SECOND YEAR RESPONSE OF APPALACHIAN MIXED HARDWOODS TO SOIL SURFACE GRADING AND HERBACEOUS GROUND COVER ON RECLAIMED MINE LAND

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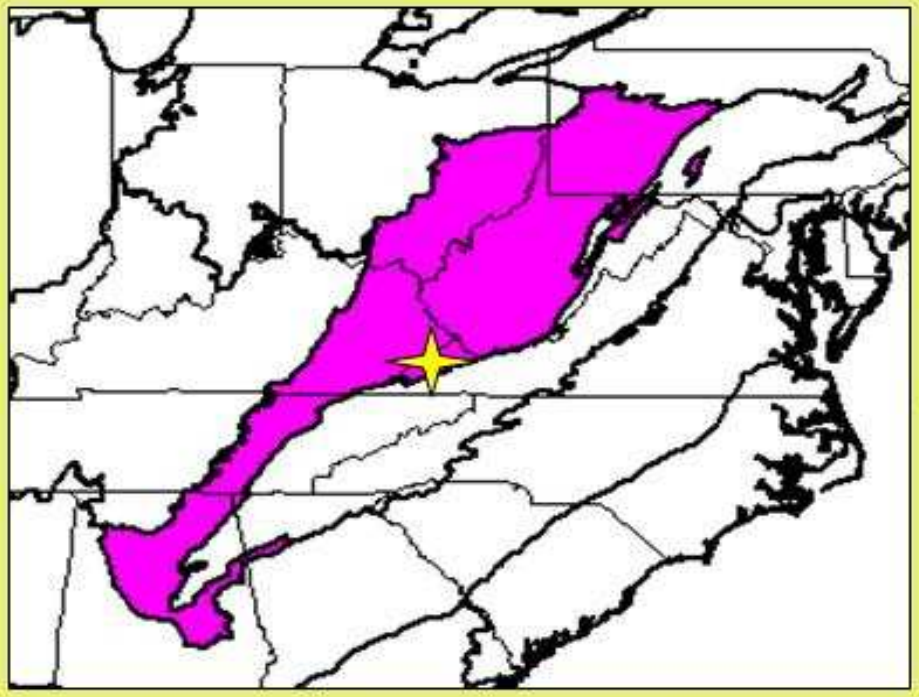
Virginia Tech and the Powell River Project

Introduction:



Study location

The Mixed Mesophytic Forest

The Appalachian Coal Basin

- **The Mixed Mesophytic Forest: Oldest and most diverse temperate forest in the Americas.**
- **Appalachian surface mining is removing this ecosystem, now we are learning to restore it**

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- During Industrial Revolution: Regional-scale clear cutting plus slash fires, this before ecological study happened
- Mining is not the first disturbance, forest is already highly degraded
- Forests need rehabilitation even without mining
- With mining, we start with a blank slate and no clear model of original forest

Challenges: Past Practices Restricted Forest Development

Typical post-mining, post-reclamation "Scrublands"

-Hundreds of thousands of acres of formerly Mixed Mesophytic Forest lands are in approximately this condition: abandoned grasslands in a state of arrested succession

-Key problems: soil compaction and aggressive herbaceous and shrubby competition, often by invasive species

FRA Steps

- Cap with suitable soil medium or topsoil
- Apply to at least five feet of depth
- Loose-grade
- Plant non-competitive groundcovers
- Plant a mix of mid to late-succession tree species
- Professional planters and techniques
- Control invasive species if necessary

Experiment Variables

Objective:

- Test mine spoil grading and groundcover effects on forest establishment and succession and on erosion

Methods: Grading Surface Soil

Natural Mountain Forest Soil in Virginia

- Want soil that will function as a stable mountain forest soil
- Appropriate materials and slope grade are already mandated and enforced
- But site compaction from heavy grading limits roots, soil respiration and water infiltration
- By limiting infiltration, compaction causes surface water flow and erosion
- Loose grading should improve forest establishment and erosion by avoiding these problems

Choosing Groundcovers

- Groundcovers must:
  - 1) Prevent erosion by covering and holding bare soil
  - 2) Accrue the nitrogen and organic matter missing in mine soil
  - 3) Allow forest establishment and succession

- Conventional mined land ground covers perform #1 and #2 well, but are too competitive with trees for light and water to reliably allow #3

- Natural groundcovers performing these three functions develop rapidly on bare ground in Appalachia, as witnessed in old field succession

- Planting only an annual groundcover should promote this natural process

Experimental Components:

- Three Complete Blocks Located on Reclaimed Surface Coal Mines in Southwest Virginia
- 18 x 1-Acre Treatment Plots

- 2 Grading Treatments: Loose and Compact
- 3 Groundcover Treatments (Hydro-seeded): Conventional, Tree Compatible and Annual Rye Only
- Uniform Mixed Hardwood Tree Planting: 13 Species
- Planting in March 2008, Re-stocking in March 2009 due to drought mortality in 2008
- All installed by industry operators for operational realism

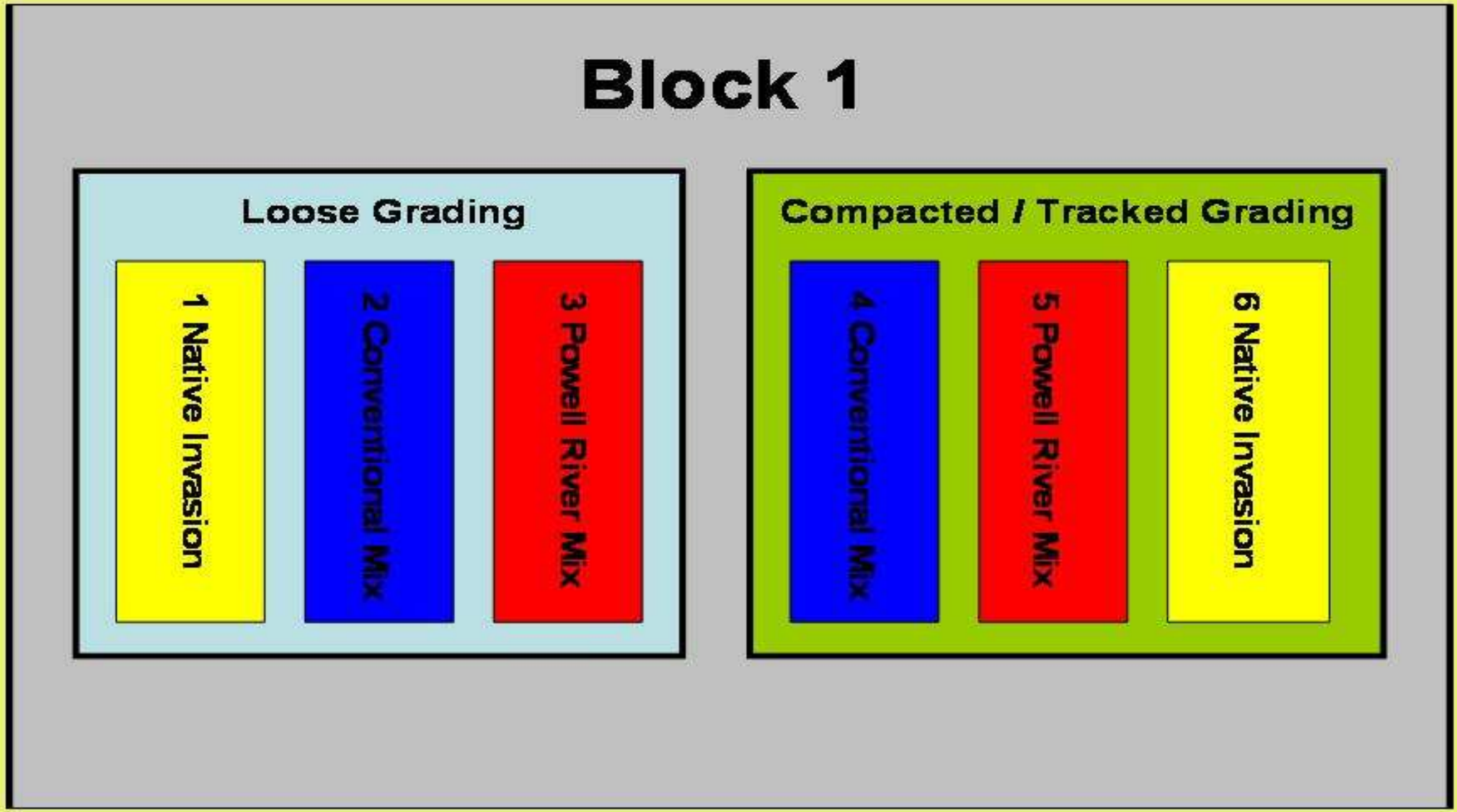
- 2009 Plot Sampling of Woody and Herbaceous Vegetation
- Erosion Pins to Track Surface Soil Loss: rebar stakes
- Analysis of the Effects of the Treatments on Tree Survival, Ground Coverage Rate, Erosion and Volunteer Species Recruitment

Tree Species Planted: 750 Trees per Acre Total

Species (descending order of survival)

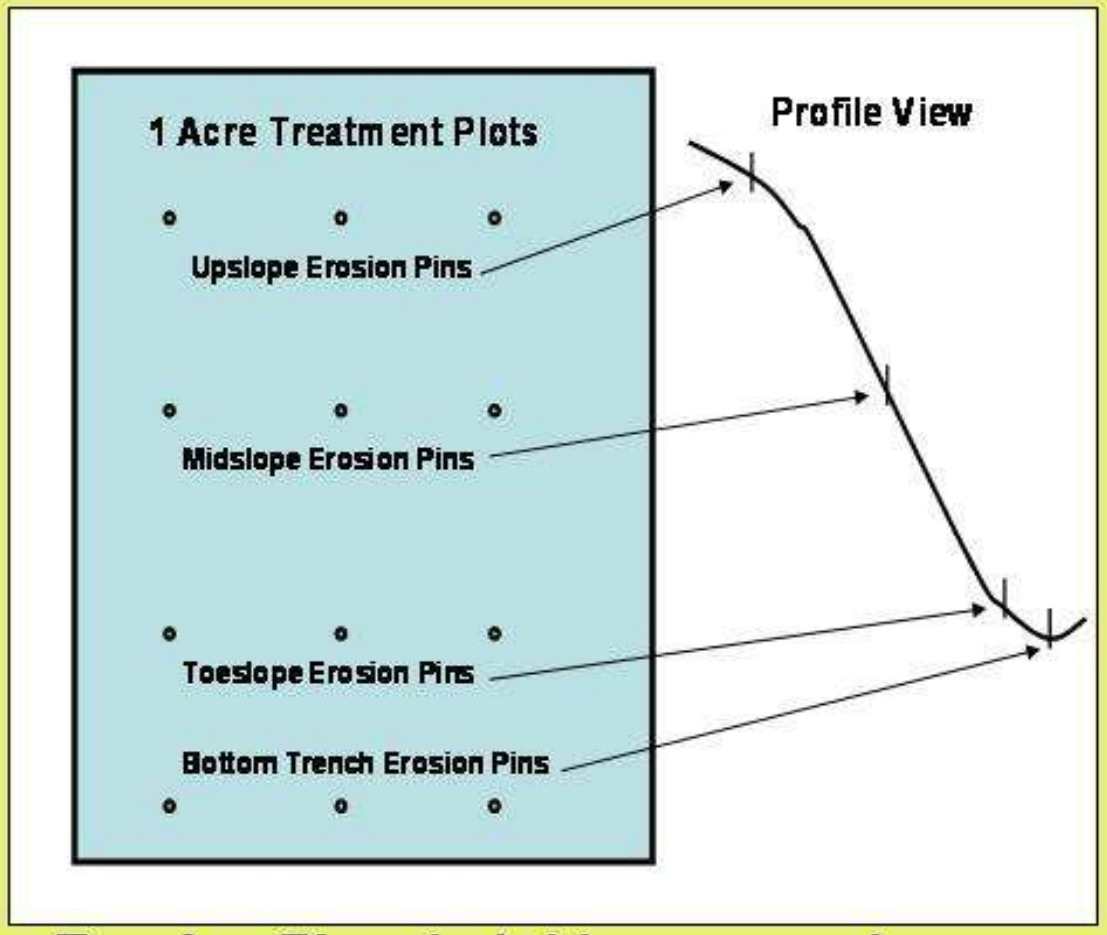
White Ash (Fraxinus allegheniensis)
White Oak (Quercus alba)
Redbud (Cercis canadensis)
Gray Dogwood (Cornus racemosa)
Red Mulberry (Morus rubra)
Black Cherry (Prunus serotina)
Red Oak (Quercus rubra)
Chestnut Oak (Quercus prinus)
Black Oak (Qurecus velutina)
Yellow-poplar (Liriodendron tulipifera)
Sugar Maple (Acer saccharum)
White Pine (Pinus strobus)
Shagbark Hickory (Carya ovata)

Experimental Design of each 6-acre block (3 blocks total)

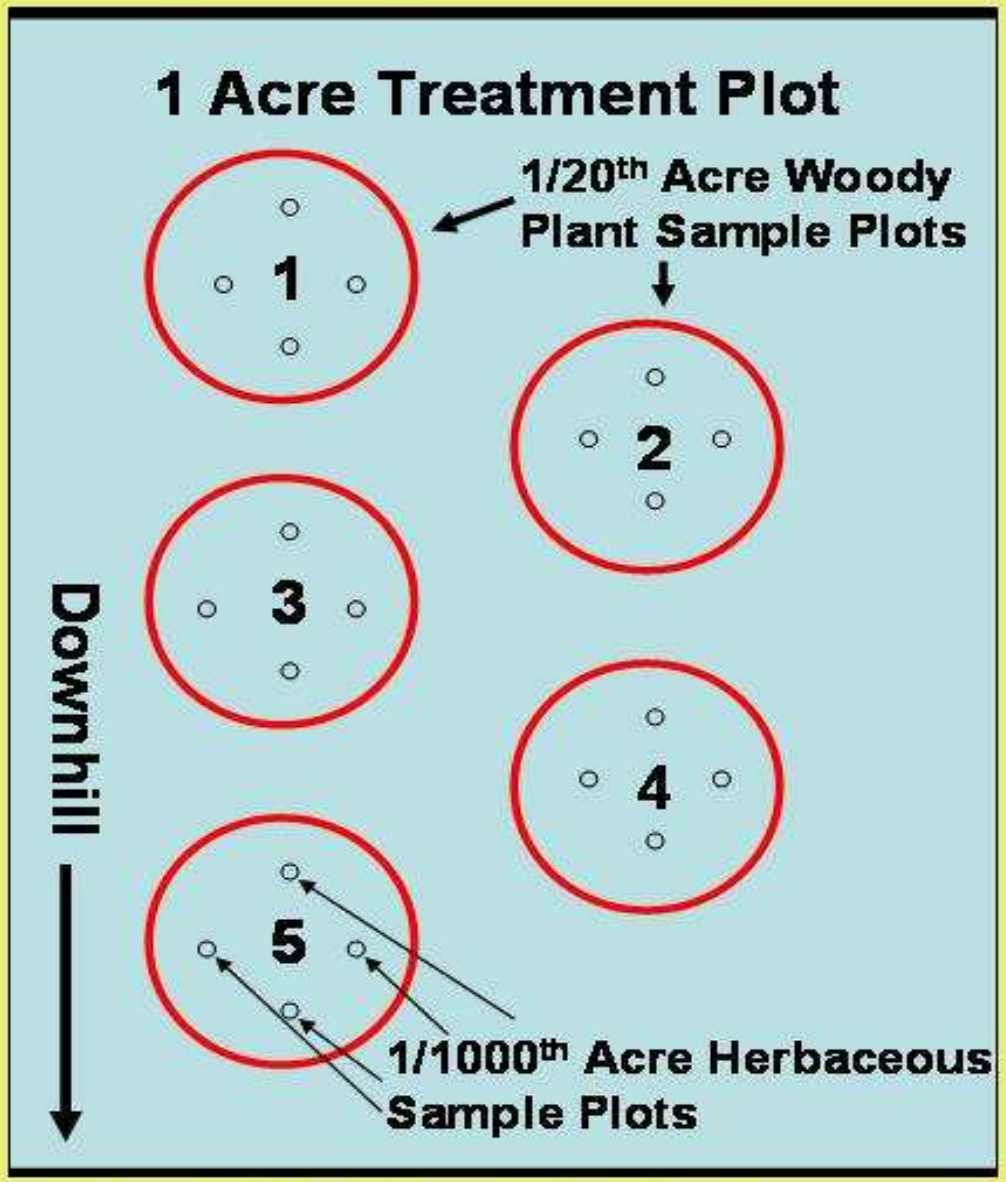


Herbaceous cover treatments were nested within grading treatments.

Experimental Design



Erosion Pins: height measured before and after growing season, relative increase in height of exposed pin indicates relative loss of soil from surface



Vegetation Sampling Plots: woody plants measured after growing season, herbs in August

Hypotheses:

- Loose grading will decrease erosion and increase tree survival compared to compact grading.
- Decreased ground coverage rates achieved by planting annual rye only will increase tree survival and increase volunteer plant recruitment.

Results:

Grading Effects

Loose Grading

- 70% groundcover
- 71% tree survival
- **+10 mm soil surface change (a)**
- 8 volunteer species per plot

Compact Grading

- 72% groundcover
- 70% tree survival
- **-8 mm soil surface change (b)**
- 6 volunteer species per plot

- **(Alpha = 0.10)**

Groundcover Effects

rye grain, orchardgrass, perennial ryegrass, Korean lespedeza, birdsfoot trefoil, ladino clover, redtop, weeping lovegrass

Conventional

- **83% groundcover (a)**
- 65% tree survival
- -7 mm soil surface change
- **4 volunteer species (b)**

annual ryegrass, perennial ryegrass, timothy, birdsfoot trefoil, ladino clover, weeping lovegrass

Tree Compatible

- **75% groundcover (ab)**
- 71% tree survival
- **+2 mm soil surface change**
- **5 volunteer spp. per plot (b)**

annual ryegrass

Annual Ryegrass

- **55% groundcover (b)**
- 75% tree survival
- **+8 mm soil surface change**
- **12 volunteer species (a)**

(Alpha = 0.10)

Discussion: Grading: Why no tree effects yet?

Compacted Plots

Loose Surface Soil

Dense Subsoil?

Root Limiting Layer Begins?

47% Brown Sandstone

15% Gray Sandstone

Loose Plots

Loose Soil

Roots Continue Growing Freely?

39% Brown Sandstone

28% Gray Sandstone

Coarse Backfill Material

- Surface soil has swelled from heaving, slaking and unloading
- Porosity is forming in upper levels of compacted soil
- Differences may not show up until roots intercept dense subsoil
- Brown sandstone is also known to be a superior medium to gray, this is muting effect

Erosion

Average soil loss is negative in many cases because porous soil is building from solid rocks as they unload and slake.

Loose Plot Gully

Mass erosion is concentrated almost entirely in gullies.

Gullies are deeper, wider and more numerous in compacted plots than in loose plots.

(Meter Stick for Scale)

Compact Plot Gully

Erosion

Nearly all of the gullies on loose plots originated from vertical dozer tracks that topped out on a road which concentrated water into them.

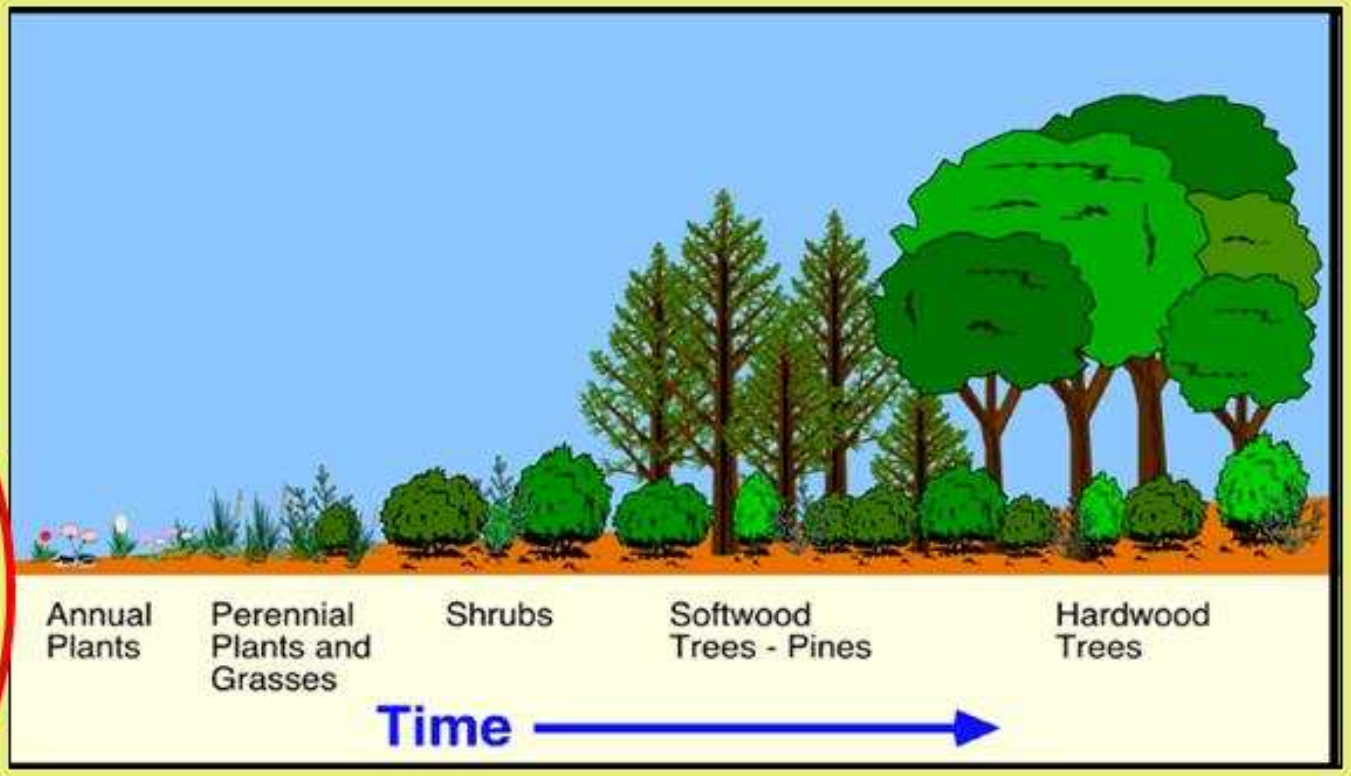
The worst gullies on the compact plots also originated from roads concentrating water onto top of the site.

Soil genesis and fill subsidence is ongoing, quantitative erosion rate is elusive.

Succession with Annual Rye

Most Common Volunteer Species:

- Red maple
- Black locust
- Coltsfoot
- Wild lettuce
- Asters



Pioneer trees and annual forbs indicate succession is beginning

- Invasives such as autumn-olive and sericea lespedeza were rare after 2 years, but remain a concern

Observations for Future Study

- Herbivores (wild, feral and domestic) are a widespread problem, may be the limiting factor when all FRA steps are followed:

  Predators & Exclusion?

- Natural corridors and islands act as seed sources to promote succession, we are seeing more recruitment of volunteers on blocks near them:

  Leave Natural Corridors?

- Tap Reclamation Lessons and Knowledge from Urban Arboriculture:

"Transplanted trees sleep, creep and then leap."

"The right tree in the right place."

The Carrie Ridge Winter Crew

Remnant Forest Adjacency

Conclusions

- Annual rye promoted succession without causing additional erosion – but will natural legumes and microbes provide adequate long term nitrogen fixing? It did nominally improve tree survival by 10%.

- Looser grading reduced erosion – but will it also increase tree performance in long term?

- Loose graded plots inadvertently ended up with significantly more gray sandstone than compacted plots which had more brown sandstone: this likely muted effects on forest establishment. The FRA is synergistic and All FRA steps are important!

Credits

- **Authors:**

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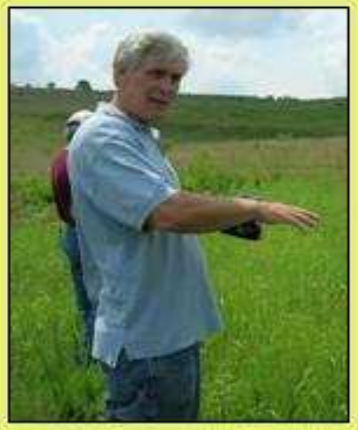
- **Cooperators:**



Rick Williams and
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The Powell River Project

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Questions and Discussion