

# Phytoaccumulation of Sodium & Chloride Into Leaf, Woody, & Root Tissue of *Populus* Irrigated with Landfill Leachate

*Jill A. Zalesny<sup>1</sup>, Ronald S. Zalesny Jr.<sup>1</sup>, Adam H. Wiese<sup>1</sup>  
Bart T. Sexton<sup>2</sup>, Richard B. Hall<sup>3</sup>*



**<sup>1</sup> U.S. Forest Service  
Northern Research Station  
Institute for Applied Ecosystem Studies  
Rhineland, WI 54501**

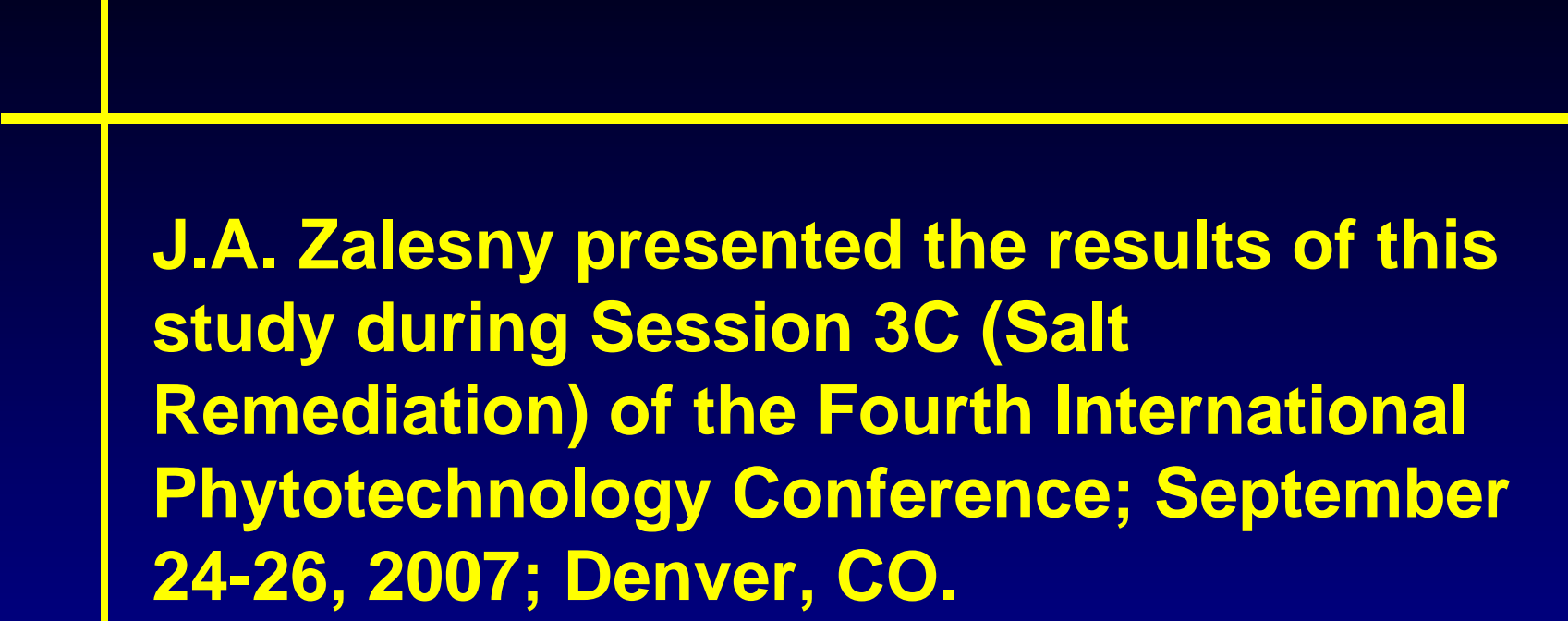


**<sup>2</sup> Oneida County Wisconsin  
Solid Waste Dept.  
Rhineland, WI 54501**



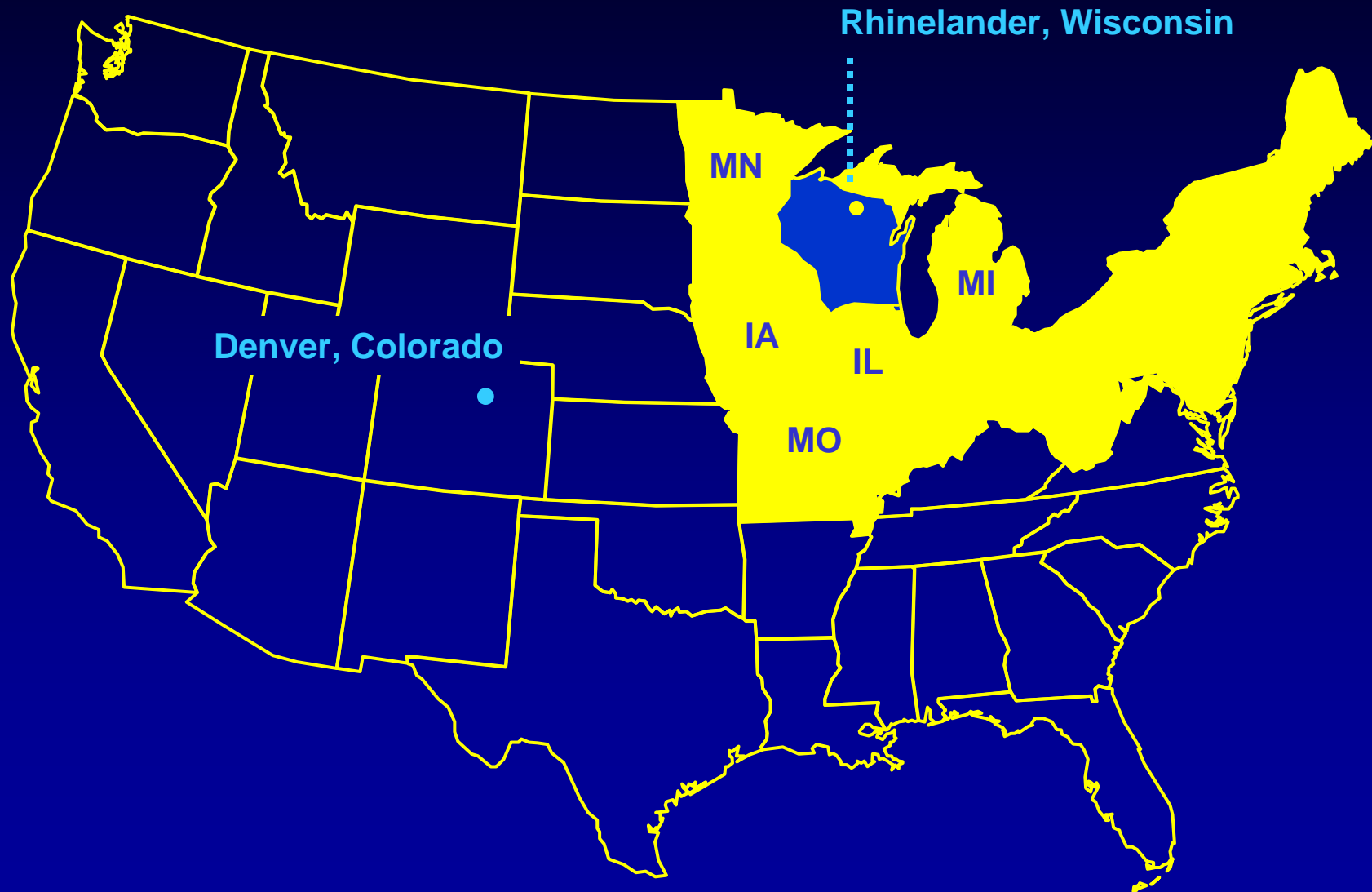
**<sup>3</sup> Iowa State University  
Dept. of Natural Resource  
Ecology & Management  
Ames, IA 50011**



A yellow crosshair graphic consisting of a vertical line and a horizontal line intersecting, located in the upper left corner of the slide.

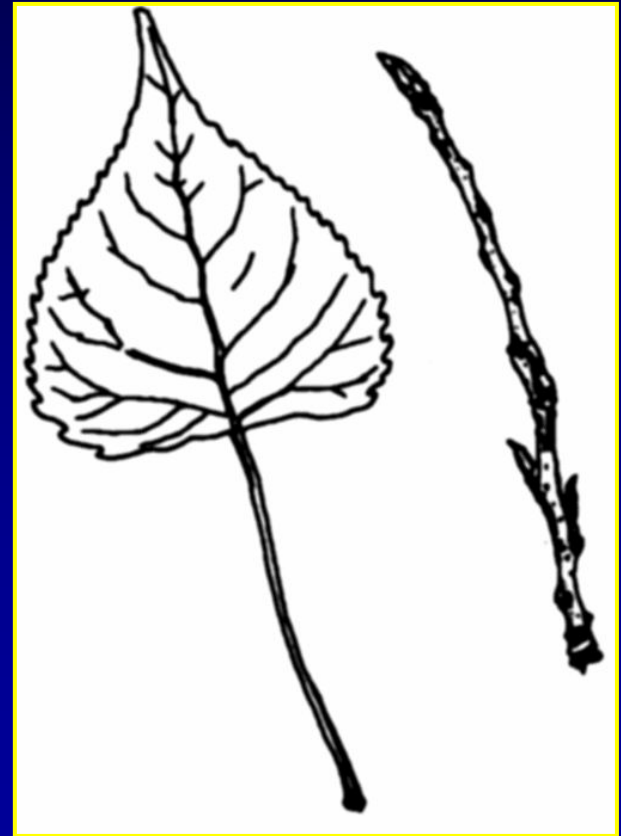
**J.A. Zalesny presented the results of this study during Session 3C (Salt Remediation) of the Fourth International Phytotechnology Conference; September 24-26, 2007; Denver, CO.**

# Northern Research Station



# Presentation Outline

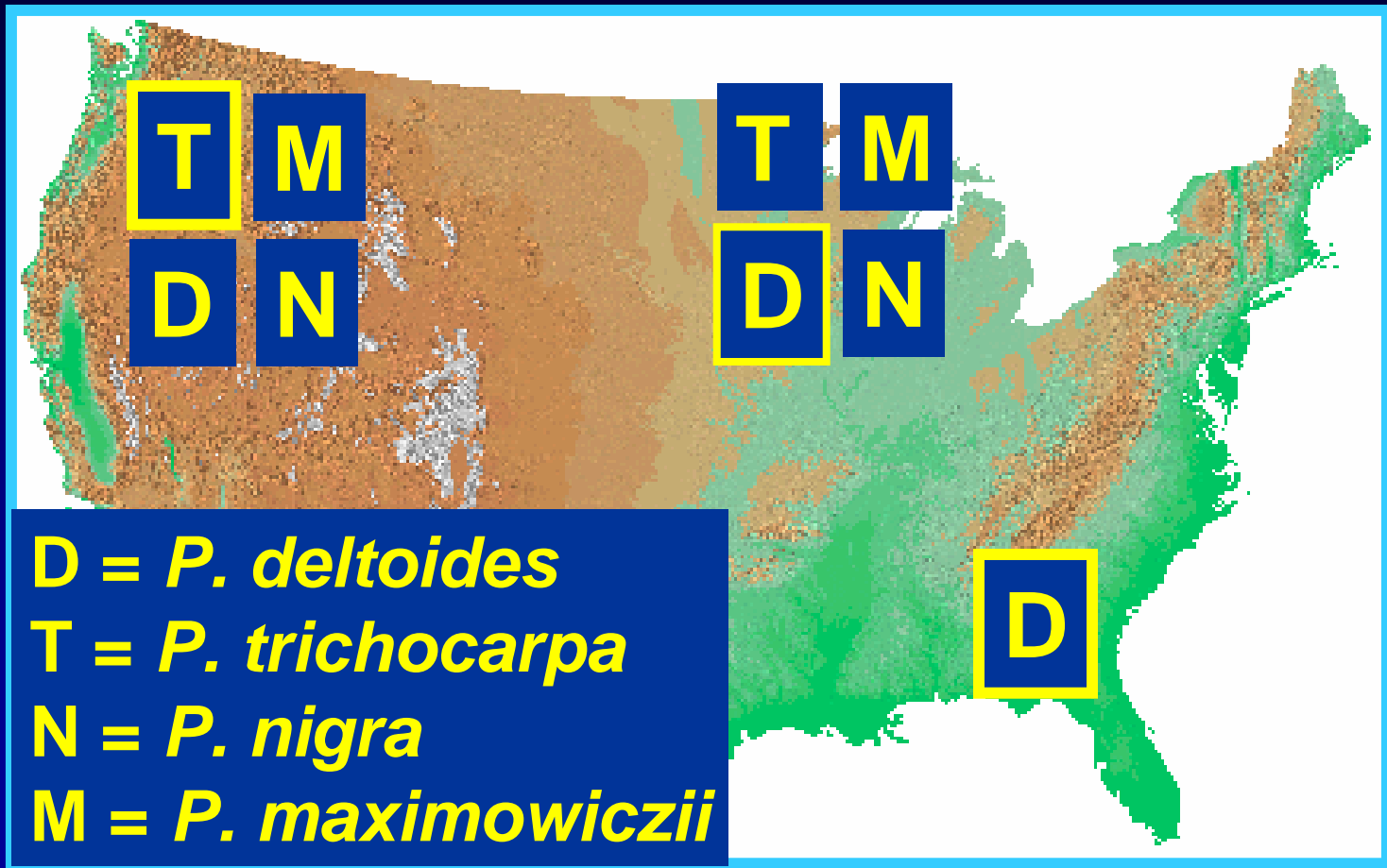
- *Populus* species and genotypes
- Field Research Site
- Field Experiment
- Ongoing Projects



## Species Used

- ***Populus deltoides* Bartr. ex Marsh**
  - Eastern cottonwood (native to US Northern Region, yield, disease/pest resistance)
- ***Populus nigra* L.**
  - European black poplar (yield, rooting)
- ***Populus trichocarpa* Torr. & Gray**
  - Western black cottonwood (native to PNW, yield, rooting)
- ***Populus maximowiczii* A. Henry**
  - Japanese poplar (yield, rooting)

# Primary Species Used



## Genotypes Studied

*P. deltoides* × *P. nigra* L. (DN)

4 genomic groups

DN5

8 clones

*P. deltoides* × *P. maximowiczii* (DM)

DM115, 14104, 14106

*P. nigra* × *P. maximowiczii* A. Henry (NM)

NM2, NM6

(*P. trichocarpa* × *P. deltoides*) × *P.*  
*deltoides* (BC<sub>1</sub>)

13460, 14018

# Oneida County Landfill

- leachate composition changes
- contaminant levels generally decrease over time
- economically-sound and environmentally-sustainable option
- alternative treatment is to utilize the leachate as an irrigation source for species and interspecific hybrids of the genus *Populus*





## Field Studies: Hypotheses and Objective

### Hypotheses:

After two seasons of irrigation with water or leachate, differences will exist among clones for:

- height, diameter, leaf area, and biomass
- phytoremediation capability
- number and size of basal/lateral roots

### Objective:

The overall objective of this research is to identify clones with elevated biomass and elevated  $\text{Na}^+$  and  $\text{Cl}^-$  levels.

	2005		2006	
	Control	Leachate	Control	Leachate
pH	6.2 ± 0.1	8.8 ± 0.0	6.3 ± 0.2	8.4 ± 0.2
EC* (mS cm <sup>-1</sup> )	0.2 ± 0.1	6.2 ± 0.5	0.1 ± 0.0	9.4 ± 0.2
Na <sup>+</sup> (mg L <sup>-1</sup> )	na	690 ± 10	2.4 ± 0.0	1200 ± 0
Cl <sup>-</sup> (mg L <sup>-1</sup> )	nd	1093 ± 178	1.8 ± 1.8	1250 ± 50
N (mg L <sup>-1</sup> )	0.92 ± 0	598 ± 86	0.86 ± 0	685 ± 25

\*Electrical conductivity

## Irrigation 2005 & 2006

- During both field seasons the treatment application modified by precipitation events to reduce leaching into groundwater.
- 3.8 L per tree per irrigation event during 2005
- 1.9 kL per treatment (64 trees) for the growing season – 2005
- 22.7 L per tree per irrigation event during 2006
- 17.4 kL per treatment (64 trees) for the growing season – 2006
- N, P, K was added to water to eliminate fertilization effects



# Field Study Methods

- test the performance of 8 genotypes
- 8 blocks  $\times$  8 clones  $\times$  2 treatments = 128 experimental units
- destructive harvest two years after planting
- height, diameter, volume
- leaf, woody, and root dry mass
- analyze each combination of clone and treatment for concentration of the following elements in leaf, woody, and root tissue: N, P, K, Ca, Mg, S, Zn, Mn, B, Cu, Fe, Al, Pb, Na, and Cl
- evaluate basal and lateral roots

# Landfill Field Study - August 12, 2005

	2005	
	Control	Leachate
Height (cm)	36.5 ± 4.1	45.2 ± 4.0
Diameter (cm)	0.4 ± 0.04	0.5 ± 0.04
Volume (cm <sup>3</sup> )	12.5 ± 5.4	23.7 ± 5.3





# Landfill Field Study - August 12, 2006

	2006	
	Control	Leachate
Height (cm)	154.6 ± 7.8	143.9 ± 7.7
Diameter (cm)	2.5 ± 0.2	2.3 ± 0.2
Volume (cm <sup>3</sup> )	1331 ± 229.7	964.2 ± 227.4

22% mortality  
6% (NM6) to 56% (13460)



# Preharvest

- leaf area
- syllepsis
- soil sampling (3 samples/tree)



## Harvest Stage I

- harvest entire aboveground portion of tree
- take to greenhouse
- leaf and woody dissection





# Plant Dissection – Leaves and Woody

- separate leaf tissue from woody tissue
- oven dry plant components at 70 °C
- bag leaves and woody tissue for testing



## Harvest Stage II

- root harvest for tissue testing, root characterization, and biomass evaluation
- uniform volume of soil removed with each experimental unit (0.28 m<sup>3</sup>)







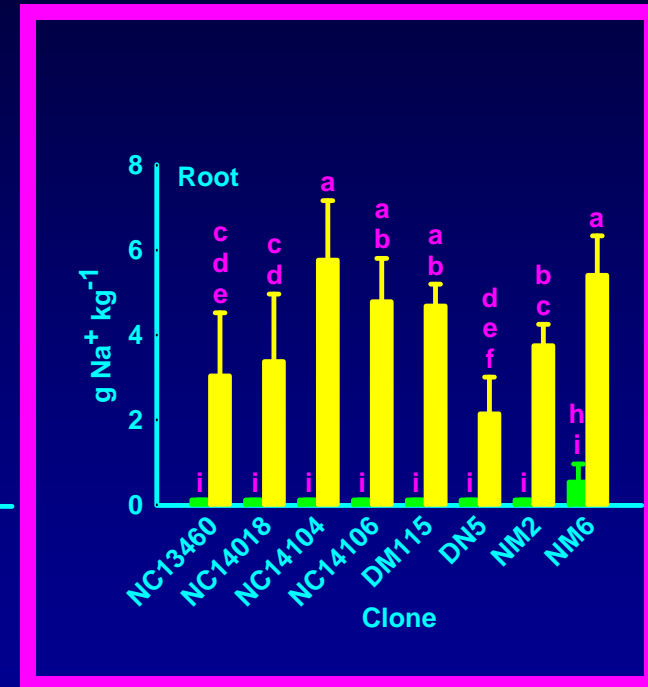
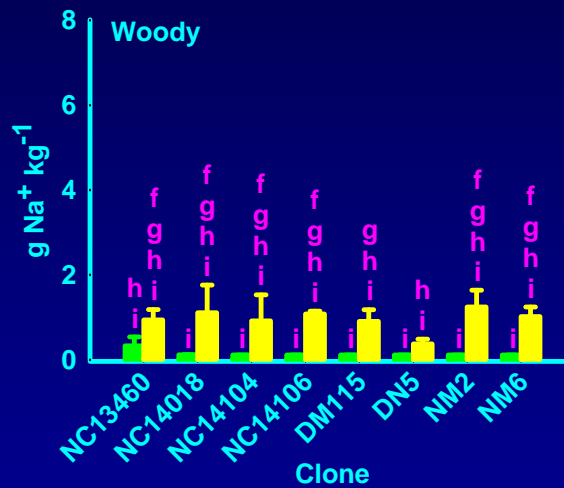
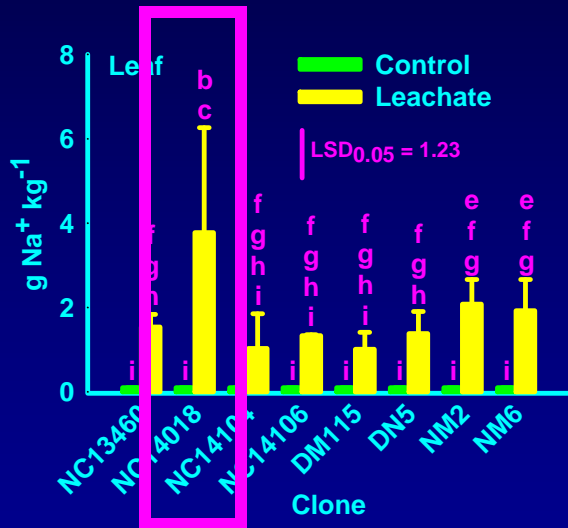


## Plant Dissection - Roots

- wash roots
- collect measurements
- oven dry root components at 70 °C
- bag for tissue testing

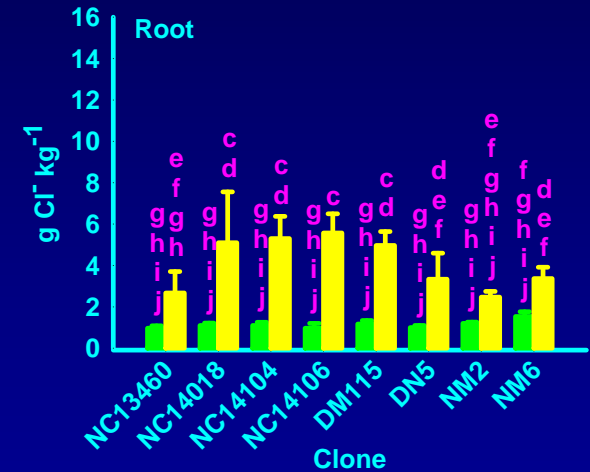
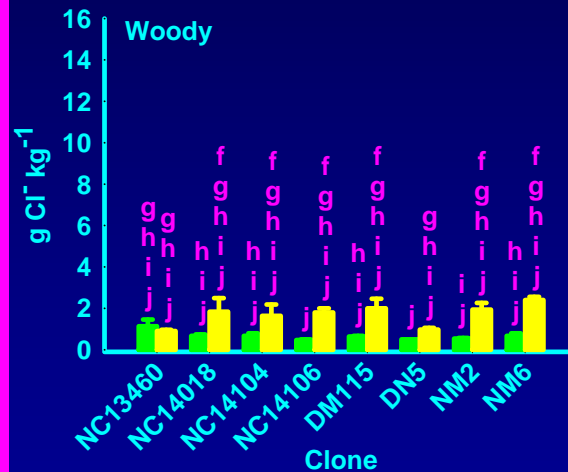
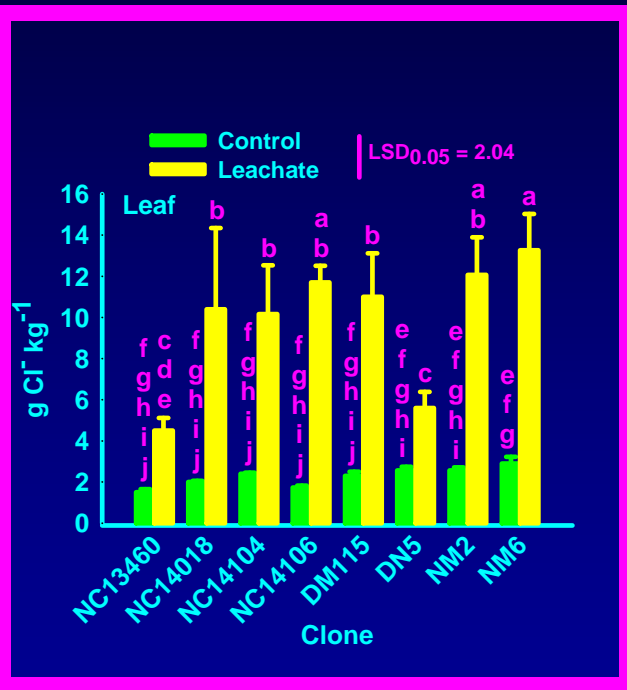


# Results - Sodium Concentration of Leaf, Woody, and Root Tissue

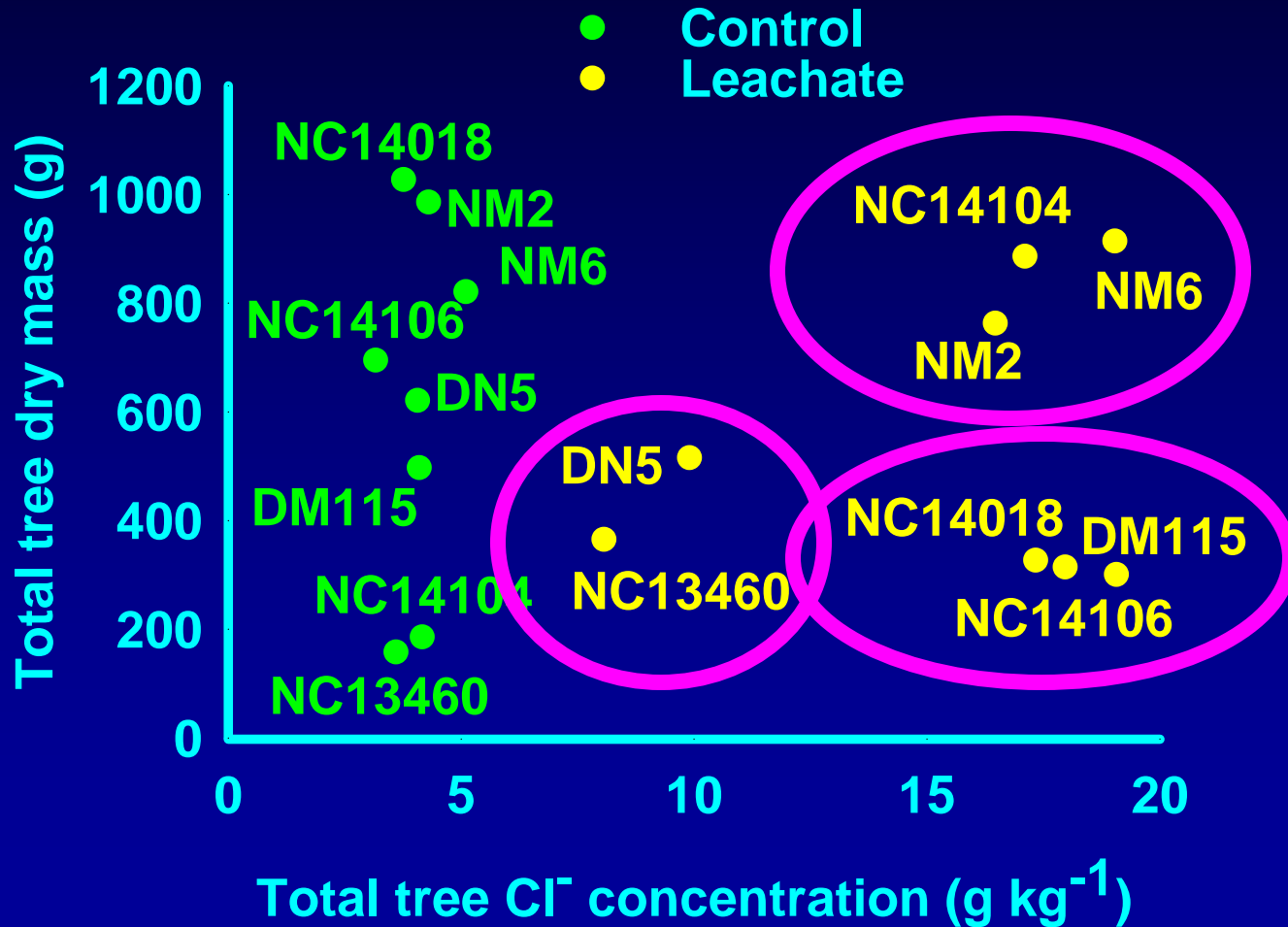


NC14018

# Results - Chloride Concentration of Leaf, Woody, and Root Tissue



# Results – Total Tree Biomass Versus Chloride Concentration



# Results – Chloride Uptake

## Second Growing Season

Clone	Total Cl <sup>-</sup> (Woody) (kg ha <sup>-1</sup> )	Total Cl <sup>-</sup> Applied (kg ha <sup>-1</sup> )	Percent Removed	Percent Removed Compared to Mean
NC13460	2.6	95.5	3	28
NC14018	6.4	95.5	7	70
NC14104	17.5	95.5	18	192
NC14106	6.1	95.5	6	67
DM115	7.0	95.5	7	77
DN5	4.1	95.5	4	45
NM2	13.7	95.5	14	151
NM6	19.9	95.5	21	218
Across Clones	9.1	95.5	10	100



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# Results – Chloride Uptake

## Second Growing Season

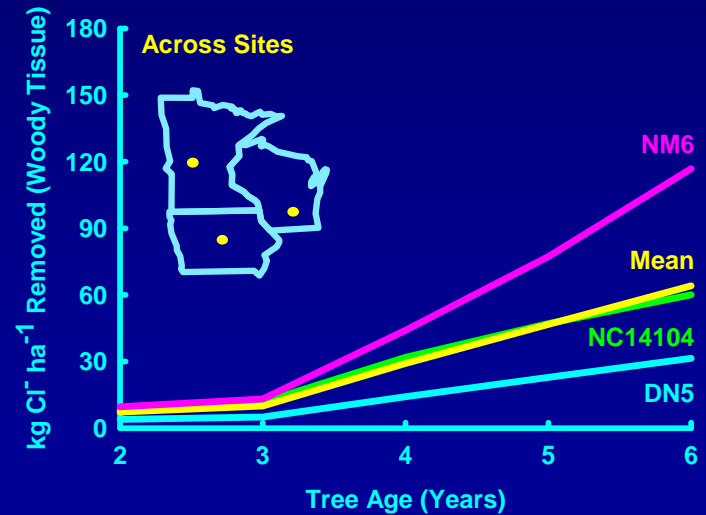
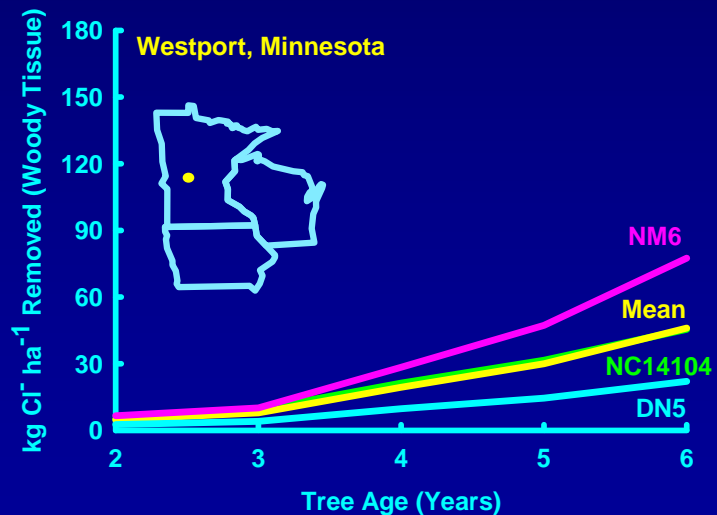
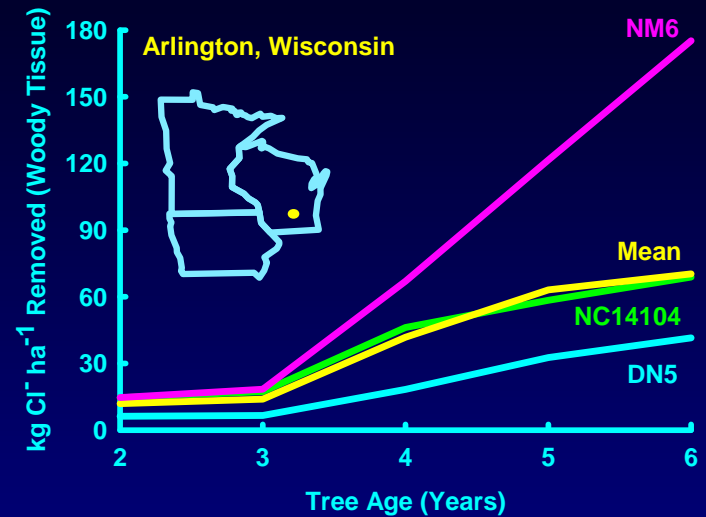
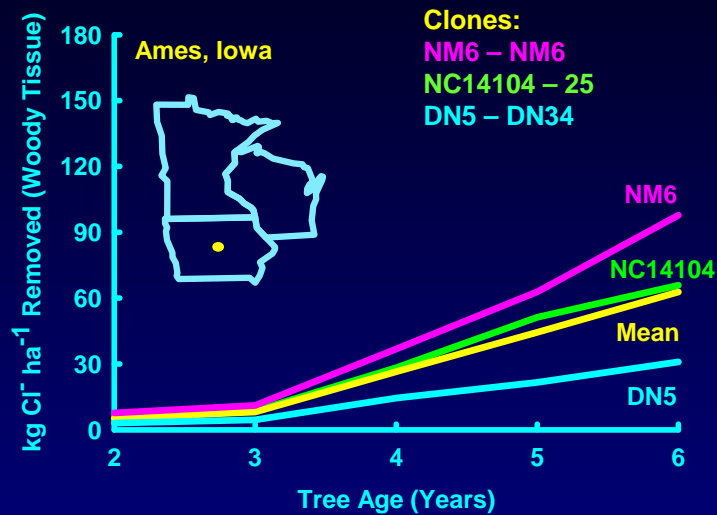
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# Results – Chloride Uptake

## Second Growing Season

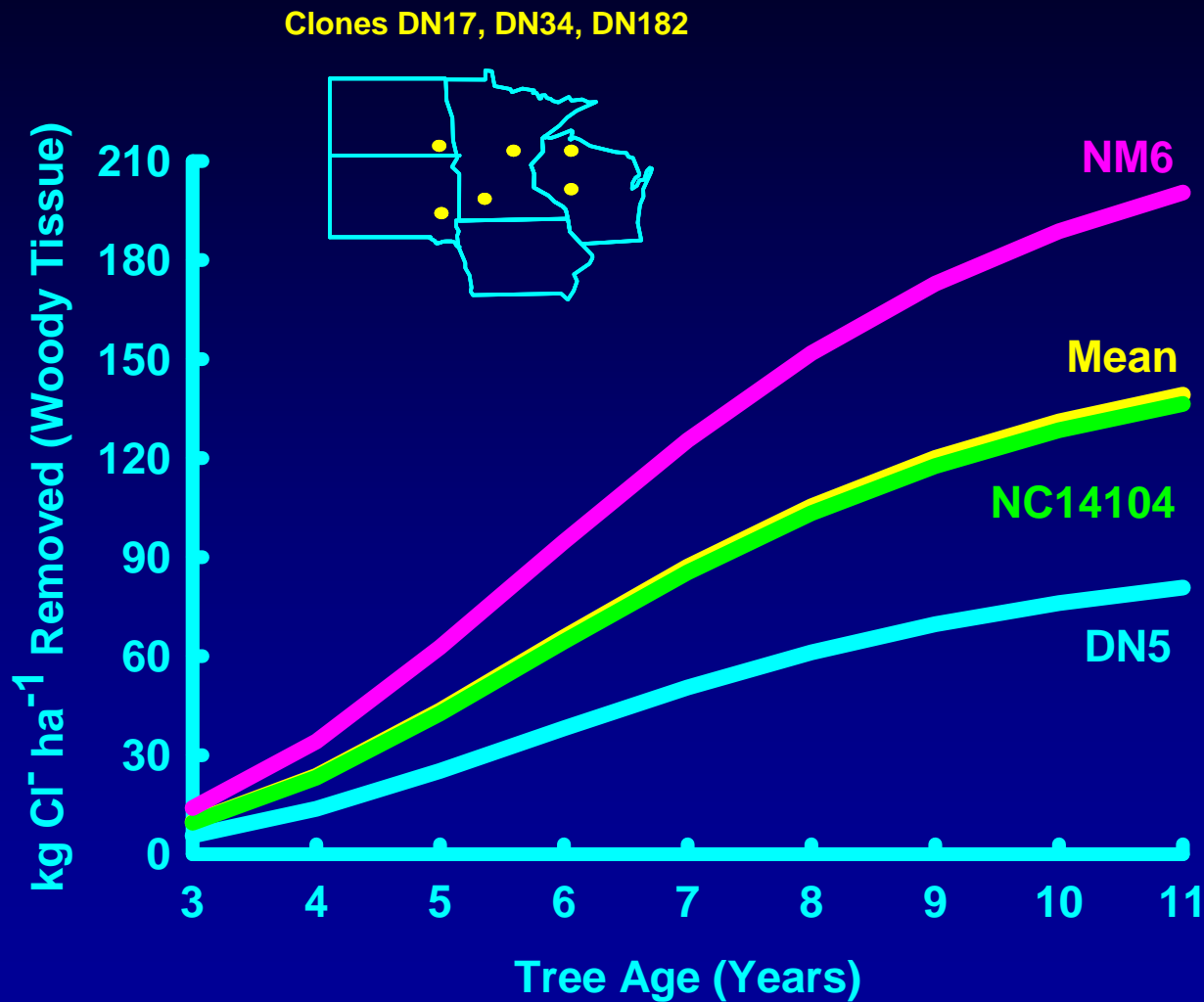
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# Results – Potential Chloride Uptake



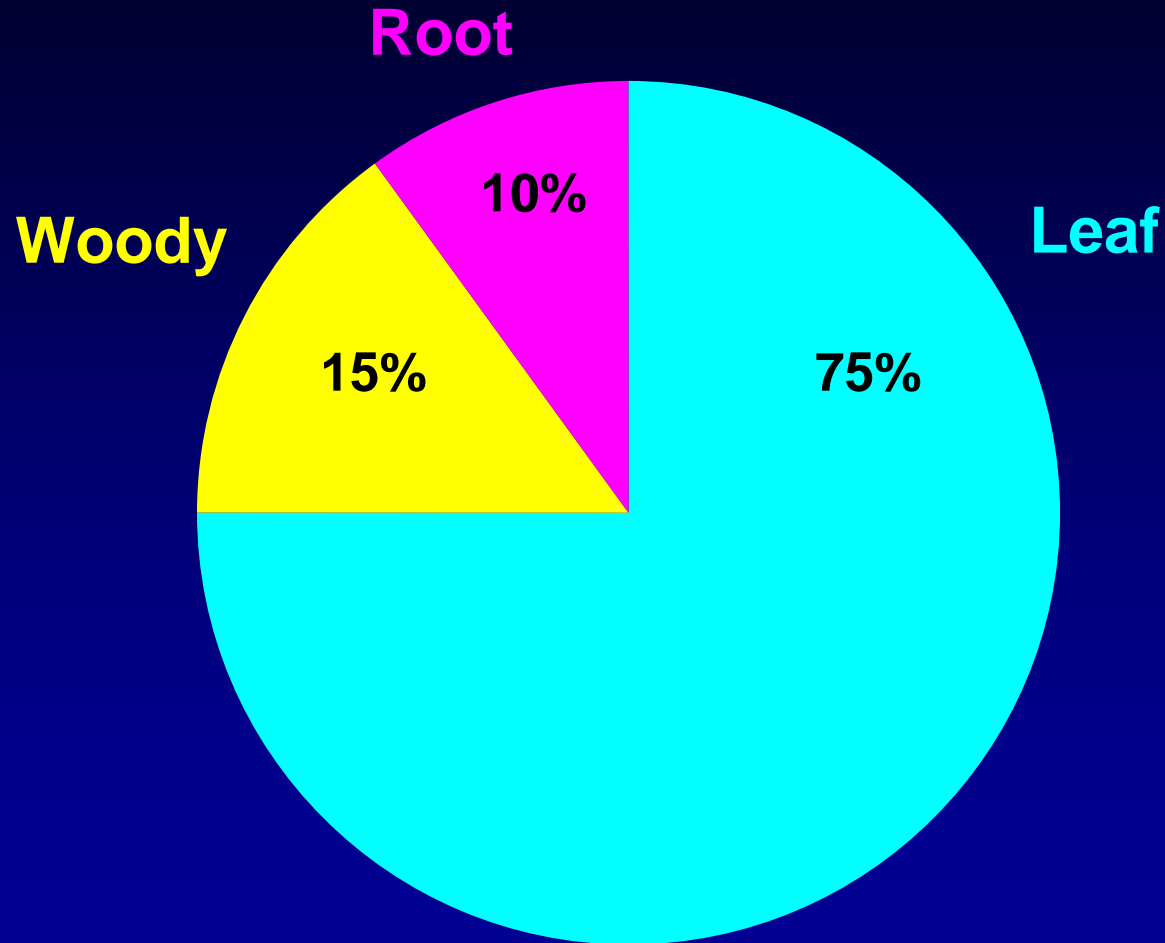
Source of biomass data: ZALESNY JR., R.S. (unpublished data from regional field testing program); RIEMENSCHNEIDER, D.E., BERGUSON, W.E., DICKMANN, D.I., HALL, R.B., ISEBRANDS, J.G., MOHN, C.A., STANOSZ, G.R., TUSKAN, G.A. 2001. Poplar breeding & testing strategies in the north-central U.S.: demonstration of potential yield & consideration of future research needs. For. Chron. 77: 245-253. Biomass =  $6.16 - 2.23(\text{dbh}) + 0.353(\text{dbh}^2)$  ( $r^2 = 0.98$ ,  $P < 0.0001$ ,  $n = 152$ )

# Results – Potential Chloride Uptake



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# Results – Uptake of Chloride into Tissues



Percentages based on estimates of  $\text{kg Cl}^- \text{ha}^{-1}$  removed.

## Overall Conclusions

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- leachate analysis throughout rotation
- leachate was not detrimental for most clones
- generalist / specialist genotypes
- entire rotation
- rooted stock – *P. deltoides*

## **Practical Implications**

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- **Phytoremediation merges the sciences of plantation forestry with environmental clean-up**
- **Ecological benefits**
  - **remove excessive nutrients and chemicals**
  - **harvestable product**
  - **carbon sequestration**



# Acknowledgments

- Iowa State University - Department of Natural Resource Ecology and Management
- Institute for Applied Ecosystem Studies and Dr. Neil Nelson
- Sigma Xi



A close-up photograph of several green leaves with serrated edges. The leaves are vibrant green with prominent veins. Some leaves show signs of damage, including small holes and brown spots. A white rectangular box with a blue border is centered over the image, containing the word "Questions?" in pink text.

Questions?