Understanding the Ecology and Management of Eurasian and Hybrid Watermilfoils in Inland Temperate Lakes

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WISCONSIN DEPT. OF NATURAL RESOURCES

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Eurasian Watermilfoil

What:

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


A bed of Eurasian watermilfoil found in Joanis Lake.

The science behind the "so-called" super weed

EWM found in Porters Lake.

RECENT STUDIES HELP TO UNDERSTAND THE EFFECTS OF EURASIAN WATERMILFOIL ON WISCONSIN LAKES.

Michelle Nault

In the early 1990s, Eurasian watermilfoil (EWM) was described in a report to the legislature: "A super weed capable of stopping a speeding boat [which] has a chokehold on Wisconsin lakes." In order to better understand the impacts of EWM in Wisconsin, DNR staff compiled a decade's worth of data collected on hundreds of waterbodies across the state. The results may surprise you, and challenge some commonly held beliefs about this invasive aquatic plant species.

resource managers are optimistic that the low percentage of Wisconsin lakes with EWM speaks to the success of our aquatic invasive species prevention and control programs.

Preliminary results from a multi-year statewide study looking at the rate of spread of aquatic invasive species indicate that the number of newly discovered EWM populations has stabilized, further suggesting that prevention programs are successfully minimizing the spread of EWM into new lakes.

Genetics makes a difference

Eurasian watermilfoil in one lake can be quite genetically different than that

Purpose:

Analyze quantitative data to understand EWM ecology and refine management strategies

Output:

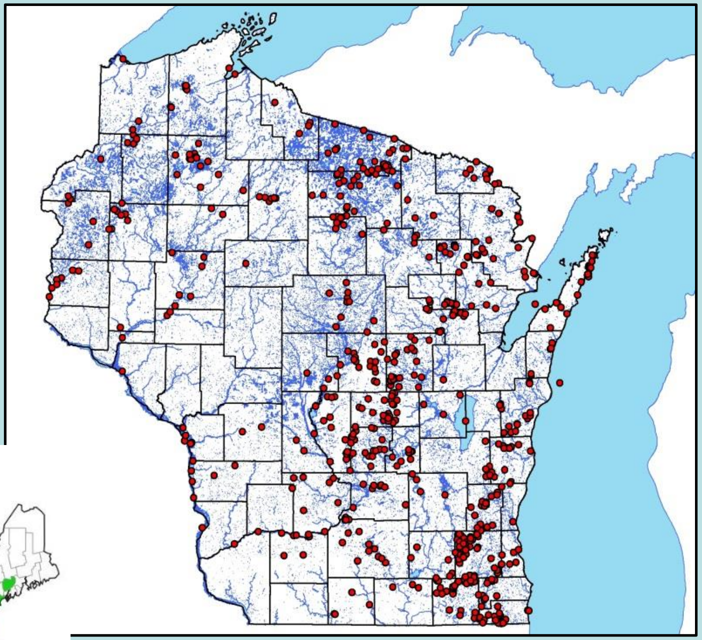
https://dnr.wi.gov/lakes/plants/research/

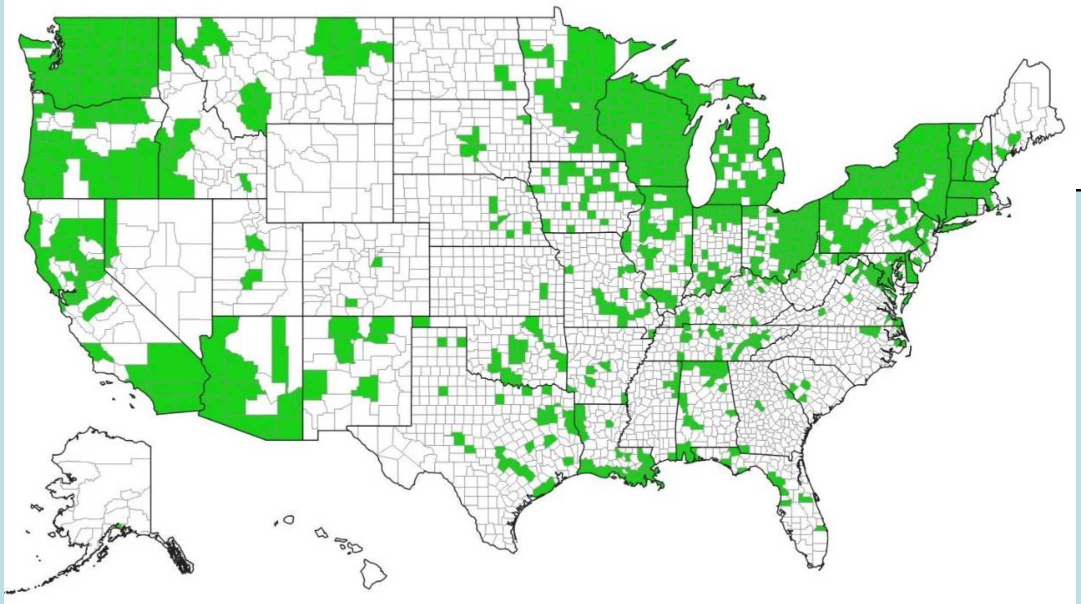
What is Milfoil?

- **EXOTIC INVASIVE**
- Groups of four feather-like leaves whorled around a long stem
- Each leaf has 12-20 pairs of threadlike leaflets
- Leaves often limp when pulled out of water; stem often reddish
- Plant often branches multiple times and can form canopies at the waters' surface
- Propagates primarily via vegetative fragmentation

Where is Milfoil?

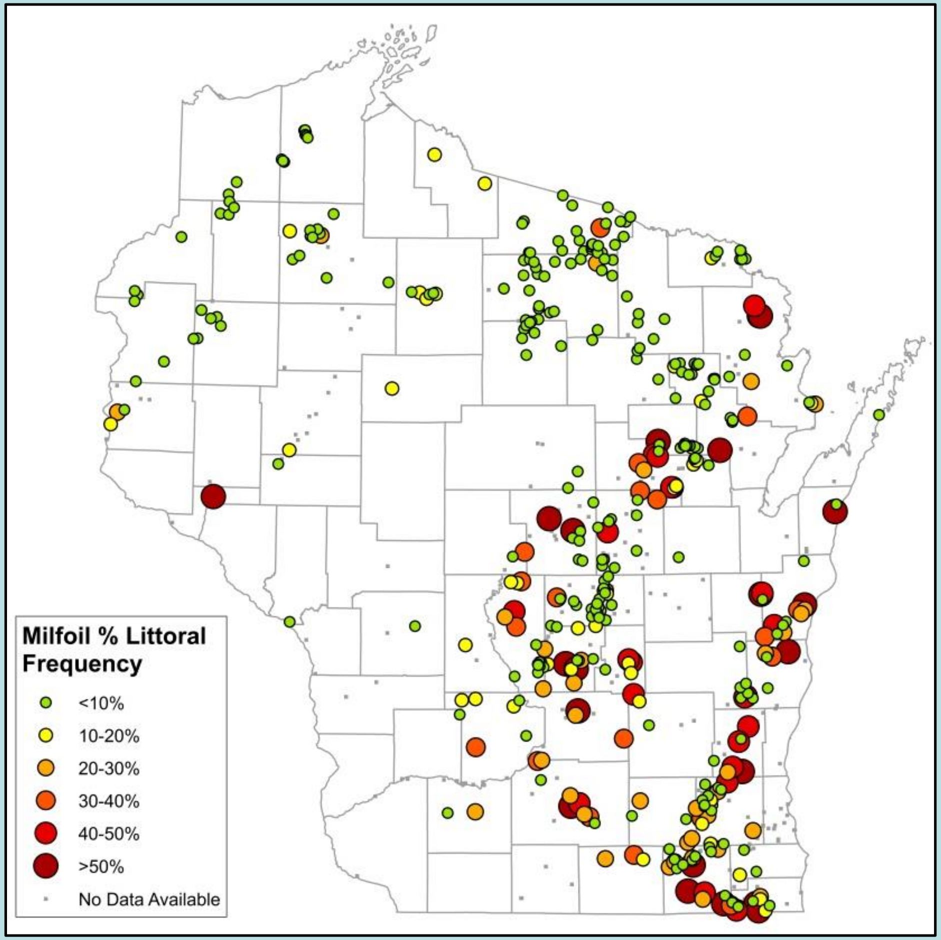
- First reported in U.S. in 1940s; Wisconsin in 1960s.
- Currently verified in ~650 inland lakes and flowages in Wisconsin.

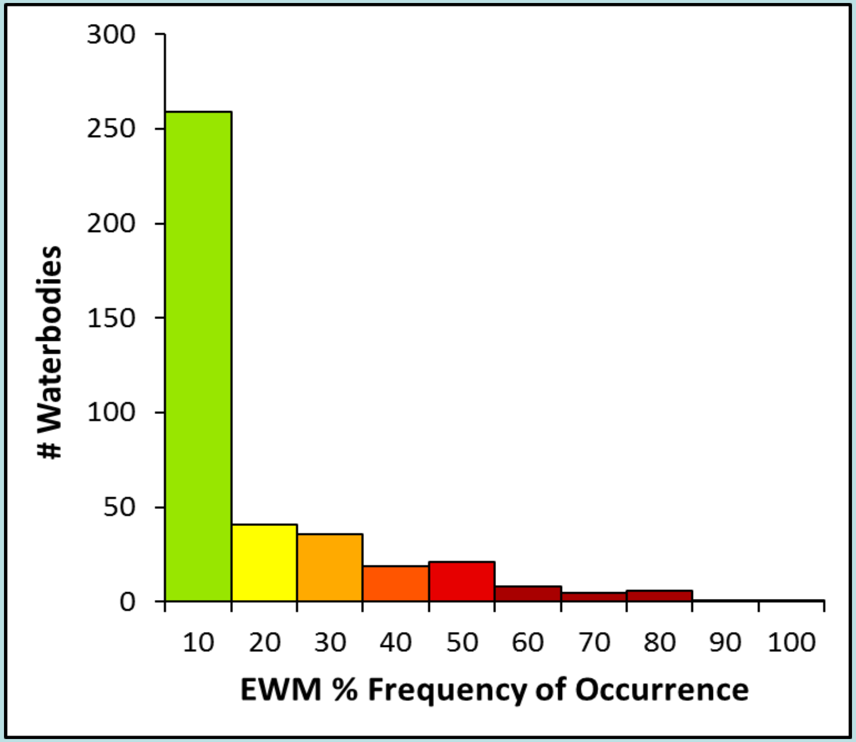




Statewide Watermilfoil Study

- What is the statewide distribution and abundance of milfoil?





n = 397 lakes

Statewide Watermilfoil Study

- Majority of lakes had low (<10%) EWM frequencies, 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 APM plans to guide adaptive management.
- However, some lakes with low frequencies had not undergone any active management, providing evidence that there may be environmental conditions that limit milfoil’s ability to spread.
- In general, higher EWM frequencies occurred in flowages and reservoirs vs. natural lakes, southern lakes vs. northern lakes, and long established populations vs. newly invaded lakes.

Long-Term Milfoil Study

What:

Collect long-term data on the distribution, ecology, and management of EWM

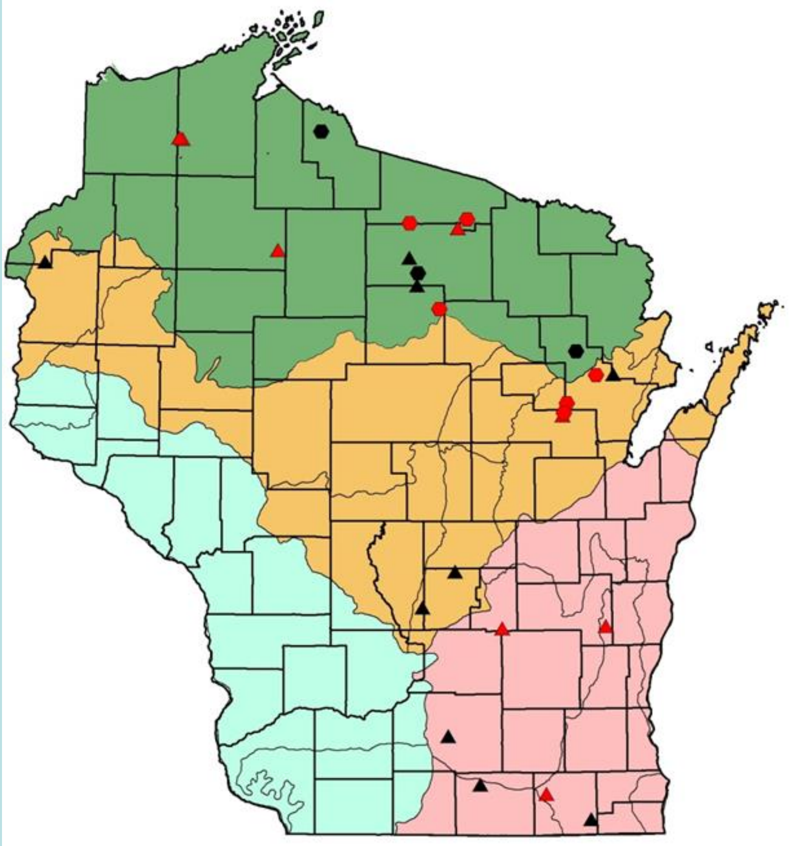
Purpose:

Create a baseline dataset on EWM populations over time

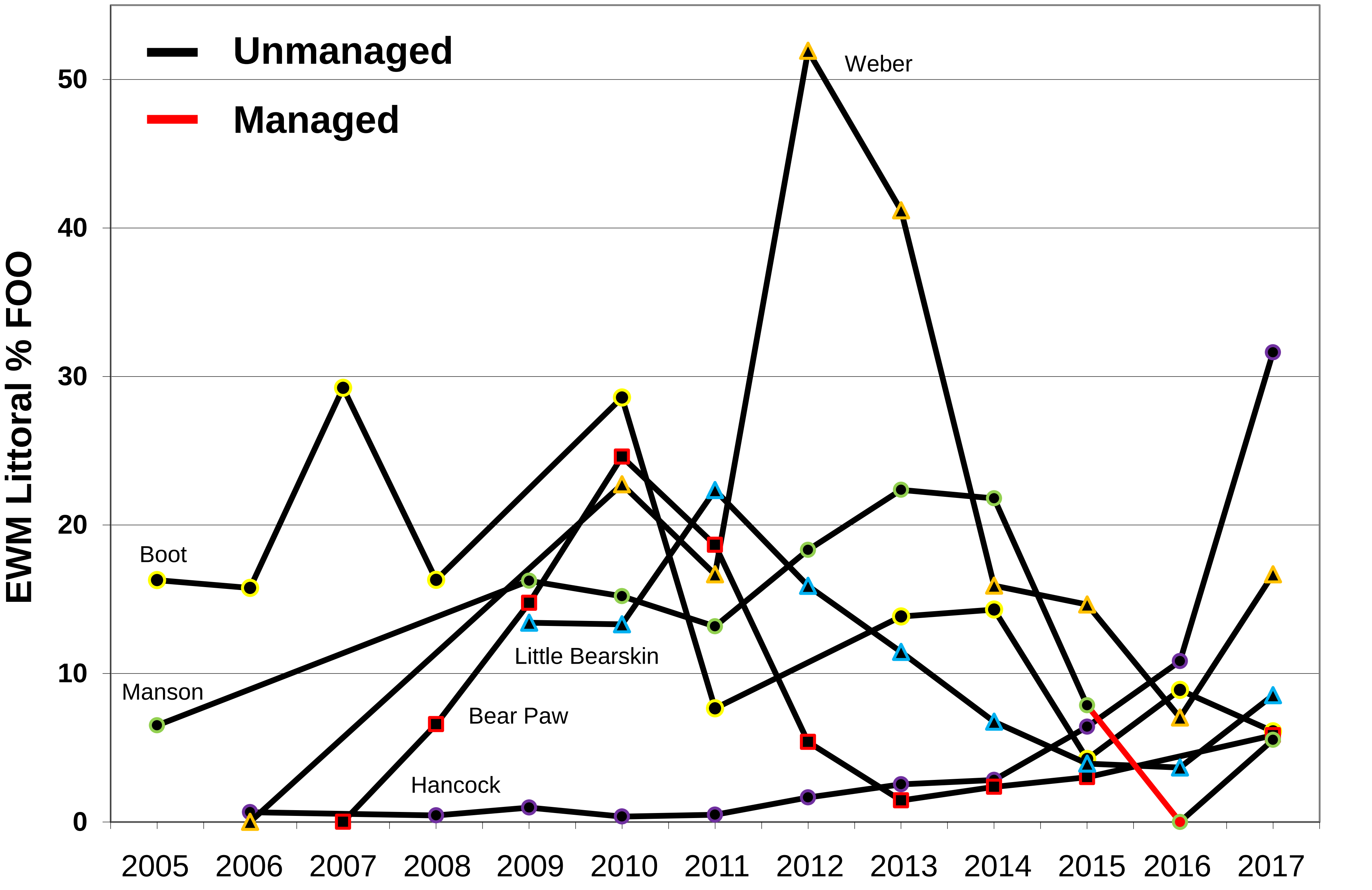
Output:

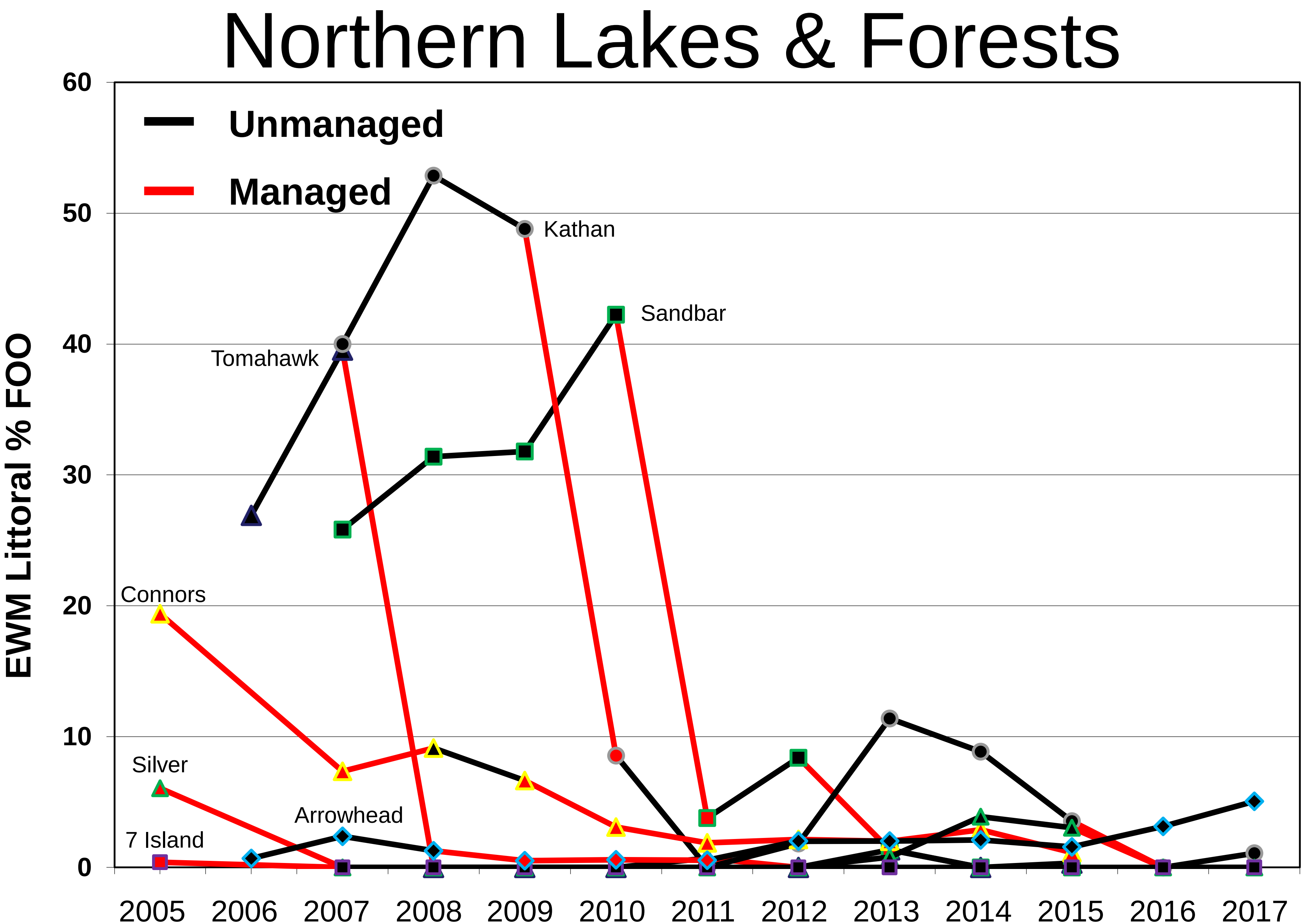
Long-term temporal and spatial EWM & natives trends

- Annual aquatic plant survey & biomass collection on 24 lakes over time
- 3 ecoregions, established and new populations, managed and unmanaged



Northern Lakes & Forests

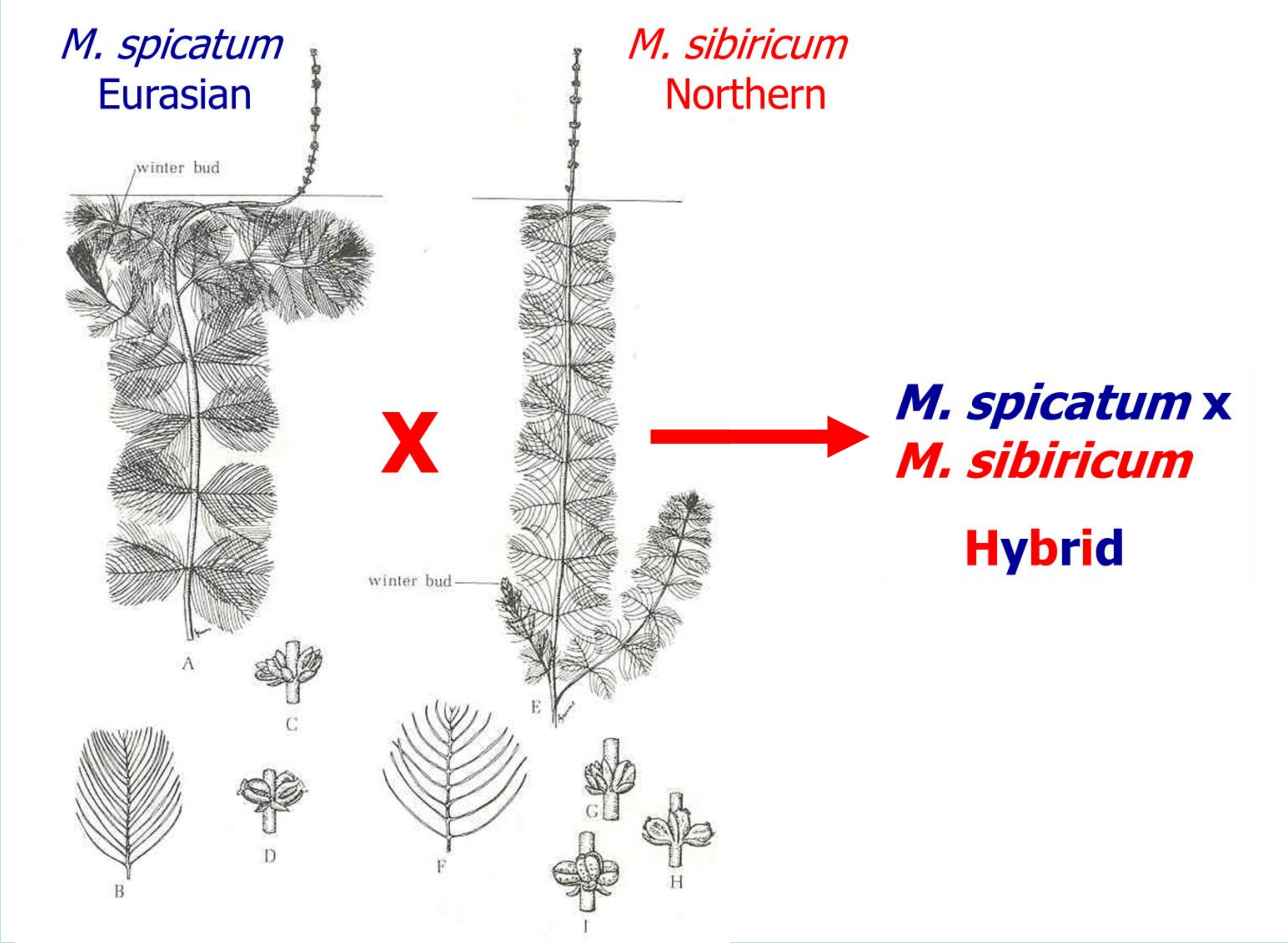



Northern Lakes & Forests
Unmanaged
Managed
Kathan
Sandbar
Tomahawk
Connors
Silver
Arrowhead
7 Island
EWM Littoral % FOO
60
50
40
30
20
10
0
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

Preliminary Findings

- EWM abundance can vary from year to year, and from lake to lake.
- After introduction, EWM expansion was observed to be variable and unpredictable.
- Low EWM abundances were observed and maintained in several lakes without any active management.
- If warranted, management can be an effective tool for EWM control if properly implemented. However, short- and long-term non-target impacts to native plants may occur.

Milfoil Genetics

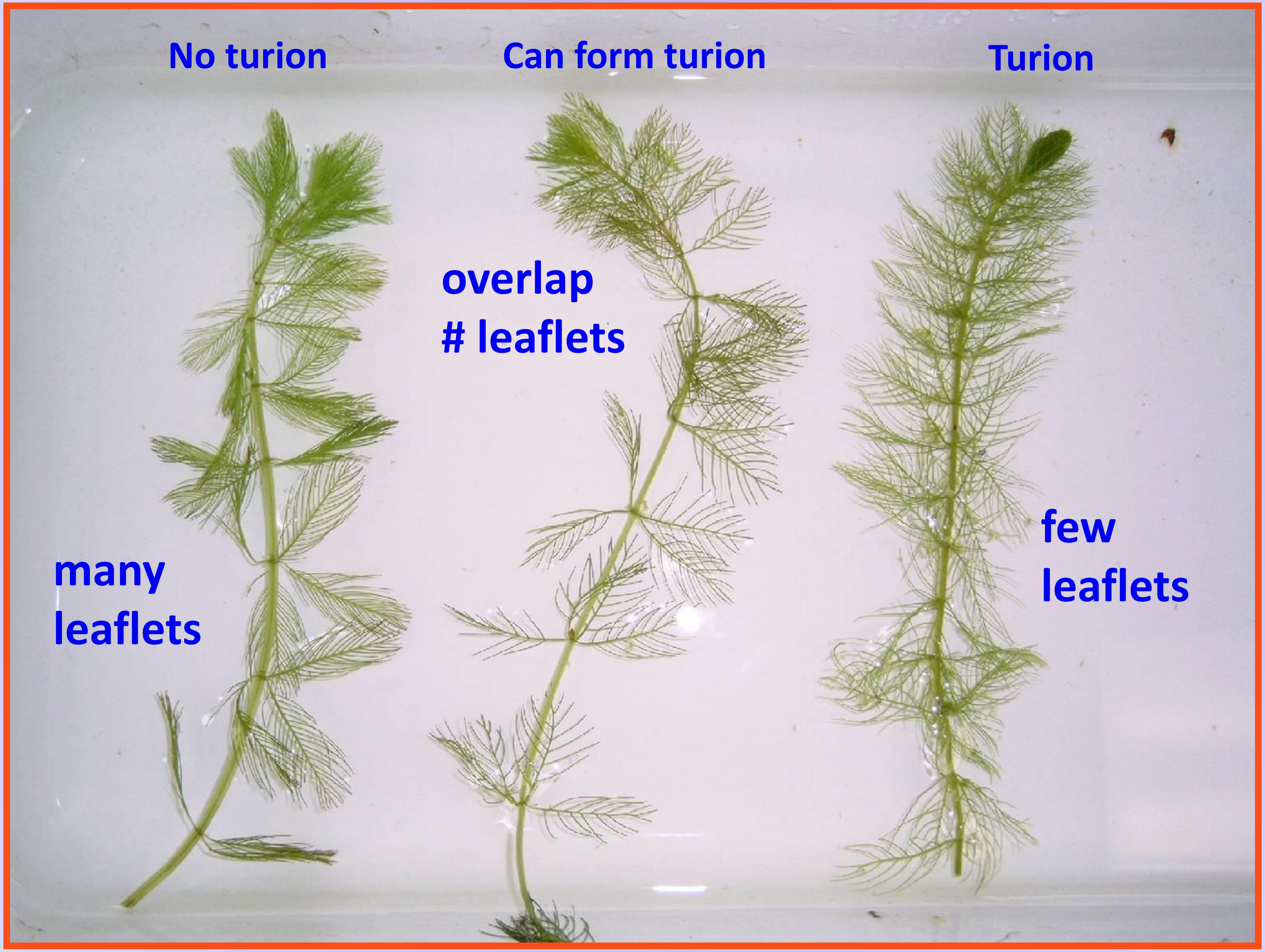


Milfoil Genetics

- “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

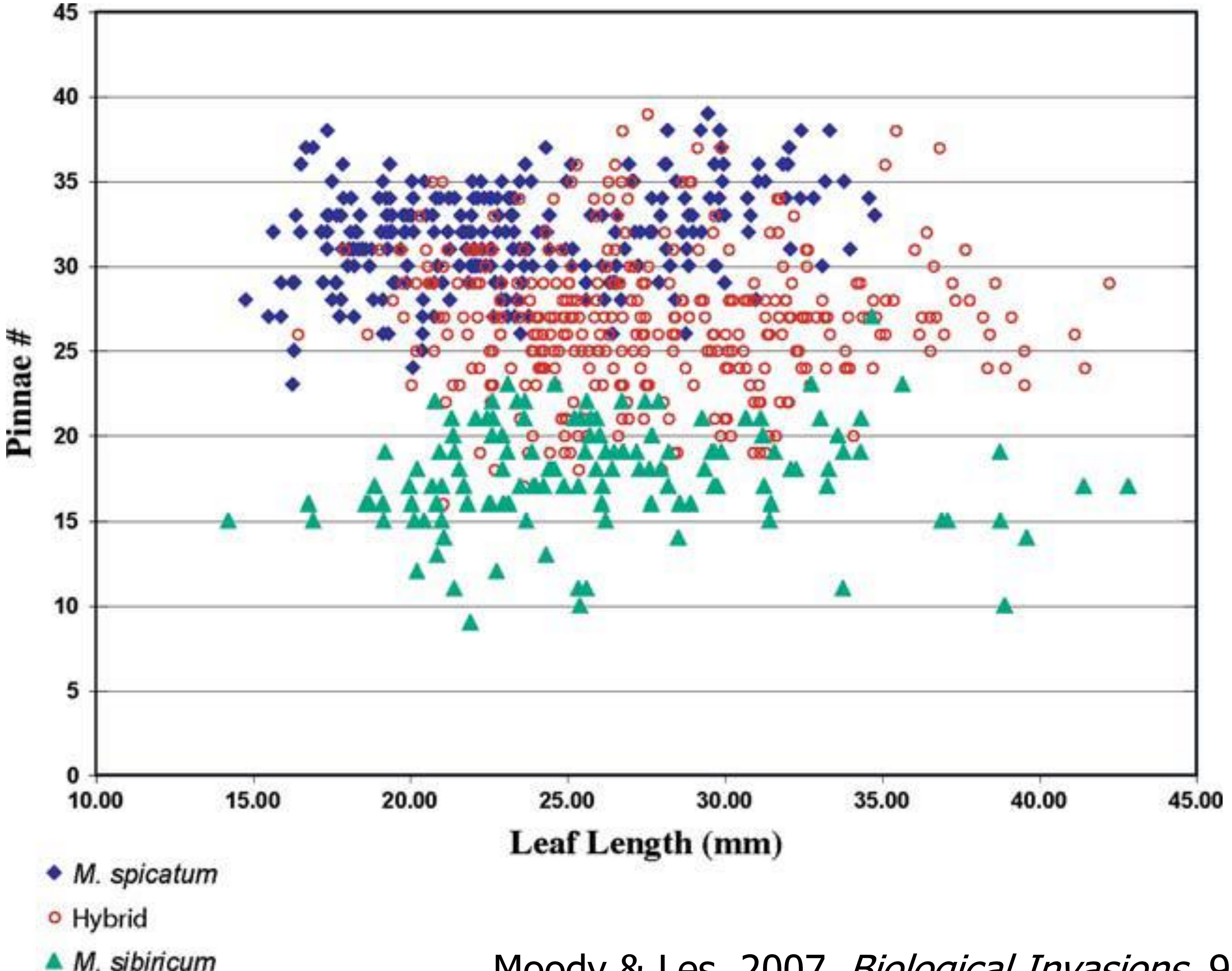
Morphological variation

Courtesy of Dr. Michael Moody



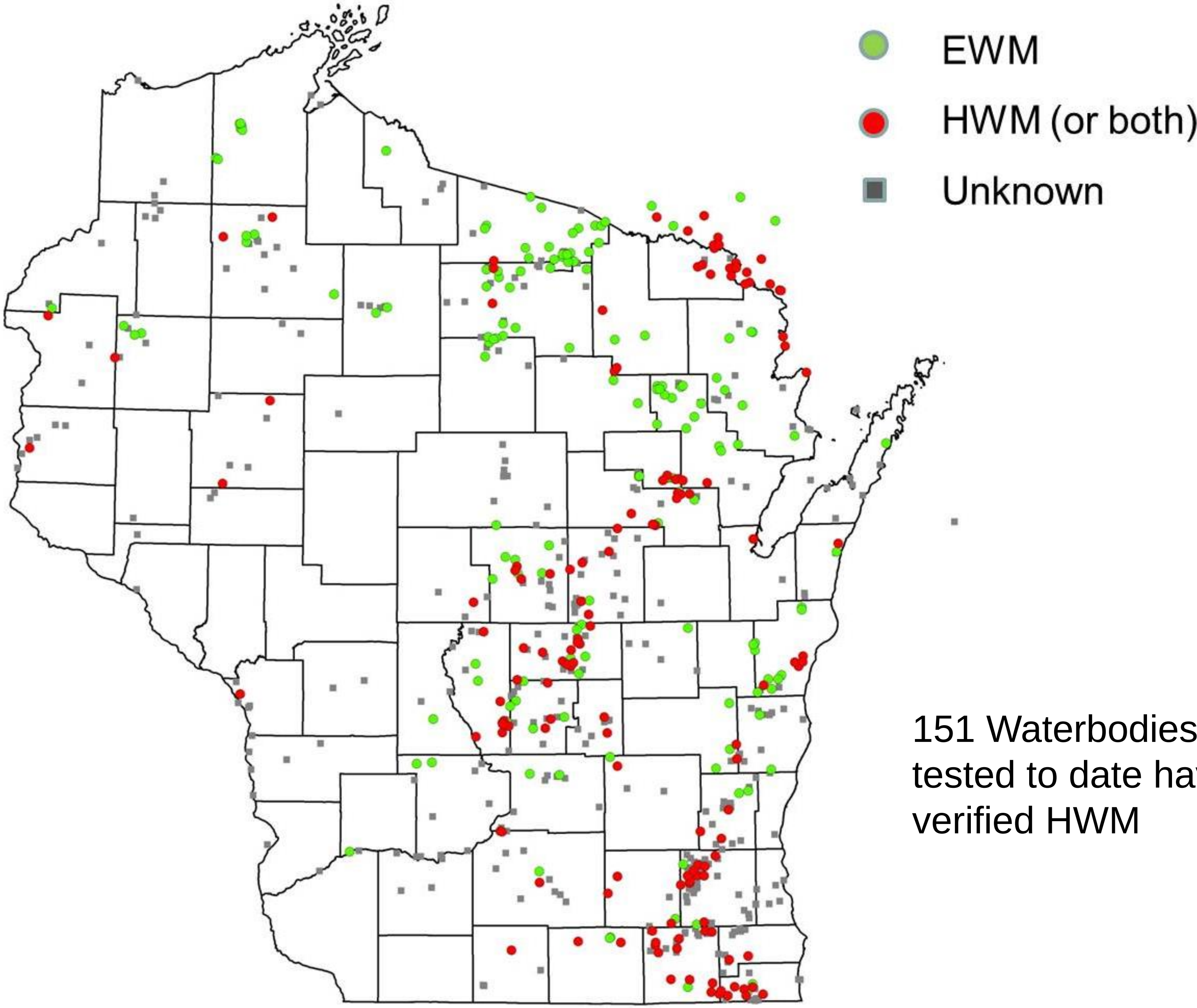
M. spicatum Hybrid *M. sibiricum*

Leaflet # vs. leaf length in North American watermilfoil populations



Moody & Les. 2007. *Biological Invasions,* 9:559-570.

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)

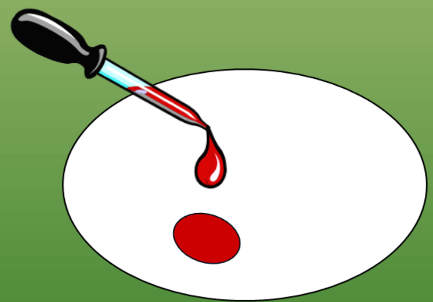
Nault et al. 2015. Small-scale treatments. NALMS LakeLine 35(1):35-39.

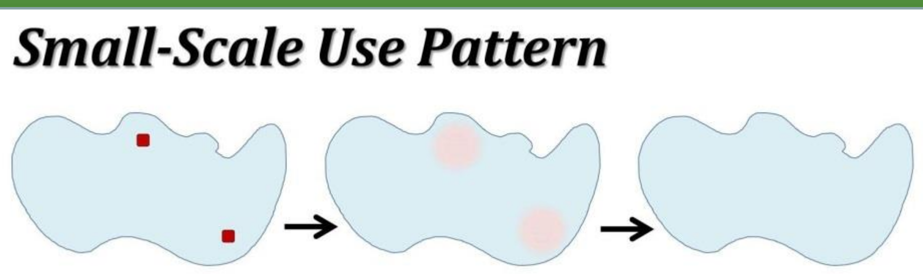
Nault et al. 2018. Large-scale 2,4-D for milfoil control across WI Lakes. Lake & Res.

Scale of Treatment

Small

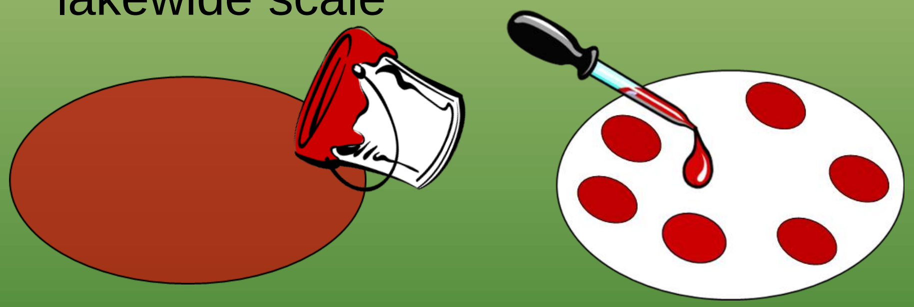
- *WI Admin. Code*: <10 acres or <10% of littoral zone
- Herbicide will be applied at a scale where dissipation will not result in significant lakewide concentrations and effects are anticipated on a localized scale

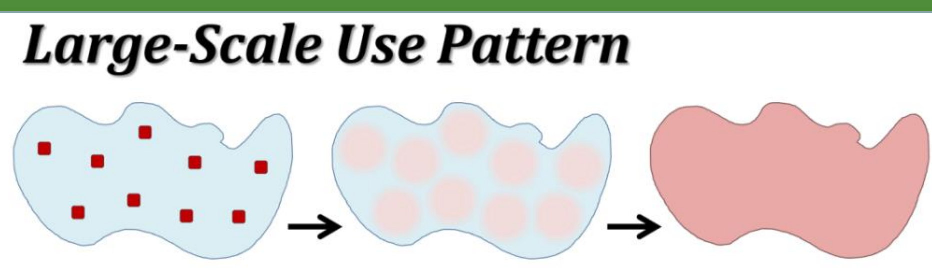




Large

- *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

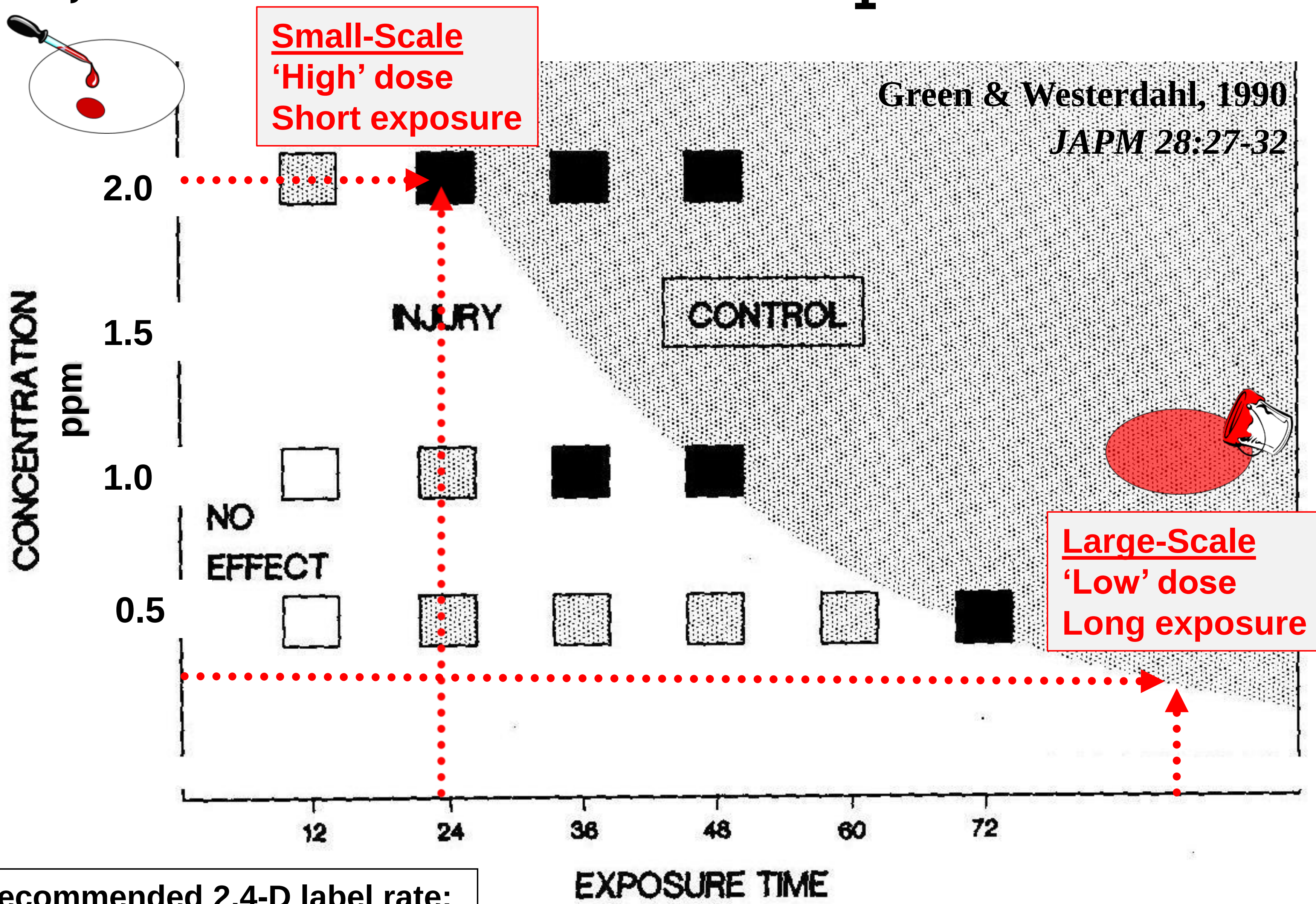




Herbicide Exposure Time

- **Dissipation:** horizontal and vertical movement of herbicide within the water column
  - Treatment area relative to lake
  - Wind
  - Water flow
  - Water depth
- **Degradation:** physical breakdown of herbicide into inert components
  - Microbial
  - Photolytic

2,4-D Concentration/Exposure Time

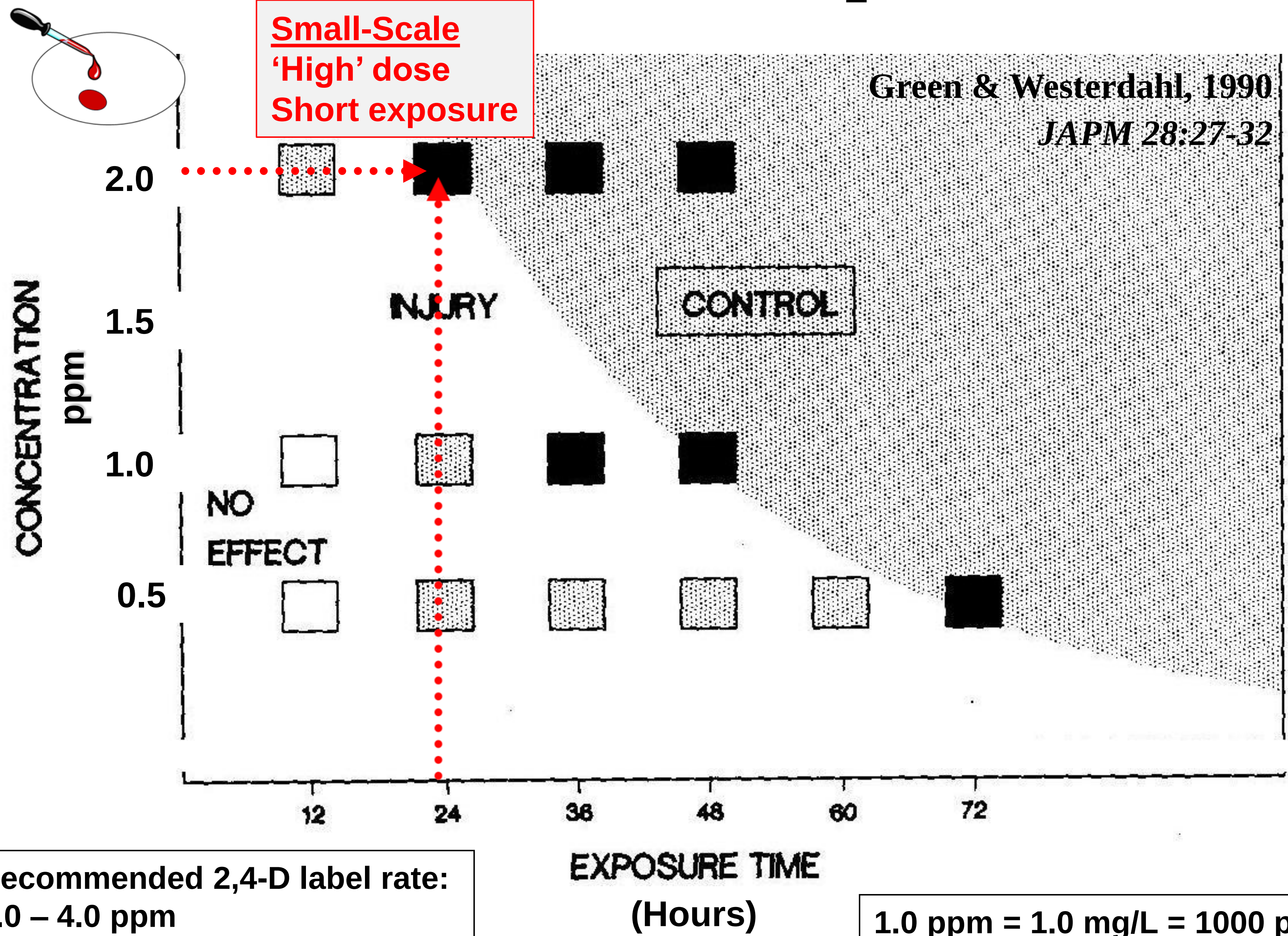


Recommended 2,4-D label rate:
2.0 – 4.0 ppm

1.0 ppm = 1.0 mg/L = 1000 ppb

2,4-D Concentration/Exposure Time

Small-Scale
'High' dose
Short exposure



Recommended 2,4-D label rate:
2.0 – 4.0 ppm

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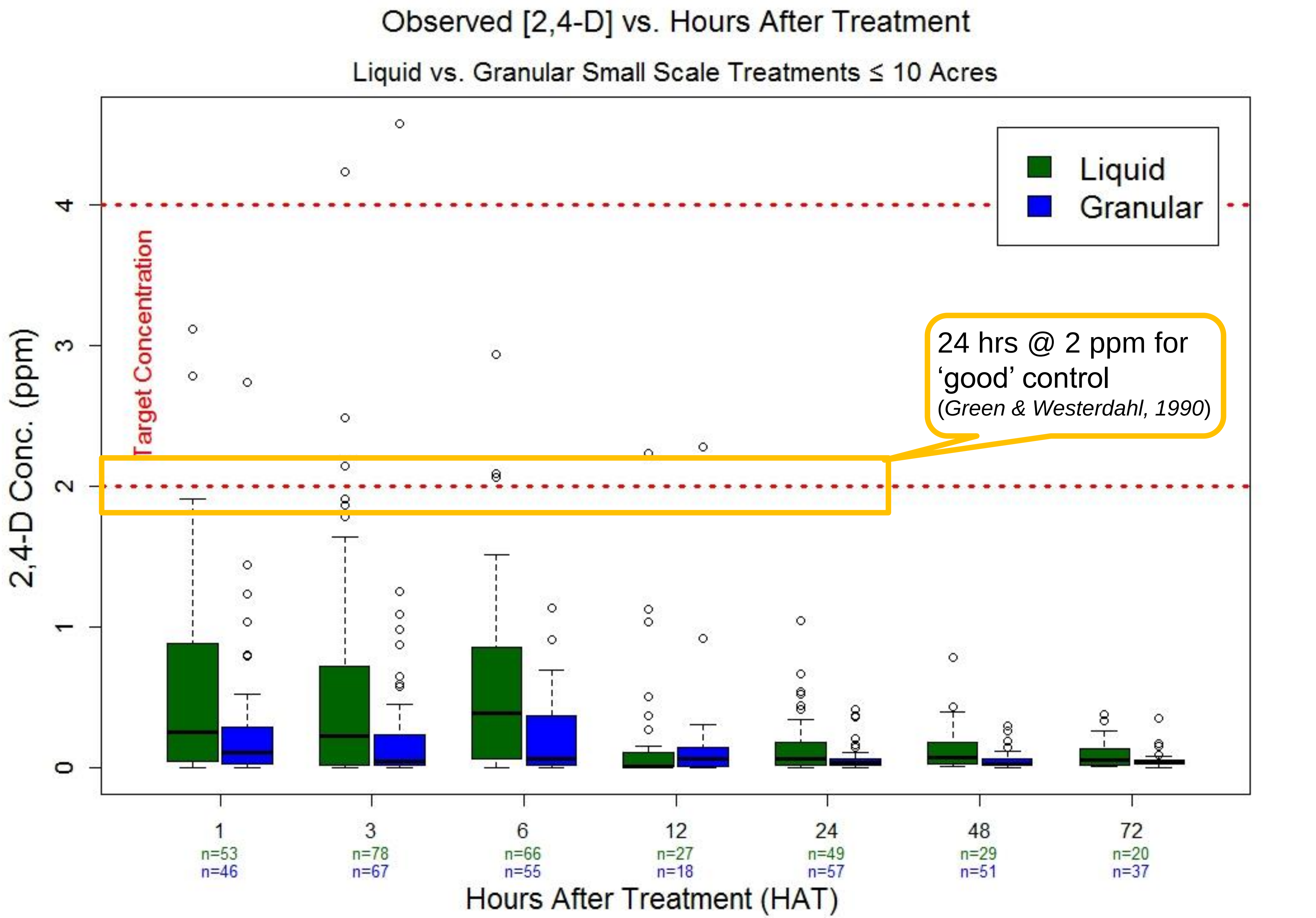
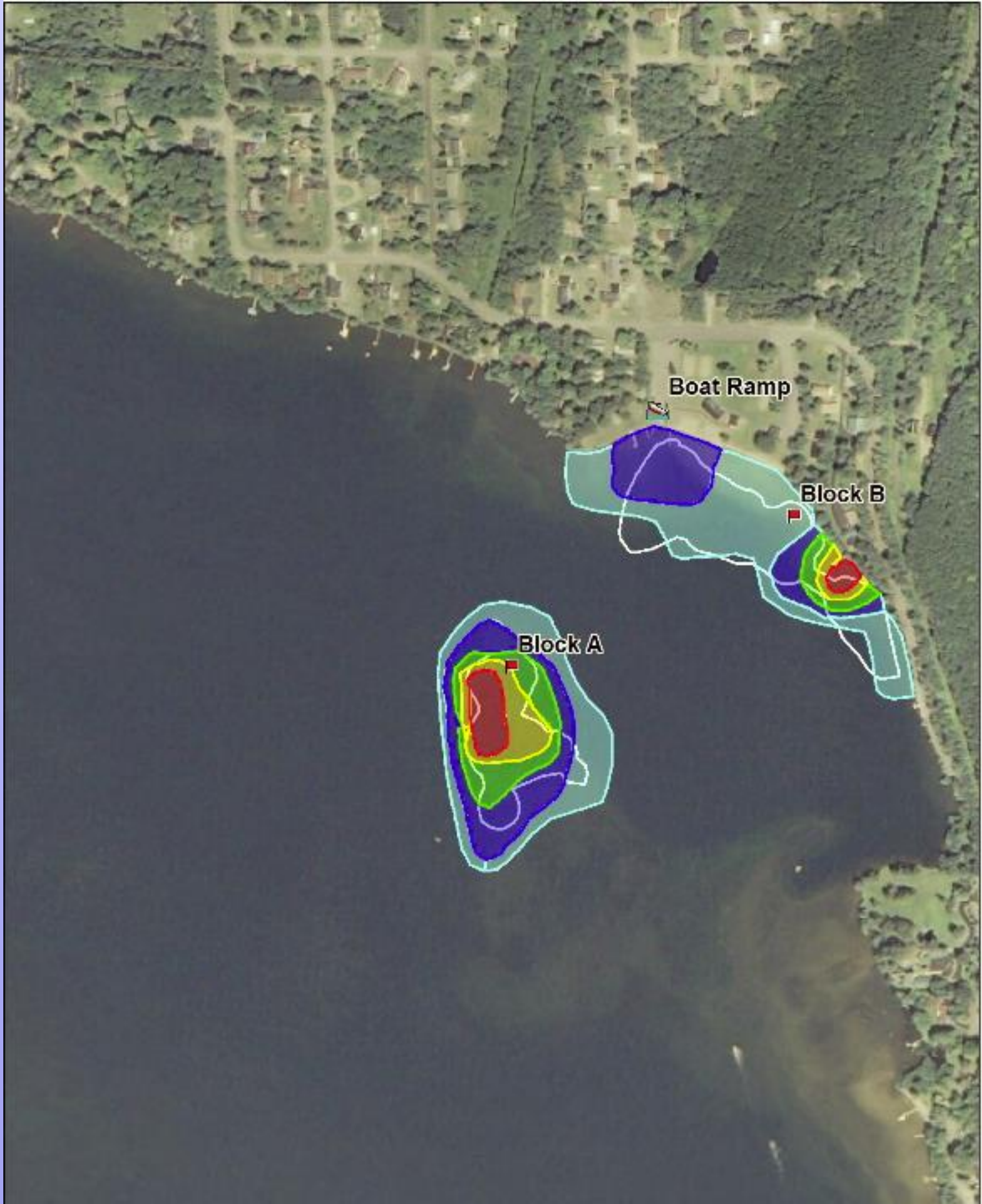

Observed [2,4-D] vs. Hours After Treatment
Liquid vs. Granular Small Scale Treatments ≤ 10 Acres
Liquid
Granular
Target Concentration
24 hrs @ 2 ppm for 'good' control
(Green & Westerdahl, 1990)
2,4-D Conc. (ppm)
0
1
2
3
4
1
n=53
n=46
3
n=78
n=67
6
n=66
n=55
12
n=27
n=18
24
n=49
n=57
48
n=29
n=51
72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

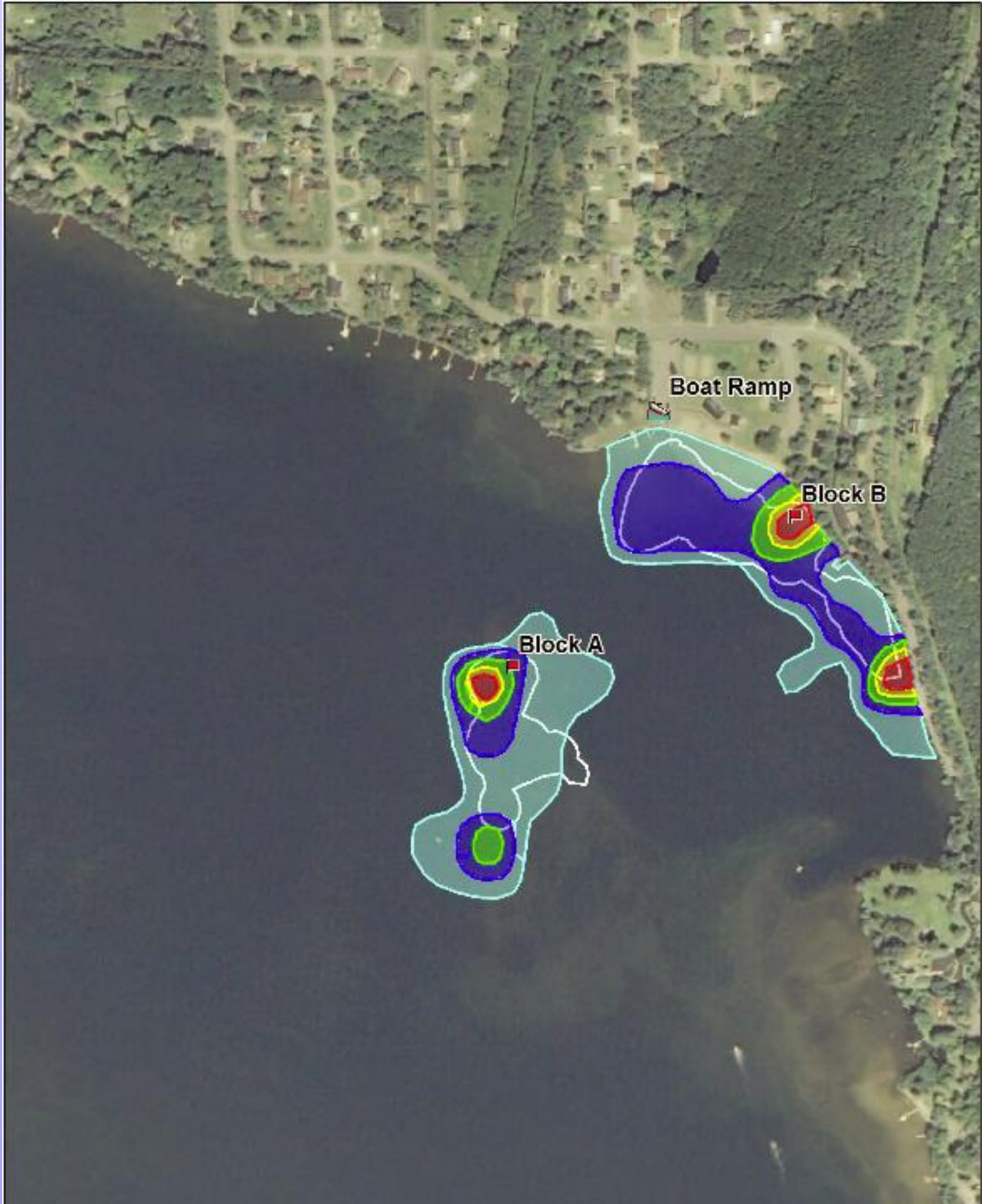
1 HAT

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



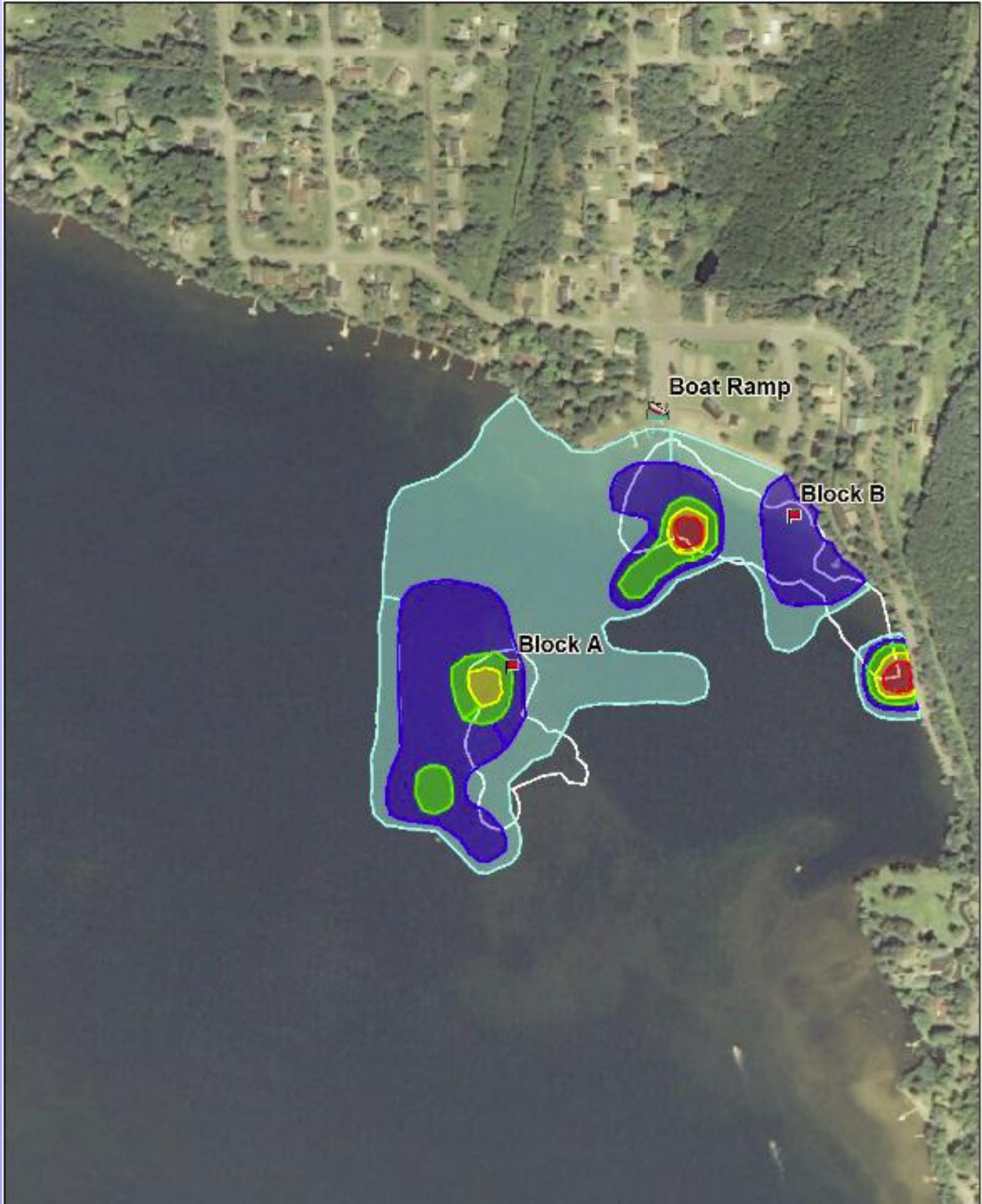
2 HAT

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%

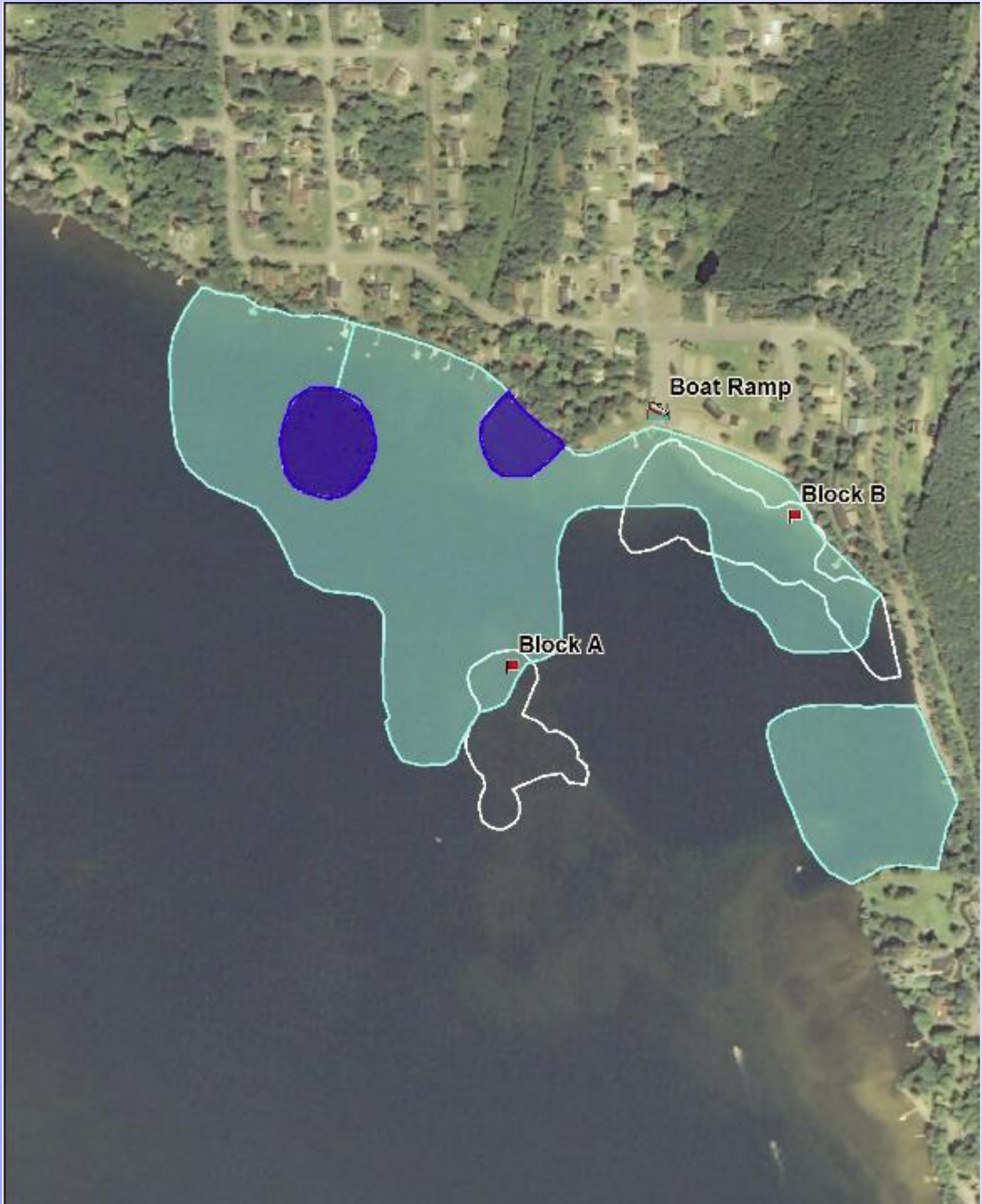
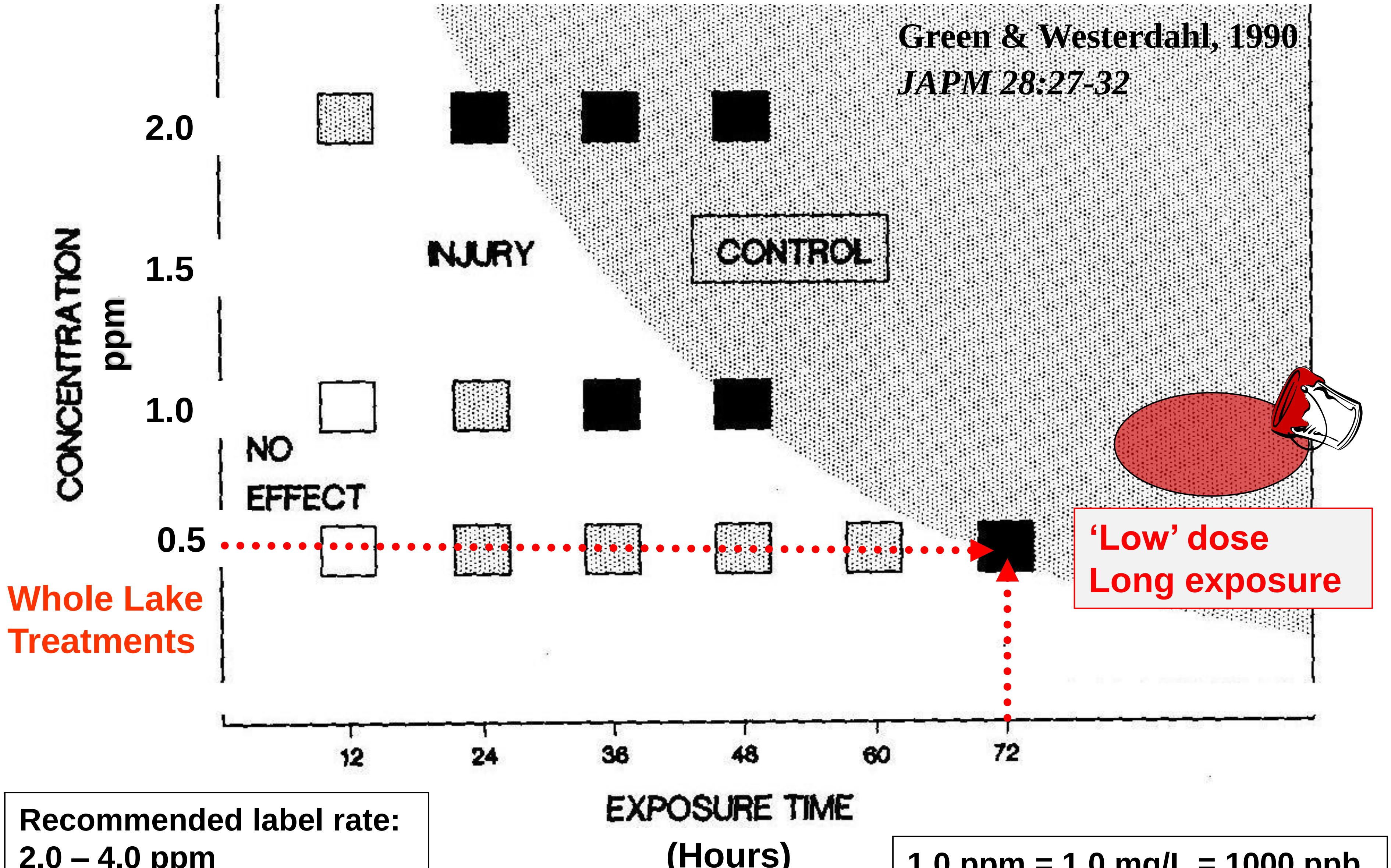


Table 3. Estimated Dye Exposure Times	
Application Block	Exposure Time (HAT)
A	1 TO 2
B	<1 TO 2

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

2,4-D Concentration/Exposure Time



Recommended label rate:
2.0 – 4.0 ppm

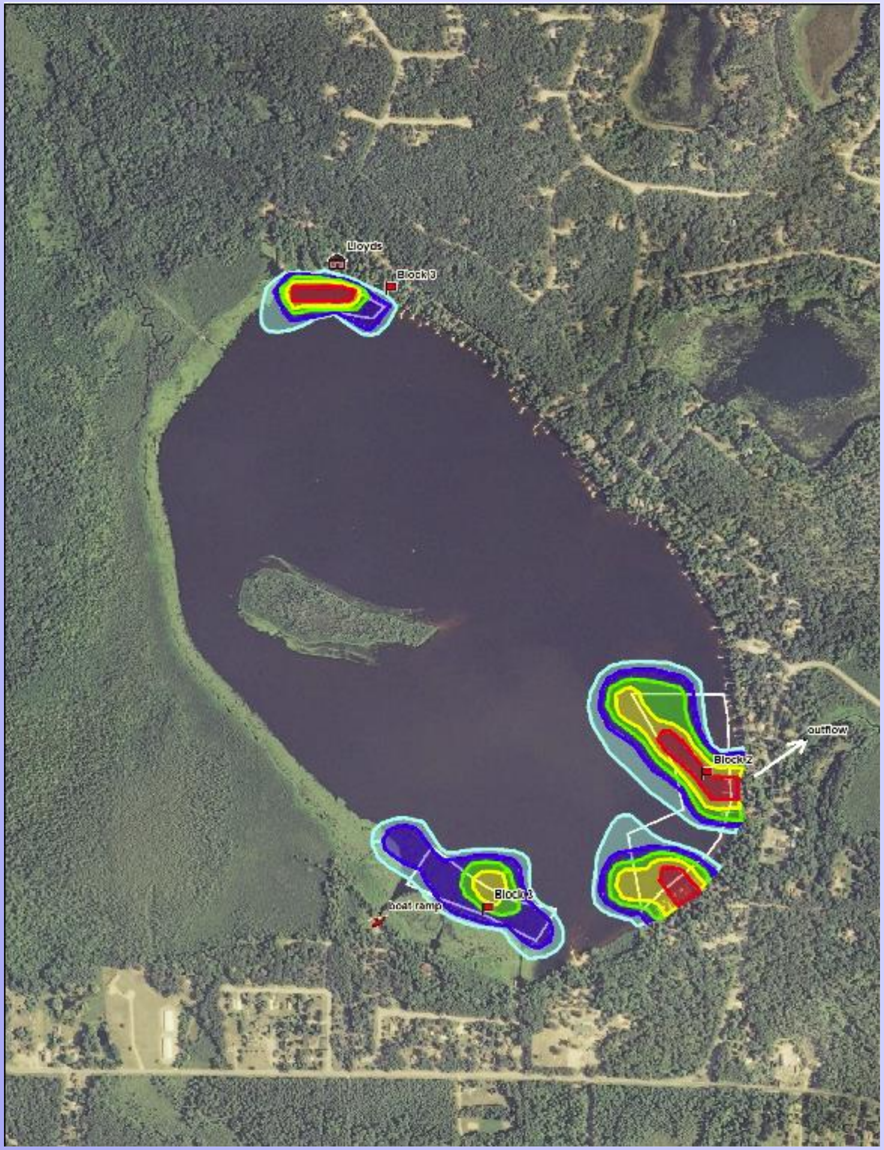
1.0 ppm = 1.0 mg/L = 1000 ppb

Horizontal Herbicide Mixing (Dissipation)

- ~25 acres of 305 acre lake (8%)
- Tracer Dye (Rhodamine WT) Survey

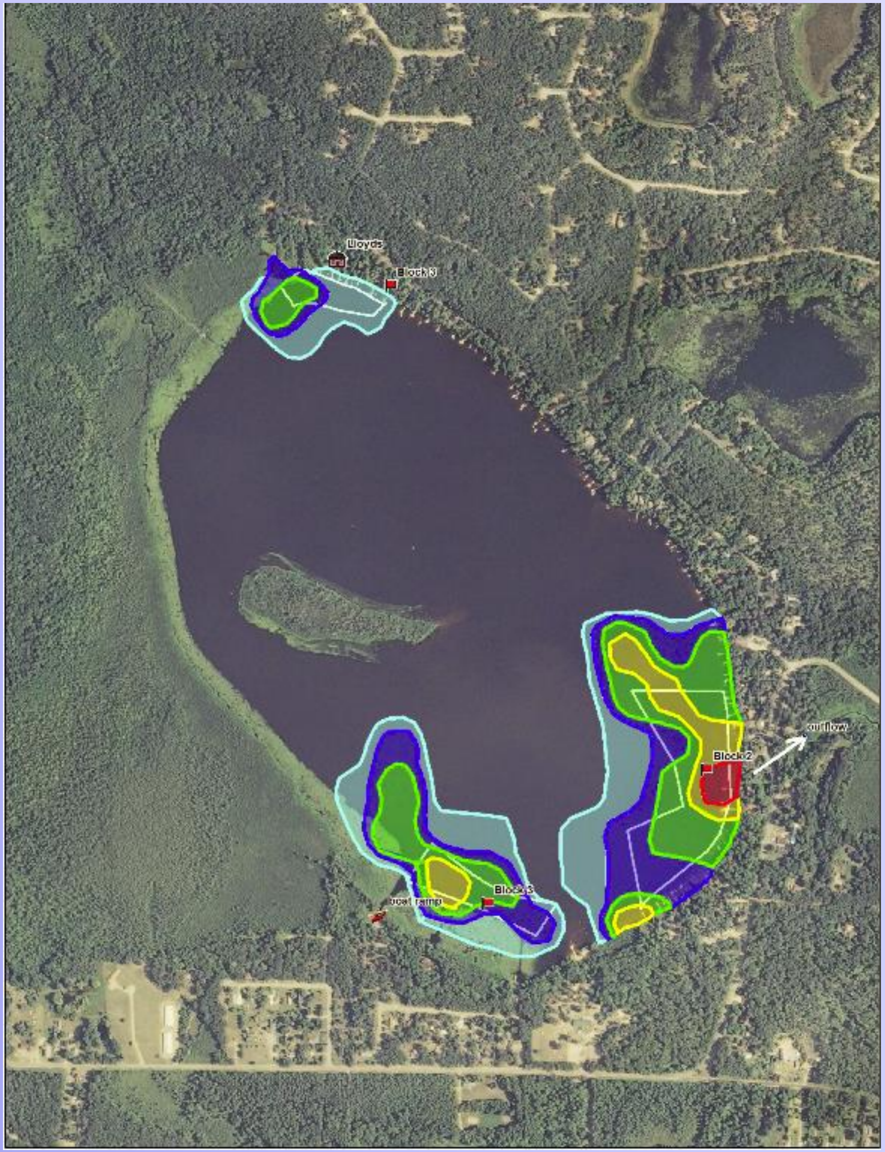
1 HAT

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



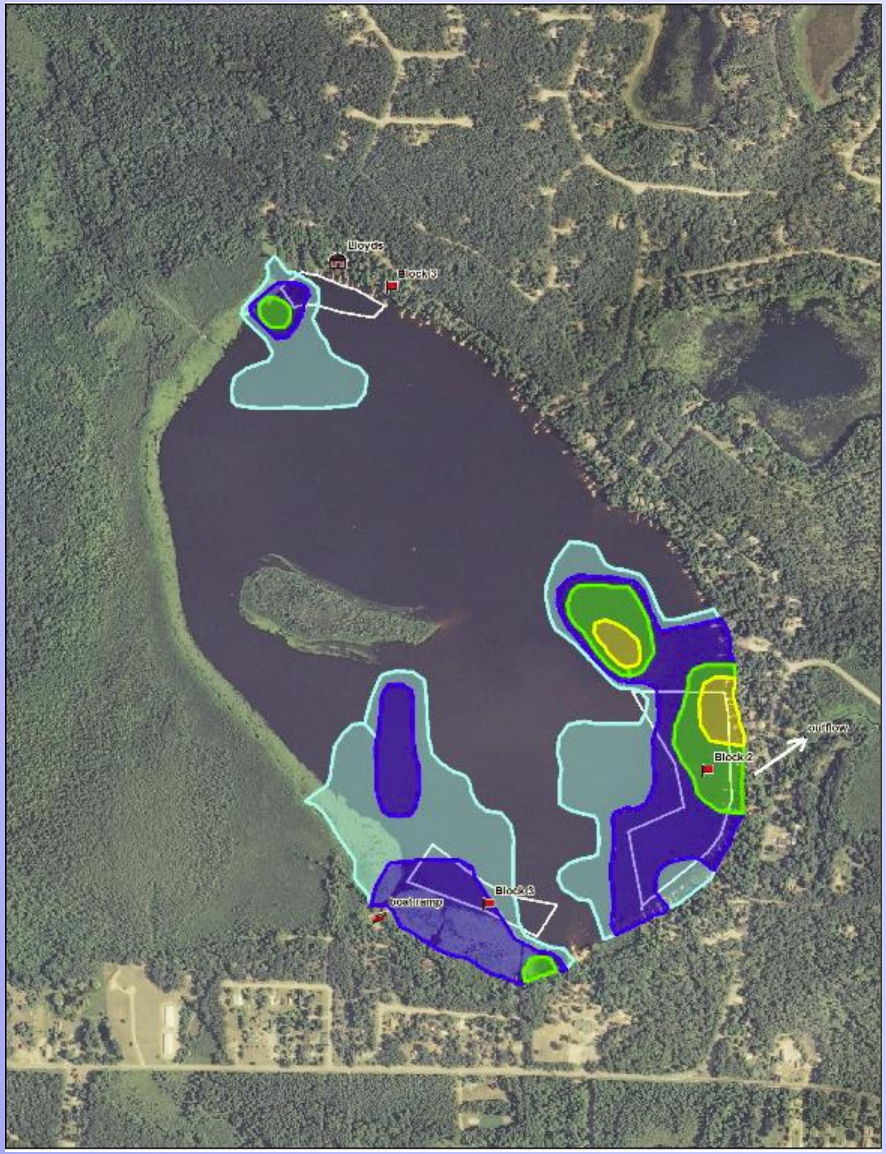
2.5 HAT

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



4 HAT

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

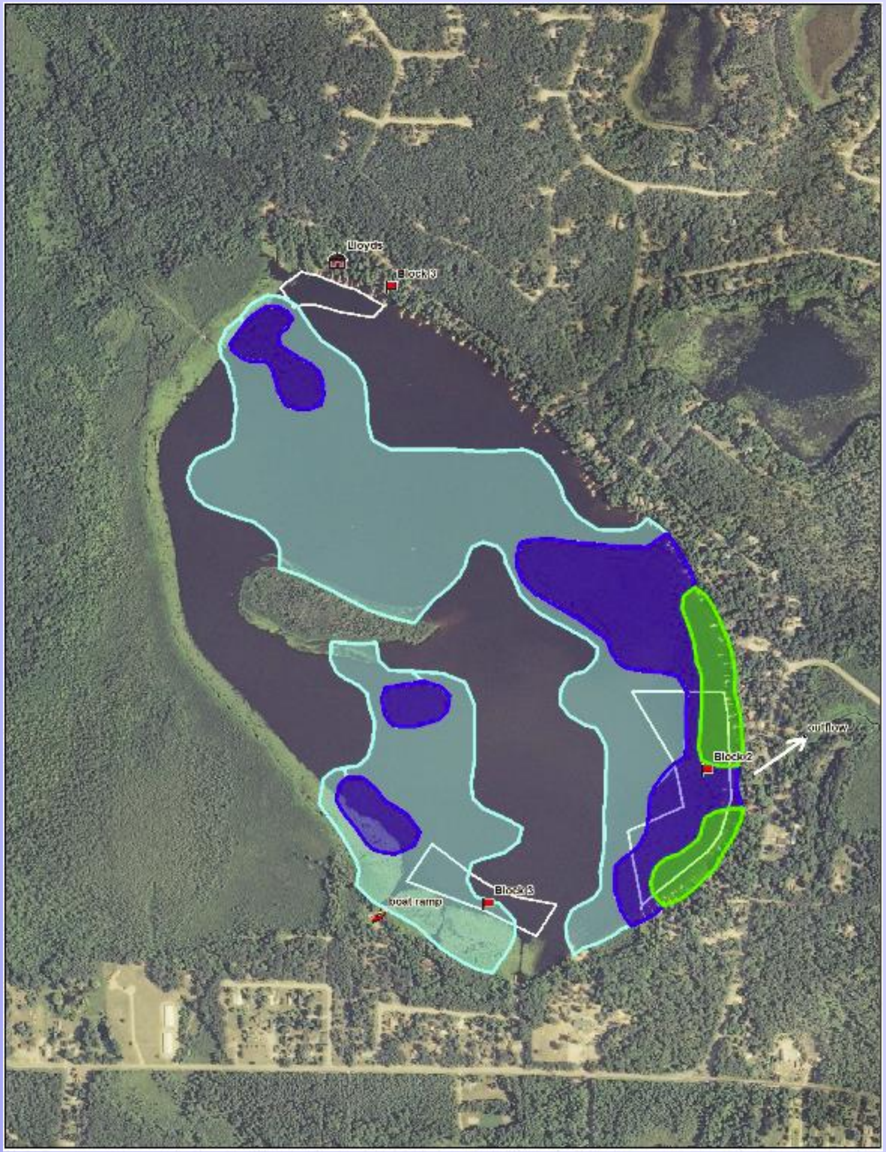


6 HAT

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

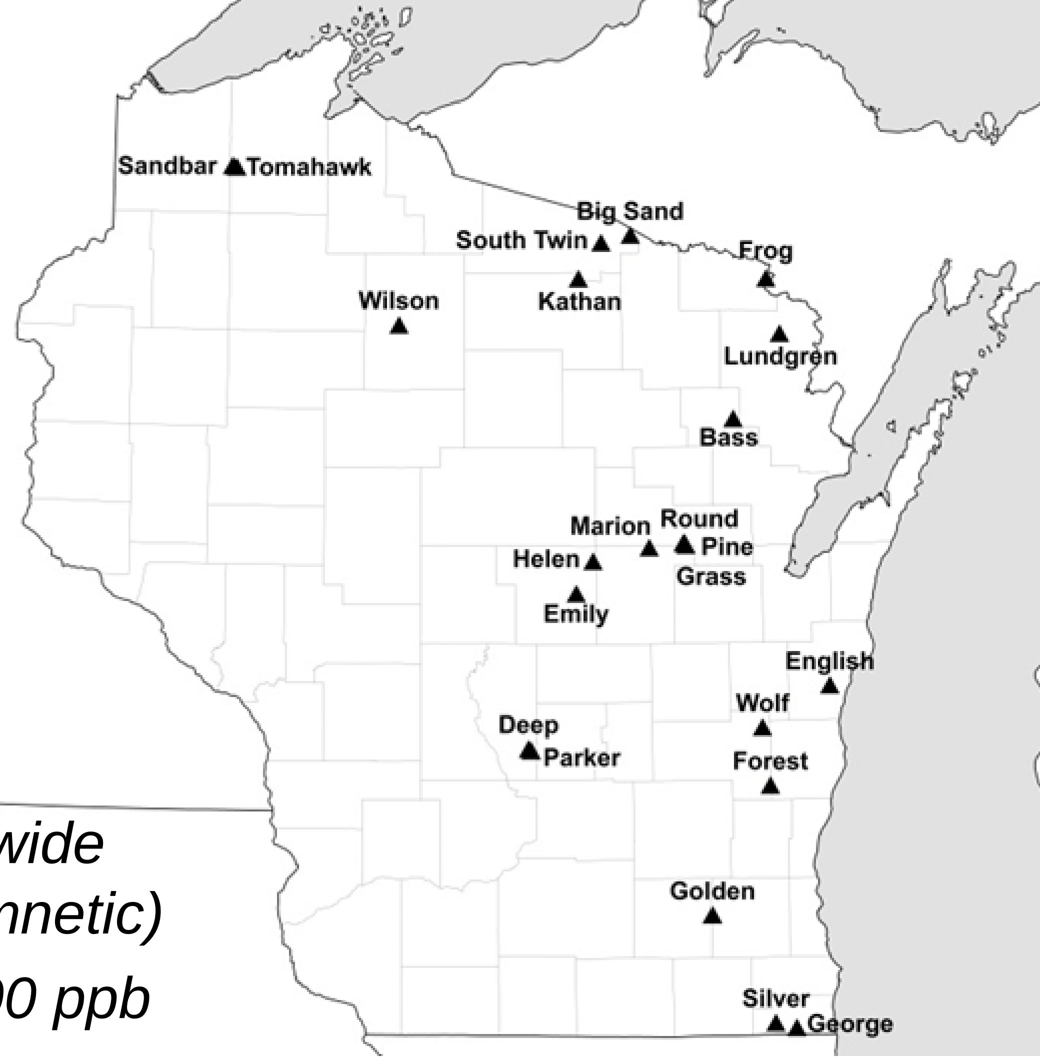
If 2,4-D was applied at 4.0 ppm,

5-10% would be 0.2 - 0.4 ppm (200-400 ppb).



Study Lakes

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



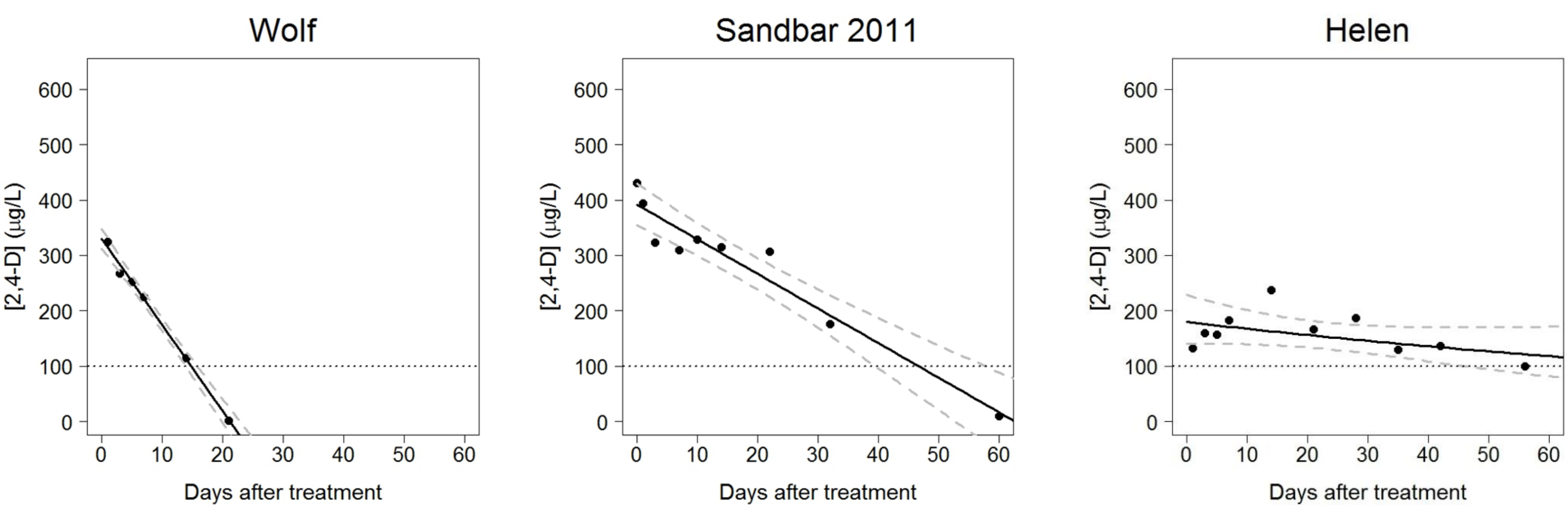
Treatments

- *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*

Nault et al. 2018. Lake & Res. Mgmt.

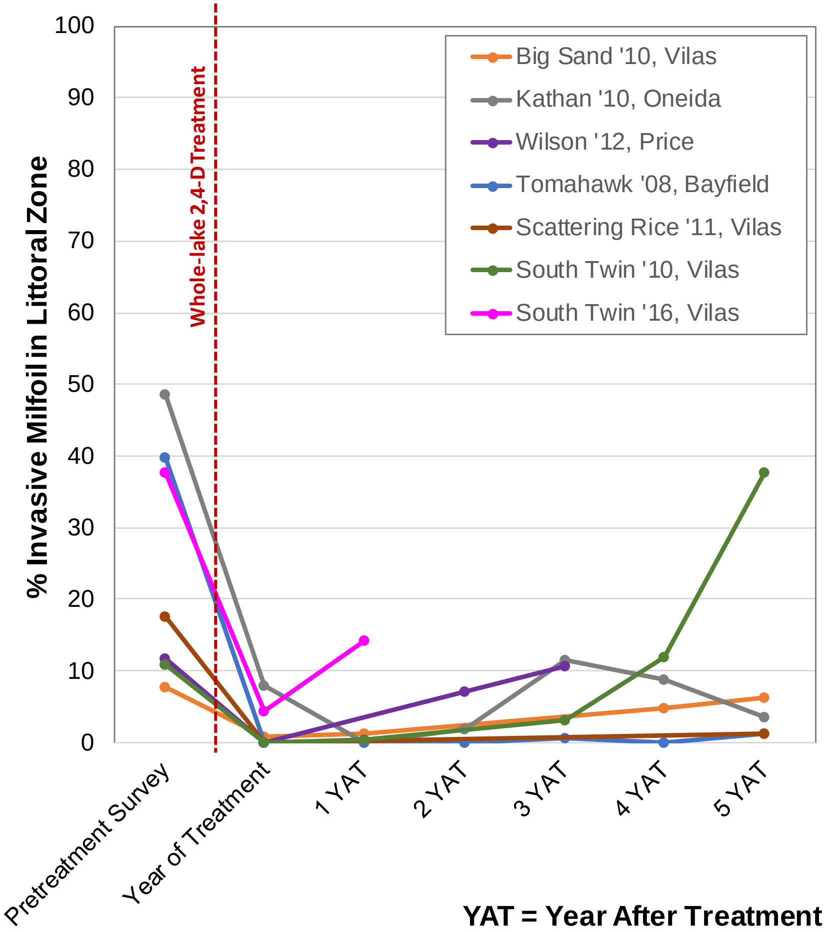
2,4-D Degradation

- 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

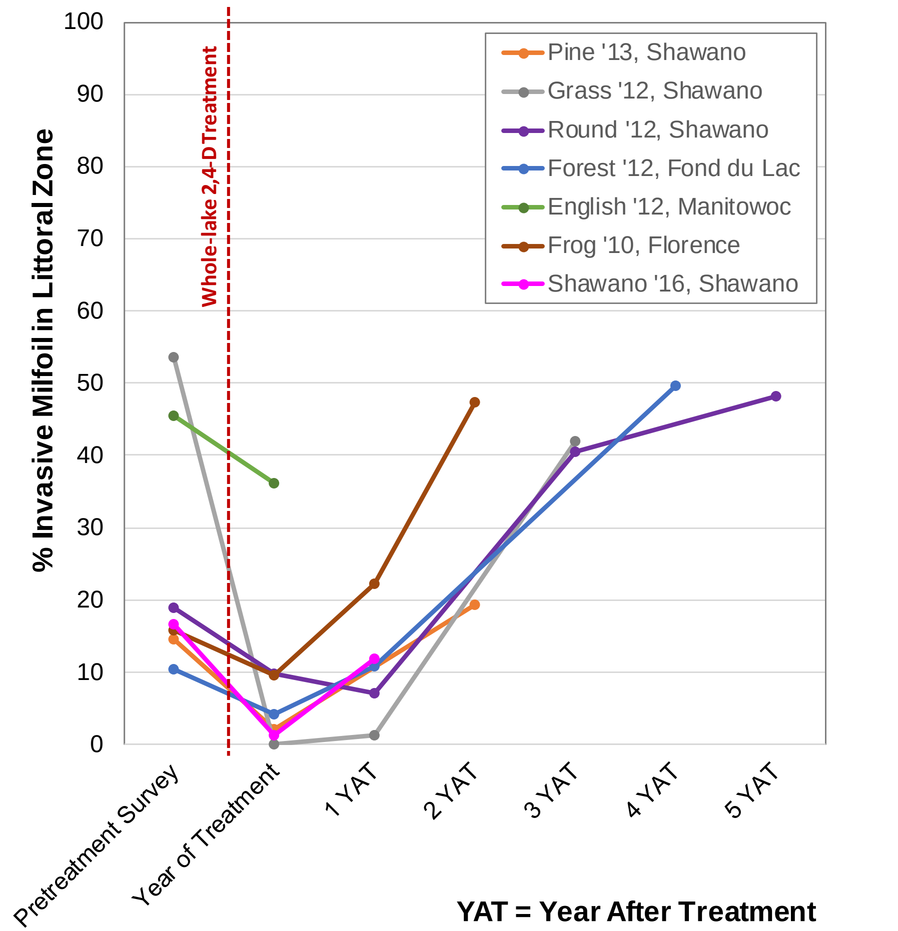


***Results** – Long-term Efficacy*

EWM



HWM



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

Questions?

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