

## Importance of Using Soils Information For Species Deployment and Nutrient Management Decisions with Southern Pines



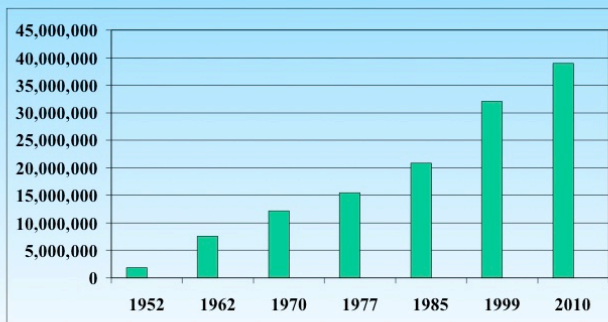
## The Spectrum of Southern Pine Silviculture



Extensive

Intensive

## Number of Acres of Southern Pine Plantations in the U.S.



USFS FIA Data

## Is Site Quality (site index) a Fixed Attribute for a Given Soil Type?

- A. Yes
- B. No
- C. I don't recall

## Is the Potential Productivity of Loblolly and Slash Pine Being Realized?



- A. Yes?
- B. No?



## Growth of Loblolly Pine in Argentina



1 year old

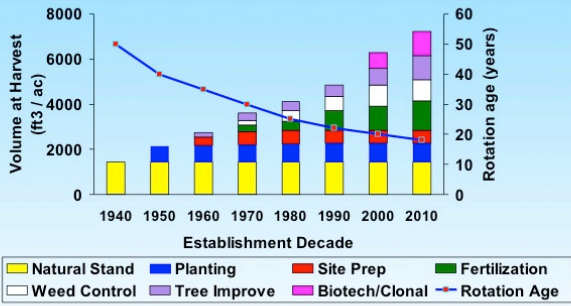


2 years old



4 years old  
Thinned + Pruned

## Contribution of Silvicultural Practices to Productivity Improvements and Rotation Lengths in Managed Southern Pine Stands



Redrawn from: Fox, T.R., E.J. Jokela and H.L. Allen. 2007. The development of pine plantation silviculture in the southern United States. J. Forestry 105:337-347.

## Background

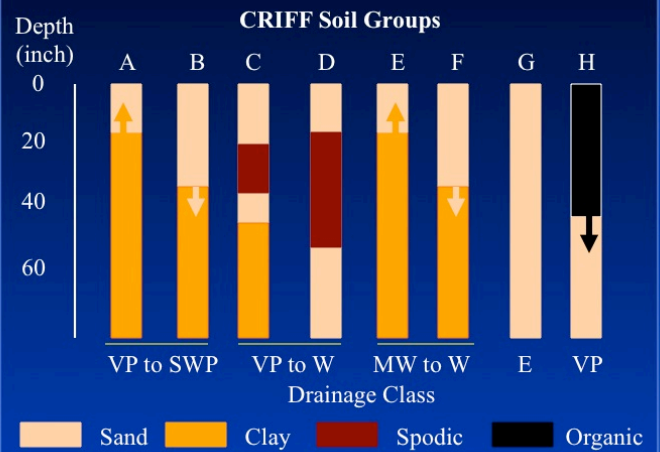
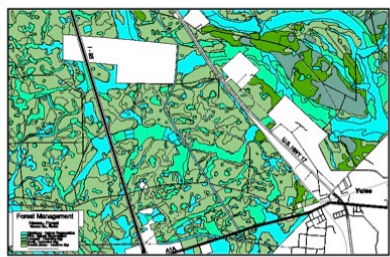
- Soil nutrient supply broadly limits forest productivity throughout the southeastern U.S.
- Regional trials indicate that soil nutrient limitations can be mitigated using a variety of silvicultural techniques (e.g., site preparation, fertilizer additions and understory competition control).
- In contrast to the 1980's, nutrient management is now practiced on a rotation-long basis.

### Land Classification Soil Mapping System

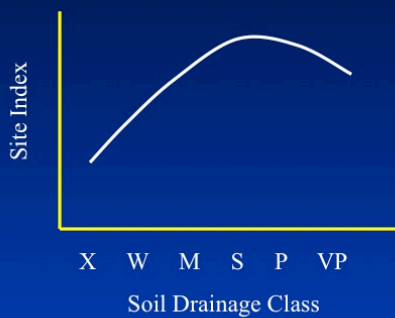


### Site Specific Silvicultural Prescriptions

### Soil Based Management Guidelines GIS Applications



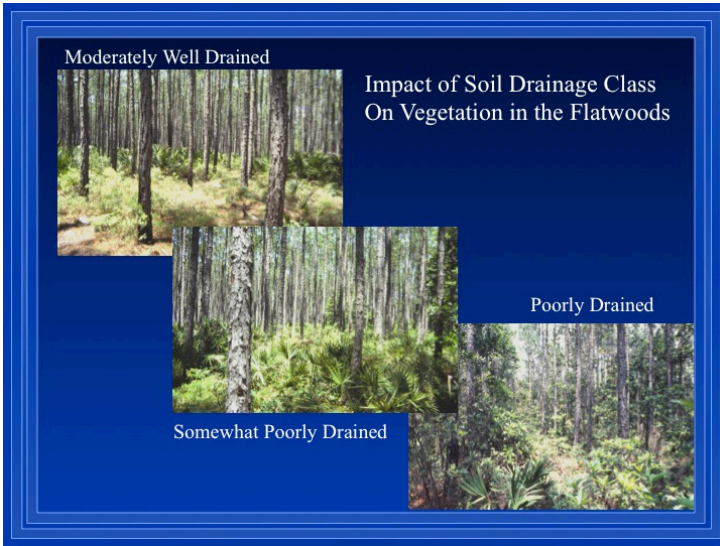
### Relationship Between Soil Drainage Class and Site Index for Slash & Loblolly Pine In the Flatwoods



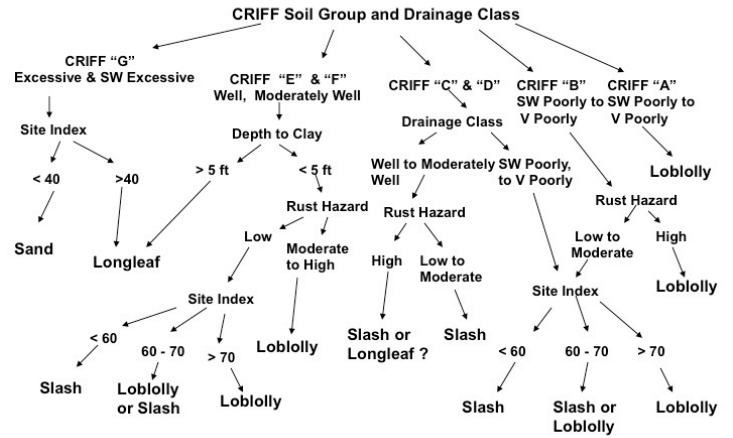
### Gallberry is a Key Indicator Plant for Drainage Class In the Flatwoods



Excessive Poorly Well Mod Well SW Poorly  
Absent Weak Present



Species Deployment Decision Key for Southern Pines the Coastal Plain of Georgia, Florida and Alabama (From: Fox 2004)



Note: Soils in CRIFF Group H are generally not well suited for pine management

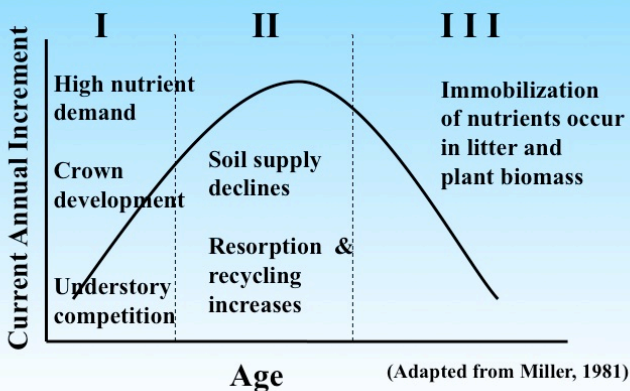
Which Nutrients Limit Southern Pine Growth?

- Nitrogen?
- Phosphorus?
- Potassium?
- Manganese?
- Copper?
- Boron?
- Potentially, all of the above?

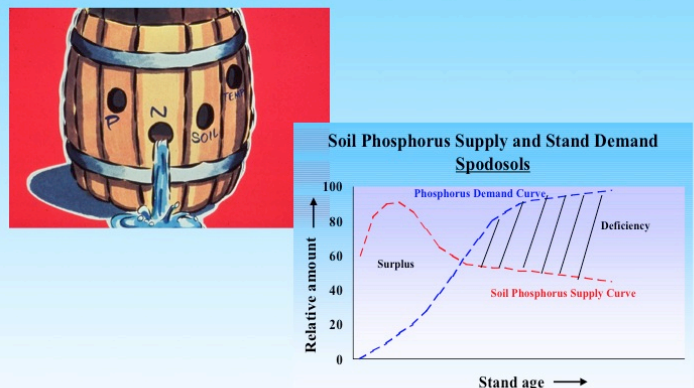
Macro and Micro-Nutrients

- Macronutrients -- required in relatively high concentrations by the plant (> 1000 ppm).
  - N, P, K, Ca, Mg, S
- Micronutrients -- required by plants in small amounts.
  - Fe, Mn, B, Cu, Zn, Mo, Cl

Nutritional Stages in the Development of Southern Pine Plantations



Soil Supply and Stand Nutrient Demand



## Diagnostic Tools

**CRIFF Soil Groups, Drainage Classes, Soil Maps**  
**Foliar/Soil Analysis**  
**Visual Symptoms**  
**Empirical/Process Models Based on Stand Nutrient Demands and Soil Supply**  
**Field Trials**

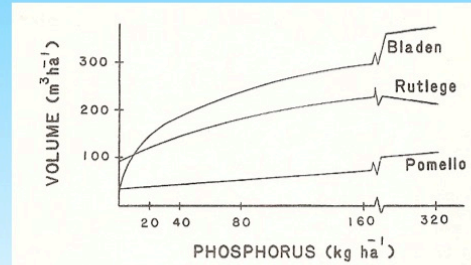


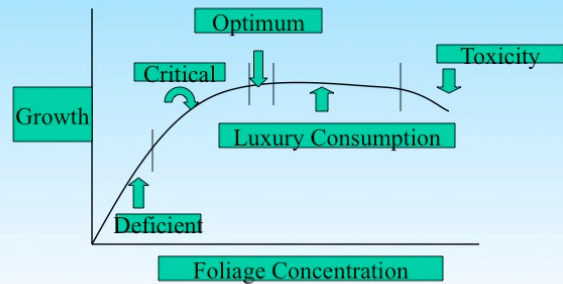
Fig. 1—Idealized volume response curves representing response of slash pine to rate of P on three sites. Curves are volume estimates after 17, 18, and 20 years of growth for the Bladen, Rutlege, and Pomello soils, respectively.

From: Pritchett and Comerford 1982. SSSAJ 46:640-644.

## Foliar Sampling



## Relationship Between Nutrient Concentration and Growth



### Foliar Nutrient Guidelines (minimum)

	<u>Slash Pine</u>	<u>(%)</u>	<u>Loblolly Pine</u>
N	1.0		1.20
P	0.09		0.12
K	0.25 – 0.30		0.30
Ca	0.08 – 0.12		0.15
Mg	0.06		0.08
S	0.08		0.10

### Foliar Nutrient Guidelines (minimum) Micronutrients

#### Slash Pine and Loblolly Pine (PPM)

B	4 – 8
Mn	20 - 40
Cu	1.5 - 3
Zn	10 - 20
Fe	15 - 35



B



Cu

## How do you Recognize a Nutrient Deficiency?

- Trees are weak and small for their age with poor foliage color. Nutrient deficiencies often have specific visual symptoms.
- Nitrogen - overall yellowing of foliage
- Phosphorus - short tufted needles on ends of side branches
- Boron - dead buds on main branches
- Potassium - older needle tips are lemon yellow in spring
- Magnesium - older tips are golden yellow in spring
- Copper - twisted branches and stems

P Deficiency – Slash pine in Florida



K Deficiency – Loblolly



## Cu Problems on Wet Areas?



Boron Deficiency



Replicated Field Trials to Document Nutrient Deficiencies and Magnitudes of Response Due to Fertilizer Additions



## 1970-80's Dramatic P Responses on CRIFF A Group Soils



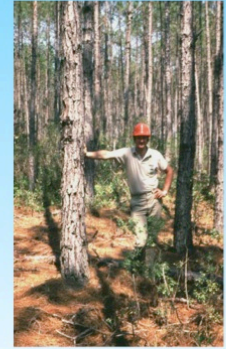
Gulf Co. Florida

## Fertilizer Response of Slash Pine at Planting - 25 Years Later

Franklin Co., Florida –  
Rutledge Series (CRIFF B)



Control – 2043 ft<sup>3</sup>/ac



50 lb/ac P –  
4502 ft<sup>3</sup>/ac

## Early Nutrient Management Can Dramatically Alter Stand Development and Productivity

CRIFF A – 13 yr-old Loblolly  
Gulf Co, FL



No Fert or Weed Control  
433 ft<sup>3</sup>/ac



Fert + Weed Control  
4212 ft<sup>3</sup>/ac

## Typical Fertilizer Application Rates for Southern Pines

- **Time of Planting:** 35-50 lbs N/ac, 25-50 lbs P/ac (elemental rate)
  - If K is needed (40-60 lbs/ac elemental)
  - If B is needed (1 lb/ac elemental)
  - If Cu is needed (3-5 lbs/ac elemental)
  - If Mn is needed (10-20 lbs/ac elemental)
- **Mid-Rotation** (closed canopy)
  - 175-200 lbs N/ac, 25-50 lbs P/ac
  - Other nutrients (listed above, if necessary)

## Common Fertilizer Sources

Diammonium Phosphate (DAP)	18-46-0
Monammonium Phosphate (MAP)	11-52-0
Triple Superphosphate (TSP)	0-44-0
Urea	45-0-0
Potassium Sulfate (KSO <sub>4</sub> )	0-0-48
Potassium Chloride (KCl)	0-0-60

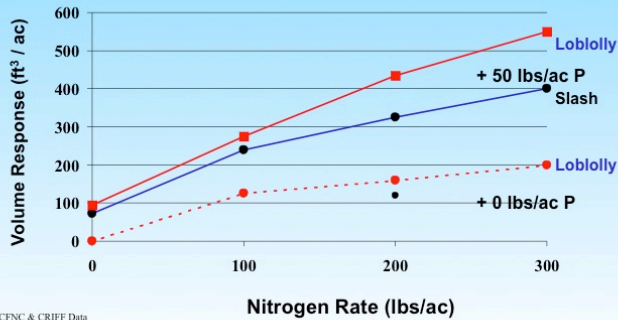
Note: P<sub>2</sub>O<sub>5</sub> x 0.436 = % P

K<sub>2</sub>O x 0.883 = % K

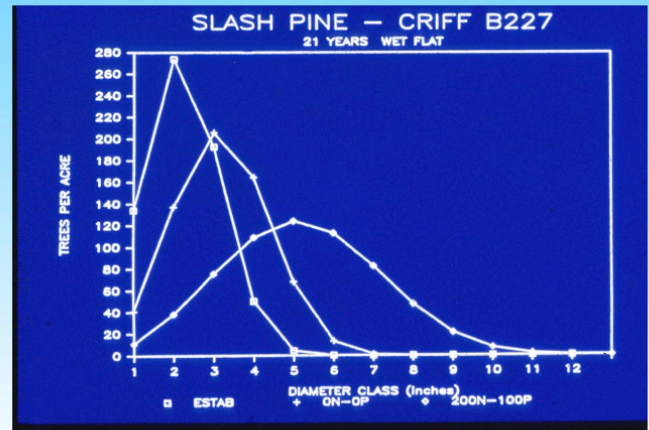
## Fertilizer Calculations

- DAP = 18-46-0
- 250 lbs DAP/ac = 45 lbs N/ac + 50 lbs P/ac
  - 250 lbs/ac x 0.18 = 45 lbs/ac N
  - 250 lbs/ac x 0.46 = 115 lbs P<sub>2</sub>O<sub>5</sub> x 0.44 = 50 lbs/ac P
  - **REMEMBER:** P and K are listed in oxide forms on the label (P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O)!!
- Urea = 45-0-0
- 335 lbs Urea/ac = 150 lbs/ac N
  - 335 lbs/ac x 0.45 = 150 lbs/ac N

## Mid-rotation Fertilization 8-Year Growth Responses



NCFNC & CRIFF Data



## Loblolly Pine Treatment Contrasts Over Time (IMPAC)

Age 4

Age 19



## Differences in Loblolly Pine Site Index<sub>(25 yrs)</sub> Among Treatments (IMPAC)

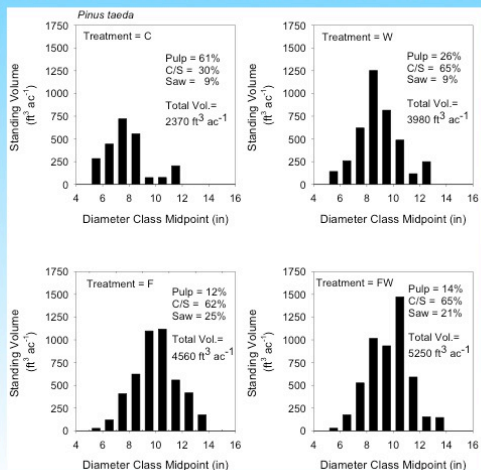
- Control: 64
- Weed Control: 74
- Fertilizer: 86
- Fertilizer + Weed: 87

Jokela et al. 2010, JOF

## Loblolly Pine (Unthinned) Volume Distributions - Age 25 - Spodosols

Nutrient management increases stand value by increasing the % of "grade" material produced.

< 39% Control  
> 86% Fert. + Weed



Jokela et al. 2010, J. For. 109:338-347

## Can micronutrient deficiencies limit production?

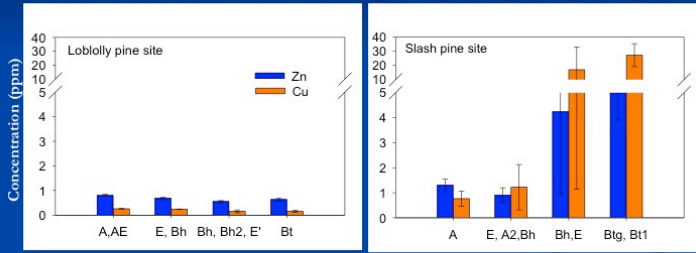
Sub-acute nutrient stresses can be induced by intensive management.

B, Mn, Cu, Zn – micronutrients of concern

Slash pine response to Mn additions over 16 yrs  
32 ft³/ac/yr above control

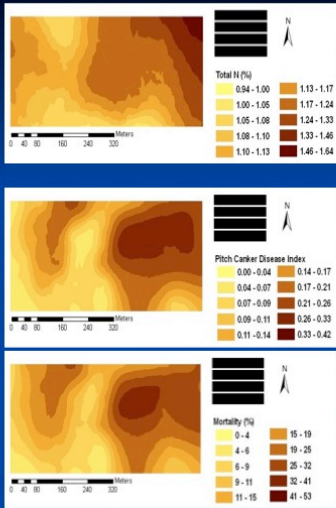
Source: Jokela et al. 1991. Soil Sci. Soc. Am. J.

Taxonomically similar Spodosols varied in extractable micronutrients, which could explain the differential (Cu) response between sites.



Vogel and Jekela 2011, SSSAJ 75:1117-1124.

## Pitch Canker – Nutrition Interactions



From: Lopez-Zamora et al. 2007. Environmental Pollution 147:101-111.

## Bedding on Poorly Drained Sites

Age 22 Slash Pine in North Florida  
Check = 2200 ft<sup>3</sup>/ac  
Bed = 2958 ft<sup>3</sup>/ac



## Mechanical Site Preparation to Simulate "Old Field" Effect on Upland Sites



Age 18 Loblolly Pine in the Piedmont  
Control 1630 ft<sup>3</sup>/ac  
Chop & Burn 2400 ft<sup>3</sup>/ac  
Shear,Pile,Disk 2958 ft<sup>3</sup>/ac

Burger 2001

## Impact of Competing Vegetation on Pine Growth (pre-plant chemical site preparation, herbaceous release)

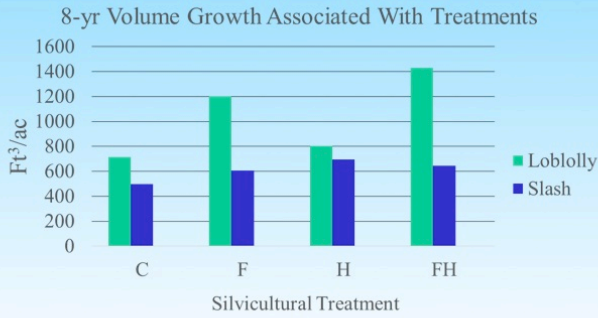


Univ of Georgia PMRC Site Prep Study -1980



Auburn Univ Herbicide Coop - 1980

Comparison of loblolly vs. slash pine growth on CRIFF A group soils (time of planting fertilization and/or weed control)



(Jokela et al. 2000)

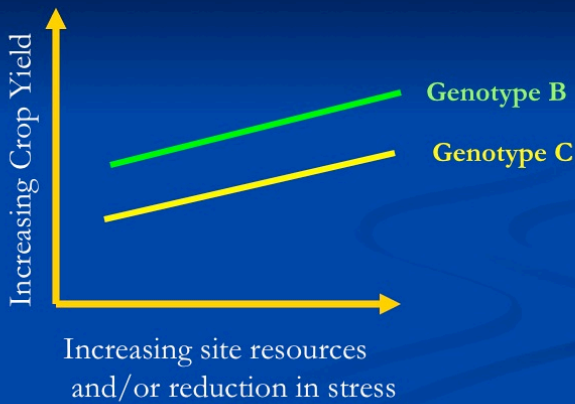
### Impacts of Intensive Management on Growth and Yield of Slash Pine in Florida (Shorter Rotation with Greater Yield)



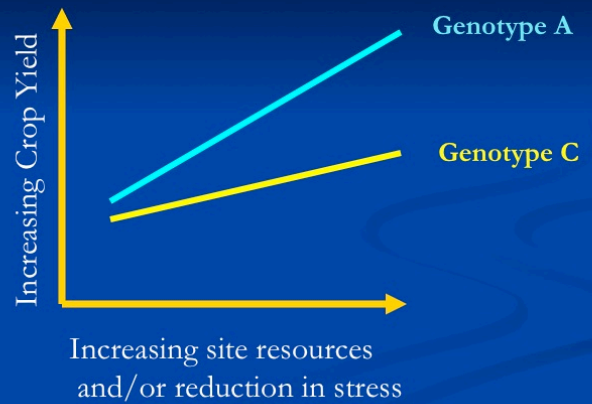
Single Bed & One Midrotation Fertilization  
Age 23 Yield = 2144 ft³/ac

Double Bed, Competition Control, & Three Fertilizations  
Age 17 Yield = 3430 ft³/ac

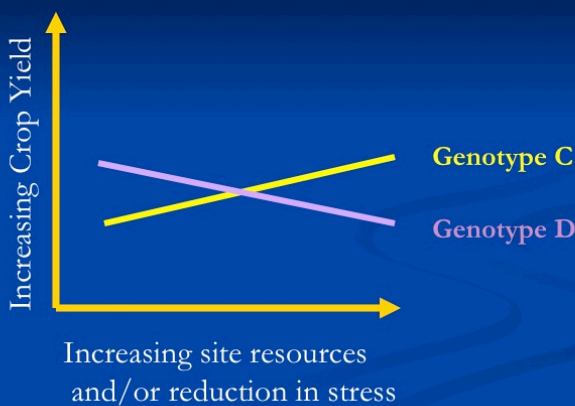
### Genotype x Environment



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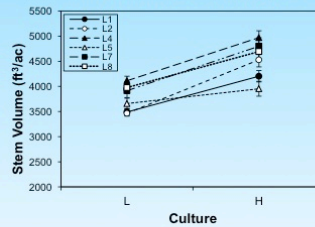


### Culture X Family

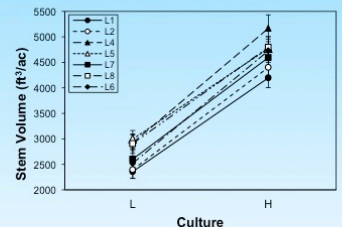
CRIFF A Group Soil (PD, gumbo clay)

CRIFF D Group Soil (Spodosol w/o clay)

Loblolly PINES, Age 12, Waverly, GA



Loblolly PINES, Age 12, Sanderson, FL

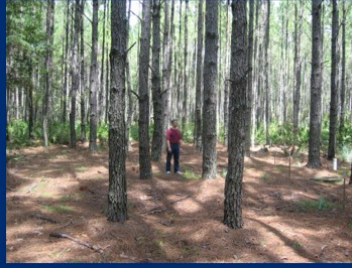


Forest Biology Research Cooperative, Univ. of Florida

# Changes in Carbon Storage with Silvicultural Treatments

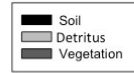
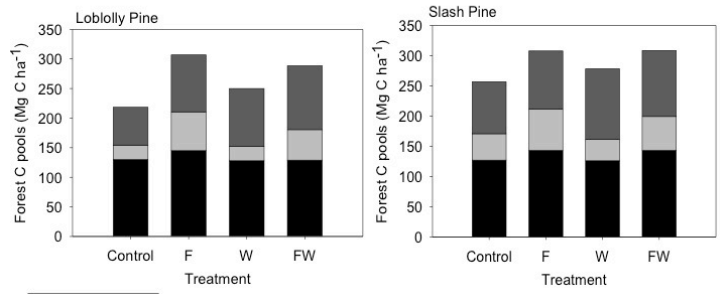


CONTROL



FERTILIZER + WEED CONTROL

## Carbon Accumulation



### Results

Vegetation carbon follows patterns in Basal Area:

But Total Ecosystem Carbon Follows the pattern:

F > FW > W > C

Vogel et al. Can J. For. Res. 41:552-567

Questions??