

**Existing and Future Methods to Improve
Nitrogen Use Efficiency
in Loblolly Pine Systems**

PINEMAP

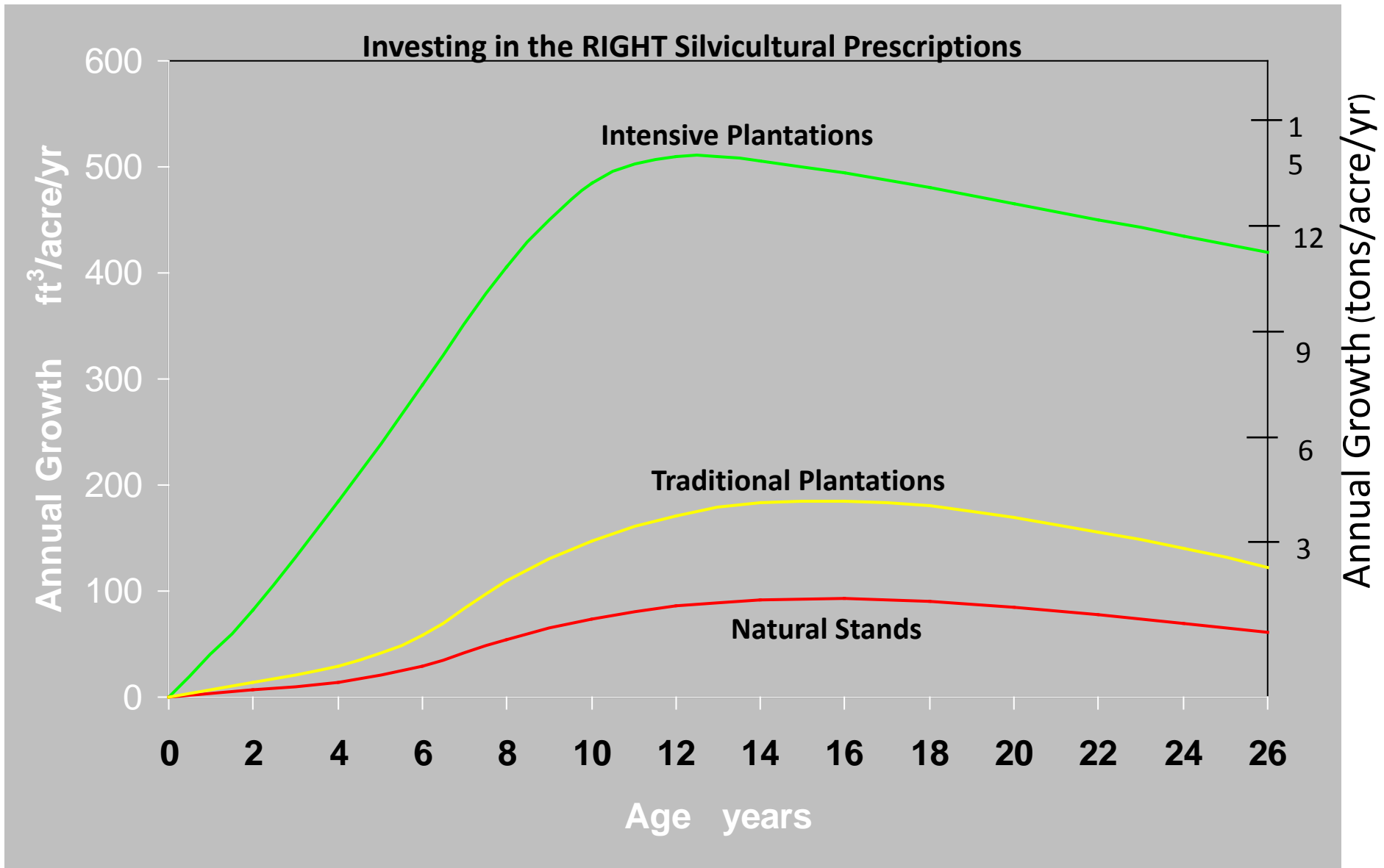
Long-Term Outcome of Program

Reduce use of energy, nitrogen fertilizer, water by 10%
increase carbon sequestration by 15%

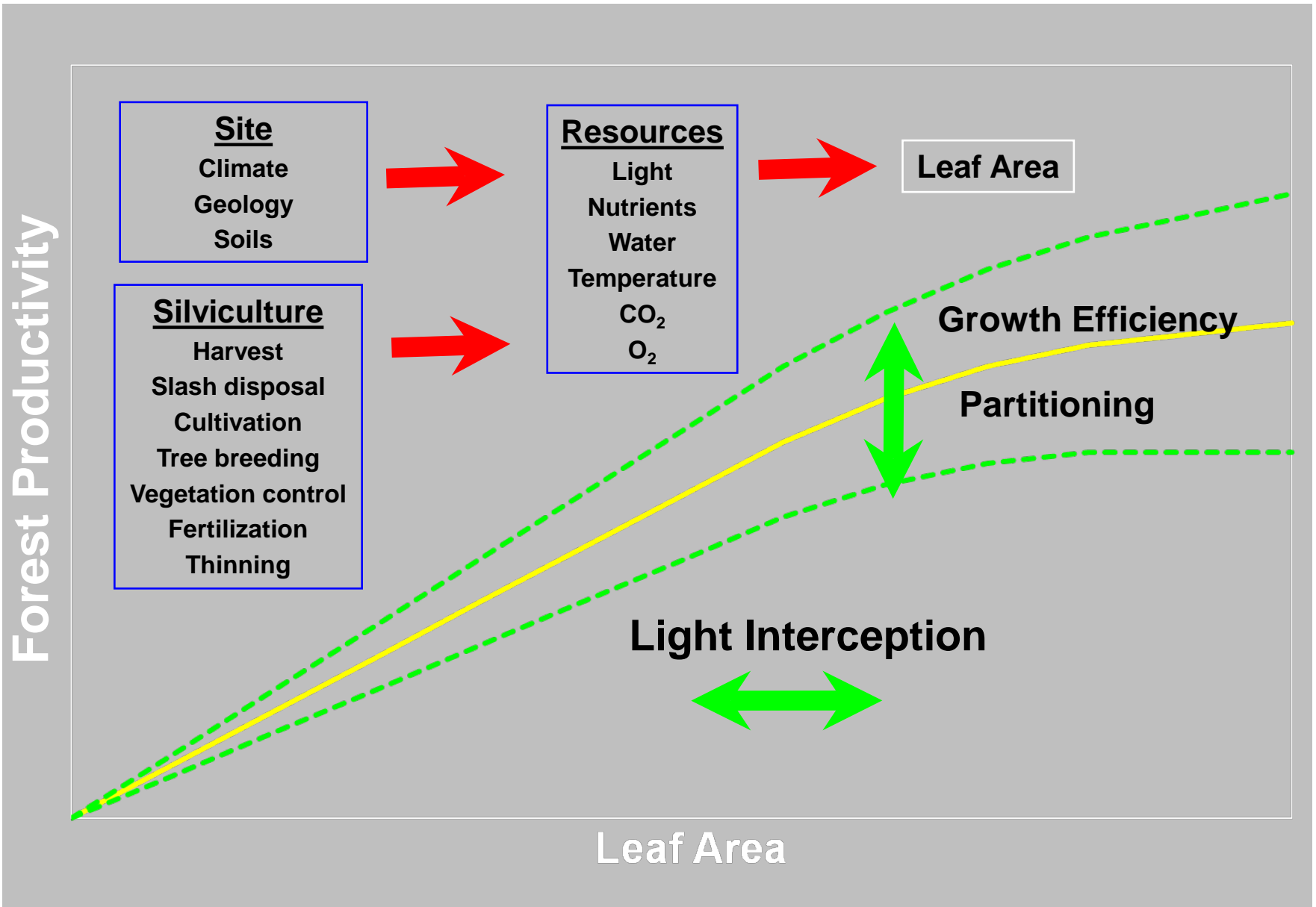
with resilient forest production systems in changing climate by 2030



What is Potential Productivity?



Silviculture - Site Resources





Fertilization



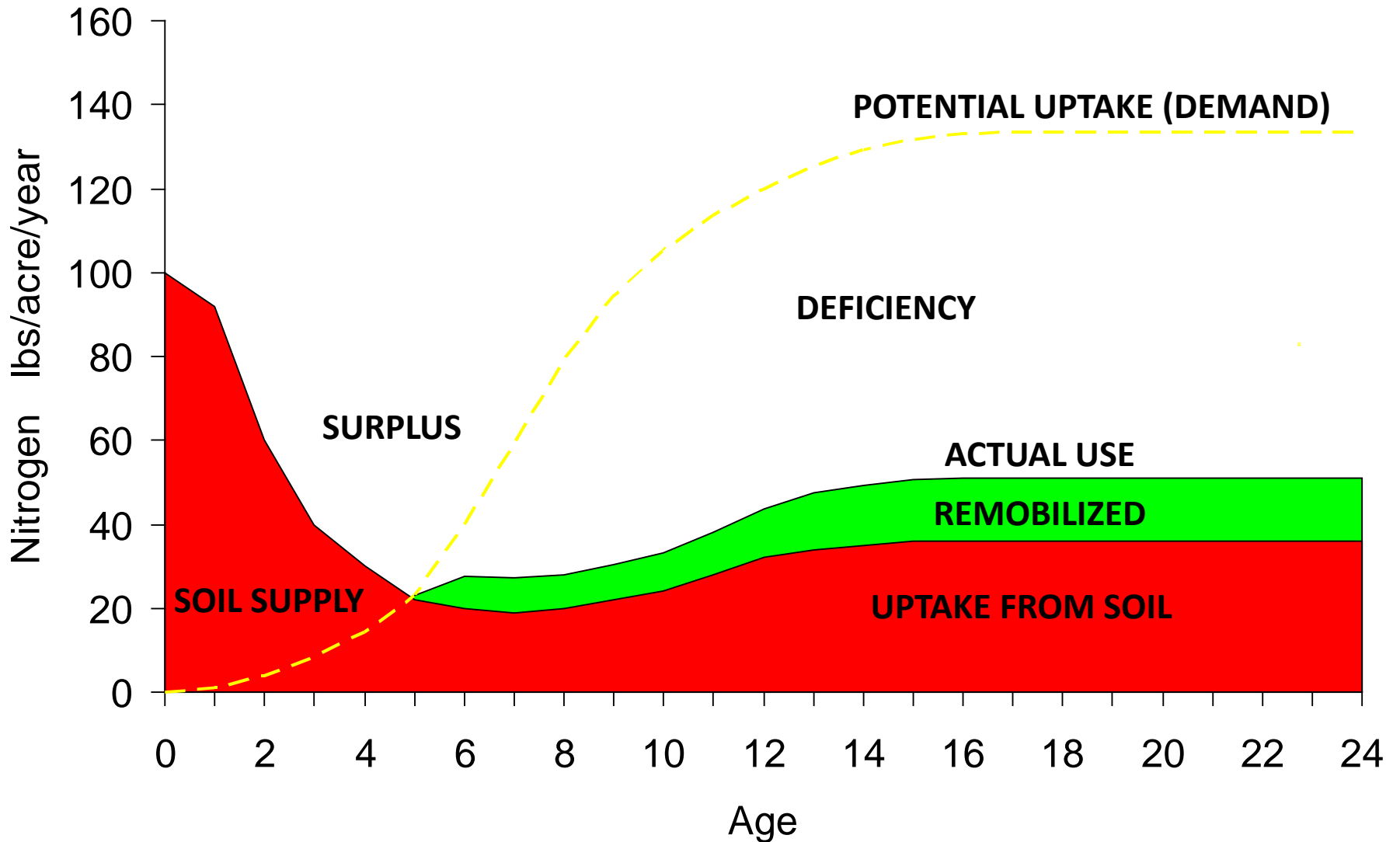
Weed Control

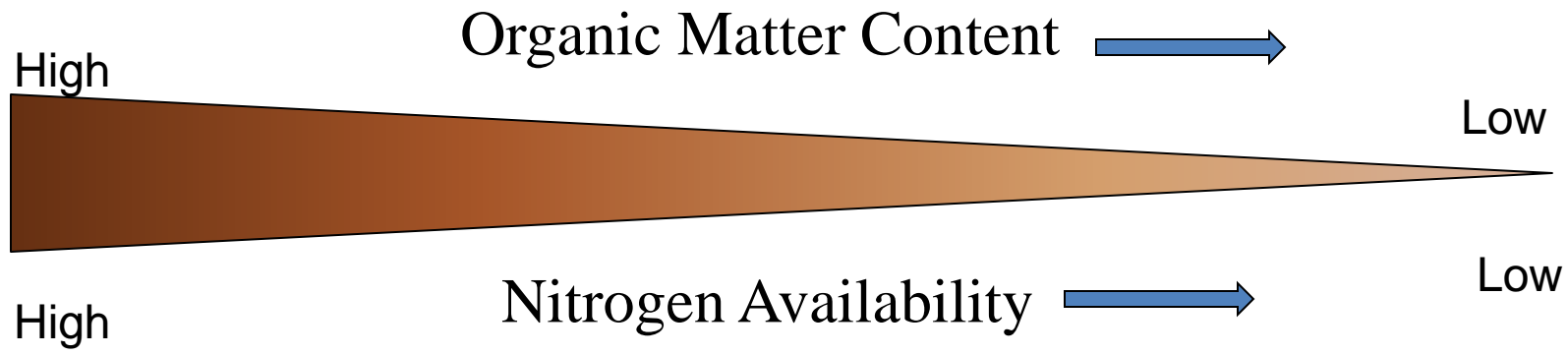
SOIL INFORMATION
NEEDED TO DEVELOP
SILVICULTURAL PRACTICES
THAT INCREASE GROWTH
AND
IMPROVE FINANCIAL RETURNS
OF
FOREST PLANTATIONS



Elite Genotypes

Changes in Nitrogen Supply and Demand During Stand Development





**Very Poorly
Drained Clay
with Umbric**



**Poorly Drained
Sandy Clay
Loam
with 4-6" Surface**



**Somewhat Poorly Drained
Sandy Clay Loam
with >20" Surface**



**Poorly Drained
Spodic with
Sandy Clay Loam**

CRIFF Soil Groups

Soil
Properties
Influence
Forest
Management



CRIFF Soil Groups

Soil
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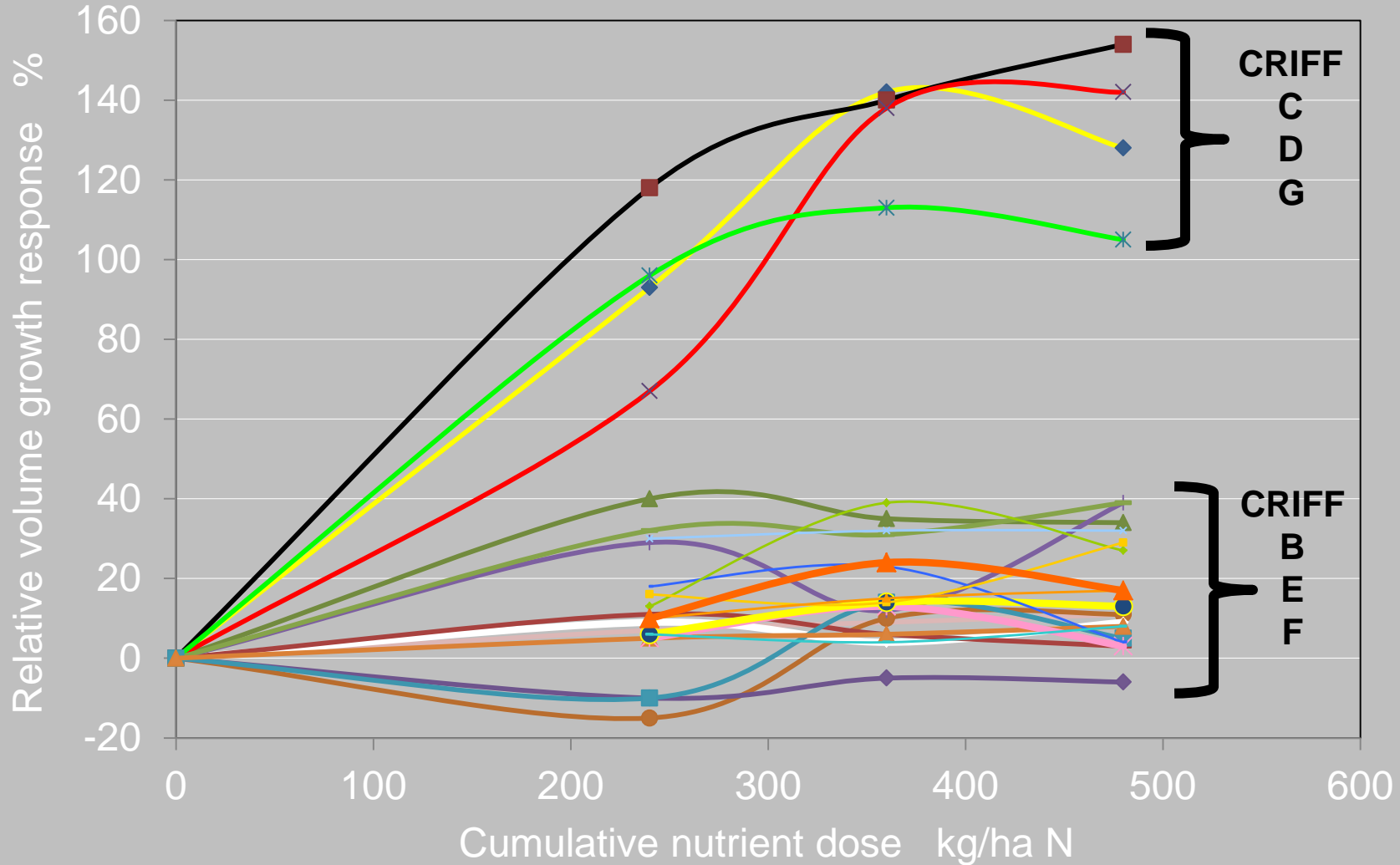


Using Soils to Guide Fertilizer Recommendations for Southern Pines¹

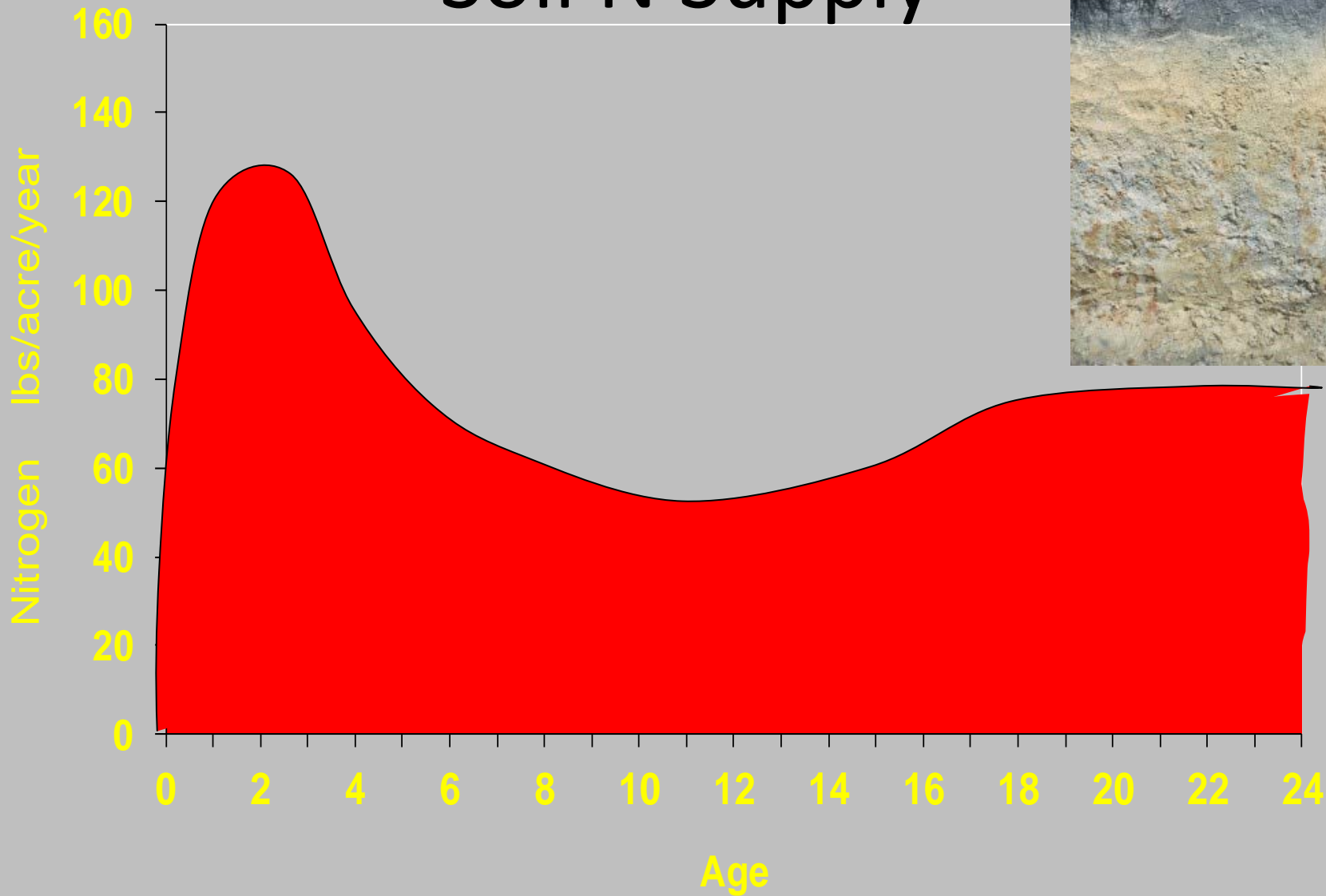
Eric J. Jokela and Alan J. Long²

Regionwide 18

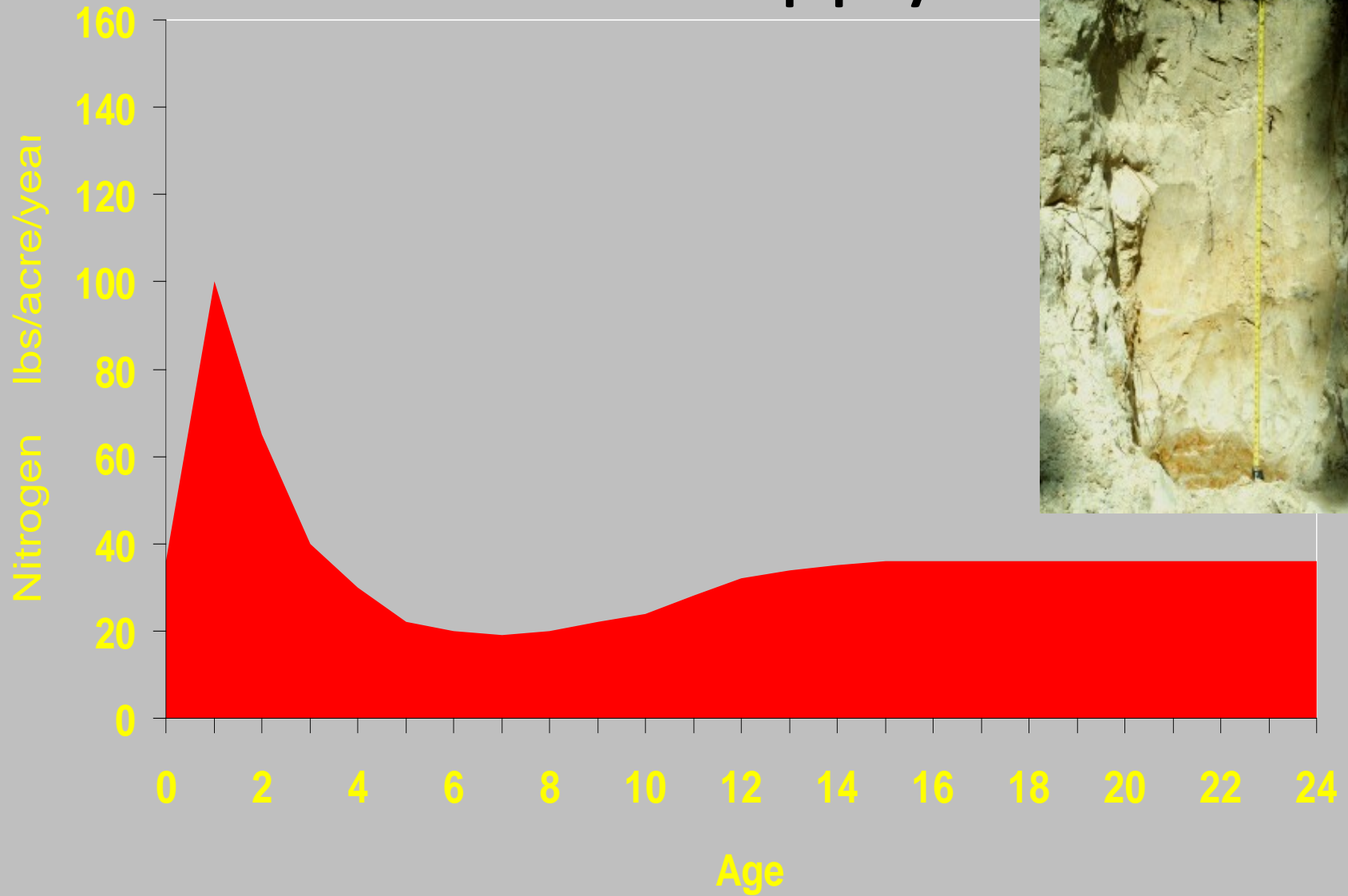
Eight-year volume growth responses



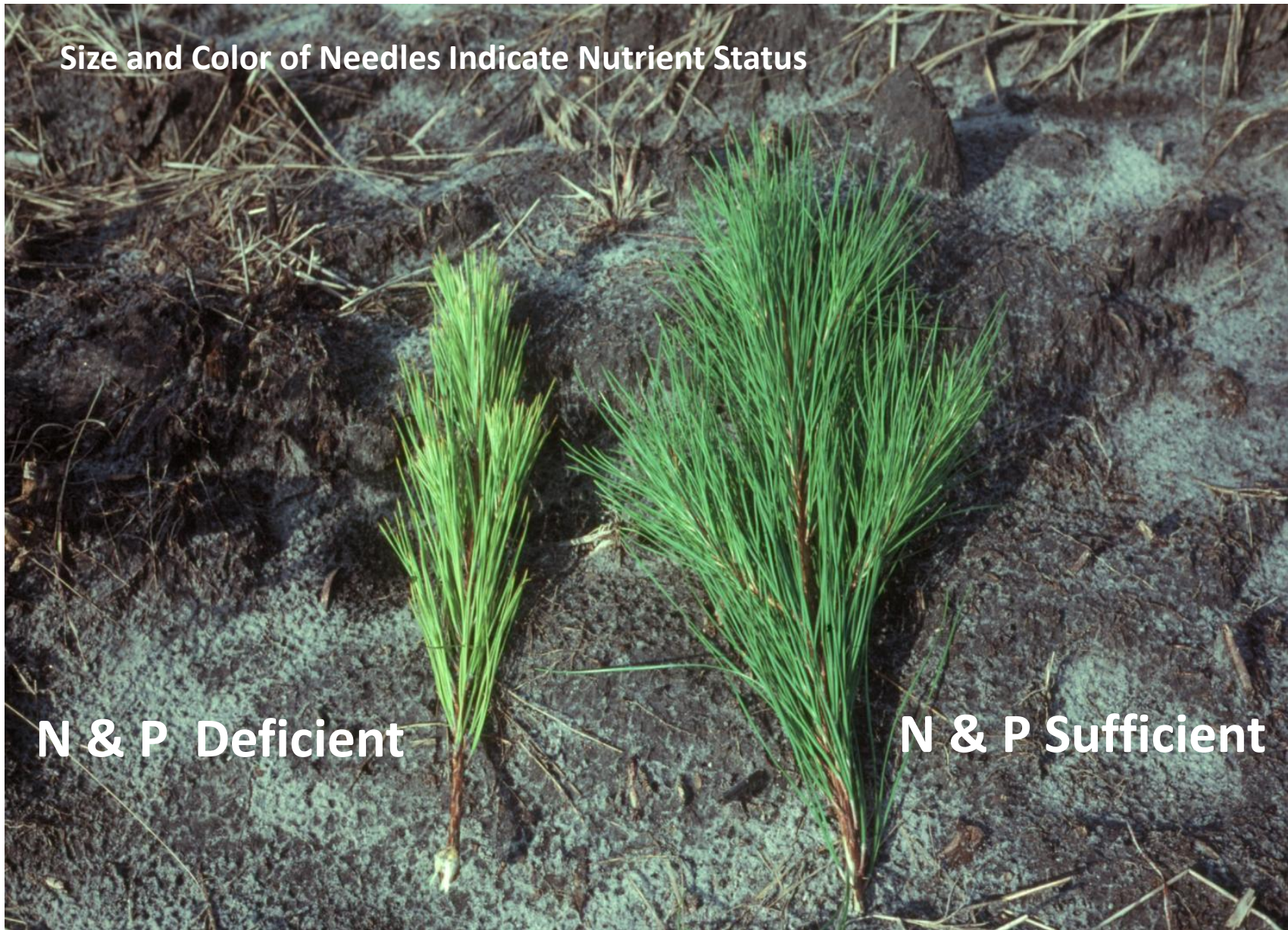
Soil N Supply



Soil N Supply



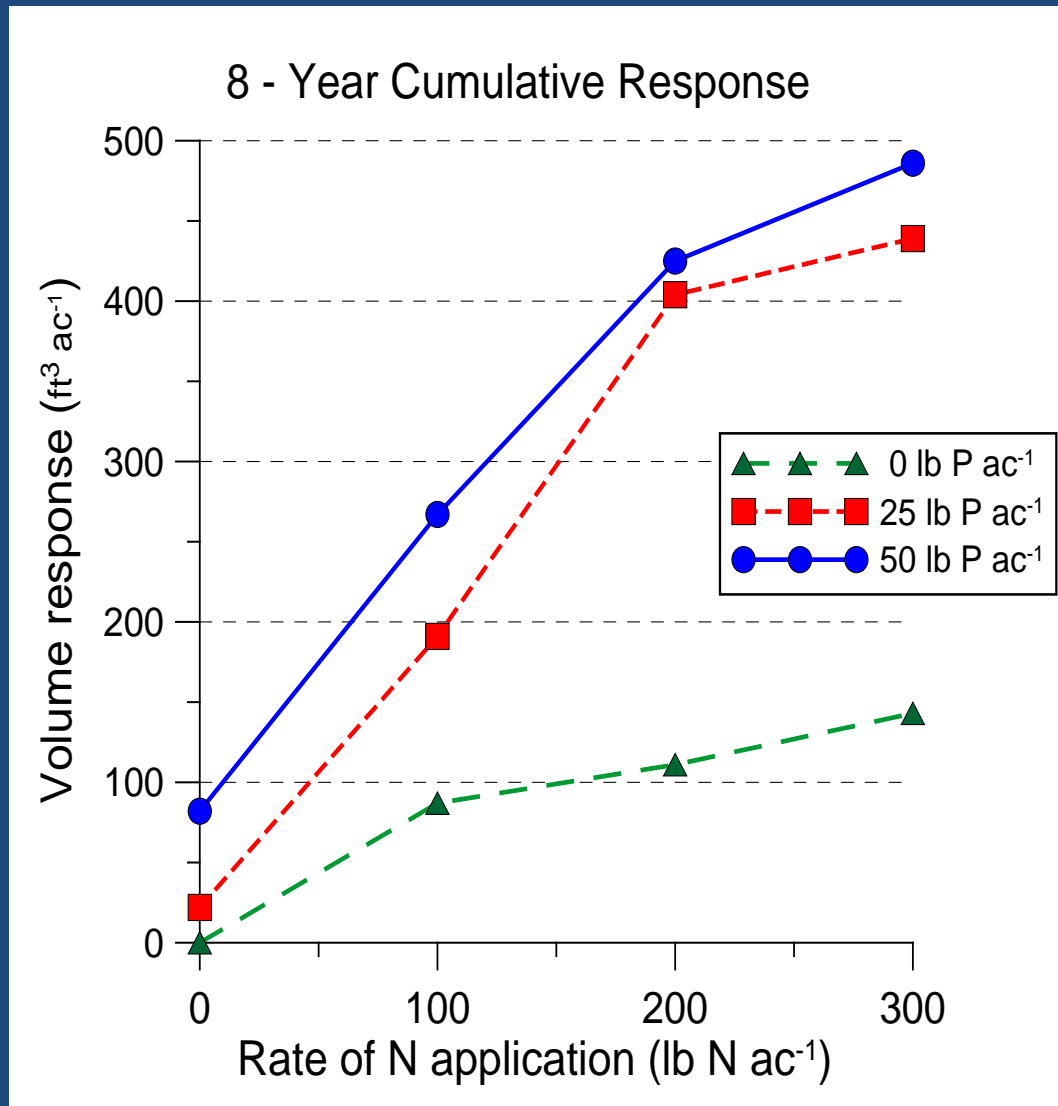
Size and Color of Needles Indicate Nutrient Status



N & P Deficient

N & P Sufficient

FNC RW 13 Growth Response

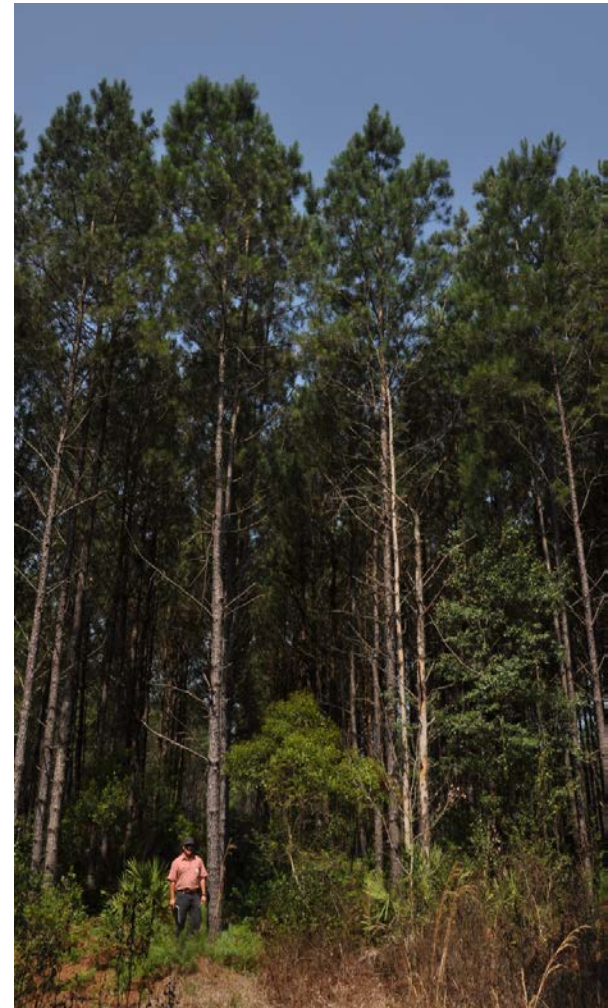


Fertilization In Pine Plantations

11 Year Fertilizer Response – SE Georgia



Control



Fertilized (N, P, K, micros)

Fertilization In Pine Plantations

11 Year Fertilizer Response – SE Georgia

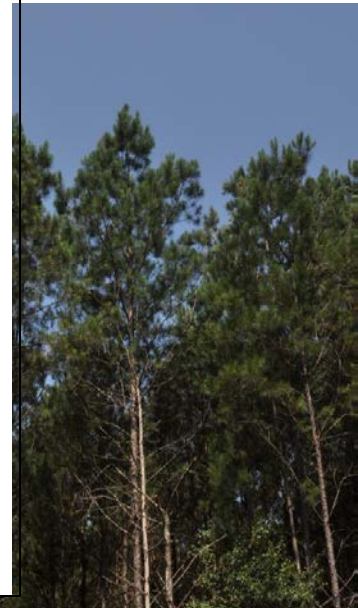
FUNDAMENTAL RESEARCH

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<http://dx.doi.org/10.5849/forsci.12-158>
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soils & hydrology

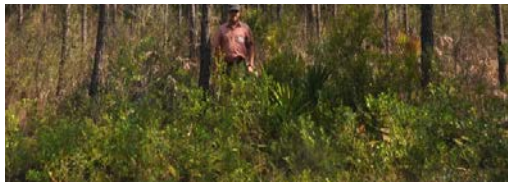
Growth Responses of Loblolly Pine in the Southeast United States to Midrotation Applications of Nitrogen, Phosphorus, Potassium, and Micronutrients

Colleen A. Carlson, Thomas R. Fox, H. Lee Allen, Timothy J. Albaugh, Rafael A. Rubilar, and Jose L. Stape



Forest, Range & Wildland Soils

Micronutrient Limitations in Two Managed Southern Pine Stands Planted on Florida Spodosols



Control

Soil Sci. Soc. Am. J. 75:1117–1124
Posted online 17 Mar. 2011
doi:10.2136/sssaj2010.0312
Received 17 Aug. 2010.

Fertilized (N, P, K, micros)

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Fertilization



Weed Control

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FOREST PLANTATIONS



Elite Genotypes

Moving Forward to Improve Nitrogen Use

Cecil Series – CRIFF E Group



- Soil Group based on dominant subsoil texture and depth
- Drainage class
- Geology (Physiographic Province and Parent Material)
- Modifier based on soil properties affecting management

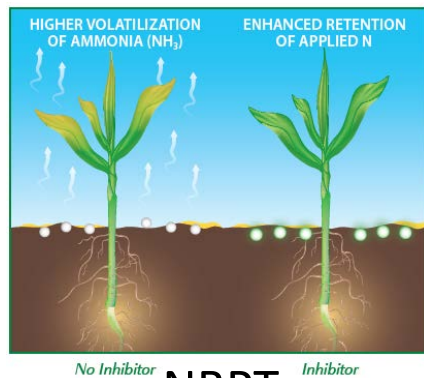
EwPDFe

well drained, sandy clay loam subsoil within 20 inches with an eroded surface, located in the Piedmont with felsic rocks as parent material

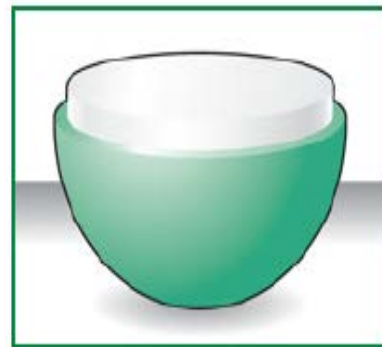
Enhanced Efficiency Fertilizers (EEFs)

Two Mechanisms – Urease Inhibitors vs. Controlled Release

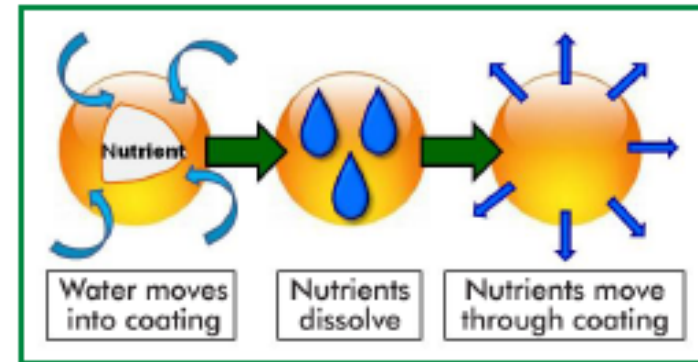
- Urea + NBPT N(n-butyl) thiophosphoric triamide (NBPT)
- Urea + NBPT coated with Monoammonium Phosphate (CUF)
- Polymer Coated Urea (PCU)



NBPT



CUF

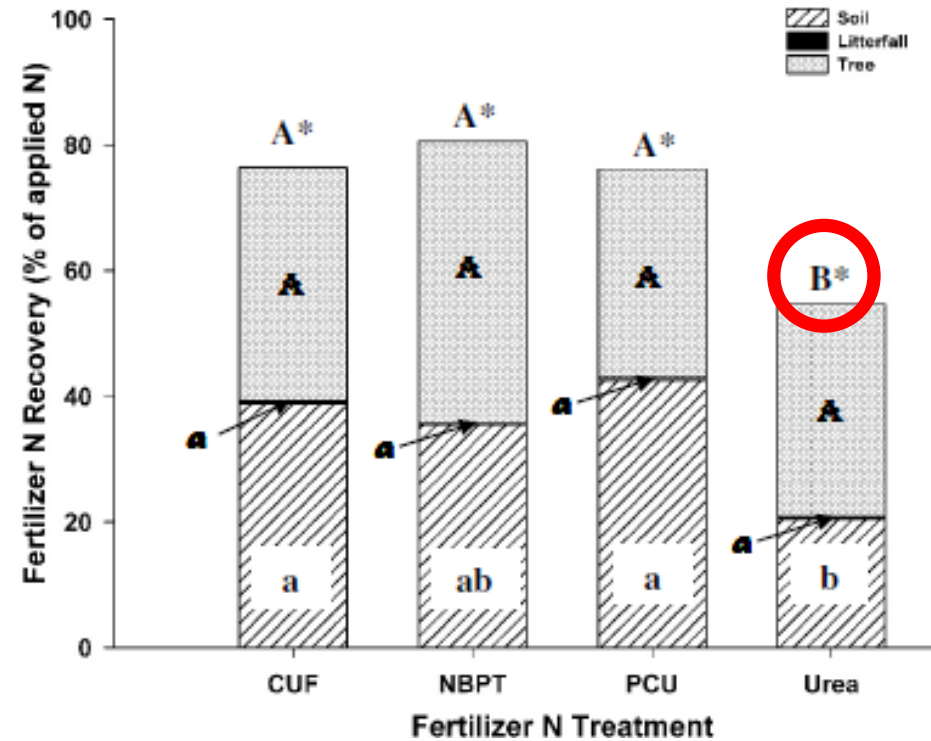
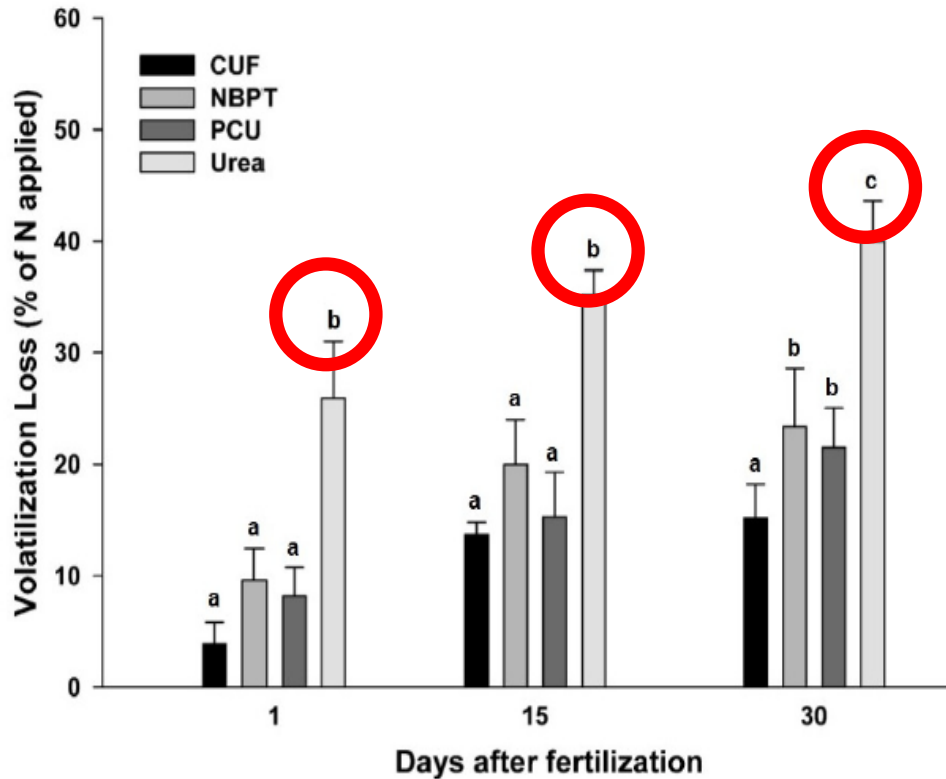


PCU

Urease Inhibitors

Controlled Release

Use of Enhanced Efficiency Products Increased System Retention of Fertilizer N

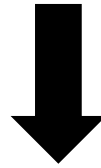


Management and Environmental Implications

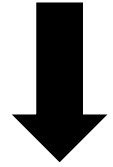
Improve fertilizer nitrogen use efficiency with EEFs



Increase System
N retention



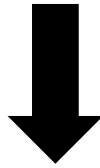
Lower Fertilizer
N Losses



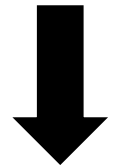
Reduce NH₃
volatilization



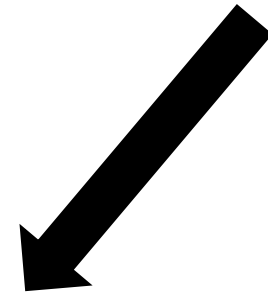
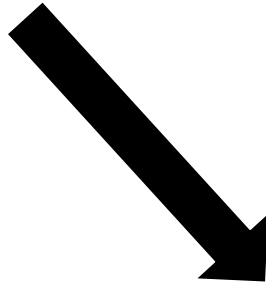
Extend N uptake
Less frequent fertilization



Less Fertilizer
N Required



Lower application rates
Broader application period
Increase fertilizer response



Increase productivity

Improve N fertilization stewardship

Future Research With Existing ^{15}N Plots Continuing to Increase NUE

- **Long term fate of fertilizer N, cycling in system**
- **Decomposition studies**
- **Fertilizer N application rate study with EEFs**
- **Additional EEF product research**
- **EEF application in winter**
- **Losses in bedded sites**

Tie in Growth Response Results with existing Coop Trials

Site Specific Silviculture



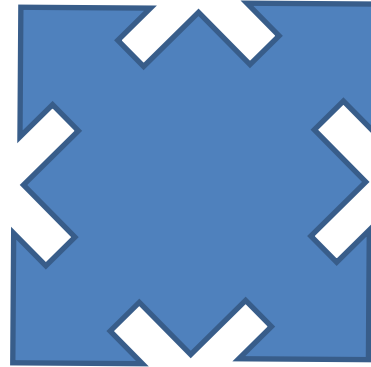
Fertilization



Weed Control



Soil Characterization



Elite Genotypes

Nitrogen Use Efficiency

Nitrogen Use Efficiency – the amount of dry matter produced per unit of nutrient applied or absorbed

- Stand efficiency (agronomic efficiency) (kg/kg)

$$\frac{\text{yield fertilized stand (kg)} - \text{yield unfertilized stand (kg)}}{\text{quantity fertilizer applied to stand (kg)}}$$

- Physiological efficiency (kg/kg)

$$\frac{[(\text{total dry matter yield of fertilized trees (kg)}) - (\text{total yield of unfertilized trees (kg)})]}{[\text{Nutrient uptake by fertilized trees (kg)}] - [(\text{nutrient uptake by unfertilized trees (kg)})]}$$

- Apparent Recovery Efficiency in %

$$\frac{(\text{nutrient uptake by fertilized tree}) - (\text{nutrient uptake by unfertilized tree})}{(\text{quantity of fertilizer applied})} * (100)$$

- Nutrient Use Efficiency

$$(\text{Physiological efficiency}) * (\text{Apparent Recovery Efficiency})$$