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North Carolina State University • Virginia Tech • Universidad de Concepción • Universidade Federal de Santa Catarina

RW28 Phosphorus Carryover Study

NC STATE UNIVERSITY · VIRGINIA TECH · Universidad de Concepción · Universidade Federal de Santa Catarina

Primary Question

Is there a phosphorus "carryover effect" into the subsequent rotation that relates to:

1. Previous P application rates
2. Soil properties

Carryover effect: A tree growth response to fertilizer added in a previous rotation

Objectives

- Determine if the amount of P fertilizer applied in the previous rotation affects *the duration and/or magnitude of response* in the subsequent rotation
- Evaluate influence of soil properties on the availability of P for the next rotation trees
- Determine if P carryover is related to forest floor and mineral soil P supply as measured in the previous rotation prior to harvest
- Determine critical values for foliar or soil P can be related to magnitude and duration of P response across multiple soils

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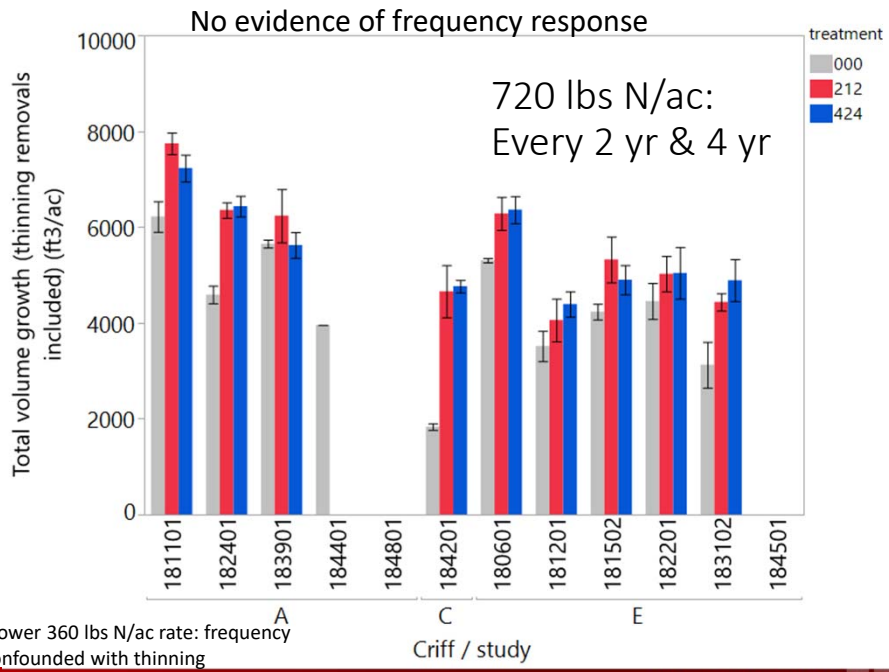
Regionwide 18 Treatments

Treatment Code	N Rate lb/ac	Frequency Years	Cumulative N at Years in Study (lb N/ac)				
			2	4	6	8	12
Control	0	None	0	0	0	0	0
206*	60	2 yrs	60	120	180	240	360
212	120	2 yrs	120	240	360	480	720
218*	180	2 yrs	180	360	540	720	1,080
412	120	4 yrs	120	120	240	240	360
418	180	4 yrs	180	180	360	360	540
424	240	4 yrs	240	240	480	480	720
624	240	6 yrs	240	240	240	480	480

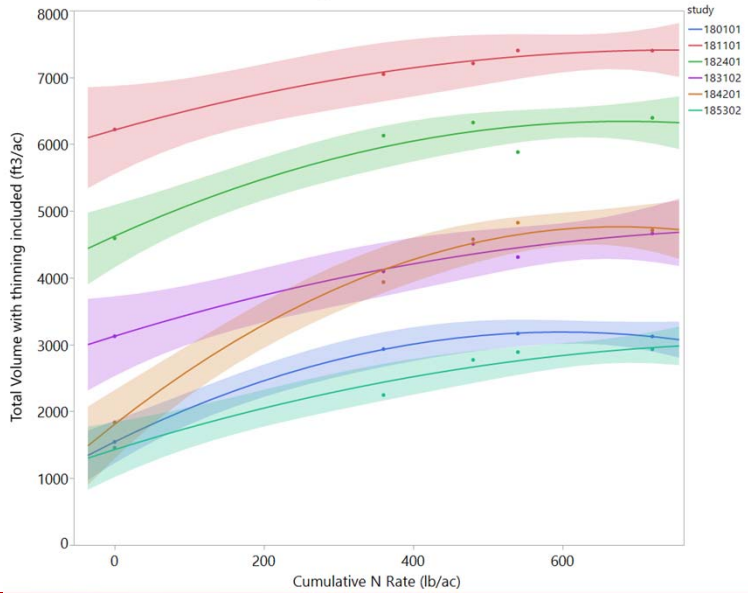
*not thinned

No evidence of frequency response

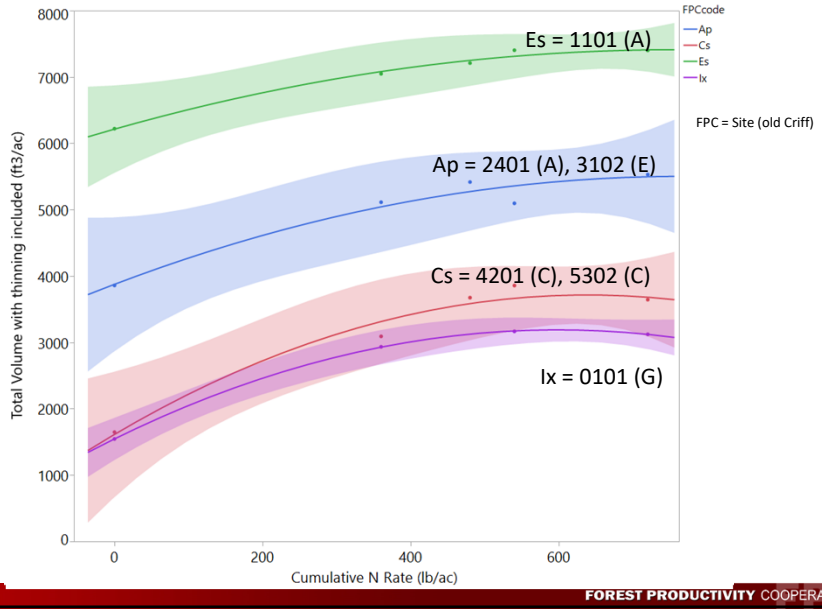


*lower 360 lbs N/ac rate: frequency confounded with thinning

Quadratic Response



Quadratic Response by FPC soil code



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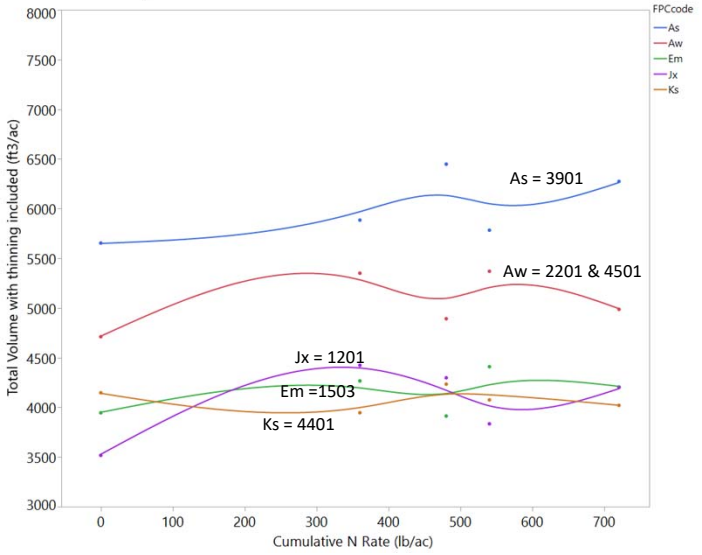
Non Responsive FPC Soil Groups



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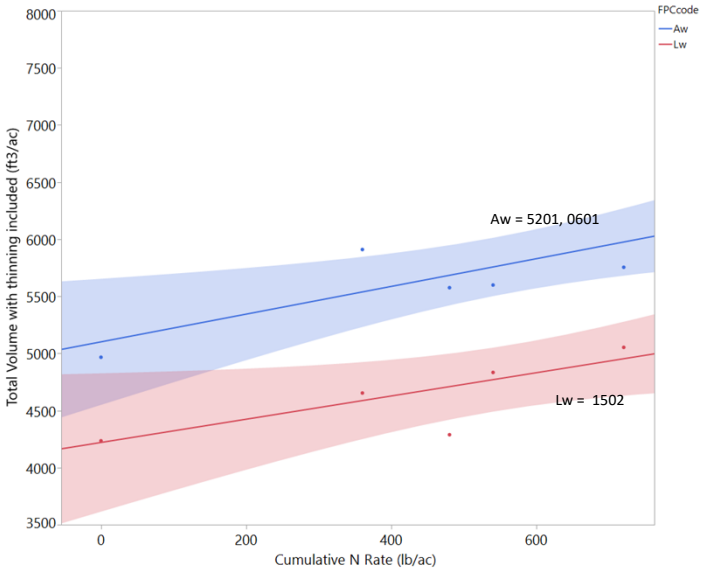
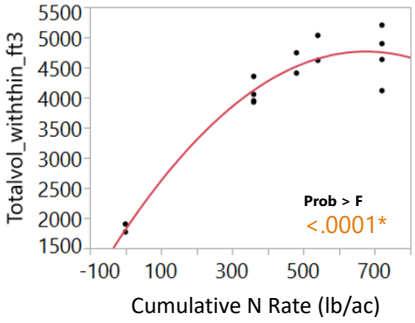
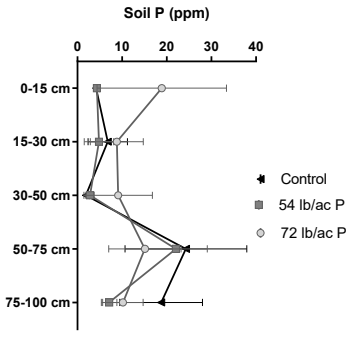
Linear Response Groups by FPC code



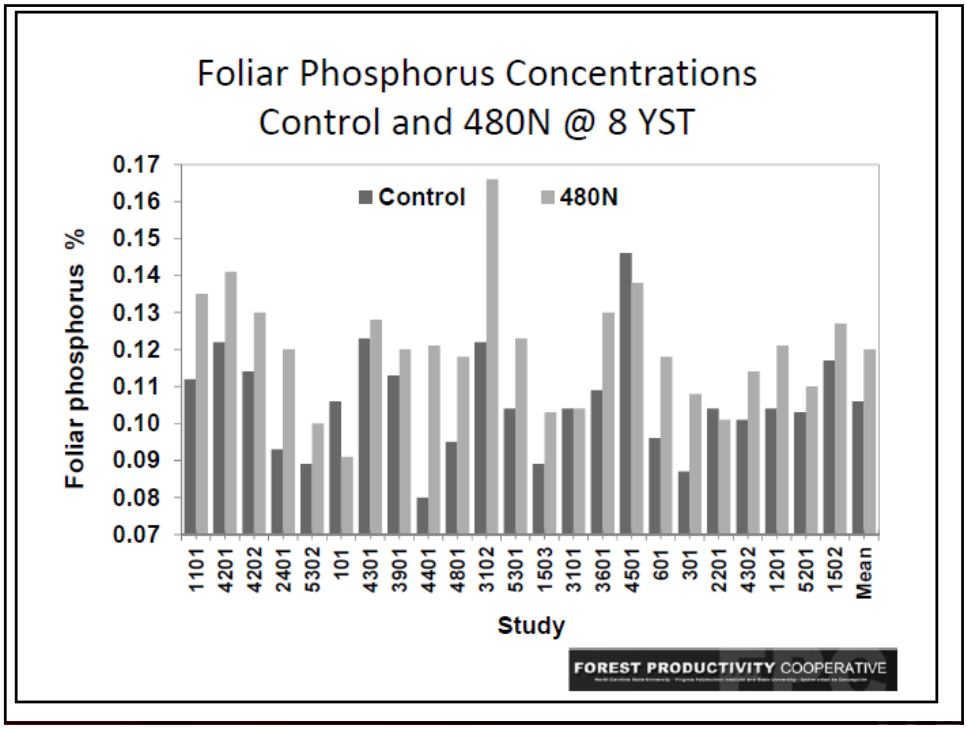
184201 – Brantley, GA





Totalvol_withthin_ft3 = 3242.99 + 2.6*Rate - 0.0064938*(Rate-470)^2

Sandy over loamy, Siliceous, Active, Thermic Typic Haplohumods, Flatwoods, Penholoway


Foliar Phosphorus Concentrations
Control and 480N @ 8 YST
Foliar phosphorus %
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.10
0.09
0.08
0.07
Control
480N
1101
4201
4202
2401
5302
101
4301
3901
4401
4801
3102
5301
1503
3101
3601
4501
601
301
2201
4302
1201
5201
1502
Mean
Study
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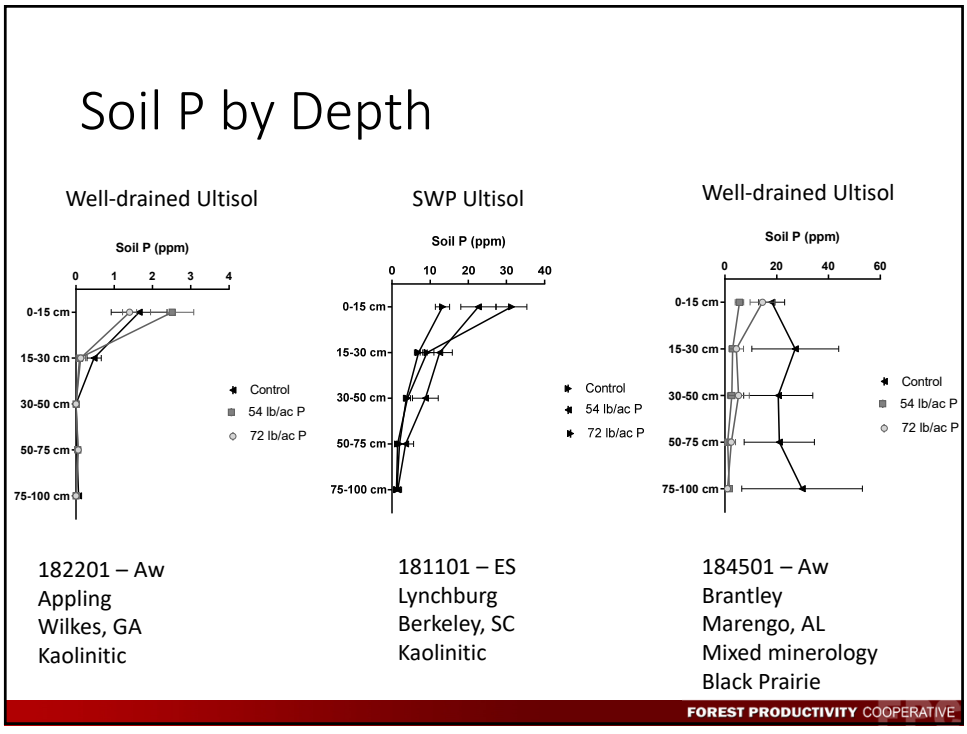
Soil P by Depth
Well-drained Ultisol
SWP Ultisol
Well-drained Ultisol
Soil P (ppm)
0-15 cm
15-30 cm
30-50 cm
50-75 cm
75-100 cm
Control
54 lb/ac P
72 lb/ac P
182201 – Aw
Appling
Wilkes, GA
Kaolinitic
181101 – ES
Lynchburg
Berkeley, SC
Kaolinitic
184501 – Aw
Brantley
Marengo, AL
Mixed minerology
Black Prairie
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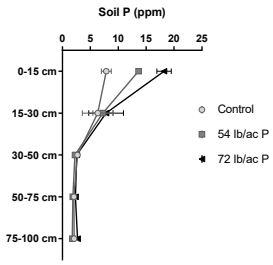
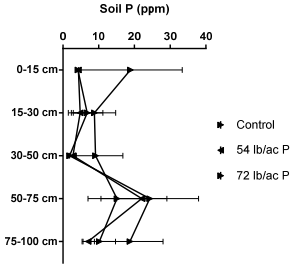
Soil P by Depth

Sandy

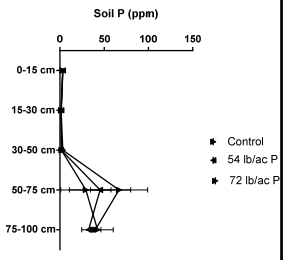


180101 – Ix
Blanton
Kershaw, SC

Spodosols

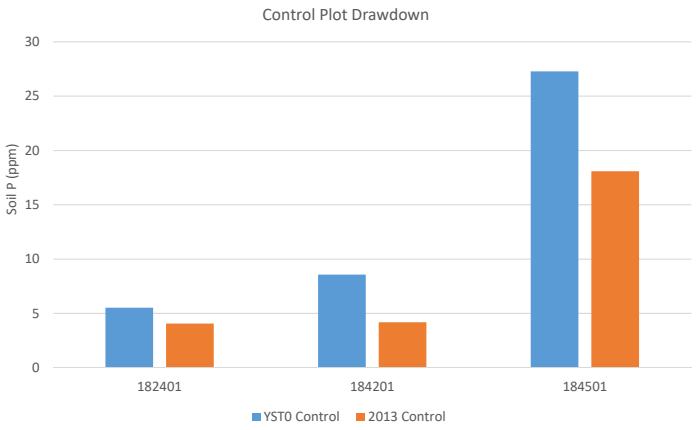


184201 – CS
Seagate
Brantley, GA



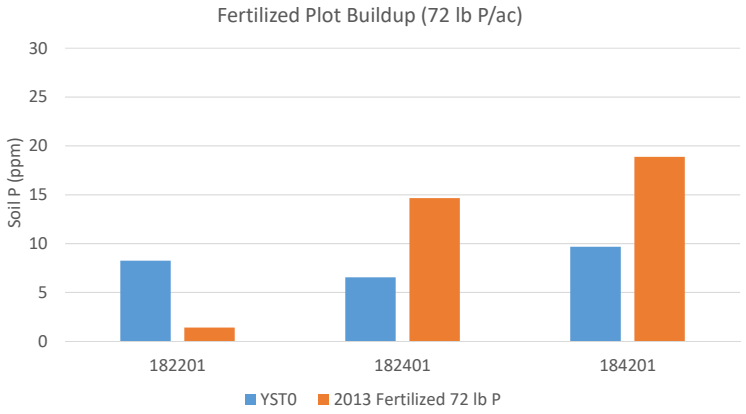
185302 – Cs
Sapelo
Dixie, FL

Buildup and Drawdown of P since Initial Sampling



Initial sampling 0 to 4-8 inches
2013 sampling 0 to 6 inches

Buildup and Drawdown of P since Initial Sampling



Initial sampling 0 to 4-8 inches
2013 sampling 0 to 6 inches

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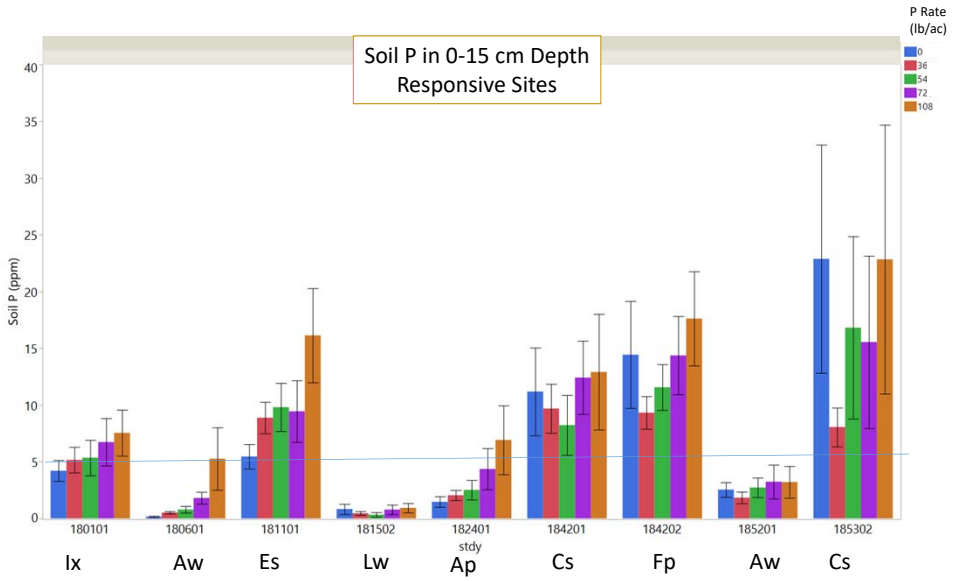
Soil P increases in some sites but not in others



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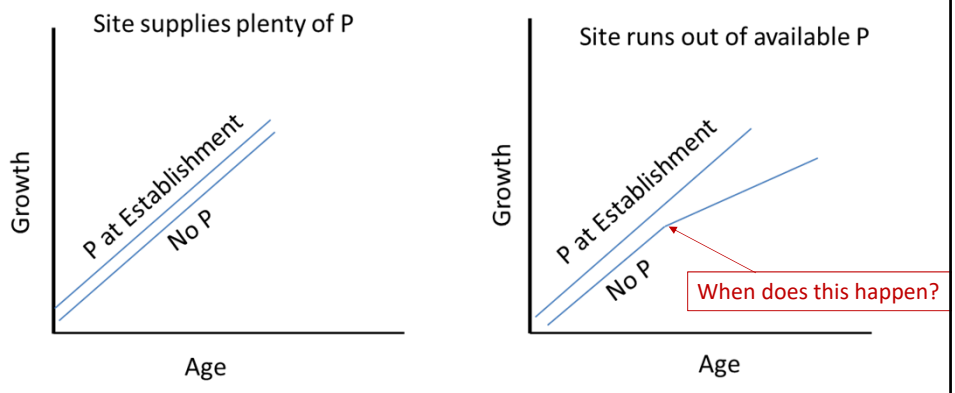
Experimental Design

Eight of the original treatments will be used to assess carryover effect

RW18 Trt Code	**RW28 Trt Code**	**Cumulative P rate applied (lb ac^{-1})**	**Prior Rotation P rate group**	**New Treatment**
0	0	0	Control	Control
206	361	36	Low	Establishment P
412	360	36	Low	No P
624	481	48	Med	Establishment P
418	480	54	Med	No P
212	721	72	High	Establishment P
424	720	72	High	No P
218	1080	108	High	No P

* All plots (except control) will receive N+K+micros at establishment

Establishment P vs No P



Plant Root Simulator Probes

- Install 1 month prior to harvest
  - Changed each month
  - In winter every two months
- Five treatments
- 9 months each year
- Two reps at each site
- 3 sites for two years
  - 2401, 4201, 1101

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Plant Root Simulator Probes

Map - 184201 near Brunswick, GA showing the 10 plots where Fungal bags and PRS probes were installed.

Why study Mycorrhizae?

- Strong correlations between Mycorrhizal symbioses and tree roots in the allocation and uptake of Nitrogen and Phosphorus
  - Microbial and fungal communities are the first to react to any addition or subtraction of a nutrient source
- On P-deficient sites Mycorrhiza have a positive influence on overall growth
  - On P-sufficient sites Mycorrhiza can have a neutral or negative effect
- As DNA and functional analysis techniques become cheaper and more efficient quantifying the microbial community/mycorrhizal community has the possibility to determine overall soil health and nutrient availability

Püschel, D., Janoušková, M., Voříšková, A., Gryndlerová, H., Vosátka, M., & Jansa, J. (2017). Arbuscular mycorrhiza stimulates biological nitrogen fixation in two Medicago spp. through improved phosphorus acquisition. Frontiers in plant science, 8, 390.

Fungal Capture Bags

- **Goals**
  - Estimate the production of fungal mycelia in response to a low, medium and high application of P on a phosphorus responsive site before and after harvest.
  - Identify species colonization of mesh bags using next generation sequencing techniques.
- **Methods and Materials**
  - Mesh (50 um) excludes plant roots and can exclude other fungal organisms by up to ~80%
  - Filled with Sterilized Baked quartz sand
  - P-amended vs. Non P-amended
  - Buried at the organic/mineral soil interface
  - Underground for ~2 months
  - Quantified using microscopy and PLFA
  - Sequencing using PCR and Next Generation Sequencing Techniques to identify organisms

Hagerberg, D., & Wallander, H. (2002). The impact of forest residue removal and wood ash amendment on the growth of the ectomycorrhizal external mycelium. *FEMS microbiology ecology*, *39*(2), 139-146.
Hedh, J., Wallander, H., & Erland, S. (2008). Ectomycorrhizal mycelial species composition in apatite amended and non-amended mesh bags buried in a phosphorus-poor spruce forest. *Mycological Research*, *112*(6), 681-688.

What these data can tell us

- No such study using mesh bags as Mycorrhizae traps has been conducted in a Loblolly Pine stand
- Recent studies using mesh bags similar to this one have mainly been conducted in northerly latitudes
- These data will facilitate our understanding of the mycorrhizal interactions in response to a Phosphorus gradient in Loblolly pine in the Southeast.

Bahr, A., Ellström, M., Akselsson, C., Ekblad, A., Mikusinska, A., & Wallander, H. (2013). Growth of ectomycorrhizal fungal mycelium along a Norway spruce forest nitrogen deposition gradient and its effect on nitrogen leakage. *Soil Biology and Biochemistry*, *59*, 38-48.

Bolan, N. S. (1991). A critical review on the role of mycorrhizal fungi in the uptake of phosphorus by plants. *Plant and soil*, *134*(2), 189-207.

Management Questions to Answer

- What rate will carry over P into next rotation?
- How many years can P fertilization be delayed at planting?
- What is the cost in growth if P fertilization is not applied?
- Can PRS probes or fungal bags help predict response?