

Greenhouse Treatability Studies That Guide Phytoremediation Nutrient Management

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Superior, WI Site



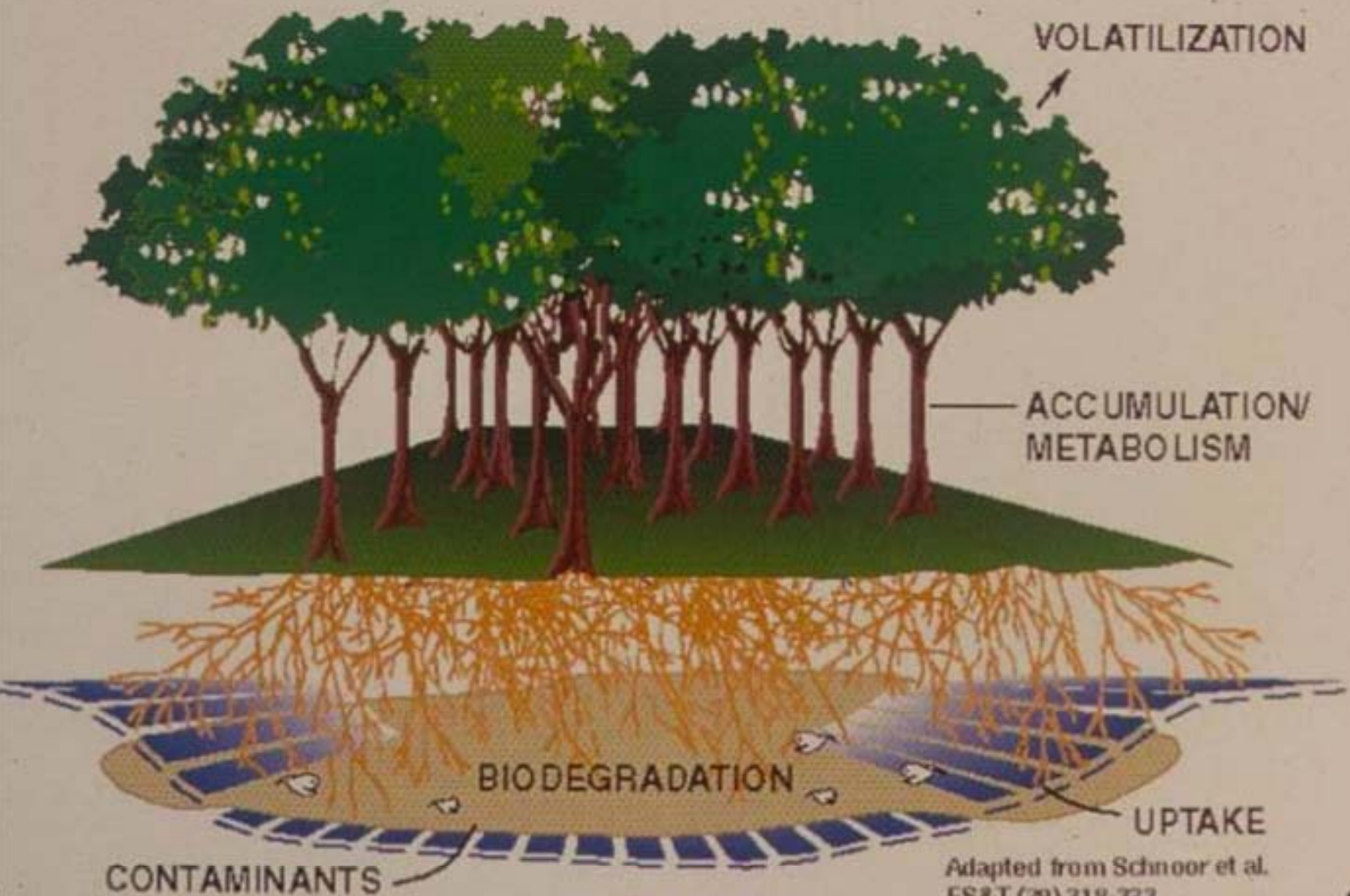
Contaminants

- Total Petroleum Hydrocarbons (TPH)
 - Gasoline Range Organics (GRO)
 - BTEX
 - Naphthalene
 - Diesel Range Organics (DRO)
 - Decanes
 - Cosanes
 - PAHs

Superior, Wisconsin



PHYTOREMEDIATION PROCESSES



Adapted from Schnoor et al.
ES&T (29) 318-323.

Nutrient Requirements

- Nitrogen (N) and Phosphorus (P)
 - Depleted during contaminant biodegradation
- May limit plant growth
- May limit microbial degradation

N/P Addition - Phytoremediation

- Hutchinson *et al.*, 2001
 - Increased degradation of TPH
- Joner *et al.*, 2002
 - Increased degradation of 3/4- ringed PAH
 - Diminished remediation of 5/6-ringed PAH
- Palmroth *et al.*, 2002
 - No improvement for diesel fuel contaminants

N/P Addition - Bioremediation

- Walworth *et al.*, 2003
 - Stimulation of diesel fuel degradation
- Breedveld and Sparrevik, 2000
 - Improved degradation of 4-ringed PAH
- Carmichael and Pfaender, 1997
 - Inhibition of 3/4-ringed PAH degradation w/ N
 - No effect for P addition
- Johnson and Scow, 1999
 - Inhibition or no effect for 3-ringed PAH

Research Objectives

- Determine suitable plants for growth in Superior, WI soils
- Examine the growth response of plants growing in contaminated soil to nutrient amendments
- Assess phytoremediation effectiveness using soil TPH DRO analysis.



Three clay soils (C)

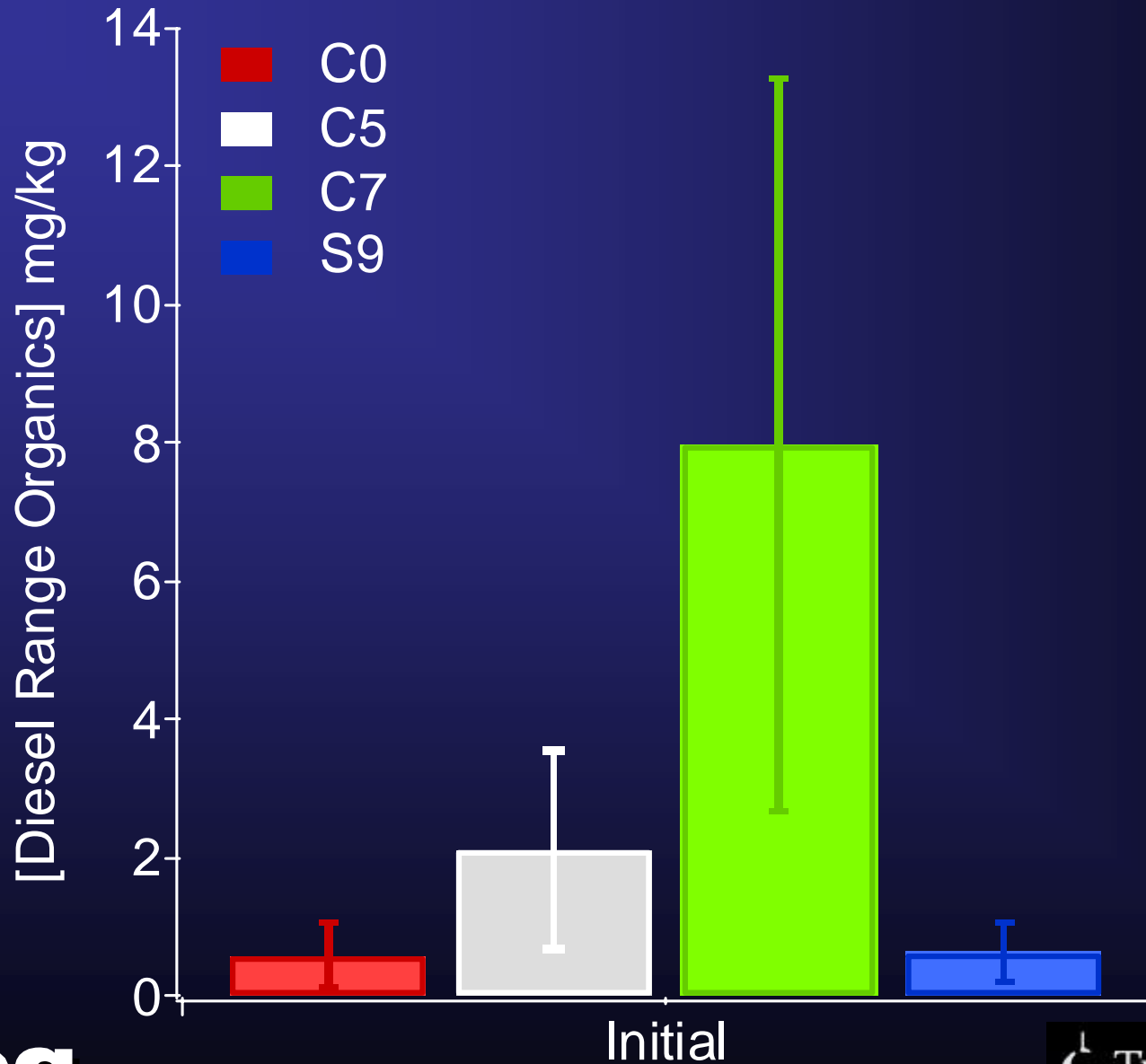
One sandy soil (S)

Differing concentrations of TPH
DRO

Soil C0 is a reference sample
collected from the northernmost
point of the property

Dashed line shows property line

Initial DRO



Experimental Design

- Nutrient Amendments (N, P, K, Zn, S)
- 11 Planted Treatments
- 5 Control Treatments
- Field Mixture – clovers, grasses alfalfa
- 53-55 day growth period

Seed mixture

Common Name	Scientific Name	Use	%
Climax Timothy	<i>Phleum pretense</i>	Cool season	35.8
Alfalfa	<i>Medicago sativa</i>	Soil nitrification	19.8
Orchard Grass	<i>Dactylis glomerata</i>	Cool season	6.2
Alsike Clover	<i>Trifolium hybridum</i>	Warm season	20.9
Red Clover	<i>Trifolium pratense</i>	Warm season	8.3
Ladino Clover	<i>Trifolium repens</i>	Warm season	2.1

Pot Arrangement



Visual Results (5 weeks)

CO

C5

C7

S9



No amendments

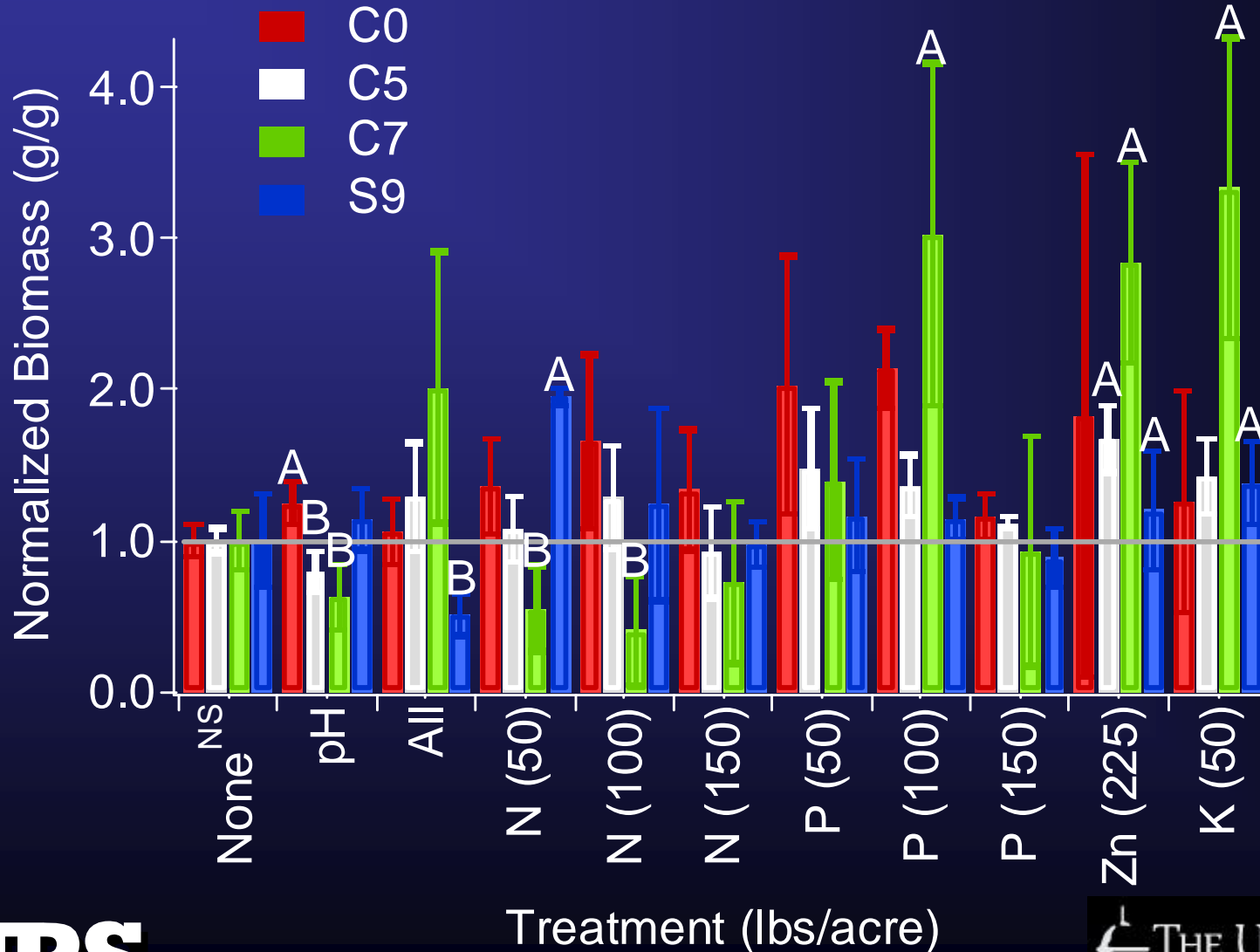


100 lb/ac P w/ 360 lb/ac S



225 lb/ac Zn w/ 360 lb/ac S

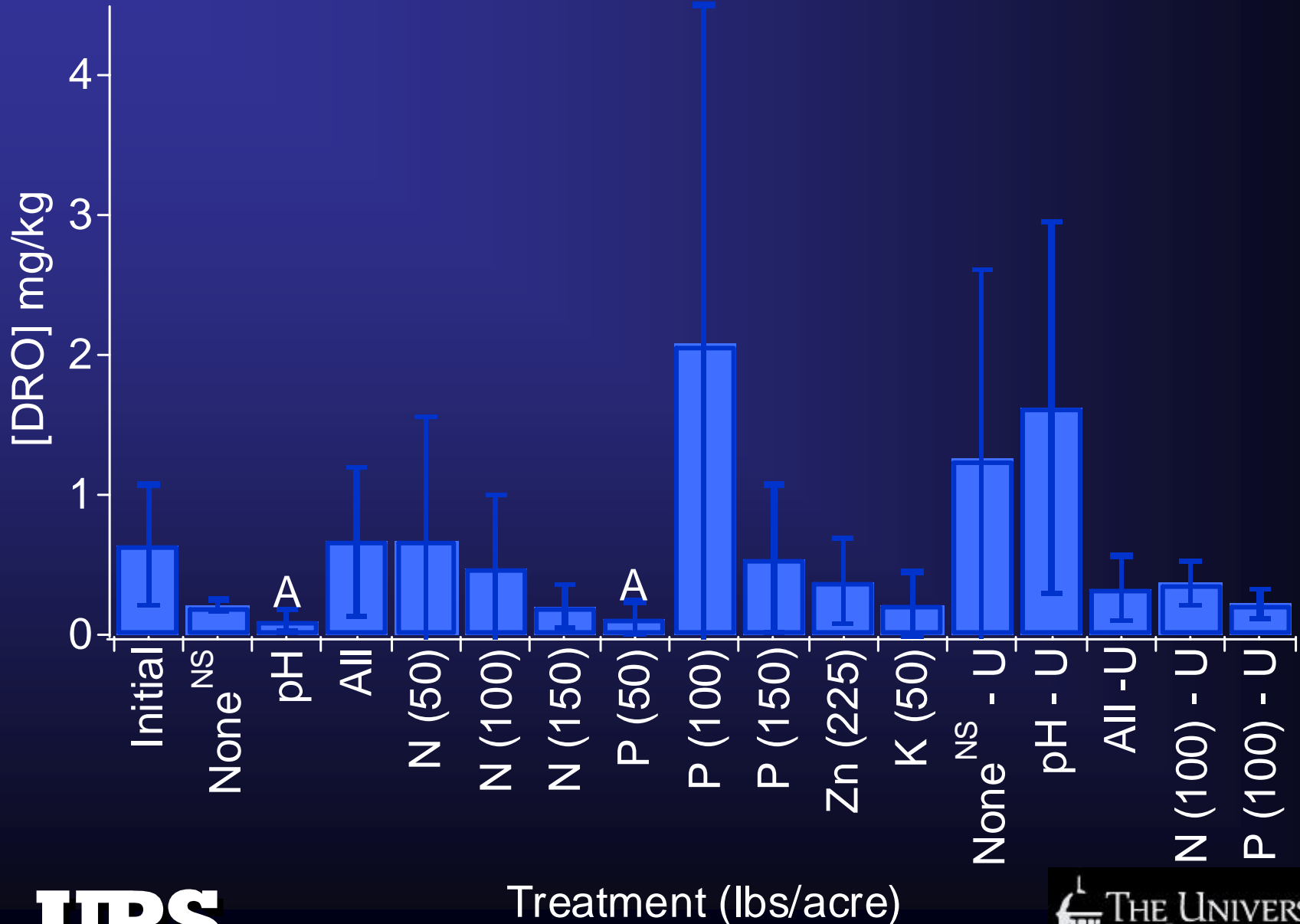
Normalized Biomass



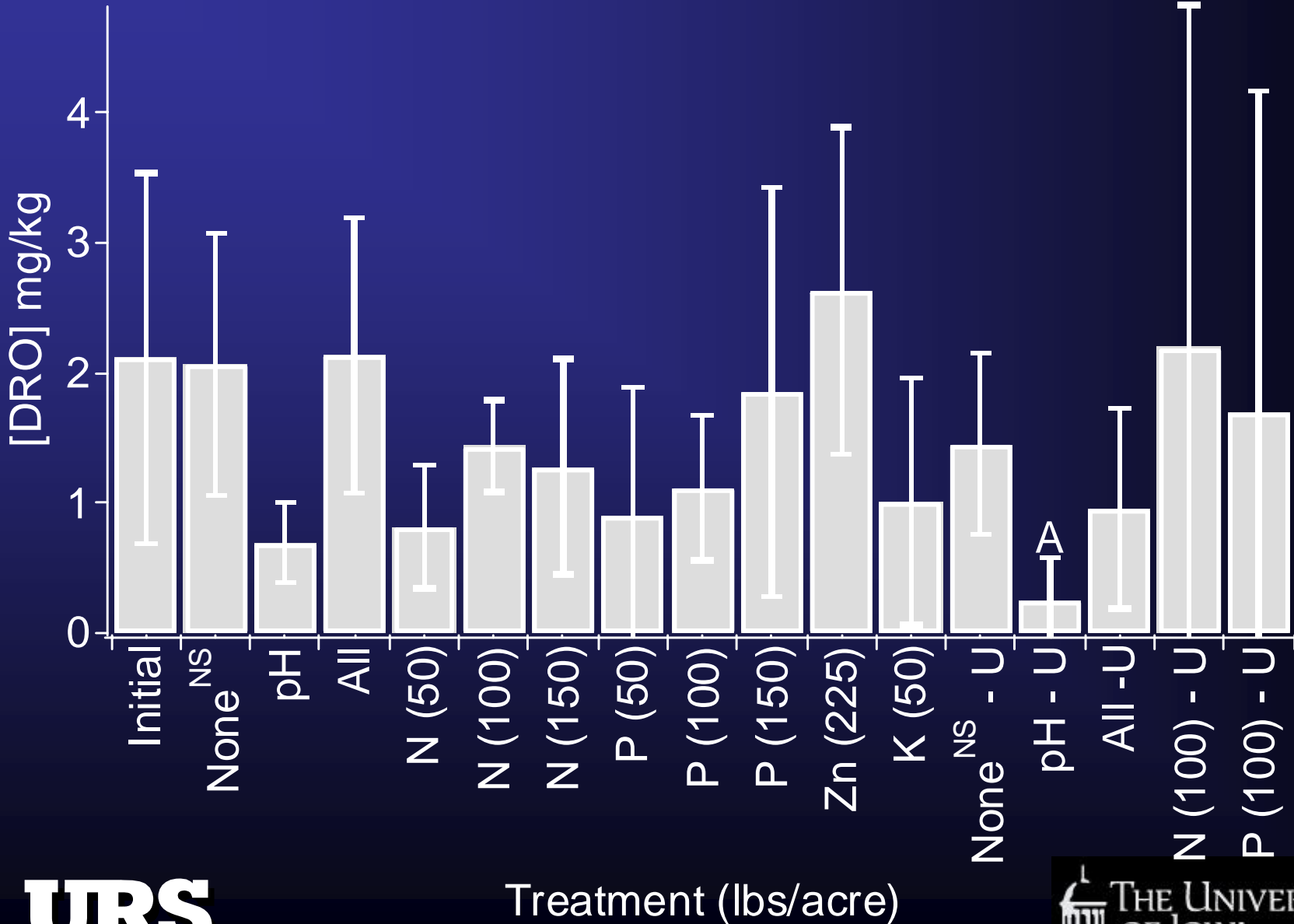
Treatability Results

- Zinc amendments stimulated early germination and optimum visual growth
- P, K, and Zinc amendments stimulated biomass growth
 - Fertilizer application of 50 lb/ac P, 225 lb/ac Zn and 50 lb/ac K was recommended
- S had a negative effect on growth
 - Added to decrease soil pH
- Nitrogen did not produce positive effects on plant growth

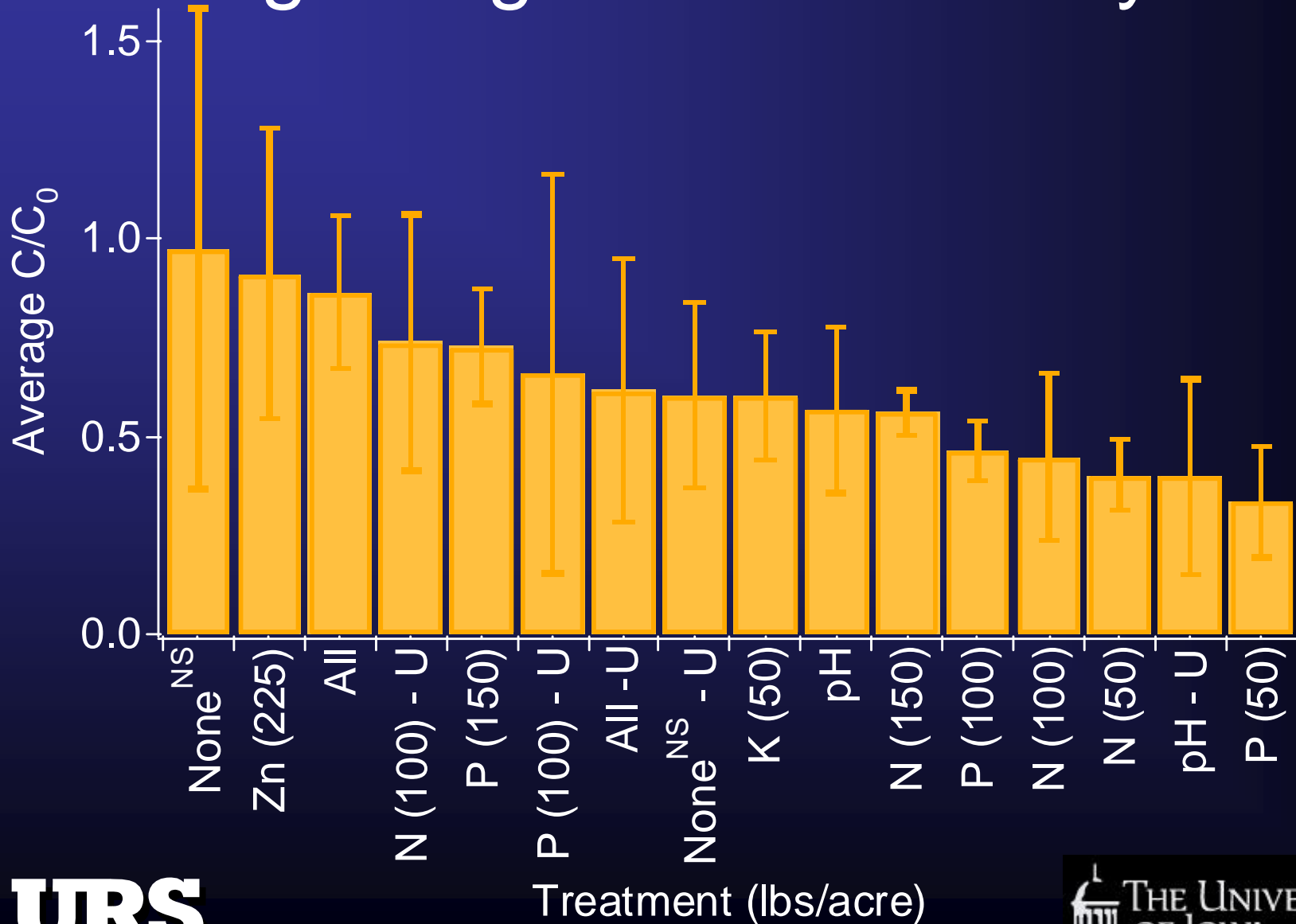
Final [DRO] for S9 Soil



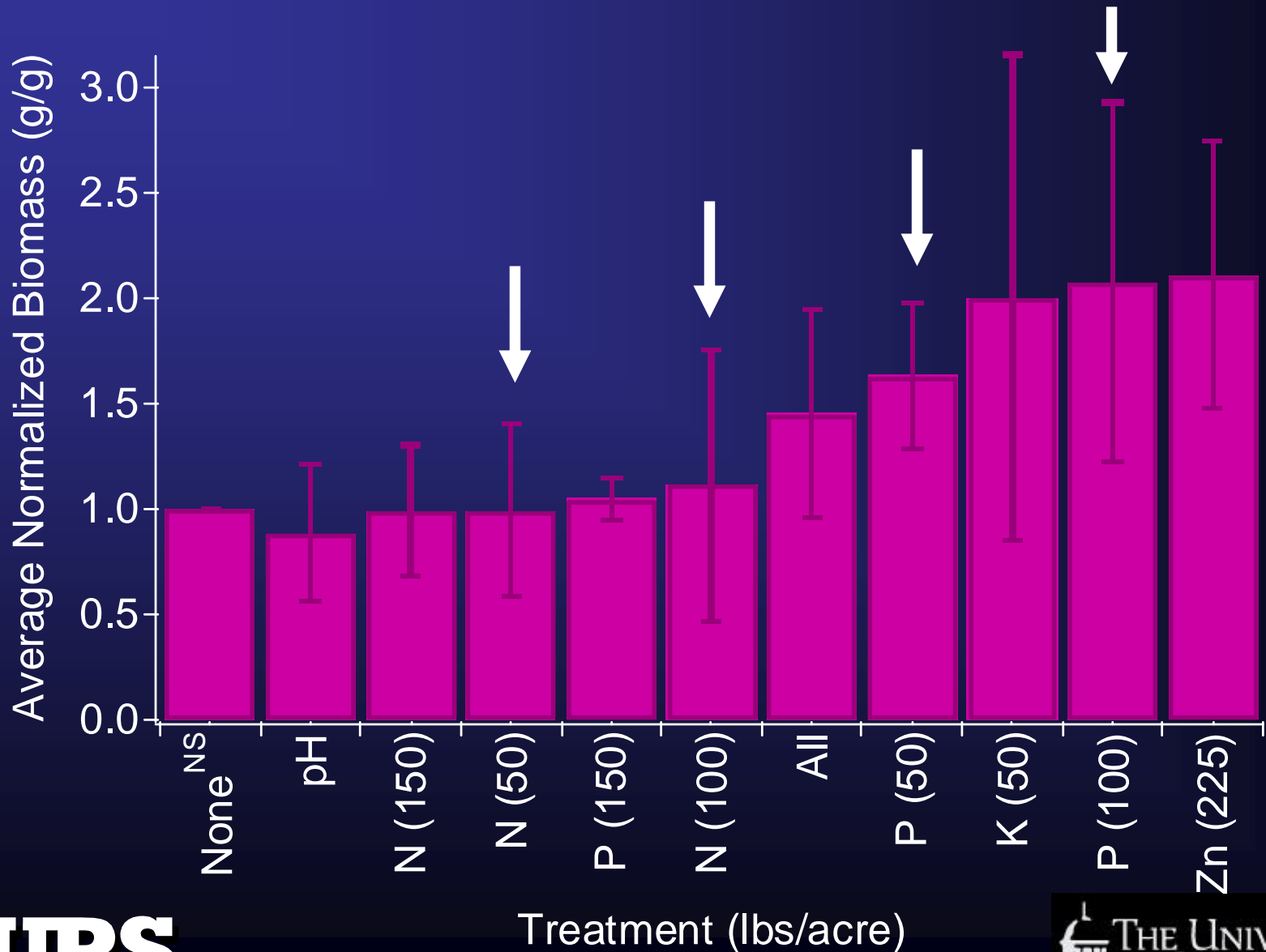
Final [DRO] for C5 Soils



Average Degradation for Clay Soils



Biomass for Clay Soils



DRO Results for Field Mixture

- N and P additions improved degradation
- Degradation was not always observed
- Results were soil specific
- No correlations between biomass and degradation were observed

Experimental Design - Trees

- Nutrients – N, P, K, S, Zn
- Mulch was added (2:1 soil:mulch)
- 4 Planted Treatments
- 1 Control Treatment
- Hybrid Poplar – *Populus deltoides x nigra DN34*
- Hybrid Willow – *Salix alba x matsudana*
- Growing Period – 109 days for willow, 119 for poplar

Pot Arrangement



Visual Results – Poplar (119 days)



No amendments



NPK-S-Zn



Visual Results Hybrid Poplars



C0 soil with 50 lb/ac
N:P:K – no mulch



C7 soil with 50 lb/ac
N:P:K – no mulch



C5 soil with 50 lb/ac
N:P:K – no mulch

Visual Results – Willow (109 days)

S9

C7

C5

C0

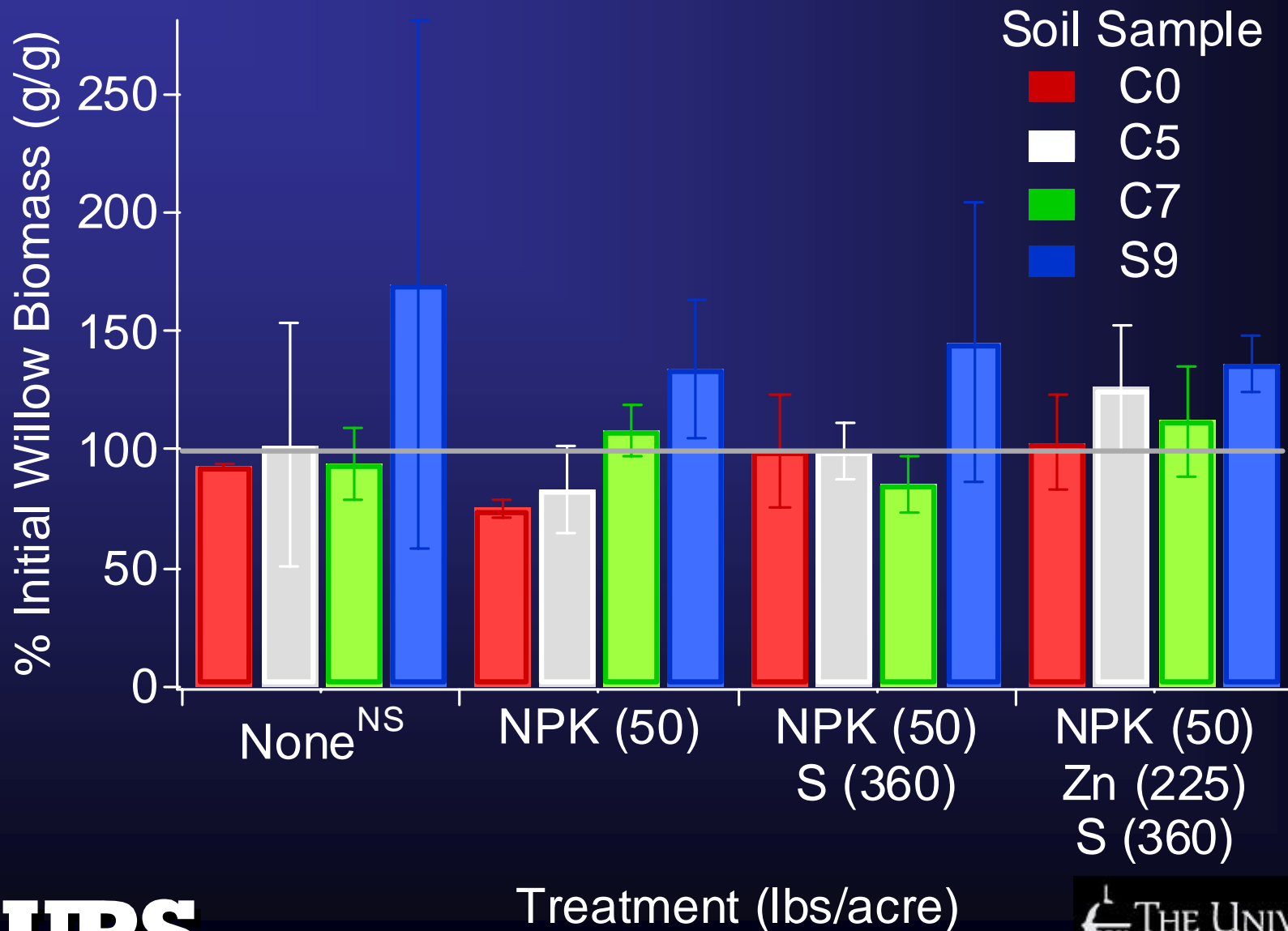


No amendments



NPK-S-Zn

Willow Biomass (109 days)



Tree Treatability Results

- Visual observations indicated limited growth
- Biomass growth was greatest for NPK-S-Zn treatment
- Zn had a stimulatory effect on growth
- Willow growth was not a result of primary production
- Low growth suspected to be a result of soil texture not toxicity

Conclusions

- Field Mixture will be successful
- Unclear if trees will be successful
- P, K, Zn stimulated field mixture and tree growth

Conclusions

- 7 of 8 best average DRO removals were for planted treatments
- Plant growth did not translate into improved DRO degradation
- Compromise between plant growth and degradation

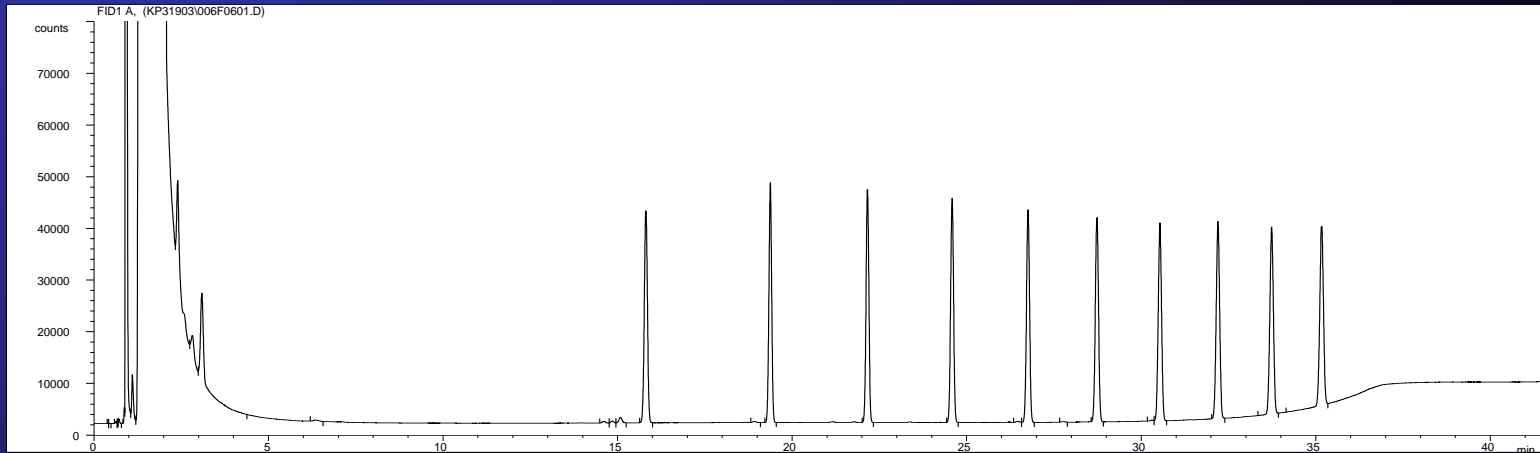
Acknowledgements

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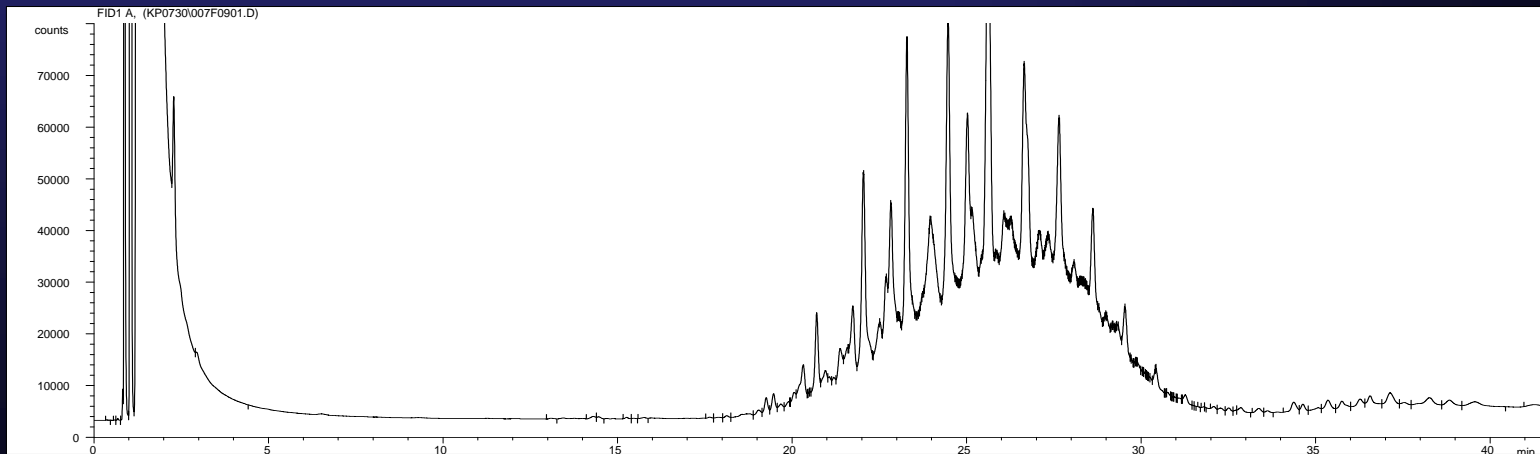
Arcadis



DRO Analysis



DRO 50 mg/L Standard



Initial C7 Sample