Morphological and Nutritional Development of Nursery-Grown Hardwood Seedlings in Tennessee

Humberto Z. dos Santos
Ken Mc Nabb

Southern Hardwood Seedling Production

2005 Survey

Total Conifer	1,109 million
Total Hardwood	57 million

Hardwoods were nearly 5% of total southern forest nursery production in 2004-2005 season.

Hardwood seedling production

Same cultural practices used across species, genera, and families (Jacobs, 2003).

1. Fertilization
2. Weed control
3. Irrigation
4. Unimproved seed (unknown origin)

Does each species need specific cultural treatments?

Hardwood seedling research

Typical seedling development for hardwood species are not well described (Gardiner et al., 2002)

Nutrient requirements for individual species are not well established (Erdmann at al., 1979)

Study objectives

Characterize the "typical" development of three commonly grown hardwood species in a southern nursery:

❶ Morphological development

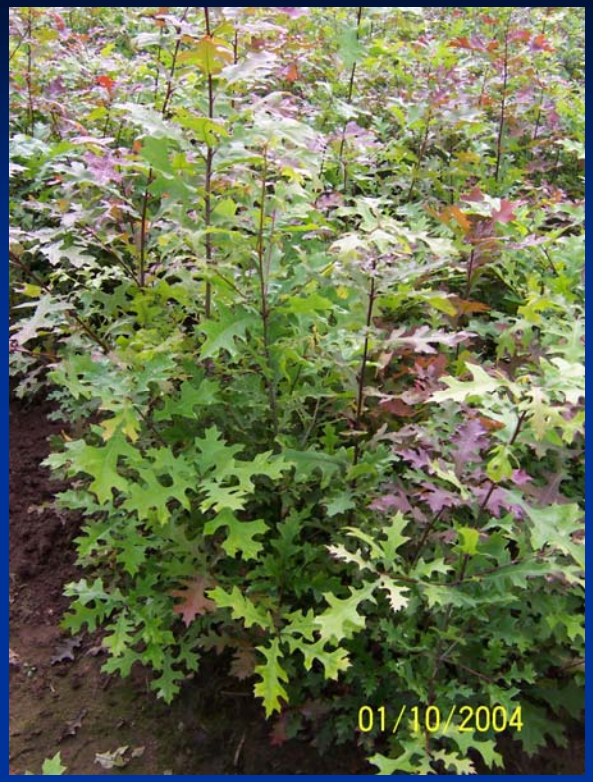
❷ Nutrient uptake and utilization

Research Site

East Tennessee Nursery

Conifer Seedlings Grown					*Hardwood Seedlings Grown*						
Bareroot Seedlings											
loblolly	shortleaf	white	Virginia	baldcypress	oak	sweetgum	g. ash	walnut	s. pecan	y. poplar	others
8,000,000	100,000	150,000	75,000	350,000	1,125,000	10,000	200,000	150,000	5,000	250,000	75,000

Study Species



Winter-sown Nuttall Oak (*Quercus nuttallii*)

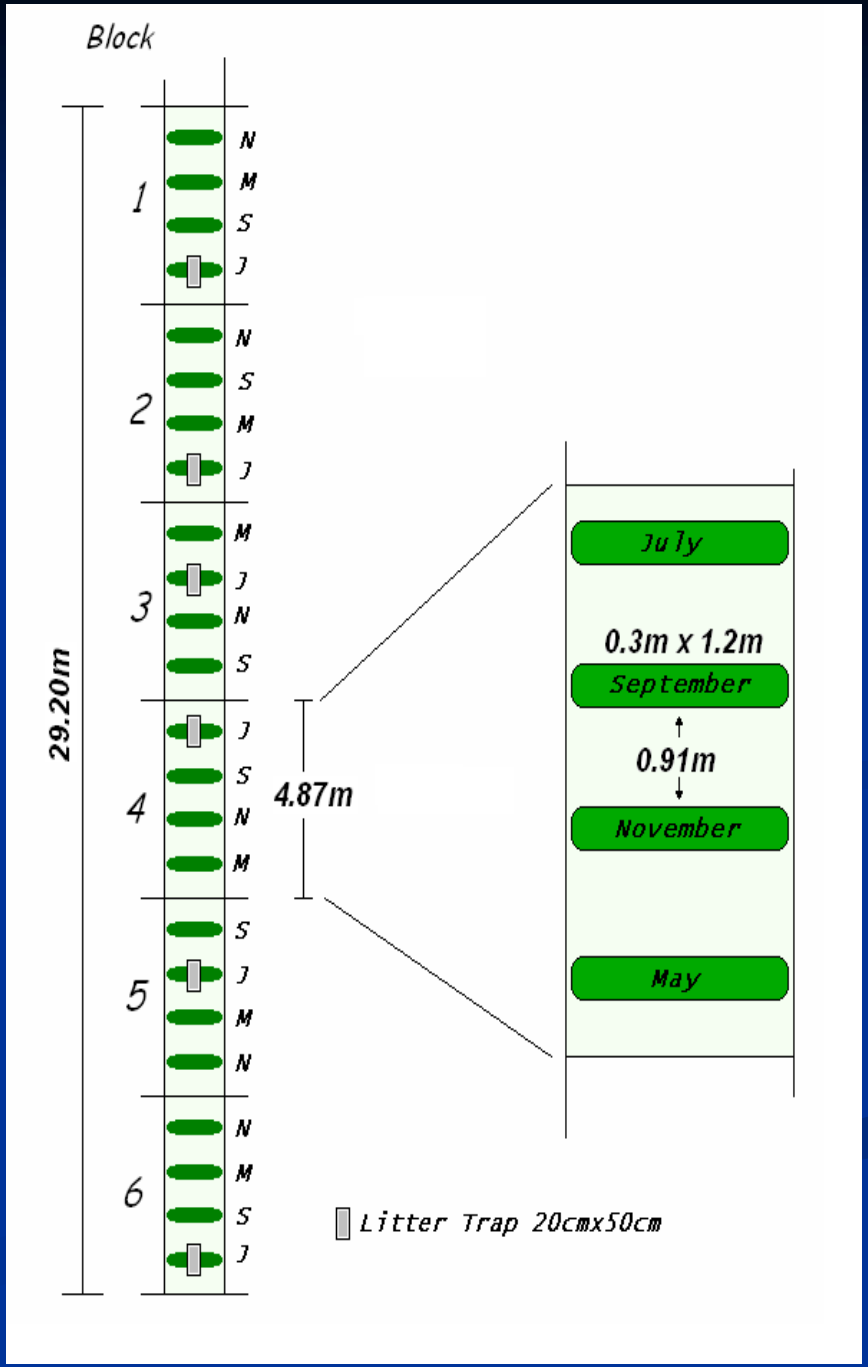
Spring-sown Green Ash (*Fraxinus pennsylvanica*)

Spring-sown Yellow Poplar (*Liriodendron tulipifera*)

STUDY DESIGN AND PLOT LAYOUT

Six blocks in a single bed for each species.

Random location of counting frame sample at four dates.



May

September

Nursery Cultural Practices

Density	Sowing	November
Nuttall oak	107 seed/m^2	52.1
Yellow Poplar	247	43.5
Green Ash	141	56.2

Fertilization

Nuttall oak	total 287 kg/ha N	May 6 - Sept. 23
Yellow Poplar	total 234 kg/ha N	May 6 - Aug. 4
Green ash	total 217 kg/ha N	May 6 - Aug 4

applied as either ammonium nitrate or DAP

Seedling Morphology

Individual seedling parameters:

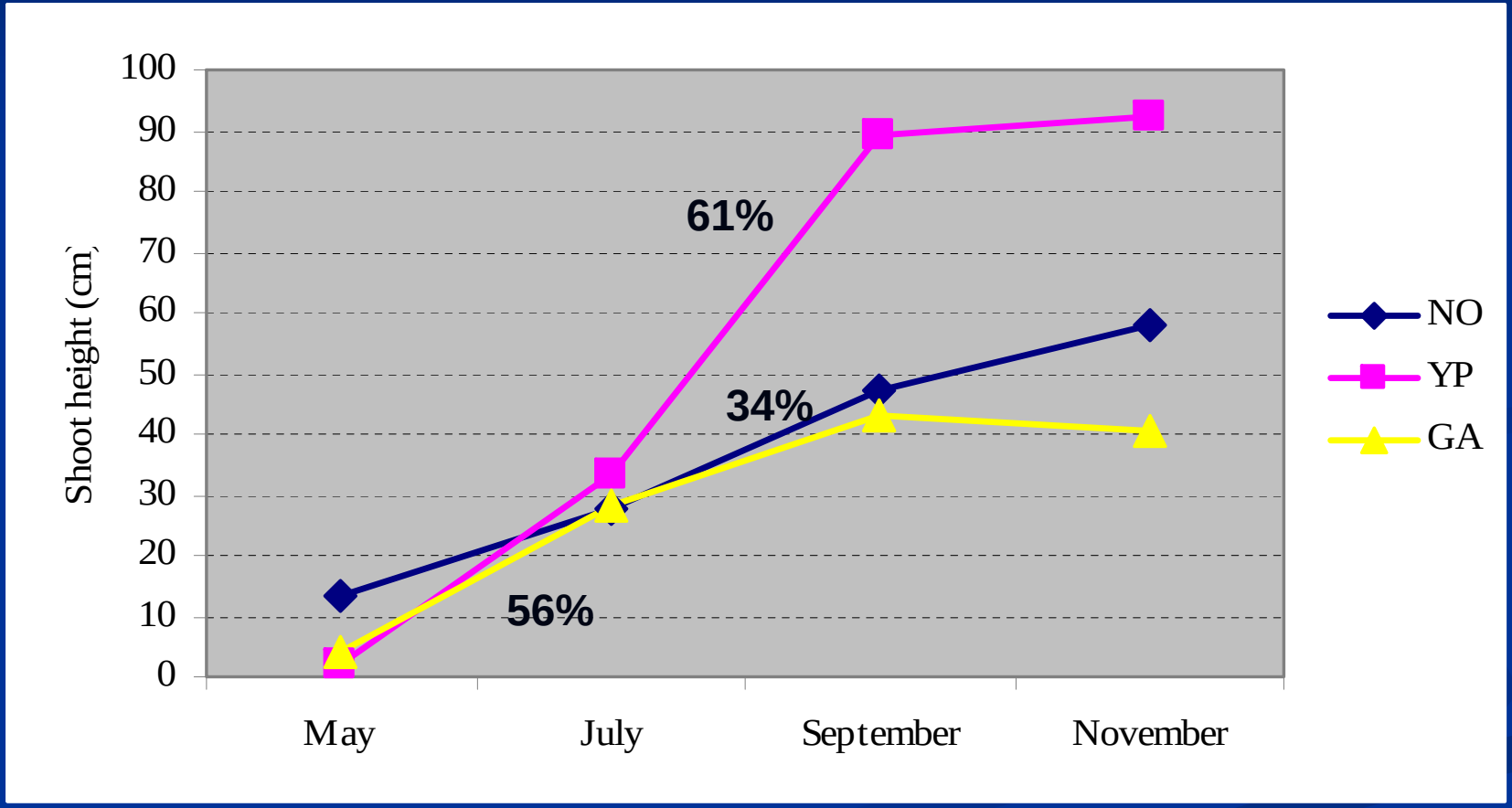
- Shoot Height (cm)
- Root collar diameter (mm)
- Number of First Order Branches (N^{o})
- Number of first Order Lateral Roots (diameter > 1mm)
- Number of leaves
- Leaf area (Li-cor) (cm^{2})

Dry and Wet Weights based on average plot values (g):

- Leaves
- Taproot
- Stem
- 1st order lateral roots
- 1st order branches

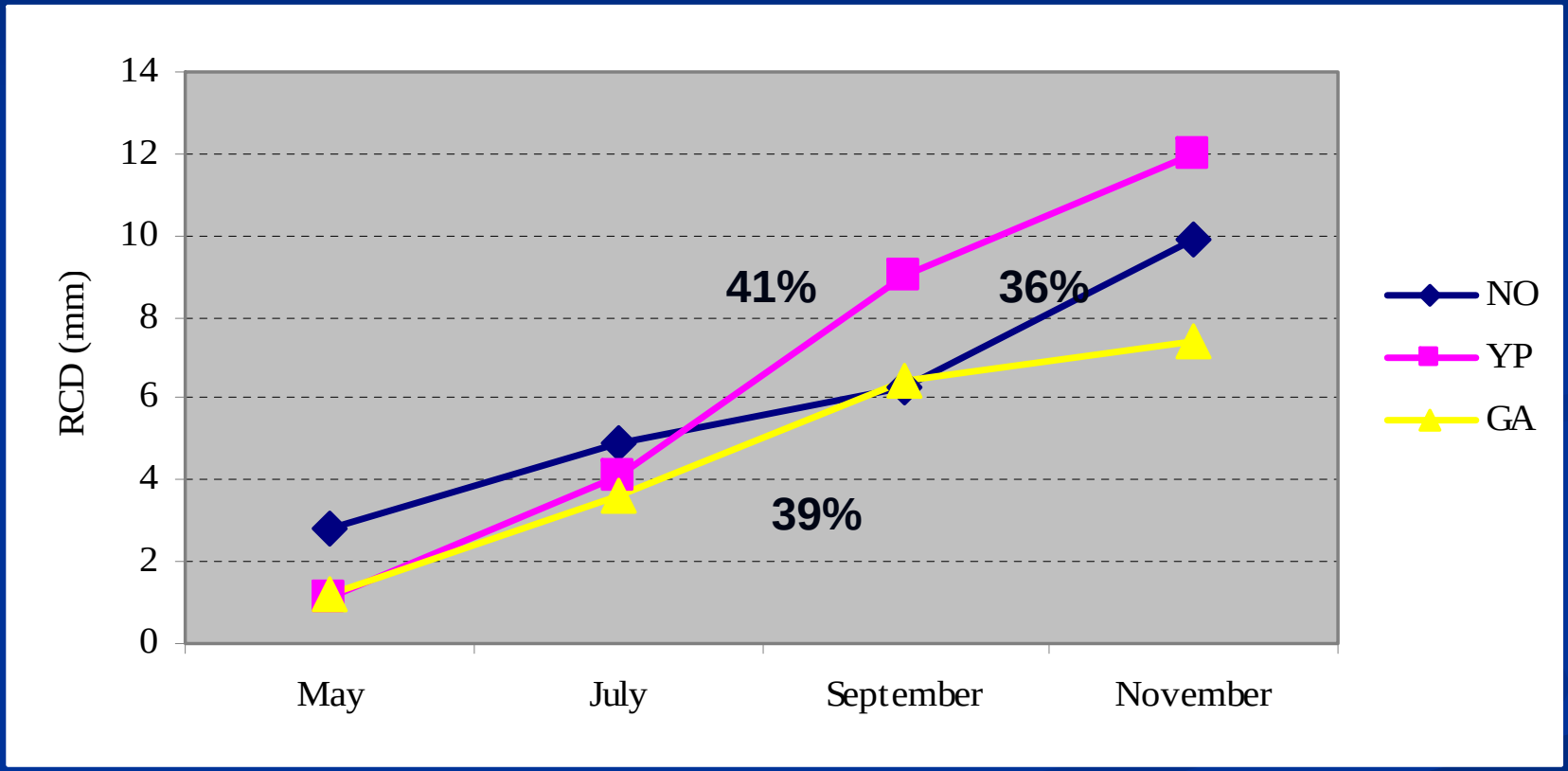
RESULTS

SHOOT HEIGHT



RESULTS

RCD


14
12
10
8
6
4
2
0
RCD (mm)
41%
36%
39%
May
July
September
November
NO
YP
GA

RESULTS

Nuttall oak seedlings

Emphasis on fall development (8 out of 13 parameters)

Yellow poplar seedlings

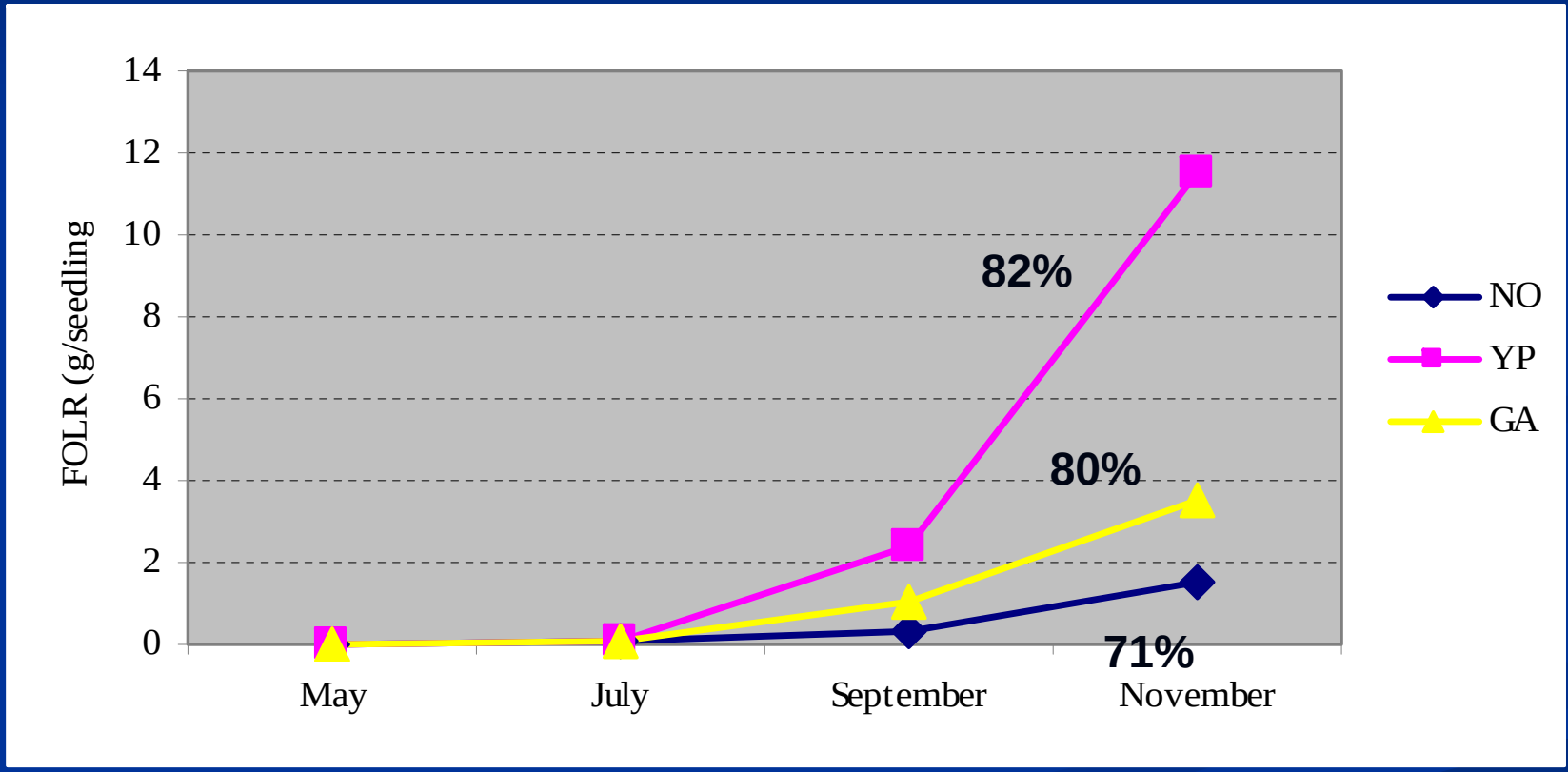
Emphasis on summer development (10 out of 13 parameters)

Green ash seedlings

Emphasis on summer development (8 out of 13 parameters)

RESULTS

FIRST ORDER LATERAL ROOT BIOMASS



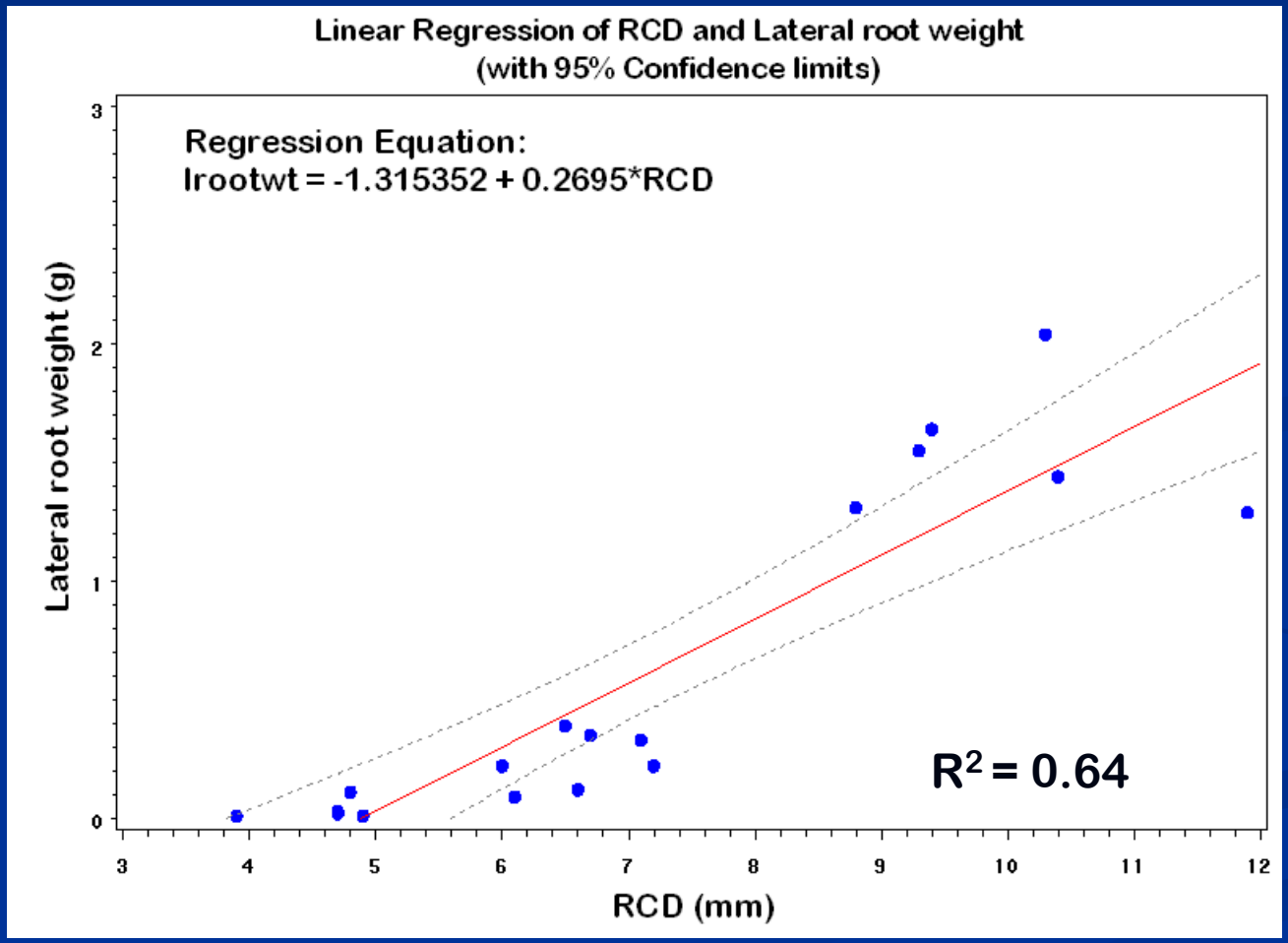
RESULTS

Regressions were performed between all morphological parameters measured.

Height, RCD, No. first order branches, No. first order lateral roots, number of leaves, leaf area, dry weights of stem, FOB, taproot, FOLR, and leaf weight.

Plot averages for July, September, November for most variables.

RELATIONSHIP BETWEEN LATERAL ROOT WEIGHT AND RCD FOR NUTTALL OAK



Shoot height

11 parameters(R^2>.70)

FOLR weight (R^2=.71)

Total Root wt (R^2=.83)

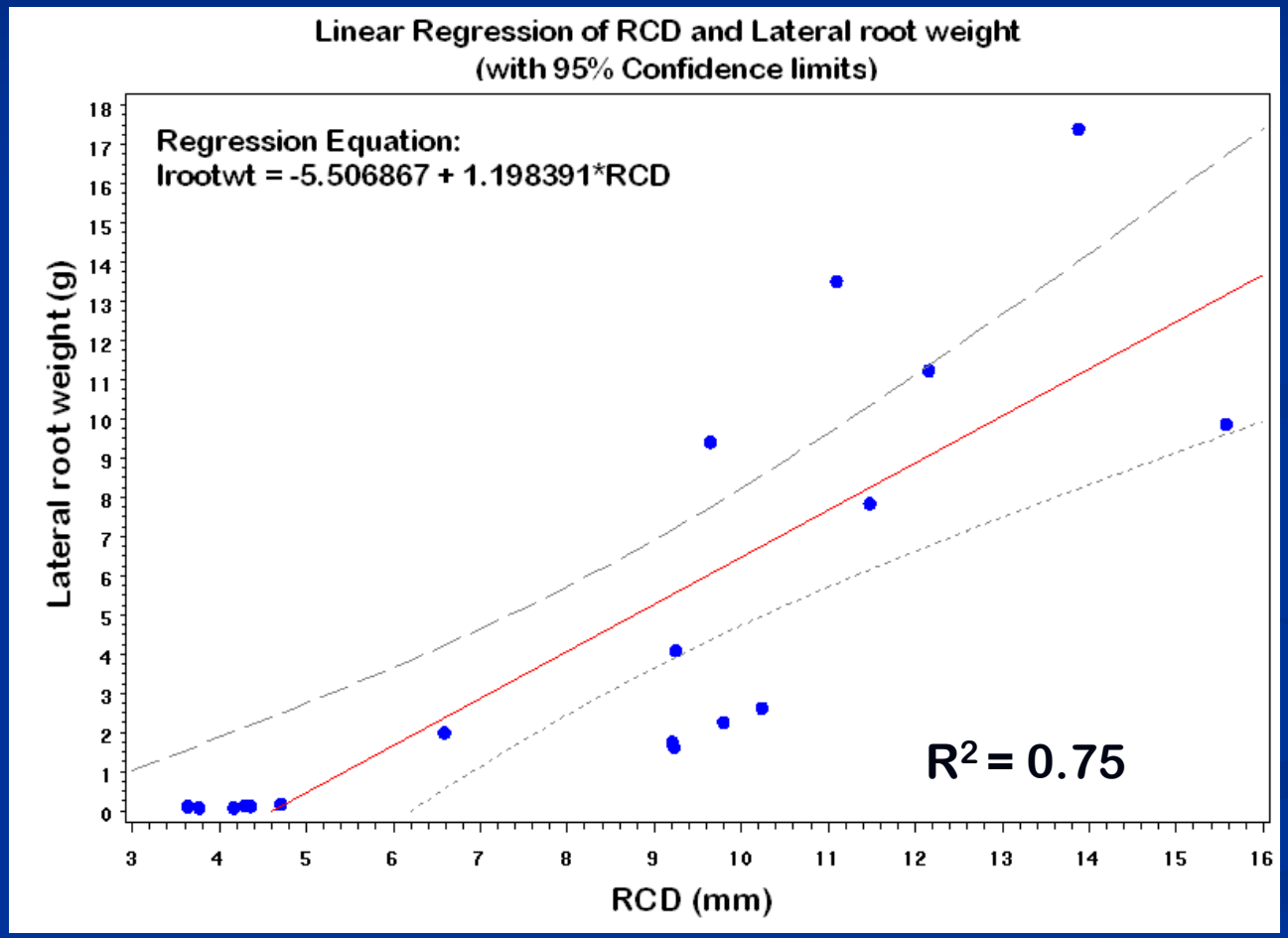
Nº of FOLR (R^2=.61)

RCD

3 parameters (R^2>.70)

Nº of FOLR (R^2=.78)

RELATIONSHIP BETWEEN LATERAL ROOT WEIGHT AND RCD FOR YELLOW POPLAR



Shoot height

11 parameters(R^2>.70)

No of FOLR (R^2= .78)

FOLR weight (R^2=.65)

RCD

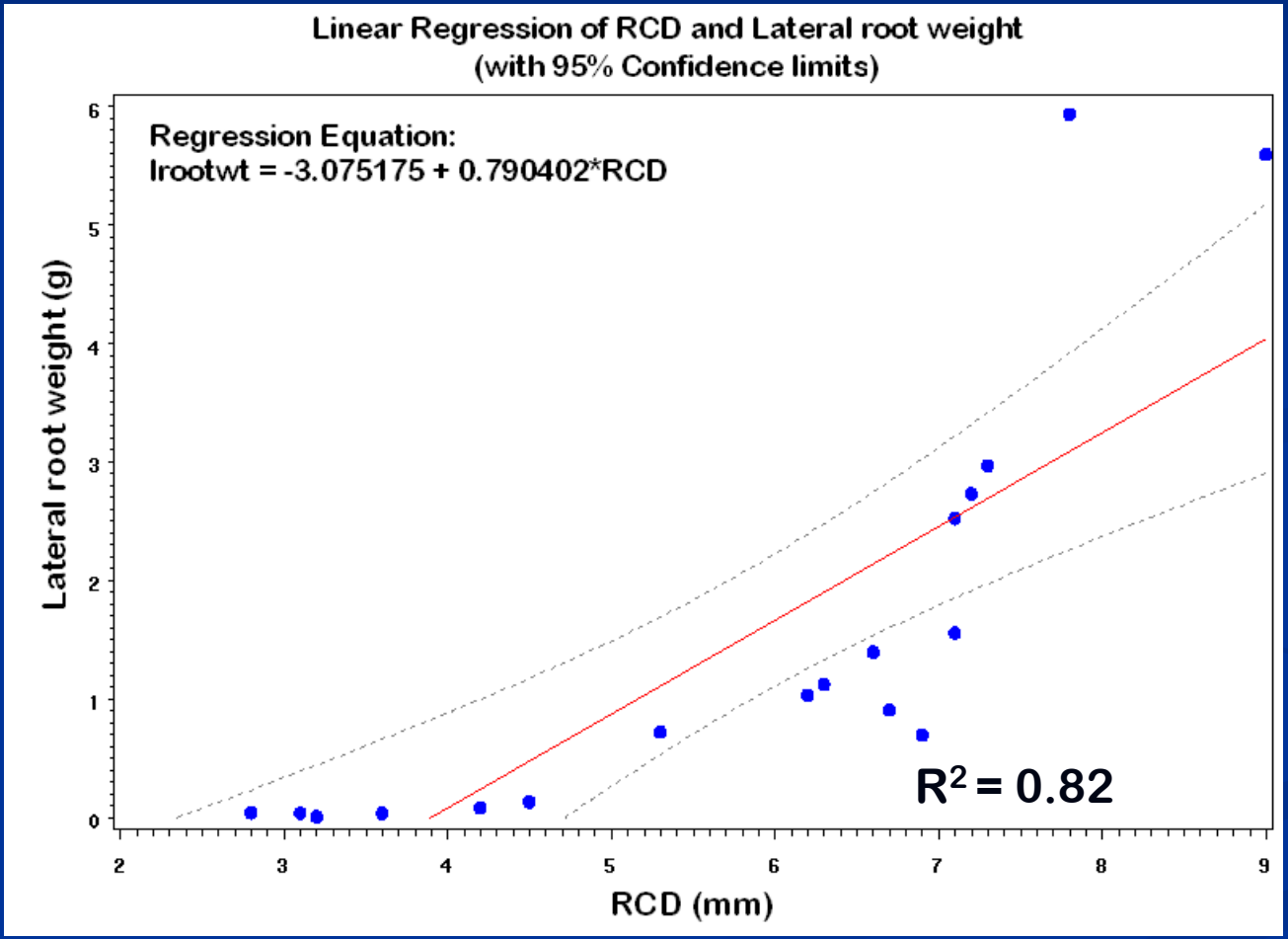
12 parameters(R^2>.70)

Nº of FOLR (R^2= .90)

FOLR weight (R^2=.75)

Total root wt (R^2= .93)

RELATIONSHIP BETWEEN LATERAL ROOT WEIGHT AND RCD FOR GREEN ASH



Shoot Height

10 parameters (R^2>.70)

No of FOLR (R^2=.84)

FOLR weight (R^2=.87)

RCD

10 parameters (R^2>.70)

Nº of FOLR (R^2=.92)

FOLR weight (R^2=.82)

Taproot wt (R^2=.90)

Hardwood seedling nutrition

Nutrient concentrations were determined for each species and sample time by each seedling morphological component (leaves, branches, stems, first order lateral roots, and taproot).

Hardwood seedling nutrition

Litterfall

May

July

September

November

Nutrient analysis done on litterfall for each sample date.

Soil Characterization

Composite soil samples were taken in each block for each species:

May, prior to N fertilization

July, September, November

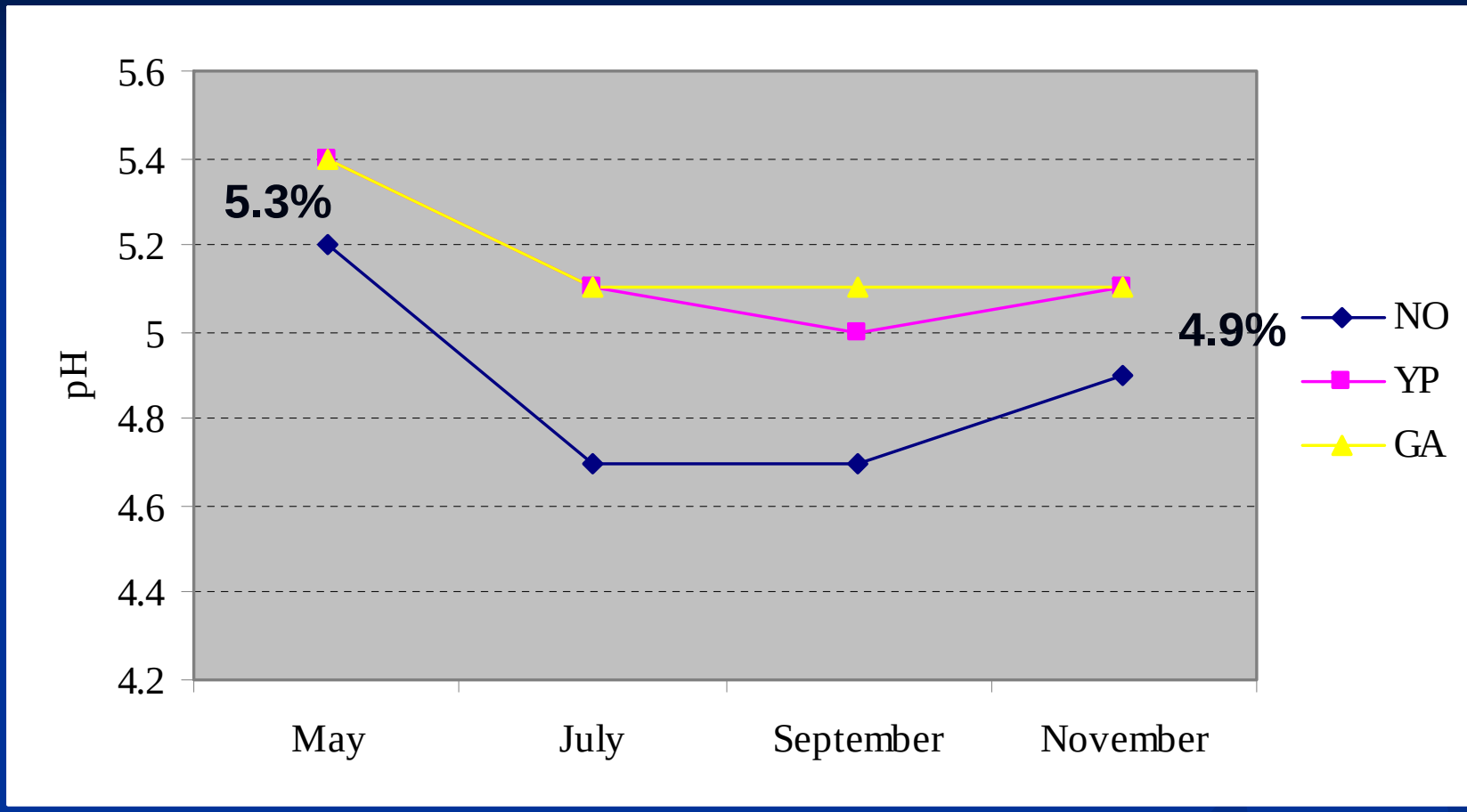
Nutrient Addition through Mulching

yellow poplar	17 kg/ha N	1 kg/ha P
green ash	22 kg/ha N	1 kg/ha P

Seedling nutrient utilization

1) Nitrogen removal efficiency (Brulsema, 2005)
2) Partial factor of productivity (Cassman et al., 2002)
3) Nutrient translocation efficiency (Ntanos and Koutroubas, 2002)
4) Resorption efficiency (Van Heerwarden at al. 2003)
5) Nutrient use efficiency (U.S. EPA, 2002)

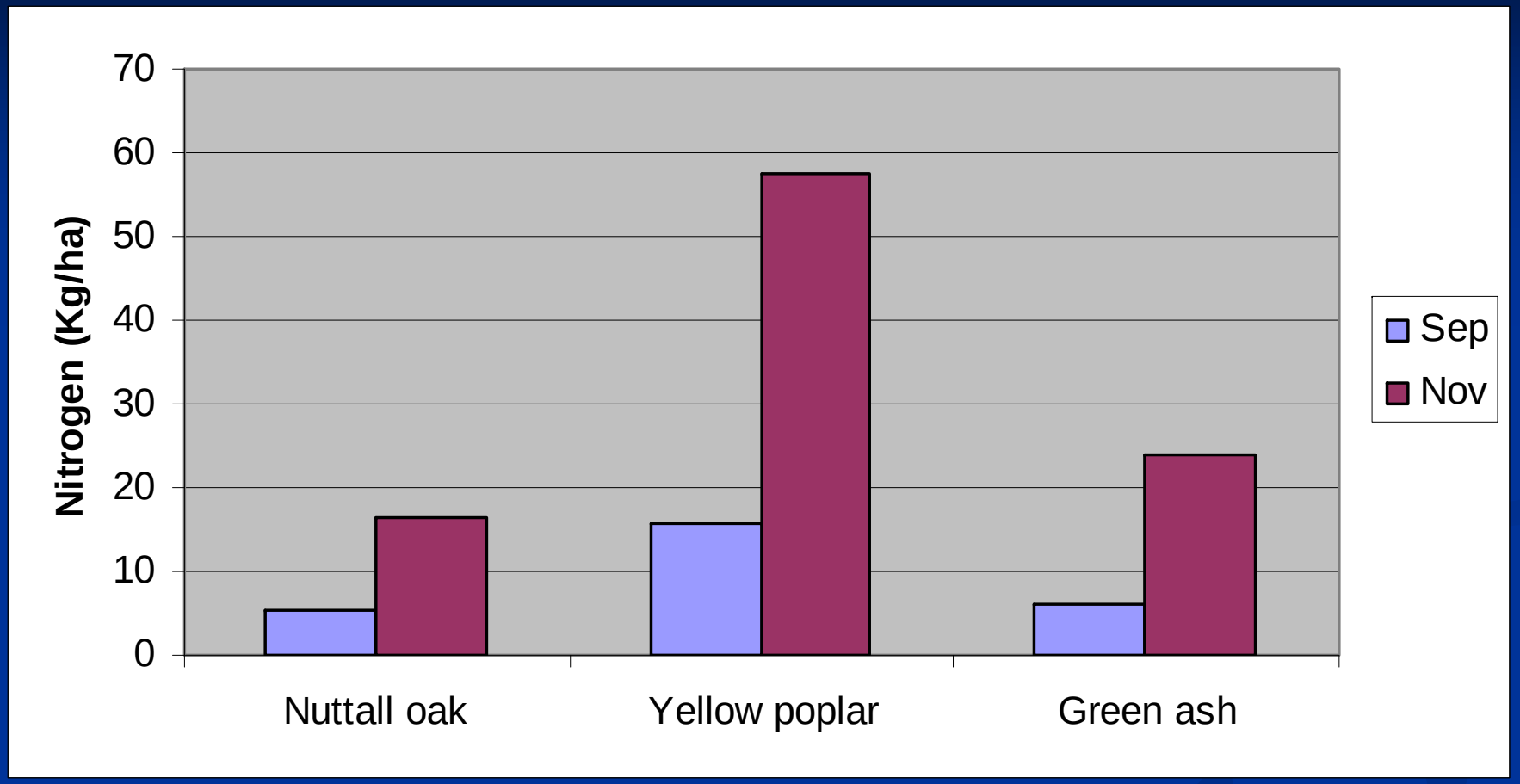
Results - soil pH



Other Changes: **K declined 21%**

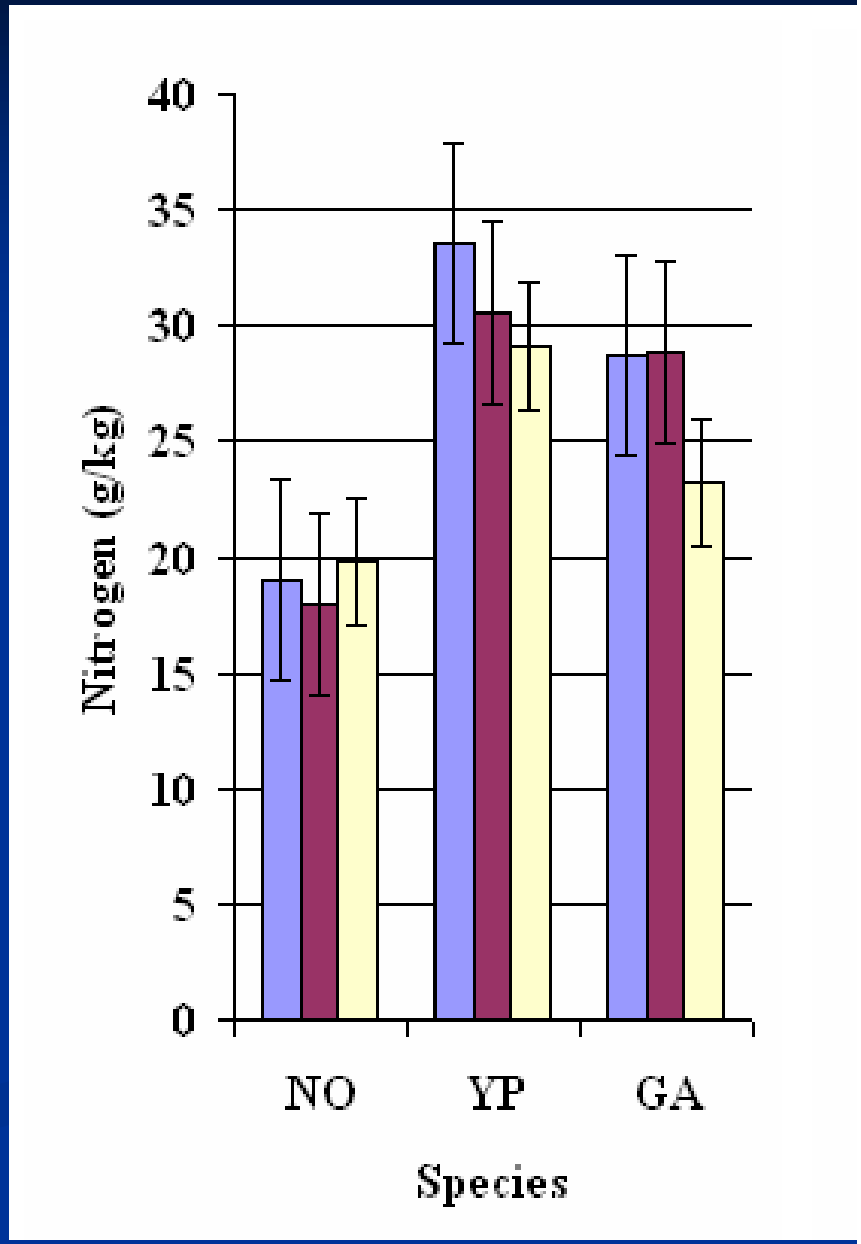
P increased 22%, Mn 23%

Deposition through litterfall

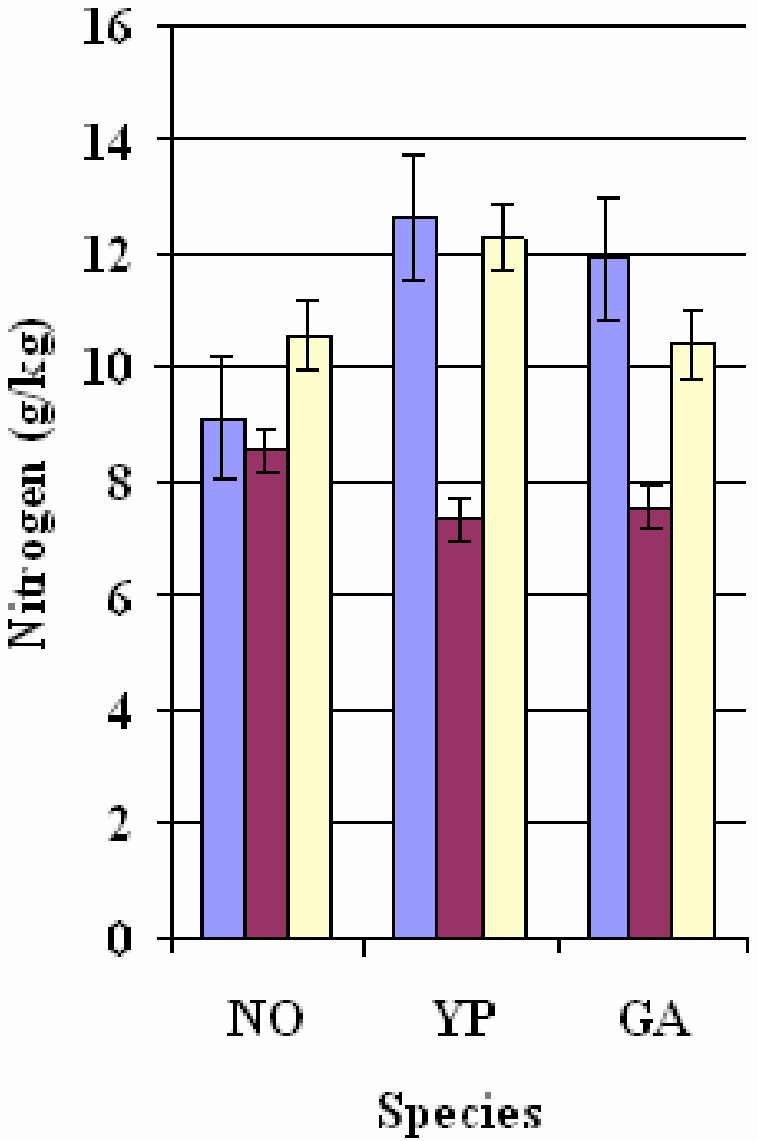


Total N (kg/ha)	**22**	**73**	**30**
% of applied N	**8**	**25**	**12**

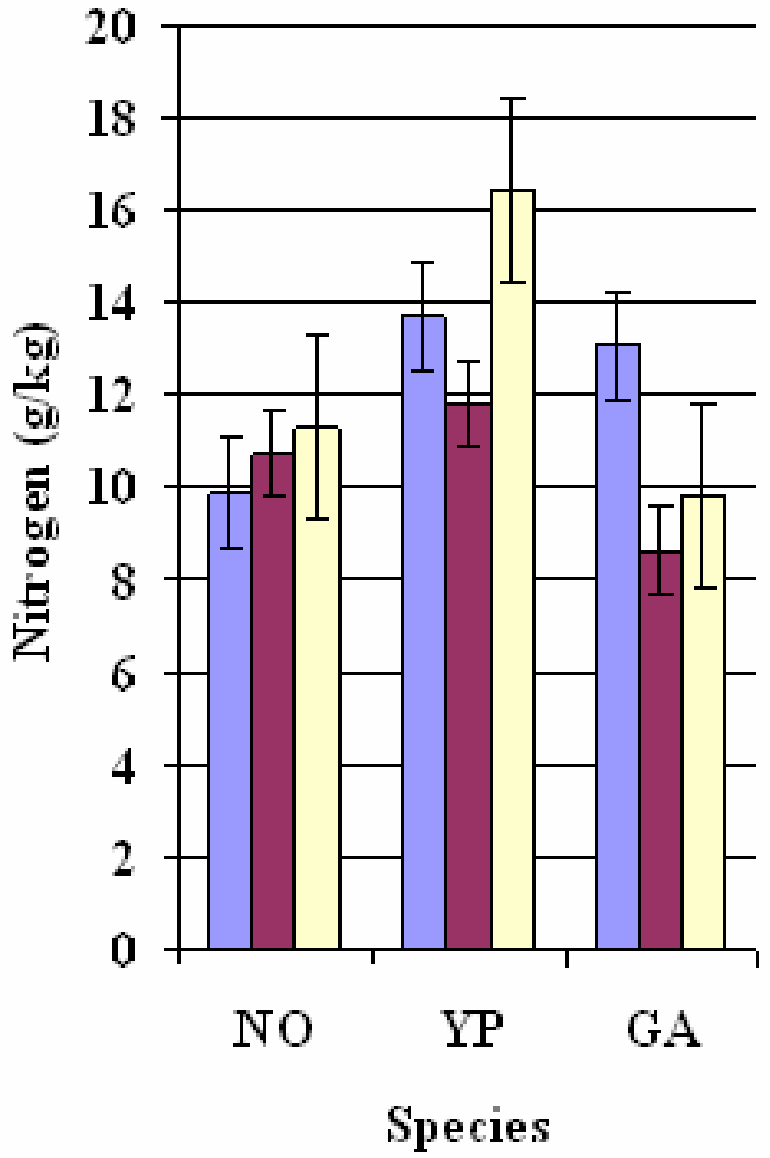
Leaf Nitrogen Concentrations by Species



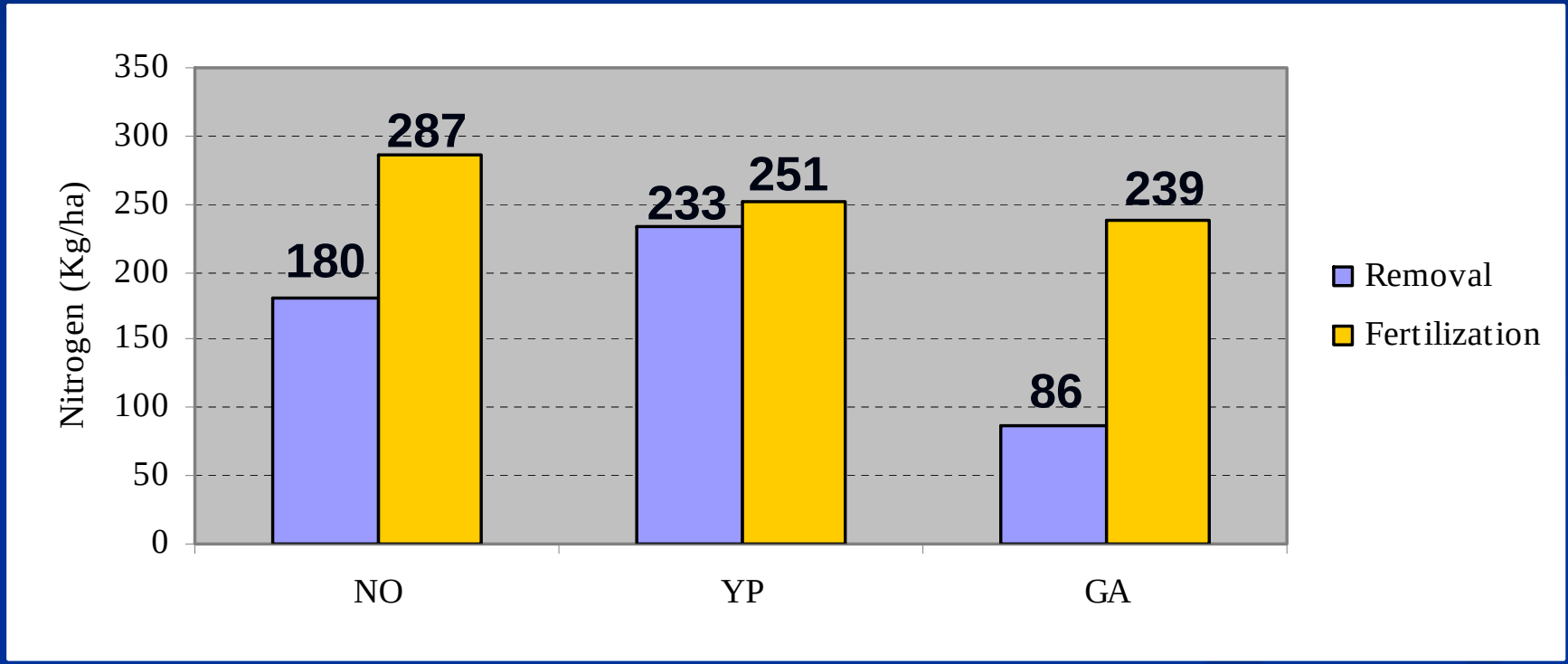
Aboveground Plant Nitrogen Concentrations



Belowground plant nitrogen concentrations



Nitrogen application and removals by species
(includes mulch application)



Balance	**+107**	**+18**	**+153**

Seedling Resorption Efficiency

The percent of a nutrient transferred out of the leaf before abscission in the fall.

Species	*N*	*P*
	%	
Nuttall oak	36.2	62.5
Yellow poplar	64.8	80.8
Green ash	23.1	53.0

Nitrogen Utilization

Nitrogen Use Efficiency: the ratio of biomass produced by unit of N taken up

Nitrogen Removal Efficiency: nitrogen removed in harvest as a percent of applied

Species	NUE	NRE
Nuttall oak	76	63%
yellow poplar	67	93
green ash	71	36

So much we don't know

1. Timing of fertilizer by species
2. Amount of fertilizer by species
3. Effect of fall cultural practices on seedling quality
4. Impact of pH on seedling development
5. Impact of seed source