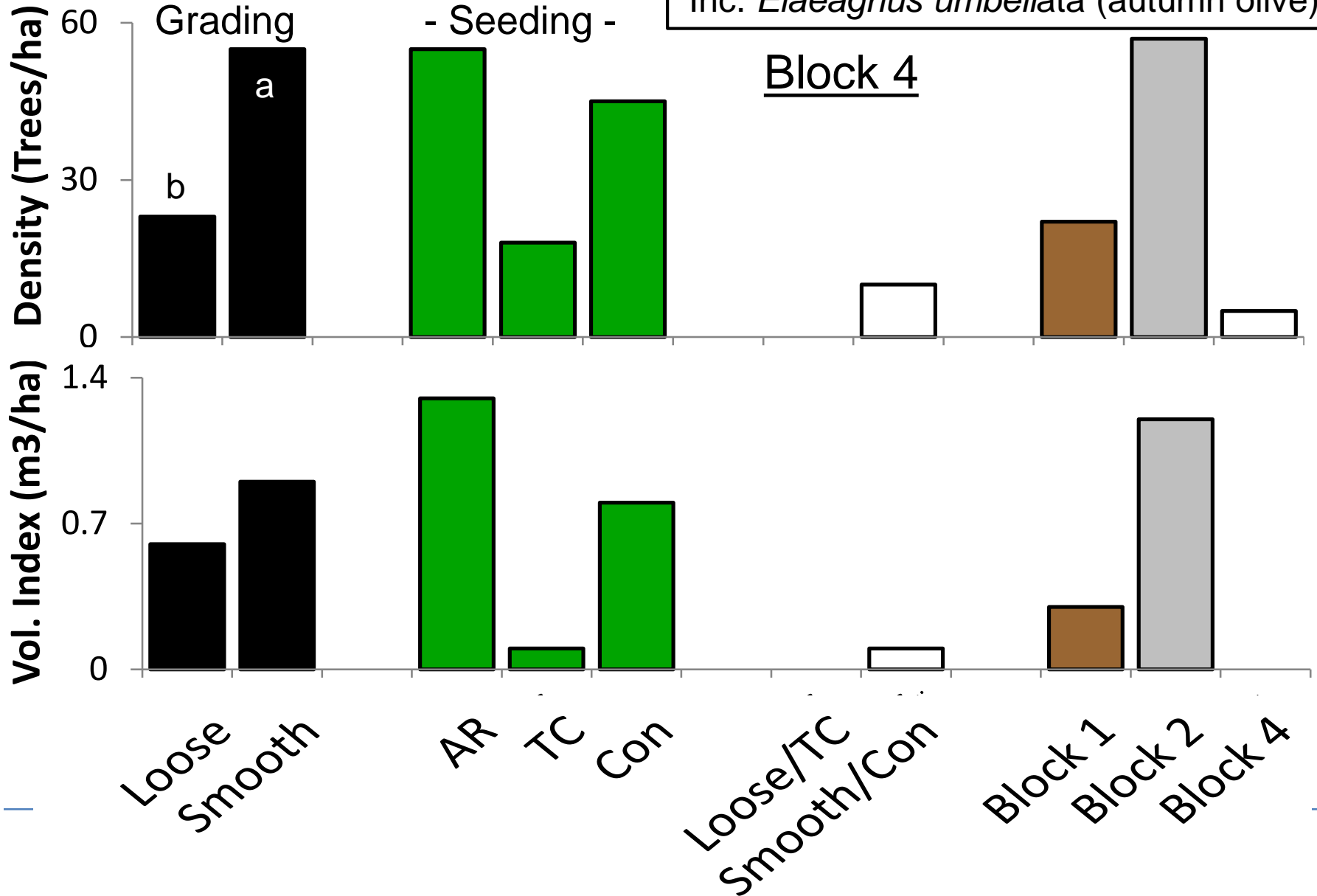
Inc. *Elaeagnus umbellata* (autumn olive)

Treatments, Blocks 1 2

Grading

- Seeding -

Block 4



# Why didn't grading influence the trees?



Block 1, fall 2007

## Theories:

1. Slope: It is tough to compact soil on steep slopes.
2. Mining Co. had initiated reduced grading as a routine practice in 2007 – so they smoothed it but did not compact it (site was not “tracked in”).
3. Soil pH? Nominally more favorable on smooth (6.6) vs. Loose (7.0).



Block 1,  
Tree-compatible,  
May 2015



Measuring Block 2  
Early April 2014



Block 2  
June 2015



**Block 4, June 2014**

(sloped area, background)



**Loose/TC in  
Summer '07**

# *Post-Hoc Observations and Analyses*

Dramatic differences between Blocks 1 and 2 – appear as soil effects that are consistent with expectations based on prior studies.

Annual Rye and Tree-Compatible seeding effects are quite similar, and were especially influential (relative to Conventional) in Block 1.

Grading treatment effects are not apparent.

Block 4 is kind of a wild card, tough to figure

*So ... Characterize plant communities based on post-hoc groupings.*

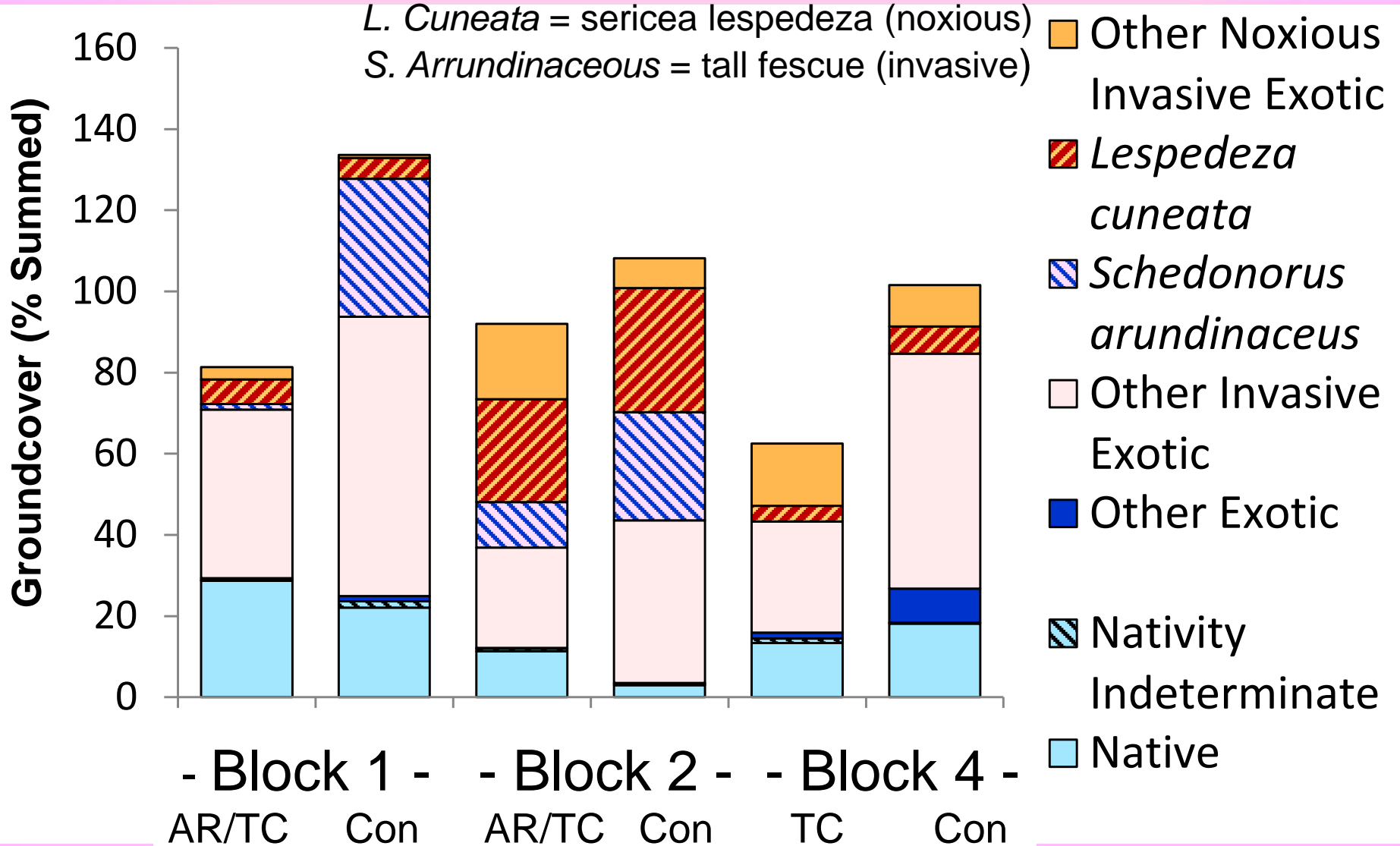
# Understory Vegetation: Post-Hoc Assessment

Seeding: AR = Annual Rye; TC = Tree-Compatible; Con = Conventional

With grading w/treatments are averaged

*L. Cuneata* = sericea lespedeza (noxious)

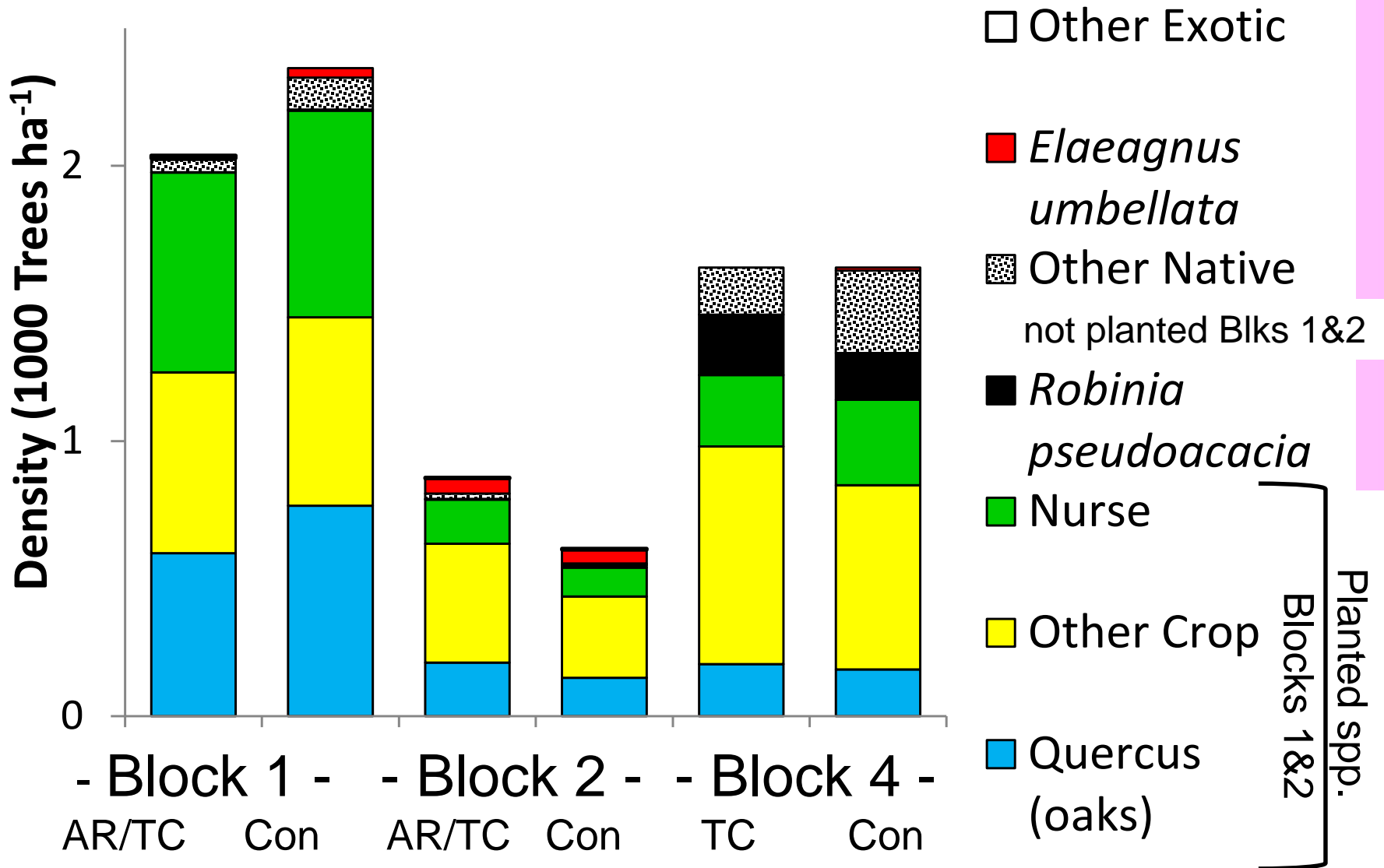
*S. Arrundinaceous* = tall fescue (invasive)



# Tree Density

*E. umbellata* = Autumn olive (noxious invasive exotic)

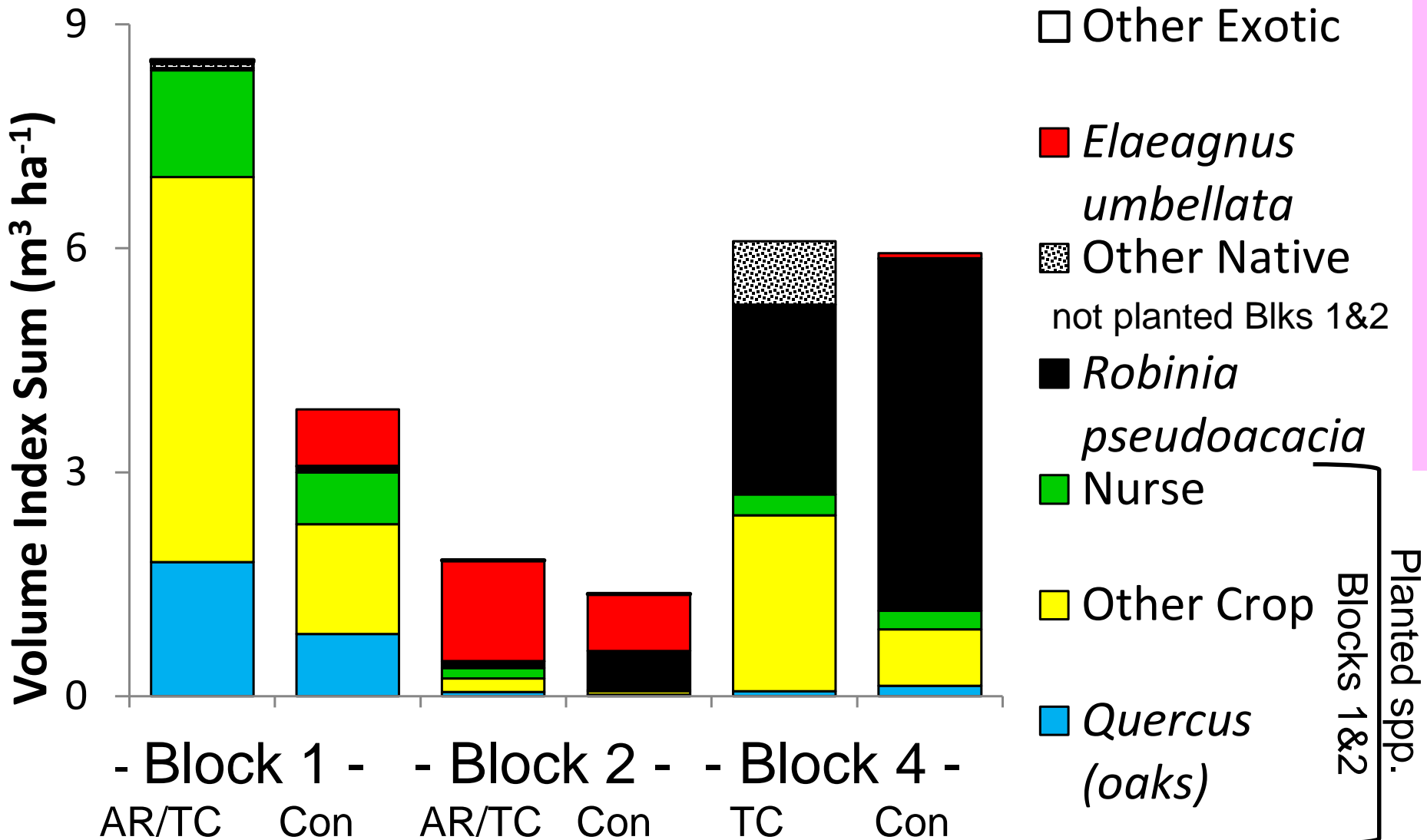
*R. pseudoacacia* = Black locust (native, early successional)

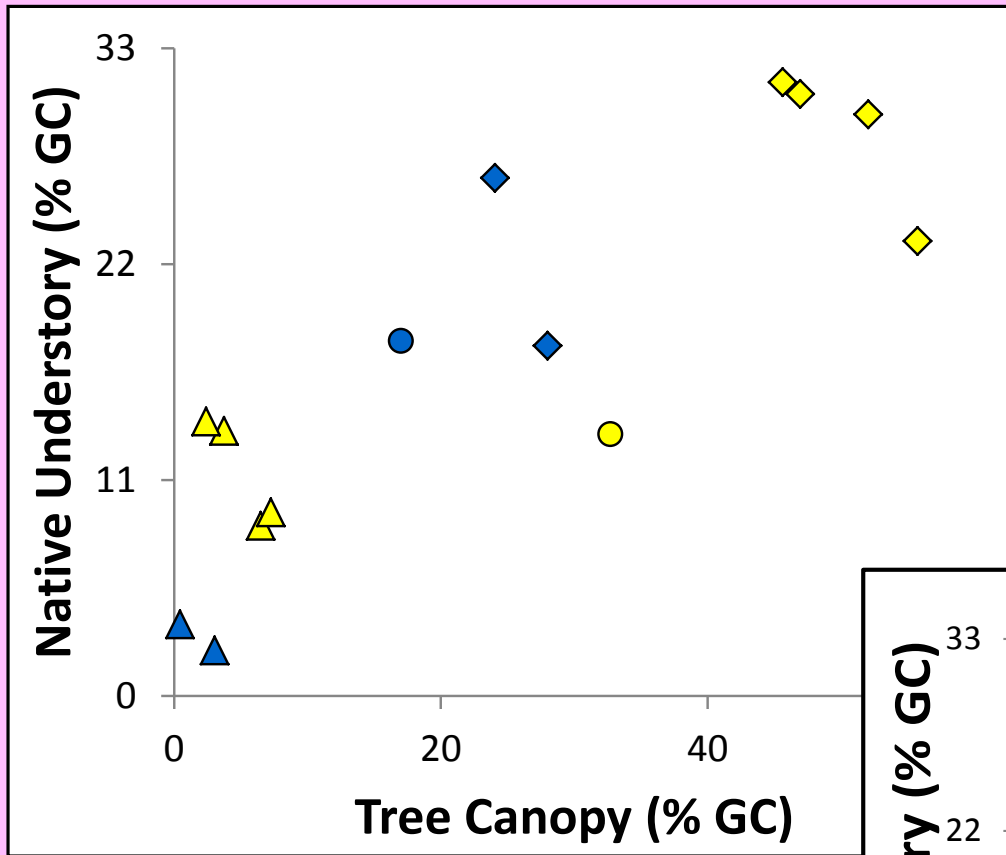


# Cumulative Volume Index (biomass indicator)

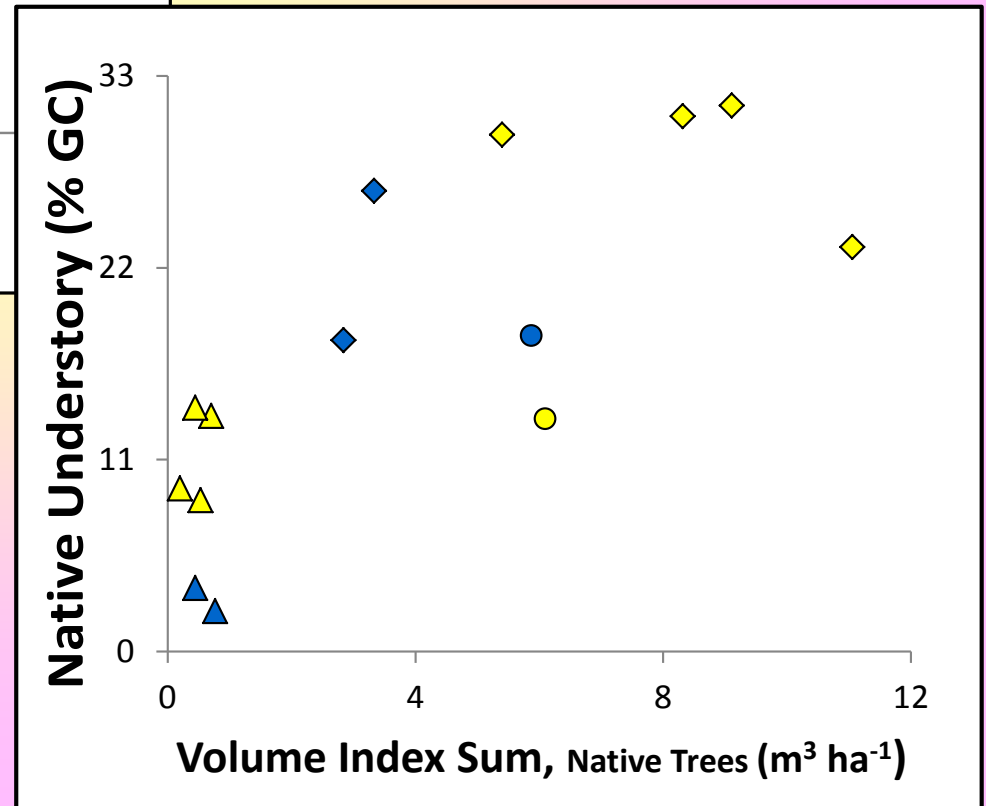
*E. umbellata* = Autumn olive (noxious invasive exotic)

*R. pseudoacacia* = Black locust (native, early successional)





Increasing tree canopy (shading) appears to favor native understory vegetation  
(% GC = Groundcover)



- ◆ Blk 1 Ann Rye & Tree Compat.
- ◆ Blk 1 Conventional
- ▲ Blk 2 Ann Rye & Tree Compat.
- ▲ Blk 2 Conventional
- Blk 4 Ann Rye & Tree Compat.
- Blk 4 Conventional

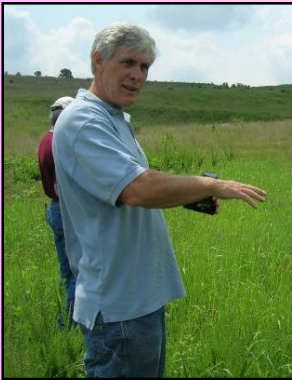
# Conclusions

Reclamation practices (esp. spoil selection for soil construction, seeding) had dramatic influence on plant communities present on different areas of the mine site, 6 to 8 years later.

Where both seeding practices (tree-compatible & annual ryegrass for reduced competition) and soil materials (with weathered sandstones) were favorable to native trees, planted trees established and grew well.

Where soil materials are unfavorable (unweathered siltstones), exotic taxa dominate plant communities.

# Thanks to



**Rick Williams  
and Williams  
Forestry for  
tree planting**



**OSM Applied Science for  
funding to initiate the project**



**Powell River  
Project for  
supplemental  
funding**



**For cooperation and  
assistance**



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