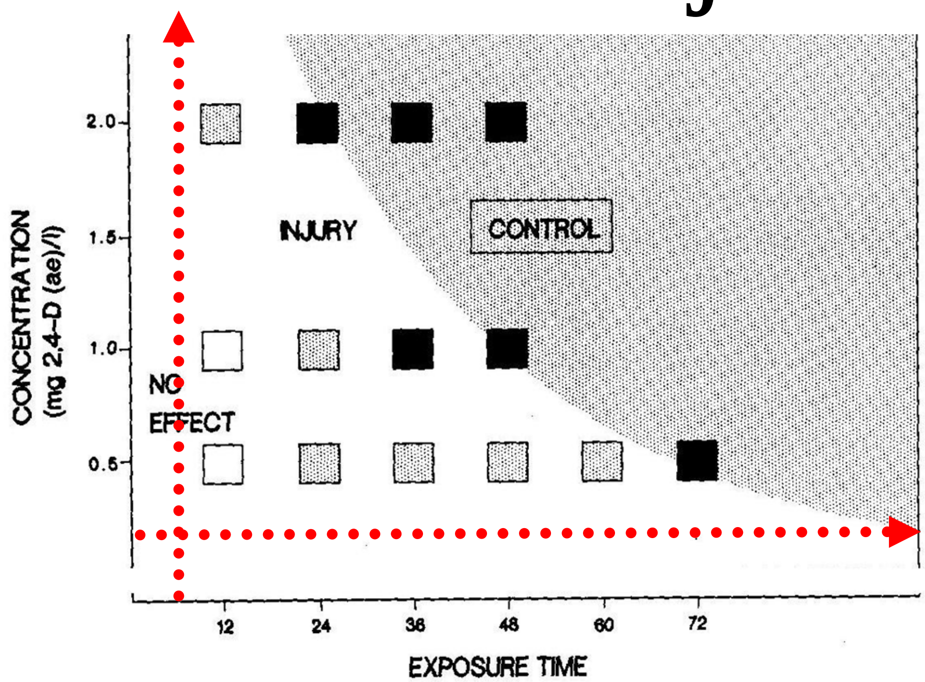
Evaluation of Statewide AIS Control Projects

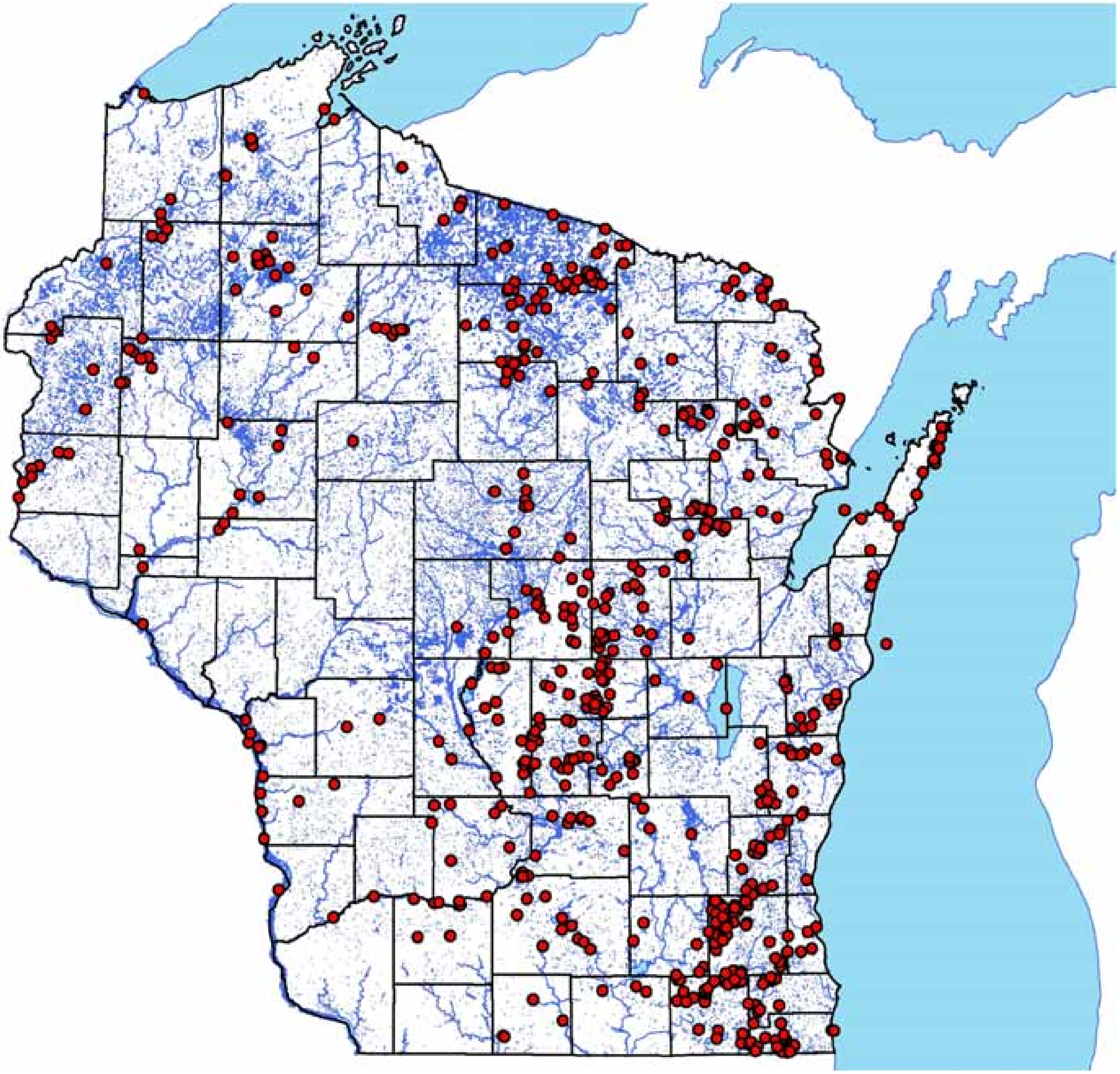


Michelle Nault
WDNR Research

John Skogerboe
Army Corps of Engineers

WI Lakes Convention
Green Bay, WI
April 10-12, 2012

EWM Distribution



Questions about EWM

1) Ecology

-What are the possible outcomes when EWM is introduced in a lake?

-What factors contribute to different outcomes?

-Interannual variation?

2) Management

-Past management (non strategic) = short term nuisance relief?

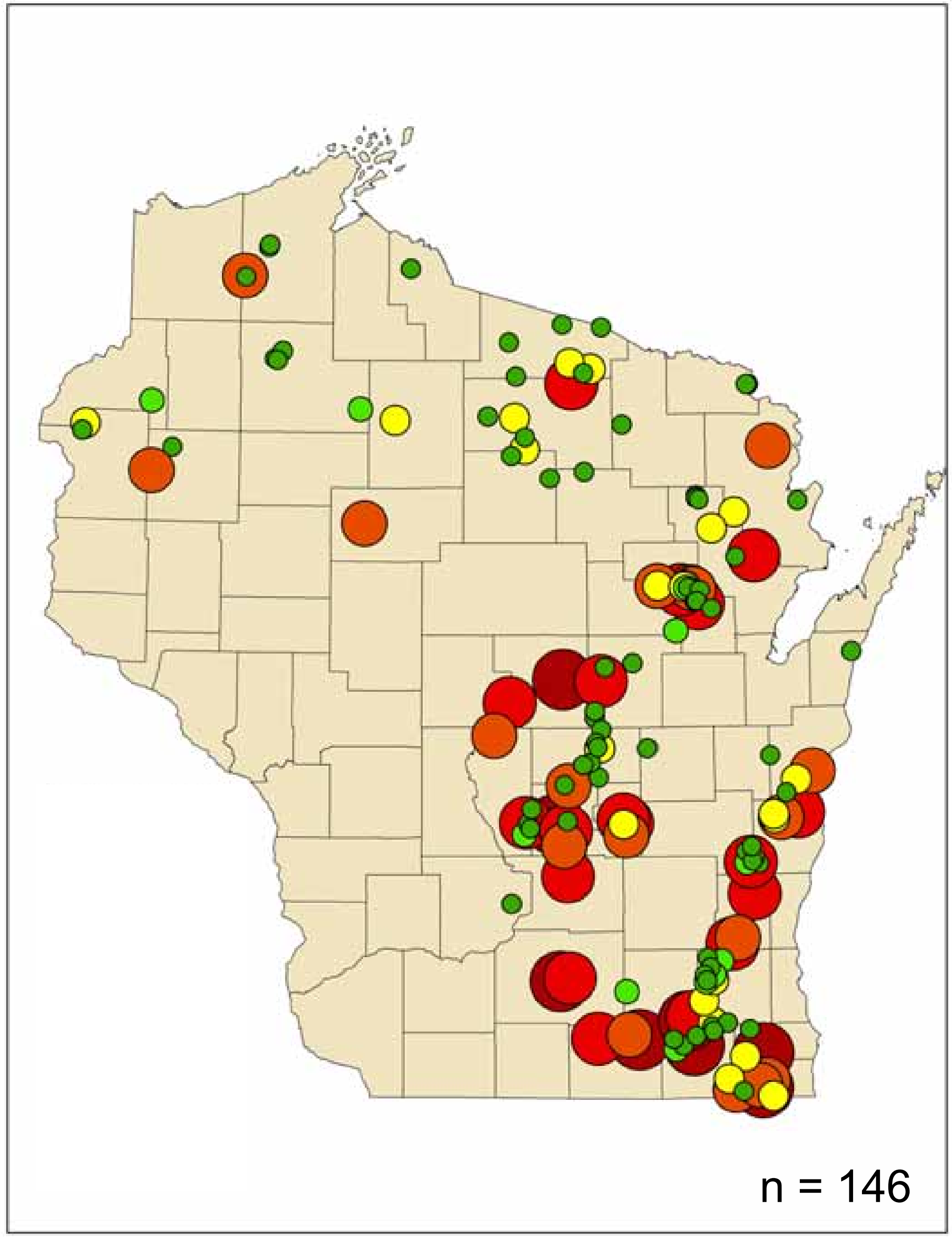
-Future management (strategic) = long term reduction and restoration?

Littoral Frequency of Occurrence of EWM Statewide

Littoral Frequency of Occurrence =

$$\frac{\text{\# of sites with EWM}}{\text{\# sites shallower than the maximum depth of plant colonization}}$$

X100



Implementation Considerations

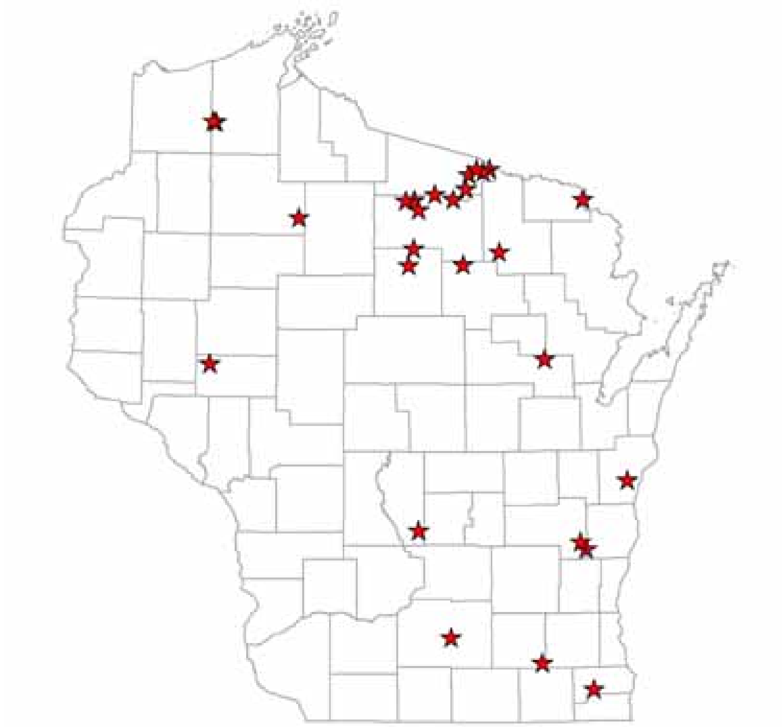
- Management tool(s)
- Management goal(s)
- Timing (seasonality, weather, water temps)
- Herbicide products and formulations
- Application rates
- Flowing water, water level management
- Lake type, size, bathymetry, water chemistry
- Target and non-target plant species

NR 107 Aquatic Plant Management – Chemical Use.

"NR 107.01. Purpose. The purpose of this chapter is to establish procedures for the management of aquatic plants and control of other aquatic organisms pursuant to s. 227.11 (2) (a), Stats., and interpreting s. 281.17 (2), Stats. A balanced aquatic plant community is recognized to be a vital and necessary component of a healthy aquatic ecosystem. The department may allow the management of nuisance-causing aquatic plants with chemicals registered and labeled by the U.S. environmental protection agency and labeled and registered by firms licensed as pesticide manufacturers and labelers with the Wisconsin department of agriculture, trade, and consumer protection. ***Chemical management shall be allowed in a manner consistent with sound ecosystem management and shall minimize the loss of ecological values in the water body****."*

Herbicide Monitoring Project Lakes

- Monona (Turville), Dane
- Tomahawk/Sandbar, Bayfield
- Eagle, Racine
- Half Moon, Eau Claire
- Loon, Shawano
- Big Sand, Vilas
- Long, Vilas
- South Twin, Vilas
- North Twin, Vilas
- Little St. Germain, Vilas
- Eagle River Chain, Vilas
- Frog, Florence
- Jordan, Adams
- Kettle Moraine, Fond du Lac
- Metonga, Forest
- Minocqua, Oneida
- Kawaquesaga, Oneida
- Tomahawk, Oneida
- Bridge, Oneida/Lincoln
- Mohawksin, Lincoln
- Connors, Sawyer
- Lower Spring, Jefferson
- Kathan, Oneida
- Enterprise, Langlade
- English, Manitowoc
- Forest, Fond du Lac



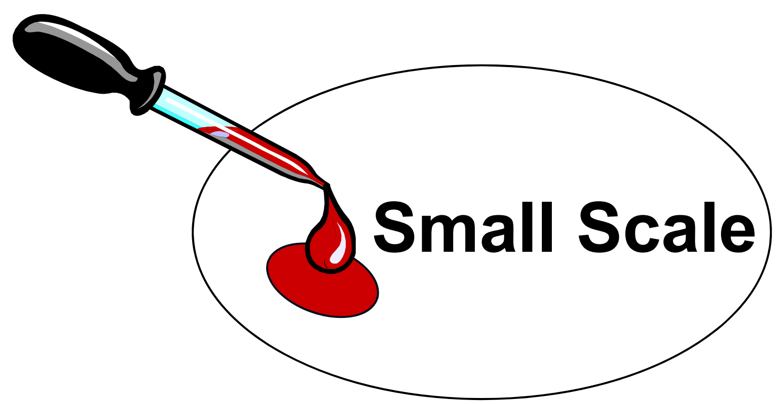
Case Studies

Whole Lake

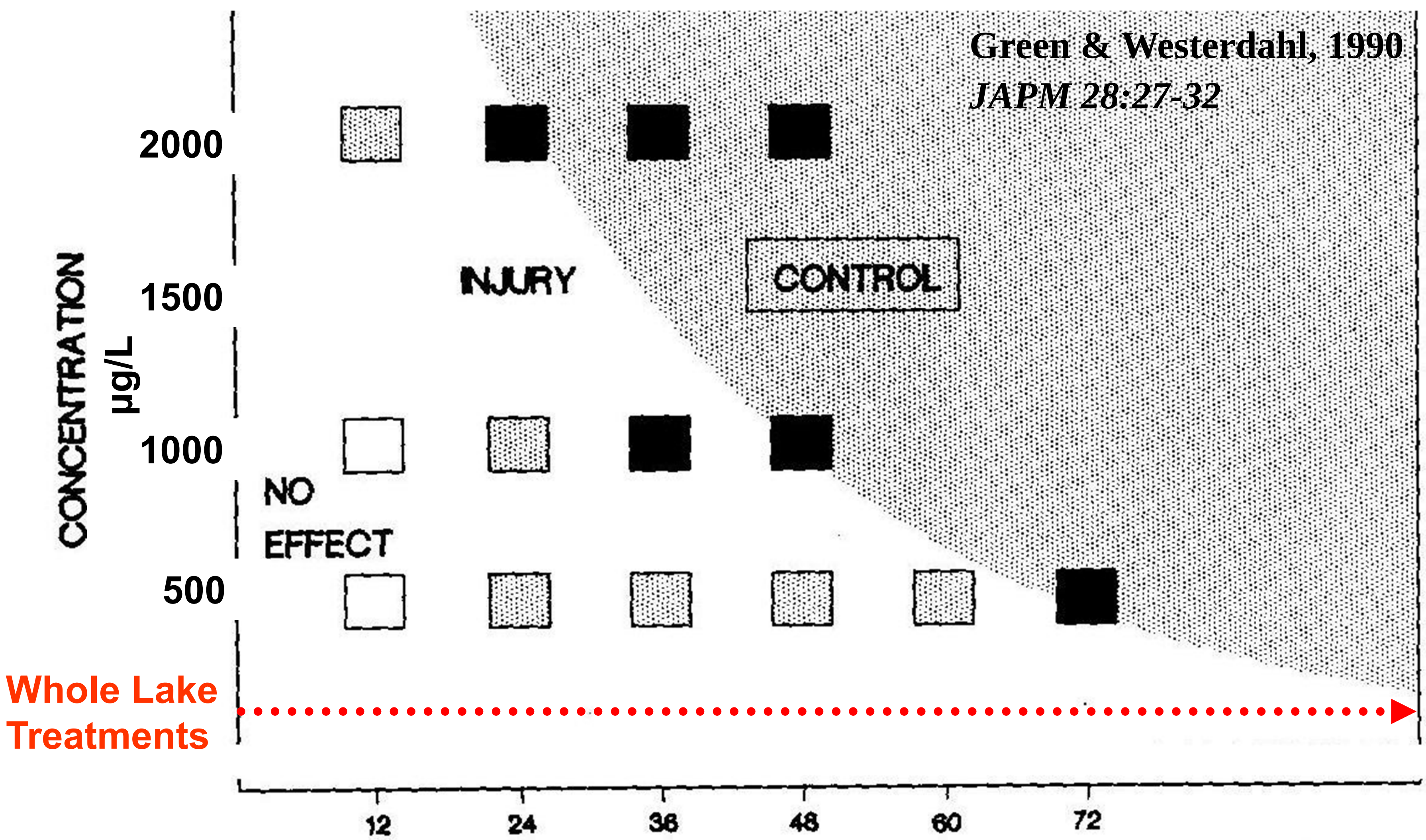
- Tomahawk/Sandbar, Bayfield Co.
- South Twin, Vilas Co.
- Forest, Fond du Lac Co.

Small Scale

- Connors, Sawyer Co.
- Little St. Germain, Vilas Co.
- Detroit Lakes, Minnesota



2,4-D Concentration/Exposure Time



Recommended label rate:
2000 – 4000 µg/L ae

1000 µg/L = 1.0 ppm

Herbicide Exposure Time

- **Dissipation**
  - **Water flow**
  - **Wind**
  - **Treatment area relative to lake**
  - **Water depth**
- **Degradation**
  - **Microbial**
  - **Photolytic**

Application Timing/Phenology

Early Spring Herbicide Applications

- Exotic species are small and most vulnerable
- Native species are dormant
- Cool water temperatures result in slower microbial degradation
- Minimize biomass decomposition

Survey Methods

Herbicide Water Sample Collection

Immunoassay Test (ELISA)

Aquatic Plant Surveys – Hauxwell et. al 2010

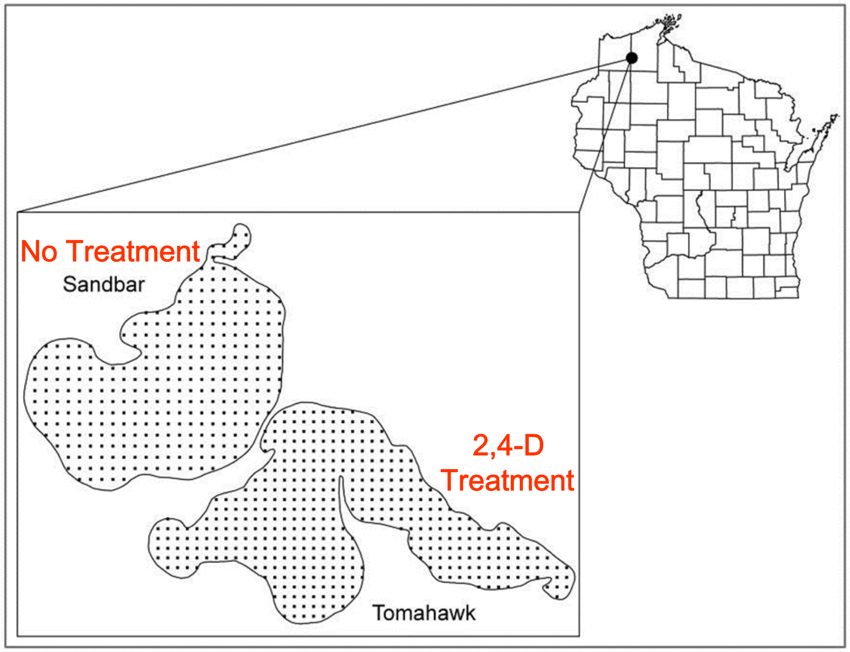
Sandbar/Tomahawk

WDNR, Army Corps of Engineers, Town of Barnes, Bayfield County

1) What are the effects of early season 2,4-D on Eurasian watermilfoil?

2) What about native plants?

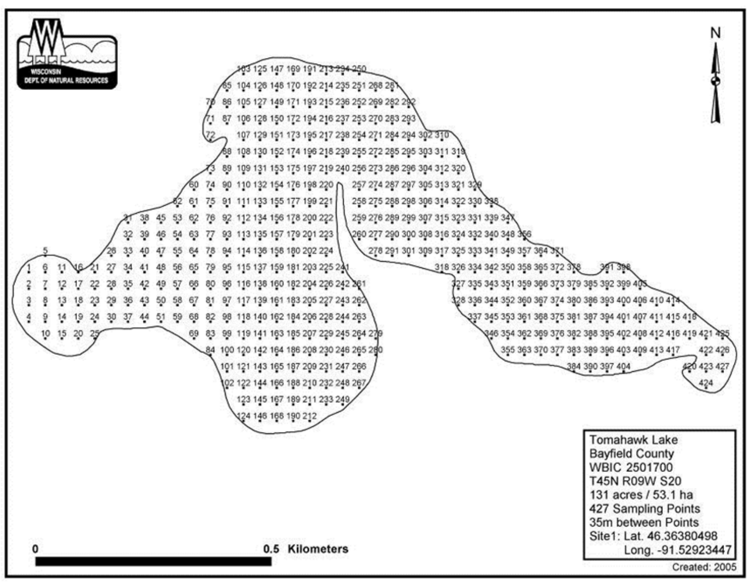
Approach: Monitor annual changes in plant communities in experimental lakes (herbicide or reference)



Study design

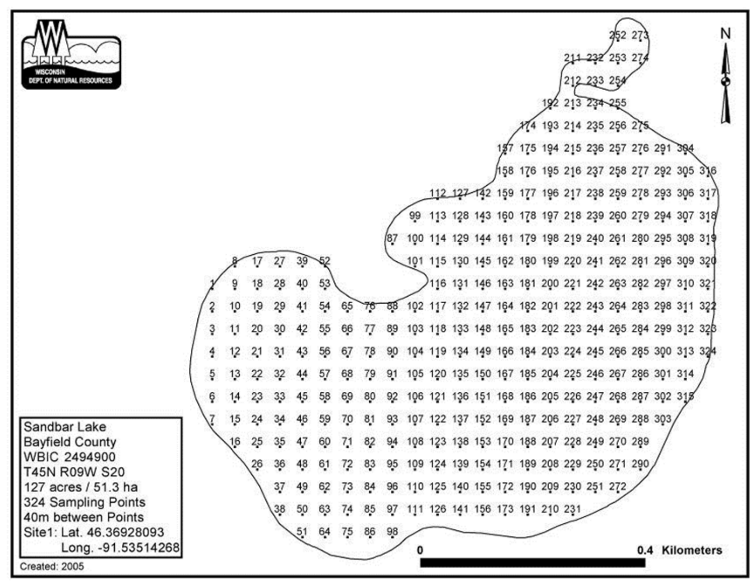
Tomahawk

- Low dose liquid 2,4-D (500 μg/L ae) treatment to whole lake (May 20, 2008)
- Aquatic plant surveys conducted 2006-2011
- Biomass collected during 2007-2011 surveys



Sandbar

- Reference lake – no treatment (2007 - 2010)
- Low dose liquid 2,4-D (275 μg/L ae) treatment to whole lake epilimnion (spring 2011)
- Aquatic plant surveys and biomass collected during 2007-2011

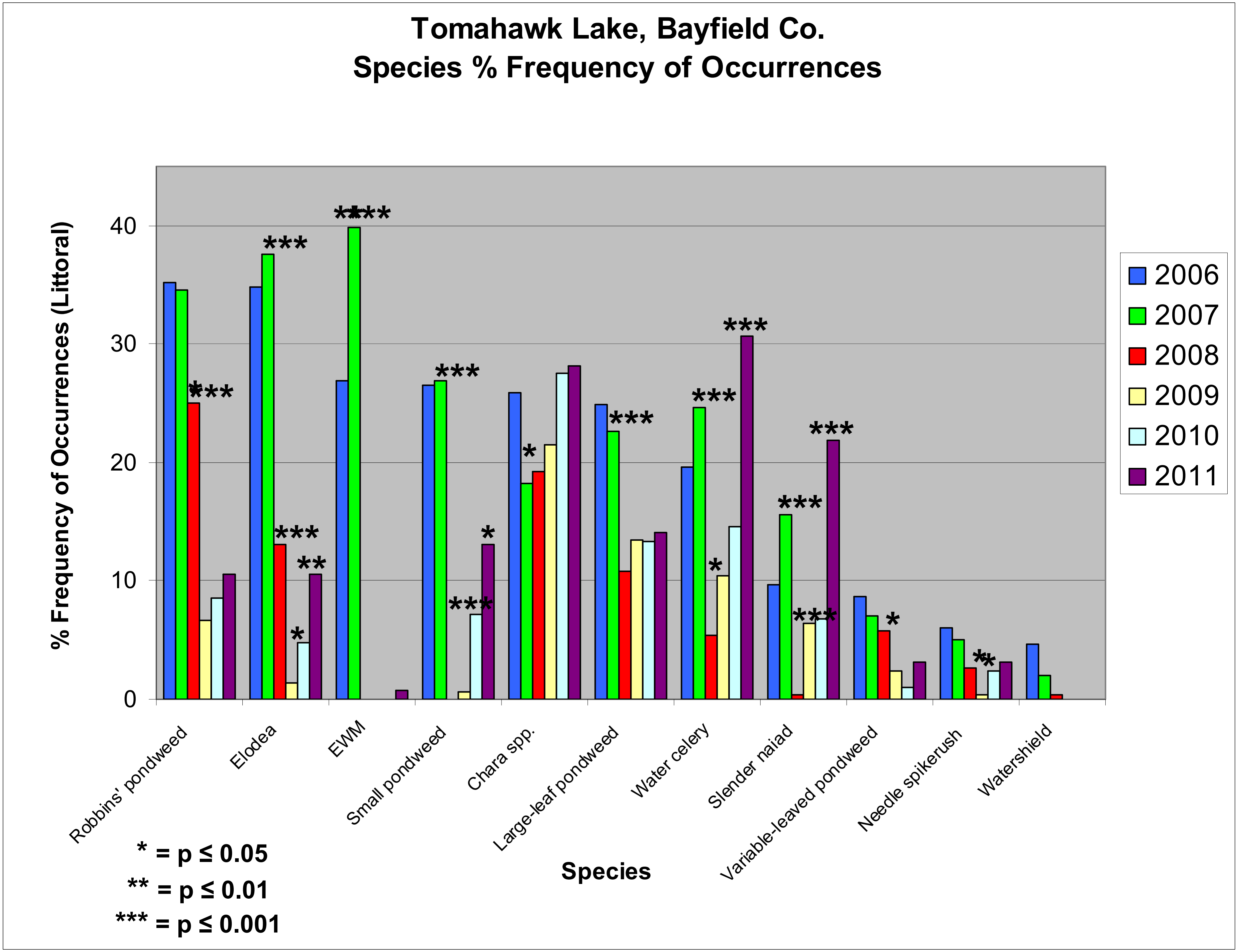


Tomahawk vs. Sandbar, Bayfield Co. July 2007 Summary Stats

	Tomahawk	Sandbar
Lake size (ha)	53.1	51.3
Maximum depth (m)	12.8	14.9
Maximum depth of plant colonization (m)	6.8	7.0
Percentage of littoral zone vegetated	86.4	86.8
Number of species	20	17
Mean number of species per site (littoral)	2.6	2.8
Simpson’s Diversity Index	0.90	0.89
Eurasian watermilfoil frequency of occurrence within littoral zone (%)	39.9	25.8

Tomahawk Lake, Bayfield Co.
2006 - 2011 Summary Stats

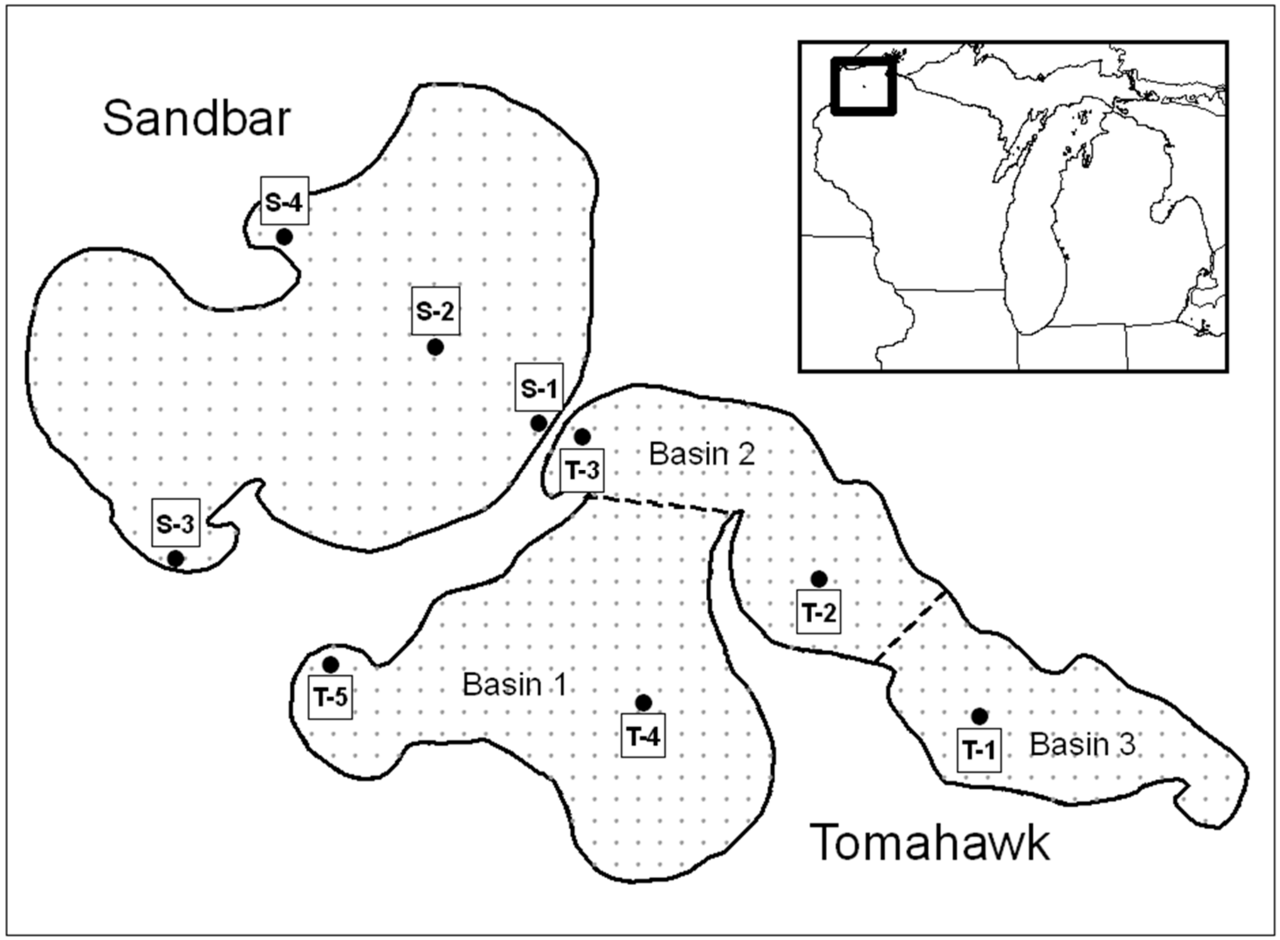
	Pre-treatment		Post Treatment			
	2006	2007	2008	2009	2010	2011
# points sampled	315	313	299	316	328	317
# of sites with vegetation	256	260	141	161	173	208
littoral FOC	85.1	86.4	54.2	54.0	58.8	73.2
simpsons diversity	0.89	0.90	0.81	0.83	0.84	0.88
avg. # species per site (littoral)	2.4	2.6	0.9	0.6	1.0	1.6
avg. # species per site (vegetated sites)	2.8	3.0	1.6	1.4	1.6	2.2
avg. # natives per site (littoral)	2.1	2.2	0.9	0.6	1.0	1.6
avg. # natives per site (vegetated sites)	2.5	2.7	1.6	1.4	1.6	2.2
species richness	20	22 (2 unverified)	11	13	12	18
species richness (+ visuals)	25	25	13	16	16	21
max depth of plant growth (ft)	20.5	25.5	17.0	26.0	27.0	21.5


Tomahawk Lake, Bayfield Co.
Species % Frequency of Occurrences
% Frequency of Occurrences (Littoral)
0
10
20
30
40
2006
2007
2008
2009
2010
2011
Robbins' pondweed
Elodea
EWM
Small pondweed
Chara spp.
Large-leaf pondweed
Water celery
Slender naiad
Variable-leaved pondweed
Needle spikerush
Watershield
Species
* = p ≤ 0.05
** = p ≤ 0.01
*** = p ≤ 0.001

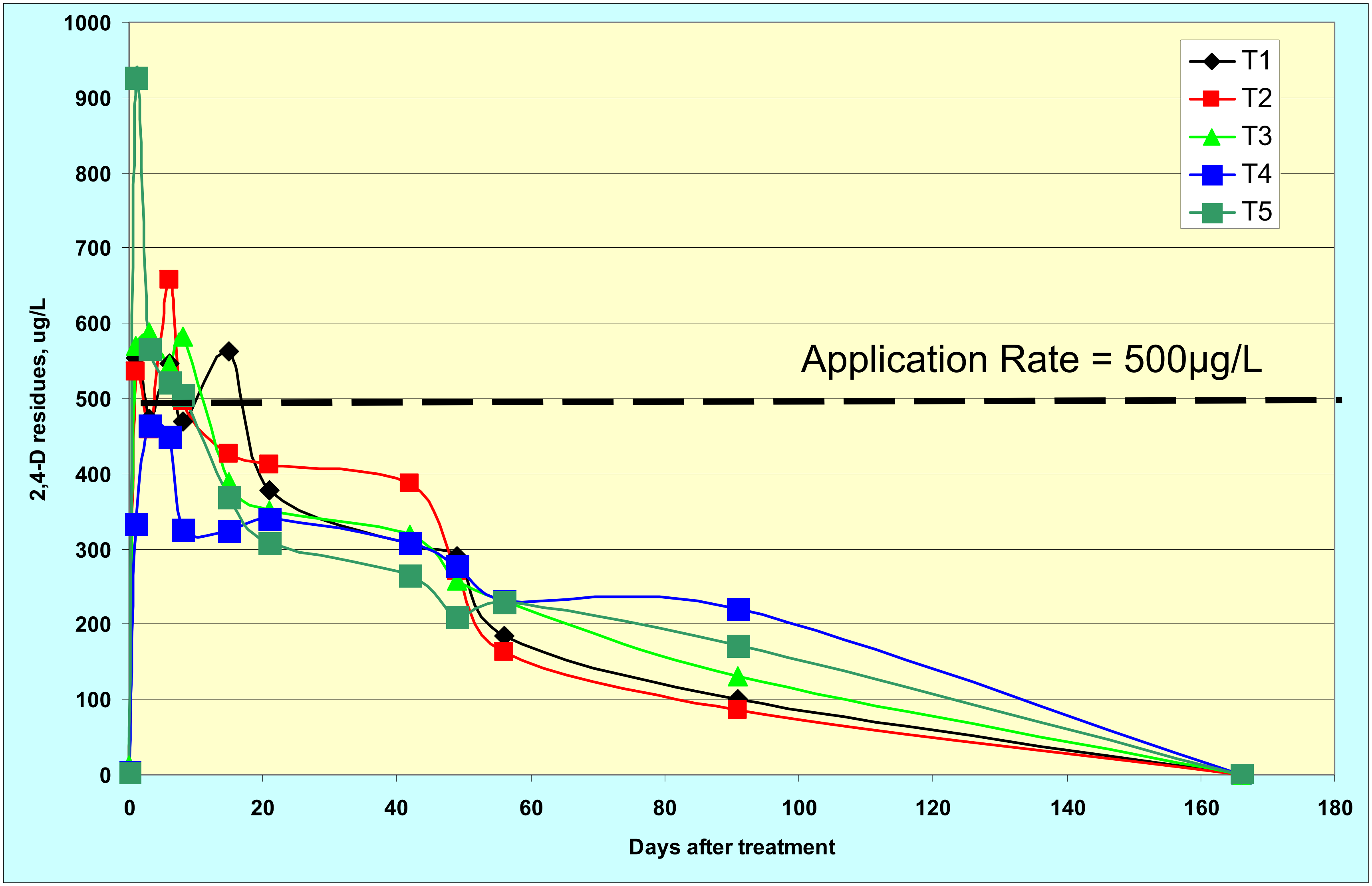
Herbicide Sample Locations

Pre, 1, 2, 3, 5, 7, 14, 21, 28, 35, 42, 49, 56+ days after treatment

Tomahawk & Sandbar

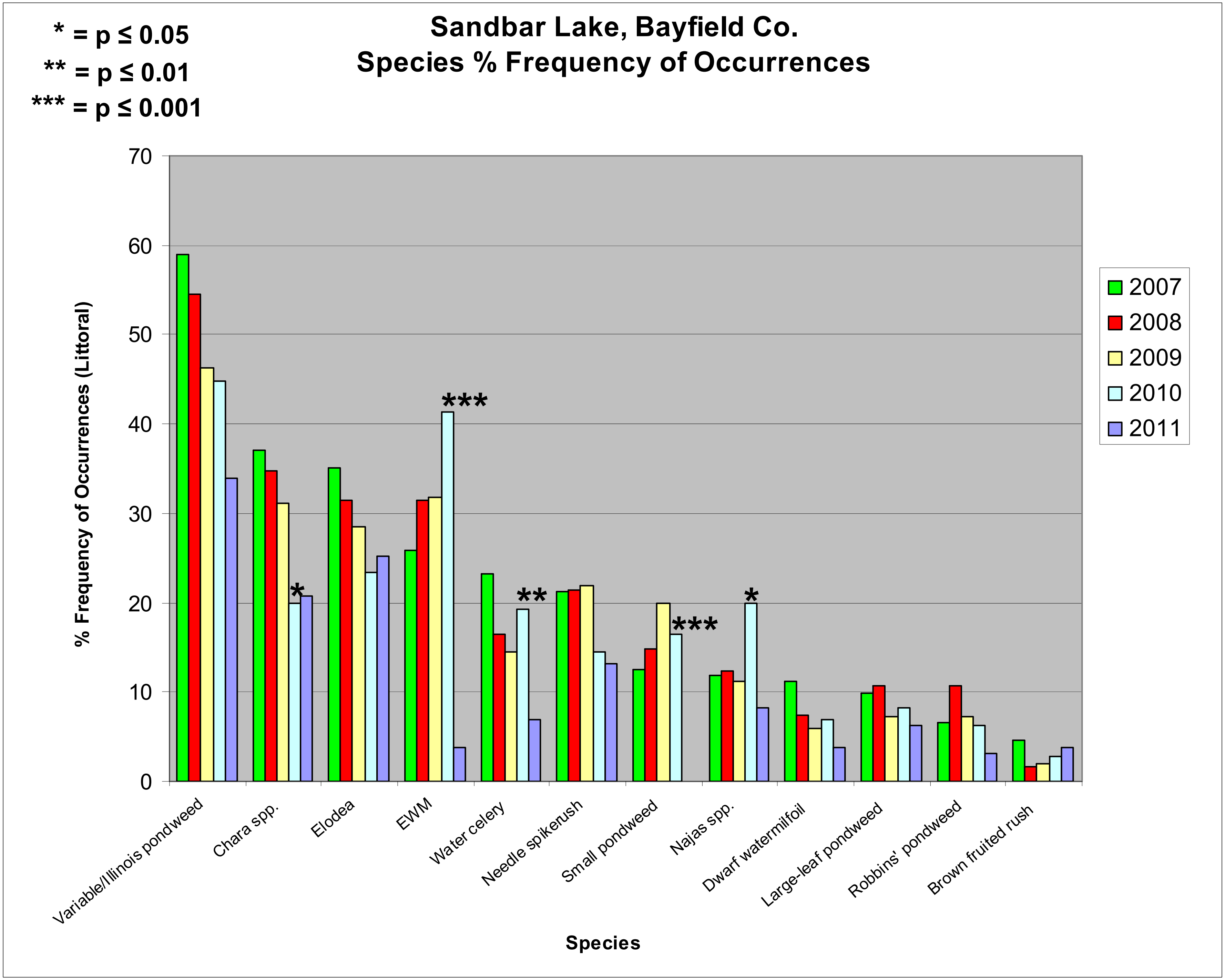


Tomahawk 2,4-D Concentrations

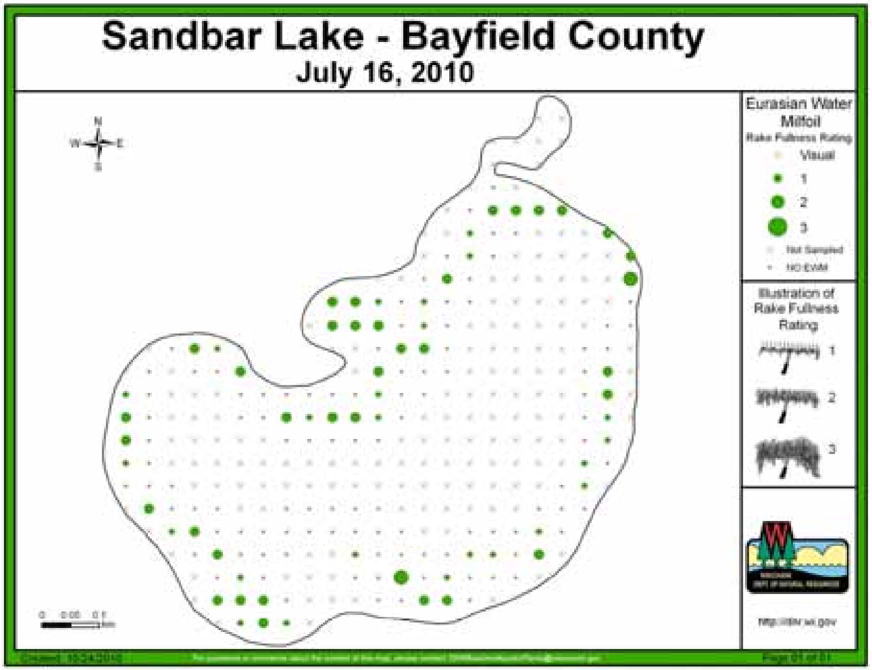


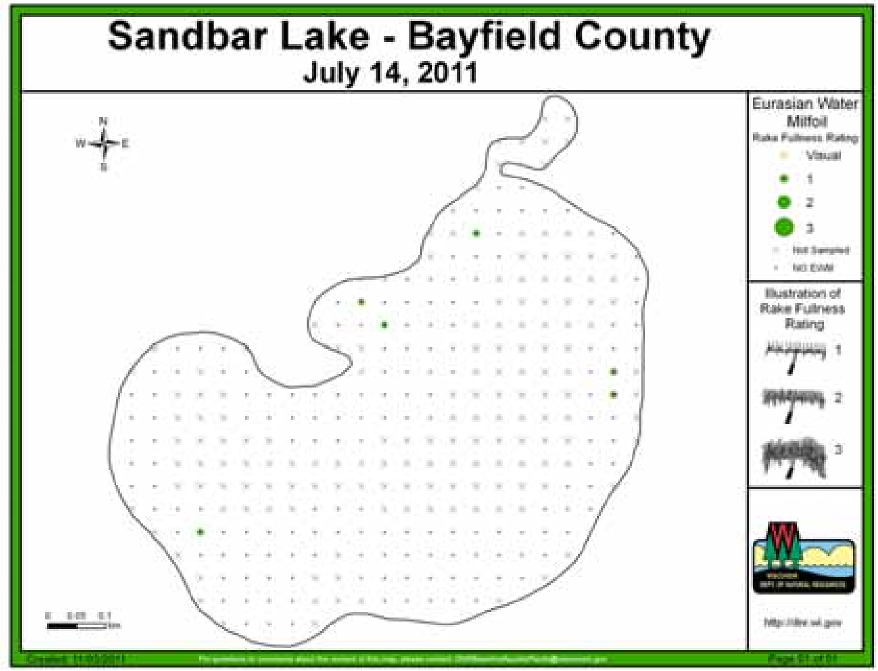
Sandbar Lake, Bayfield Co.
2007 - 2011 Summary Stats

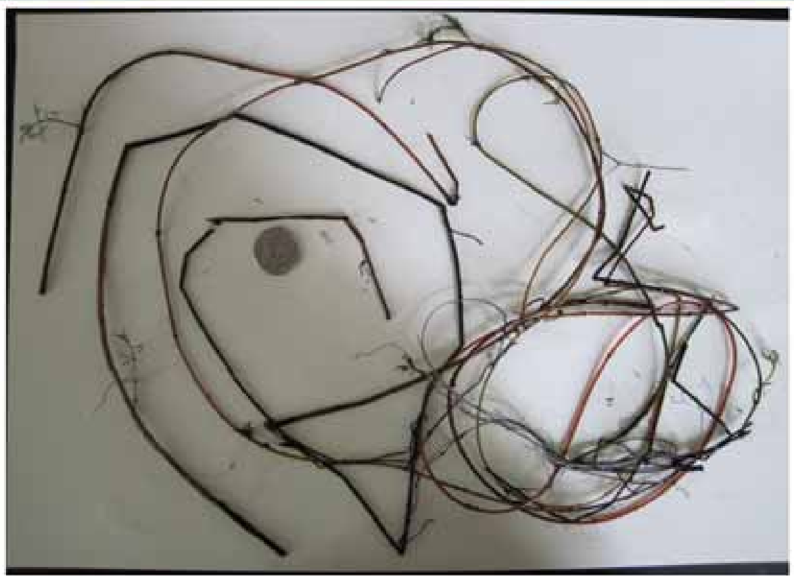
	Pre-treatment				Post-treatment
	2007	**2008**	**2009**	**2010**	**2011**
# points sampled	190	125	221	182	168
# of sites with vegetation	131	107	126	119	103
littoral frequency of occurrence	86.75	88.43	83.44	82.07	64.78
simpsons diversity	0.89	0.88	0.89	0.90	0.88
avg. # species per site (littoral)	2.8	2.54	2.02	2.43	1.44
avg. # species per site (vegetated sites)	3.23	2.87	2.95	2.97	2.22
avg. # natives per site (littoral)	2.54	2.22	1.75	2.02	1.4
avg. # natives per site (vegetated sites)	2.95	2.61	2.66	2.69	2.21
species richness	17	14	15	19	18
species richness (+ visuals)	19	14	16	20	19
max depth of plant growth (ft)	23	21	26	23.5	27


* = p ≤ 0.05
** = p ≤ 0.01
*** = p ≤ 0.001
Sandbar Lake, Bayfield Co.
Species % Frequency of Occurrences
% Frequency of Occurrences (Littoral)
70
60
50
40
30
20
10
0
***
*
**
***
*
2007
2008
2009
2010
2011
Variable/Illinois pondweed
Chara spp.
Elodea
EWM
Water celery
Needle spikerush
Small pondweed
Najas spp.
Dwarf watermilfoil
Large-leaf pondweed
Robbins' pondweed
Brown fruited rush
Species

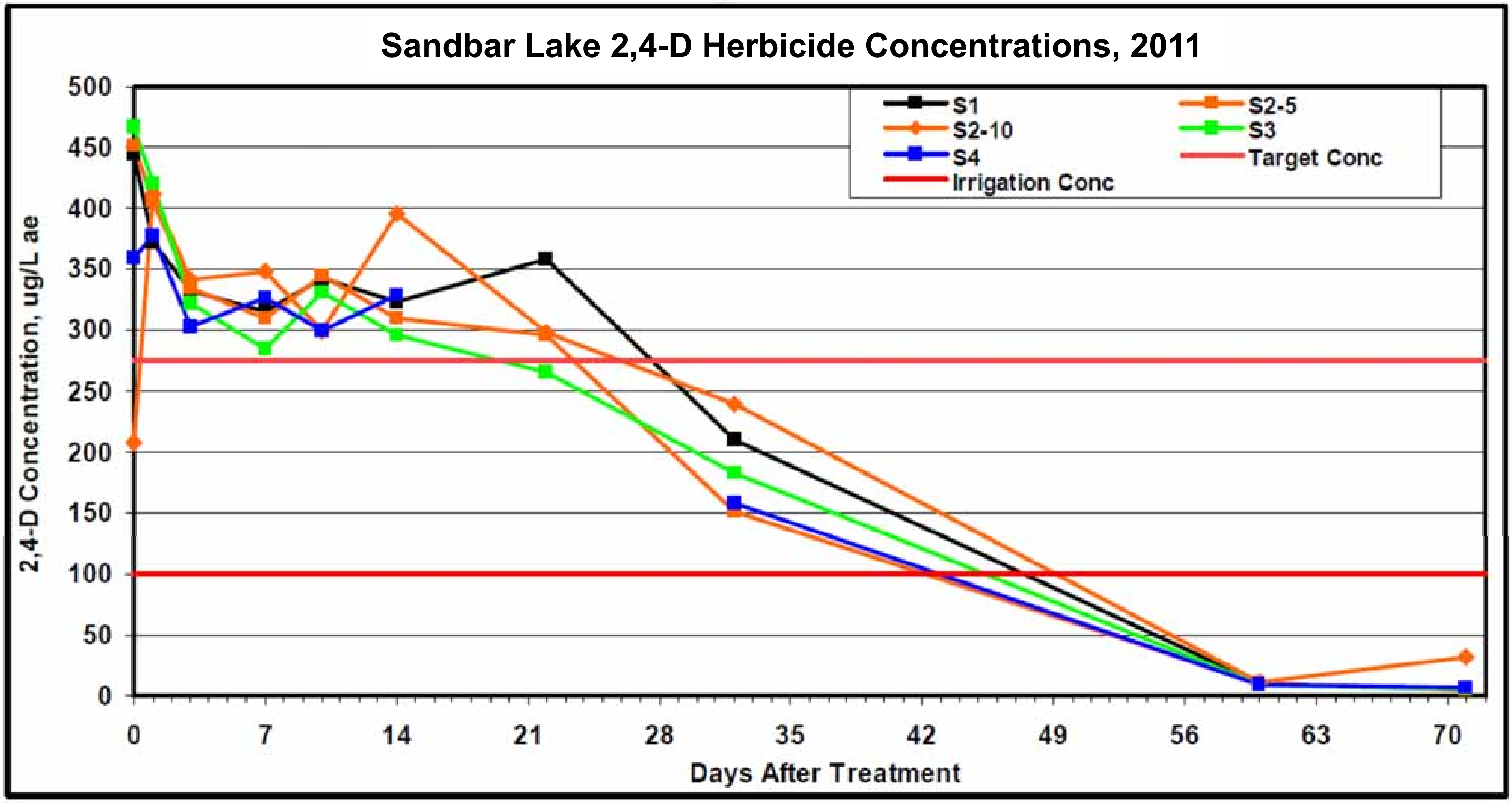
Sandbar EWM


Sandbar Lake - Bayfield County
July 16, 2010
Eurasian Water Milfoil
Rake Fullness Rating
Visual
1
2
3
Not Sampled
NO EWM
Illustration of Rake Fullness Rating
1
2
3
N
W
E
S
http://dnr.wi.gov

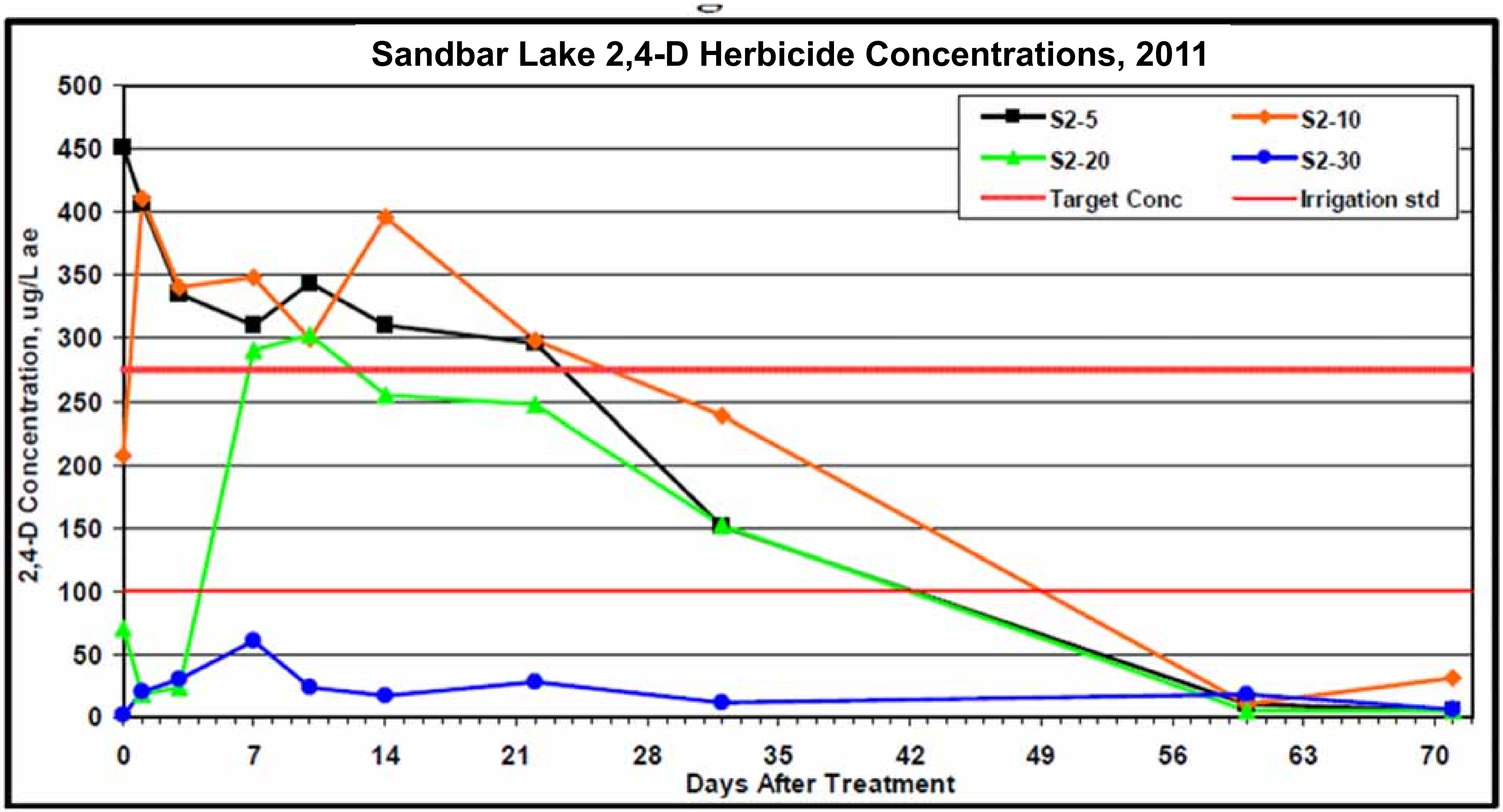

Sandbar Lake - Bayfield County
July 14, 2011
Eurasian Water Milfoil
Rake Fullness Rating
Visual
1
2
3
Not Sampled
NO EWM
Illustration of Rake Fullness Rating
1
2
3
N
W
E
S
http://dnr.wi.gov

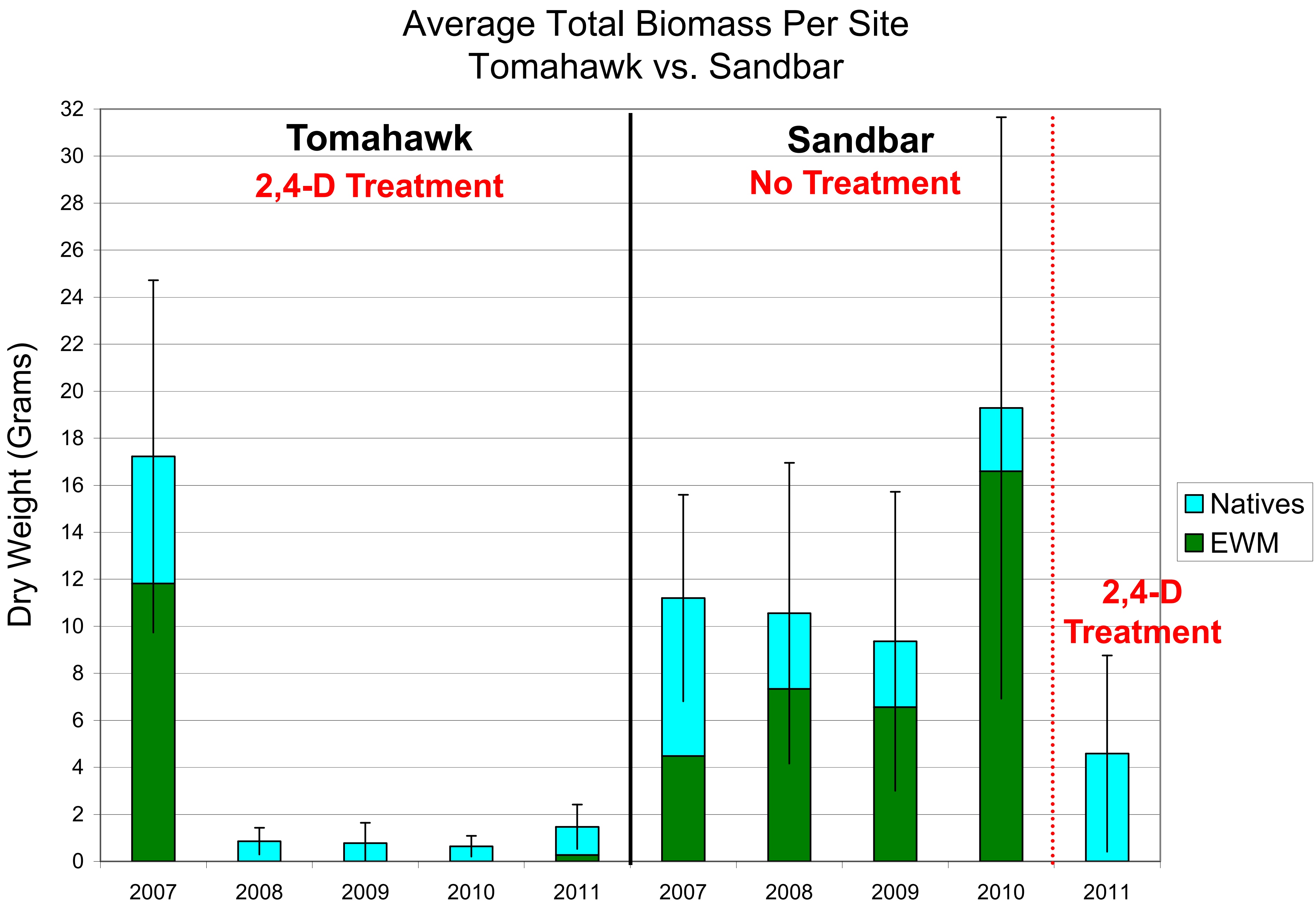


Sandbar 2,4-D Concentrations



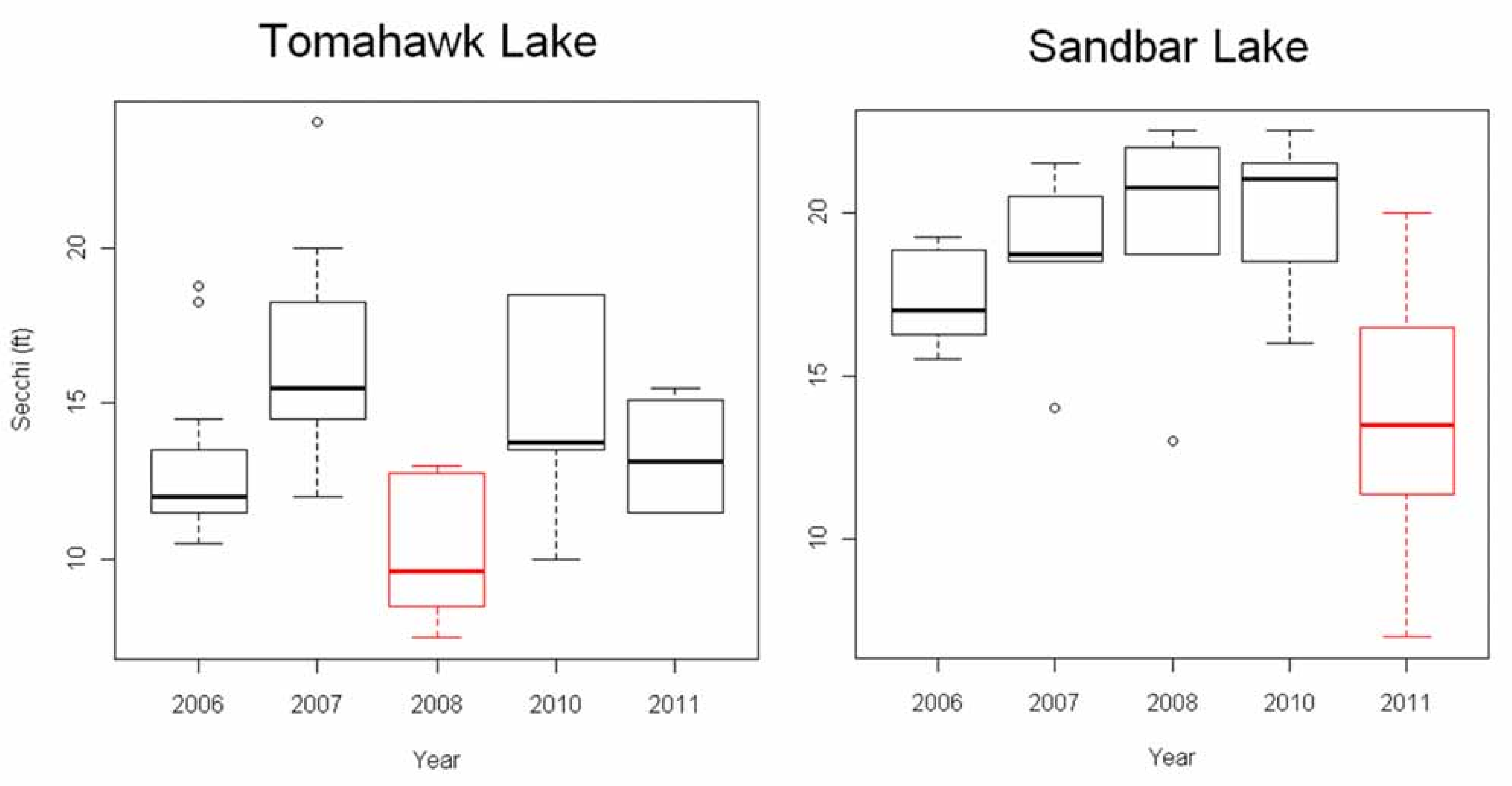
Sandbar 2,4-D Concentrations





Average Total Biomass Per Site
Tomahawk vs. Sandbar
Tomahawk
2,4-D Treatment
Sandbar
No Treatment
2,4-D
Treatment
Natives
EWM
Dry Weight (Grams)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
2007
2008
2009
2010
2011
2007
2008
2009
2010
2011

Water Quality



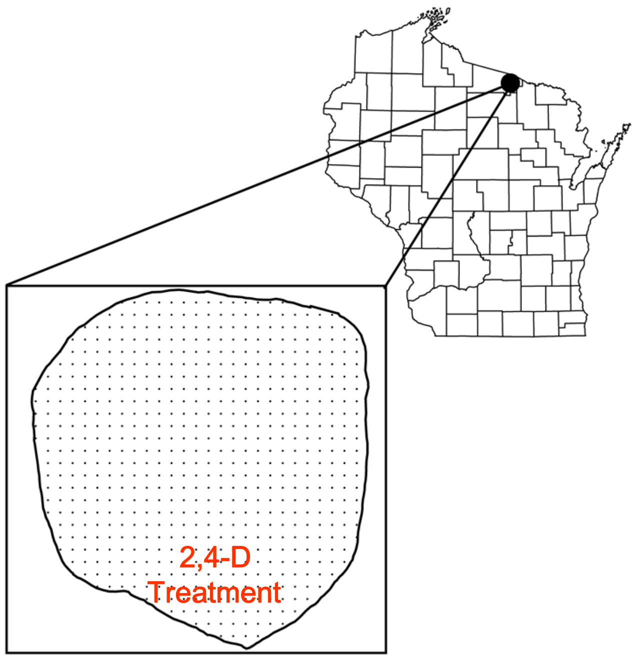
South Twin Lake, Vilas Co.

WDNR, Army Corps of Engineers, Onterra LLC

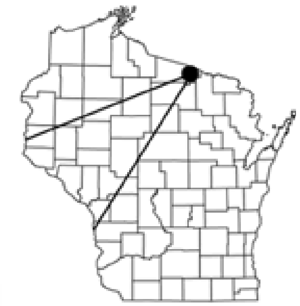
1) What are the effects of early season 2,4-D on Eurasian watermilfoil?

2) What about native plants?

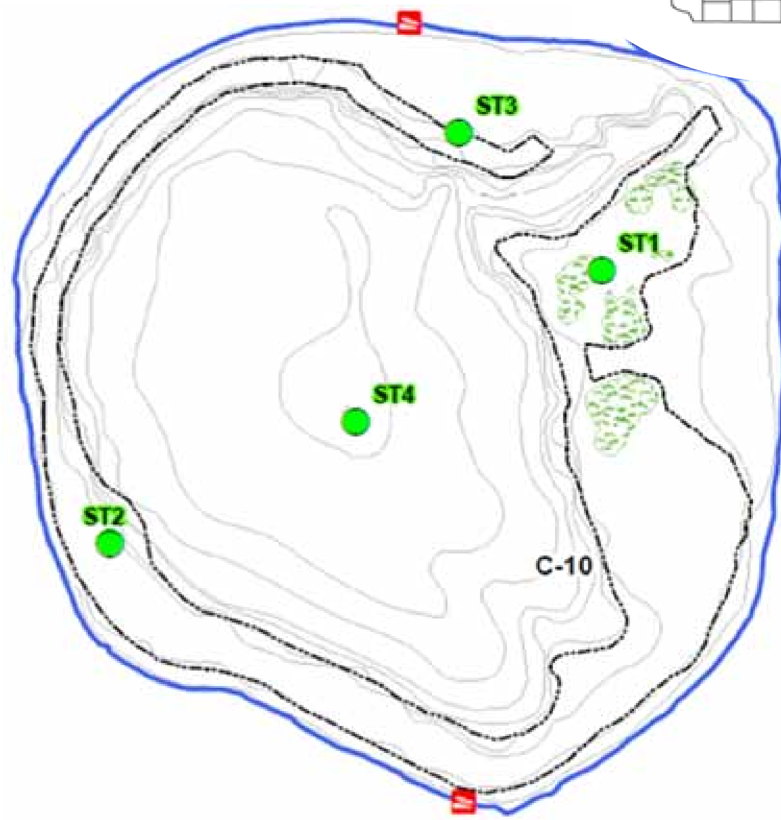
Approach: Monitor annual changes in plant communities pre- and post- treatment



South Twin, Vilas Co.

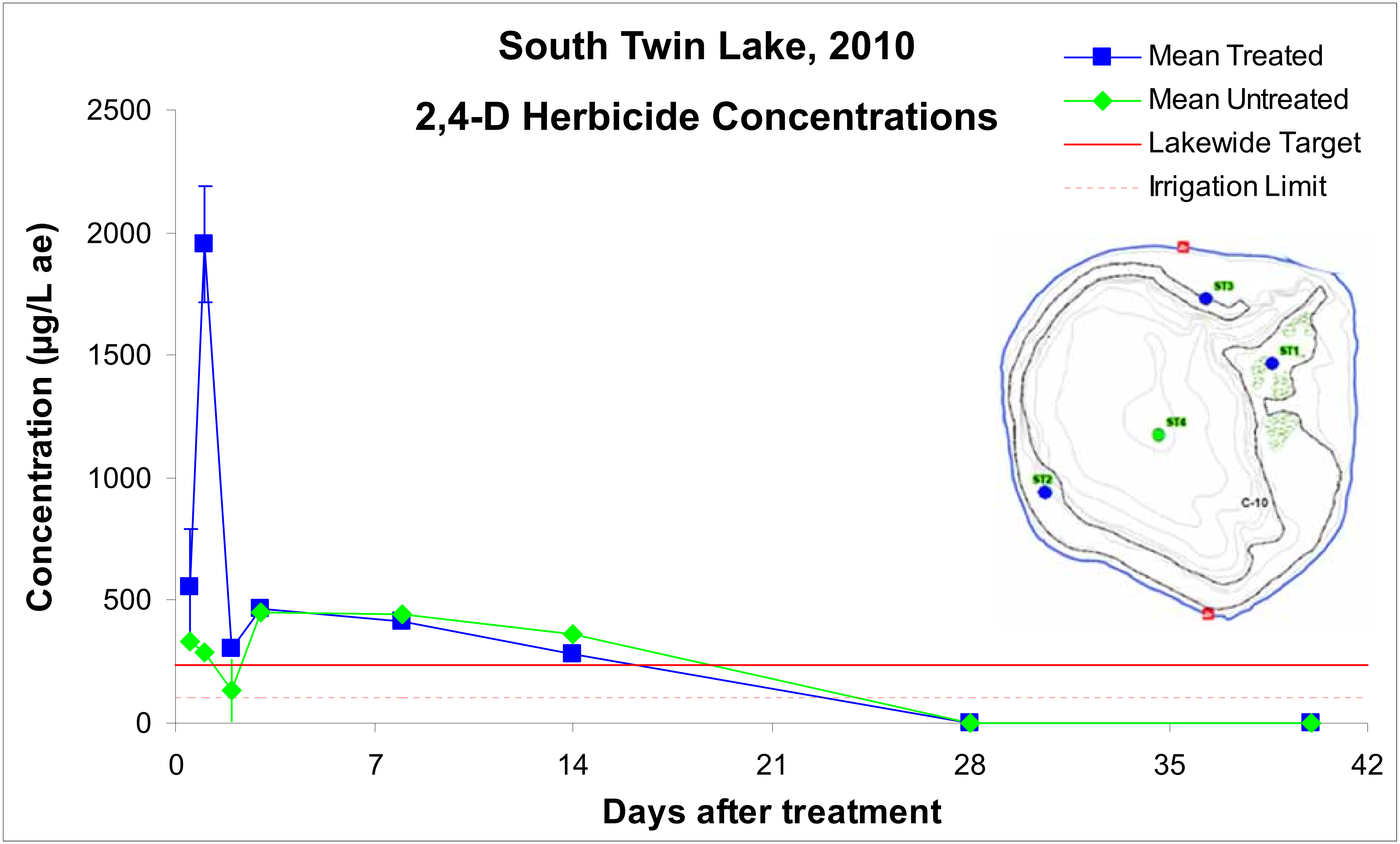


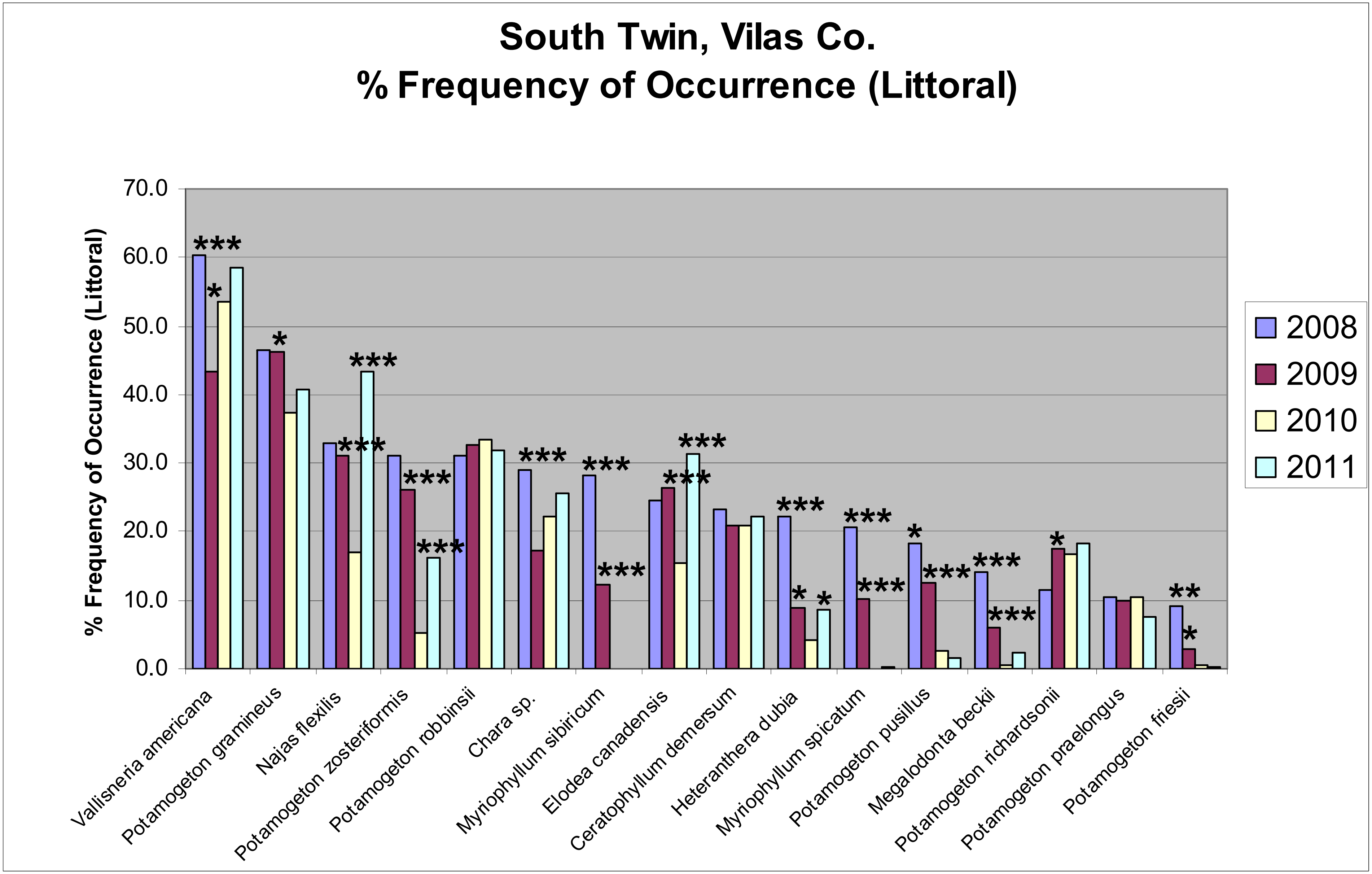
- EWM discovered July 2001
- Spring 2009 - Liquid 2,4-D applied to EWM areas at 1750 µg/L ae (lakewide target = 167 µg/L ae)
- May 2010 - Liquid 2,4-D applied to EWM areas at 2500 µg/L ae (lakewide target = 240 µg/L ae)
- Aquatic plant surveys 2008-2011



SOUTH TWIN, VILAS	
Lake size (acres)	627.71
Max depth (ft)	43
Avg depth	20
Lake type	Drainage

Lakewide Dissipation



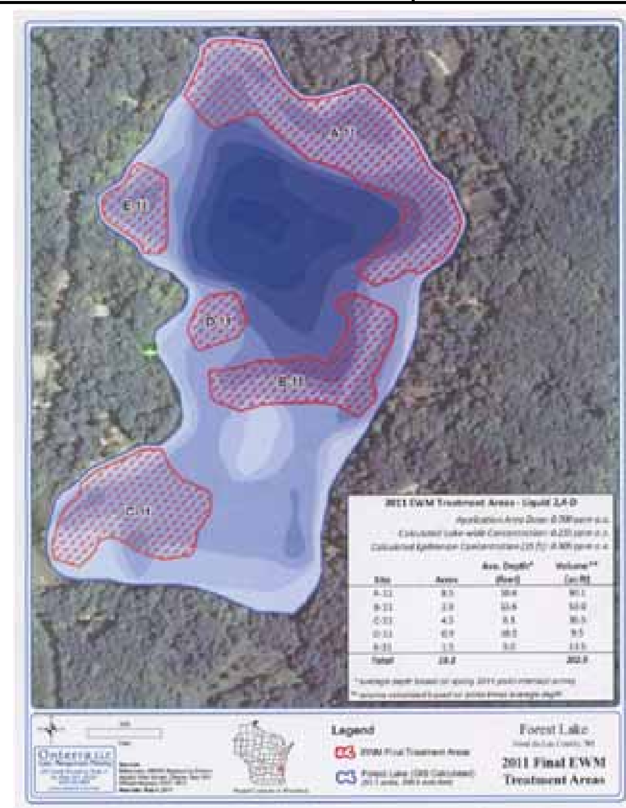


South Twin, Vilas Co.
% Frequency of Occurrence (Littoral)
% Frequency of Occurrence (Littoral)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
2008
2009
2010
2011
Vallisneria americana
Potamogeton gramineus
Najas flexilis
Potamogeton zosteriformis
Potamogeton robbinsii
Chara sp.
Myriophyllum sibiricum
Elodea canadensis
Ceratophyllum demersum
Heteranthera dubia
Myriophyllum spicatum
Potamogeton pusillus
Megalodonta beckii
Potamogeton richardsonii
Potamogeton praelongus
Potamogeton friesii

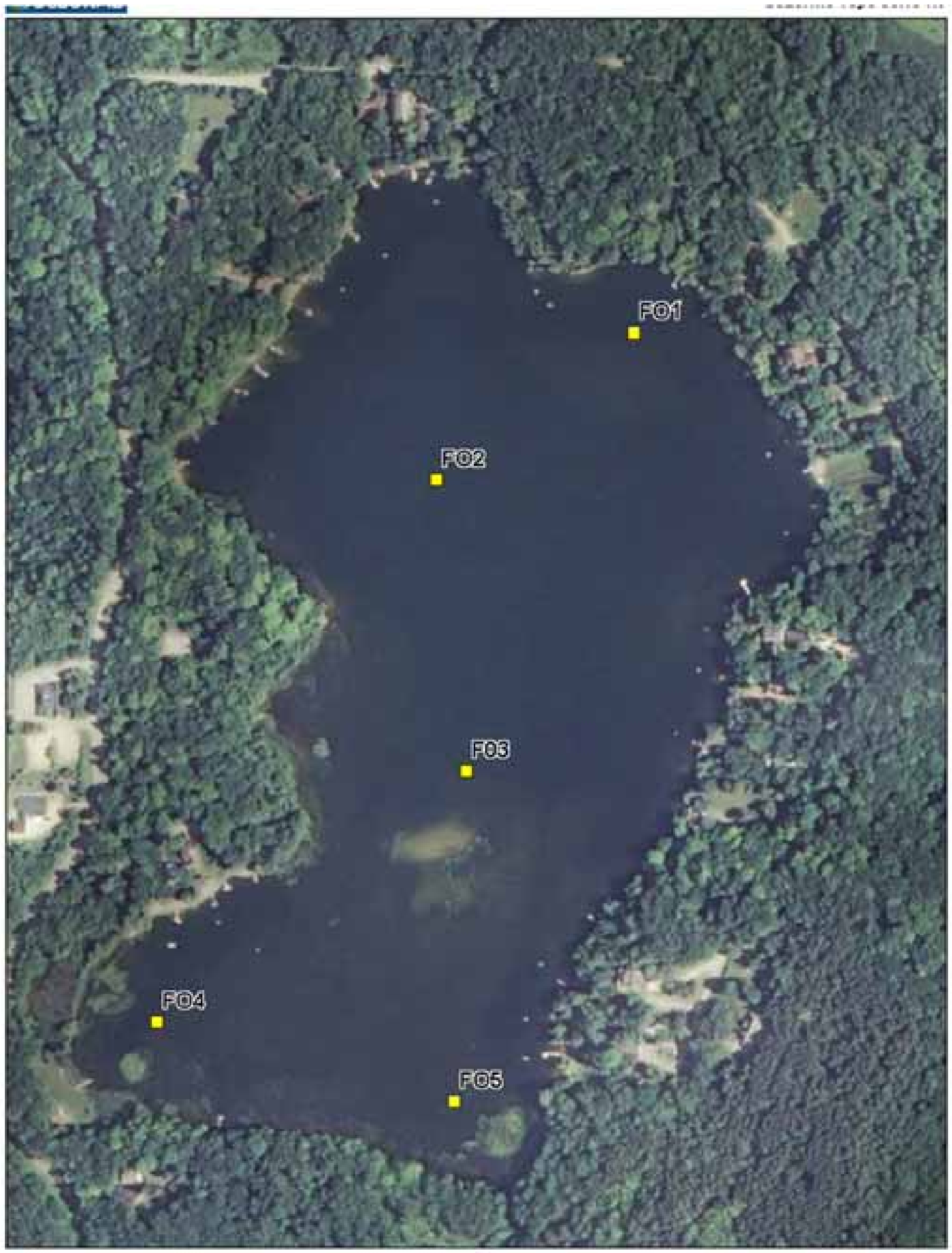
Forest Lake, Fond du Lac Co.

- EWM first discovered 1992
- DNA analysis confirmed as *M. spicatum* X *M. sibiricum*
- Liquid 2,4-D applied to 5 sites at 600 µg/L ae on May 18, 2011
- Whole-lake target = 305 µg/L ae
- Lake volume factored in stratification at ~15 feet
- EWM surveys 2011 pre- and post-treatment by Onterra

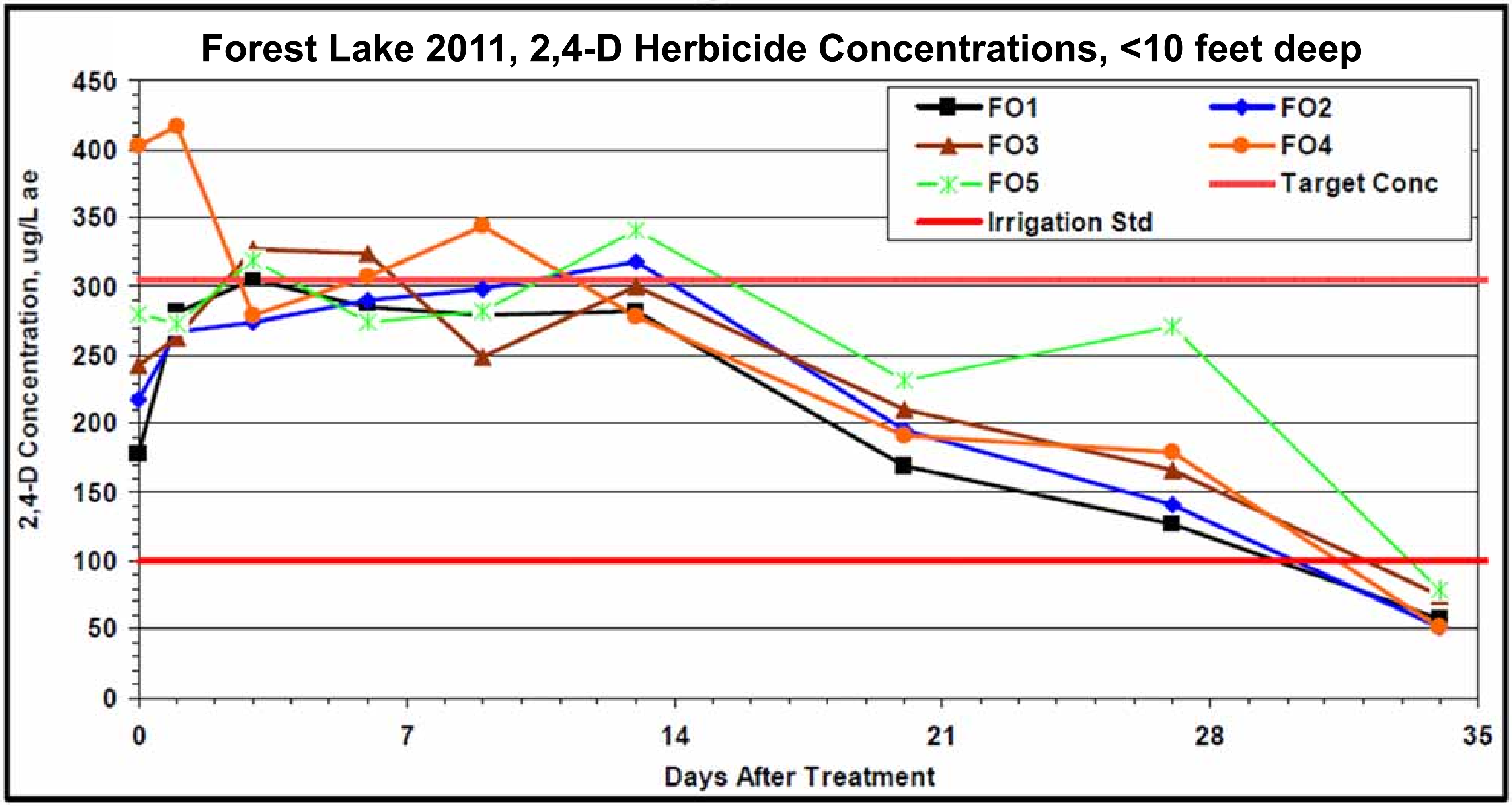
FOREST, FOND DU LAC	
Lake size (acres)	51
Max depth (ft)	32
Avg depth	11
Lake type	Seepage



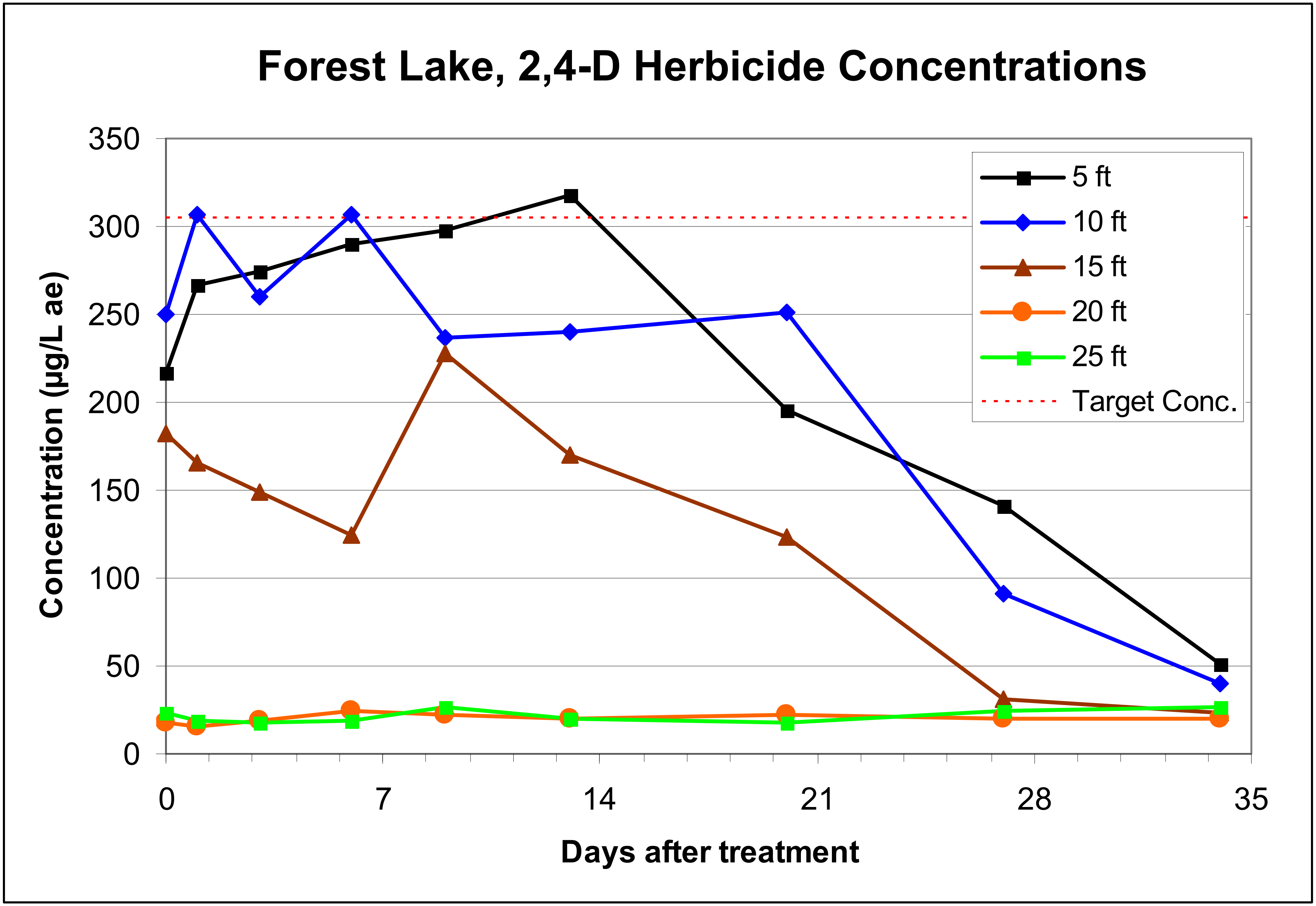
Forest – Herbicide Monitoring

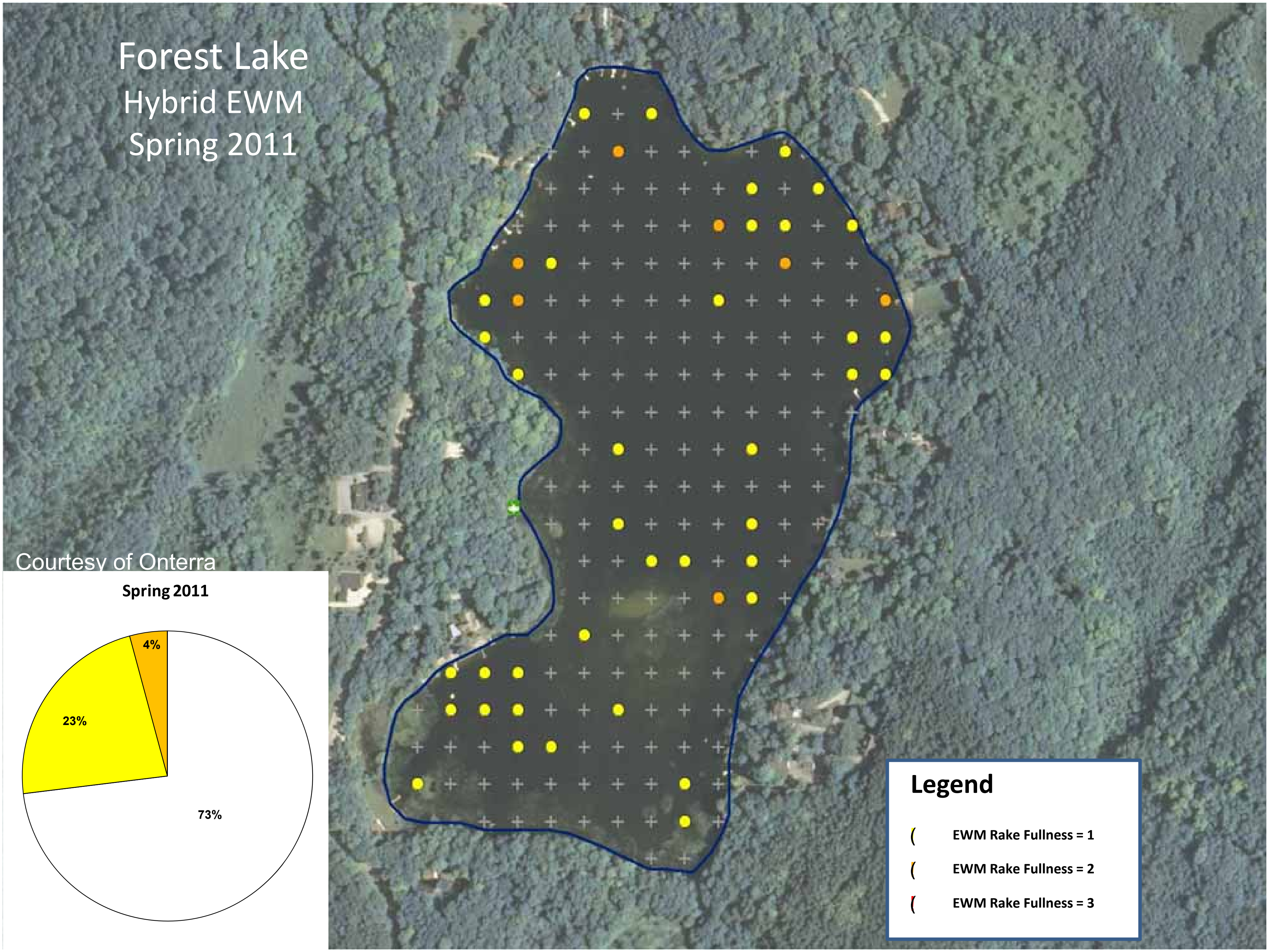


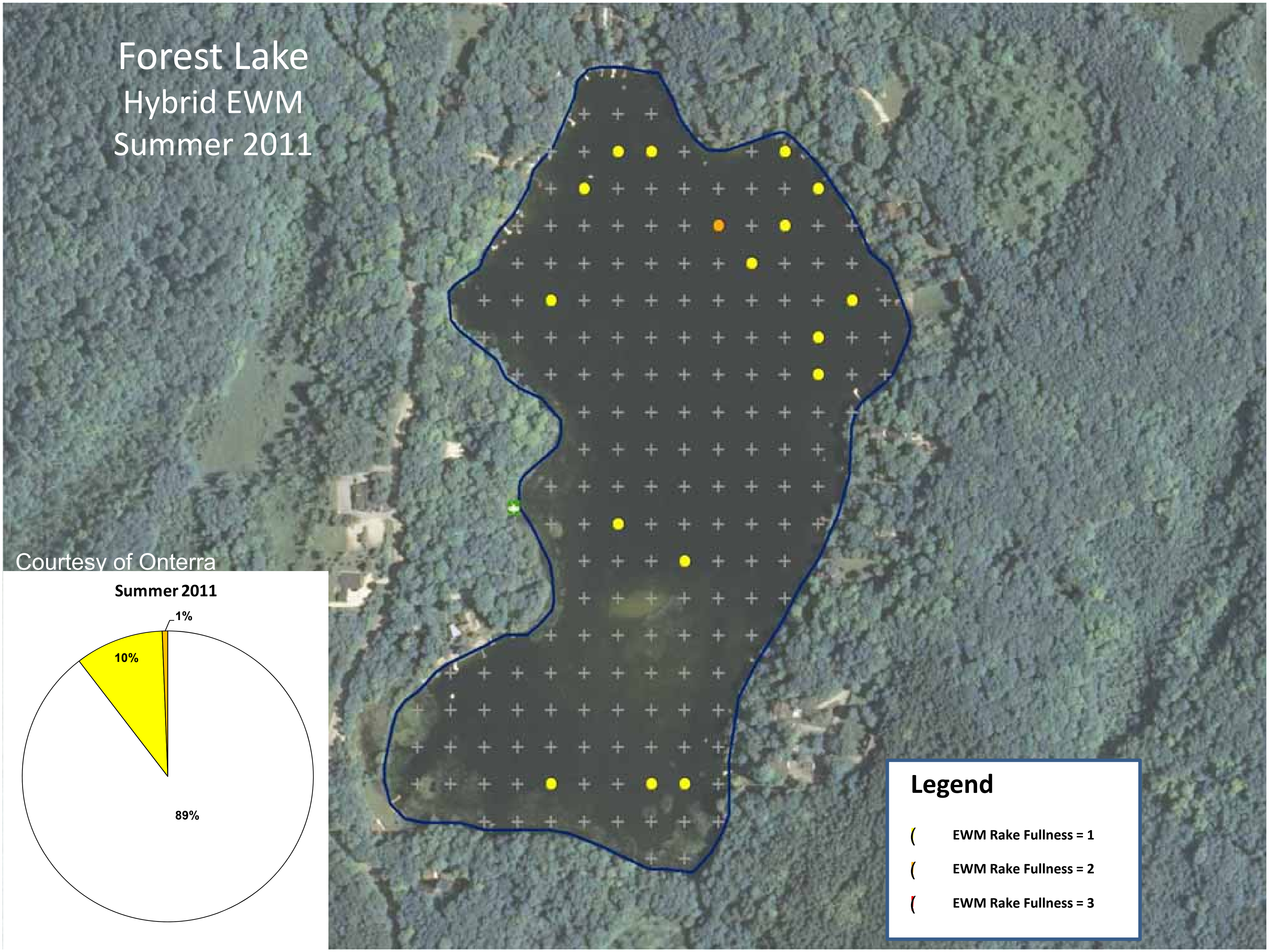
Forest 2,4–D Concentrations



Lake Stratification

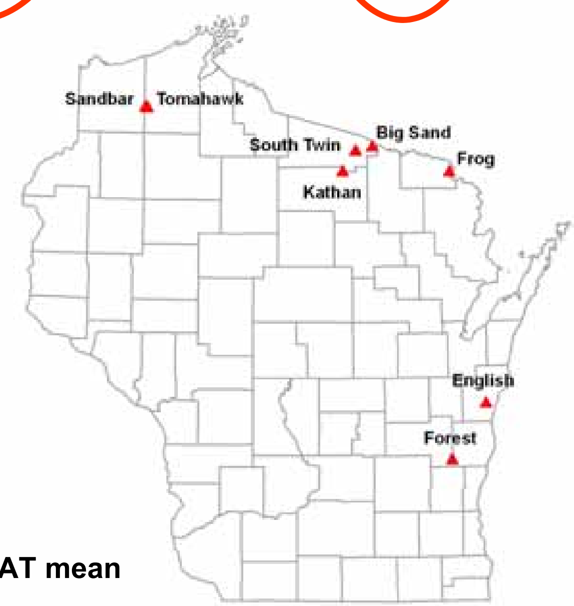



Forest Lake
Hybrid EWM
Spring 2011
Courtesy of Onterra
Spring 2011
4%
23%
73%
Legend
EWM Rake Fullness = 1
EWM Rake Fullness = 2
EWM Rake Fullness = 3


Forest Lake
Hybrid EWM
Summer 2011
Courtesy of Onterra
Summer 2011
1%
10%
89%
Legend
EWM Rake Fullness = 1
EWM Rake Fullness = 2
EWM Rake Fullness = 3

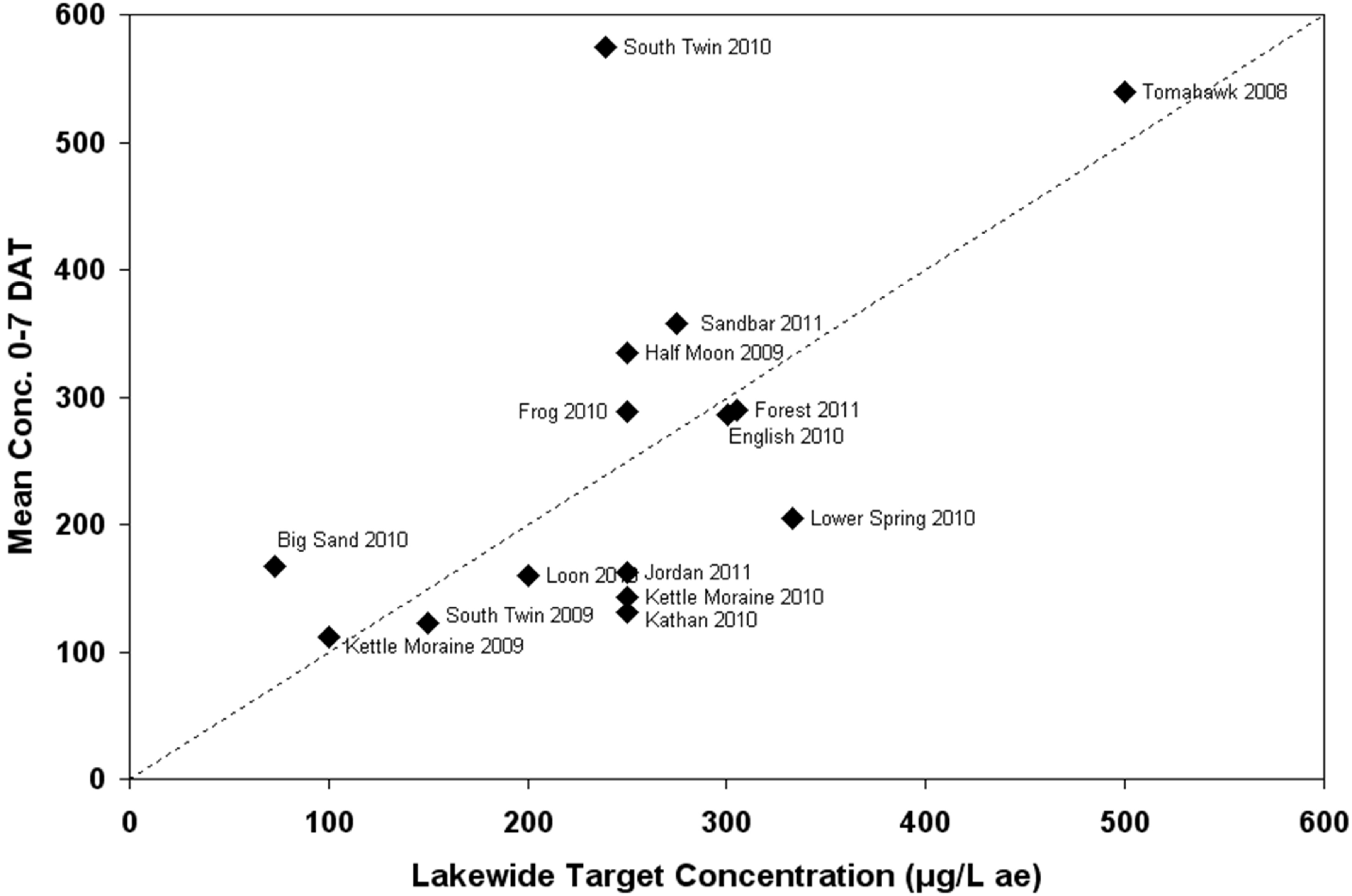
Whole Lake Treatments

Lake	Year	% EWM Control	Lake Area (acres)	% Lake Area Treated	Target Conc. In Treated Area (µg/L ae)	Target Lakewide Conc. (µg/L ae)	Mean 0-3 DAT Lakewide Conc. (µg/L ae)	Mean 0-7 DAT Lakewide Conc. (µg/L ae)	Days Conc. > 100 µg/L ae	Confirmed Hybrid?
Tomahawk	2008	100	114	100	500	500	563 ± 44	539 ± 25*	110	No
South Twin	2010	100	628	26	2500	239	613 ± 139	575 ± 112*	23	No
Big Sand	2010	97	1427	8	2100	73	194 ± 61‡	167 ± 31	14	No
Sandbar	2011	90	108	100	275	275	370 ± 17	357 ± 14	44	No
Kathan	2010	83	214	54	500	250	149 ± 30	131 ± 21	14	No
Forest	2011	62	52	37	700	305	286 ± 13	289 ± 10**	31	Yes
English	2010	51	48	27	2000	300	306 ± 64‡‡	286 ± 48***	38	Yes
South Twin	2009	51	628	26	1750	150	122 ± 12‡	122 ± 7	17	No
Frog	2010	41	17.5	100	250	250	297 ± 22	289 ± 14	22	Yes

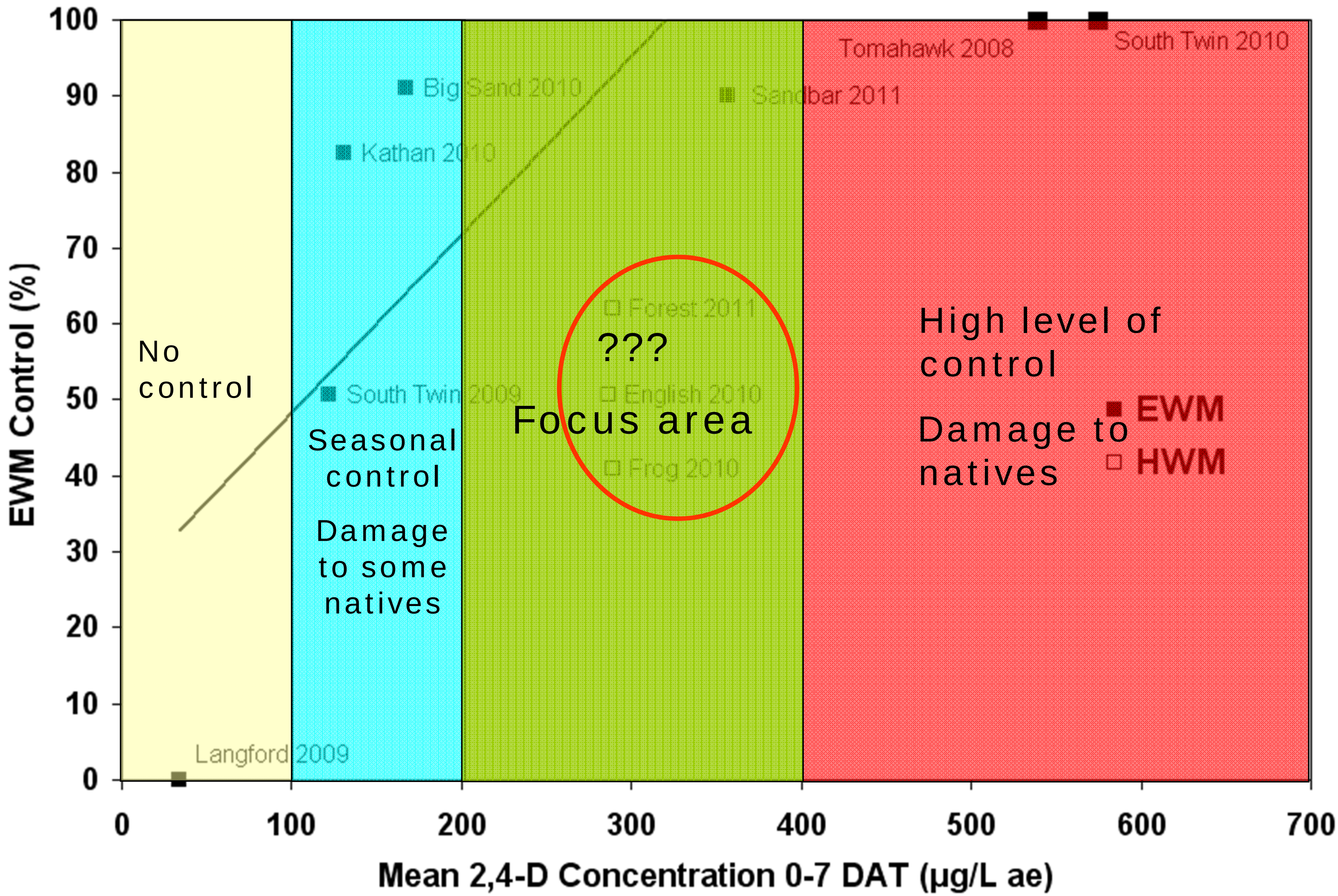


(‡) 0-2 DAT mean, (‡‡) 0-4 DAT mean, (*) 0-8 DAT mean, (**) 0-6 DAT mean, and (***) 0-9 DAT mean

Are lakewide targets being met?



EWM Control



100
90
80
70
60
50
40
30
20
10
0
EWM Control (%)
0
100
200
300
400
500
600
700
Mean 2,4-D Concentration 0-7 DAT (µg/L ae)
No control
Seasonal control
Damage to some natives
Focus area
???
High level of control
Damage to natives
Big Sand 2010
Kathan 2010
South Twin 2009
Langford 2009
Sandbar 2011
Forest 2011
English 2010
Frog 2010
Tomahawk 2008
South Twin 2010
EWM
HWM

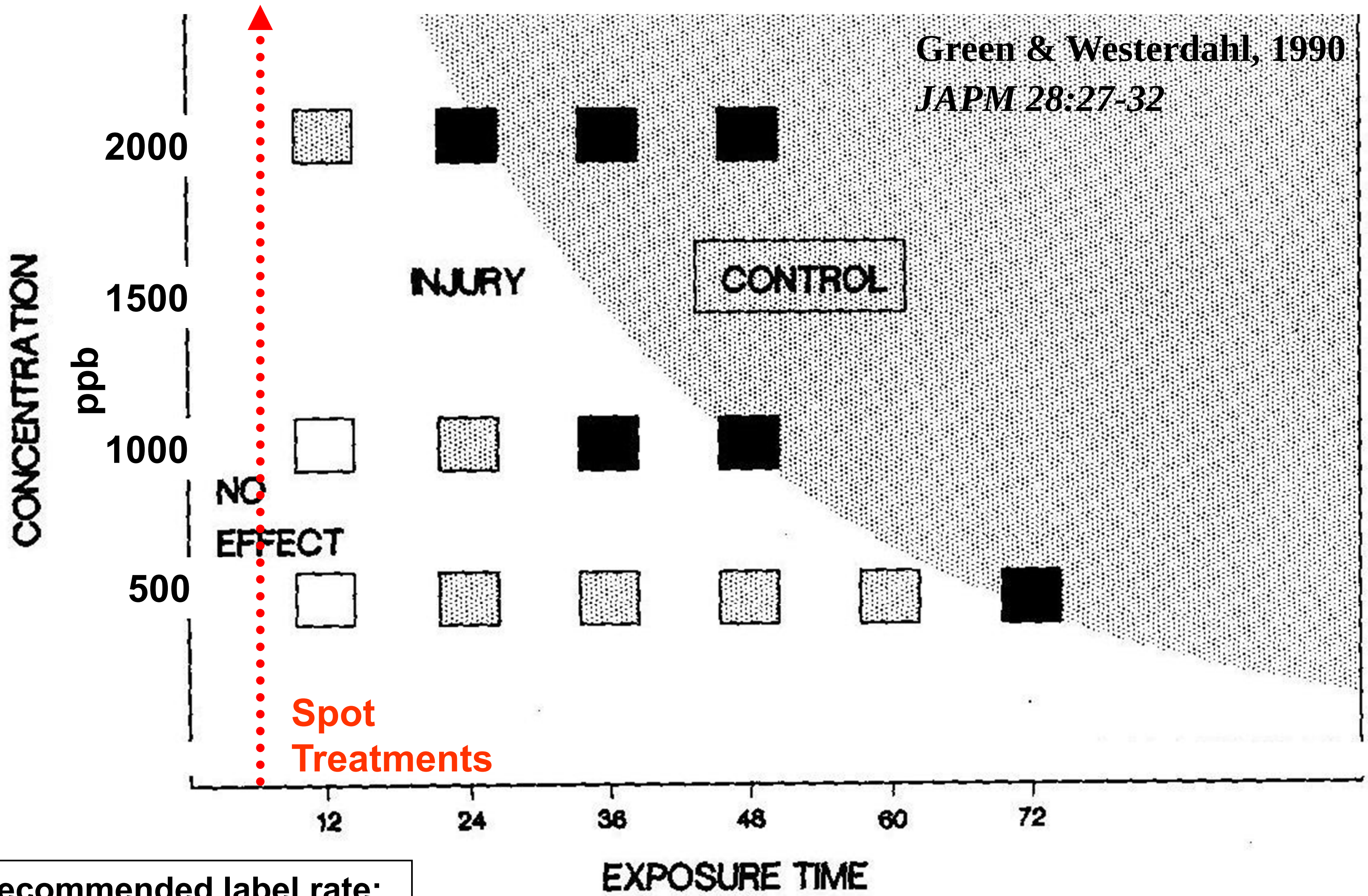
Native Species

Scientific Name, Common Name	Group	Sandbar	Tomahawk	Frog	Kathan	S. Twin '09	S. Twin '10
Bidens beckii, Water marigold	Dicot	-	<5%	-	-	***	***
Brasenia scherberi, Watershield	Dicot	-	<5%	-	n.s.	-	-
Ceratophyllum demersum, Coontail	Dicot	<5%	<5%	-	n.s.	n.s.	n.s.
Chara spp., Muskgrasses	Macroalgae	n.s.	n.s.	n.s.	n.s.	***	n.s.
Eleocharis acicularis, Needle spikerush	Monocot	n.s.	<5%	-	<5%	n.s.	n.s.
Elodea canadensis, Common waterweed	Monocot	n.s.	***	-	n.s.	n.s.	***
Heteranthera dubia, Water star grass	Monocot	-	<5%	-	-	***	*
Myriophyllum tenellum, Dwarf watermilfoil	Dicot	n.s.	<5%	-	-	<5%	-
Myriophyllum sibiricum, Northern watermilfoil	Dicot	-	<5%	-	<5%	***	***
Najas flexilis, Bushy pondweed	Monocot	*	***	***	***	n.s.	***
Nitella spp., Stoneworts	Macroalgae	n.s.	***	-	***	<5%	<5%
Nymphaea odorata, White water lily	Dicot	-	<5%	<5%	n.s.	-	-
Potamogeton amplifolius, Large-leaf pondweed	Monocot	n.s.	***	n.s.	n.s.	<5%	<5%
Potamogeton epihydrus, Ribbon-leaf pondweed	Monocot	-	-	-	***	-	-
Potamogeton foliosus, Leafy pondweed	Monocot	-	-	*	-	-	-
Potamogeton friesii, Fries' pondweed	Monocot	-	-	-	-	**	<5%
Potamogeton gramineus, Variable leaf pondweed	Monocot	n.s.	n.s.	<5%	<5%	n.s.	*
Potamogeton pusillus, Small pondweed	Monocot	***	***	n.s.	***	*	***
Potamogeton richardsonii, Clasping-leaf pondweed	Monocot	<5%	-	-	<5%	+	n.s.
Potamogeton robbinsii, Robbins pondweed	Monocot	n.s.	*	-	-	n.s.	n.s.
Potamogeton strictifolius, Stiff pondweed	Monocot	-	-	***	***	<5%	<5%
Potamogeton zosteriformis, Flat-leaf pondweed	Monocot	-	-	n.s.	+	n.s.	***
Stuckenia pectinata, Sago pondweed	Monocot	-	-	n.s.	-	-	-
Utricularia minor, Small bladderwort	Dicot	-	-	-	*	-	-
Vallisneria americana, Wild celery	Monocot	*	***	<5%	+	***	+
Native spp. Significant Decrease (FOO > 5%)		3	7	3	6	7	8
Native spp. Significant Increase (FOO > 5%)		0	0	0	2	1	1
Net Native spp. Loss/Gain		-3	-7	-3	-4	-6	-7

Preliminary Findings

- Recommended label concentrations may not be applicable for whole lake treatments (too high)
- Herbicide dissipation is rapid and large scale treatments can result in a whole-lake treatment if the scale of the treatment area is large compared to the overall lake volume
- Lake stratification and water temperature are important to consider when calculating volume
- Early spring, large scale treatments may result in longer persistence of herbicides than expected; may exceed 100 µg/L ae for >21 days
- EWM control looks promising, however short-term damage to certain native species may occur and long term effects on biotic and abiotic parameters is uncertain
- Hybrid watermilfoils need to be better documented and studied in both field and laboratory studies

2,4-D Concentration/Exposure Time

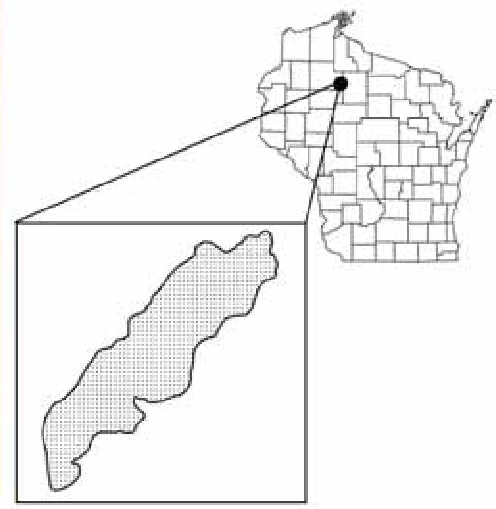


Recommended label rate:
2000 – 4000 ppb

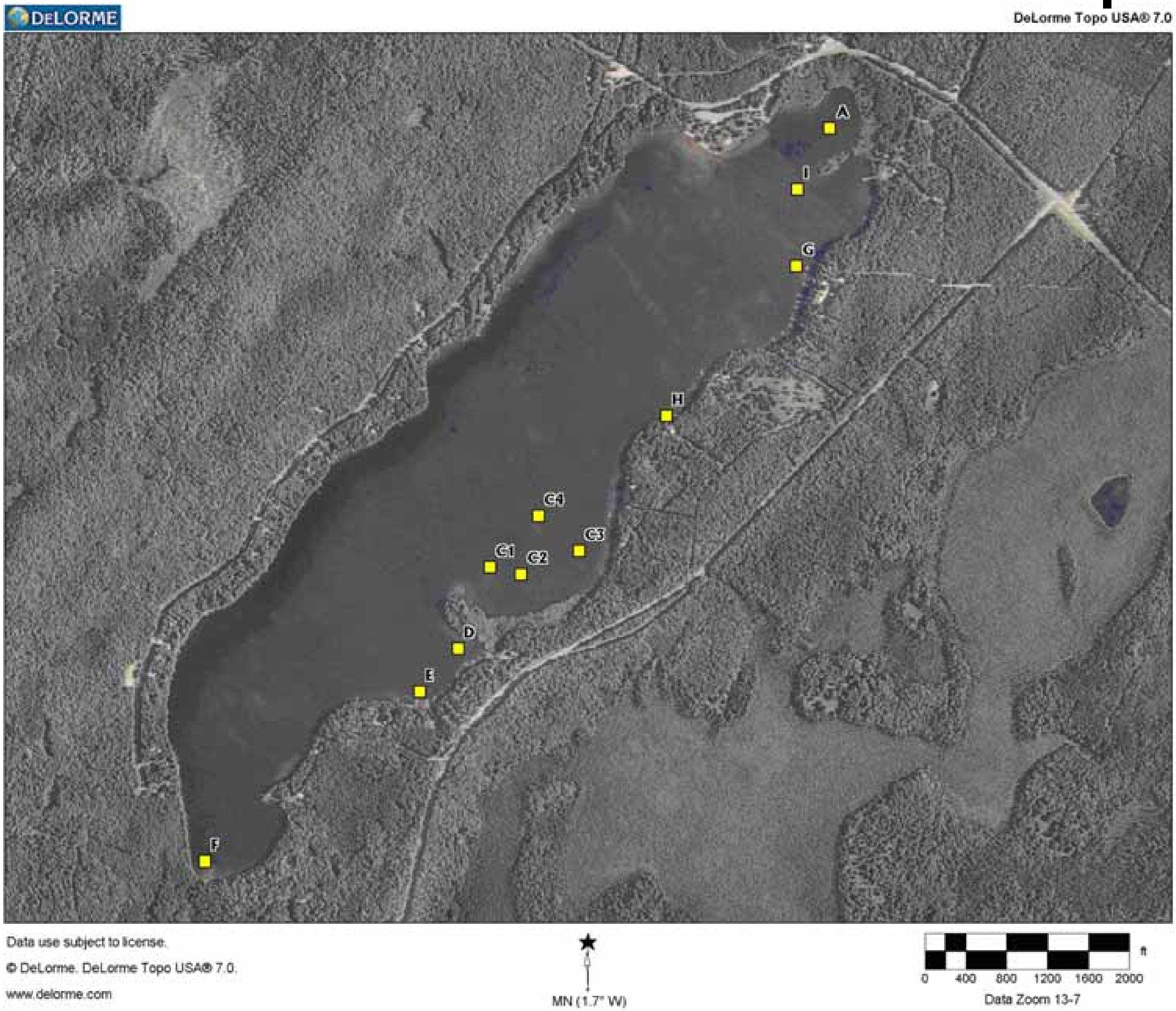
Connors – Treatment Map

Connors Lake 2010 Treatment

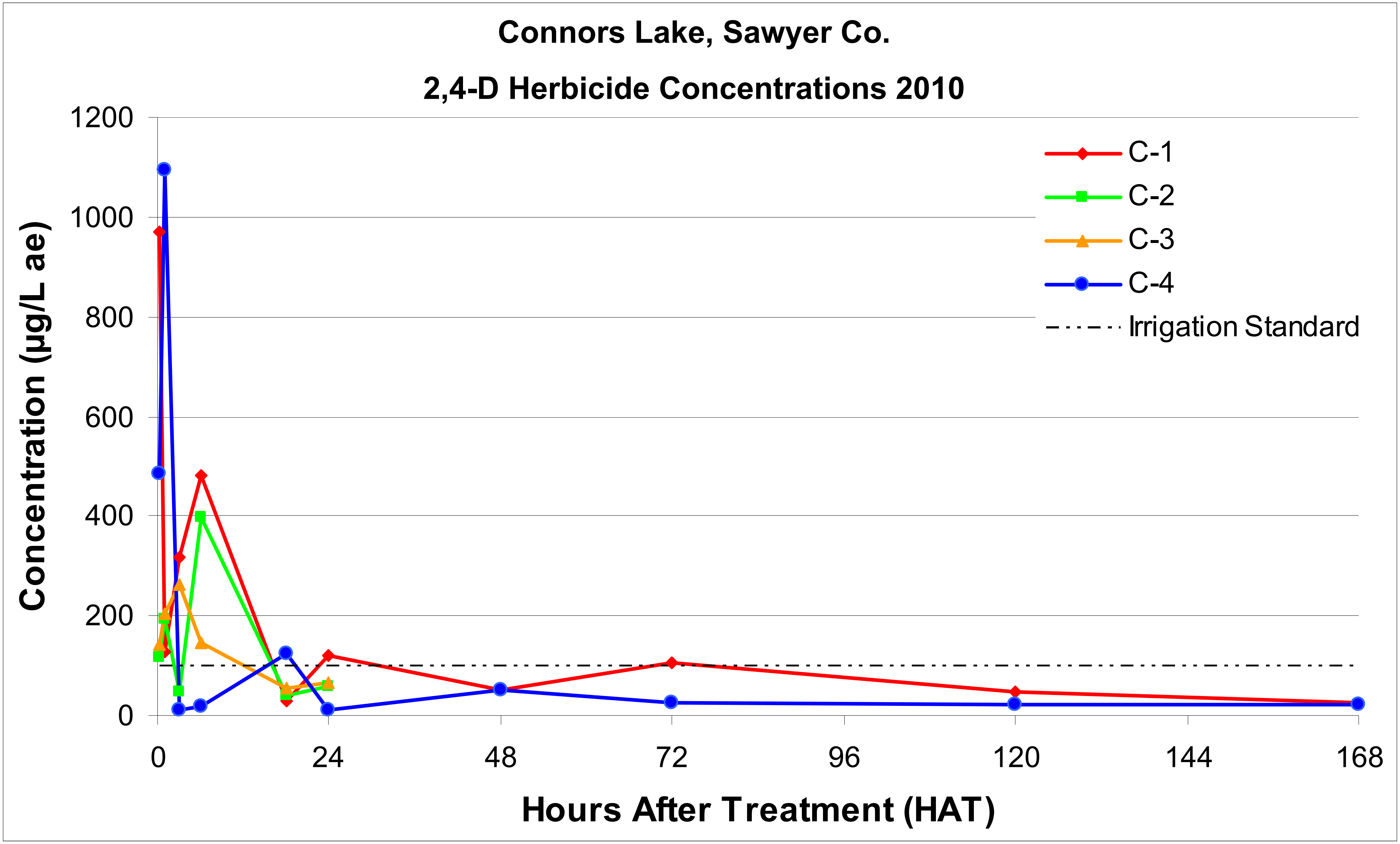
Bed polygon	***Acres***
A and B	0.94
C	12.04
D	1.63
E	0.53
F	0.12
G	0.9
H	0.22
I	0.22
Total	16.6



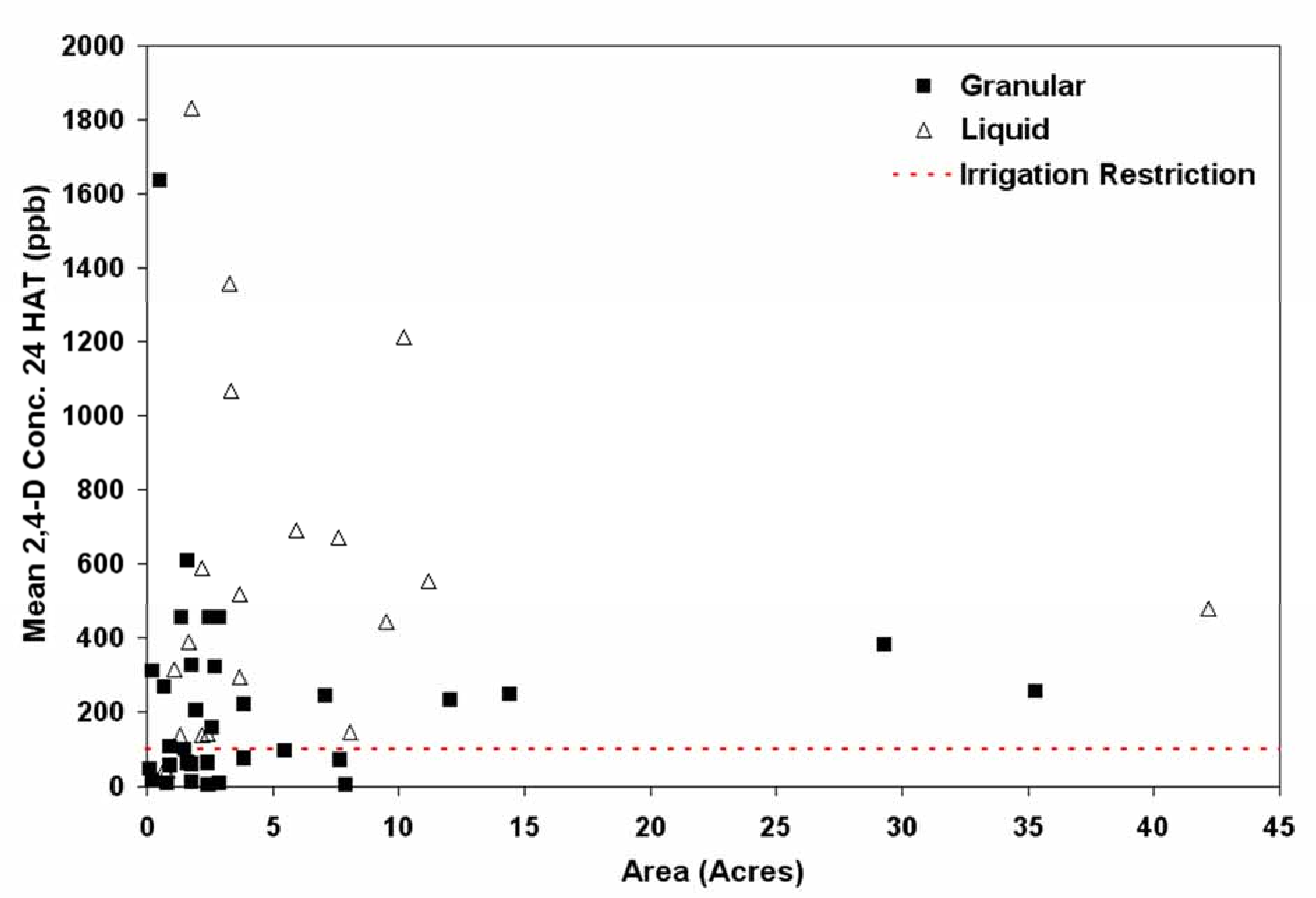
Connors – Treatment Map



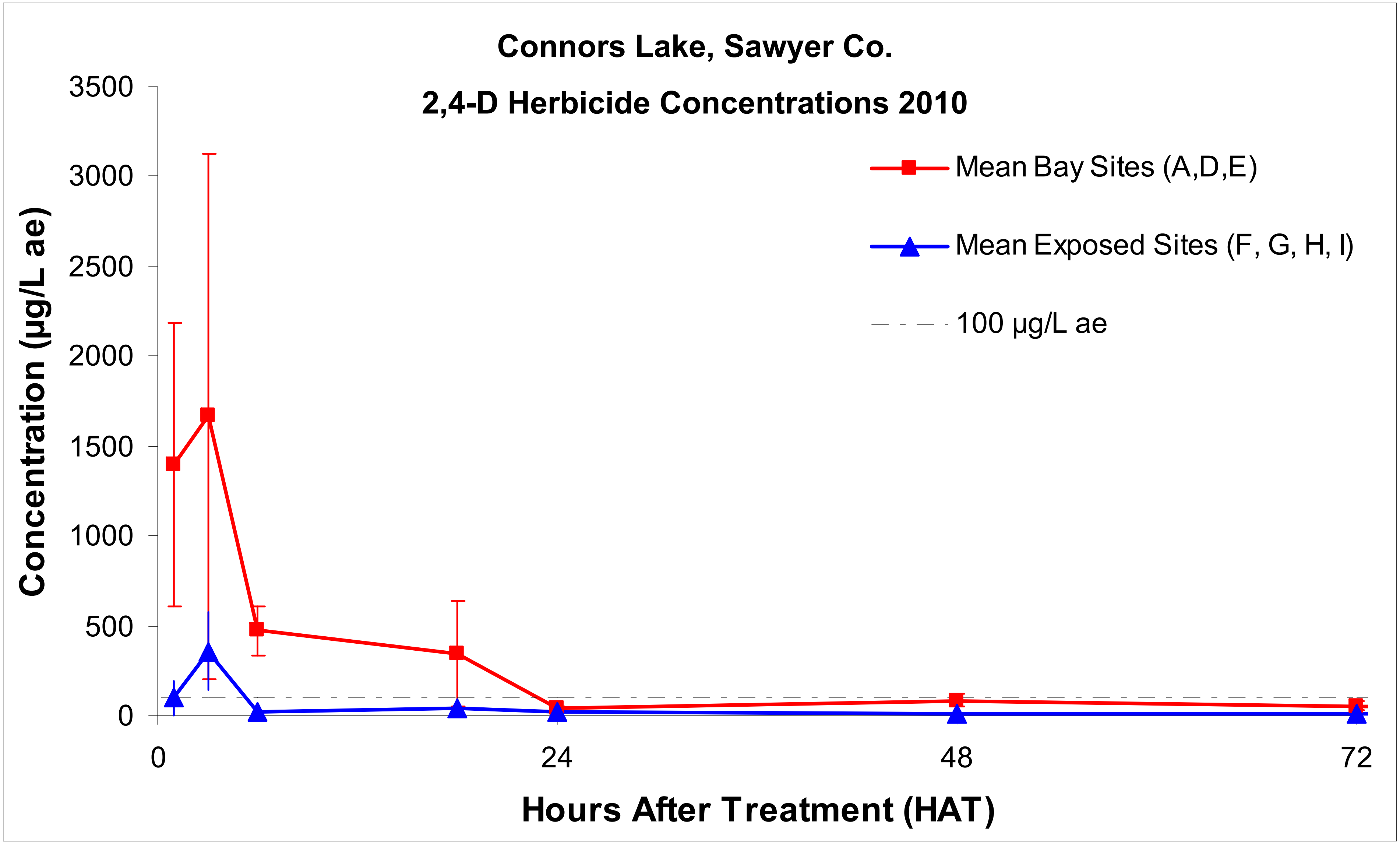
Connors – 2,4-D Concentration



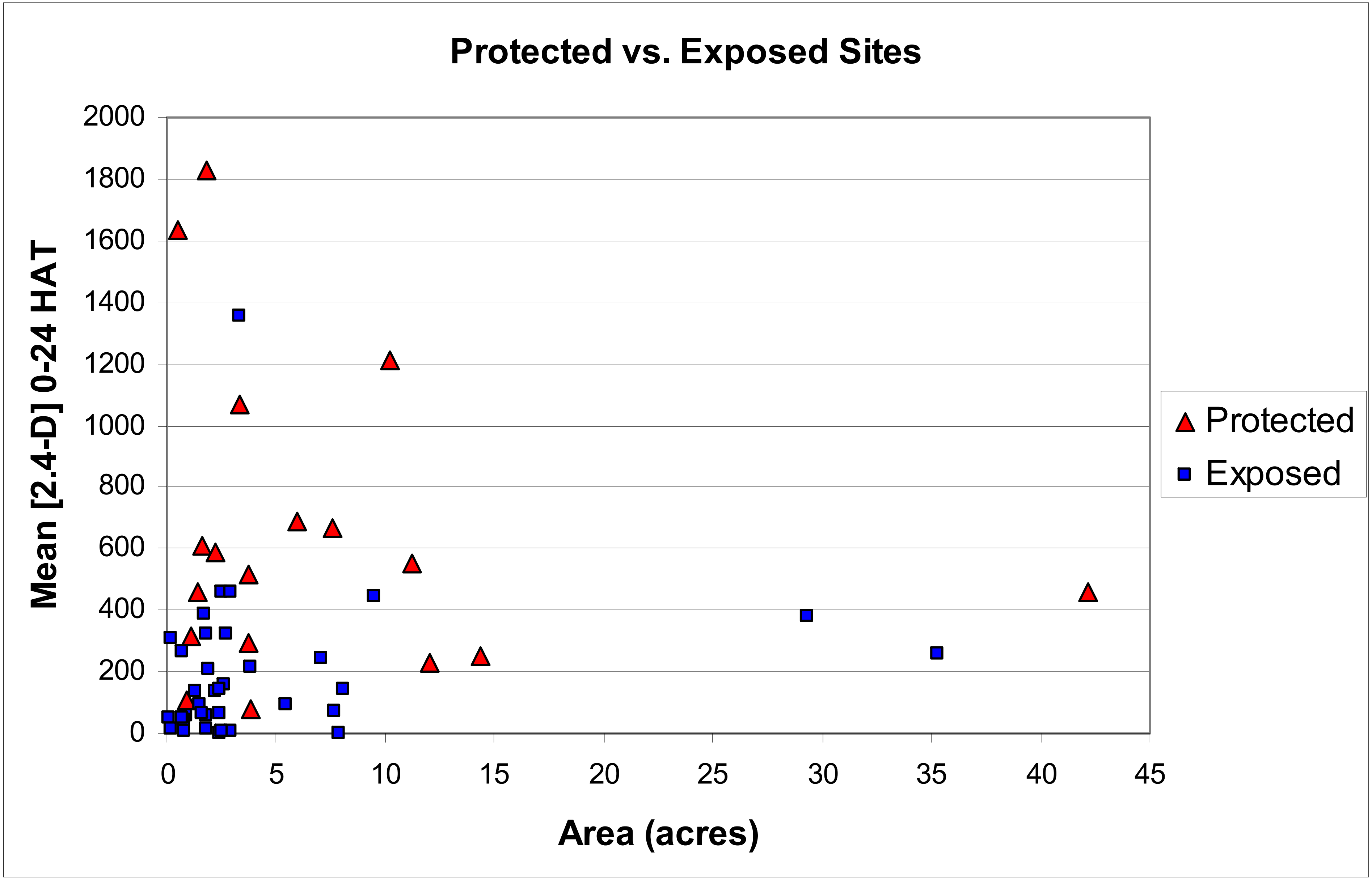
Area vs. Concentration 24 HAT



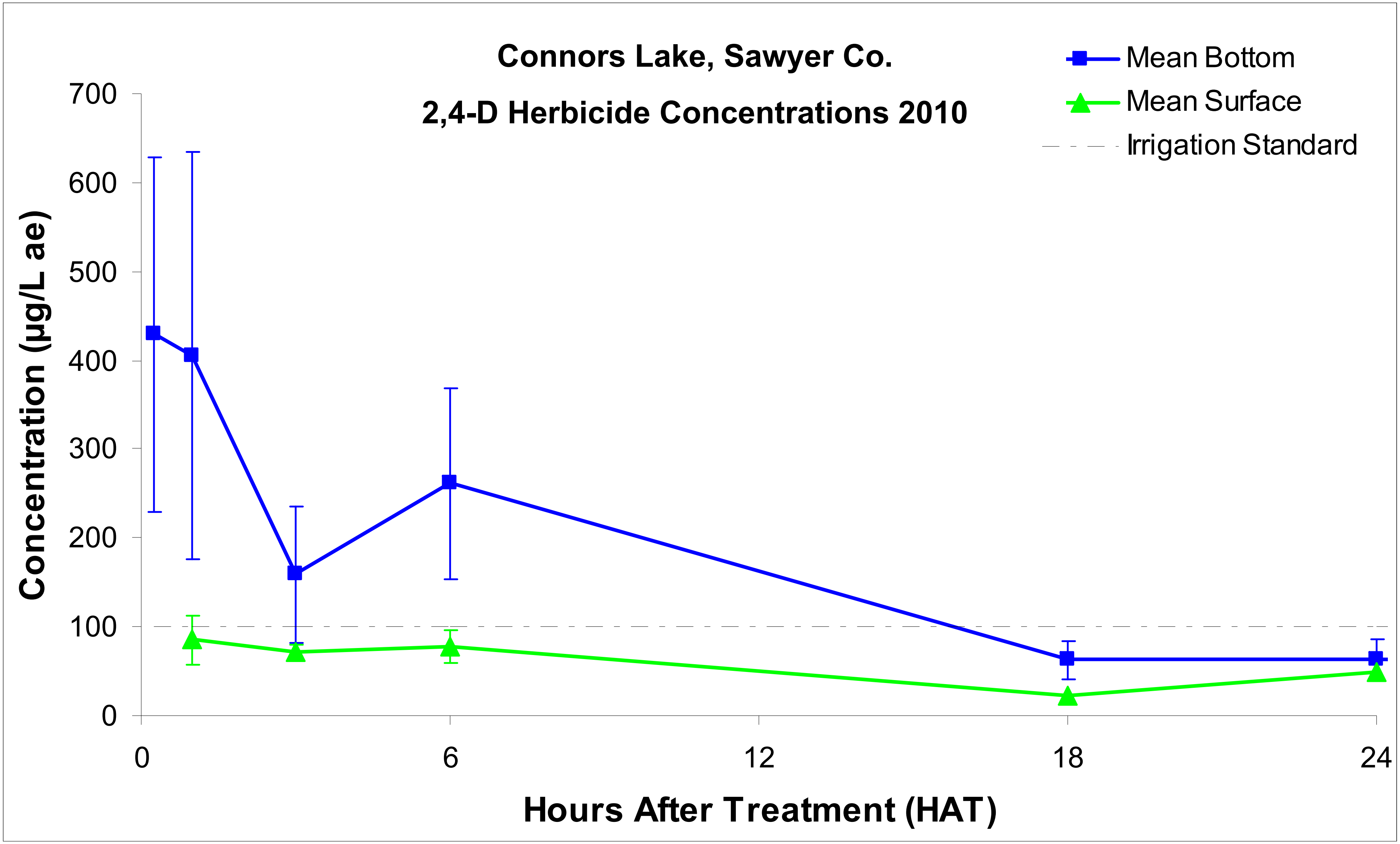
Connors – 2,4-D Concentration



Treatment Site Location



Connors – 2,4-D Concentration

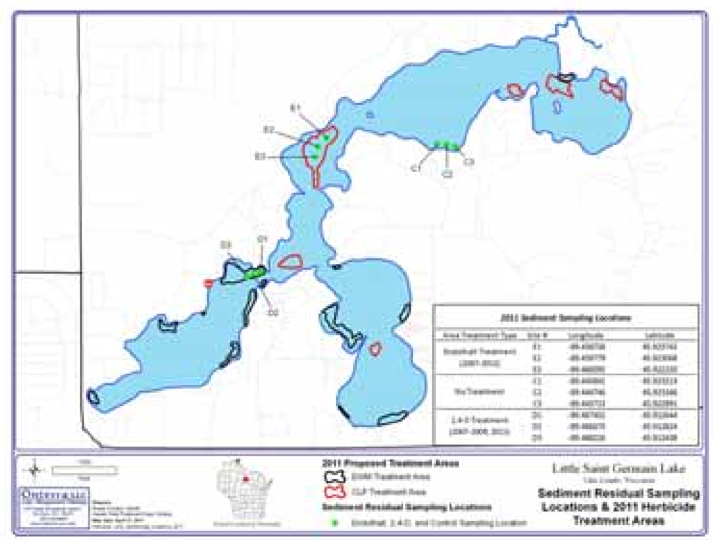


Preliminary Findings

- Actual CET in the field is more difficult to predict and maintain in smaller spot treatments
- Aquatic plant data is more difficult to collect and analyze in smaller spot treatments
- Rapid dissipation occurred and concentrations were < 100 µg/L ae by 24 HAT in many treatment sites
- Mean concentrations in the protected sites were greater than those from the more exposed sites
- Granular formulation did result in a vertical gradient from top to bottom, however horizontal dissipation through the water column was rapid and similar to liquid formulations

Sediment Pore Water Sampling

- Do these herbicides accumulate in sediment over the long term?
- How quickly to they breakdown or dilute after treatment?
- Study design employed on Little St. Germain, Vilas Co.
- Sampling conducted at three sites both pre- and post-treatment for both 2,4-D and endothall



Sediment Pore Water Sampling

- Two chambered pore water equilibrators (peepers); one chamber is in the sediment and the other is just above the sediment at the sediment water interface.
- Peepers set and retrieved by scuba diver
- Peepers allowed to equilibrate for 10 -14 days under each sampling event

Preliminary 2,4-D Results

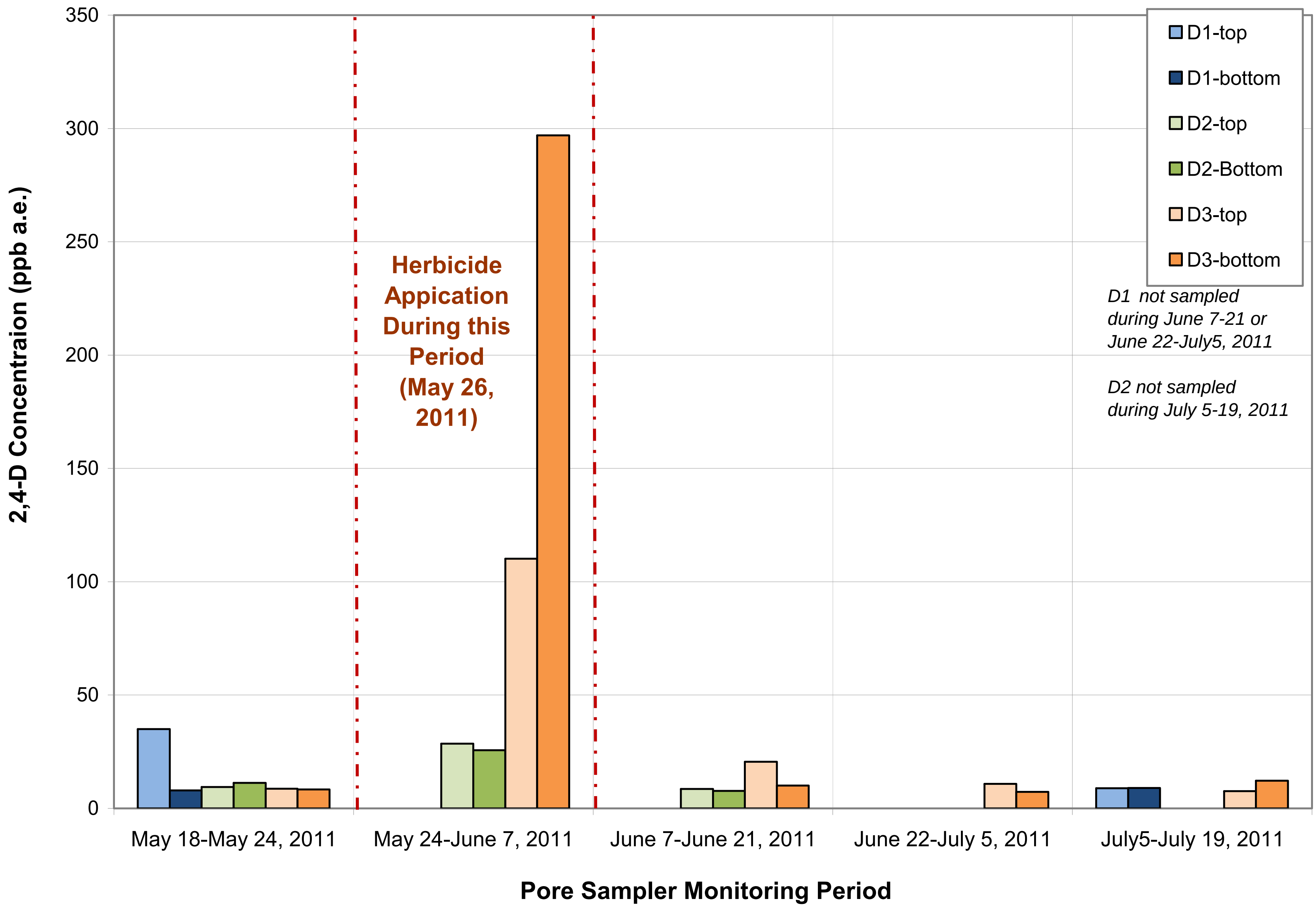


Chart provided by Onterra

Preliminary Endothall Results

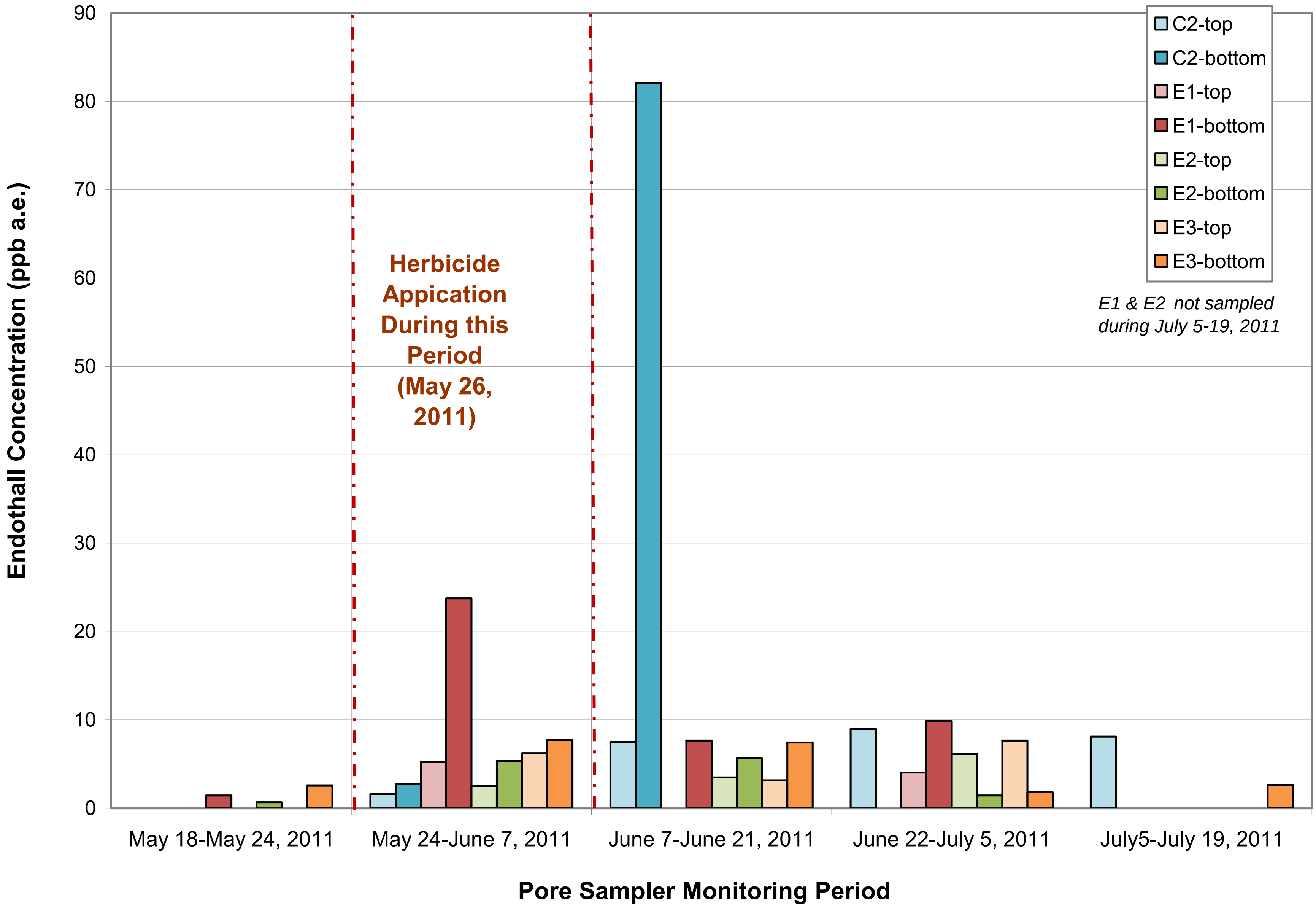


Chart provided by Onterra

Conclusions

- Very little difference between the top and bottom wells of the peepers
- Nearly all of the samples taken outside of the treatment week were below detection limits or just slightly above
- Preliminary data shows no short or long-term accumulation of endothall or 2,4-D in the sediment pore water either prior to or 2 weeks after treatment
- Conduct more intensive pore water sampling and possibly expand to additional lakes

Evaluation of contact aquatic herbicides for controlling submersed flowering rush

Detroit Lakes

Minnesota

US Army Corps of Engineers

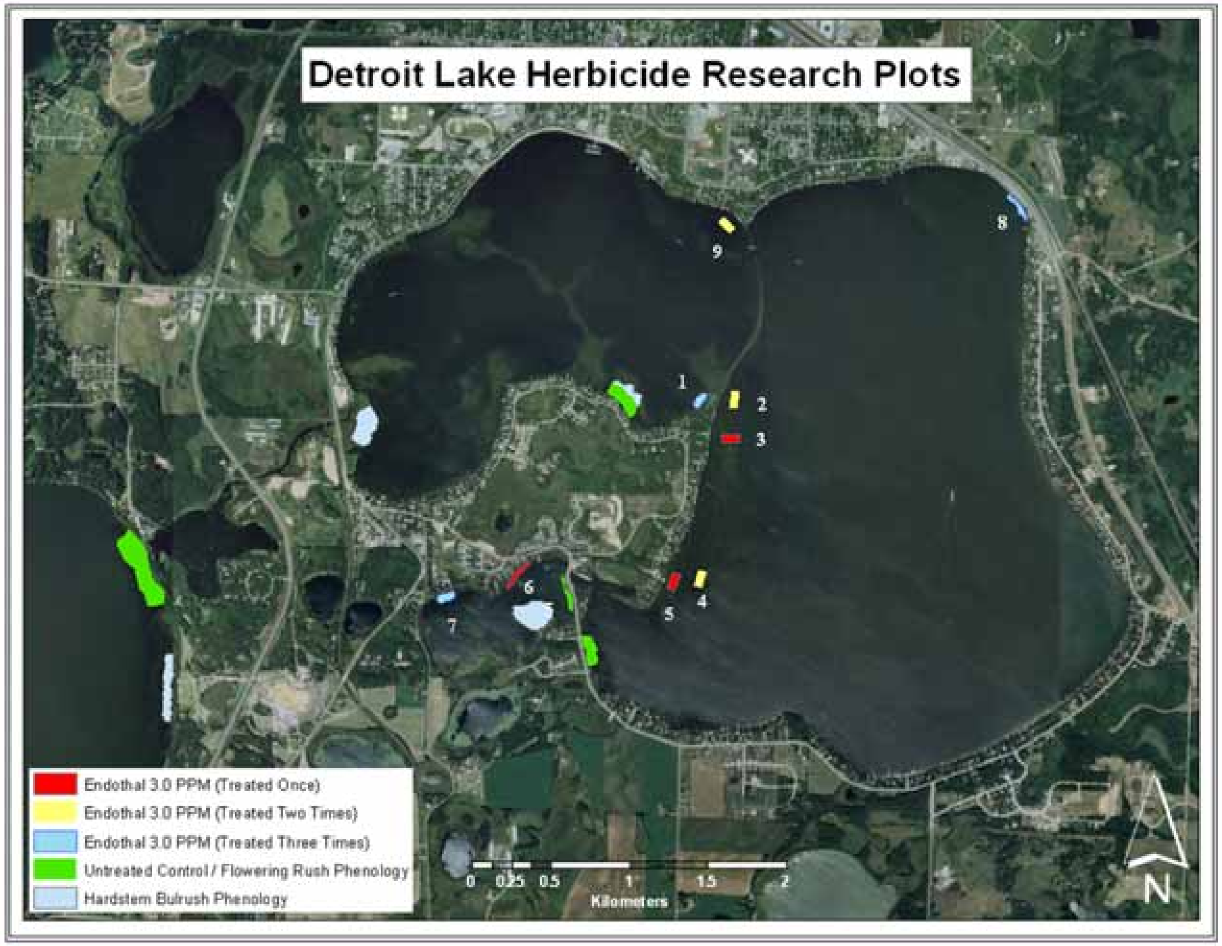
Engineer Research and Development Center

Approach

•Conduct water exchange studies in the field to quantify potential exposure times

Water Exchange Studies, Detroit Lakes 2010

- Nine, 1.5 acre plots
- Endothall: 3 mg/L ai (2.1 mg/L ae)
- Jun, Jul, Aug



Conclusions from 2010

•Exposure times on Detroit Lakes are short (< 12 hrs for 1.5 acre plots) making control difficult

2011 Approach

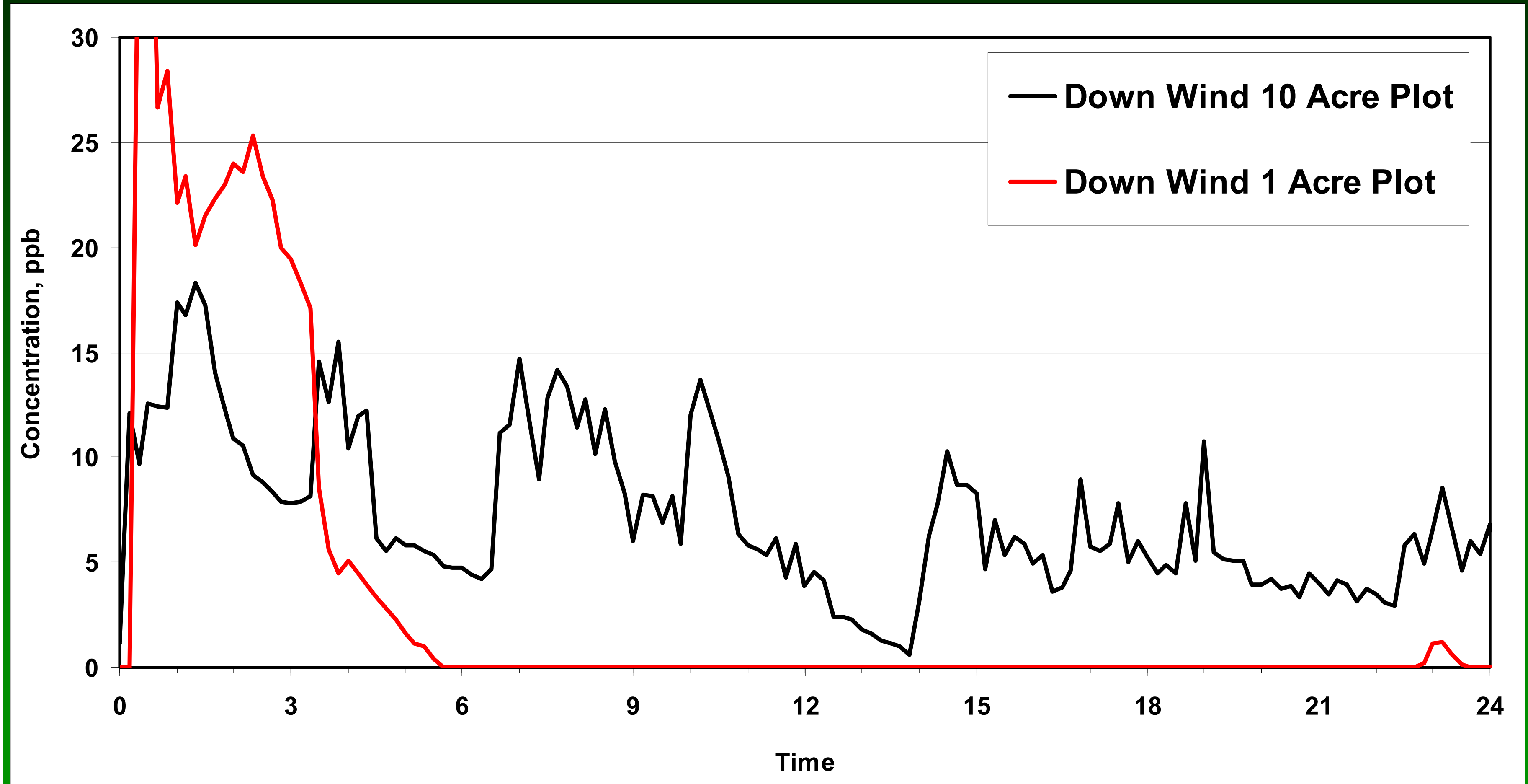
- Treat two, 1 acre plots with diquat
- Treat two, 10 acre plots with endothall
- Apply rhodamine wt dye at 10 ppb to all treatments
    - Turner Aquafluor fluorometers
    - Hydrolab submersible data sondes

Water Exchange Studies, 2011

- two, 10 acre plots
- two, 1 acre plots
- Treatments dates
  16 June
  28 July

US Army Corps
of Engineers

Exposure Times
10 Acre Plots vs. 1 Acre Plots



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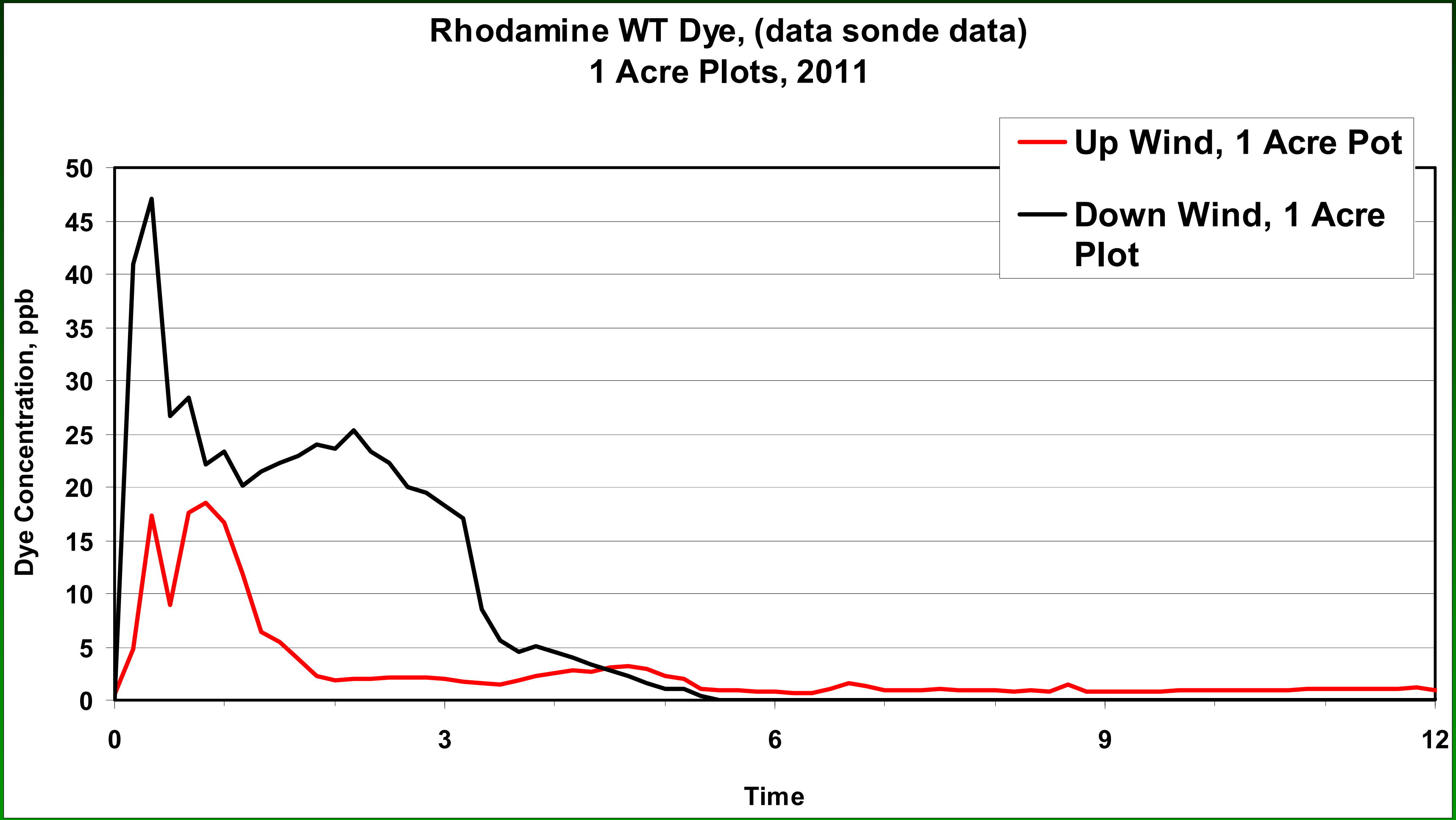
Exposure Times in 1 Acre Plots
Down Wind vs. Up Wind



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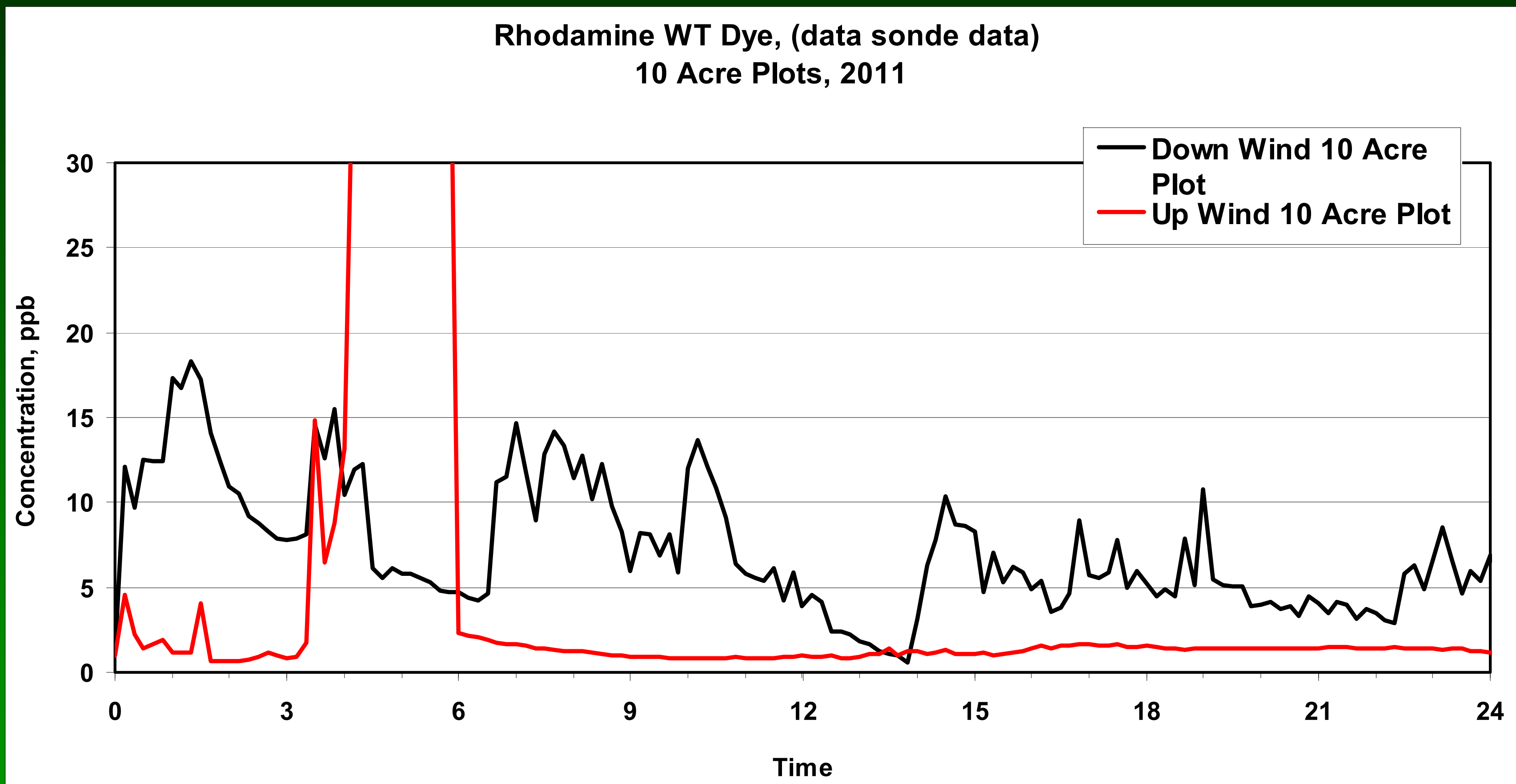
Exposure Times in 10 Acre Plots
Down Wind vs. Up Wind



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Conclusions

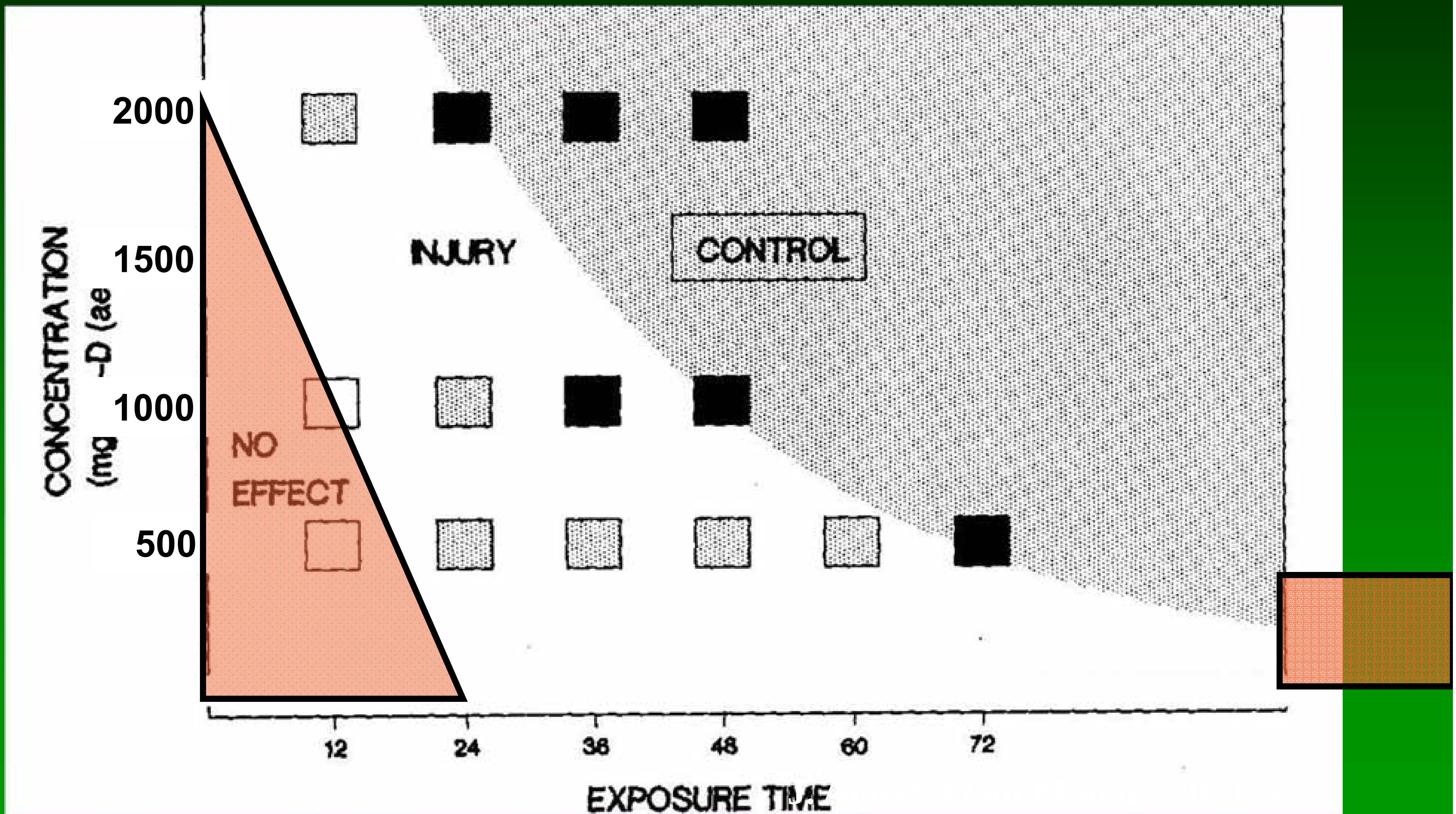
- Water movement is complicated
- Treatment area size matters
- Wind direction is very important in determining exposure time
- Significant movement of herbicide is possible into non target areas

Summary of Field Herbicide Concentration, Exposure Time Studies, 2008-2011

- 2,4-D
- Triclopyr
- Endothall

J. Aquat. Plant Manage 30: 1-5

2,4-D Concentration/Exposure Time Whole Lake versus Spot Treatments



Factors That Appear to Affect Control in Whole Lake Treatments

- Lake wide concentration
- Stratification depth
- Eurasian watermilfoil vs. hybrid milfoil

Factors That May Affect Control in Spot Treatments

- Application rate
- Exposure time
  - Treatment size and configuration?
  - Wind speed and direction?
  - Formulation?
  - Application method?
- Different herbicides, non auxin herbicides
  - Endothall?
  - Diquat?

Next Steps

- The WDNR and Army Corps of Engineers have compiled a draft summary report of the residual monitoring project case studies, and will continue with a final synthesis
- Peer-reviewed journal articles on Tomahawk/Sandbar and overall whole-lake treatment synthesis
- Continue evaluation of the longevity of whole lake treatment impacts as well as native plant and water quality responses
- Continue evaluation of the efficacy of small scale treatments utilizing different application techniques and formulations
- Further exploration of hybrid water milfoils and effectiveness of herbicide treatments
- Further exploration of potential direct and indirect impacts on other organisms

Deciding on the best management approach:

1) Quantify the perceived problem – collect data!

2) Set reasonable expectations and goals (ecological and economical)

3) Weigh the benefits with the risks

4) Recognize that managing invasives is a long-term commitment with any tool (action based on data)

5) Don't forget about the watershed

DISCUSSION