Effect of Harvest Residue Management on Nutrient Cycling and Tree Growth in a Young Loblolly Pine Plantation

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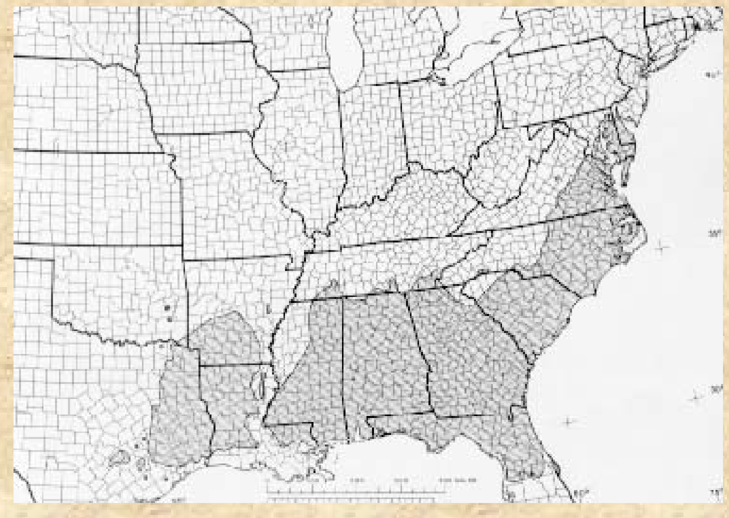
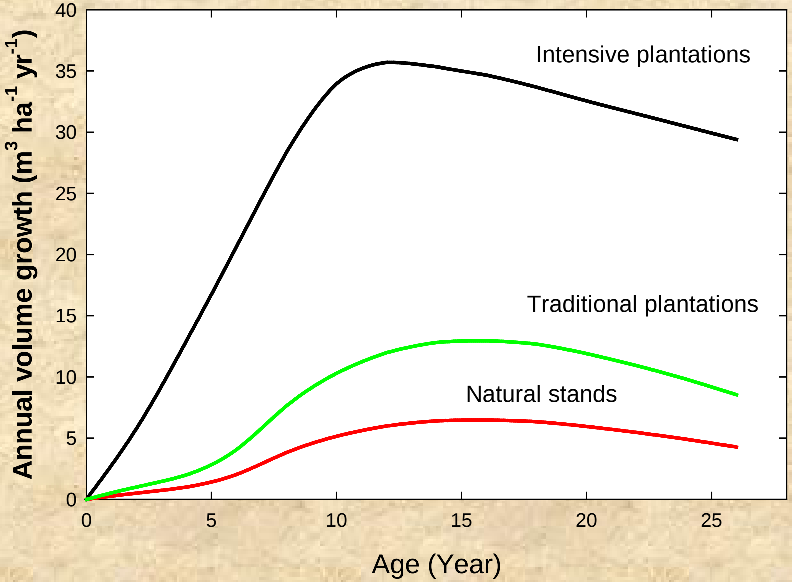
Loblolly Pine (*Pinus taeda* L.)

- Loblolly pine plantations cover more 13 million hectares in the U.S. Southeast
- Harvested on 20 – 35 year rotation depending on products
- Genetic improvement and silviculture are highly advanced (50+ years of research)
- Potential productivity can exceed 35 $m^3\ h^{-1}$ year^{-1}
- Deployment of clonal systems promises to further increase productivity





Source: adapted from Allen and Albaugh 2010

Organic Matter Management

- Proactive soil management that stabilizes or increases soil organic carbon is necessary to realize the productive potential of genetically improved material.

5 – 50 Mg C ha^{-1}

80 - 200 kg N ha^{-1}

Courtesy: Mike Tyree

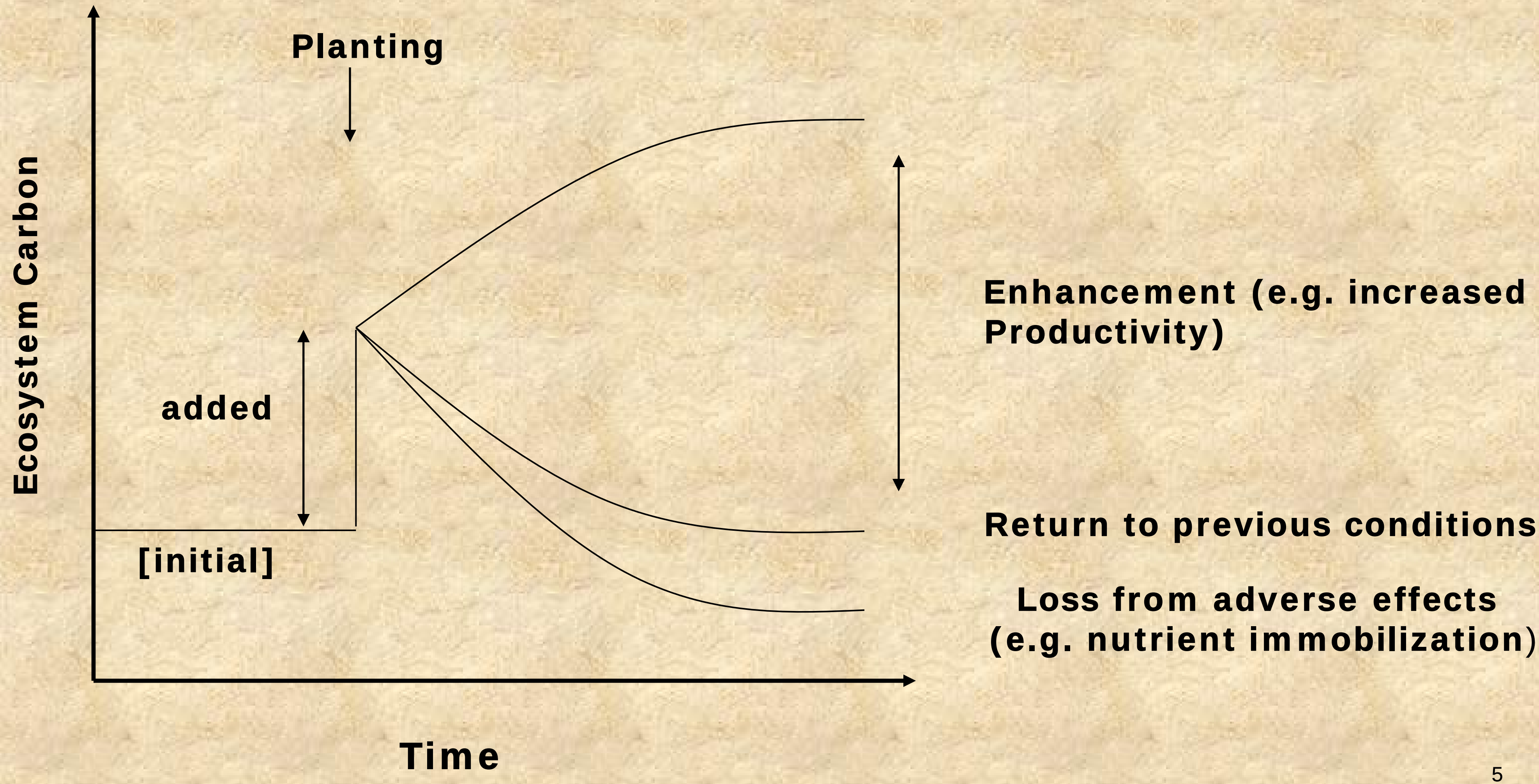
Courtesy: H. Lee Allen

Cross Carbon Study: Objective

- **Investigate the potential to use forest logging residues incorporated into the soil during site preparation to enhance soil quality, promote short- and long-term net ecosystem productivity or carbon sequestration.**

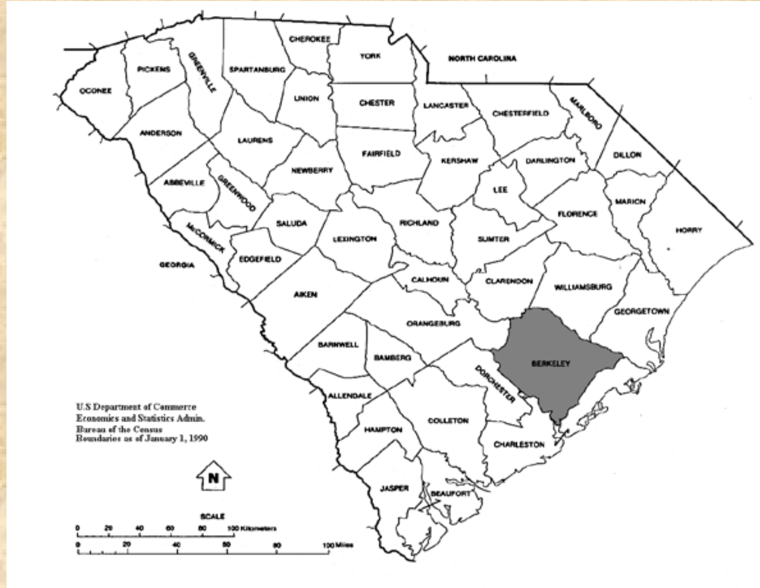
  - manipulate N availability by soil incorporation of logging residues or forest floor during site preparation
  - manipulate N demand using clones with different growth or nutrient use efficiencies

General Hypotheses



Adapted from Harrison et al. 1995

Site Location



- MeadWestvaco lands
- Berkeley County, SC
- Soils: Lynchburg/Ocilla - moderate OM, low P, SW poorly drained, high water table

- Annual precipitation: 1358 mm
- Mean temperature: January – 8 ^{o}C; July – 27 ^{o}C

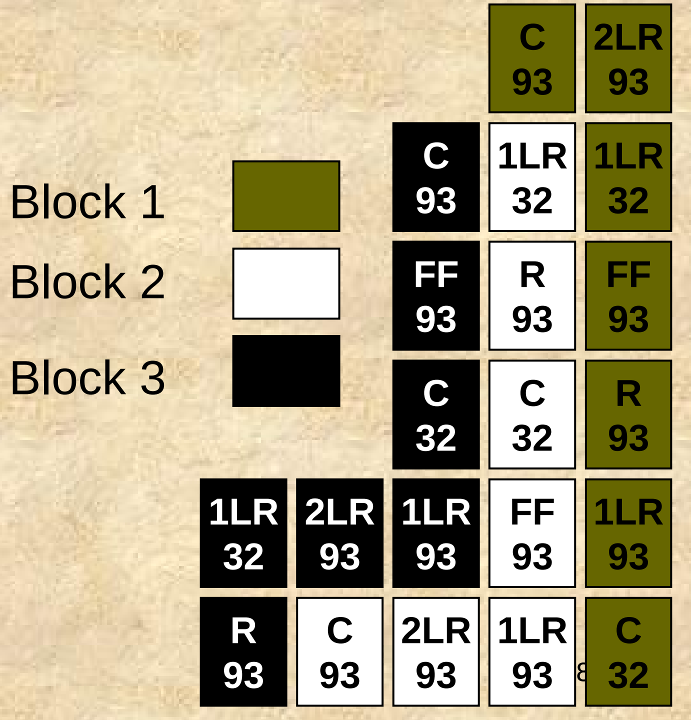
Site Characteristics

- Previous Stand: 21 years old, 2nd rotation, harvested in May 2004
  - 518 trees ha^{-1}
  - 43 m^2 ha^{-1} BA, SI_{25}=23m (75 ft)
  - ≈ 93 Mg C ha^{-1} in total biomass
- Following harvest:
  - ≈ 24.5 Mg ha^{-1} litter (<0.5 cm)
  - ≈ 22.0 Mg ha^{-1} wood (>0.5 cm)
- Forest floor (C:N ≈ 112) and chipping effluent (C:N ≈ 700) used as source for treatment residue.

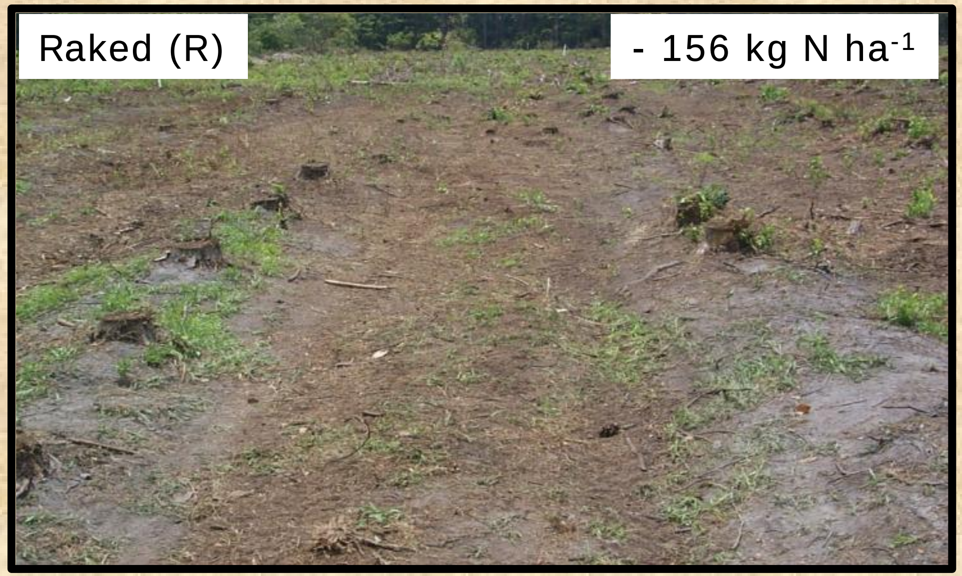
Treatments

- Five residue treatments:
  - **Control** – no treatment
  - **Raked (R)**– ≈ 25 Mg ha^{-1} Forest Floor removed
  - **Forest floor (FF)** - 25 Mg ha^{-1} FF added (High Quality, C:N≈112)
  - **1x Logging residue (1LR)** – 25 Mg ha^{-1} LR (Low Quality, C:N≈700)
  - **2x Logging residue (2LR)** – 50 Mg ha^{-1} LR
- 38 m x 48 m treatment plots replicated 3x
- Planted with ArborGen Clone

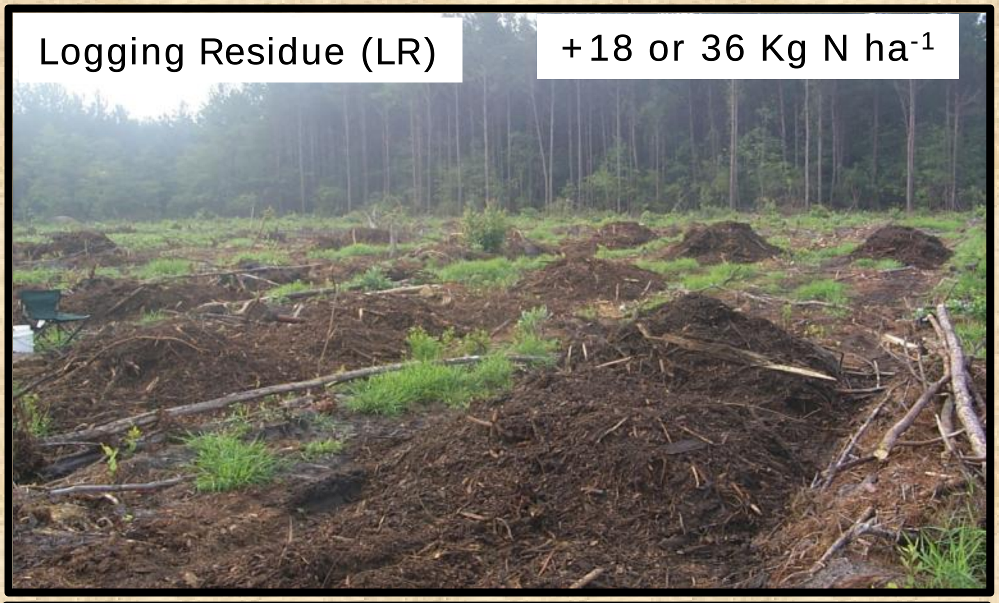
  (1.8 x 4.3 m spacing-1292 trees ha^{-1})
  - AA93
  - AA32 (in C and 1LR treatments only)
- Weed control first two years
  - Arsenal, Oust
  - Broadcast or hand applied



Site Preparation



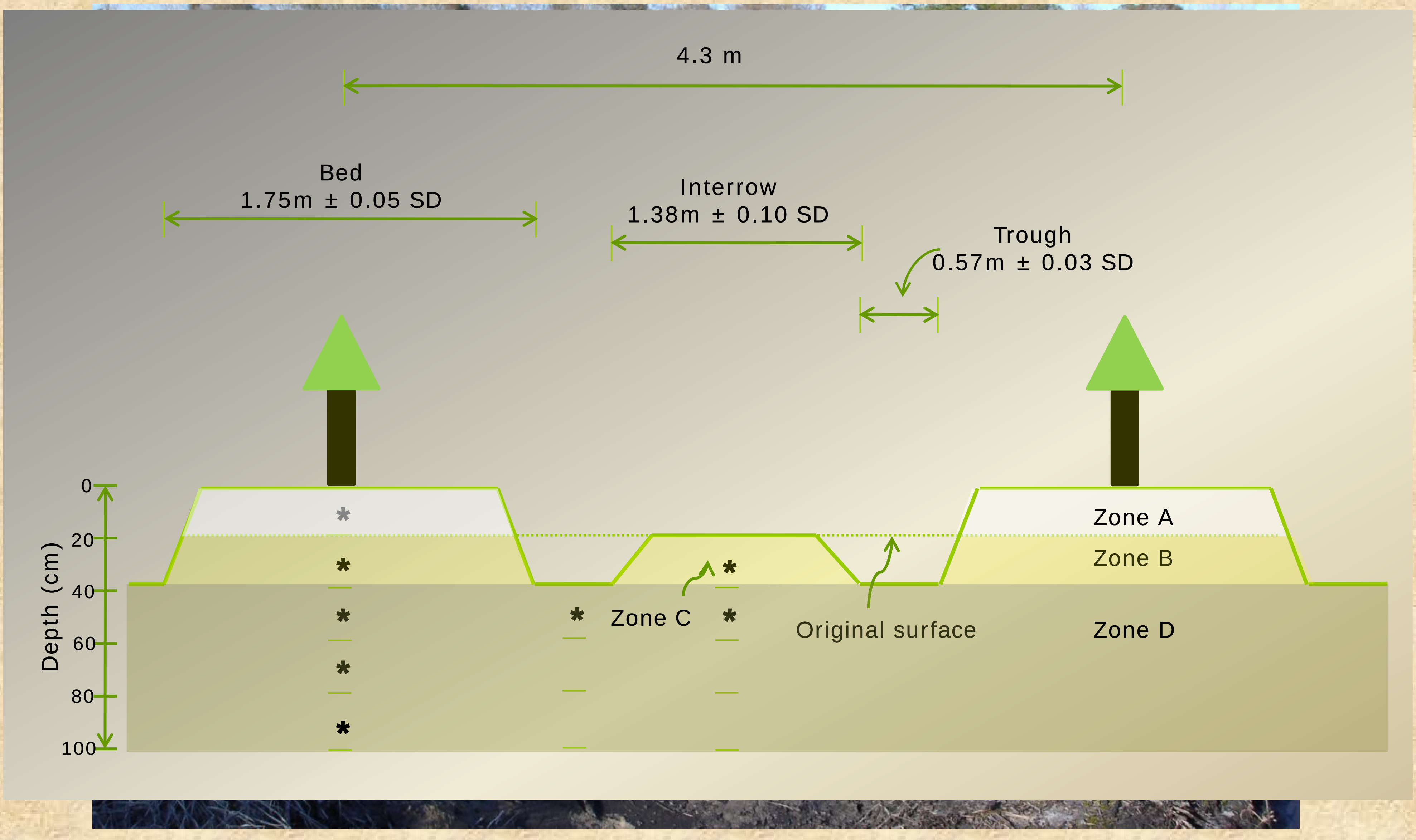
Site Preparation



Results

- Evaluate the influence of the residue characteristics on decomposition and nutrient release (nutrient dynamics).
- Residue effects on soil and microbial biomass carbon and nutrients
- Residue effects on tree and stand growth
- Clone x Residue

Soil Carbon - Sampling Locations



Coarse Organic Fragments (COF)

COF (kg C m^{-2})

Stand Age

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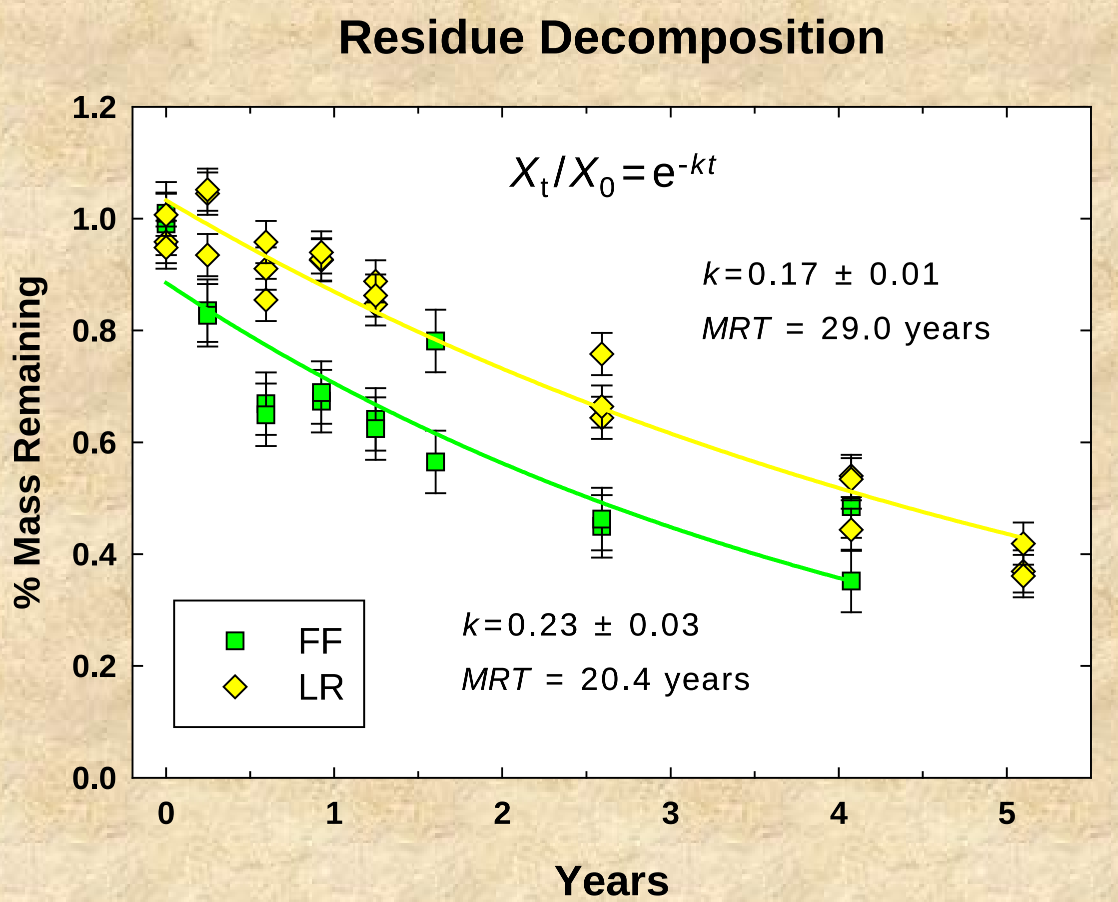
COF: decomposition



- ❑ Soil incorporated residues will persist for much of the rotation.

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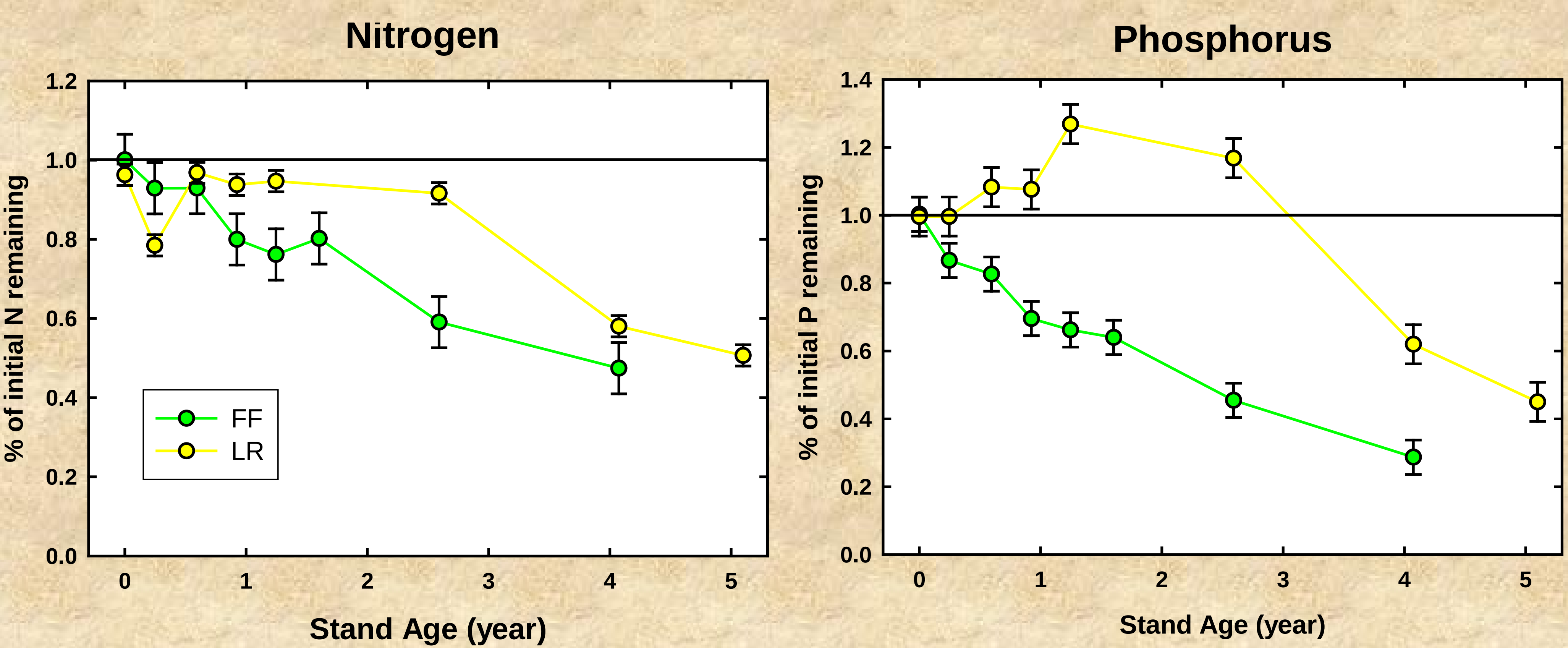
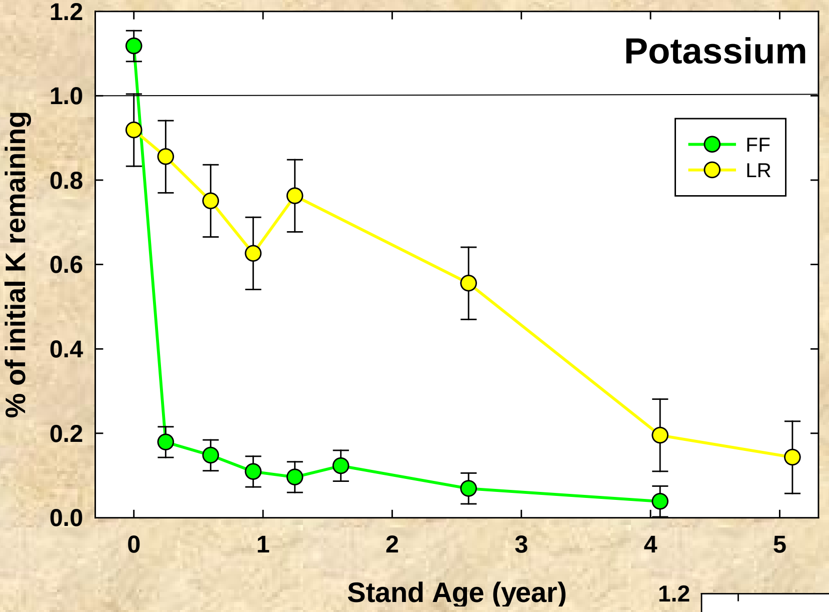
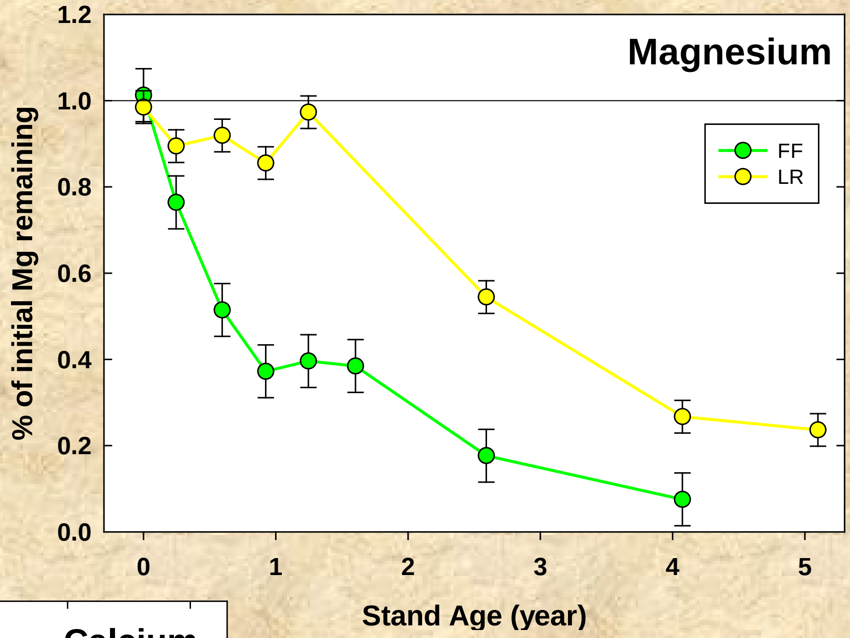
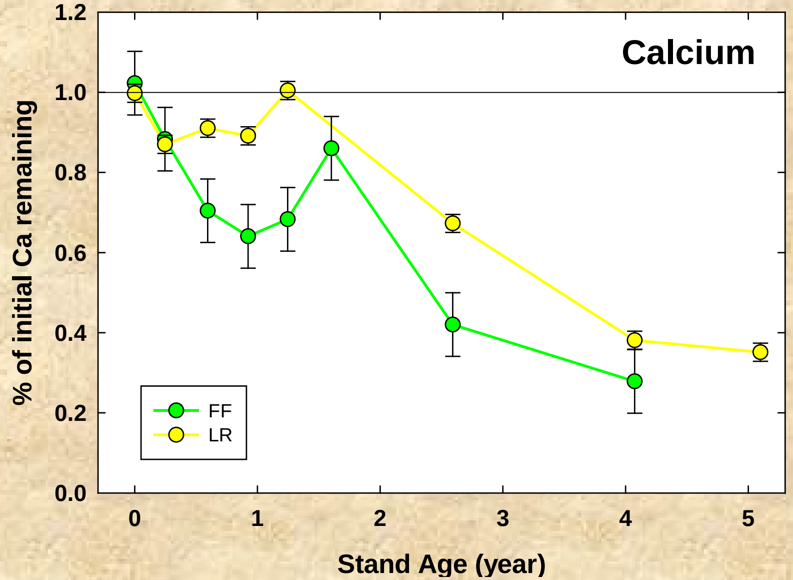
COF: N and P Release



COF: K, Mg, and Ca release







Soil Nutrients: Mineral Soil (<2mm)

(Bed, 0 – 60 cm)

	C (g kg^{-1})	N (g kg^{-1})	C / N	P (mg kg^{-1})	Mg (mg kg^{-1})	K (mg kg^{-1})	Ca (mg kg^{-1})
Control	37.3 ab	1.18 ab	34.9	26.2	40.8 a	37.8 a	217 ab
R	31.2 a	0.99 a	36.7	27.4	34.8 a	38.7 a	173 a
FF	46.5 bc	1.44 b	39.9	25.1	63.9 c	45.1 ab	339 d
1LR	48.0 c	1.41 b	54.9	27.7	51.8 b	49.9 b	264 bc
2LR	54.7 c	1.50 b	41.1	27.5	65.8 c	64.3 c	307 cd
SE	3.1	0.09	7.8	2.5	2.9	2.6	18

- Average over years 0 – 7.

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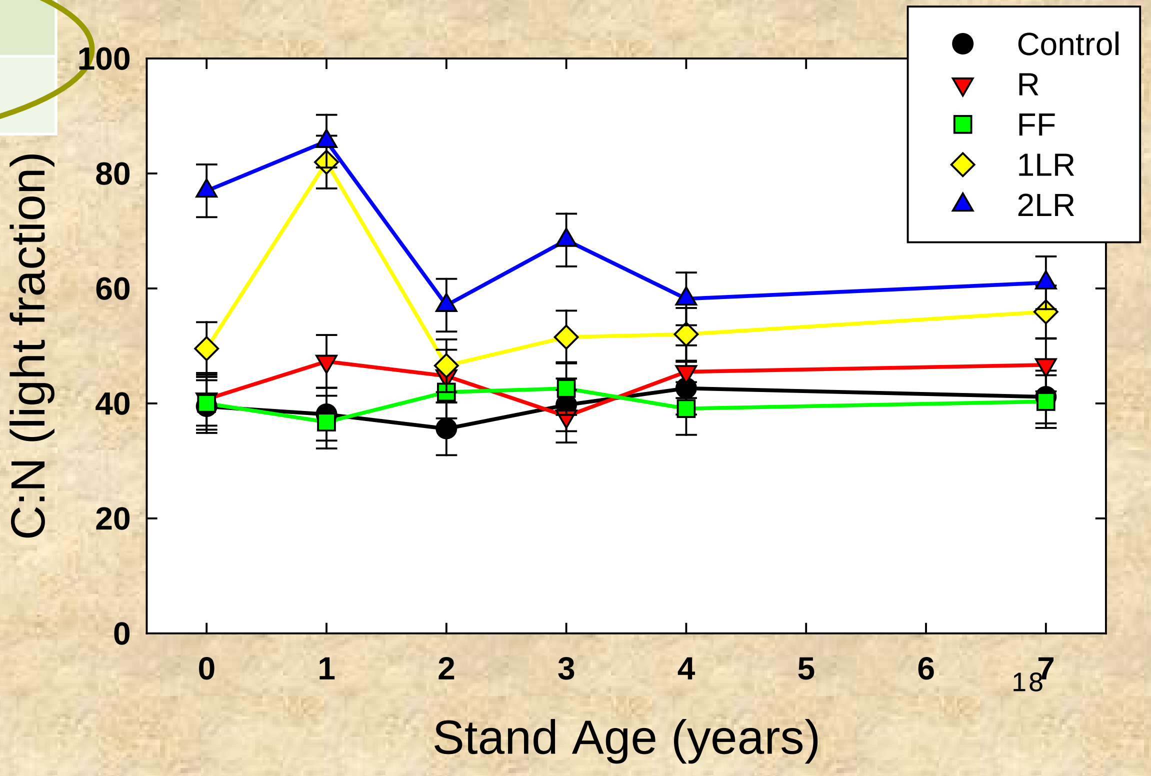
Soil Carbon: Soil Macro-Organic Matter

Carbon OM fraction (g C kg soil^{-1})			
	Light	**Medium**	**Heavy**
Control	3.5 a	7.4 ab	15.6 ab
R	2.3 a	4.8 a	12.5 a
FF	5.8 b	12.5 c	16.4 b
1LR	6.5 b	10.7 bc	20.7 c
2LR	9.3 c	14.2 c	22.2 c

- Age 7
- Macro-organic matter (150-2000 µm) – density fractions
- 60 – 80% of total soil C
- >45% OM in heavy fraction

- LR increased C in all fractions
- LR treatments are a sink for N



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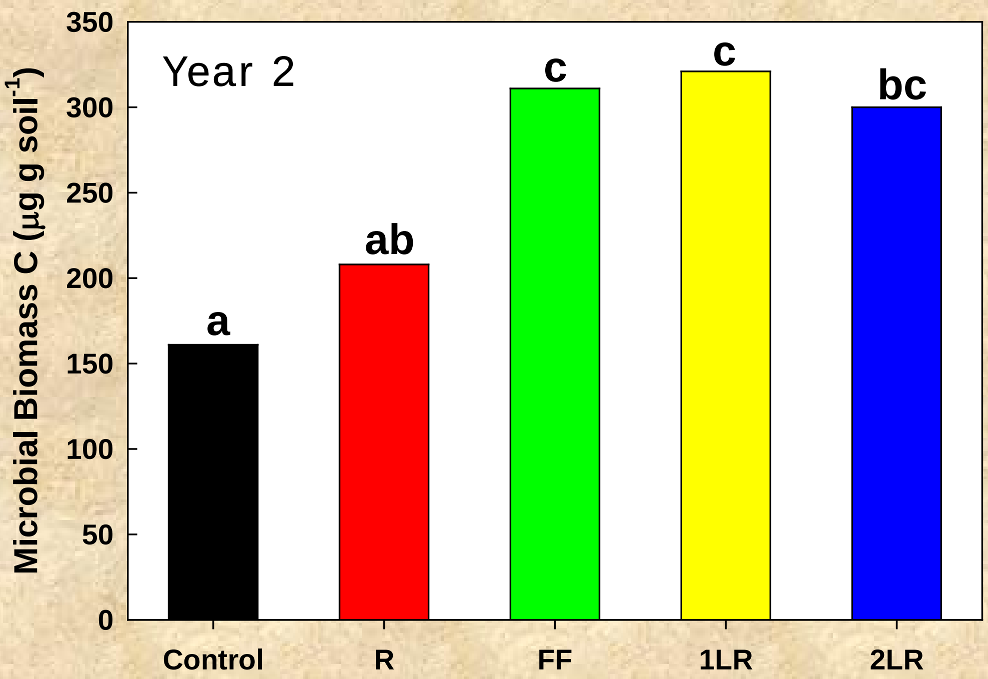
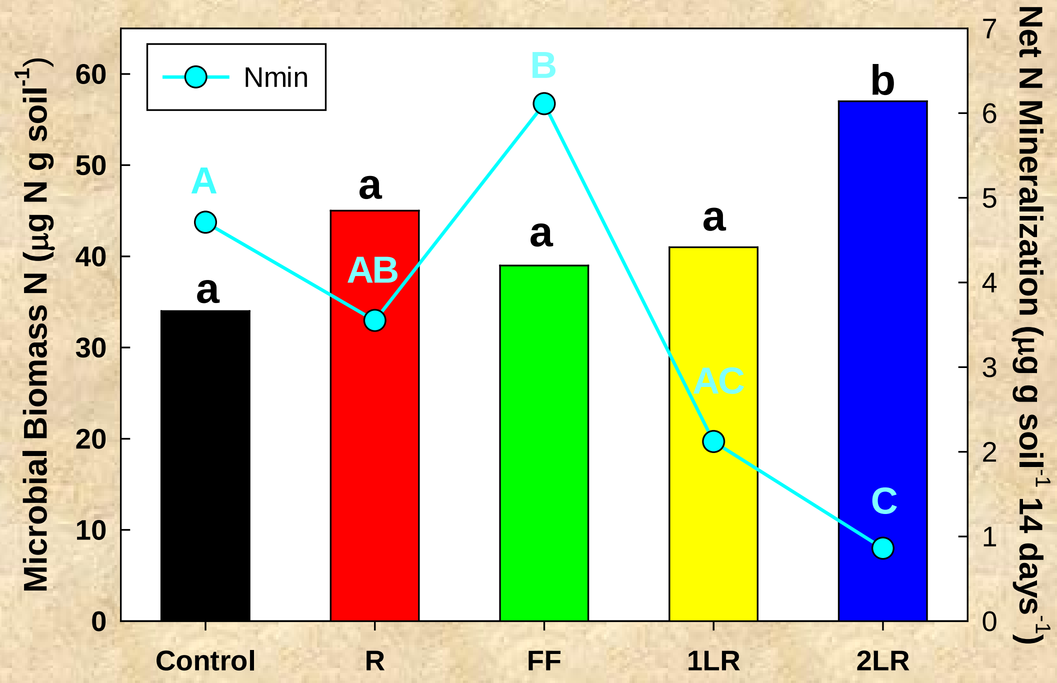
Microbial Biomass C and N





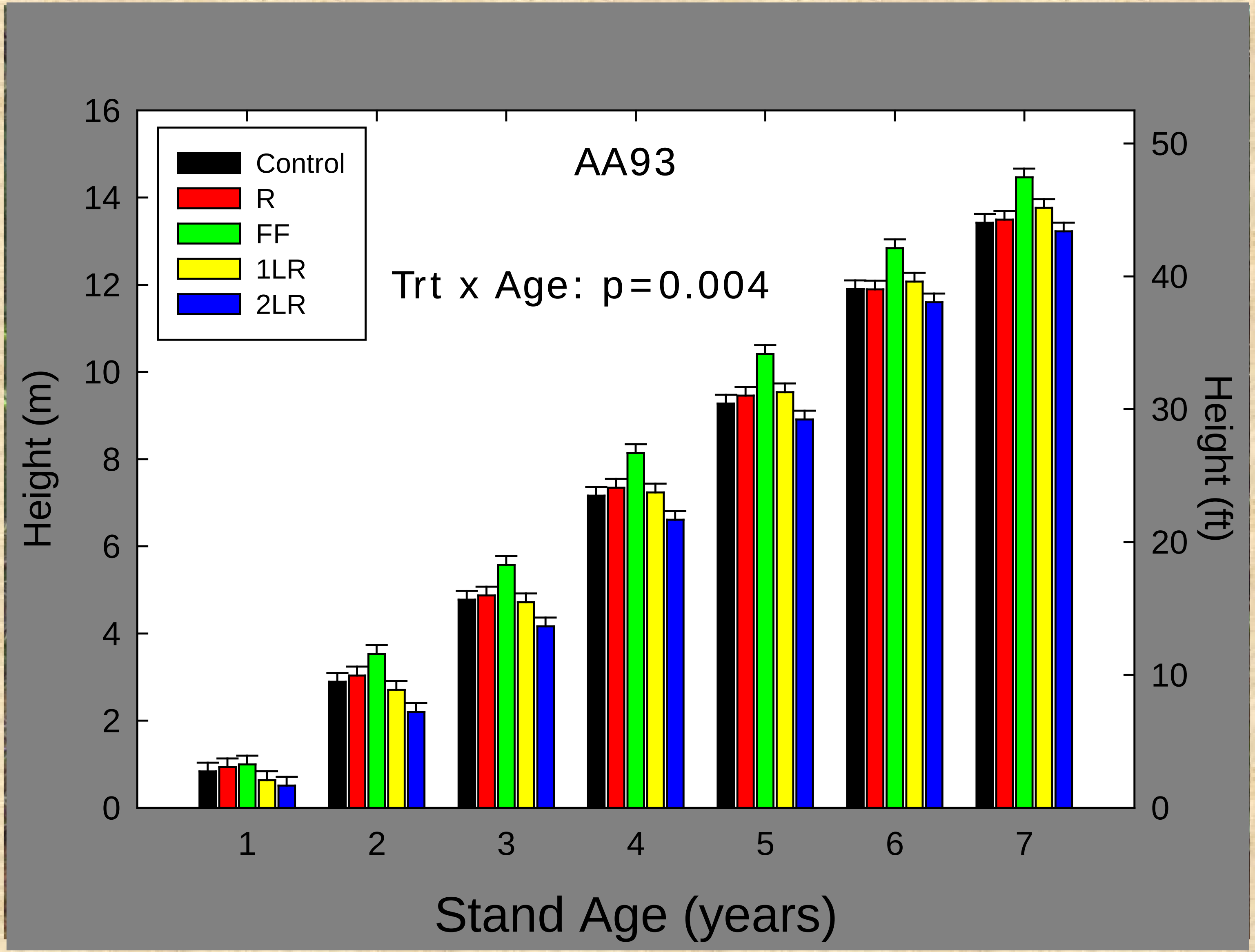
- Residue treatments increased microbial biomass C
- FF increased N mineralization
- LR decreased N mineralization.

Tisdale 2008 NCSU

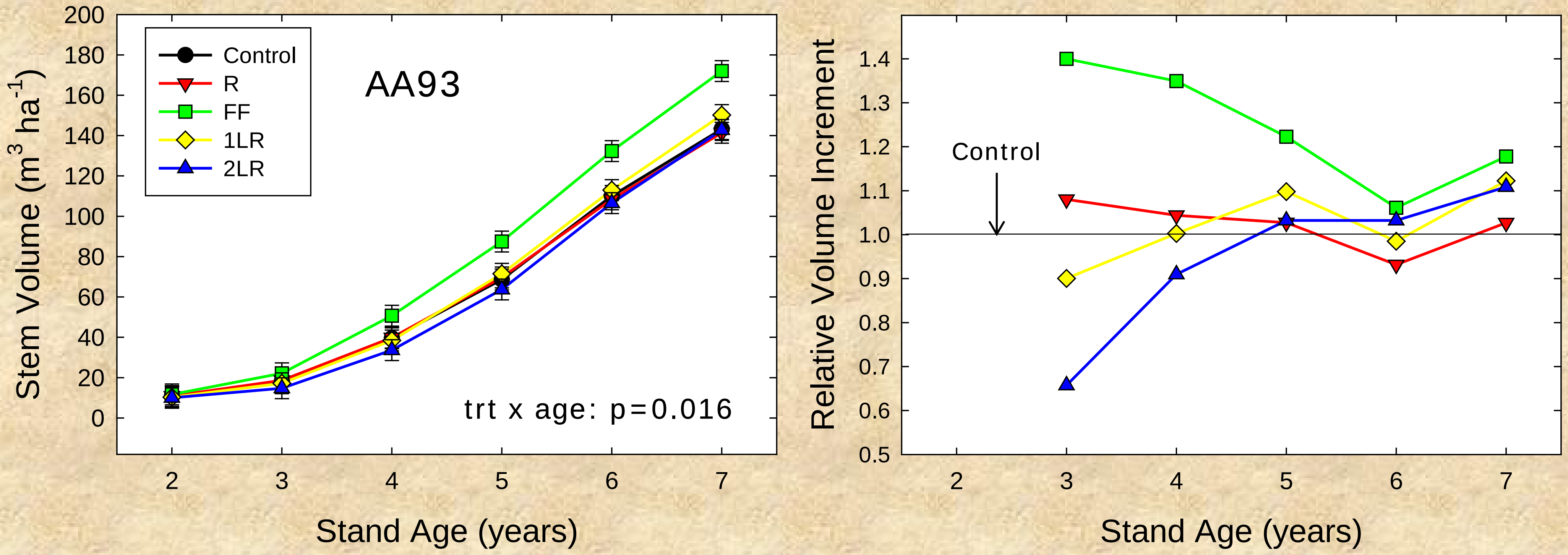
Residue Treatments: Productivity

Age: 18 months

Residue Treatments: Height



Residue Treatments: Volume



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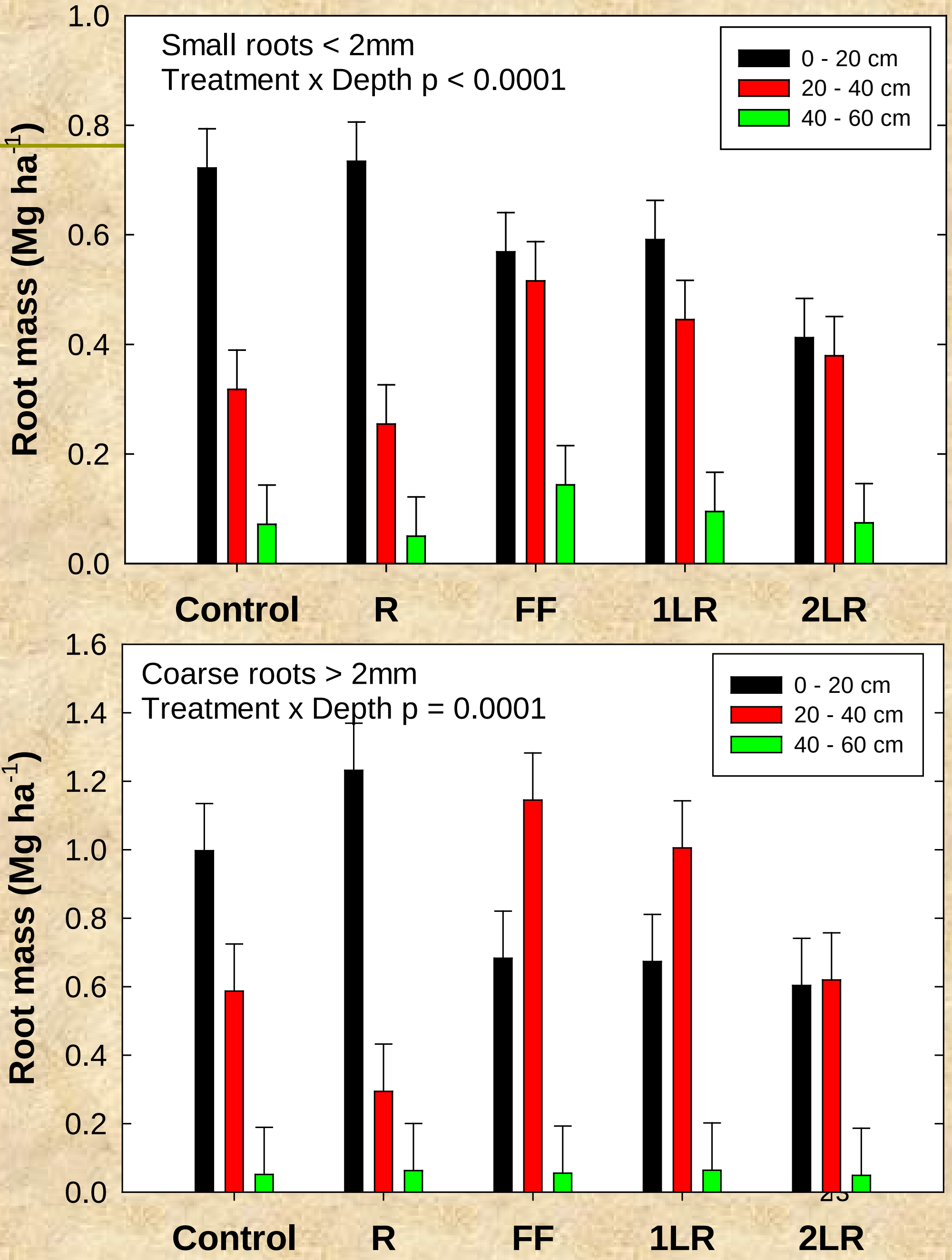
Belowground Biomass



- Root distribution within beds differed with treatment.
- Significance for long-term productivity?

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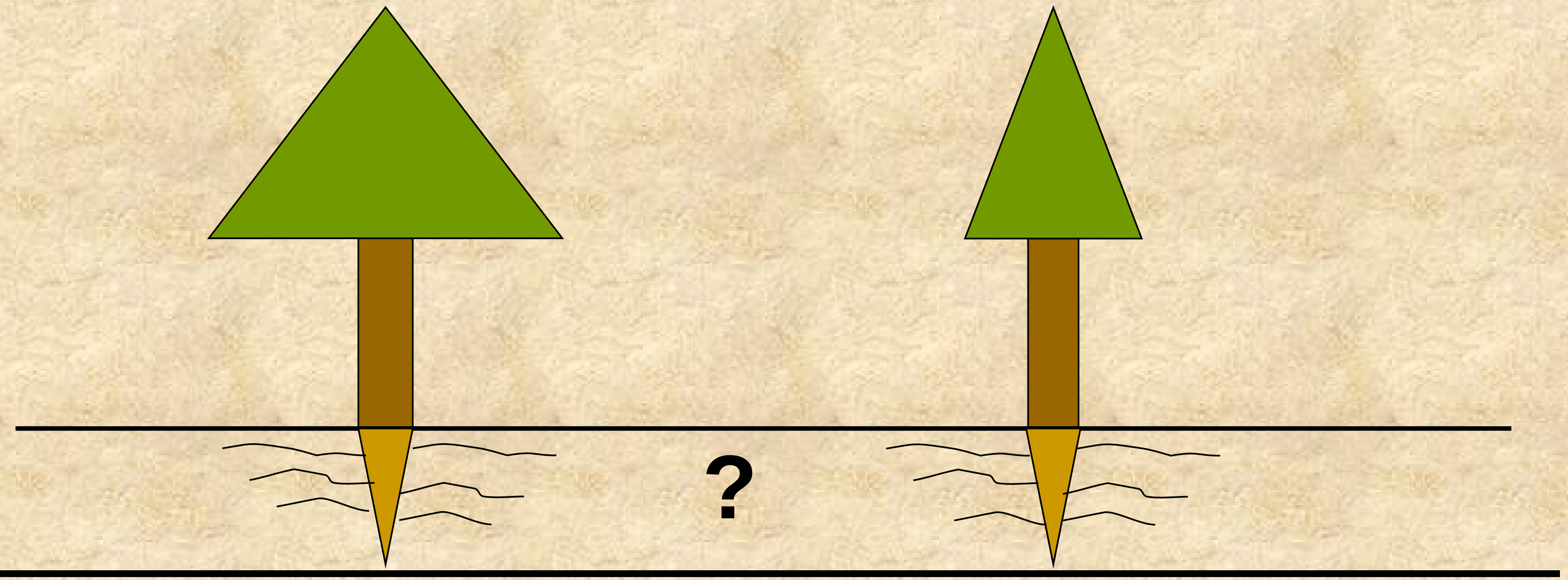
Genetics x Silviculture

AA-32

"Wide Crown" ideotype (Low GE)

AA-93

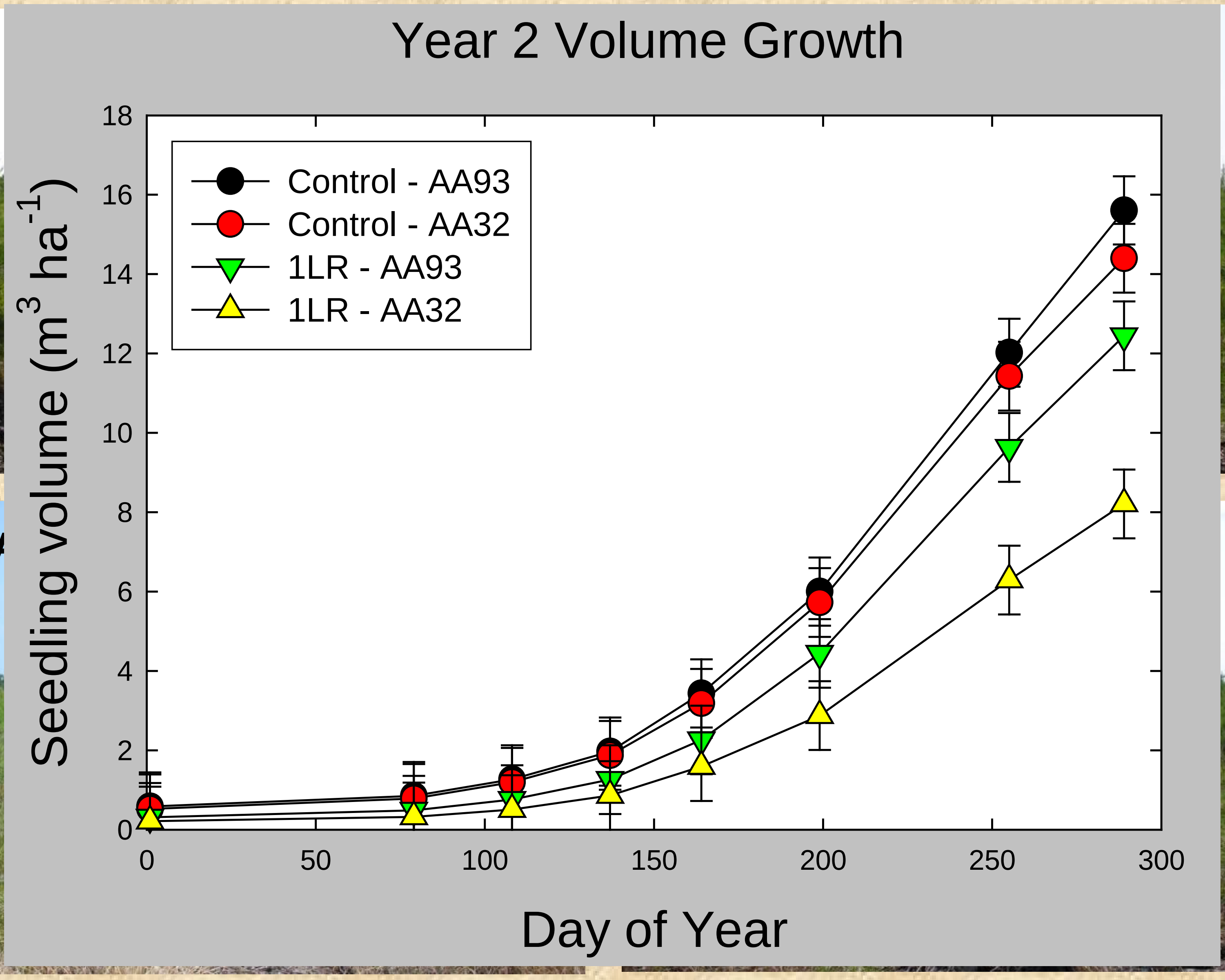
"Narrow Crown" ideotype (High GE)



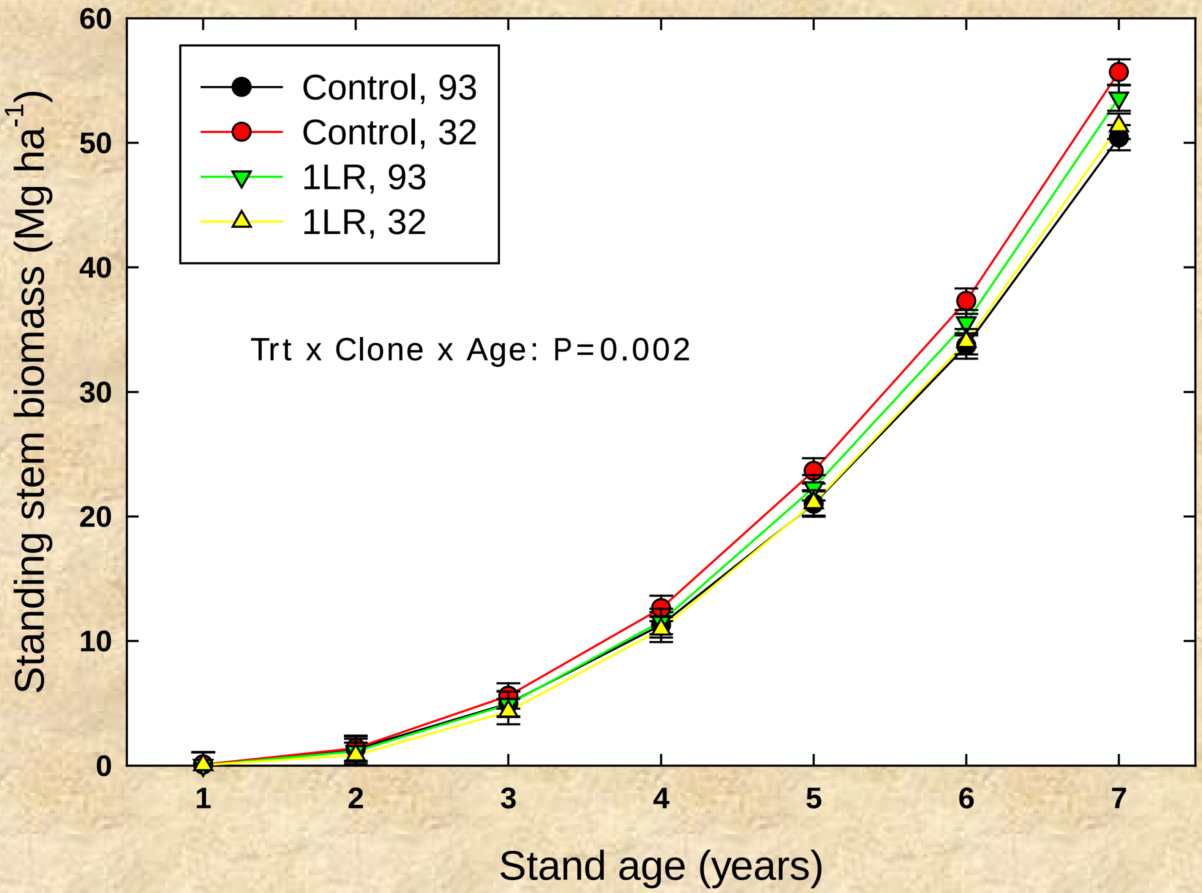
Hypotheses:

Biomass Production	**- -**	**1LR**	**-**

Genetics x Silviculture: Year 2 Growth



Genetics x Silviculture: Stem biomass



- Year 7: Treatment x Clone p=0.04
- AA32 10% more stem biomass in Control than AA93

Summary

- Residue quality had a significant effect on rate of decomposition, nutrient immobilization and release:
  - LR treatments initially immobilized N and P
  - FF treatment was a source of N and P
- Residue treatments increased mineral soil C, N, Mg, K, Ca, but not P.
- Residue treatments increased microbial biomass C and N.
- Residue quality altered rates of N availability
  - high quality FF treatments increased productivity
  - low quality LR treatments inhibited productivity
  - Residue effect on growth disappeared by age 6, but…
- Raked treatment had no effect on productivity or soil C, but…
- Clone x LR treatment interaction on stem biomass accumulation.