Science behind the "so-called" super weed

Understanding the effects of Eurasian watermilfoil on Wisconsin lakes

Wisconsin Lakes Convention
Stevens Point, WI
April 6, 2017

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Eurasian Watermilfoil

What:

Collect data on the distribution, ecology, and management of non-native watermilfoil

Purpose:

Create a baseline statewide dataset on milfoil populations

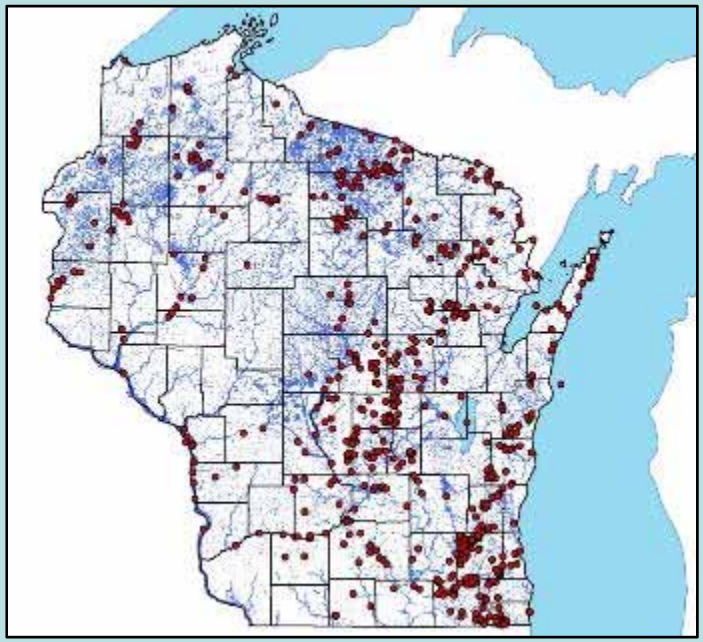
Output:

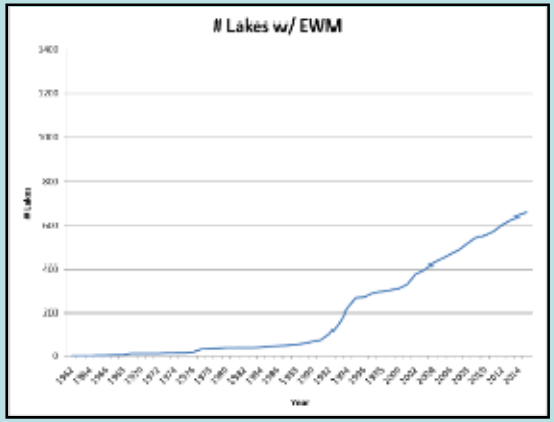
EWM Factsheet (PUB-SS-1074 2011)

The science behind the 'so-called' super weed. WDNR Magazine – Aug. 2016.

Where is Milfoil?

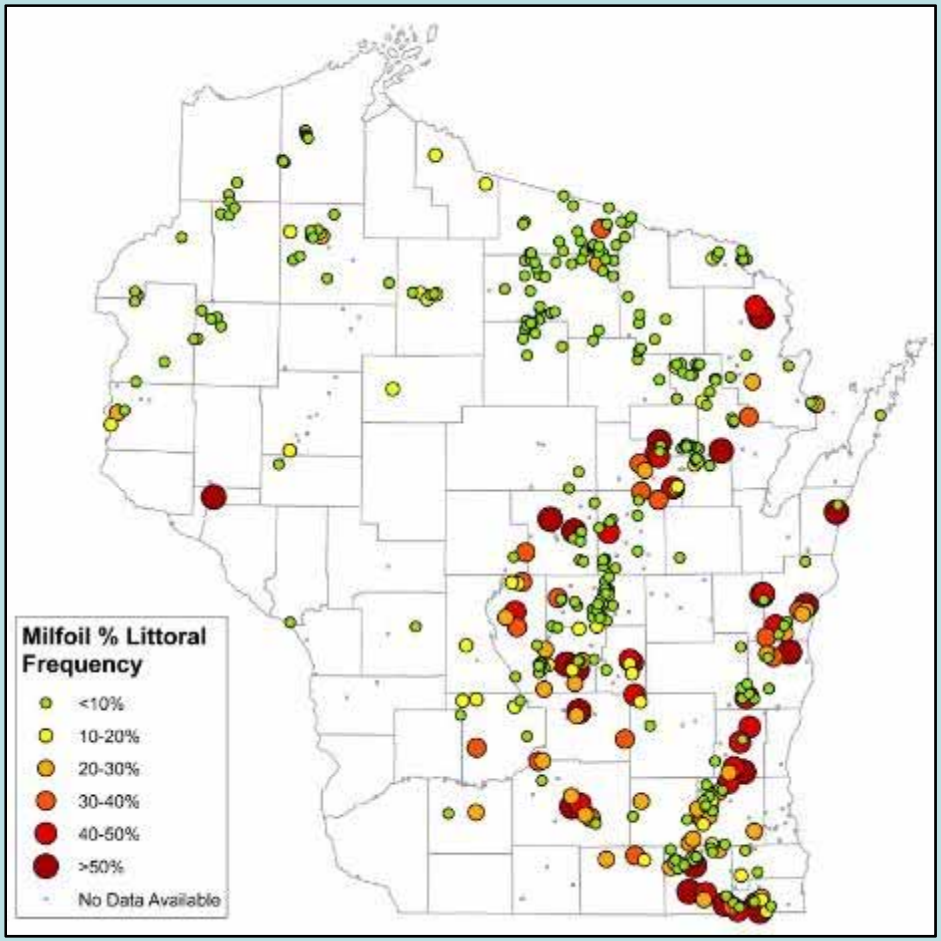
- First reported in U.S. in 1940s; Wisconsin in 1960s.
- Currently verified in ~650 inland lakes and flowages.
- Many lakes with public access still don't have milfoil, especially in the north.
- Number of newly reported populations has possibly 'stabilized', but overall number of invaded lakes continues to rise.

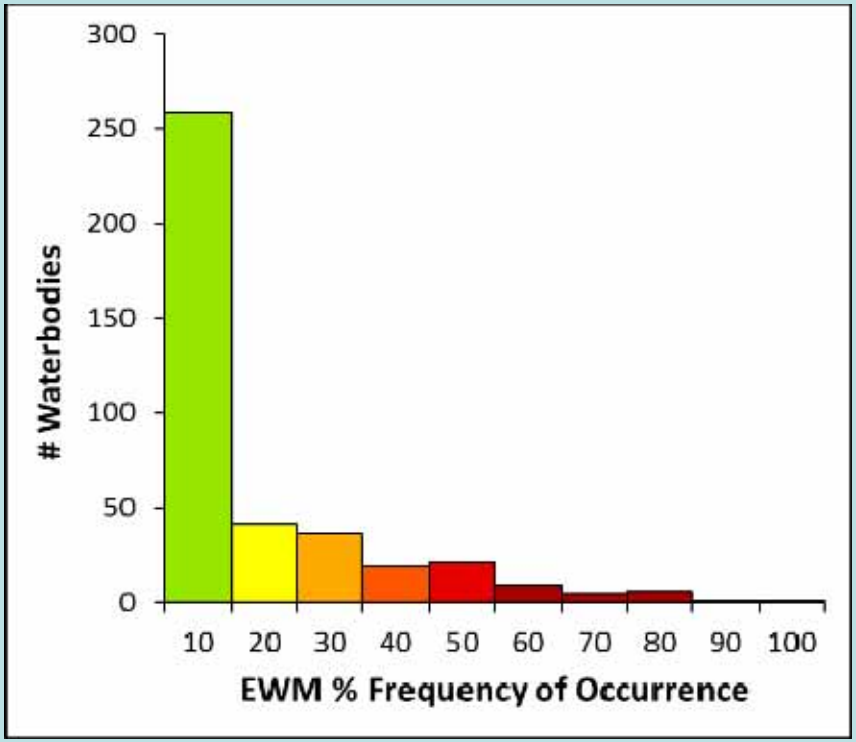




Statewide Watermilfoil Study

- What is the statewide distribution and abundance of milfoil?





n = 397 lakes

Statewide Watermilfoil Study

- Majority of waterbodies with milfoil had low littoral frequencies (<10%) which is below the level where most lake users would consider the plant to be a ‘nuisance’.
- Many waterbodies with low frequencies were being regularly monitored and following aquatic plant management plans to guide adaptive management actions.
- However, some lakes with low milfoil frequencies had not undergone any active management, providing evidence that there may be environmental conditions that limit it’s ability to spread.

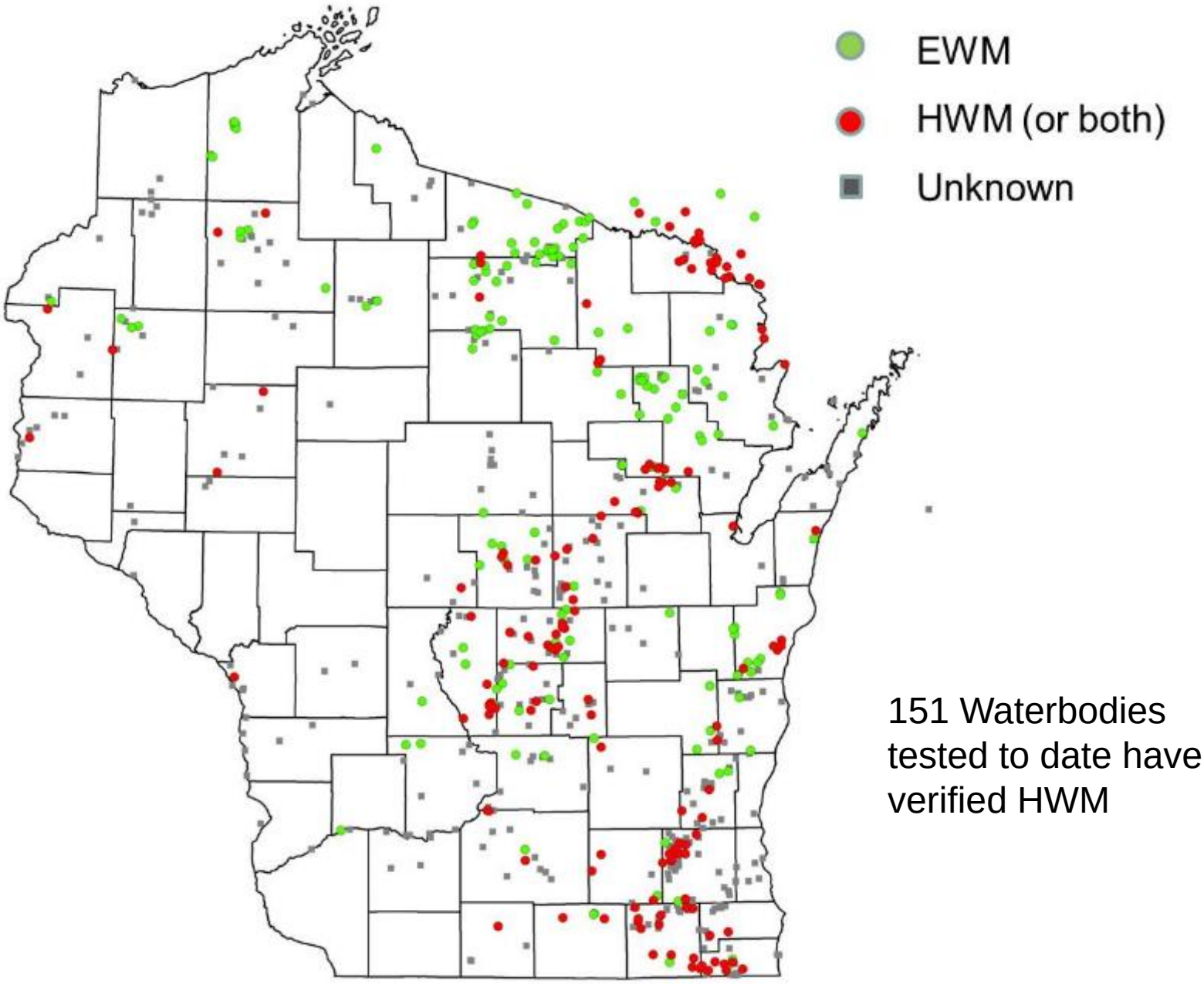
Statewide Eurasian Watermilfoil Study

- Relatively few lakes had high milfoil frequencies. Some of these lakes were unmanaged, while others were activity managed, indicating that management techniques currently used on those lakes is likely ineffective at reducing milfoil populations over the long term.
- In general, higher milfoil frequencies tended to occur on:
  * reservoirs and flowages versus natural lakes
  * southern lakes versus northern lakes
  * well-established populations versus newly invaded lakes
- While milfoil can undoubtedly become a dominant species in certain lakes, more often than not it does not exhibit these tendencies

Milfoil Genetics

- “Eurasian watermilfoil” is a diverse and complex group of plants with unique genetics lineages
- Eurasian watermilfoil can cross-pollinate and hybridize with native northern watermilfoil (*M. spicatum* x *sibiricum*)
- Hybrids are viable and can back cross with parents species and each other
- Certain hybrid strains may grow more aggressively and/or be more tolerant to commonly used herbicides
- Even waterbodies in close proximity to one another may have unique genetics strains of watermilfoil
- An individual waterbody may have one or more unique genetic strains of watermilfoil

Confirmed Hybrid Watermilfoil



151 Waterbodies tested to date have verified HWM

Herbicide Monitoring

What:

Collect and analyze data on herbicide concentration and exposure times, efficacy of milfoil control, and selectivity on native plants under varying 'real world' conditions

Purpose:

To provide recommendations for improving control of invasive aquatic plants and reducing damage to native plants

Output:

Scientific evaluation of herbicide treatments

Nault et al. 2012. Large-scale treatments. NALMS LakeLine 32(1):19-24

Nault et al. 2014. Whole-lake 2,4-D for EWM Control. Lake & Res. 30(1):1-10.

Large Scale Treatment Factsheet (PUB-SS-1077 2011)

Small Scale Treatment Factsheet (PUB-SS-1143 2014)

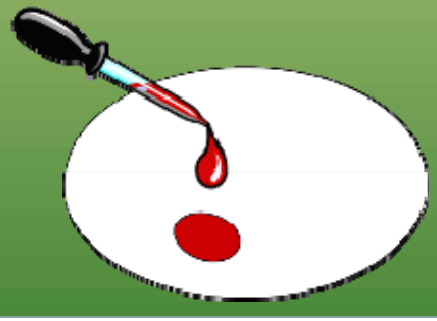
Nault et al. 2015. Small-scale treatments. NALMS LakeLine 35(1):35-39.

Nault et al. *In prep.* Large-scale 2,4-D for EWM/HWM control across WI Lakes.

Scale of Treatment

Small

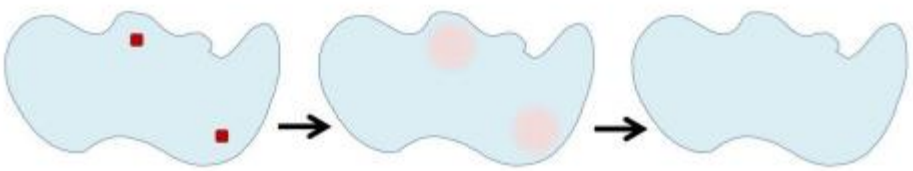
- *WI Admin. Code*: <10 acres or <10% of littoral zone
- Herbicide will be applied at a scale where dissipation will not result in significant lakewide concentrations and effects are anticipated on a localized scale



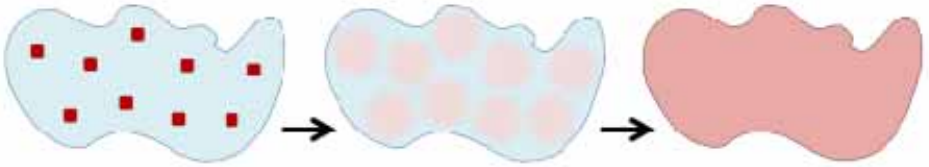
Large

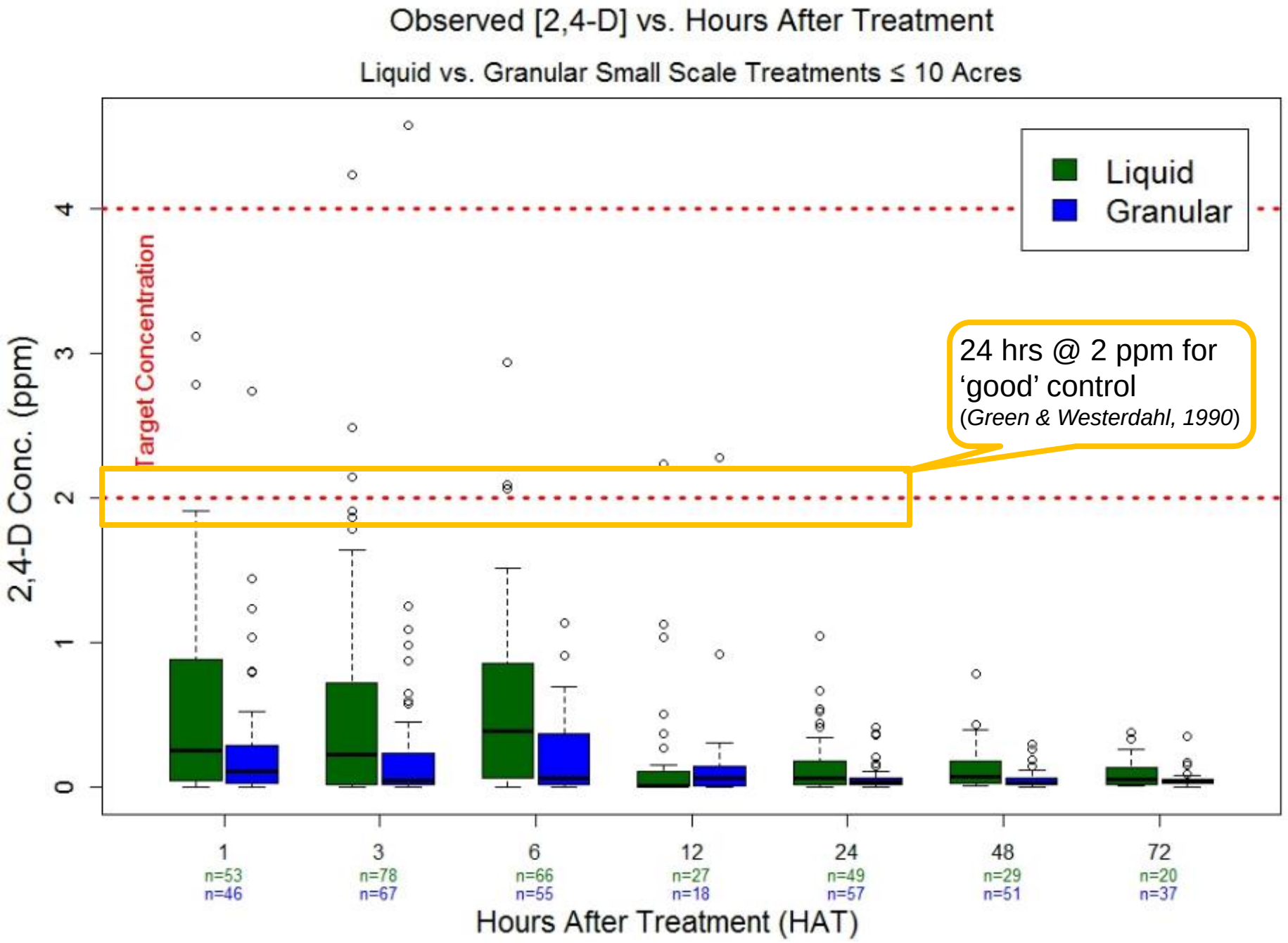
- *WI Admin. Code*: >10 acres or >10% of littoral zone
- *Ecological*: Herbicide will be applied at a scale where dissipation will result in significant lakewide concentrations and effects are anticipated on a lakewide scale

Small-Scale Use Pattern



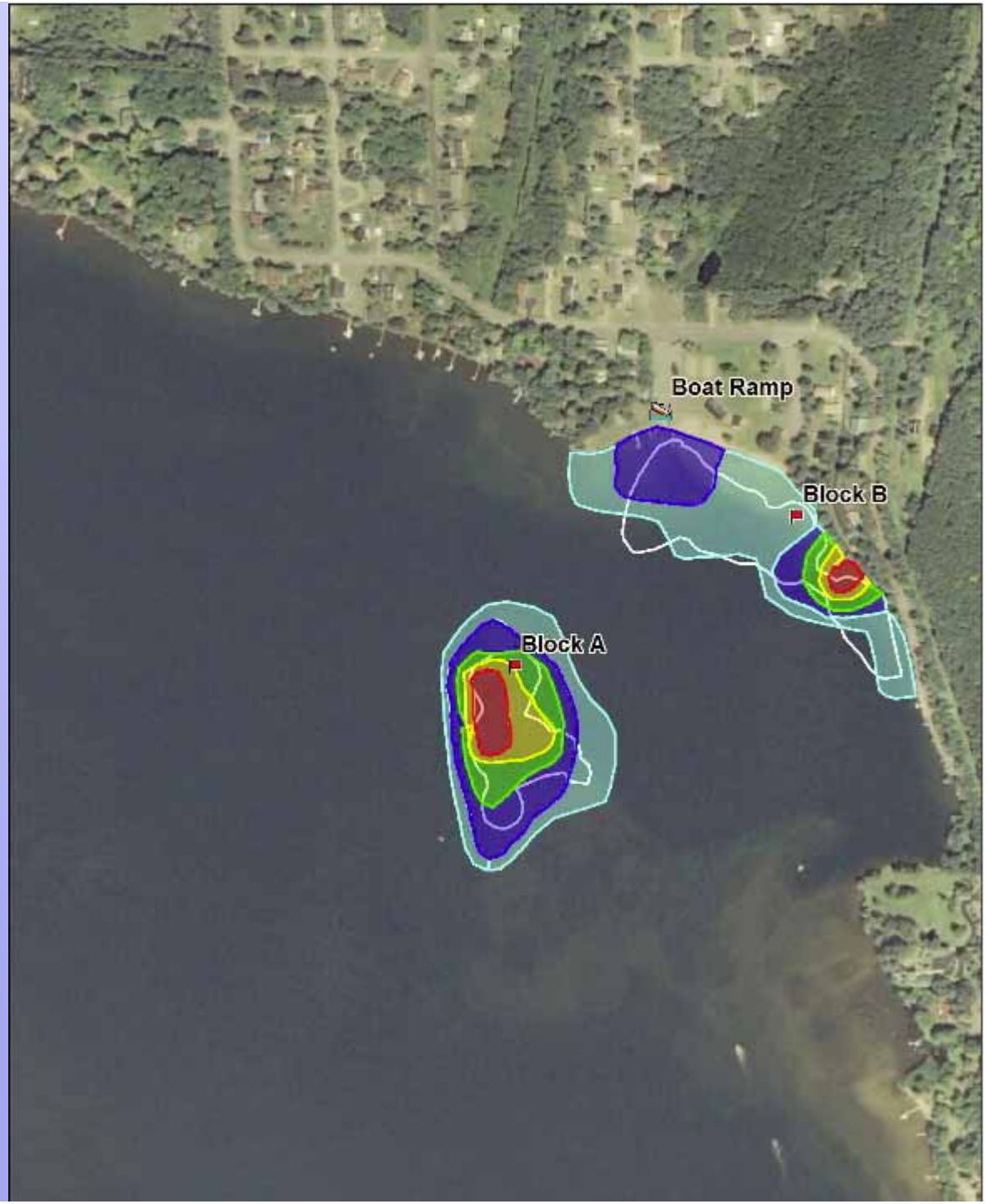
Large-Scale Use Pattern




Observed [2,4-D] vs. Hours After Treatment
Liquid vs. Granular Small Scale Treatments ≤ 10 Acres
Liquid
Granular
Target Concentration
24 hrs @ 2 ppm for 'good' control
(Green & Westerdahl, 1990)
2,4-D Conc. (ppm)
0
1
2
3
4
1
n=53
n=46
3
n=78
n=67
6
n=66
n=55
12
n=27
n=18
24
n=49
n=57
48
n=29
n=51
72
n=20
n=37
Hours After Treatment (HAT)

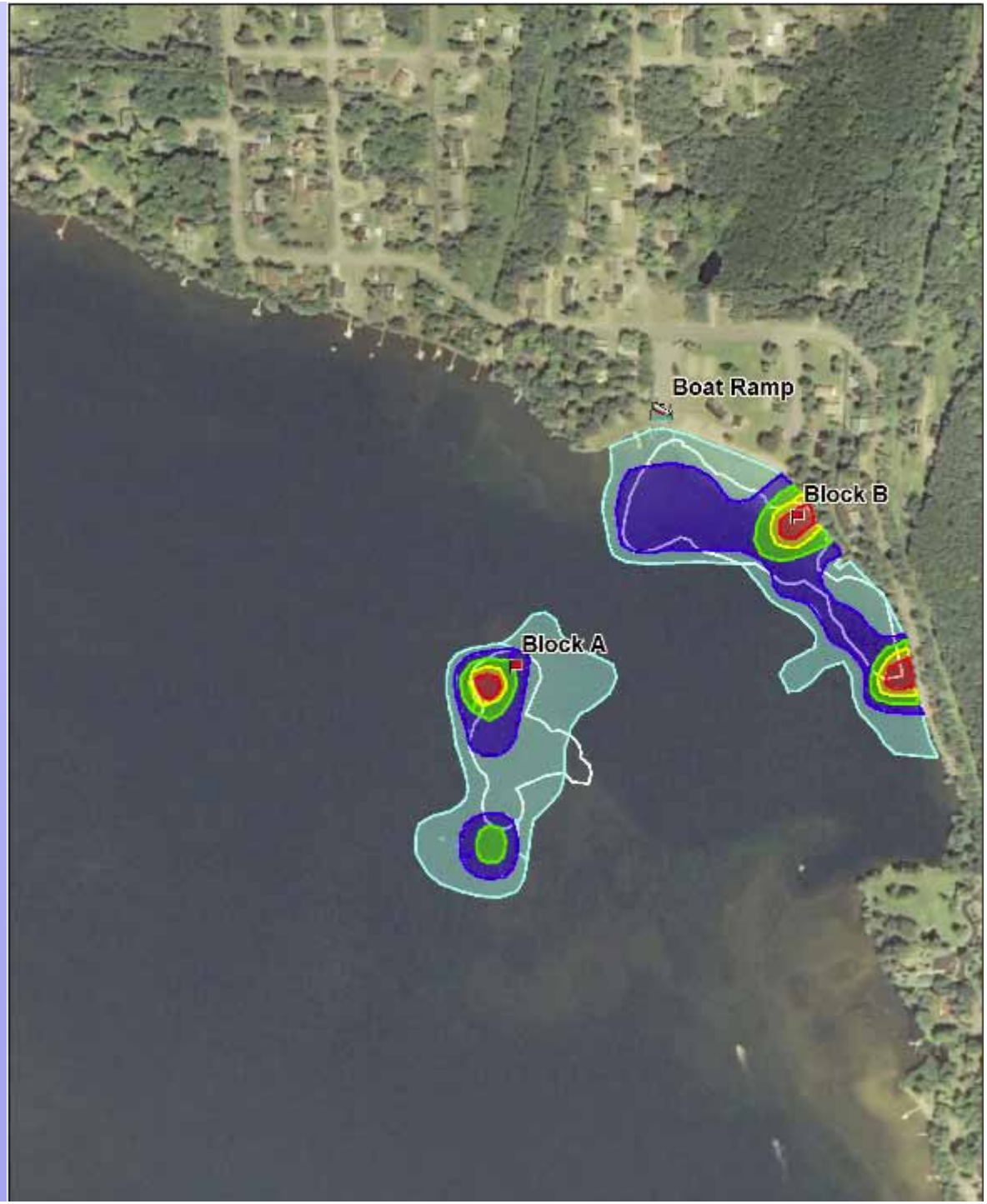
1 HAT

75-100%
50-75%
25-50%
10-25%
5-10%



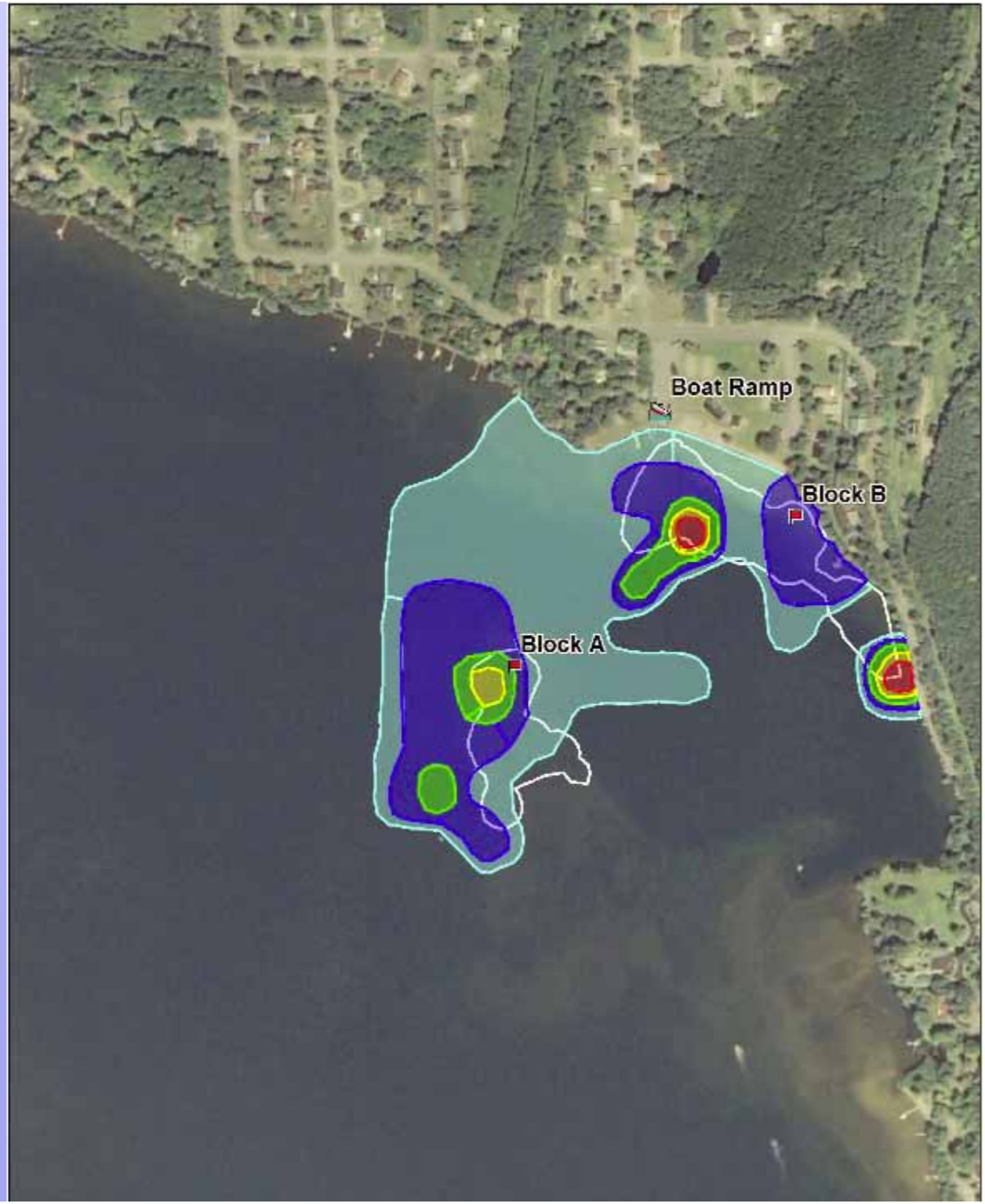
2 HAT

75-100%
50-75%
25-50%
10-25%
5-10%



3 HAT

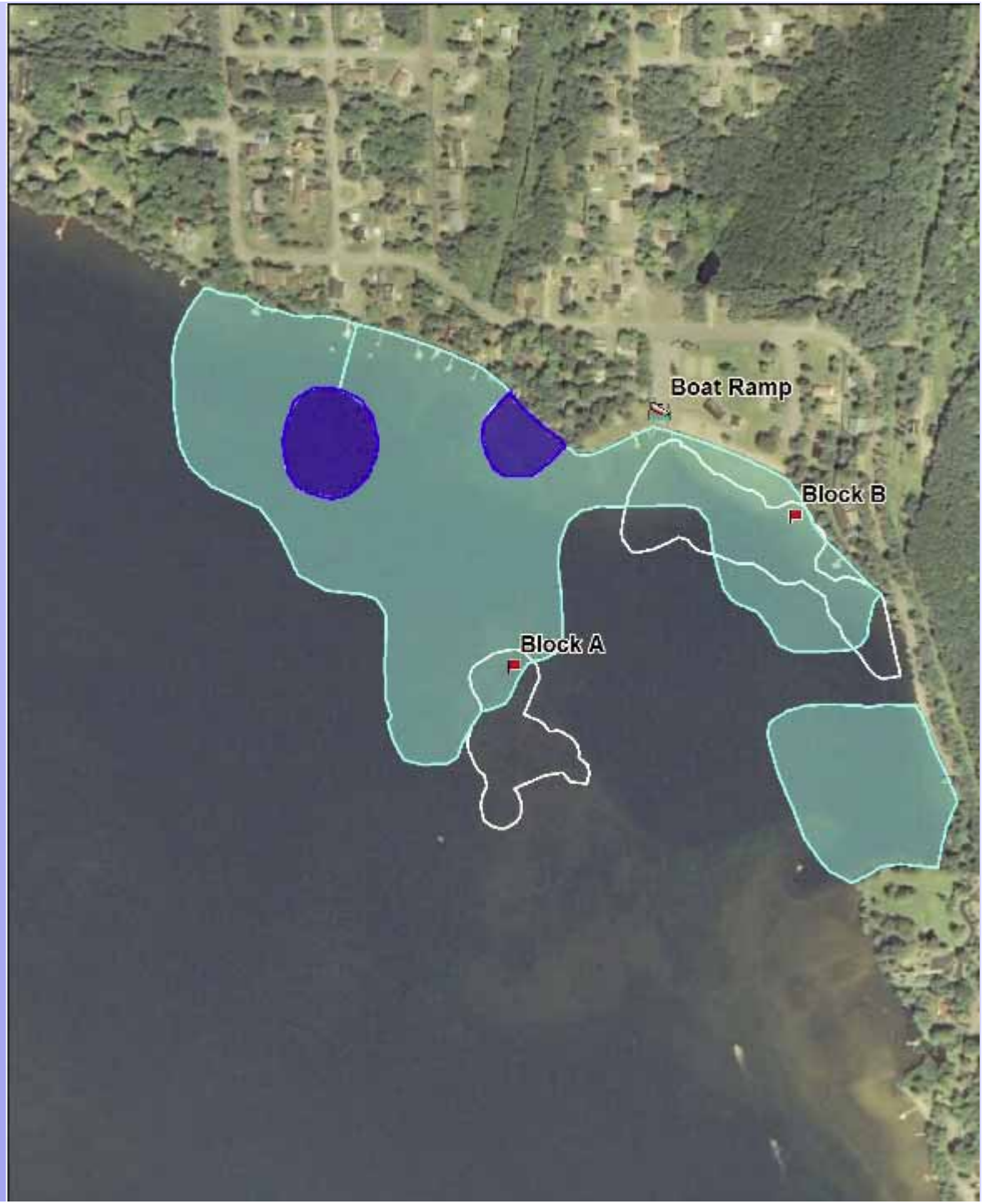
75-100%
50-75%
25-50%
10-25%
5-10%



5 HAT

75-100%
50-75%
25-50%
10-25%
5-10%

Table 3. Estimated Dye Exposure Times	
Application Block	Exposure Time (HAT)
A	1 TO 2
B	<1 TO 2

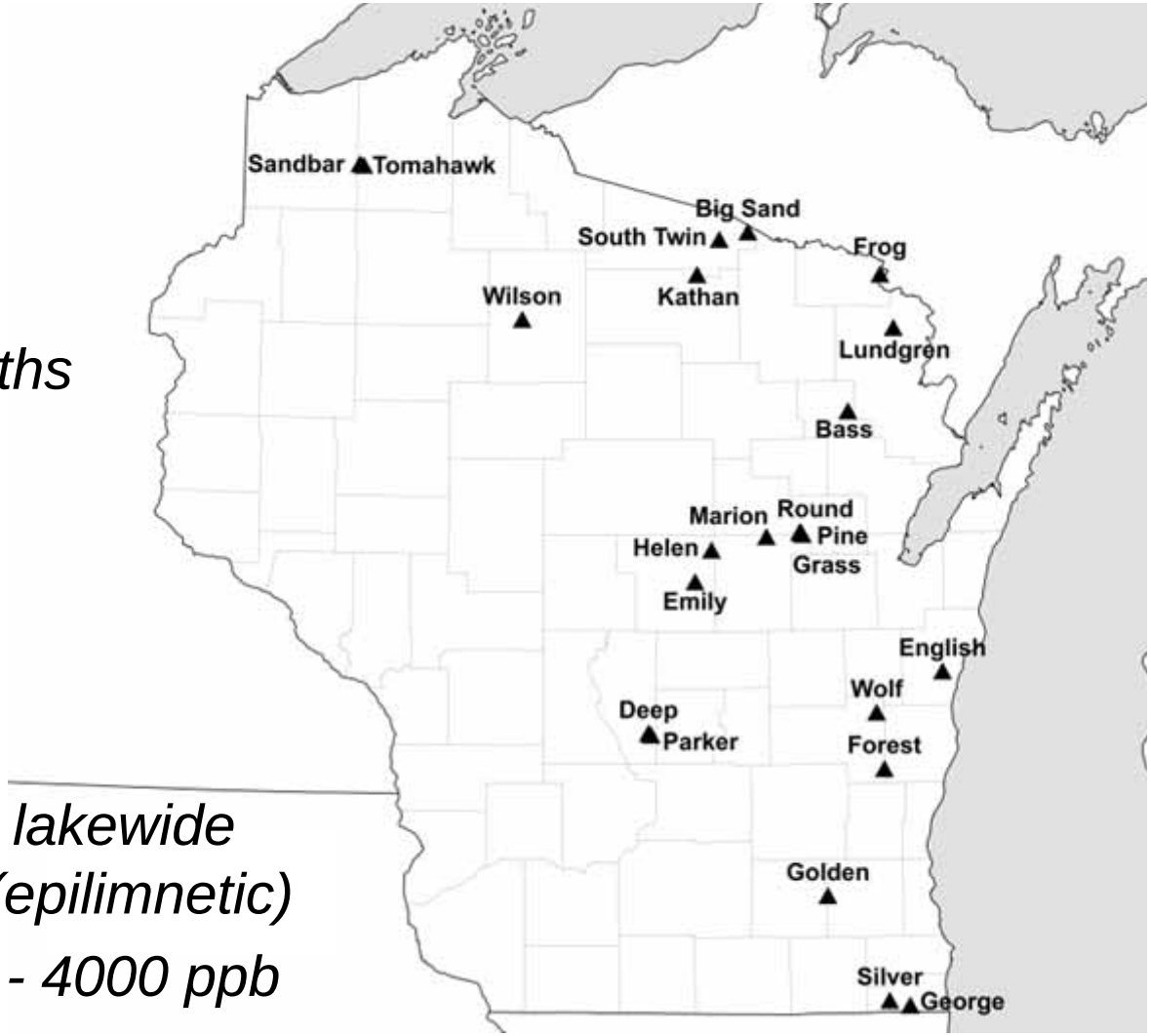


Findings and Future Research

- Actual CET in the field is very difficult to maintain in smaller scale ‘spot’ treatments
- Rapid dissipation occurs and concentrations were below what laboratory CET studies recommend for control
- No “one size fits all” solution - future research into other herbicides (diquat, flumioxazin, etc.)
- Future research into other IPM (hand-removal, DASH, biocontrol, etc.) for small-scale AIS control
- Future research into extending exposure time (i.e. barrier curtains)
- Conduct laboratory mesocosm studies at ‘real world’ exposures and concentrations

Study Lakes

- *23 lakes*
- *Variety of lake types*
- *Range of sizes and depths*
- *Range of trophic status*

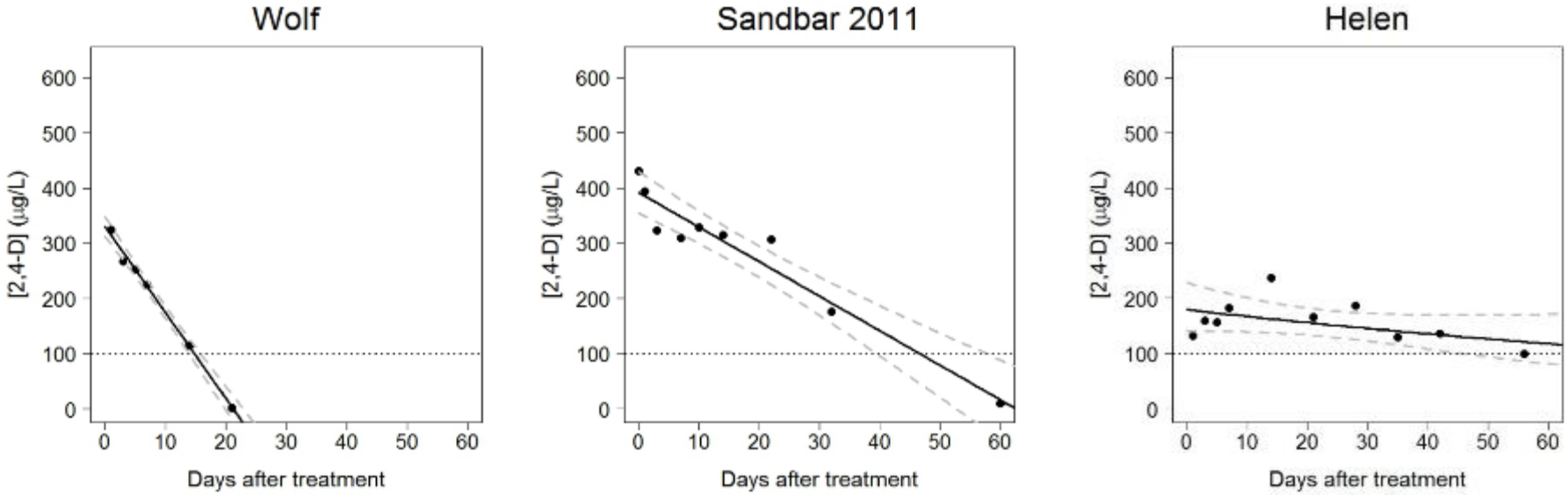


Treatments

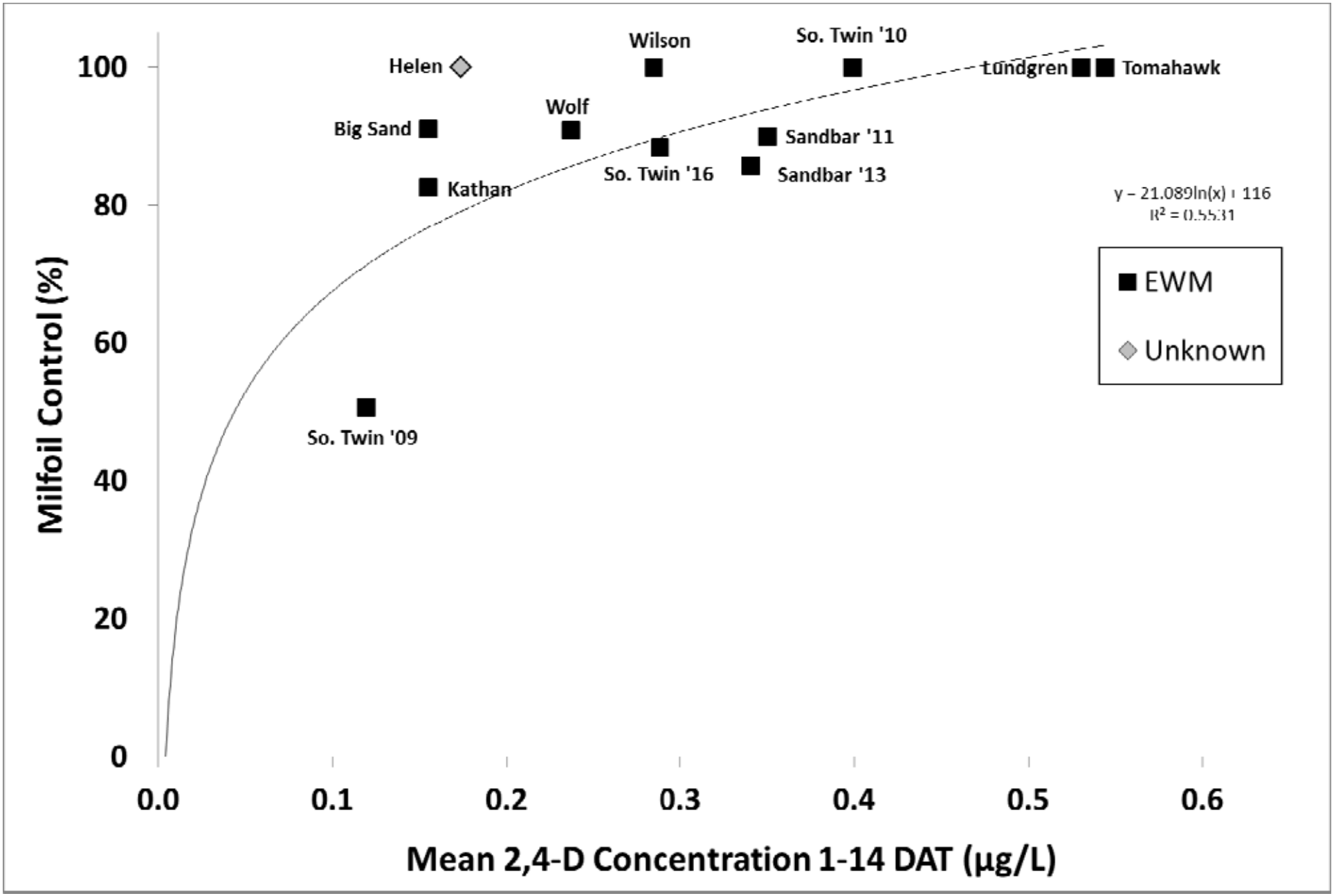
- *Large-scale liquid 2,4-D lakewide targets of 73 - 500 ppb (epilimnetic)*
- *Application rates of 250 - 4000 ppb*
- *8-100% of lake surface area treated*
- *Early season (spring) treatments*
- *Monitored from 2008-2016*

2,4-D Degradation

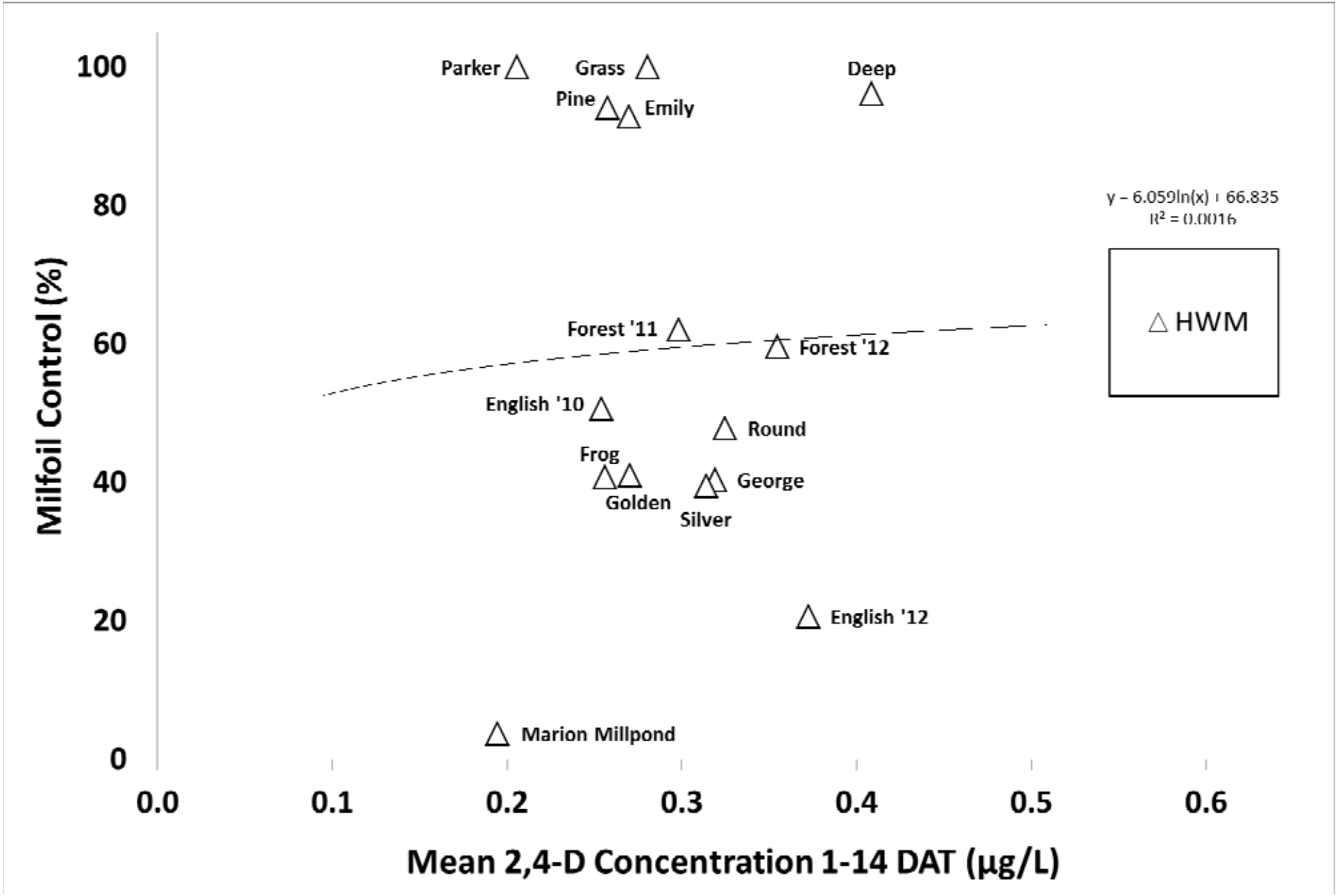
- *Majority of models highly significant (p <0.001)*
- *Mean [2,4-D] 1-14 DAT ranged from 119-544 ppb*
- *2,4-D half-lives ranged from 4-76 days*
- *Irrigation restriction (<100 ppb by 21 DAT) exceeded in more than half the treatments*
- *Rate of herbicide degradation was generally observed to be slower in oligotrophic seepage lakes*



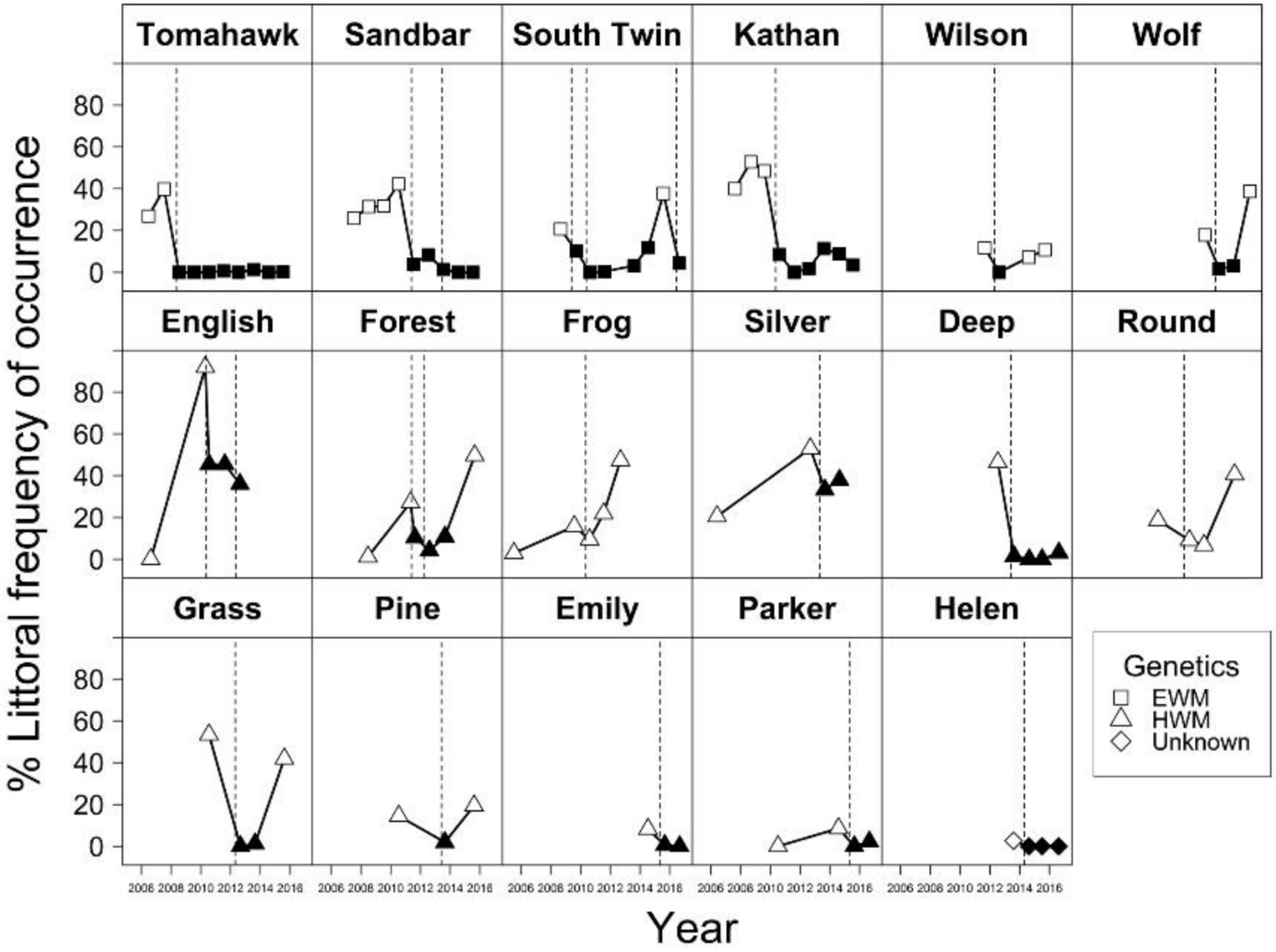
Eurasian Watermilfoil & Management



Hybrid Watermilfoil & Management



Long-Term Milfoil Control



Pre/Post Native Species
2,4-D Whole Lake Treatments

	Tomahawk	Sandbar '11	South Twin '09	Kathan	Wilson	Frog	Silver	Deep	Marion	Wolf	Helen	Emily	Parker	Lundgren
B. beckii	-	-	↓↓↓	-	-	-	-	-	-	-	-	-	-	↓↓
B. schreberi	-	-	-	n.s.	-	-	-	-	-	-	-	-	-	↓↓
C. demersum	-	-	n.s.	n.s.	↓↓↓	-	n.s.	-	n.s.	n.s.	-	-	-	-
Chara spp.	n.s.	n.s.	↓↓↓	n.s.	-	n.s.	n.s.	n.s.	-	↓	↑	↑	n.s.	↑
E. acicularis	-	n.s.	-	-	-	-	-	-	-	-	-	-	-	-
E. canadensis	↓↓↓	n.s.	n.s.	n.s.	-	-	-	-	↓↓↓	-	-	-	-	-
H. dubia	-	-	↓↓↓	-	-	-	-	-	-	-	-	-	-	-
M. sibiricum	-	-	↓↓↓	-	-	-	-	↓↓	-	-	↓↓↓	-	-	-
N. flexilis	↓↓↓	↓↓	n.s.	↓↓↓	-	↓↓↓	n.s.	-	↓↓↓	-	↓↓↓	↓↓↓	↓↓↓	↓↓
N. guadalupensis	-	-	-	-	-	-	↑↑↑	-	-	-	↓↓↓	-	↑↑↑	-
*N. marina**	-	-	-	-	-	-	↑↑↑	-	-	-	-	-	-	
Nitella spp.	-	-	-	↓↓↓	-	-	-	n.s.	↓↓↓	-	-	↑	-	-
N. odorata	-	-	-	-	-	-	-	-	-	-	-	n.s.	-	-
P. amplifolius	↓↓↓	-	-	-	-	n.s.	-	n.s.	-	-	-	-	-	n.s.
P. epihydrus	-	-	-	↓↓↓	-	-	-	-	-	-	-	-	-	-
P. foliosus	-	-	-	-	-	-	-	-	-	-	-	-	-	↓↓↓
P. friesii	-	-	-	-	-	-	-	-	↓↓↓	-	-	↓↓↓	-	-
*P. gramineus/P. illinoensis***	↓	↓	n.s.	-	-	-	n.s.	-	-	-	↓↓↓	n.s.	↓↓↓	n.s.
P. praelongus	-	-	n.s.	-	-	-	-	-	↑	-	-	-	-	n.s.
P. pusillus	↓↓↓	↓↓↓	↓	↓↓↓	-	n.s.	-	-	-	-	-	-	-	-
P. richardsonii	-	-	n.s.	-	-	-	-	-	-	-	-	-	-	-
P. robbinsii	↓	-	n.s.	-	↓↓↓	-	-	-	-	-	-	-	-	-
P. strictifolius	-	-	-	↓↓↓	-	↓↓↓	-	-	-	-	-	-	-	-
P. zosteriformis	-	-	n.s.	↑	↓↓↓	-	-	↓↓↓	-	-	-	↓↓↓	-	-
S. pectinata	-	-	-	-	-	-	n.s.	-	↓↓↓	↓	↓↓↓	-	↓↓↓	-
U. vulgaris	-	-	-	n.s.	-	-	-	-	-	-	-	-	-	-
V. americana	↓↓↓	↓↓↓	↓↓↓	↑	-	-	↑	-	-	n.s.	-	n.s.	n.s.	-
# native spp sig increase	0	0	0	2	0	0	2	0	1	0	1	2	1	1
# native spp sig decrease	7	4	6	5	3	2	0	2	5	2	5	3	3	4
net increase/decrease	-7	-4	-6	-3	-3	-2	+2	-2	-4	-2	-4	-1	-2	-3

*considered non-native in Wisconsin

***P. gramineus* and *P. illinoensis* (& hybrids) combined for analysis

Findings & Future Research

- Herbicide dissipation is rapid and treating multiple ‘small’ areas can result in a large-scale treatment if the scale of the treatment area is large compared to the overall lake epilimnetic volume
- 2,4-D degradation rates and half-lives are variable across lakes
- Early spring, large scale treatments may result in longer persistence of herbicides than expected; may exceed 100 ppb for >21 days
- EWM control looks promising, however damage to certain native species may occur and long-term recovery is variable
- Hybrid watermilfoils need to be better documented and studied in both field and laboratory
- Conduct laboratory mesocosm studies looking at milfoil control efficacy, native plant selectivity, and other potential non-target biotic impacts at ‘real world’ exposures and concentrations

Linking the Efficacy and Side Effects of Long-Term Best Management Practices for Eurasian Watermilfoil Control in Wisconsin Lakes

Chelsey Blanke, Ellen Kujawa, Paul Frater, Alison Mikulyuk, Martha Barton, Michelle Nault, Scott Van Egeren, Jennifer Hauxwell

2017 Wisconsin Lakes Partnership Convention - April 2017

Eurasian watermilfoil (*Myriophyllum spicatum*)

- Widespread
- Ecological/economic effects
- Management strategies and herbicide treatment
  - Treatment appears to decrease EWM, but most research is limited to one lake for one year.
  - What about the long-term?

Monitored 28 Wisconsin lakes for 11 years:

- Long-term herbicide efficacy
- Early response
- Non-target effects

Managed and unmanaged lakes from each of WI's 3 lake-rich ecoregions

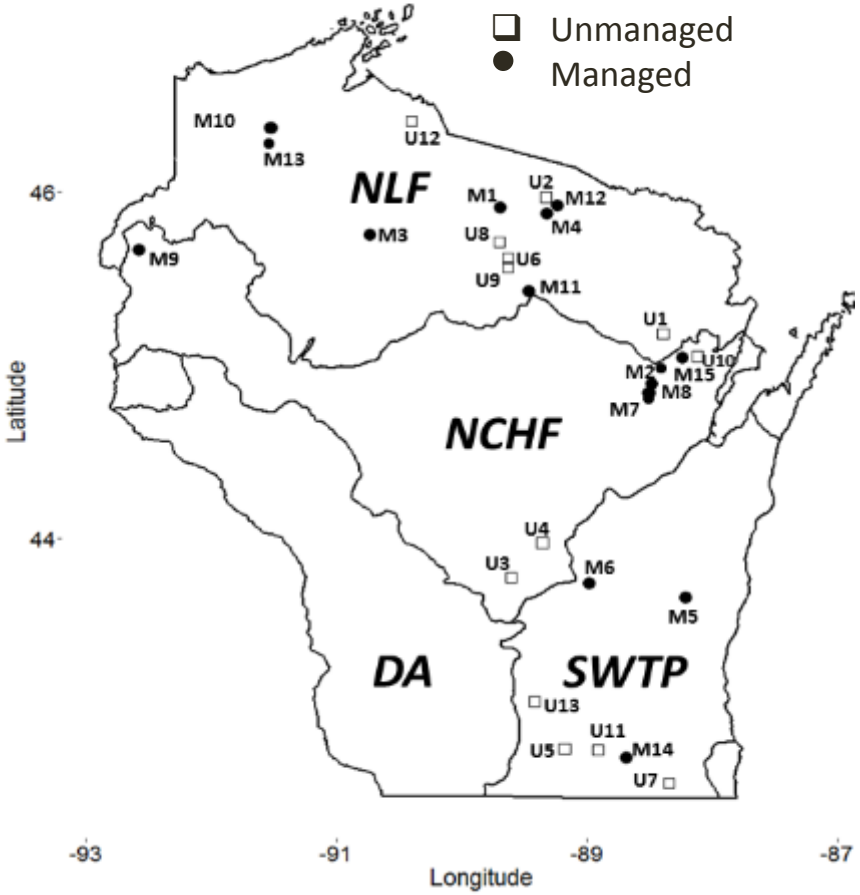
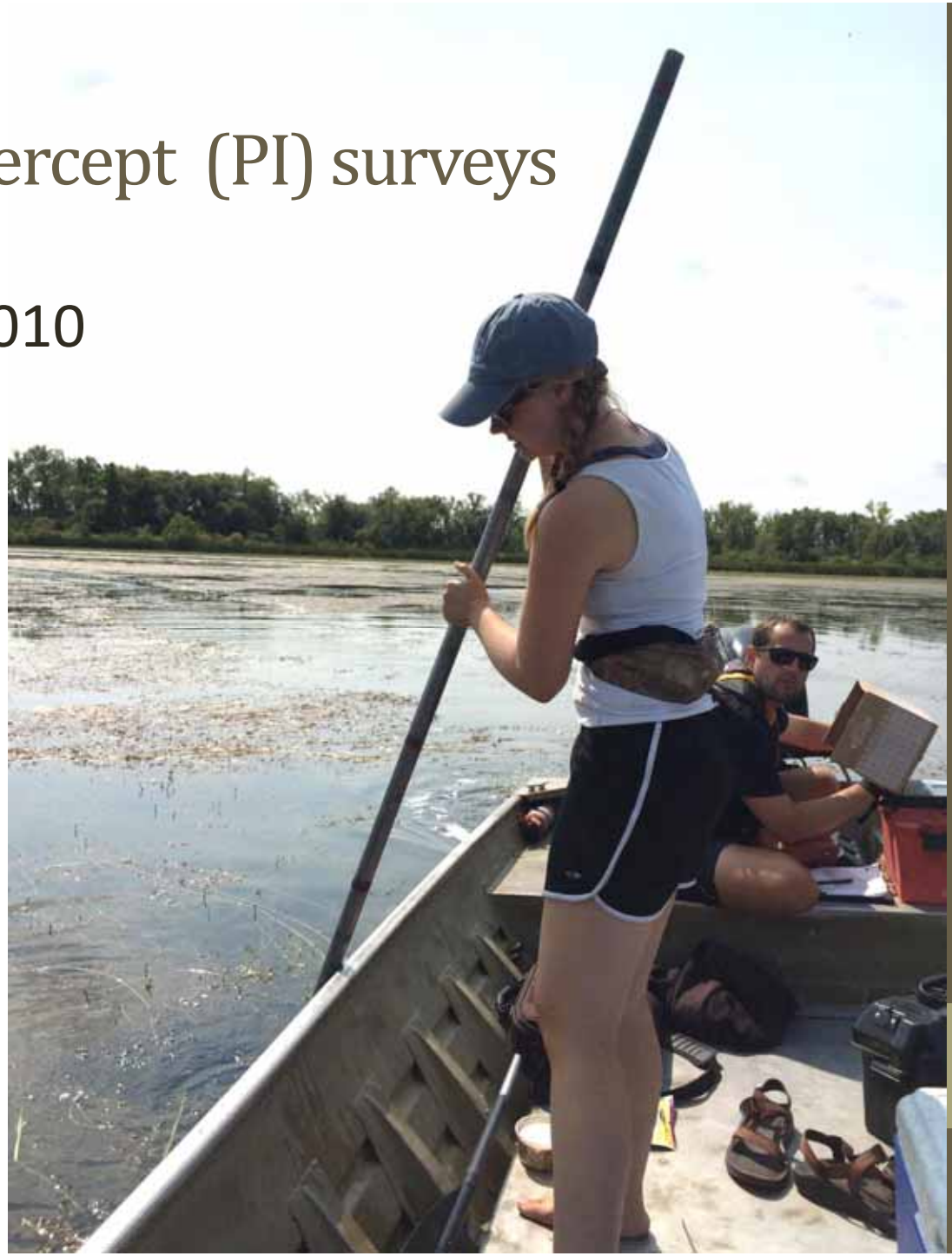


Fig. 1: Site map of long term study lakes

Annual point-intercept (PI) surveys

- Hauxwell et al. 2010

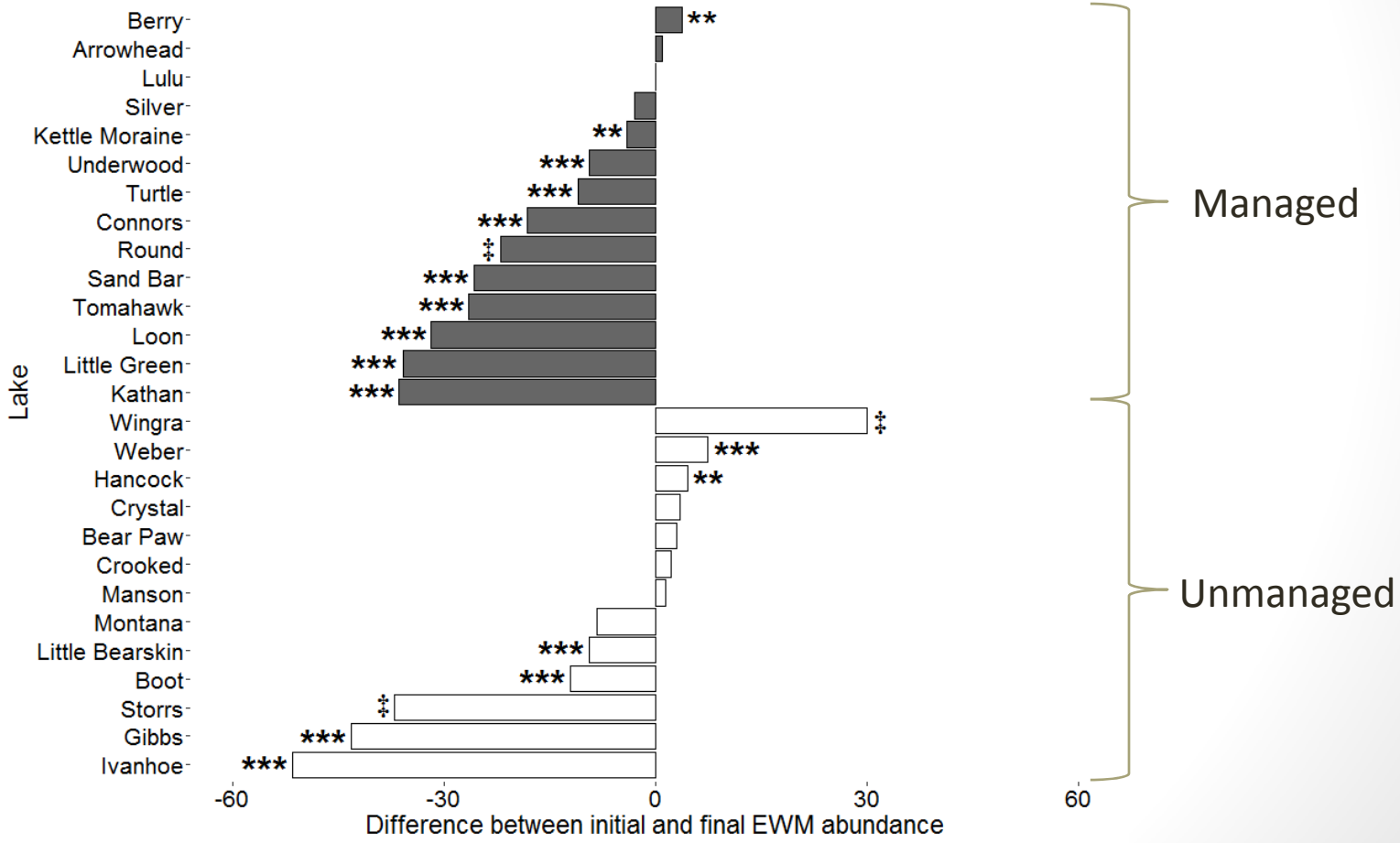


Statistical analyses

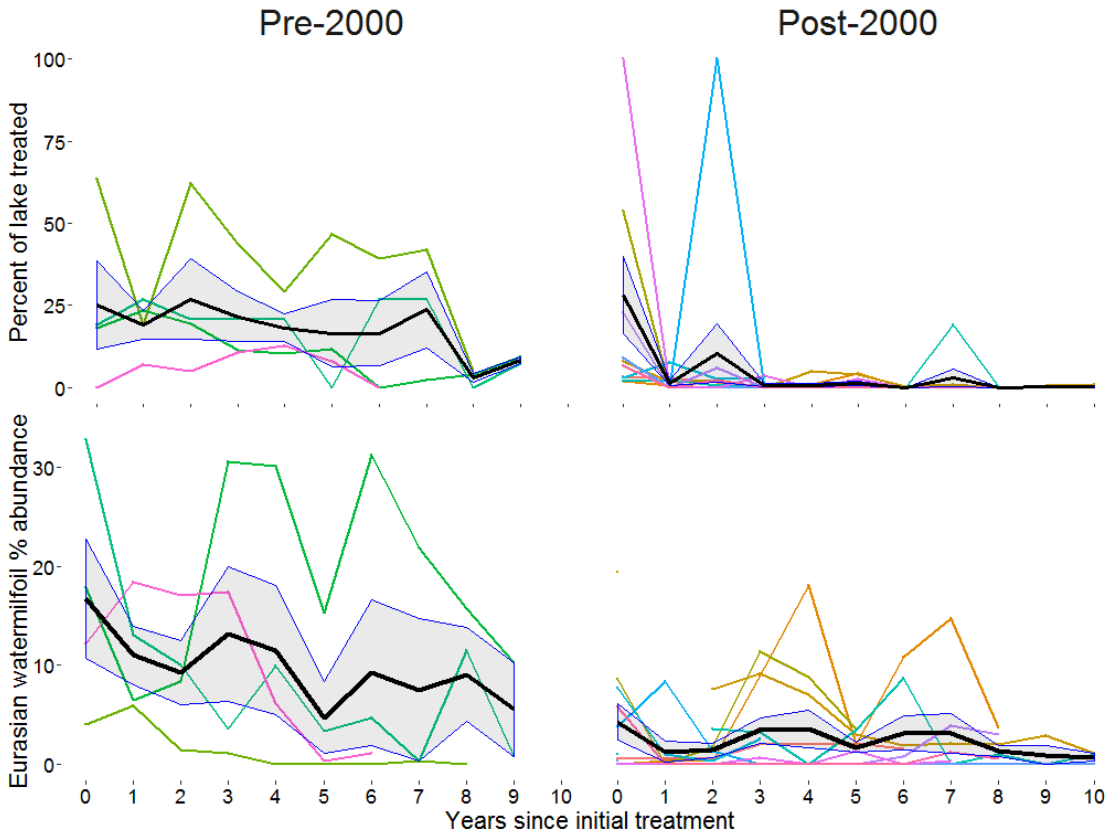
- Generalized estimating equations (GEE): trends in macrophyte abundance over time
- McNemar's tests: change in EWM abundance over the course of the entire study and in response to individual treatments
- Kolmogorov-Smirnov tests: differences in distribution of year-to-year native species abundance between managed and unmanaged lakes

Lakes that treated as part of an adaptive management strategy have lower EWM abundance

Managed lakes had more significant decreases in EWM abundance over the course of the study



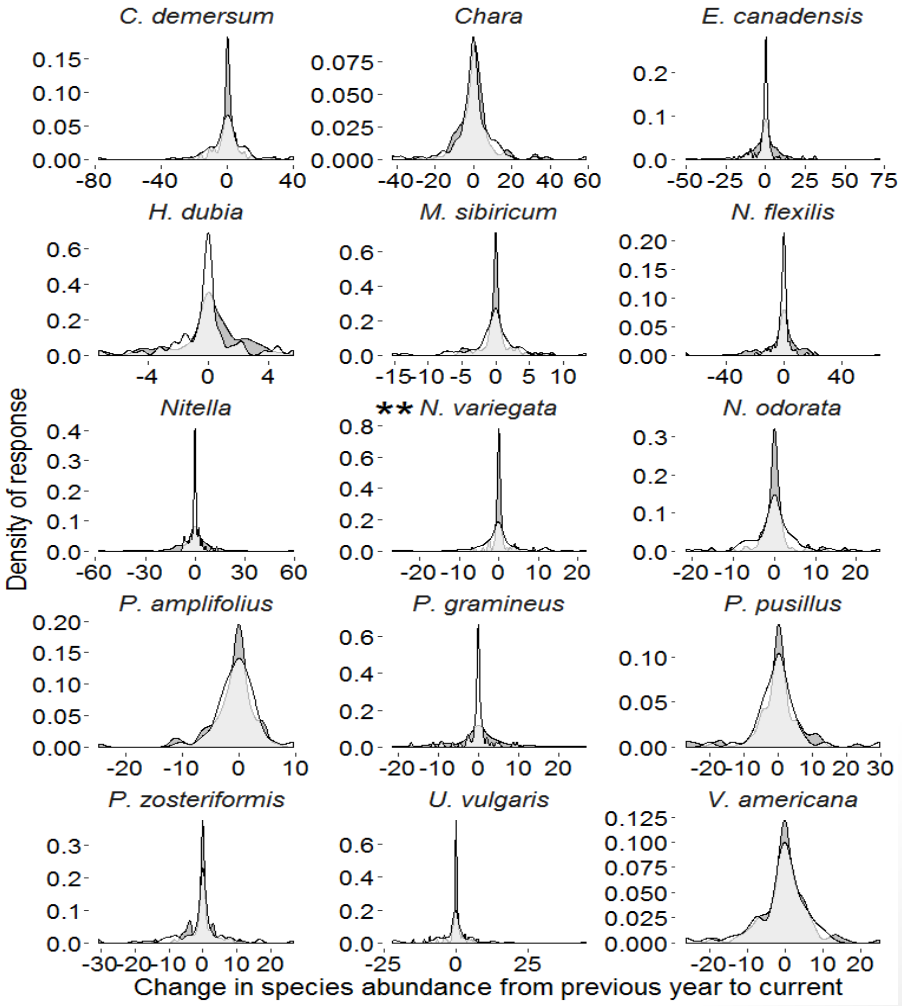
Early response to EWM invasion appears to increase treatment efficacy.



Time lags? Improved management strategies

Native macrophyte responses to management are variable and can be significant.

- Decreased coontail and yellow-pond lily
- Increased Canadian waterweed and *Nitella* spp.



Results Recap

- Lakes that treated as part of an adaptive management strategies had lower EWM abundance.
- Managed lakes had more significant decreases in EWM abundance over the course of the study.
- Early detection of, and response to EWM invasion increases treatment efficacy
- Native macrophyte responses to management are variable and can, in a few cases, be significant.

Conclusions and further research directions

- Herbicide treatment appears to be an effective long-term management tool, particularly for recently invaded lakes, though responses by native species should be considered carefully.
- To our knowledge, this is the largest and longest study of EWM, and provides new information to researchers, managers, and other lake stakeholders.
- Further research areas include:
  - Which factors optimize treatment efficacy
  - Viability long-term management from an economic and social perspective
  - Predicting EWM abundance in a given lake


Questions?