

# Research and Monitoring to Improve Selective Control of Invasive Aquatic Plants in WI

**Michael D. Netherland**  
Research Biologist  
ERDC – Gainesville, FL



BUILDING STRONG®



*Innovative solutions for a safer, better world*

# Cooperative Research

- The US ARMY ERDC and WI DNR have been working under a multi-year Cooperative Research & Development Agreement (CRADA)
- CRADA Focused On:
  - ▶ Monitoring of large-scale herbicide applications.
  - ▶ Long-term impacts of management on SAV
  - ▶ Addressing anecdotal management observations
  - ▶ Small-scale research to enhance field observations



BUILDING STRONG®

**ERDC**

*Innovative solutions for a safer, better world*

John Skogerboe – was the major ERDC collaborator for this project.



BUILDING STRONG®

**ERDC**

*Innovative solutions for a safer, better world*

# Management Options for Submersed Invasive Plants are Limited

EPA registered herbicides



Grass Carp – SE Reservoirs



Mechanical Harvesting  
(hand pulling, diver suction dredge)



Environmental Extremes



Selective Biocontrol



Do Nothing



BUILDING STRONG®



*Innovative solutions for a safer, better world*

# 14 Herbicides Labeled for Aquatic Use

(~223 labeled for terrestrial use)

Copper (1900's)

Endothall (1960)

Glyphosate (1977)

2,4-D (1950's)

Diquat (1962)

Fluridone (1986)

Triclopyr (2002)

Imazapyr (2003)

Carfentrazone (2004)

Imazamox (2008)

Bispyribac (2011)

Penoxsulam (2007)

Flumioxazin (2010)

Topramazone (2013)

Blue = Plant Enzyme Specific Inhibitors



BUILDING STRONG®

**ERDC**

*Innovative solutions for a safer, better world*

# Respect for Agency Resource Managers

- Make decisions that will make someone unhappy
  - ▶ Even no decision = unhappy stakeholders
- Nexus between science, public expectations, political & internal agency pressure
- Make decisions with imperfect information
  - ▶ Research support is a critical function



# Respect for Applicator/Managers

- Decisions must make customer/stakeholders and regulators happy
  - ▶ A Difficult Feat
- Create & then try to meet customer expectations
  - ▶ This is vetted through a permitting process
  - ▶ Research is sometimes viewed as “interfering”
- Treatments impacted by environmental variables
  - ▶ most treatments provide acceptable control
    - Margin for error



# Social Dimension: We often treat where people live & recreate



## Milfoil is foiled by herbicide on Minnetonka bays

As milfoil spread, so does interest in using chemicals to control it on Lake Minnetonka.

By [LAURIE BLAKE](#), Star Tribune





# Key Issues in WI

- The most problematic species are curlyleaf pondweed and Eurasian watermilfoil
  - ▶ Hybrid watermilfoil
- WI DNR – decision to focus on 2,4-D and endothall as primary large-scale tools
  - ▶ Diquat, fluridone, triclopyr
- Monitoring behind operational treatments in the agency funded grant program



# Addressing 50+ year Old Weed Problems with Tools that have been around for 50+ years

Is innovation still possible ?



BUILDING STRONG®



*Innovative solutions for a safer, better world*

# Herbicide Studies Conducted Across a Broad Scale



Scaling up or down



## Impacts on Emergents



## Biotypes, ecotypes hybrids, resistance

### Cabomba Populations

Red

Green

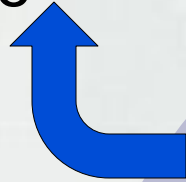


Aquarium



solut

Operational  
Guidance



Small-scale  
Research

Unexpected Results Can  
Occur Anywhere in Process

Research  
Hypothesis:  
Observation  
Or Insight

Field  
Monitoring

Improved  
Field Study  
Design



Asking Better  
Research Questions



Improved  
Small-Scale  
Study  
Design



BUILDING STRONG®

**ERDC**

*Innovative solutions for a safer, better world*

Mesocosm Testing has been crucial in developing many of our insights regarding plant response to herbicides



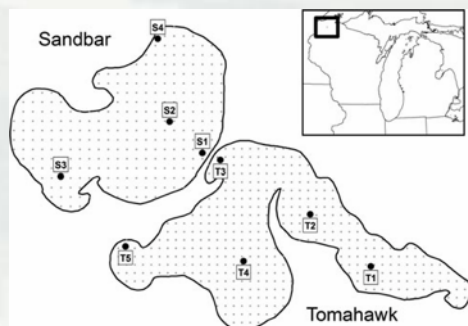
Seed Research



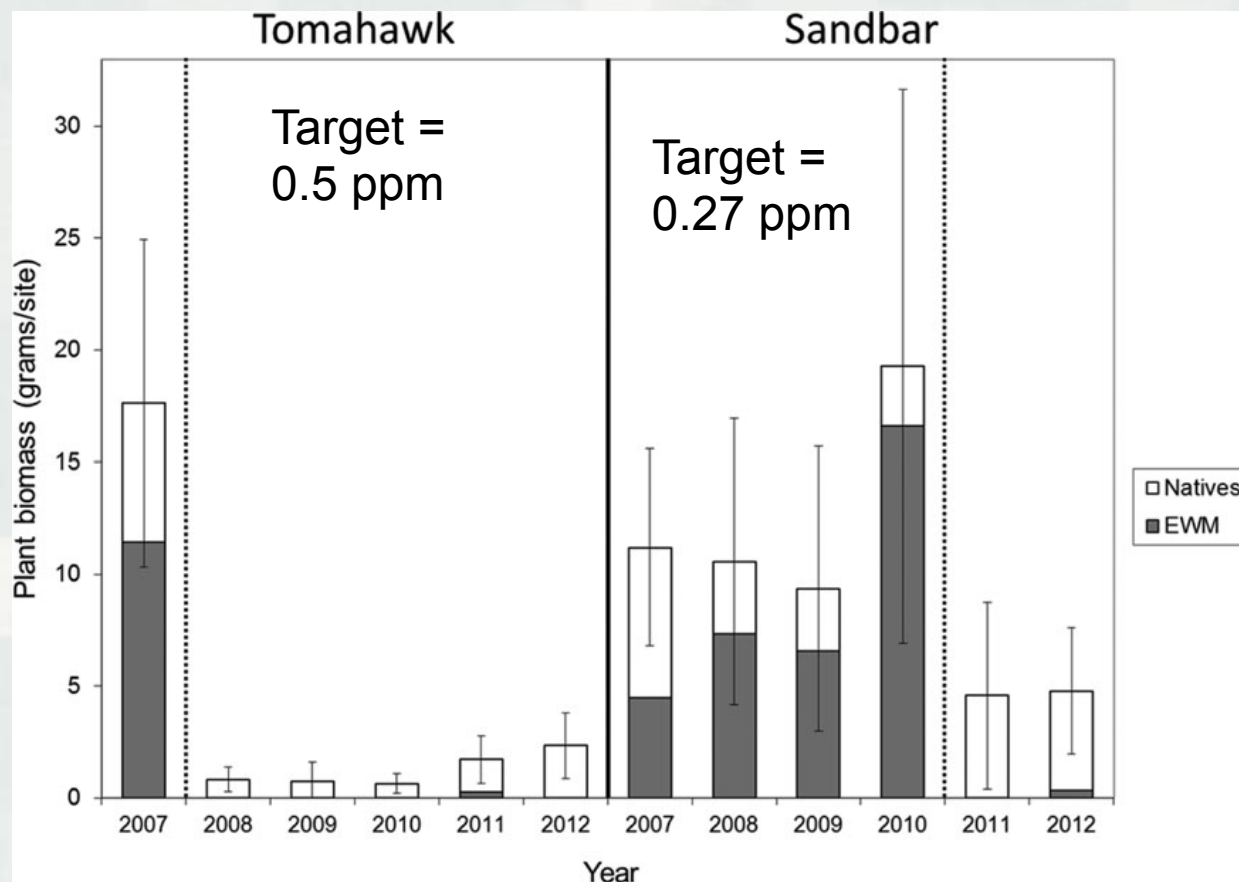
**ERDC**

ns for a safer, better world

# An Early Project Was Very Informative



Each lake ~ 150 acres in size

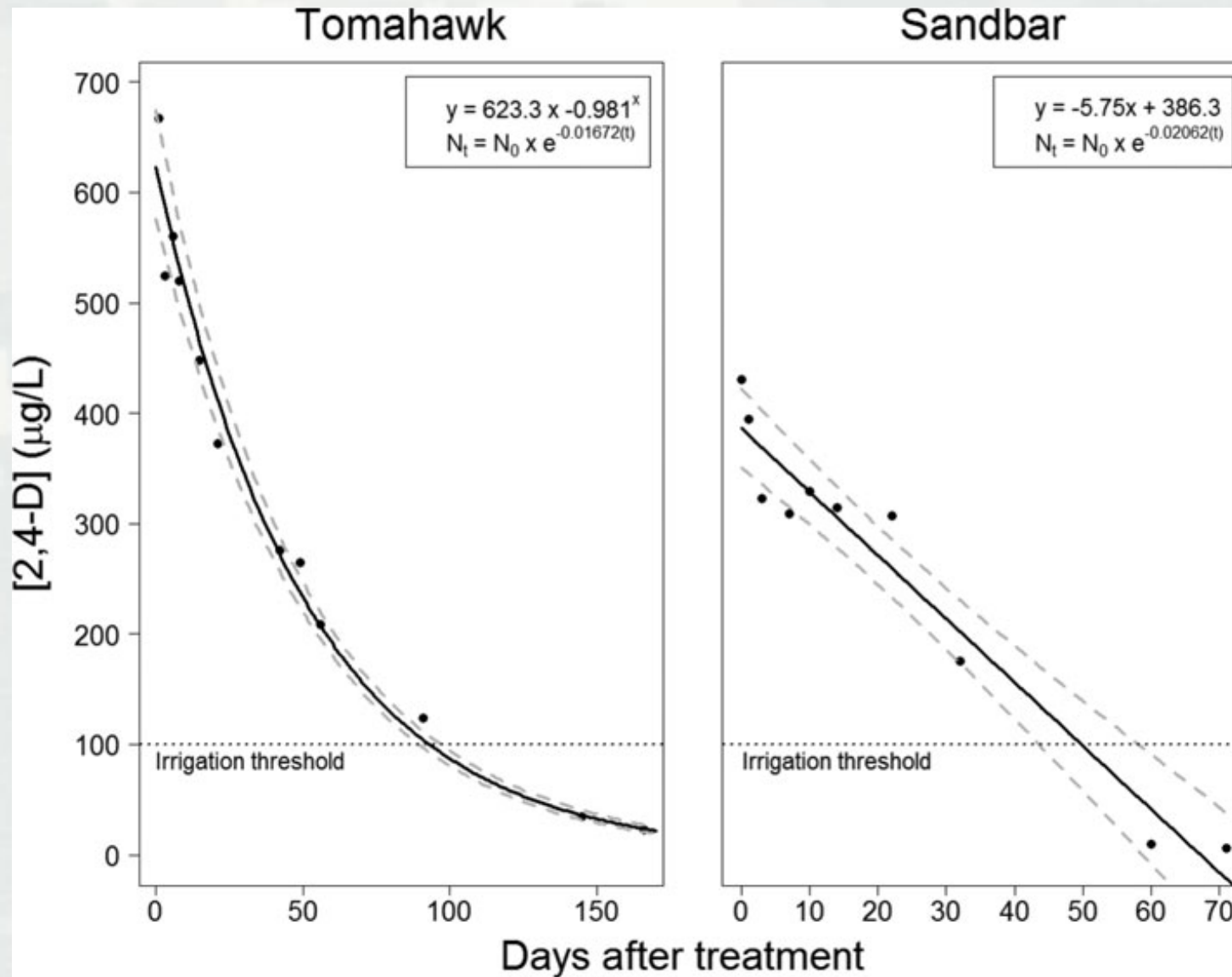


From Nault et al. 2014

**ERDC**

BUILDING STRONG®

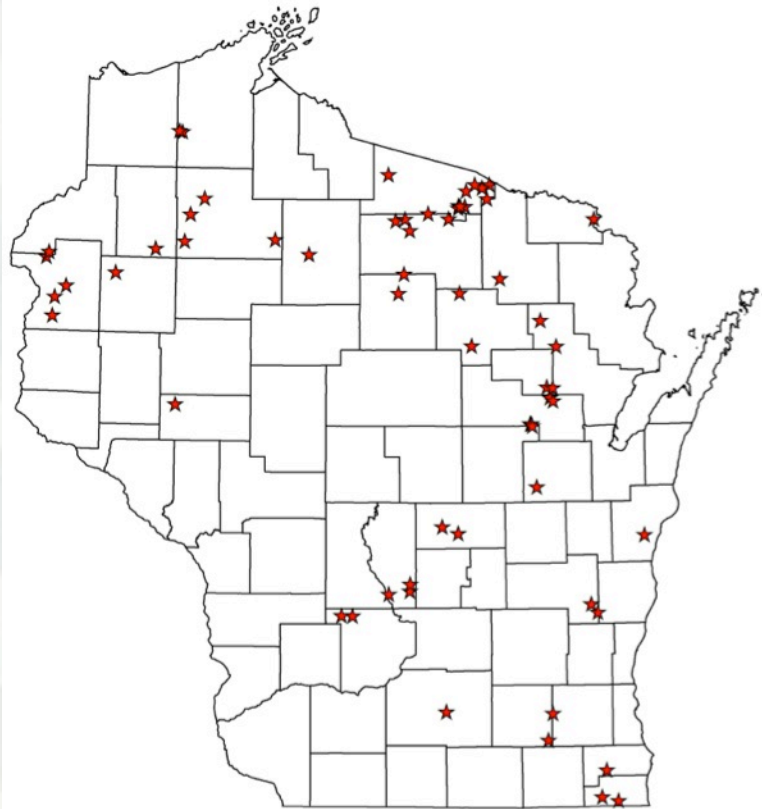
*Innovative solutions for a safer, better world*



From Nault et al. 2014



# Herbicide Monitoring Project Lakes



WI and FL - only states that have sustained long-term operational monitoring

Objective is to improve use patterns & document effective & selective strategies

FL FWC just approved additional 4 year monitoring program



BUILDING STRONG®



*Innovative solutions for a safer, better world*

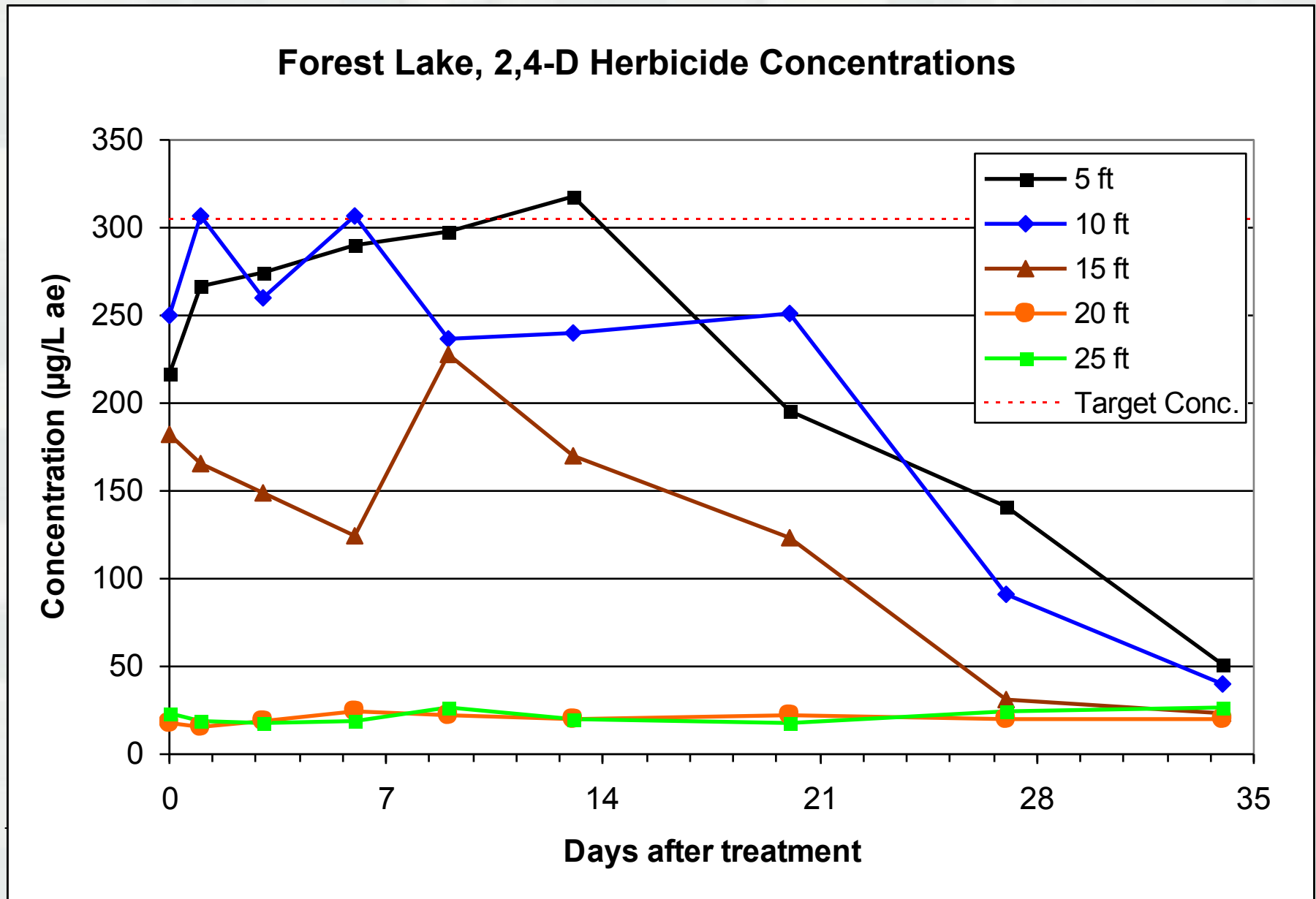


# Some Lessons Learned

- Patterns of herbicide degradation can be used to explain treatment outcomes
  - ▶ Large-scale – generally predictable patterns
  - ▶ Small-scale – highly variable patterns impact efficacy
- Importance of thermoclines and timing
  - ▶ Can use this information strategically
- Liquids vs. Granules, Hybrids, Mapping
- Addressing Anecdotal Observations/statements

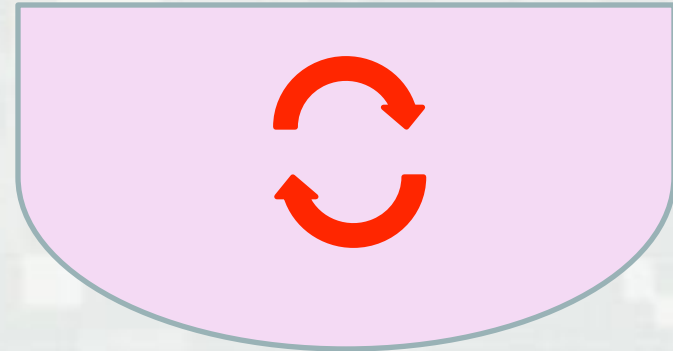
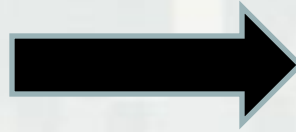


# Lakewide Dissipation

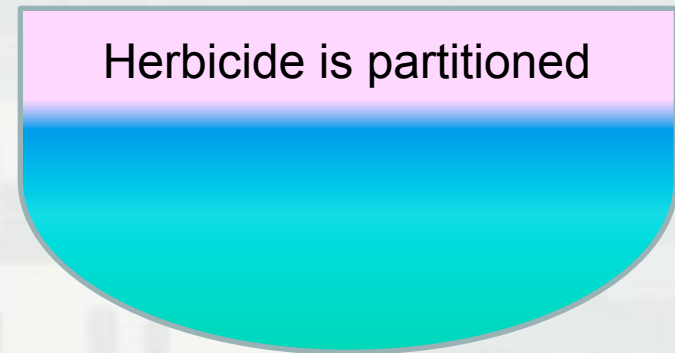
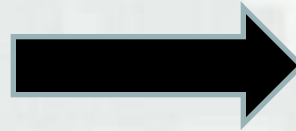
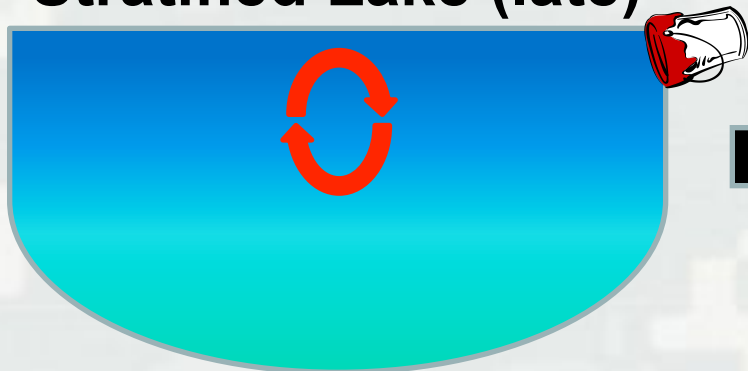


# Lakewide Dissipation Patterns

**Mixed Lake (early)**



**Stratified Lake (late)**



**Economics, Total Amount of Herbicide Used,  
Timing, Timing, Timing**

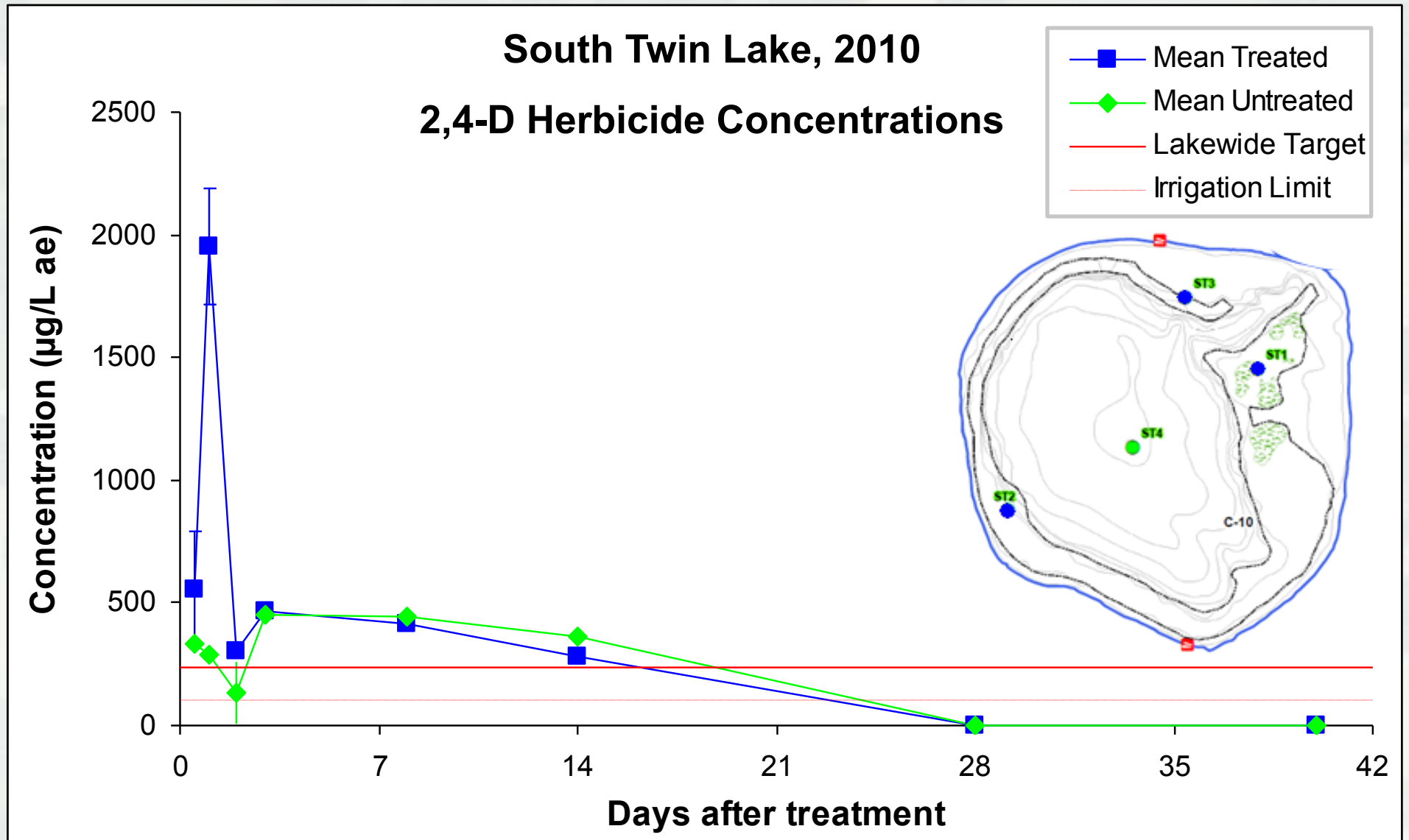


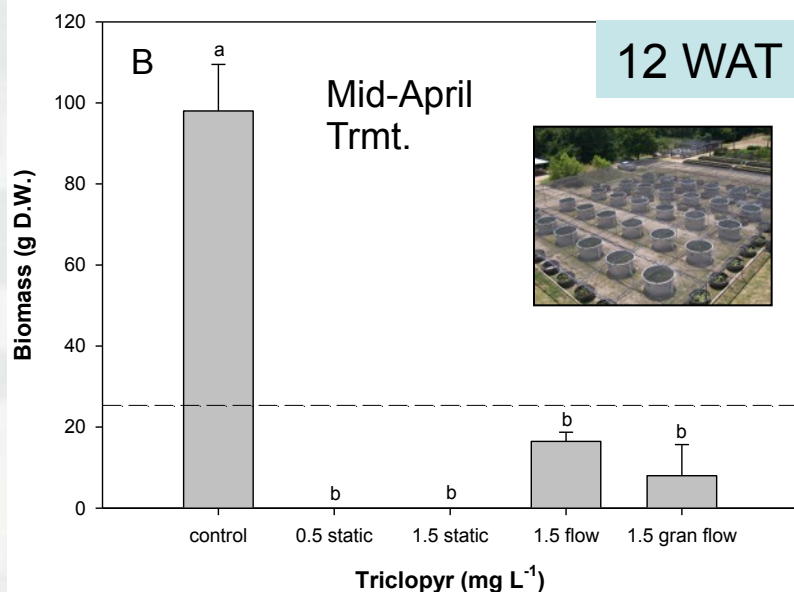
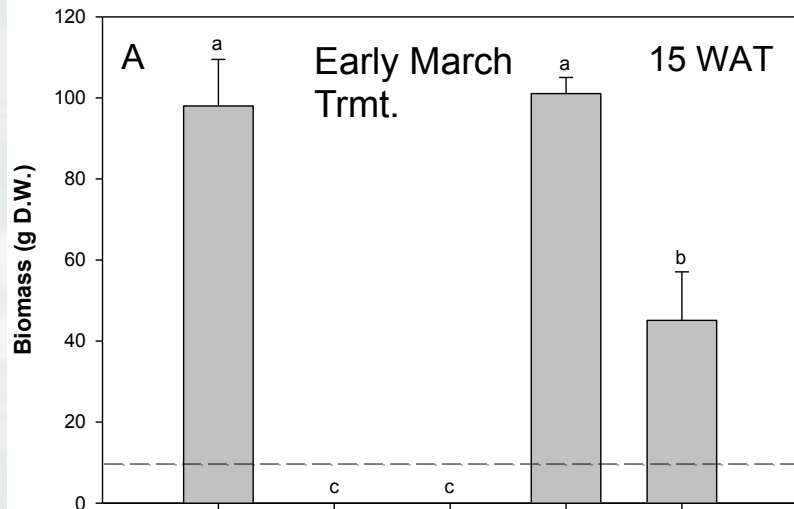
BUILDING STRONG®

**ERDC**

*Innovative solutions for a safer, better world*

# Lakewide Dissipation





EWM & Timing – Whole-Lake  
Or whole bay 2,4-D or triclopyr

Early season – highly effective  
Late season – highly effective

Selectivity differences are small

EWM and Timing – small or spot

Early season – less effective  
Late season – more effective

**More Tissue Available for Uptake**



Netherland and Glomski (2014)

BUILDING STRONG®



*Innovative solutions for a safer, better world*

# Plants and Herbicide Uptake

- Many people state the plants absorbed or “took up” a large portion of the herbicide”
- This is NOT the case
- Multiple lines of evidence refute this
  - ▶ Radiolabel studies – 1 to 3% of herbicide in plants
  - ▶ Mesocosm studies – herbicide loss not related to plant density
  - ▶ Field studies – whole lake (fluridone, 2,4-D, endothall)
    - Target rates maintained for multiple days
    - Plants DO NOT re-release phytotoxic conc. of herbicide



# Numerous Claims and Counter-claims regarding granules vs. liquid strategies

The majority of treatments work well and it is difficult to distinguish between most granular and liquid applications



BUILDING STRONG®



*Innovative solutions for a safer, better world*

# A recent focus on spot applications

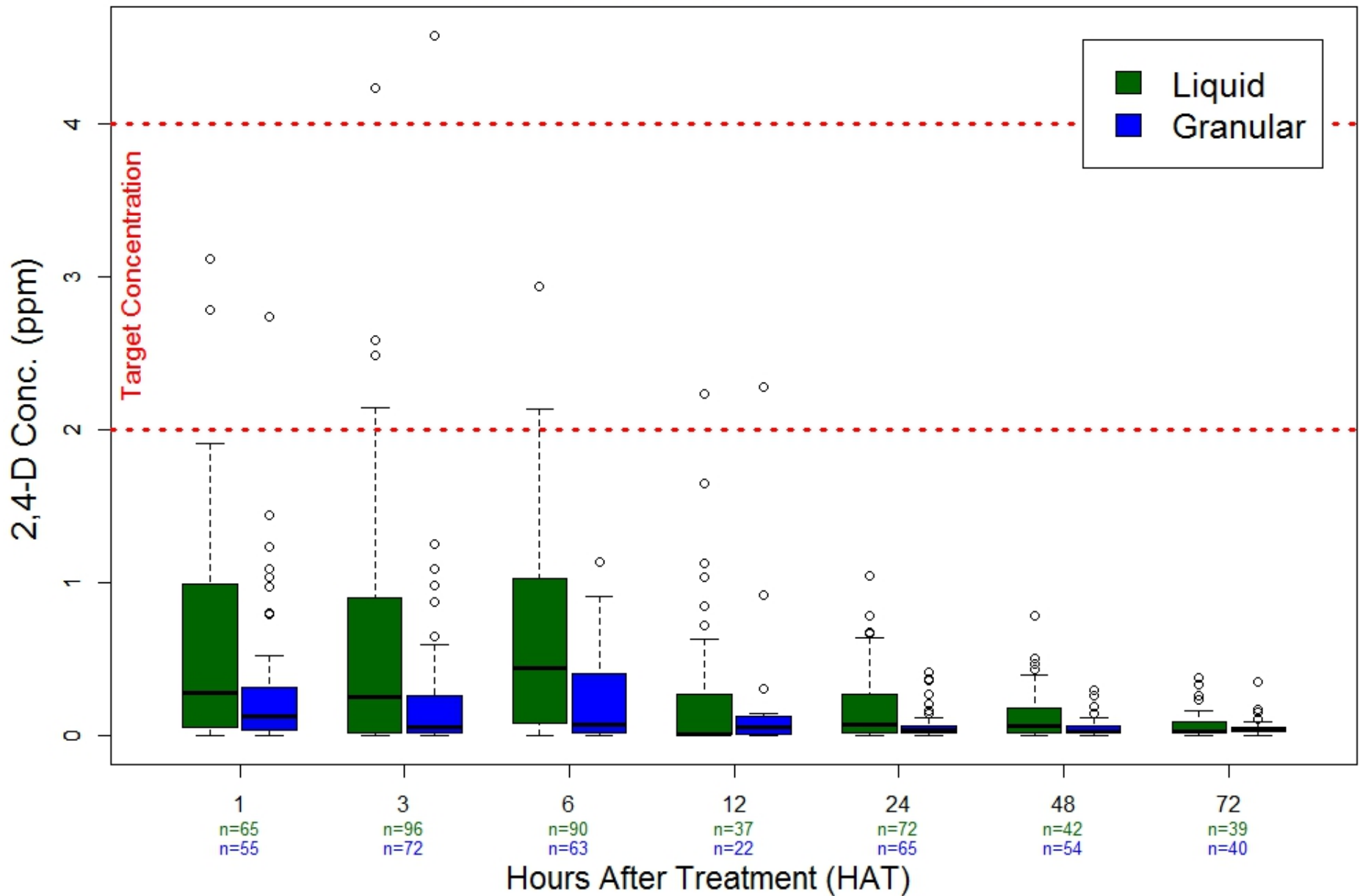
- Do granulars or liquids provide superior performance for spot applications ?
- Multiple confounding issues with comparing field treatments and proving superior performance
  - ▶ Timing, scale, hydrodynamics
- Is root uptake a possible mechanism for granular treatments ?





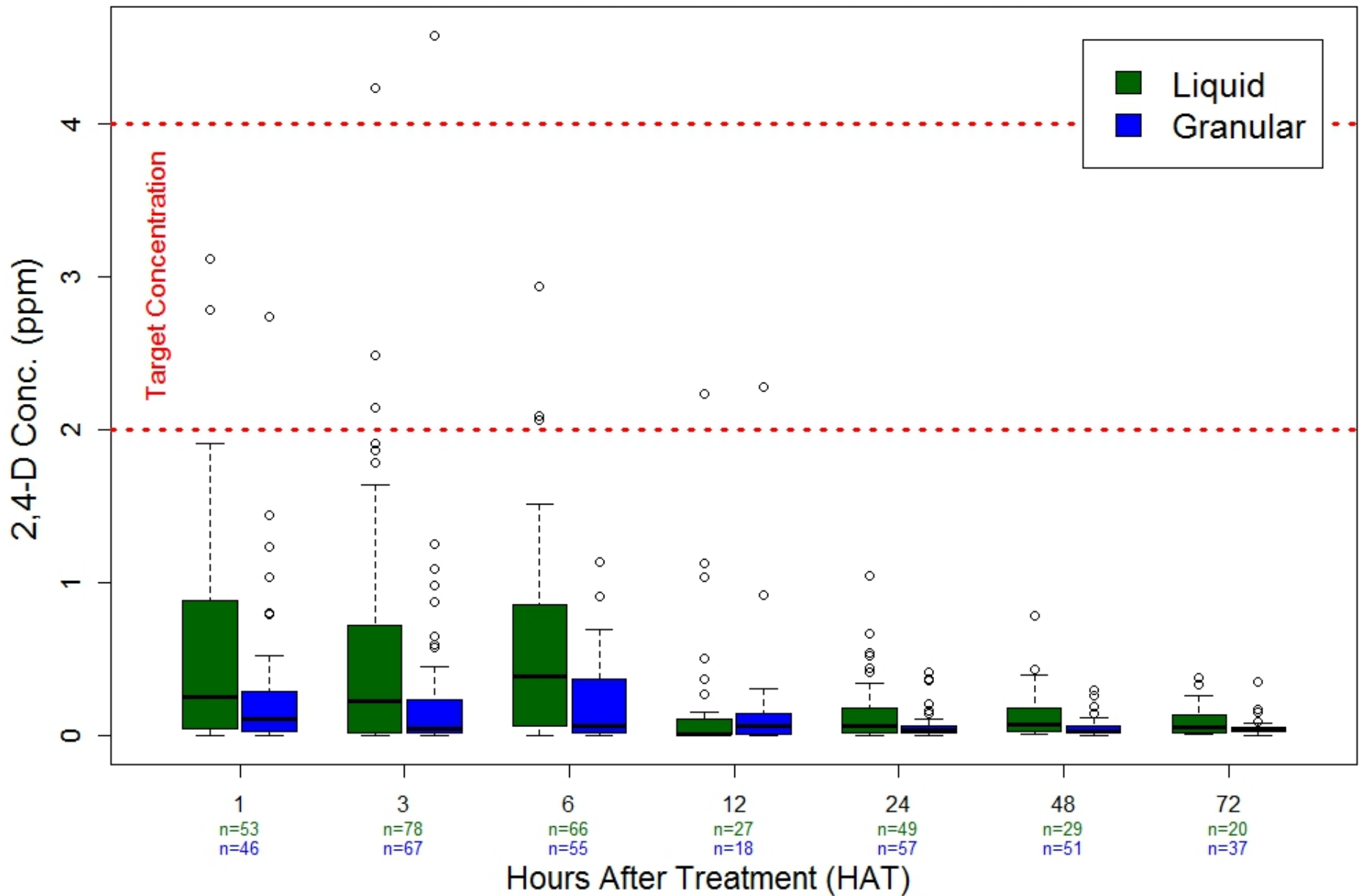
# Observed [2,4-D] vs. Hours After Treatment

## Liquid vs. Granular Small Scale Treatments



# Observed [2,4-D] vs. Hours After Treatment

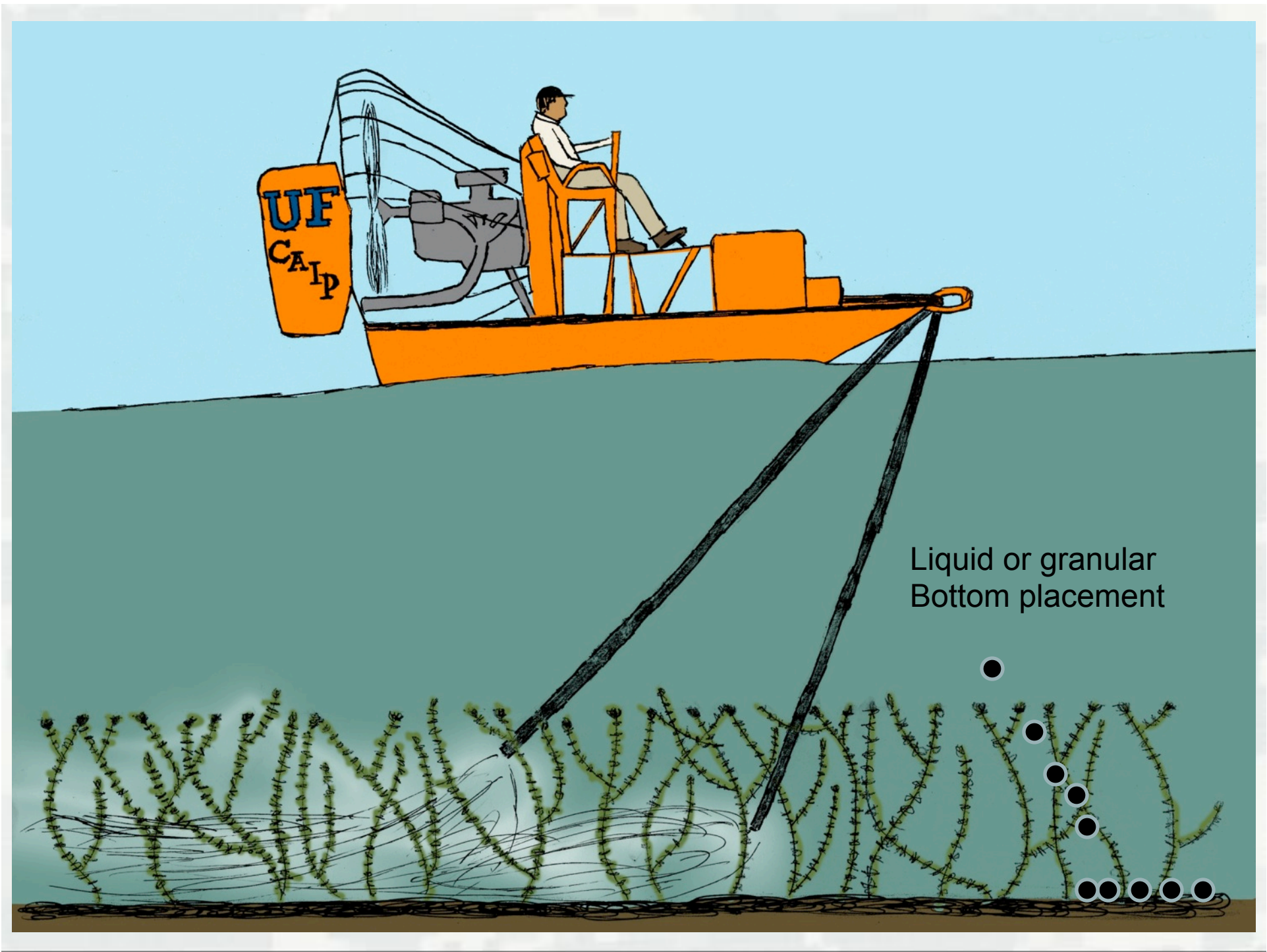
Liquid vs. Granular Small Scale Treatments  $\leq 10$  Acres



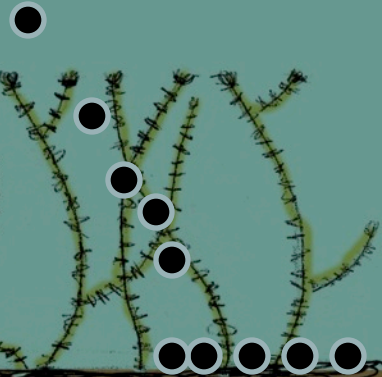
# Comparative Application Techniques

- It is difficult to generate useful field comparison data for different application techniques ?
  - ▶ Herbicides are good at killing target plants
  - ▶ When a treatment works, it may or may not be related to the application strategy
    - Field data is often confounding
    - It's all about the CET
  - ▶ When the scale gets big enough, just about every technique works





Liquid or granular  
Bottom placement



# OBJECTIVE

- Develop mesocosm methods that simulate unique exposure pathways observed in the field
- Research Questions
  1. *Does EWM respond to granular placement or root uptake of the herbicide from porewater ?*
    1. *WI DNR studies confirm short-term higher porewater concentrations*
  2. *How does EWM respond to localized short-term exposure of herbicides ?*



# Does root/rootcrown uptake of herbicides provide control of EWM ?

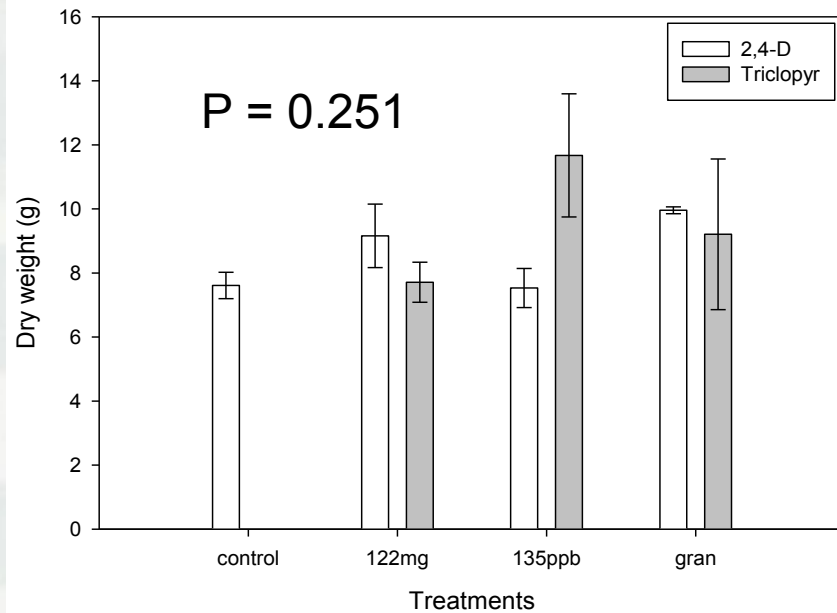
- 2X Max rates applied directly to sediment or as granules to sediment surface next to root crowns
  - Granules concentrated in a small area
- EWM active & well-established - high flow env.
  - 12 hour half-life in 900 L tanks
  - A liquid trmt. of 135 ppb/48 hrs also included



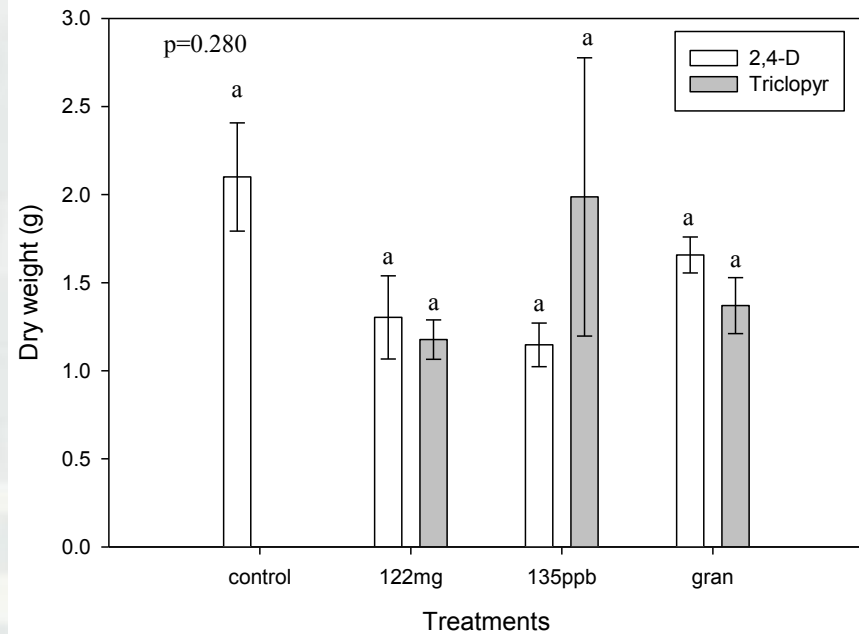
## Auxin symptoms observed through 1 week

NO CONTROL at 6 WAT

EWM shoot mass at 6 WAT with 2,4-D and triclopyr



EWM root mass at 6 WAT with 2,4-D and Triclopyr



BUILDING STRONG®

**ERDC**

*Innovative solutions for a safer, better world*

# Results

- Herbicide conc. in the water ranged between 50 & 124 ppb for 1 to 4 days post-treatment
  - Both porewater and granular treatments
  - Faster release of triclopyr vs. 2,4-D from granules
- Sediment porewater concentrations following injection ranged from 3 to 13 ppm from 1 to 5 d
- NO plant control was observed





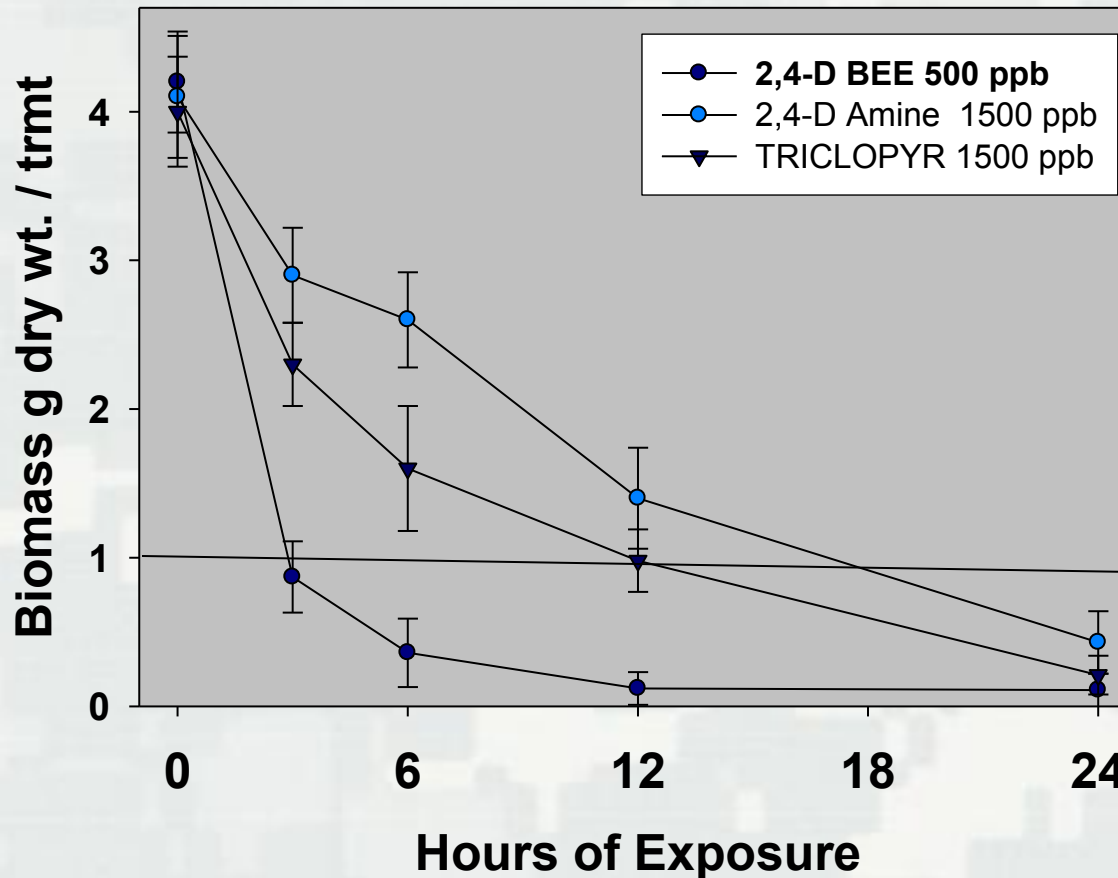
# Discussion

- Results suggest root uptake is an unlikely pathway for granular efficacy w/ auxin mimics
  - High porewater concentrations detected in field
- Concentrating granules near rootcrown was not effective under high water exchange conditions
  - 2,4-D ester or triclopyr amine granule
- More work needed to determine mechanisms for granular efficacy



# Is Efficacy Related to Ester vs. Amine Formulation

Clearly Demonstrated Ester was Superior on Variable Milfoil



BUILDING STRONG®

**ERDC**

*Innovative solutions for a safer, better world*

# We Have Not Been Able to Repeat this Observation With EWM

- Higher Alkalinity/pH in WI waters
  - ▶ Ester converts to acid upon release from granule
- Limited trialing with variable results
- Recent development of granular amines should help to improve head to head testing



# Hybrid Milfoils:

A Look Into Our Future

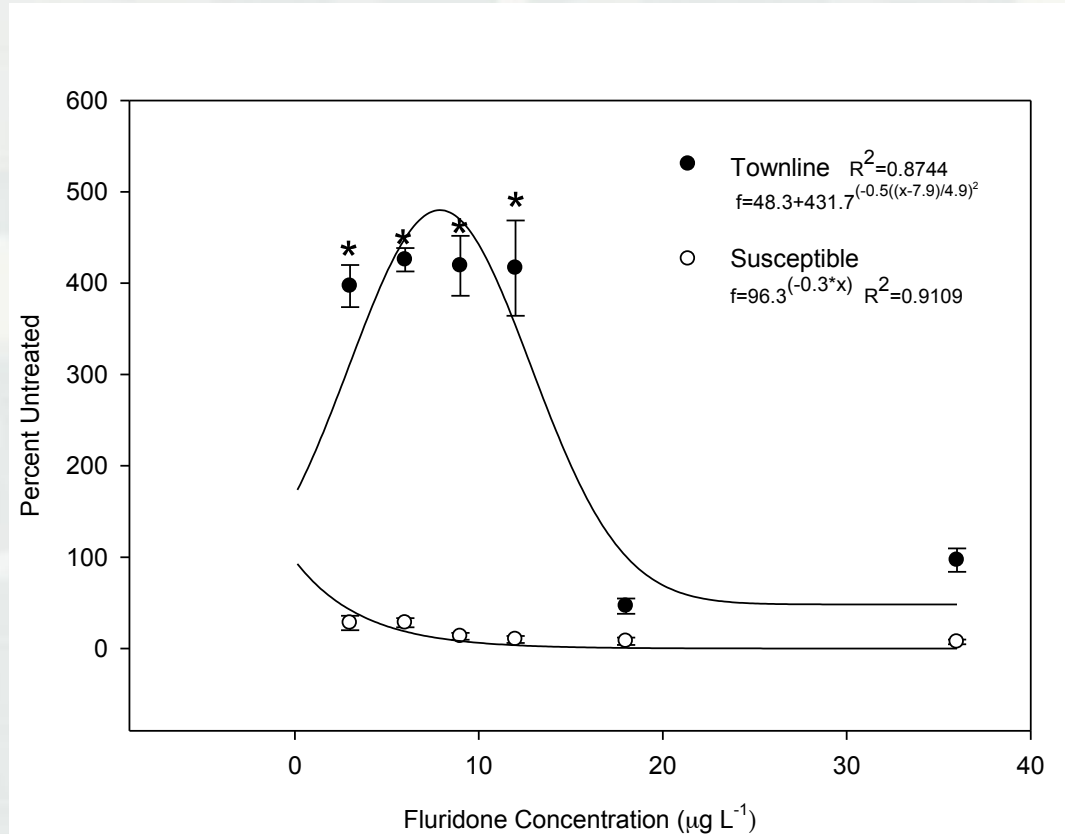


BUILDING STRONG®



*Innovative solutions for a safer, better world*

# Change in Biomass of Townline MI Hybrids compared to 6 Other Milfoil Populations (2 other hybrids)



-Graph explains how a hybrid can become Dominant

**SUBTLE CHANGES CAN DRIVE SELECTION OF HYBRIDS !**

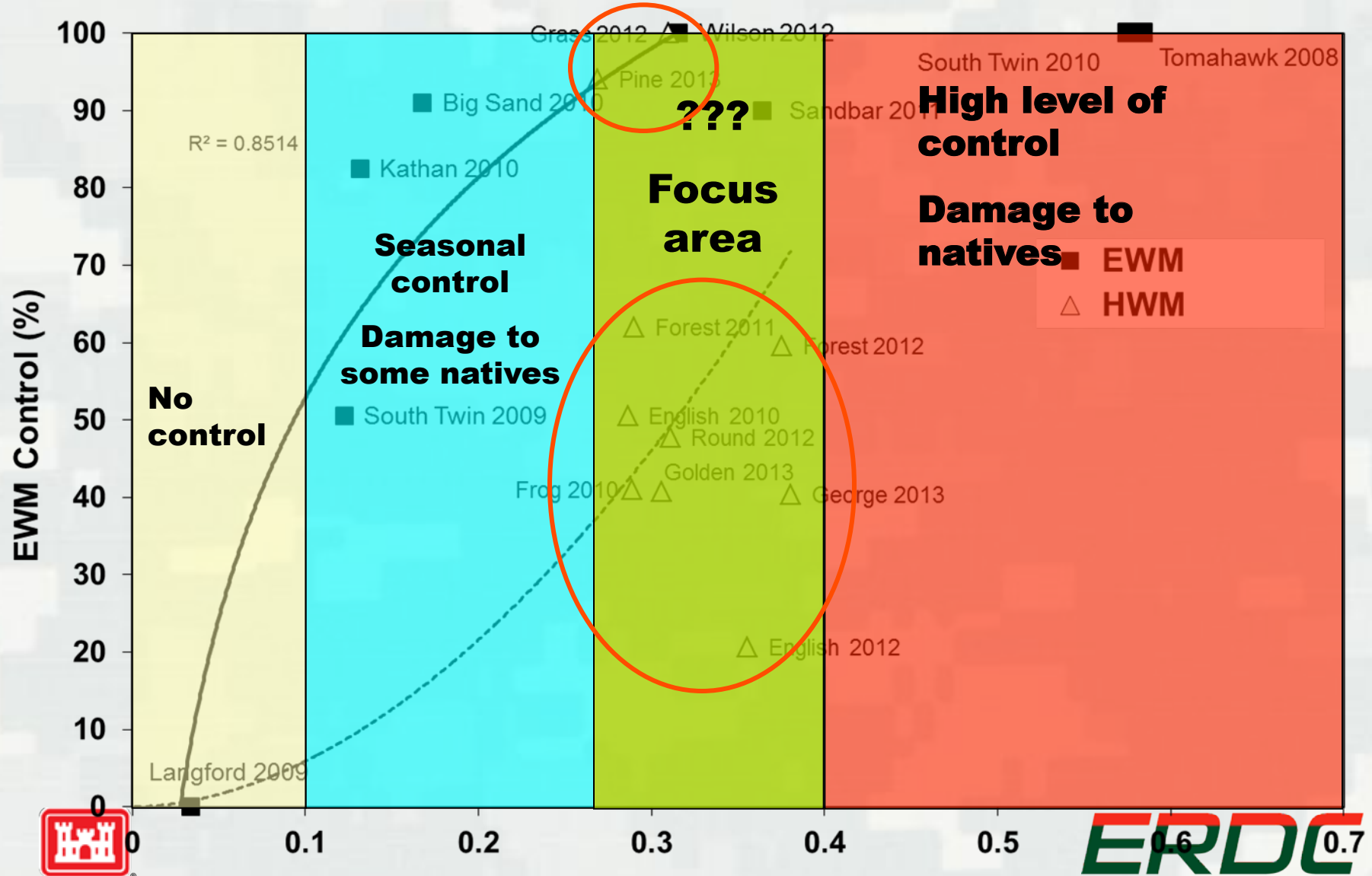


BUILDING STRONG®



*Innovative solutions for a safer, better world*

# EWM Control

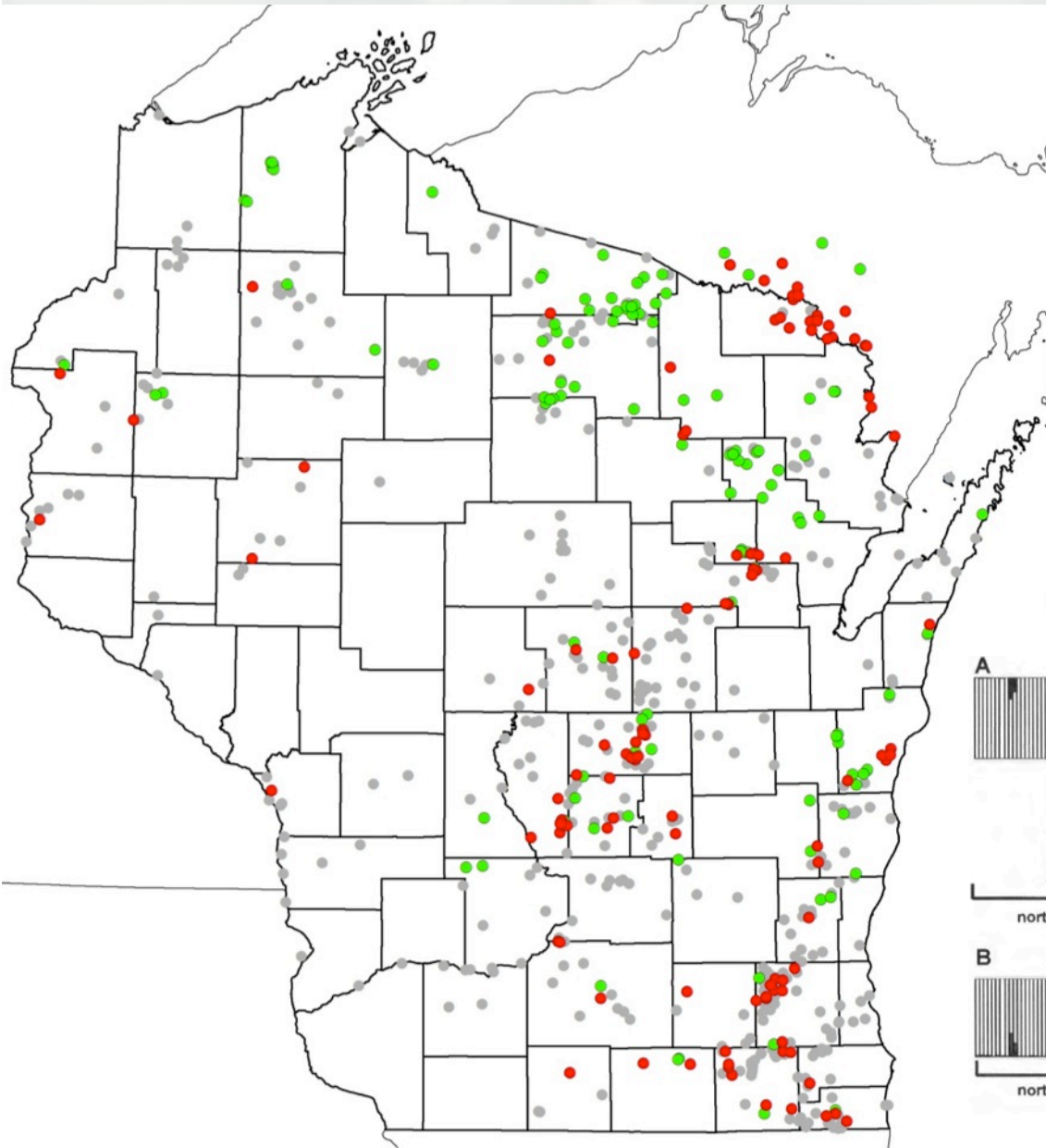


BUILDING STRONG®

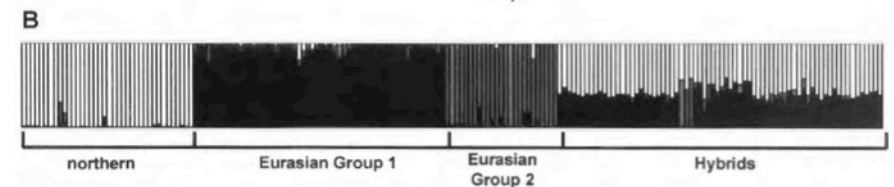
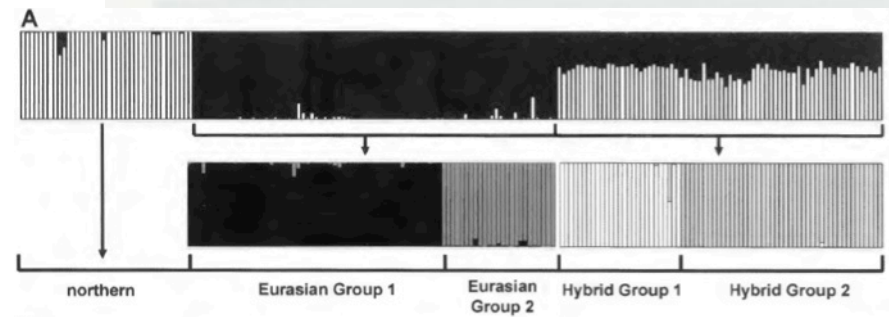


Innovative solutions for a safer, better world

# Watermilfoil DNA Analysis



- EWM
- HWM (or both)
- Unknown



Some believe that only “whole lake treatments”  
can result in selection pressure”



Whole-lake treatment strategy  
Vs  
Whole-lake impacts

- Treat a 15 acre block (5 feet deep) on a 150 acre lake (10% of the lake)
- 2,4-D or Triclopyr at 2 ppm or 2000 ppb
- Thermocline = 10 feet - Lakewide avg. concentrations of ~125 ppb
  - 125 ppb strong impacts to EWM
  - 125 ppb - impacts on Hybrid ?

**Higher Rate Spot Treatments may create a Stronger Selection Pressure for Hybrids Outside the Treatment Zone**



BUILDING STRONG®



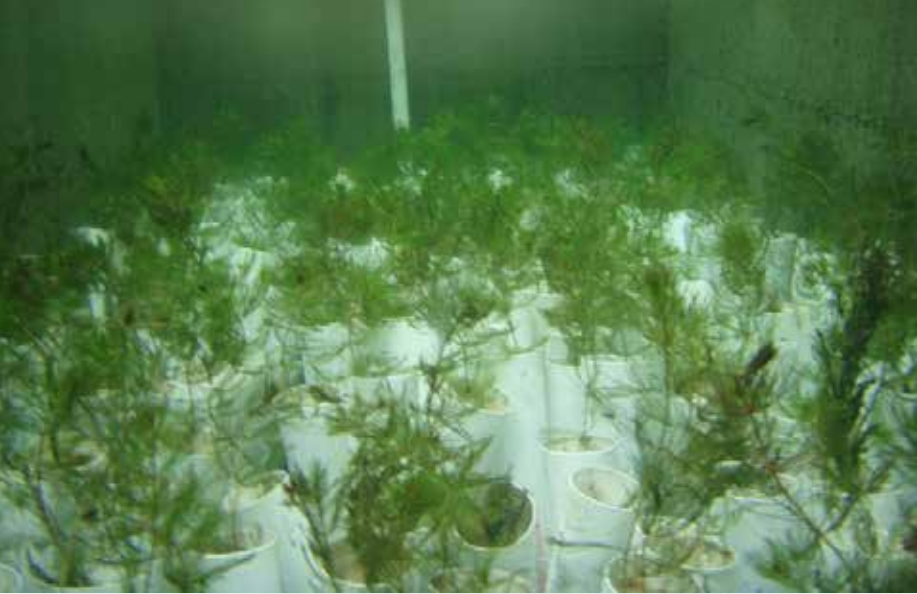
*Innovative solutions for a safer, better world*



# Are Higher Rates the Answer ?

- Convince permitting agencies that there is Science behind asking for higher rates ?
  - ▶ Agency concerns = native plant selectivity and fear that we will select for even more tolerant strains
- Product combinations ?
  - ▶ Large-scale auxin-mimics + endothall
  - ▶ May impact selectivity patterns
- Regulators -long memories when it comes to products/ strategies that reduce overall SAV





BUILDING STRONG®



*Innovative solutions for a safer, better world*

# Hybrids – Can minimize your margin for error

- You must think in terms of both concentration and **exposure time**

Milfoil % control following 2,4-D exposure

<b>2,4-D 1.5 mg/L</b>	<b>6 hr % control</b>	<b>12 hr % control</b>	<b>24 hr % control</b>	<b>96 hr % control</b>
Minnetonka EWM	56	92	100	100
Frog, WI Hybrid	<b>13</b>	<b>43</b>	<b>59</b>	100
English, WI Hybrid	<b>16</b>	<b>28</b>	<b>64</b>	100
Townline, MI Hybrid	48	89	100	100



# Conclusions

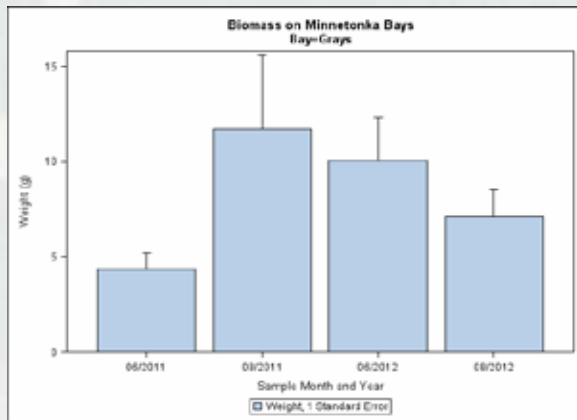
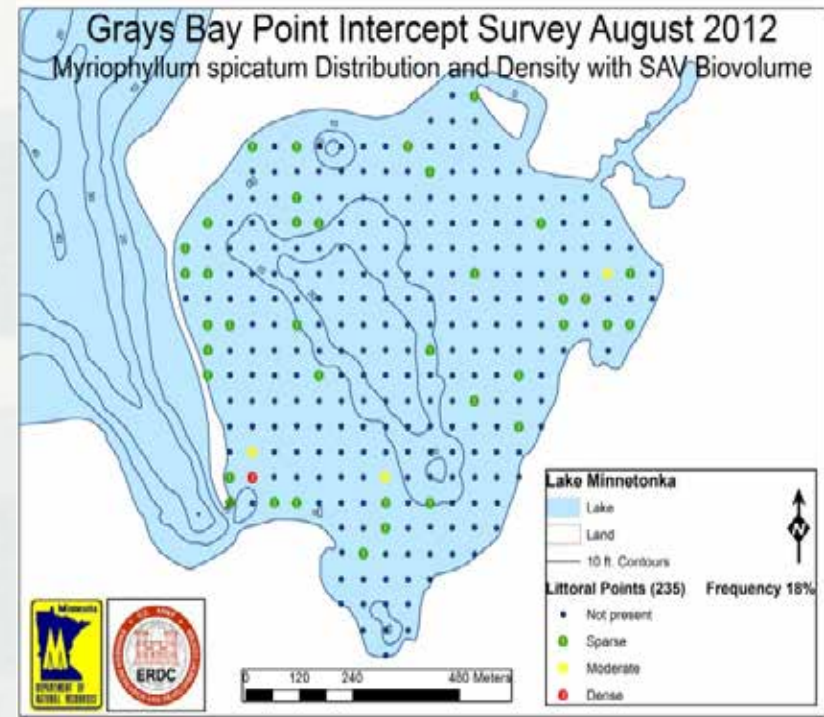
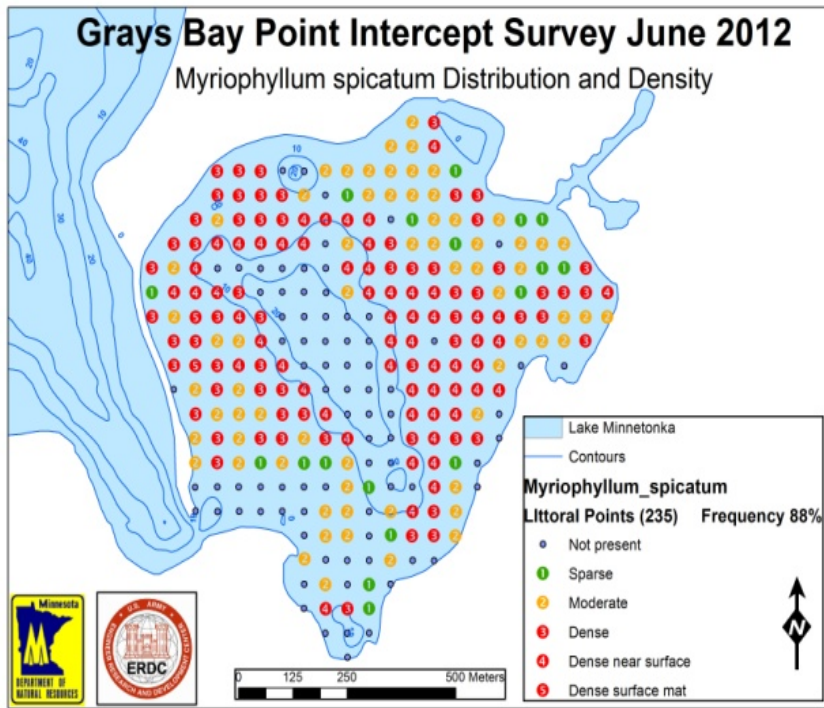
- Management with herbicides has likely selected for hybrid watermilfoils
  - ▶ Selection is inevitable (time and pressure)
- These hybrids should be considered invasive
  - ▶ Possibly more invasive than EWM
- Differences in herbicide susceptibility are subtle, but meaningful
- May need to rethink use of Fluridone in WI



# Tools to Reconcile Plant Data with Stakeholder Perceptions

- Methods for Assessing Treatment Outcomes Suffer from a Variety of Weaknesses
  - ▶ Biomass – cost/benefit, variation
  - ▶ Point Intercept – frequency of occurrence
    - Over estimate impacts on nuisance level of invasive
    - Under estimate impacts on native vegetation
  - ▶ In 2011 incorporated hydroacoustics assessments
    - Large-scale Hydrilla Treatments in FL (1000's of acres)
    - Bay-wide treatments in Lake Minnetonka





Biomass (g dry wt. – June 2012)						
Bay	N Obs (total)	Sum (total)	N Obs (Native)	Sum (Native)	N Obs (Invasive)	Sum (Invasive)
Grays	101	1018.3	73	<b>356.8</b>	26	<b>661.5</b>

Biomass (g dry wt.) – August 2012						
Bay	N Obs (total)	Sum (total)	N Obs (Native)	Sum (Native)	N Obs (Invasive)	Sum (Invasive)
Grays	77	527.0	75	<b>515.6</b>	4	<b>11.3</b>

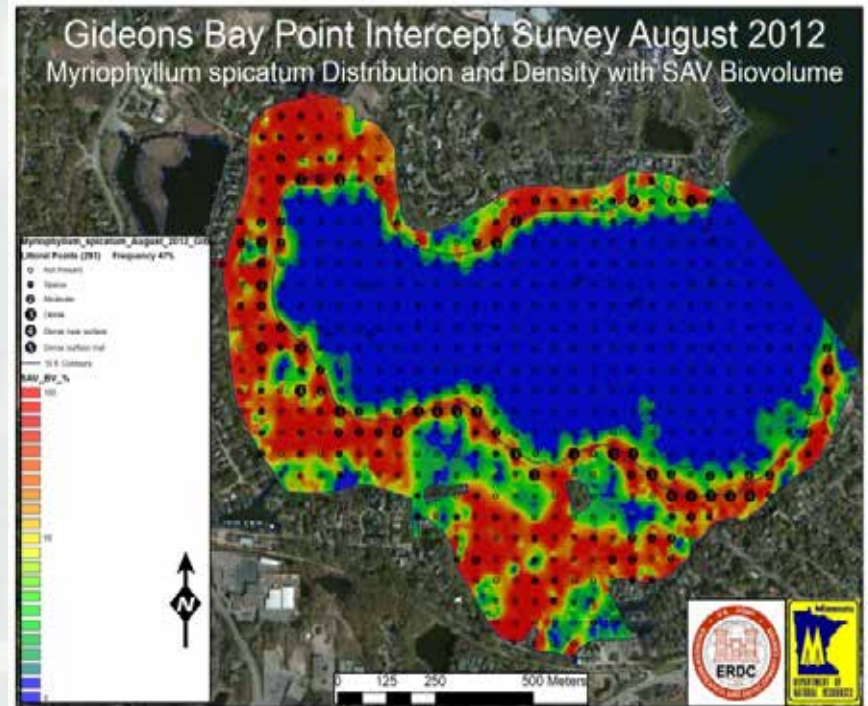
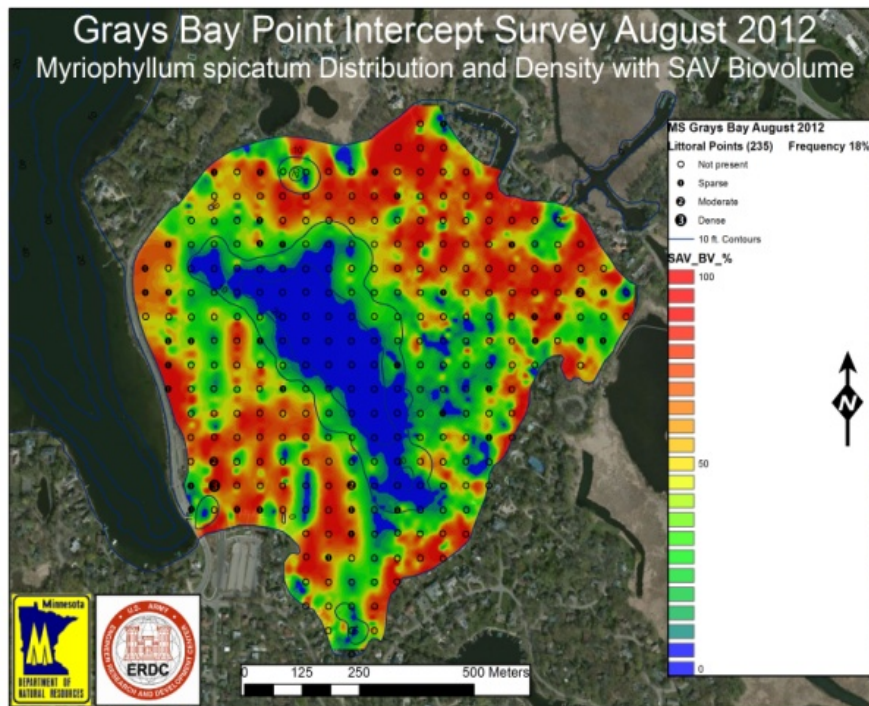


BUILDING STRONG®



Innovative solutions for a safer, better world

Mapping is a tool that helps us visualize pre and post-treatment conditions  
- patterns of recovery (hot spots)



Still in the early stages of determining how to use this technology



BUILDING STRONG®

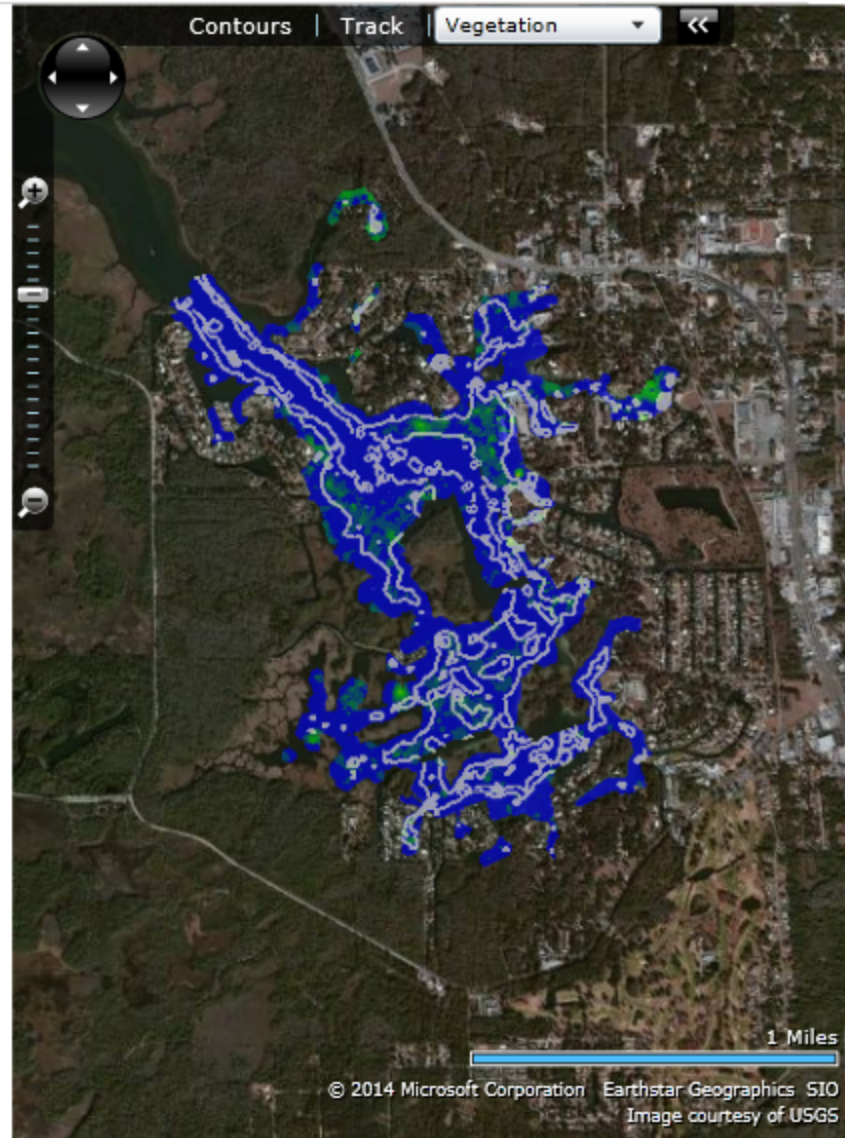
**ERDC**

*Innovative solutions for a safer, better world*

Trip #1 Date: 9/10/2013 7:36:37 AM

## Kings Bay

Trip #2 Date: 3/5/2014 8:34:58 AM



BUILDING STRONG®

*Innovative solutions for a safer, better world*



# Parting Thoughts and Parting Shots



BUILDING STRONG®



*Innovative solutions for a safer, better world*

# EWM and CLP

- Different life histories and invasive strategies
- This impacts mgmt. strategies
  - ▶ Morphology also impacts response to mgmt.



Harder to Control  
But  
Easier to Manage



Easy to Control  
But  
Harder to Manage

Early season - ALWAYS

Scale and Product Dictate  
Strategy and Herbicide



BUILDING STRONG®



*Innovative solutions for a safer, better world*

# Managing Curlyleaf Pondweed

- Are we too focused on reducing turions
  - Multi-year treatments
- Have documented reductions from 600 to 50 turions per square meter
- Can 50 turions / square meter create “problematic growth” ?
  - What if 45 of these turions are buried > 1” deep ?
  - Light requirement for sprouting ?
- Obtaining excellent seasonal control !



# Lessons Learned with CLP

- Highly sensitive to Herbicides at a wide scale under a broad range of exposures
  - Early-season is effective
  - Killing a plant growing from a single turion
- We don't know when it is okay to stop managing
  - What is the objective ?
- The plant can be highly variable in density/nuisance in the absence of management



# Observations on Managers

- Get too excited when something works
- Too negative when something fails
- What did you learn and was it documented ?
  - ▶ Can you apply this to other sites ?
  - ▶ Can you repeat the success across a broad range of scenarios ?



# Recommendations to WI DNR

- Continue Monitoring Key Projects
  - ▶ Observations often require small-scale validation
- Consider developing a better process for evaluating new products/ technologies
  - ▶ Too reliant on two tools
- Don't become too insular
  - ▶ Work with other states, research organizations
  - ▶ Familiarize yourselves with their strategies



# Managing Plants vs. Expectations

- There is a general view that a “right way” exists to manage invasive aquatic plants
  - ▶ The problem:
    - Strategies are Highly Variable Between States
- Why do aquatic herbicide use patterns vary so significantly?
  - State to State (rules/laws)
  - Region to Region
  - Learn from Others



# Does Hydrilla Pose a Greater Threat to Northern Waters Than Other Invasive Plants ?



Hydrilla



Eurasian Milfoil



Curlyleaf Pondweed

We Don't Know & We Can't Know without Letting  
Hydrilla Spread and Compete  
**Monoecious Hydrilla will test our commitment to  
Prevention and EDRR**



# Thank You

- Jen Hauxwell, Carroll Schall, Tim Asplund
- Michelle Nault and DNR staff (collections)
- John Skogerboe



BUILDING STRONG®



*Innovative solutions for a safer, better world*