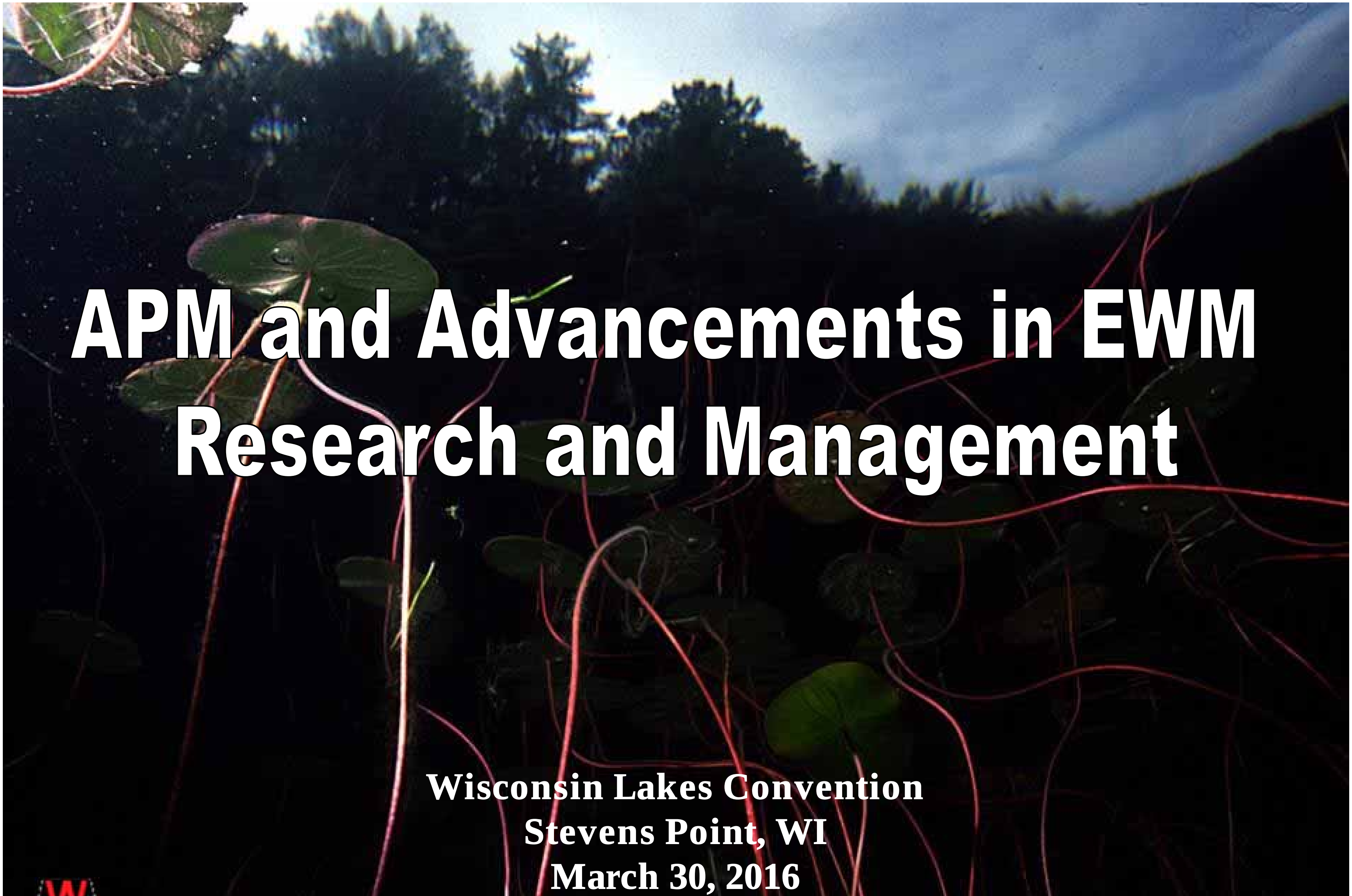


APM and Advancements in EWM Research and Management

Wisconsin Lakes Convention
Stevens Point, WI
March 30, 2016

Scott Provost, Michelle Nault, Scott Van Egeren – Wisconsin DNR
Eddie Heath – Onterra LLC

APM Technical Session Outline

- Introductions – Scott Provost
- AIS Active Management Discussion – Eddie Heath
- Current Research Findings – Michelle Nault
- Implementing IPM/Policy – Scott Provost
- Grants – Scott Van Egeren
- Q&A Panel – 5:45pm ~ 6:15pm

AIS Active Management Philosophy

But…is it really that simple?

AIS Active Management Discussion

Pros

- Keep AIS population low so native ecosystem can function as it did prior to AIS
- Keep AIS population low so the lake is not a source population for other nearby lakes
- Keep AIS population low so they do not cause recreational, navigational, or aesthetic issues

Cons

- Management action itself may be ecologically damaging to the lake, either through improper implementation or unanticipated impacts
- Management action may not be fully supported by public
- Equilibrium ***unmanaged*** AIS population may be low enough to not cause large ecosystem or user conflicts

Developing a Control Strategy & Monitoring Plan

AIS Control Strategy

- Realistic and ecologically beneficial for the lake
- Inline with lake group's lake management goals
  - Influenced by stage & population of AIS
- Based upon lake group's support for various methods (e.g. drawdown, herbicide use)
- Prioritization based upon financial limitations and/or volunteerism
- Obtain support from additional management entities

AIS Monitoring Plan

- Collection of pre- & post treatment data for evaluation and adaptive management decisions

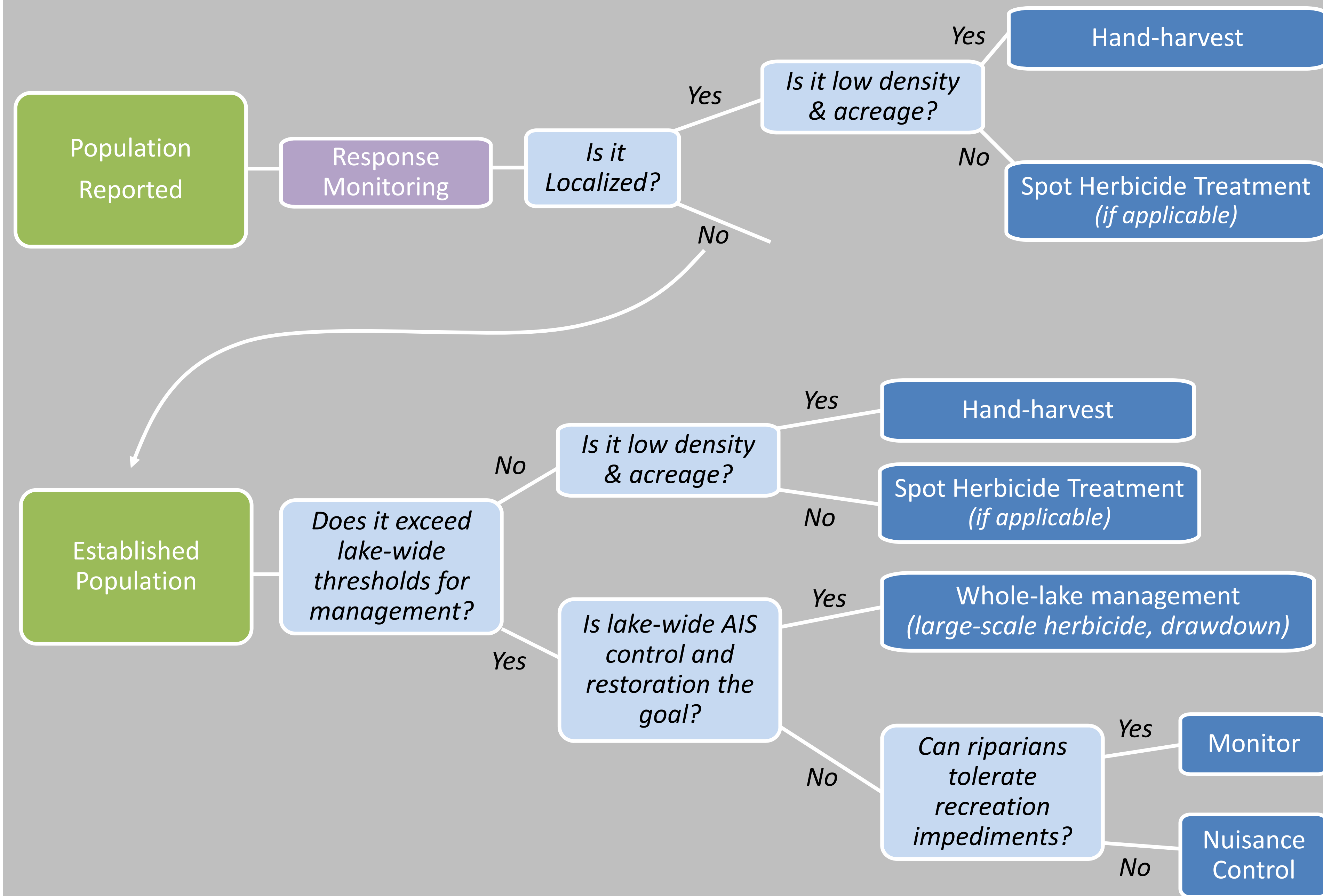
AIS Control Strategies

- Do nothing (monitor)
- Biocontrol (weevils)
- Herbicide treatment
- Hand removal (DASH)
- Winter drawdown
- Mechanical harvesting

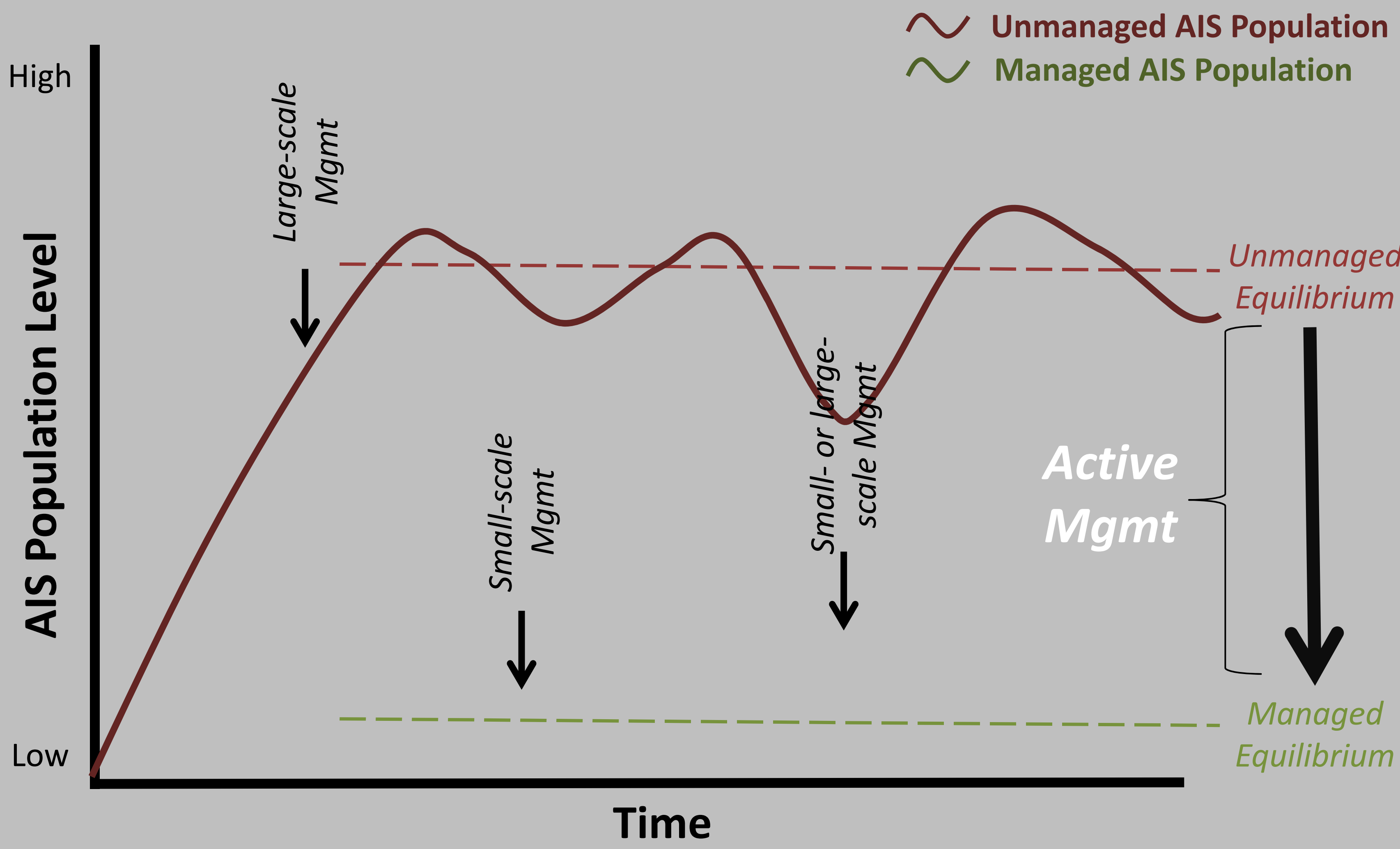
AIS Monitoring Plan

- Lake-wide point-intercept surveys
- Sub-sample point-intercept surveys
- Biomass assessment
- GPS-based AIS Mapping
- Turion assessment
- Hydroacoustic survey
- Weevils/stem

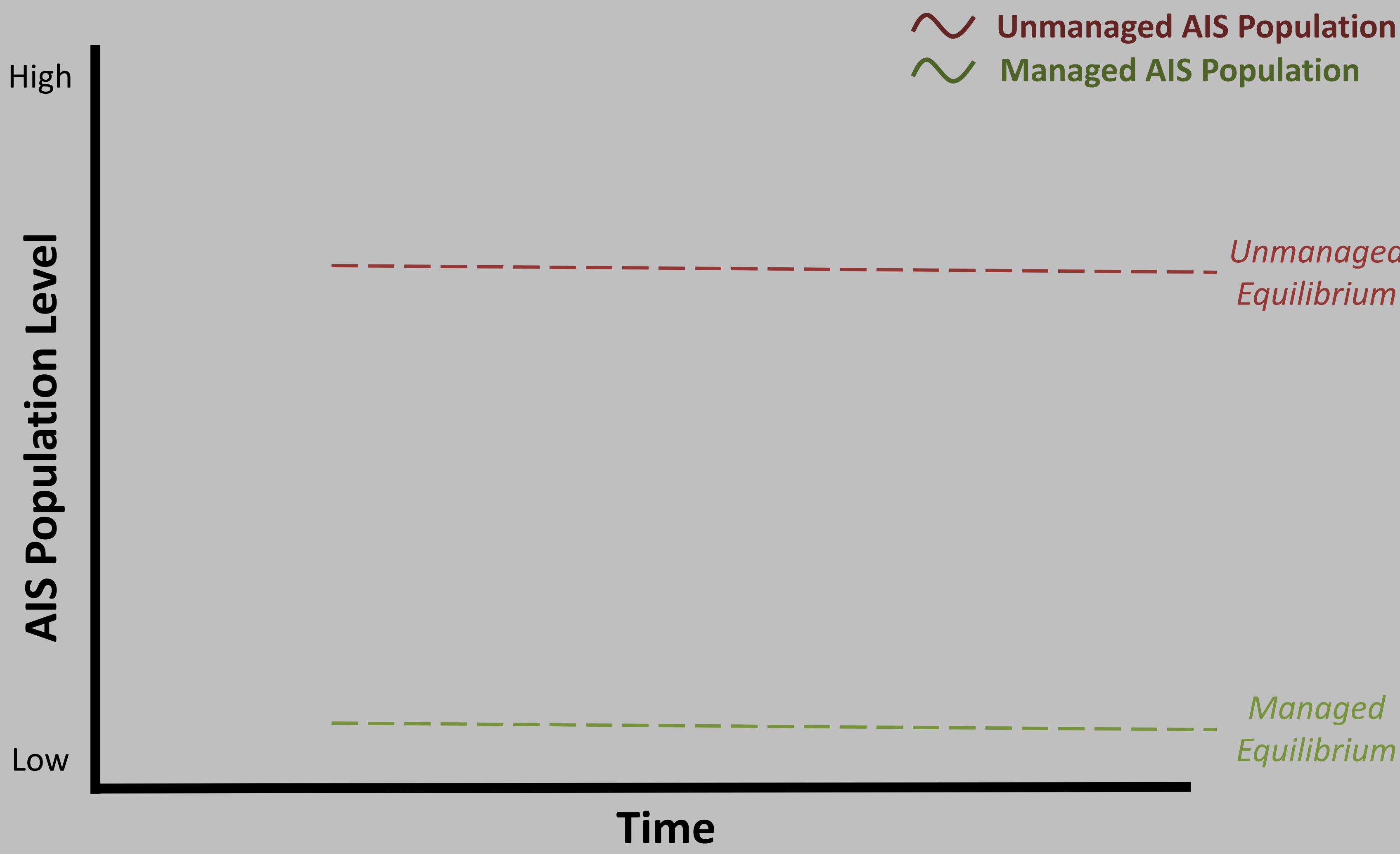
AIS Management Decision Tree



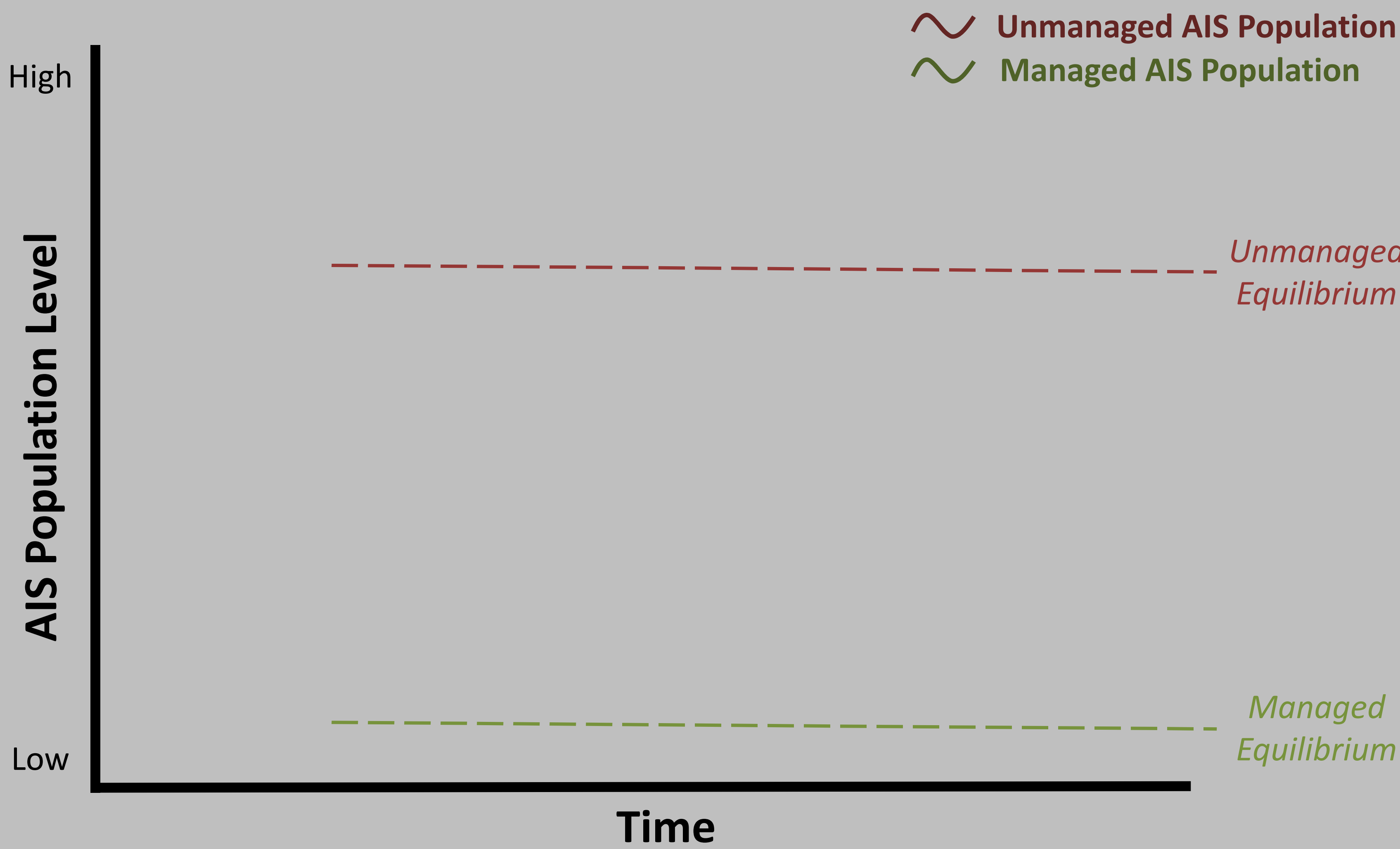
Hypothetical AIS Populations



Hypothetical AIS Populations

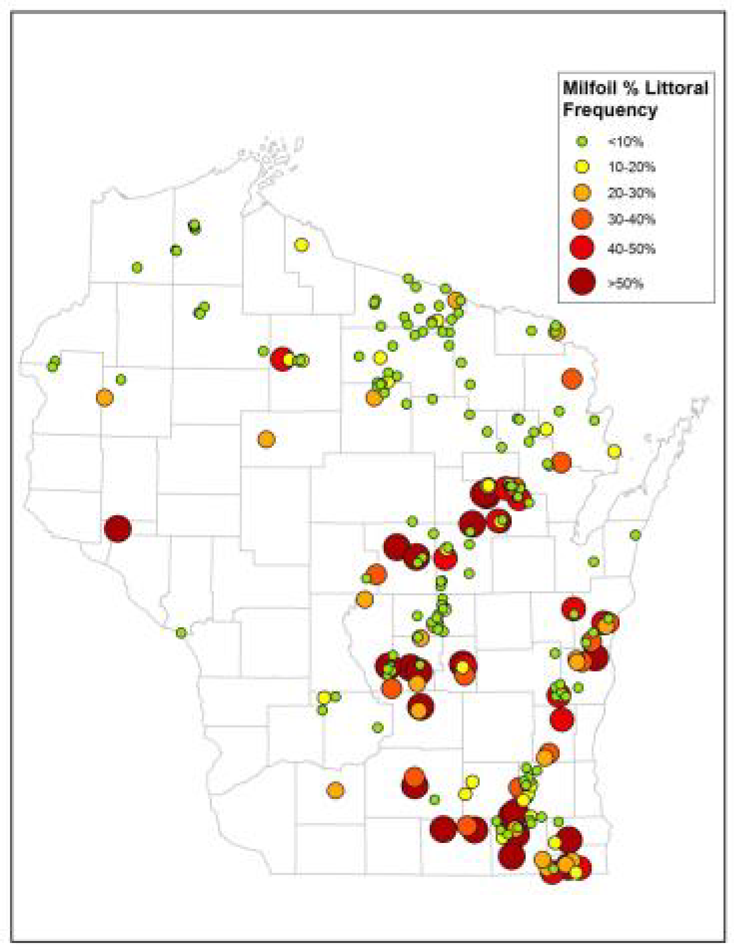


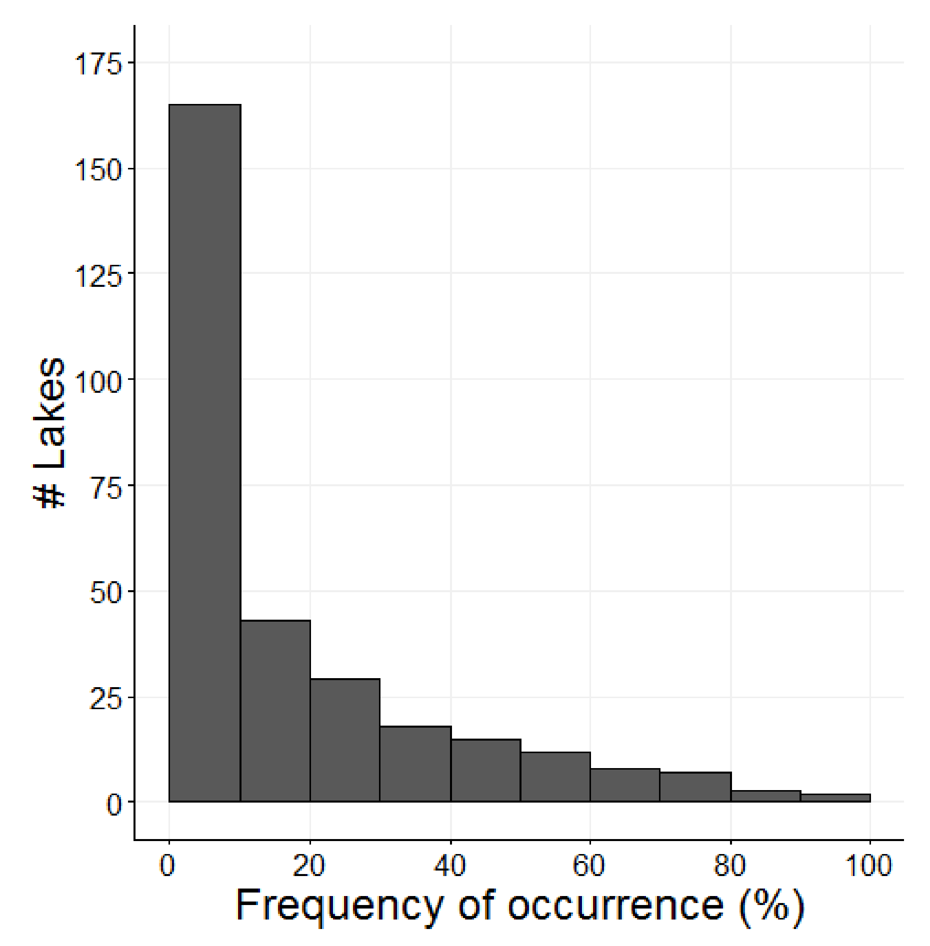
Hypothetical AIS Populations



Statewide Eurasian Watermilfoil Study

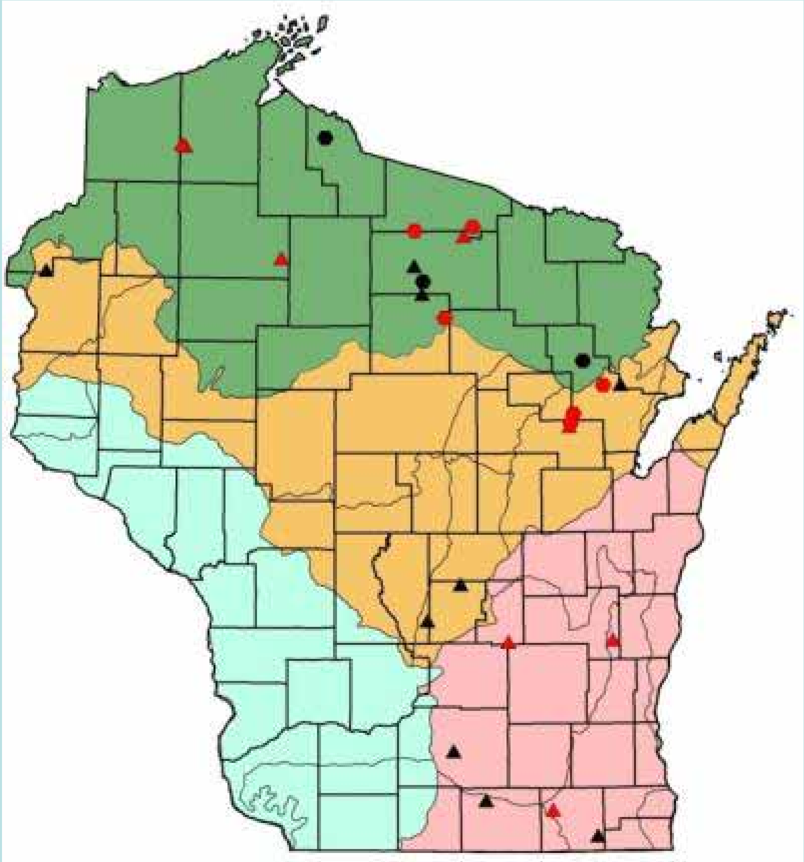
- What is the statewide distribution and abundance of EWM?

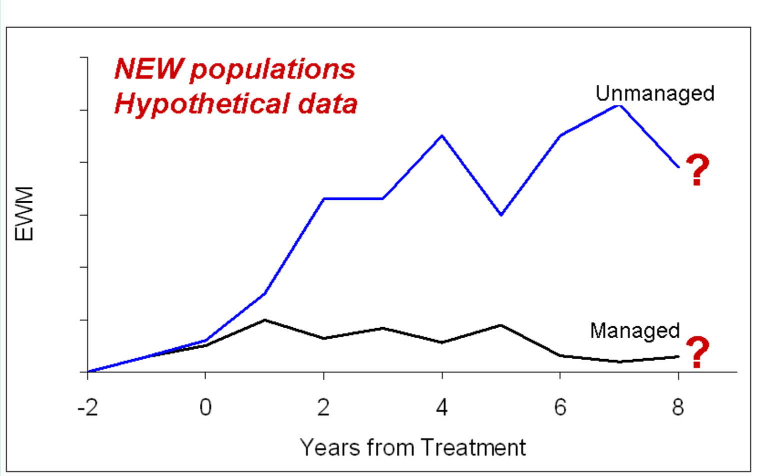


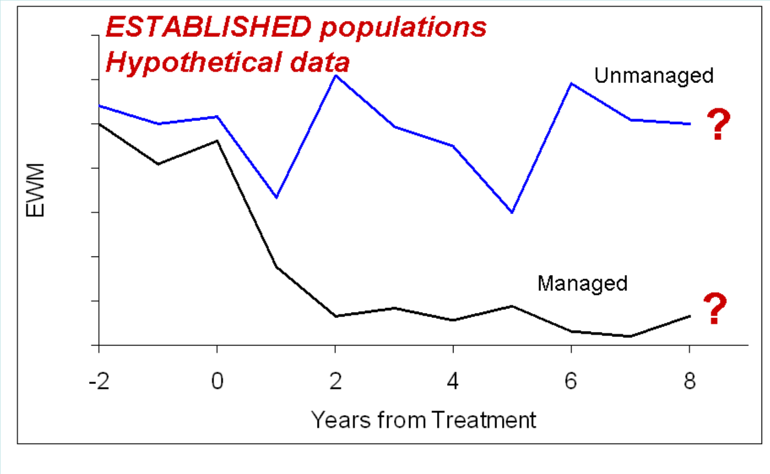


Long-Term Eurasian Watermilfoil Study

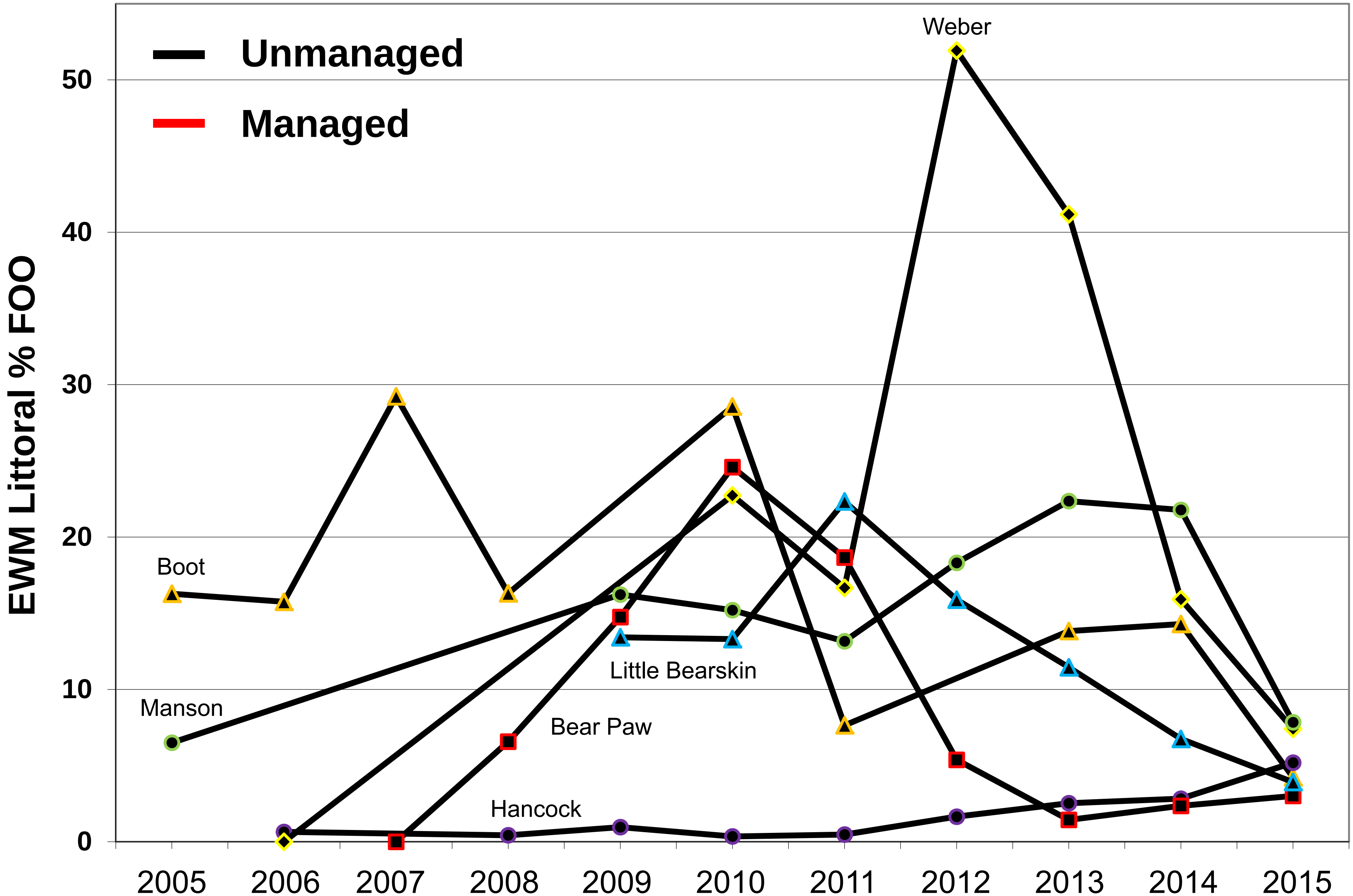
- How does management affect long-term EWM population levels?



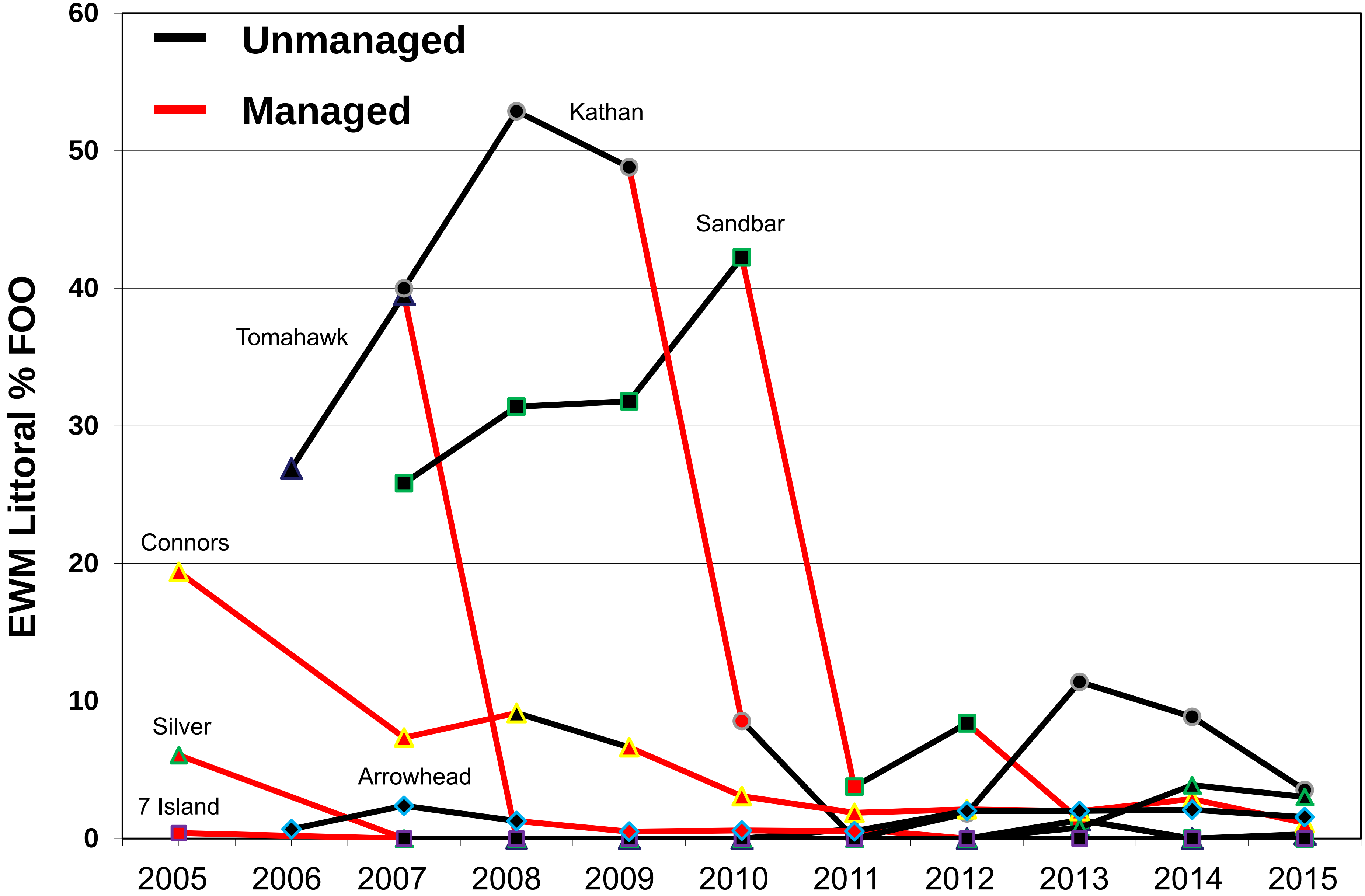


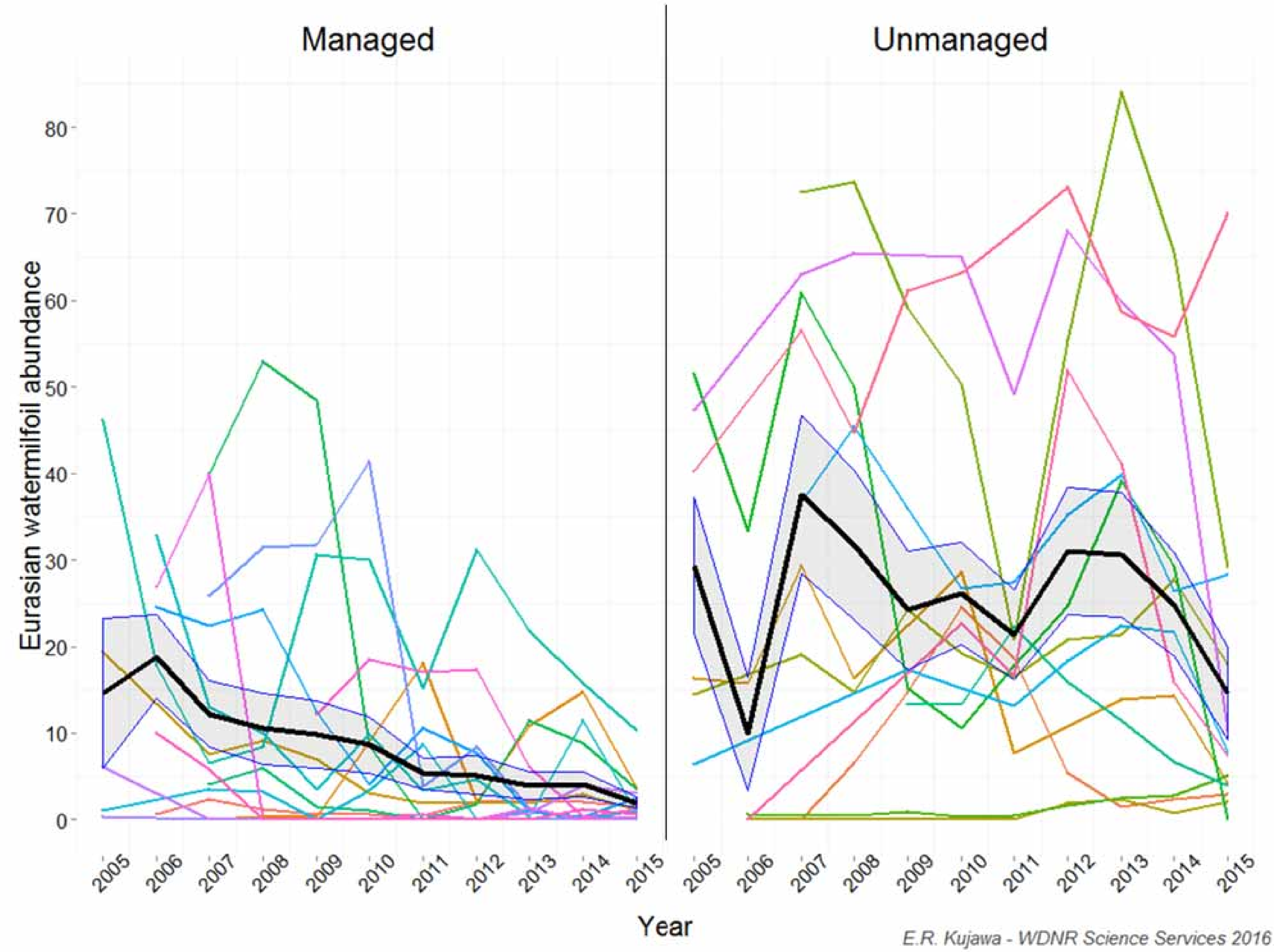


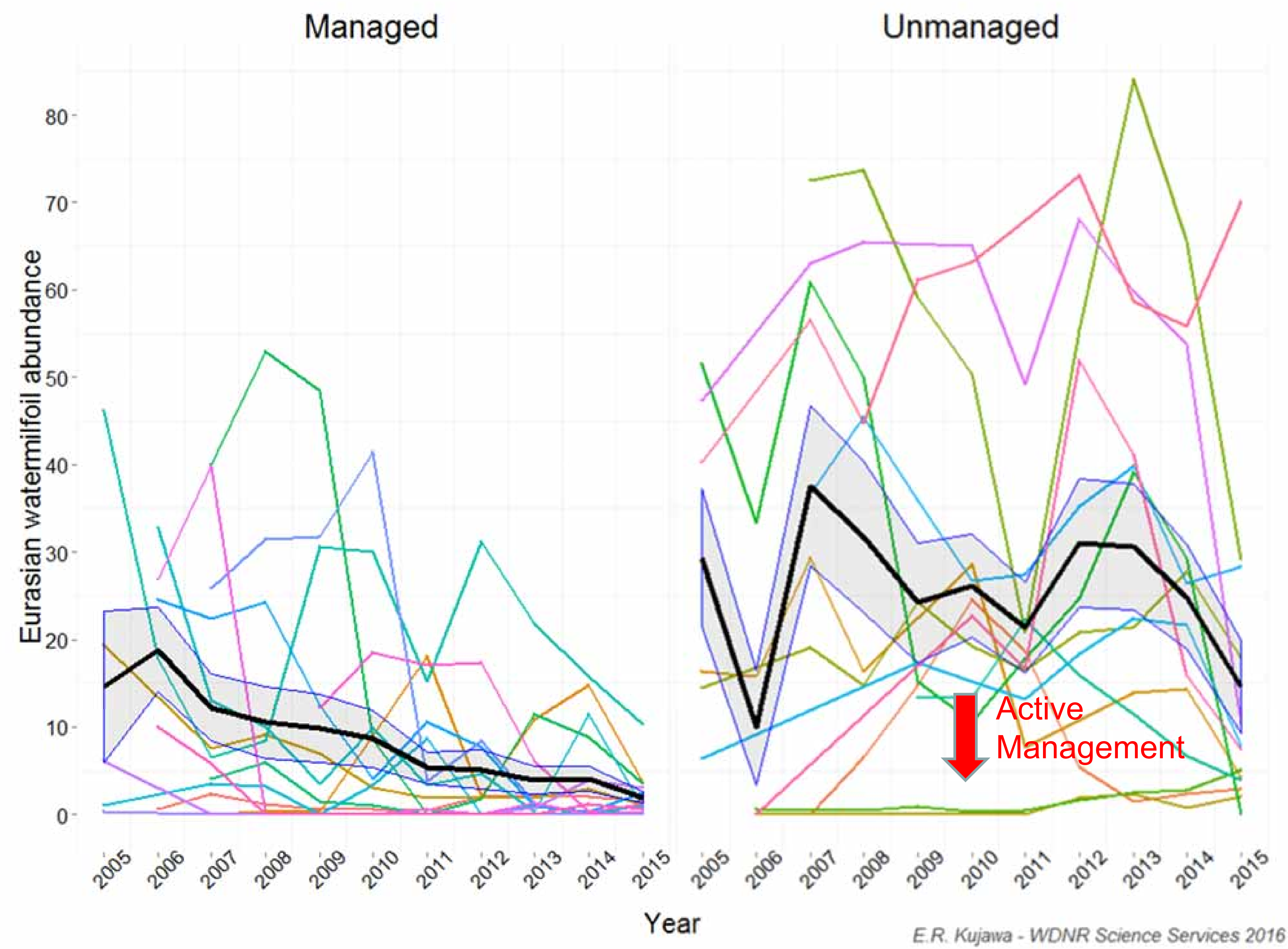
Northern Lakes & Forests



Northern Lakes & Forests




Managed
Unmanaged
Eurasian watermilfoil abundance
0
10
20
30
40
50
60
70
80
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Year
E.R. Kujawa - WDNR Science Services 2016



Managed
Unmanaged
Eurasian watermilfoil abundance
0
10
20
30
40
50
60
70
80
2005
2006
2007
2008
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2010
2011
2012
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Year
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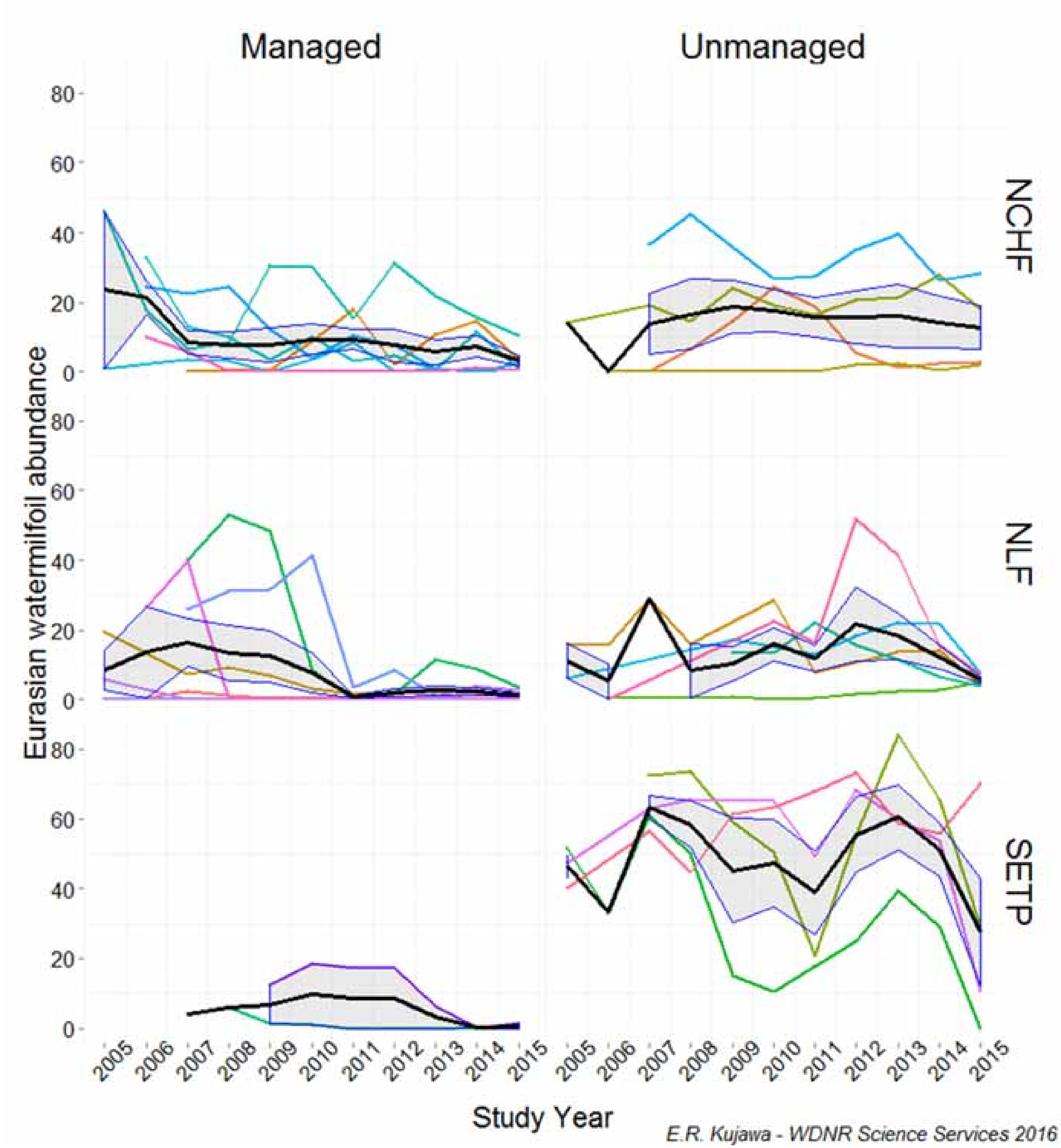
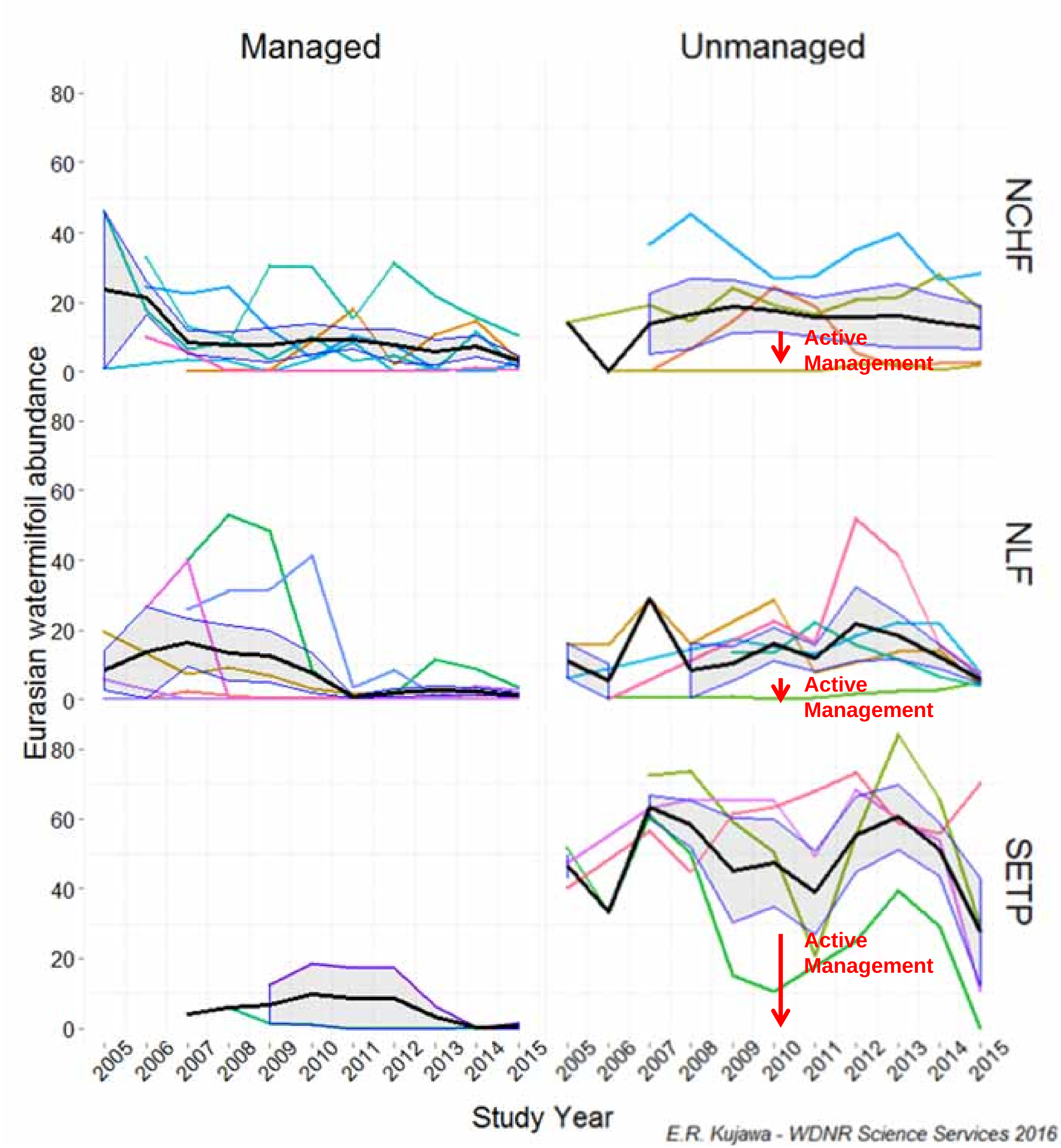
Management
E.R. Kujawa - WDNR Science Services 2016



Managed
Unmanaged
NCHF
NLF
SETP
Eurasian watermilfoil abundance
0
20
40
60
80
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Study Year
E.R. Kujawa - WDNR Science Services 2016

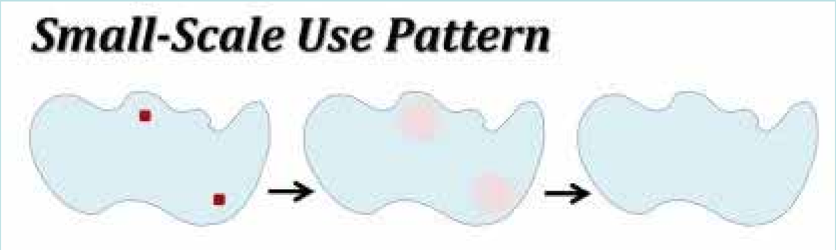

Managed
Unmanaged
NCHF
NLF
SETP
Eurasian watermilfoil abundance
Study Year
Active Management
Active Management
Active Management
E.R. Kujawa - WDNR Science Services 2016

Scale of Management

- How does the scale of management affect EWM efficacy and selectivity?

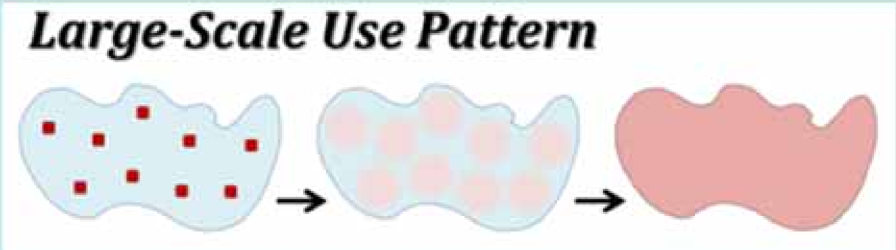
Small-scale

- Herbicide or alternative management will be conducted at a scale which will not result in significant lakewide effects and effects are anticipated on a localized scale



Large-scale

- Herbicide or alternative management will be conducted at a scale which will result in significant lakewide effects



Small-Scale Treatment Resources

Control of Invasive Aquatic Plants **on a Small Scale**

Michelle Nault, Susan Knight, Scott Van Egeren, Eddie Heath, John Skogerboe, Martha Barton, and Scott Provost

Wisconsin has a diversity of landscapes, including a rich array of natural lakes. Especially prized for their recreational opportunities, residents and visitors enjoy fishing, swimming, and boating on these abundant and diverse waterbodies. Unfortunately, these lakes are increasingly threatened by aquatic invasive species – exotic plants and animals, as well as viruses and other pathogens, which can change the ecology of the lake. Some invasive aquatic plants such as Eurasian watermilfoil (*Myriophyllum spicatum*; EWM) hold much of their biomass near the waters' surface where it is often perceived as a nuisance, interfering with recreational activities and aesthetic appeal (Figure 1). Although there have been a variety of management techniques investigated for EWM control (mechanical harvesting, biocontrol, hand-removal, bottom barriers, etc.), lake organizations and managers in Wisconsin have primarily relied on auxin herbicides, especially 2,4-D, which are viewed as a cost effective management tool. At the same time, it is widely acknowledged that appropriate herbicide selection and application is essential, as managers need to balance the desired effects of the herbicides on target plants, while concurrently minimizing any unintended harm to native communities.

In an attempt to accomplish this selective control, one strategy has been to target EWM with herbicides early in the growing season. Treating in early spring has several advantages in northern temperate lakes. First, cooler water temperatures result in slower microbial degradation of many herbicides, which may increase the effectiveness of control. Second, EWM is actively growing and vulnerable to chemicals, while a majority of native plants are still largely dormant,

Figure 1. Colony of surface matted Eurasian watermilfoil (Myriophyllum spicatum) in a northeastern Wisconsin seepage lake.

and are less likely to be affected by the herbicide. Third, although EWM is actively growing, plants have not yet amassed much biomass, which minimizes oxygen depletion when they decompose, and reduces excess nutrient inputs that may stimulate algal growth.

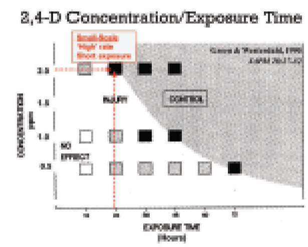
Along with this strategic seasonal timing, managers often attempt to target isolated invasive plant colonies rather than treating at a larger scale. Several situations may warrant a small-scale treatment; a discovery of a small pioneer colony of EWM, an effort to keep small populations of EWM from rebounding following a larger control effort, or a need to control a specific colony causing a navigational impairment. Wisconsin state administrative code defines small-scale treatments as those less than 10 acres or less than 10% of the littoral zone. From an ecological standpoint, small-scale treatments are those in which the total quantity of applied herbicide is anticipated to have an effect on plants at a localized, not lake-wide, scale.

Treating aquatic invasive plants at a small-scale with auxin herbicides in early spring has been well integrated into Wisconsin's aquatic plant management program. However, the efficacy and observed longevity of invasive control, as well as impacts on native species has not been well documented. The Wisconsin Department of Natural Resources (WDNR), in conjunction with the U.S. Army Corps of Engineers and private lake management consultants, is conducting an ongoing study monitoring the fate of 2,4-D used in small-scale treatments. Here we review some efforts to evaluate these treatments, with specific objectives

SMALL-SCALE HERBICIDE TREATMENTS FOR CONTROL OF INVASIVE AQUATIC PLANTS

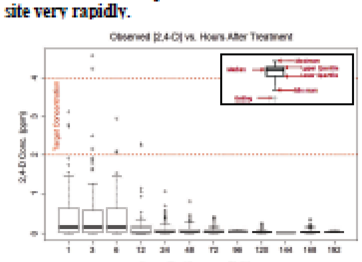
The Wisconsin Department of Natural Resources and U.S. Army Corps of Engineers have been evaluating small-scale herbicide treatments for managing invasive aquatic plants. Monitoring of 2,4-D applications for control of Eurasian watermilfoil (EWM) and endothall for curly-leaf pondweed (CLP) are ongoing, and preliminary information is already available regarding large-scale applications[1,2]. This fact sheet summarizes what researchers have learned so far from monitoring herbicide concentrations following small-scale treatments.

Concentration and exposure times of 2,4-D required for effective EWM control have been studied in the laboratory.



Treatments targeting small areas typically use higher rates of herbicide, since exposure time with the plants will be short. Recommended 2,4-D label rates for a small-scale treatment range from 2 to 4 parts per million (ppm), and based upon laboratory studies, require 12-24 hours of contact time to control EWM effectively.

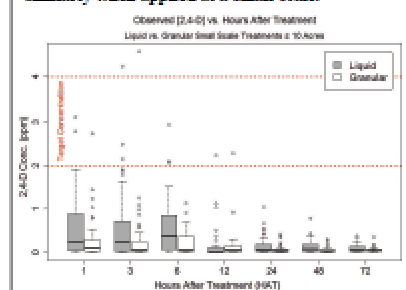
Herbicides can dissipate off of a small treatment site very rapidly.



This graph shows 2,4-D dissipation measured over hours after treatment (HAT) after it was applied to 98 small (0.1-10 acre) treatment areas across 22 study lakes with application rates of 2-4 ppm.

- Initial 2,4-D concentrations detected in the water column were well below application targets.
- Herbicide moved quickly away from treatment sites within a few hours after treatment.
- The rapid dissipation of herbicide indicates that the concentrations in target areas may be lower than what is needed for effective EWM control.

Granular and liquid formulations dissipate similarly when applied at a small-scale.



This graph shows the concentrations of granular and liquid 2,4-D detected in the water column after small-scale treatments with application rates of 2-4 ppm.

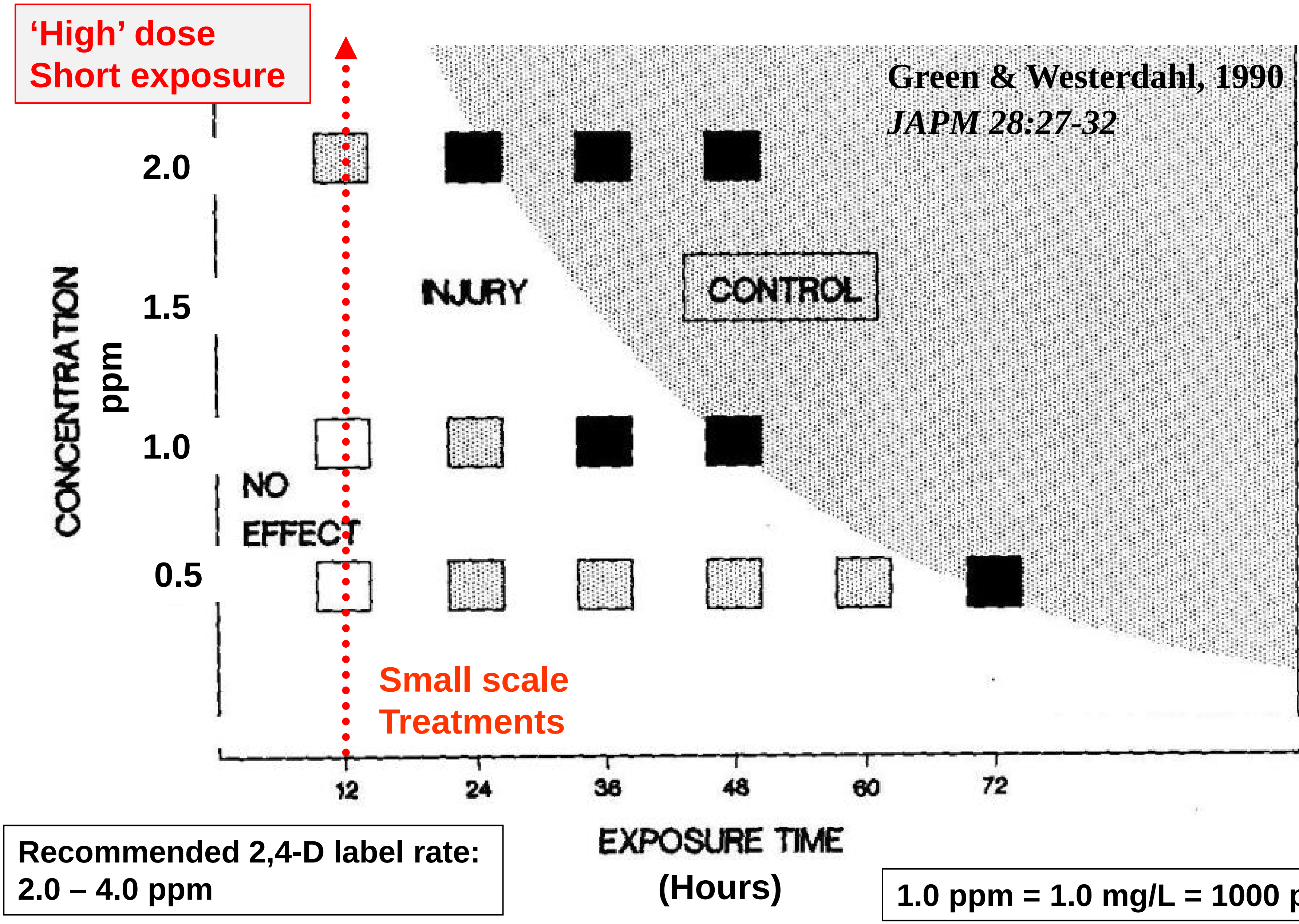
- Initial concentrations (1-6 HAT) were higher with liquid formulations, however, both formulations dissipated quickly from the treatment area.
- Under most conditions, concentrations of 2,4-D were below detectable limits by 24 HAT.
- Attaining target concentrations and maintaining exposure times required for control is more difficult to achieve in small-scale treatments.
- Dissipation is affected by multiple factors such as treatment size and location, wind, and water flow.

Treatment of many small-scale areas on a lake may result in cumulative lake-wide effects due to rapid dissipation and dilution off multiple sites.

If the volume of all waters treated is more than 5% of the volume of the waterbody, impacts may be expected at a whole-lake scale.

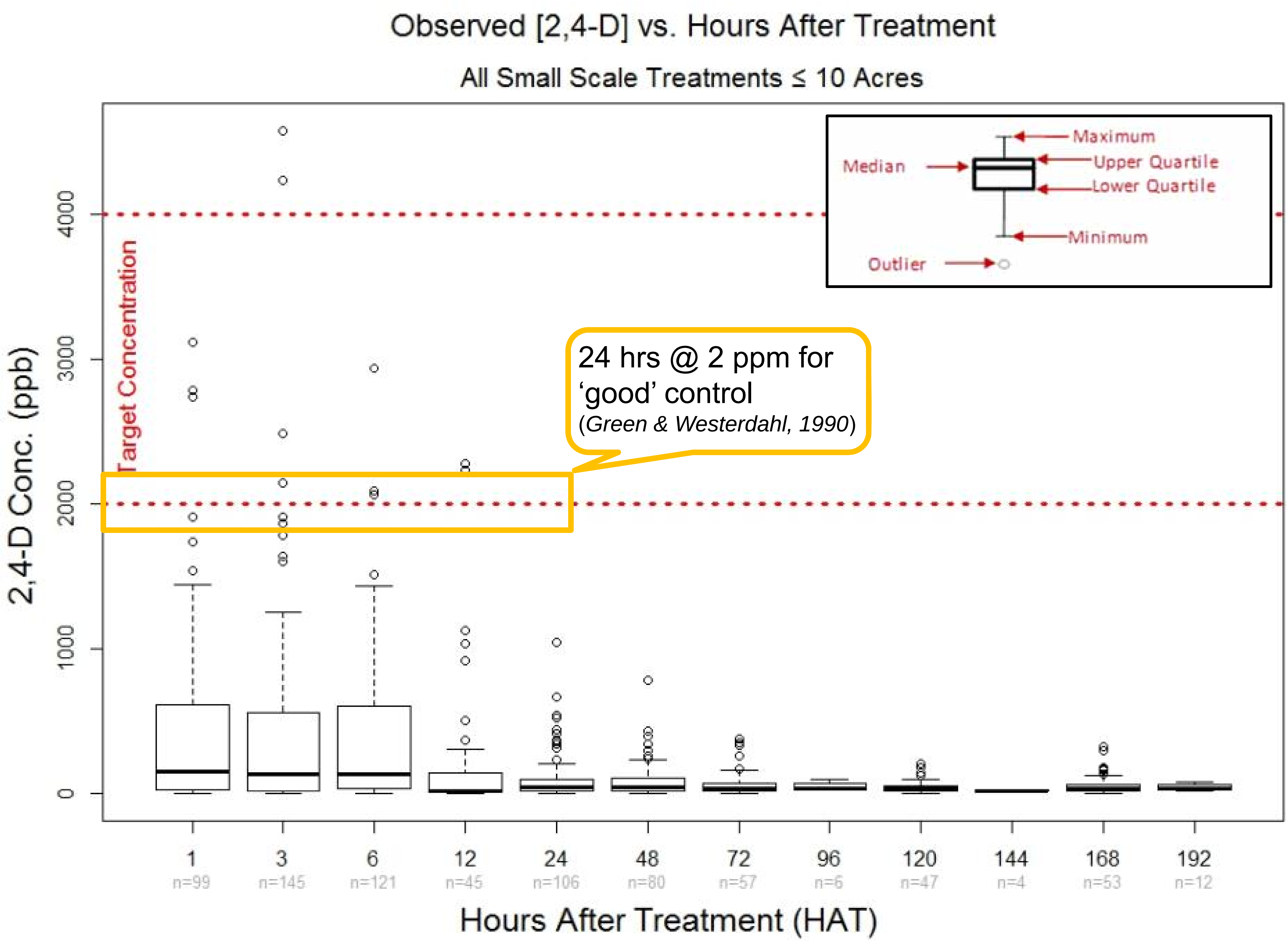
[1]Nault et al. 2012. Herbicide treatments in Wisconsin lakes. *LakeLine* 32:1-5.
[2]Nault et al. 2014. Efficacy, selectivity, and herbicide concentrations following a whole-lake 2,4-D application targeting Eurasian watermilfoil in two adjacent northern Wisconsin lakes. *Lake and Reservoir Management* 30:1-10.

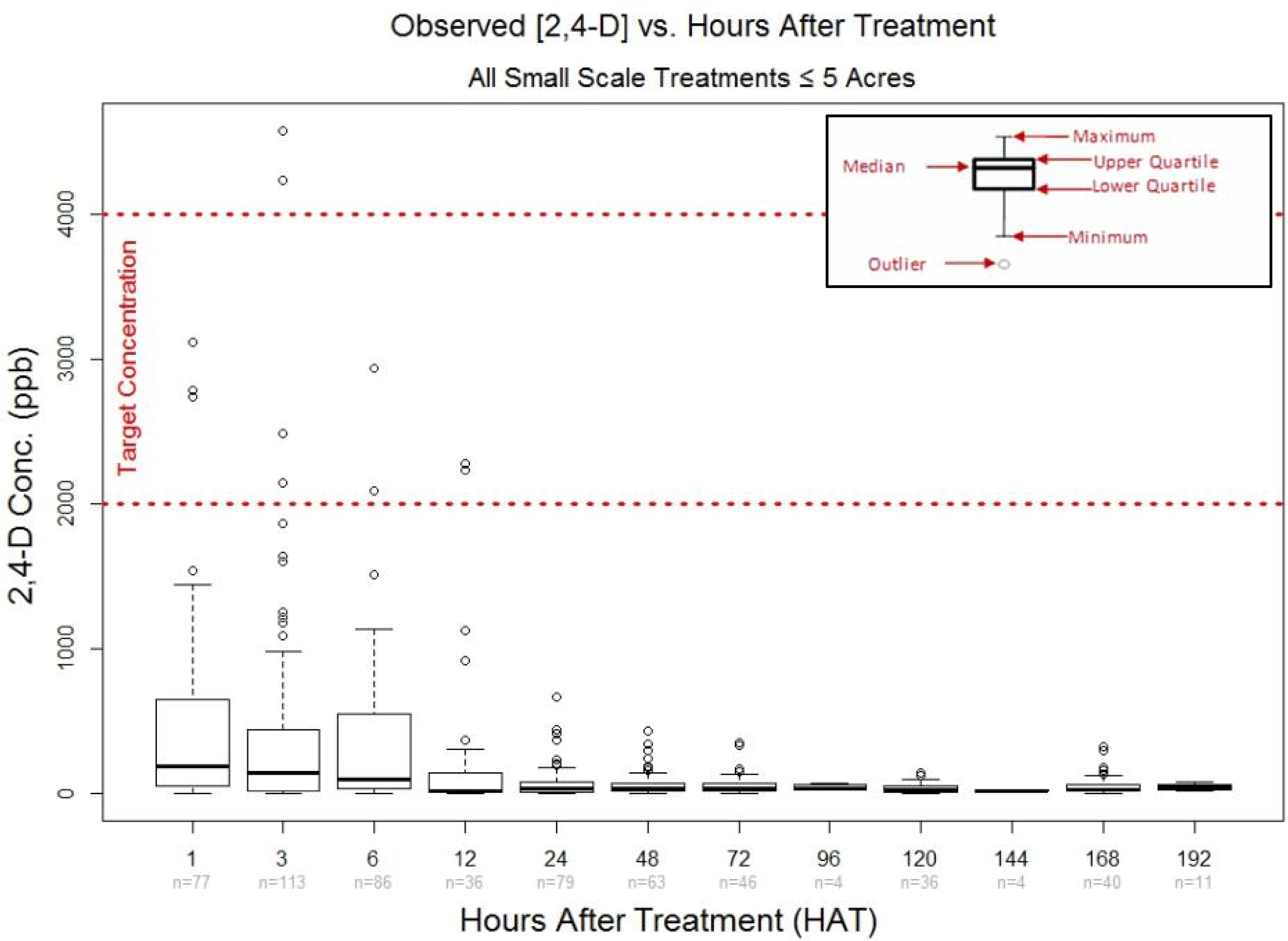
2,4-D Concentration/Exposure Time

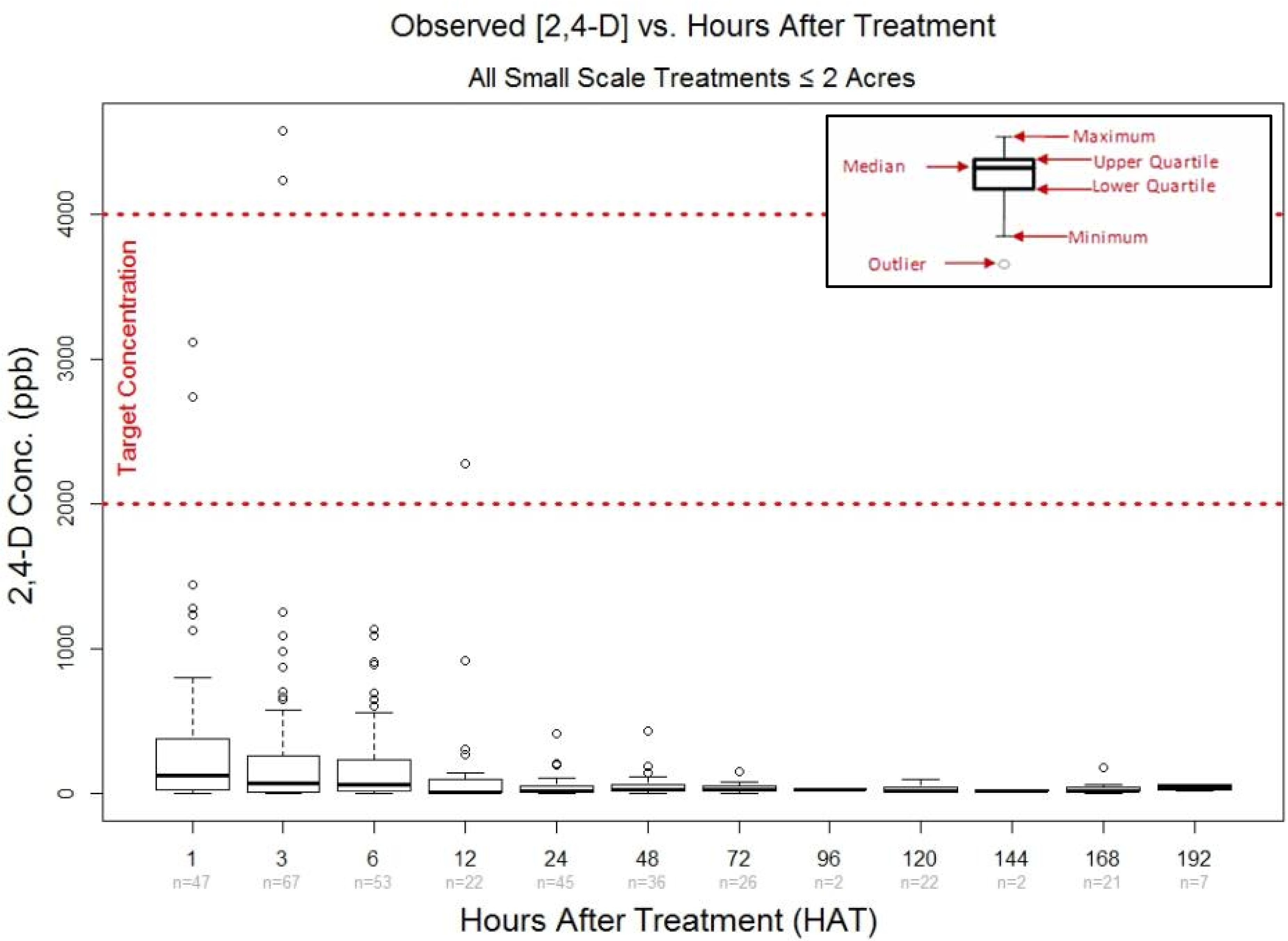


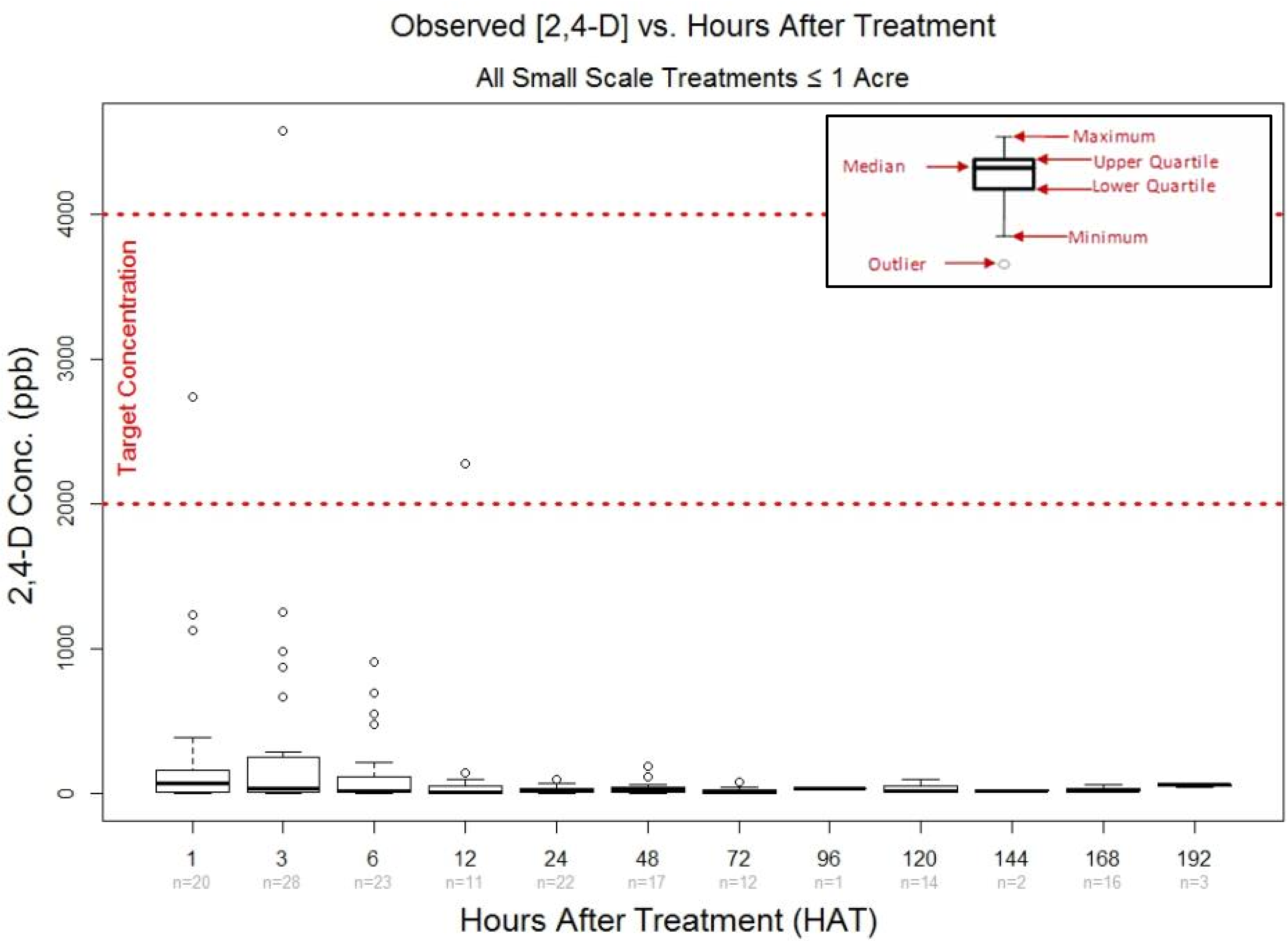
Recommended 2,4-D label rate:
2.0 – 4.0 ppm

1.0 ppm = 1.0 mg/L = 1000 ppb

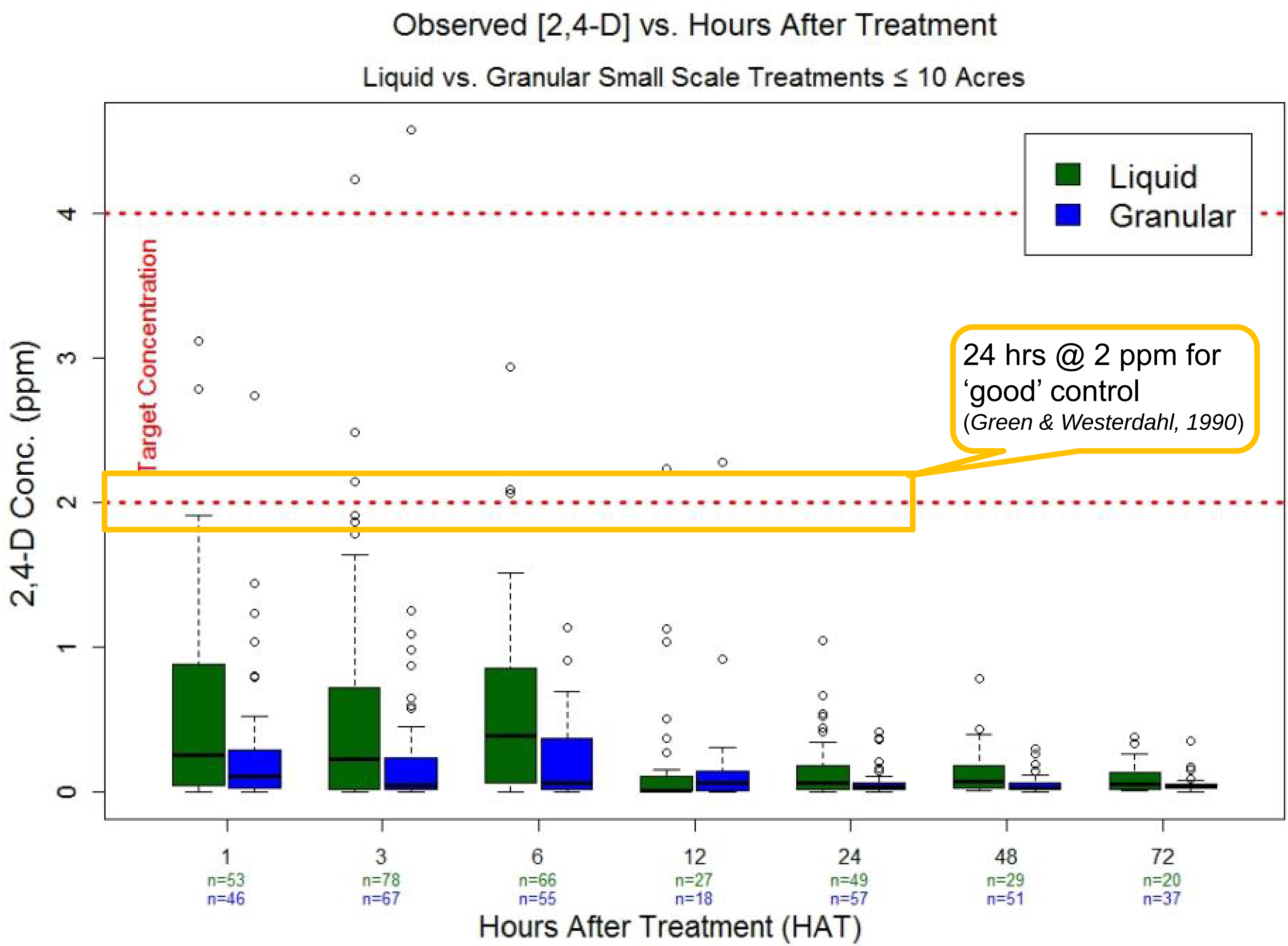

Observed [2,4-D] vs. Hours After Treatment
All Small Scale Treatments ≤ 10 Acres
2,4-D Conc. (ppb)
Target Concentration
0
1000
2000
3000
4000
Median
Maximum
Upper Quartile
Lower Quartile
Minimum
Outlier
24 hrs @ 2 ppm for
'good' control
(Green & Westerdahl, 1990)
1
n=99
3
n=145
6
n=121
12
n=45
24
n=106
48
n=80
72
n=57
96
n=6
120
n=47
144
n=4
168
n=53
192
n=12
Hours After Treatment (HAT)


Observed [2,4-D] vs. Hours After Treatment
All Small Scale Treatments ≤ 5 Acres
Maximum
Median
Upper Quartile
Lower Quartile
Minimum
Outlier
Target Concentration
2,4-D Conc. (ppb)
0
1000
2000
3000
4000
1
n=77
3
n=113
6
n=86
12
n=36
24
n=79
48
n=63
72
n=46
96
n=4
120
n=36
144
n=4
168
n=40
192
n=11
Hours After Treatment (HAT)

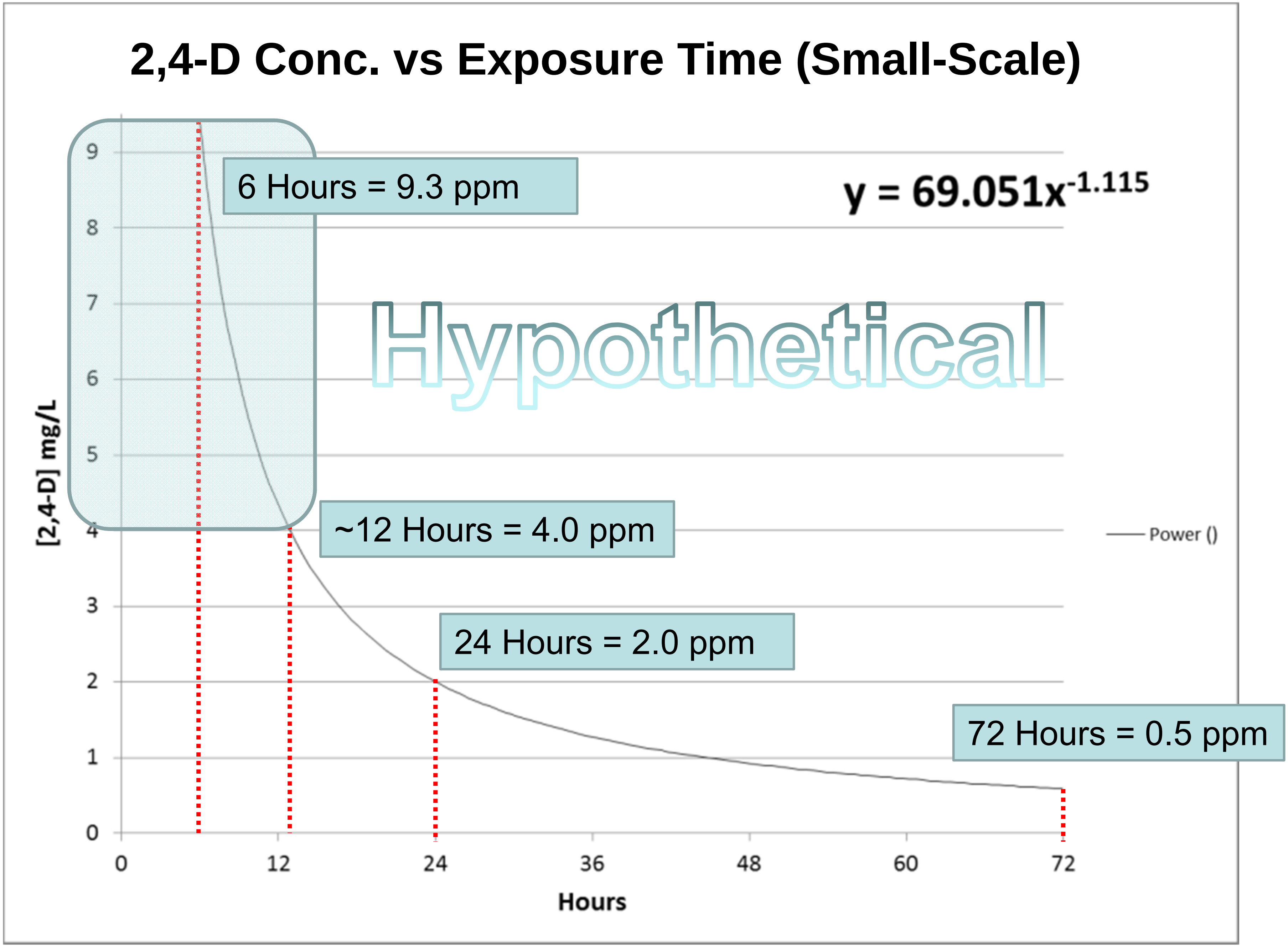

Observed [2,4-D] vs. Hours After Treatment
All Small Scale Treatments ≤ 2 Acres
Maximum
Median
Upper Quartile
Lower Quartile
Minimum
Outlier
Target Concentration
2,4-D Conc. (ppb)
0
1000
2000
3000
4000
1
n=47
3
n=67
6
n=53
12
n=22
24
n=45
48
n=36
72
n=26
96
n=2
120
n=22
144
n=2
168
n=21
192
n=7
Hours After Treatment (HAT)



Observed [2,4-D] vs. Hours After Treatment
All Small Scale Treatments ≤ 1 Acre
2,4-D Conc. (ppb)
0
1000
2000
3000
4000
Target Concentration
Maximum
Median
Upper Quartile
Lower Quartile
Minimum
Outlier
1
n=20
3
n=28
6
n=23
12
n=11
24
n=22
48
n=17
72
n=12
96
n=1
120
n=14
144
n=2
168
n=16
192
n=3
Hours After Treatment (HAT)



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)



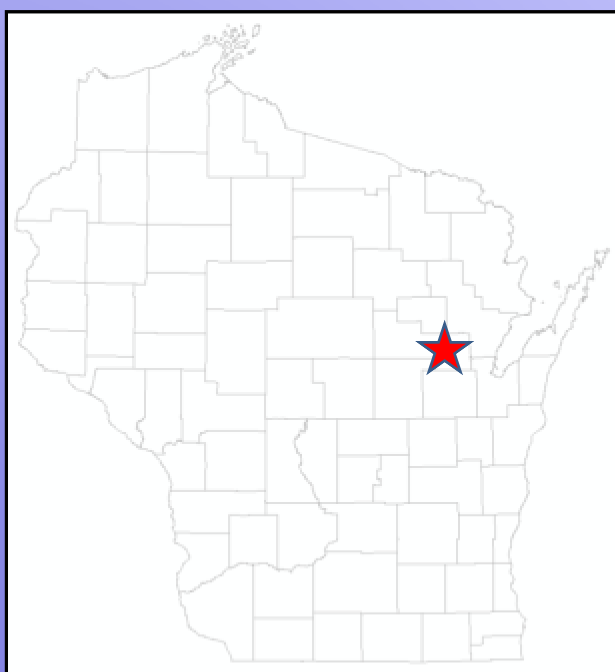
2,4-D Conc. vs Exposure Time (Small-Scale)
6 Hours = 9.3 ppm
y = 69.051x^-1.115
Hypothetical
~12 Hours = 4.0 ppm
24 Hours = 2.0 ppm
72 Hours = 0.5 ppm
Power ()
[2,4-D] mg/L
Hours
0
1
2
3
4
5
6
7
8
9
0
12
24
36
48
60
72

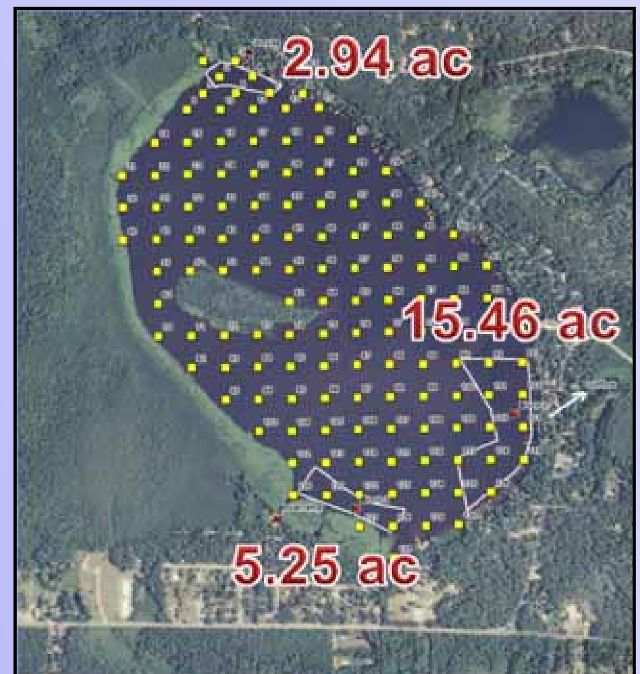
Rhodamine Dye Studies

- Explore use of alternative herbicides (i.e. Diquat, Aquastrike) and combos (2,4-D/endothall) for small-scale treatments.
- Required exposure time for these herbicides is less than that required for herbicides such as 2,4-D.
- A fluorescent rhodamine dye is simultaneously applied with the herbicide in order to track movement and estimate CET.
- Modified PI grid used to measure dye concentrations using a sensor during initial hours after treatment.
- Colored contour maps created to track movement.

Case Study: Loon Lake (Diquat)

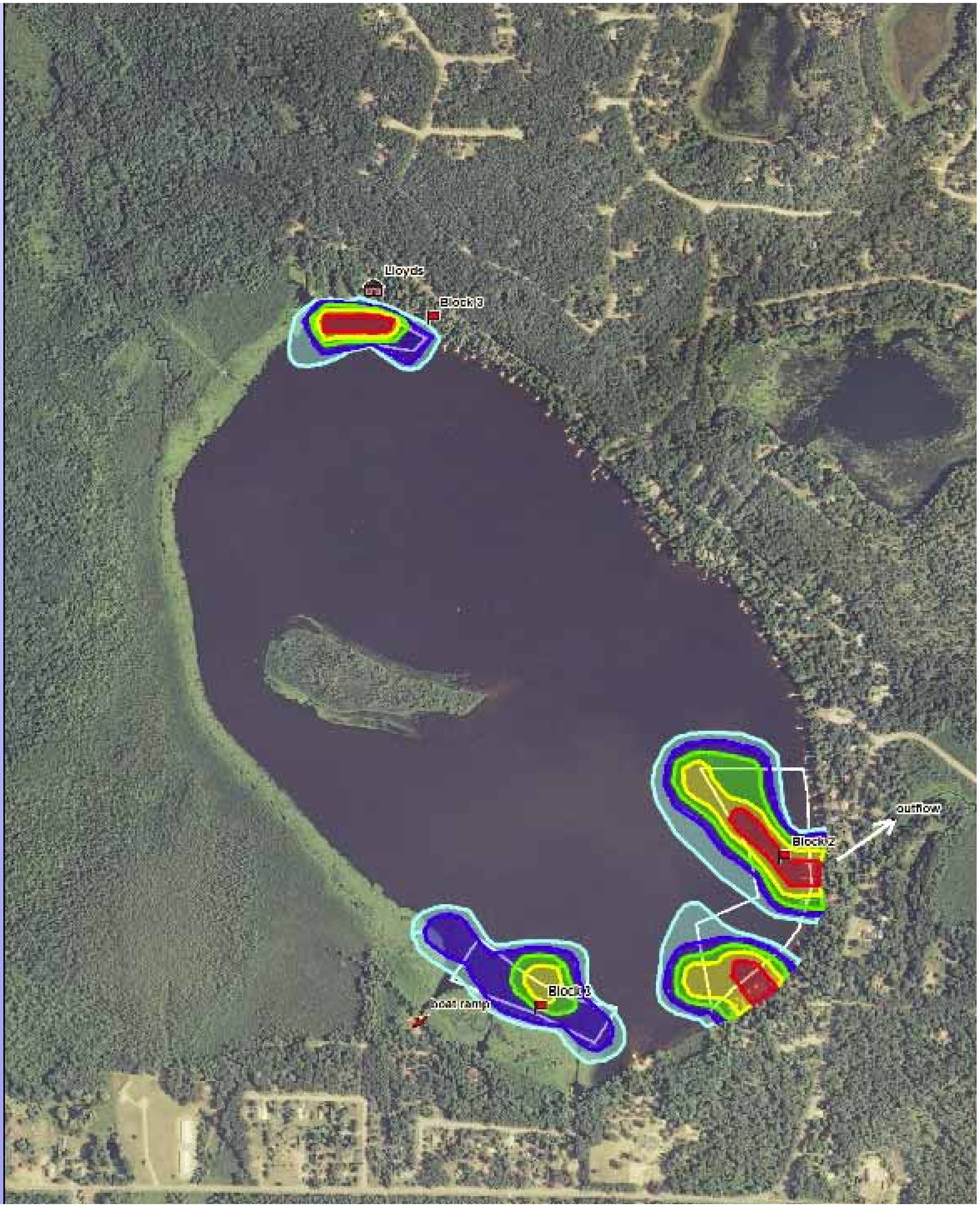
- Three small areas were treated with liquid diquat for hybrid watermilfoil (HWM) control.
- Diquat applied at a rate of 2 gal/acre, in conjunction with 10 ppb of fluorescent dye (Rhodamine WT)
- Pre (spring) & post (late-summer) PI sub-sampling





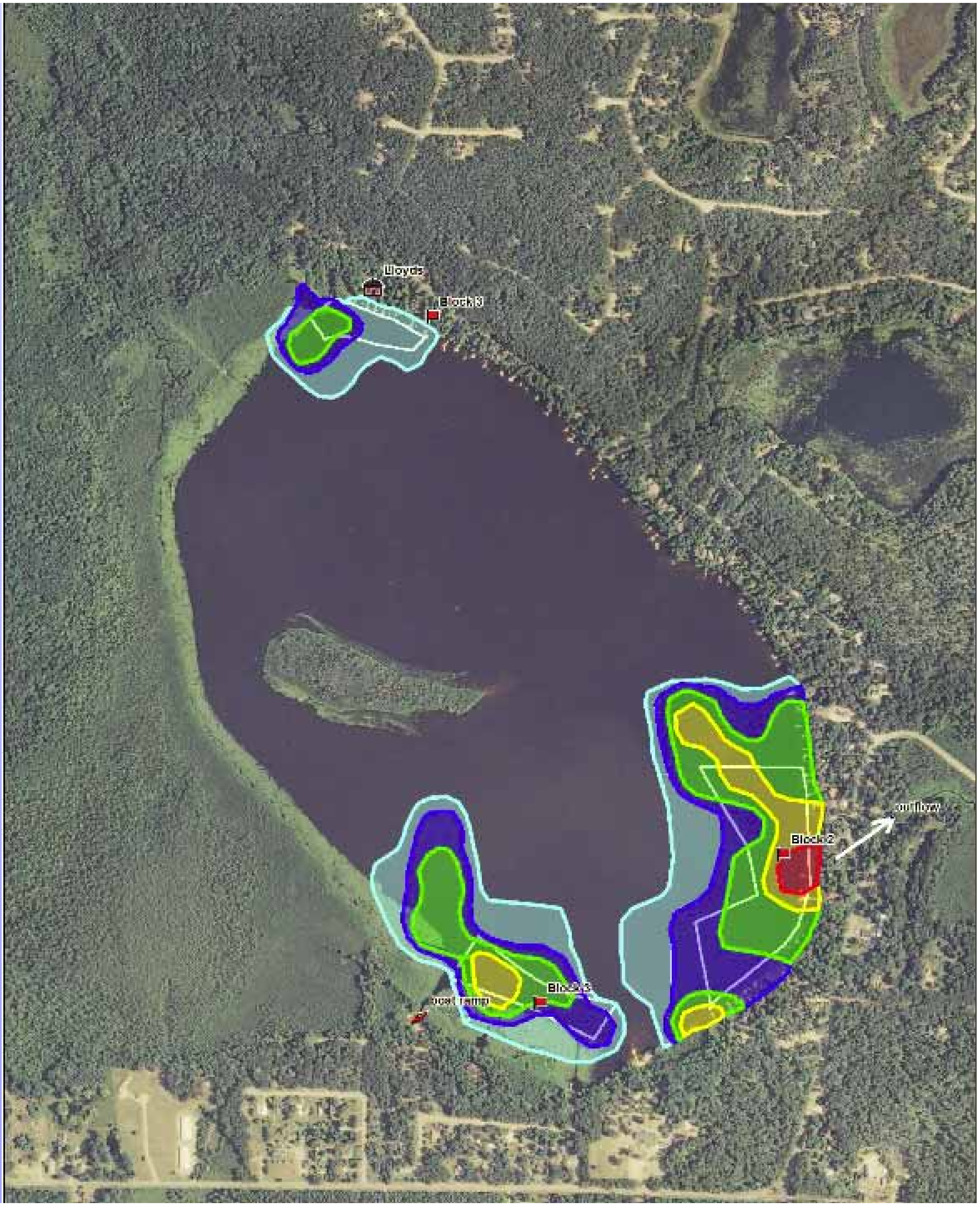
1 HAT

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



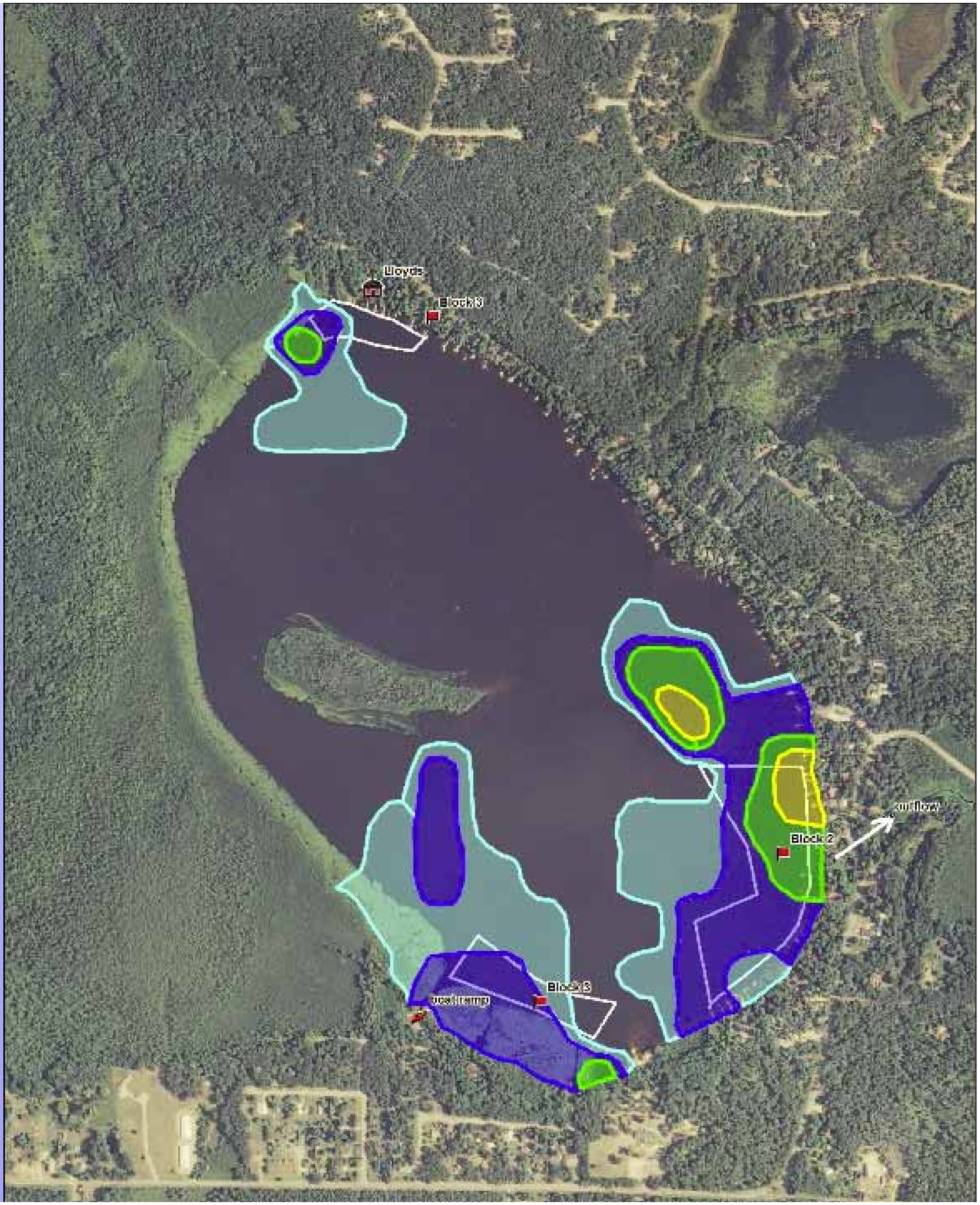
2.5 HAT

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%

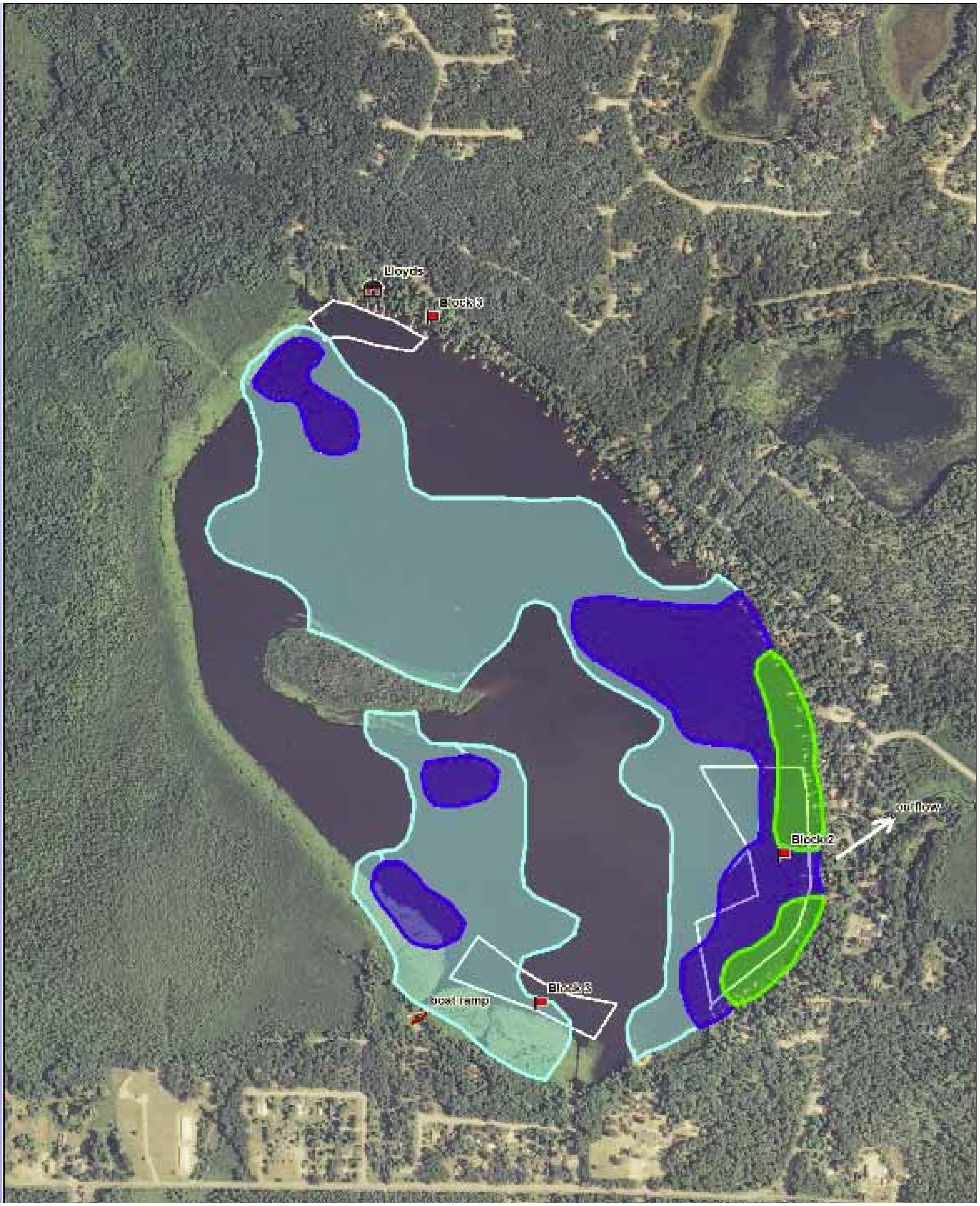
50-75%

25-50%

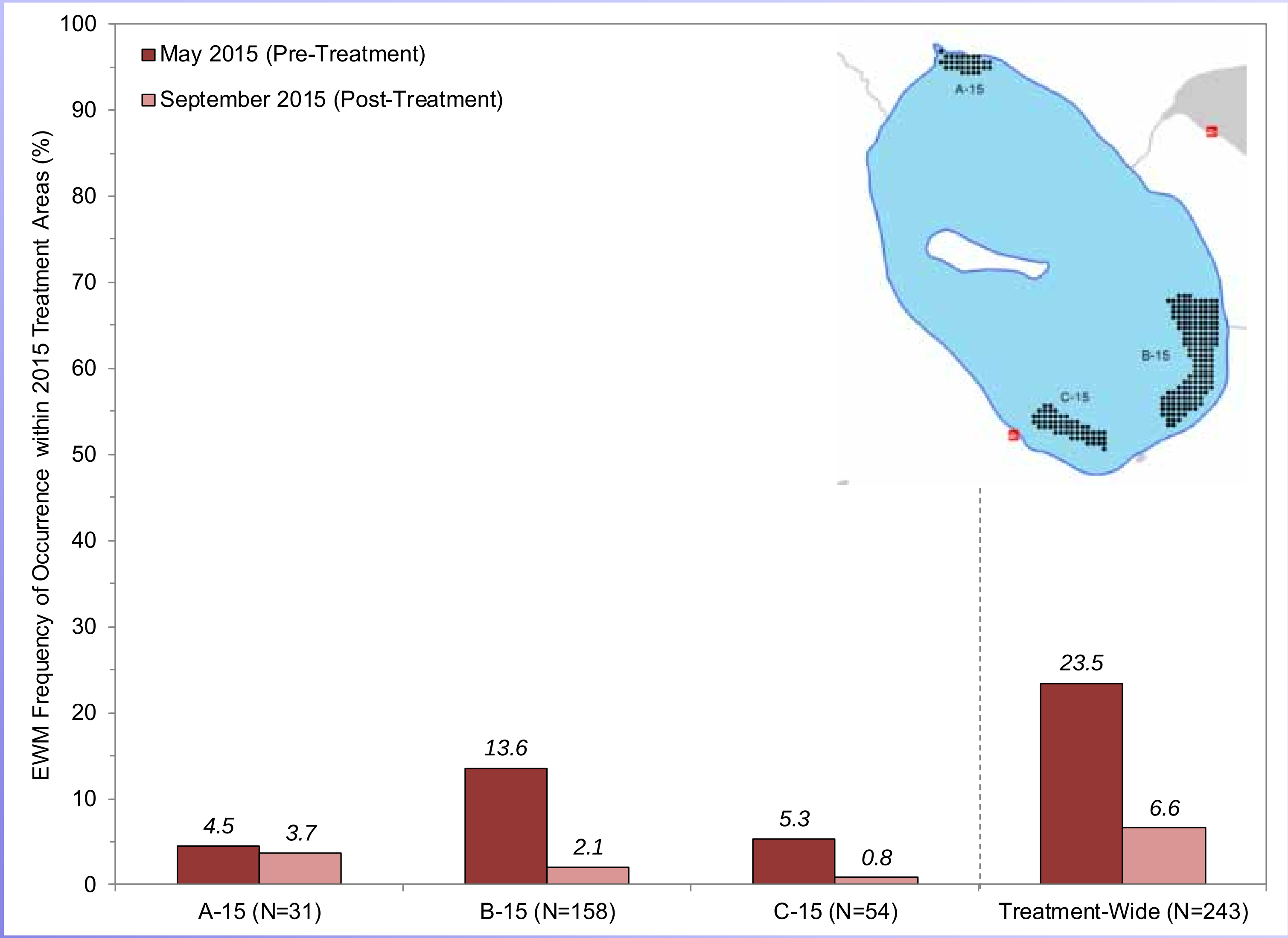
10-25%

5-10%

Table 3. Estimated Dye Exposure Times	
Application Block	Exposure Time (HAT)
1	1
2	2 to 3
3	2 to 3



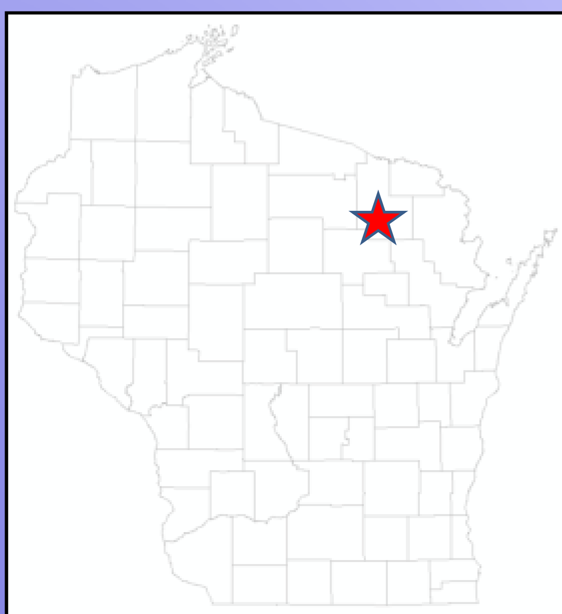
Efficacy



EWM Frequency of Occurrence within 2015 Treatment Areas (%)
100
90
80
70
60
50
40
30
20
10
0
May 2015 (Pre-Treatment)
September 2015 (Post-Treatment)
4.5
3.7
13.6
2.1
5.3
0.8
23.5
6.6
A-15 (N=31)
B-15 (N=158)
C-15 (N=54)
Treatment-Wide (N=243)
A-15
B-15
C-15

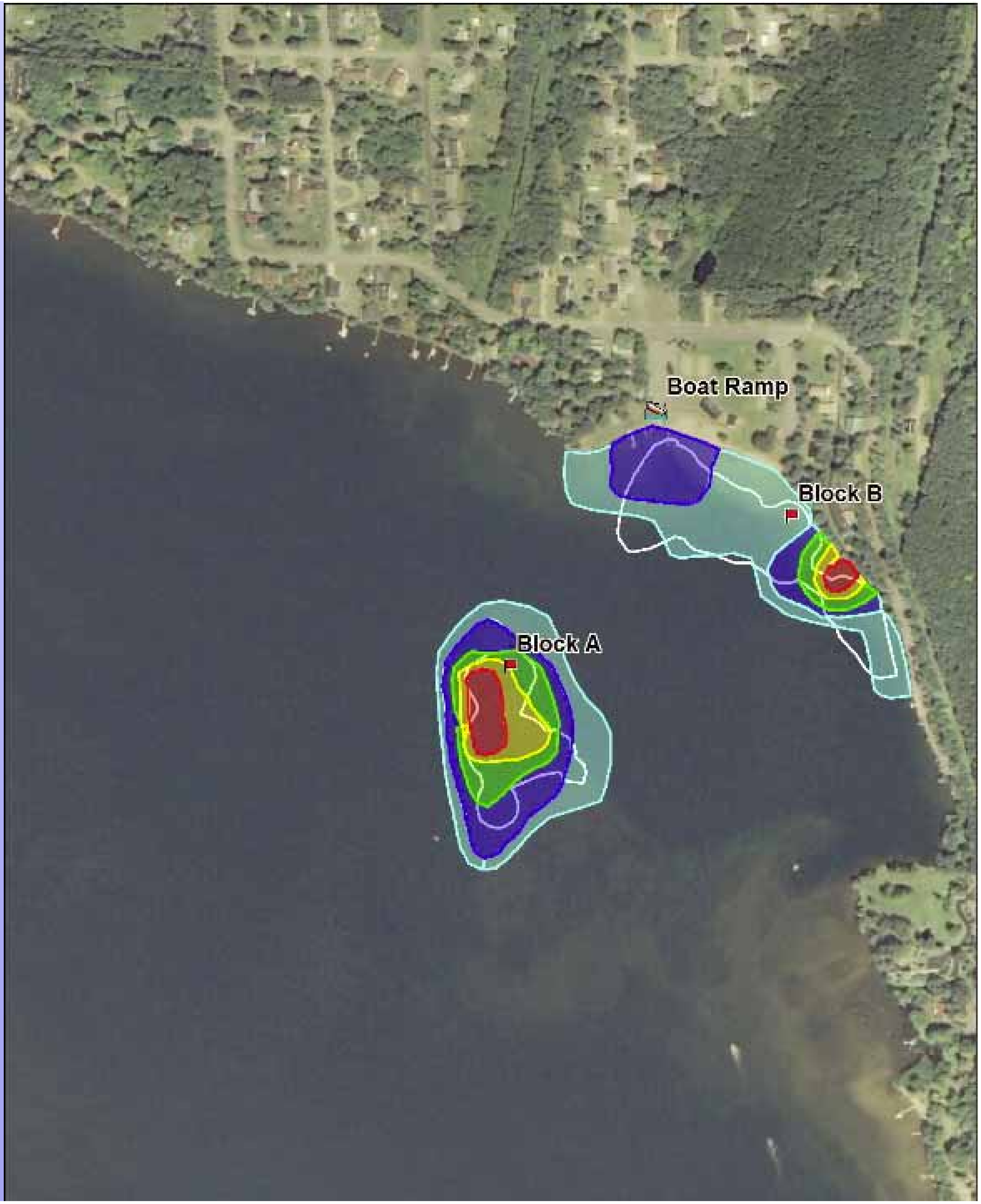
Case Study: Lake Metonga (2,4-D/Endothall)

- Two small areas treated with a combination of liquid 2,4-D and endothall for Eurasian watermilfoil (EWM) control.
- 2,4-D applied at 4.0 ppm and endothall at 1.5 ppm (ai), in conjunction with 10 ppb of fluorescent dye (Rhodamine WT)
- Pre (spring) & post (late-summer) PI sub-sampling
- Pre (summer '14) & post (summer '15) EWM mapping survey



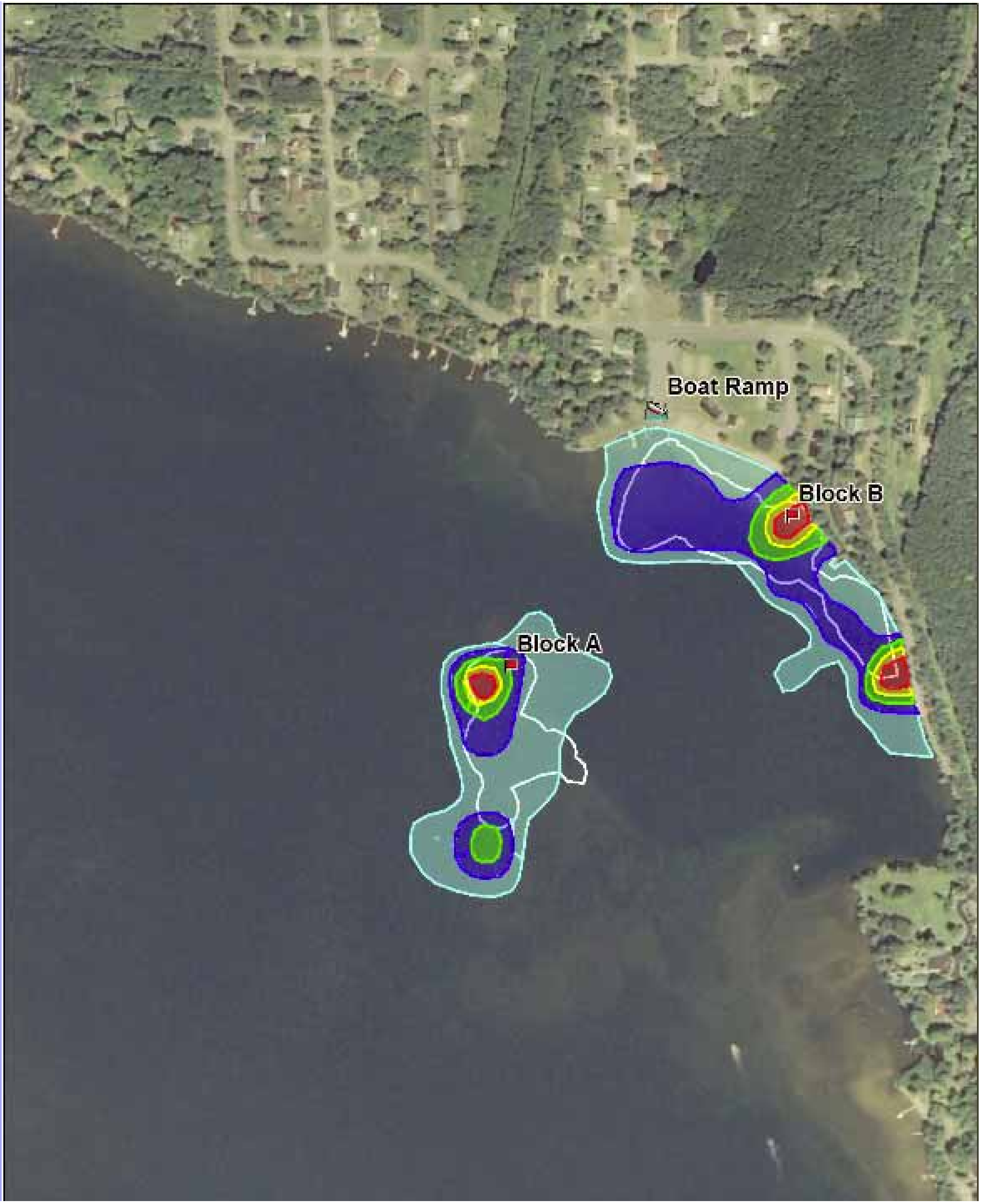
1 HAT

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



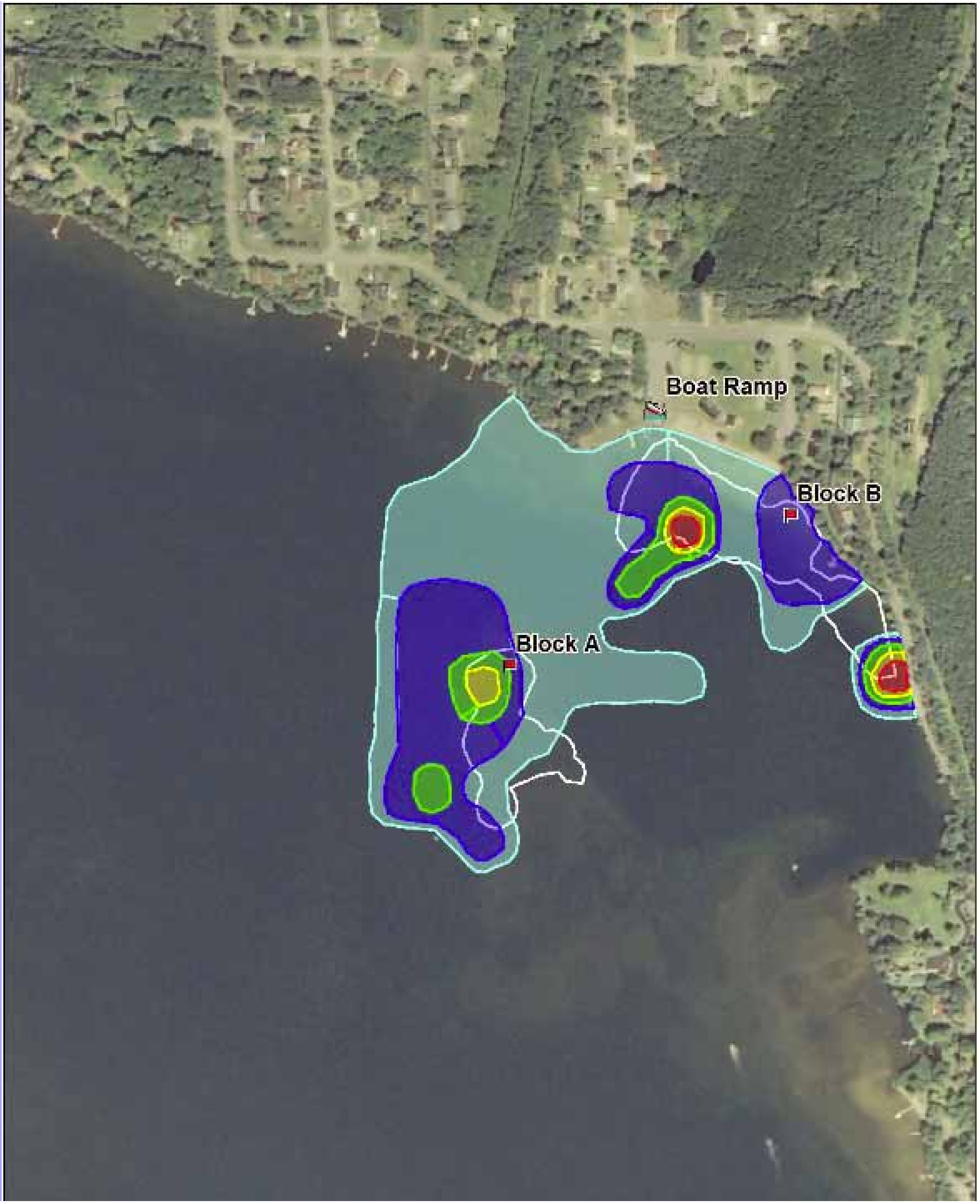
2 HAT

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



3 HAT

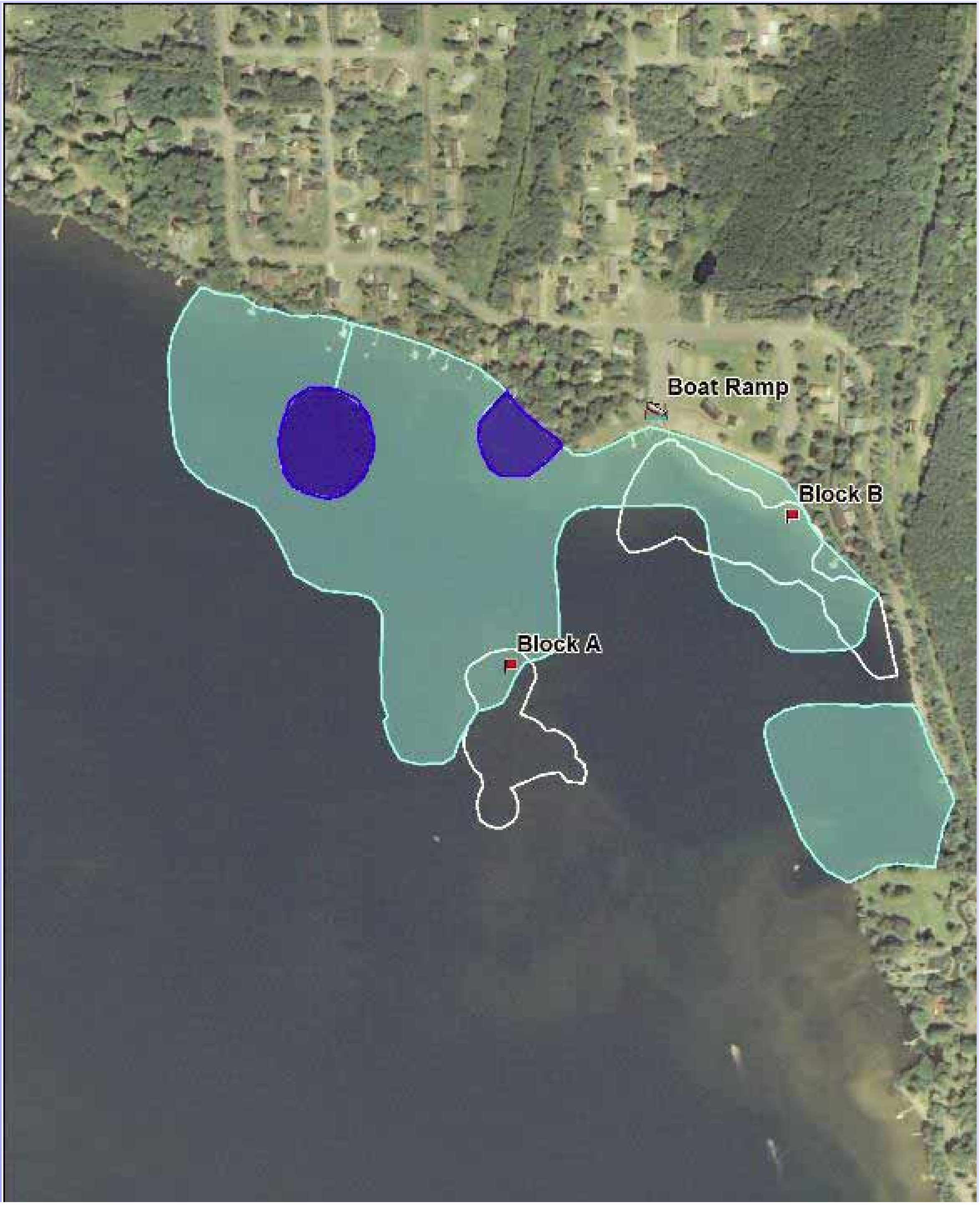
75-100%
50-75%
25-50%
10-25%
5-10%



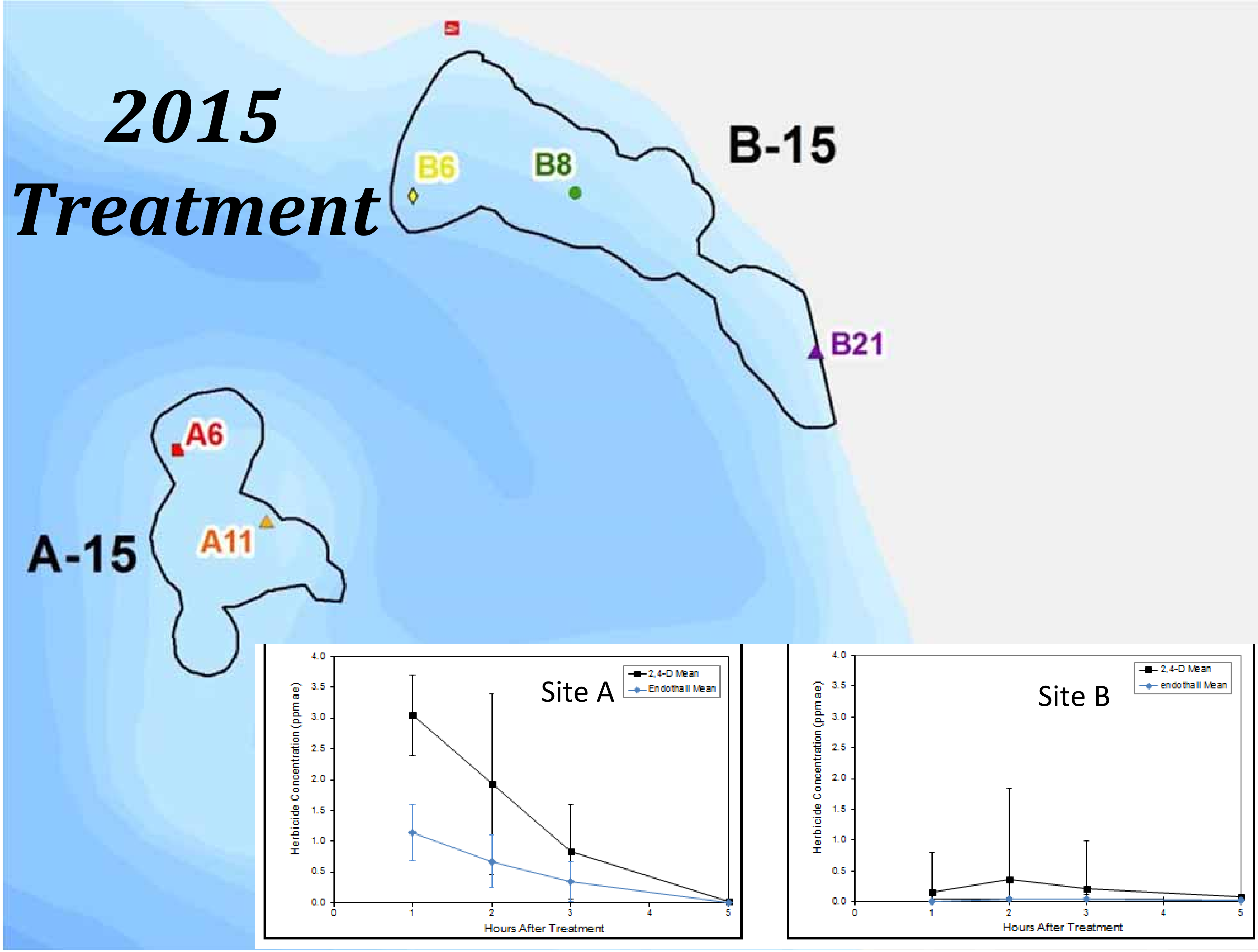
5 HAT

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

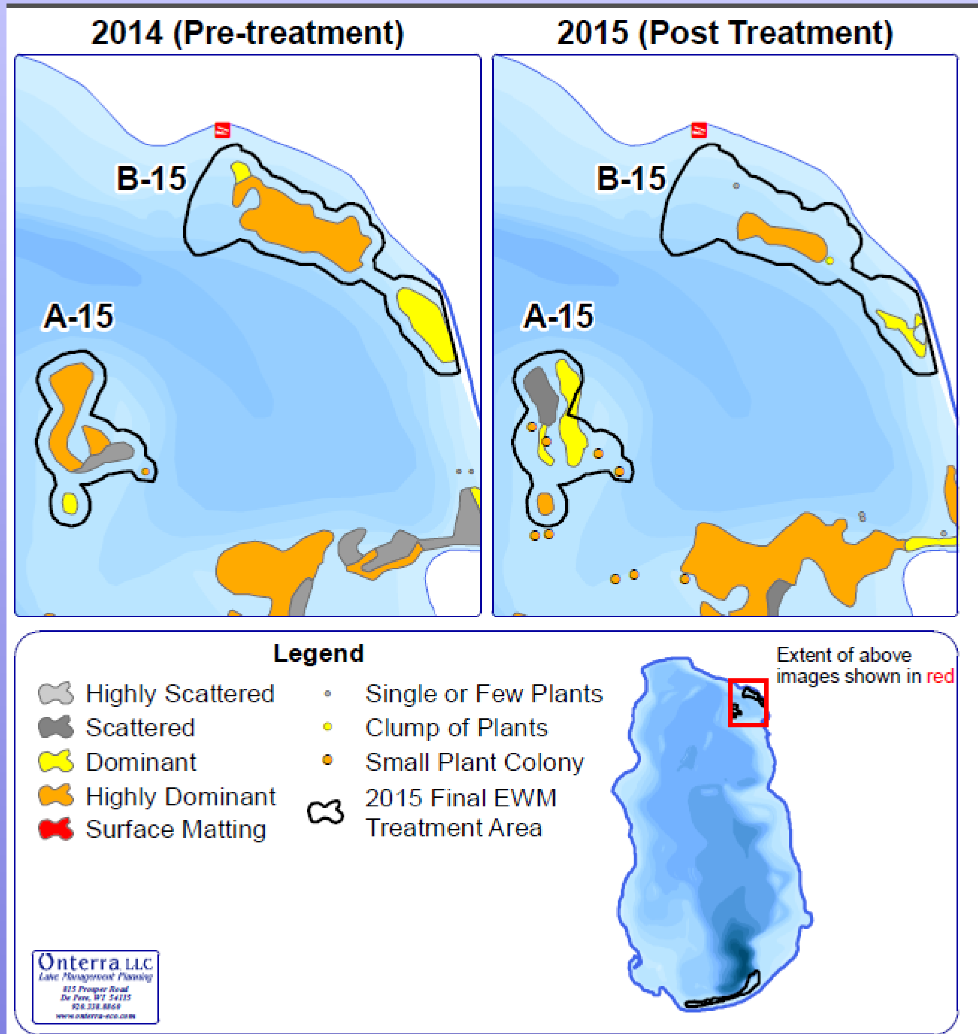
Table 3. Estimated Dye Exposure Times	
Application Block	Exposure Time (HAT)
A	1 TO 2
B	<1 TO 2

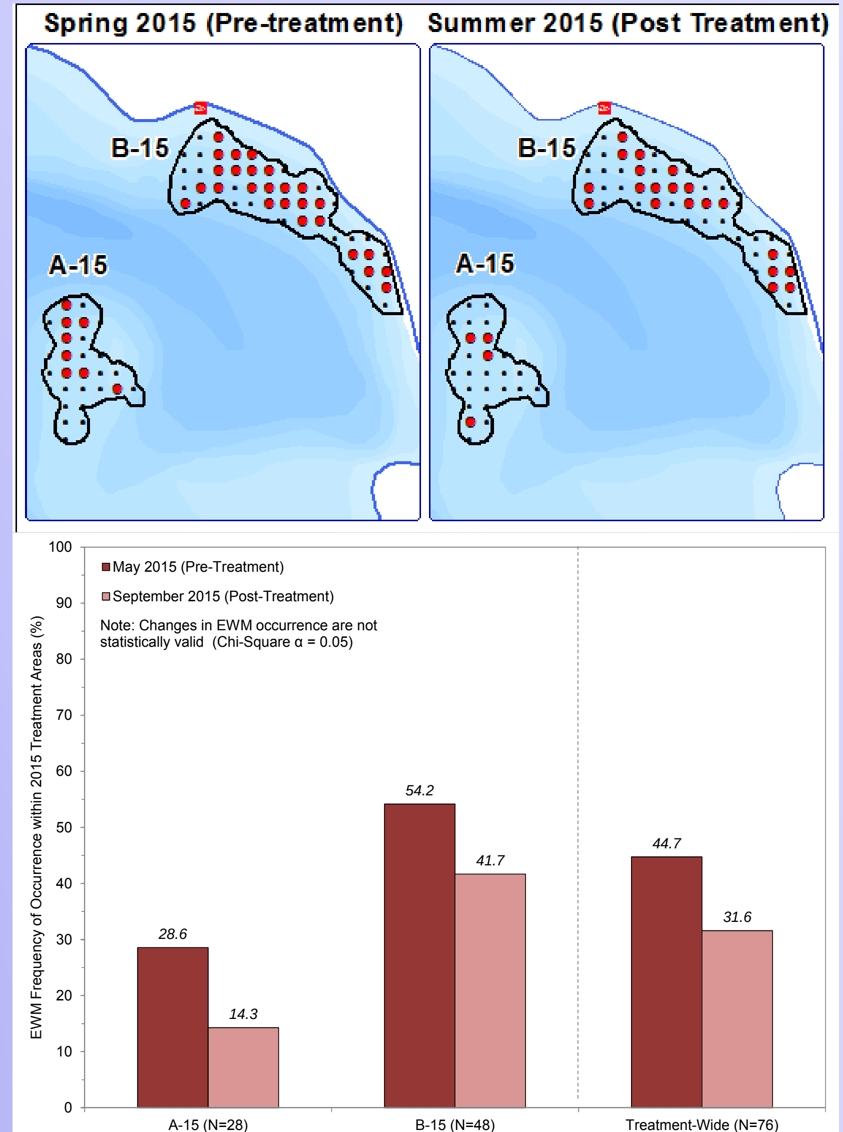


2015 Treatment



Efficacy





Courtesy of Onterra, LLC

Preliminary Findings

- Actual CET in the field is more difficult to predict and maintain in smaller scale treatments
- Aquatic plant data is more difficult to collect and analyze in smaller scale treatments
- Rapid dissipation of herbicide occurs within 1-4 HAT in many small-scale treatment sites
- No “one size fits all” solution - future research into other herbicides (diquat, combos)
- Future research into other IPM (hand-removal, DASH, etc.) for small-scale AIS control
- Future research into extending exposure time (i.e. barrier curtains)

Preliminary Recommendations

- Use the appropriate herbicide product for your expected exposure time. A short expected exposure time may require a fast-acting contact herbicide versus a systemic.
- Treat blocks (>5 acres) vs. ‘amoeba’ shapes.
- Treat blocks when winds are <5 mph. Stronger winds increase dissipation rates and reduce contact time.
- Treat blocks on windward side of shorelines. Do not treat on leeward, protected shorelines.
- Treat early in the morning, or late in the evening when low winds may be sustained for a longer period of time.

Hand-Removal (DASH) Studies

• What is the efficacy, selectivity, and longevity of hand removal of AIS?

- Efficiency or rate of harvest will vary from lake to lake.
- The ability to maintain long term control is lake to lake specific.
- To ensure “success”, it’s important to have a good plan. Follow up visits may be required as well as continued monitoring.

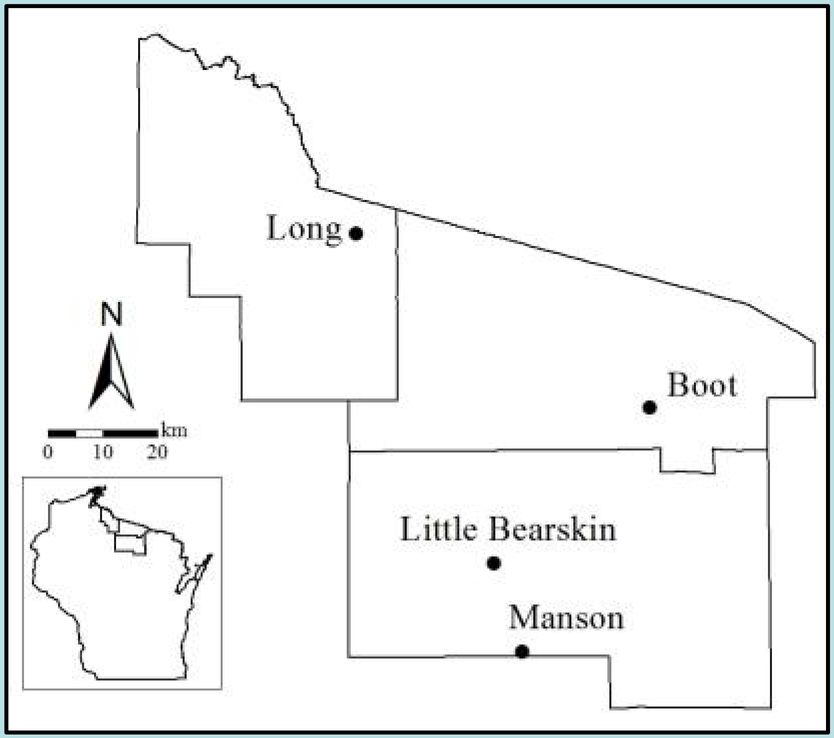
Considerations for Success, Challenges and Sharing our Experience: Hand-pulling and DASH for Aquatic Invasive Plant Removal
Planning, Management, and Implementation - Thursday, 11:00 am-12:00 pm

Integrated Pest Management: Manual Removal of Eurasian Water-milfoil on Silver Lake
Aquatic Invasive Species - Friday, 8:50-9:50 am

Wisconsin’s Rapid Response to the Introduction of Starry Stonewort and a Case Study Using Diver Assisted Suction Harvesting on Silver Lake, Washington County
Aquatic Invasive Species - Friday, 10:30-11:30 am

Weevil Study

- How do weevils (*Euhrychiopsis lecontei*) affect milfoil population levels?



Integrated Pest Management:
Testing the Efficacy of Milfoil Weevils in Controlling Eurasian Water-milfoil
Aquatic Invasive Species - Friday, 8:50-9:50 am

Large-Scale Treatment Resources

Herbicide Treatments in **Wisconsin Lakes**

Michelle Nault, Alison Mikulyuk, Jennifer Hauxwell, John Skogerboe, Tim Asplund, Martha Barton, Kelly Wagner, Tim Hoyman, and Eddie Heath

Building a Framework for Scientific Evaluation of Large-scale Herbicide Treatments in Wisconsin Lakes

Wisconsin's 15,000 lakes provide rich recreational, ecological, and economic benefits. However, Wisconsin lakes are facing a growing number of threats, including excess nutrient runoff from agricultural and urban development, contamination from mercury and other pollutants, modification of ecologically important nearshore habitats, and the invasion and spread of non-native invasive aquatic species.

Eurasian watermilfoil (*Myriophyllum spicatum* L.) is a non-native aquatic plant that was introduced to Wisconsin in the 1960s and is currently known to be present in approximately 600 lakes and rivers (Figure 1). While landscape-scale patterns of Eurasian watermilfoil (EWM) abundance look similar to those of natives, EWM may have more negative impacts at higher densities. In some of these waterbodies, EWM interferes with recreation and may displace native species (Figures 2 and 3). The Wisconsin Department of Natural Resources (WDNR) has been working to develop and implement plans for strategic and efficient control of EWM, and to prevent its further spread in the state.

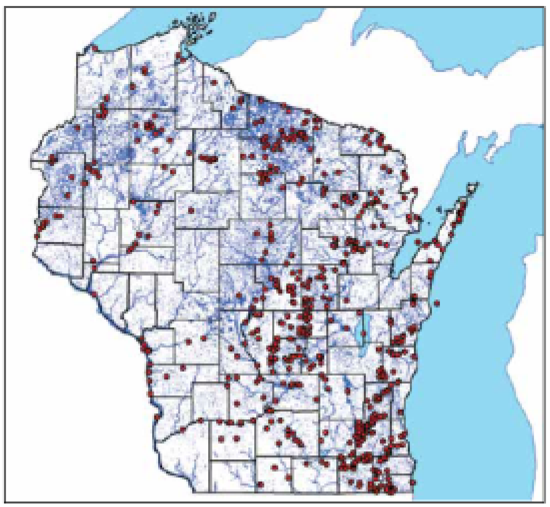


Figure 1. Statewide map of known distribution of Eurasian watermilfoil in Wisconsin.

Defining the Questions

There are many considerations when forming and implementing an aquatic plant management (APM) control plan, including different management tools and approaches (e.g., harvesting, drawdowns, herbicides, and biological controls), and in the case of herbicides – timing, formulations and application rates, water flow, lake type, and target and non-target species. Wisconsin aquatic plant management administrative rules (NR 107 Wis. Adm. Code) state the guidance and procedures for utilizing chemical herbicides for the management of aquatic plants. The rule emphasizes a balanced and healthy aquatic ecosystem, and specifically states that *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.* Historically, resource managers have applied a "do-no-harm" philosophy for public waters when permitting measures to provide nuisance vegetation relief over the short-term, as opposed to setting concrete restoration goals achievable over the long term – for example, to strategically reduce populations of an invasive, or to restore or protect the native plant community. Whether achievement of these long-term goals is possible or feasible in Wisconsin lakes is yet to be

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Efficacy, selectivity, and herbicide concentrations following a whole-lake 2,4-D application targeting Eurasian watermilfoil in two adjacent northern Wisconsin lakes

Michelle E. Nault,[1,*] Michael D. Netherland,[2] Alison Mikulyuk,[1] John G. Skogerboe,[2] Tim Asplund,[1] Jennifer Hauxwell,[1] and Pamela Toshner[3]

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[2]US Army Engineer Research and Development Center, Center for Aquatic and Invasive Plants, 7922 NW 71st St, Gainesville, FL 32653
[3]Wisconsin Department of Natural Resources, 810 W Maple St, Spooner, WI 54801

Abstract

Nault ME, Netherland MD, Mikulyuk A, Skogerboe JG, Asplund T, Hauxwell J, Toshner P. 2014. Efficacy, selectivity, and herbicide concentrations following a whole-lake 2,4-D application targeting Eurasian watermilfoil in two adjacent northern Wisconsin lakes. Lake Reserv Manage. 30:1–10.

The herbicide 2,4-D (2,4-dichlorophenoxy acetic acid) has been used to control the nonnative aquatic plant Eurasian watermilfoil (*Myriophyllum spicatum*; EWM) since the 1950s. Although published research evaluates the herbicide's predicted and observed concentration and exposure times in both laboratory and field settings, few data are available evaluating selectivity and long-term efficacy as well as herbicide concentration behavior following large-scale, whole-lake applications. A controlled study was conducted on 2 adjacent oligo-mesotrophic northern Wisconsin lakes to determine the potential efficacy and selectivity of large-scale and low-dose 2,4-D applications. Initial 2,4-D concentrations in both treated lakes were approximately 100 μg/L higher than the nominal lakewide targets of 500 and 275 μg/L, respectively, and the herbicide dissipated and degraded more slowly than predicted. A lakewide regression model relating 2,4-D concentration at monitoring sites to days after treatment (DAT) found the mean half-life of 2,4-D to be 34–41 DAT, and the threshold for irrigation of plants not labeled for direct treatment with 2,4-D ($<$100 μg/L) was not met until 50–93 DAT. In the lake treated at the higher 2,4-D rate, EWM was not detected for 3 consecutive years posttreatment. Additionally, several native monocotyledon and dicotyledon species also showed sustained significant declines posttreatment. This study is the first to link field-collected 2,4-D concentration measurements to selectivity and long-term efficacy in EWM control following whole-lake management efforts. Although multiyear EWM control was achieved with these single low-dose applications, longer than expected herbicide persistence and impacts to native plants demonstrate the challenges facing aquatic plant managers and the need for additional field studies.

Key words: 2,4-dichlorophenoxy acetic acid, aquatic plant management, chemical control, herbicide, invasive species, *Myriophyllum spicatum*, native macrophytes

The herbicide 2,4-D (2,4-dichlorophenoxy acetic acid) has been used to control the invasive aquatic plant Eurasian watermilfoil (*Myriophyllum spicatum*; EWM) since the 1950s (Gallagher and Haller 1990). Both a granular ester and several liquid amine 2,4-D formulations are currently registered for aquatic use. The herbicide acts by mimicking the natural plant hormone auxin, resulting in epinastic bending and twisting of stems and petioles followed by chlorosis at growing points, growth inhibition, and necrosis of sensitive species (WSSA 2007). One of the key properties featured in using 2,4-D for EWM control programs has been an inherent selectivity that allows managers to target this invasive dicotyledon with a general lack of activity on numerous submersed monocotyledons (Bates et al. 1985).

Variability in achieving efficacy with 2,4-D is likely a function of concentration and exposure time (CET) relationships; Green and Westerdahl (1990) describe numerous short-term CET scenarios (up to 72 h of exposure) that can occur following various operational treatments. Prior field research has demonstrated efficacy and selectivity of

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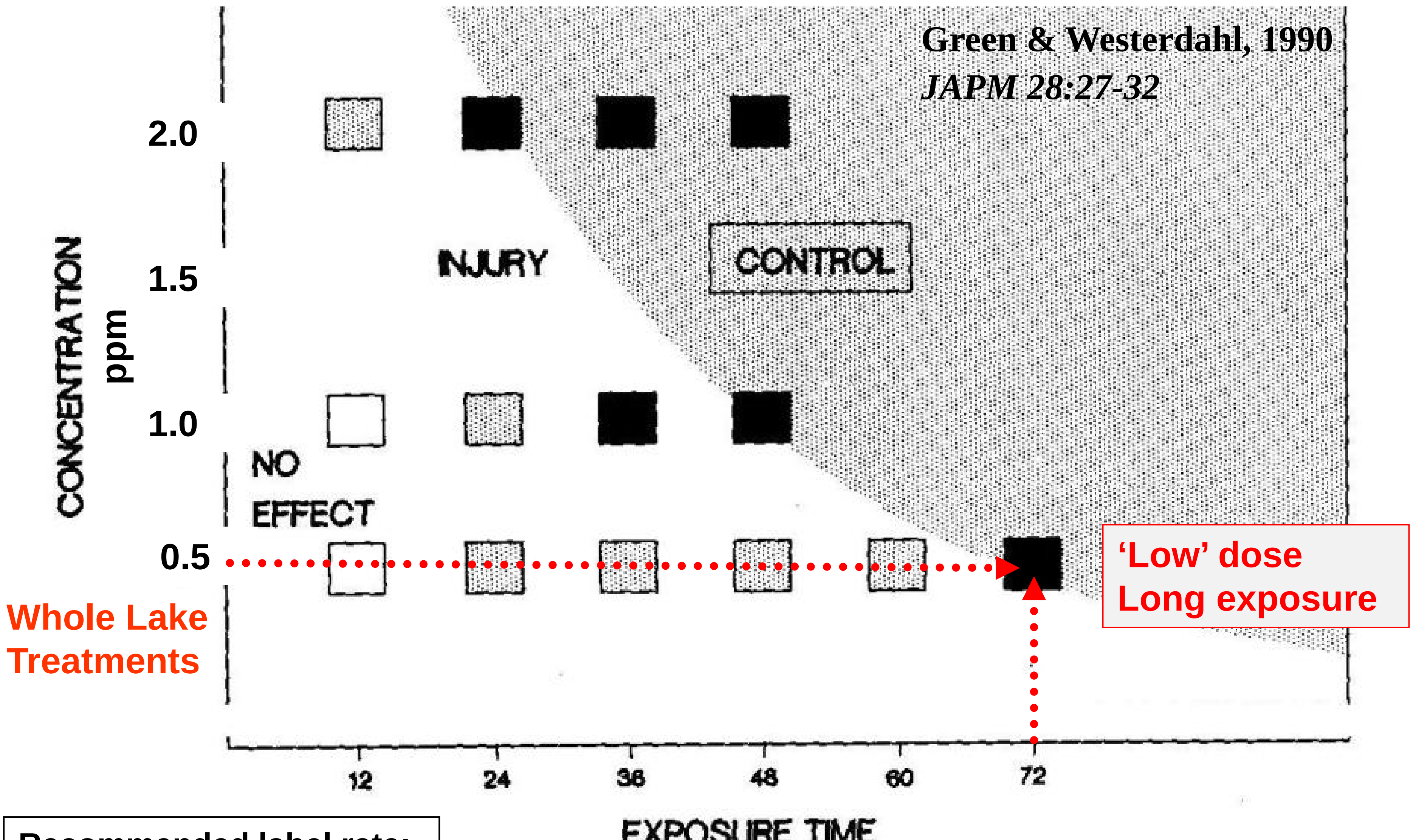
2,4-D Concentration/Exposure Time

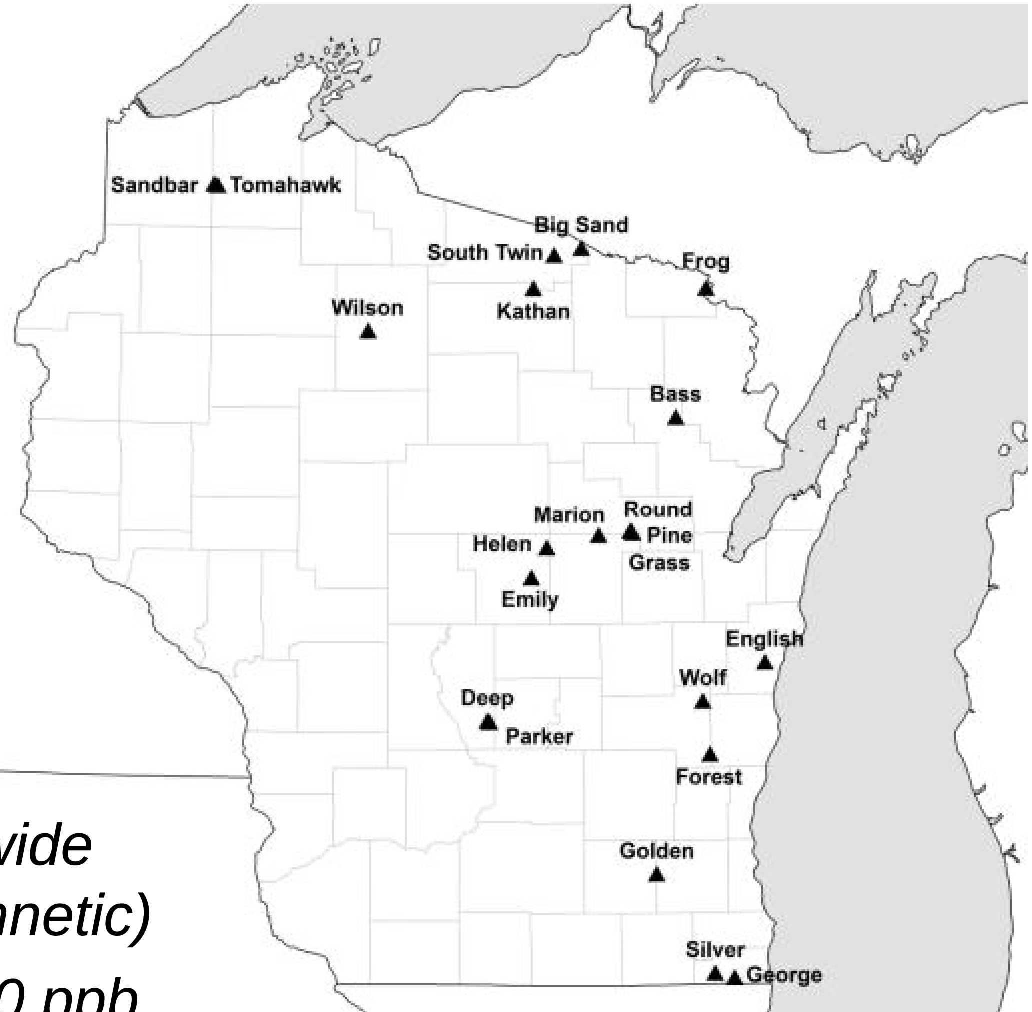


Recommended label rate:
2.0 – 4.0 ppm

1.0 ppm = 1.0 mg/L = 1000 ppb

Study Lakes

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

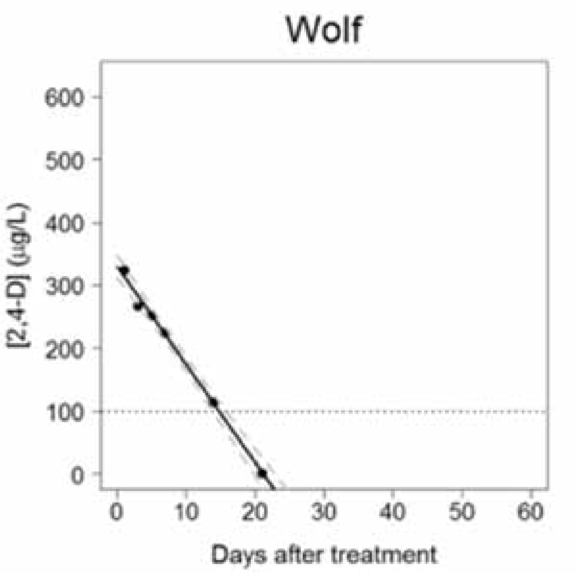


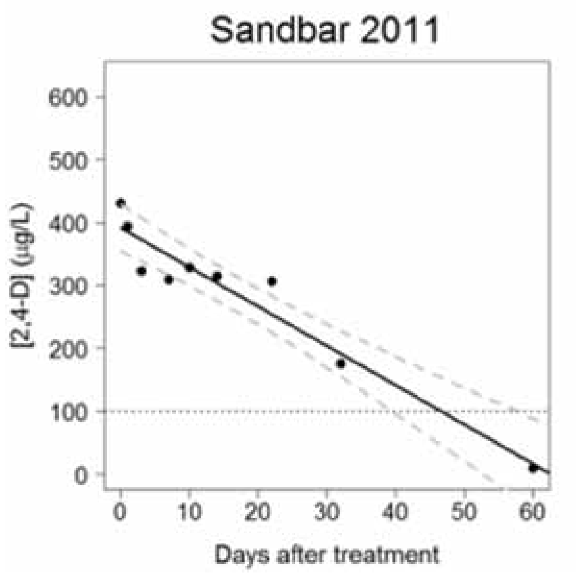
Treatments

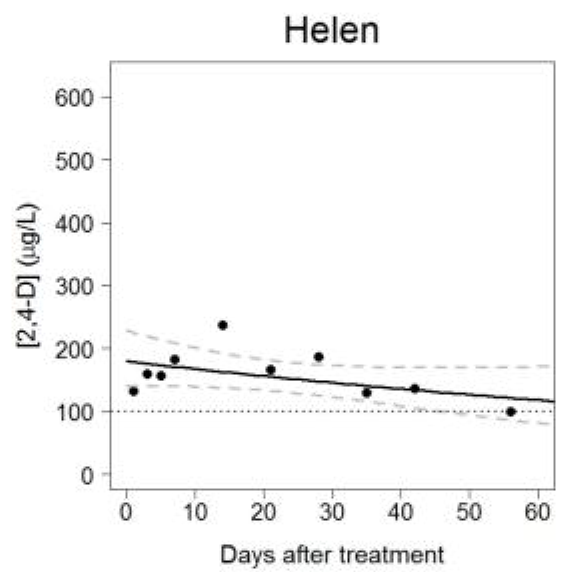
- *Large-scale liquid 2,4-D lakewide targets of 73 - 500 ppb (epilimnetic)*
- *Application rates of 250 - 4000 ppb*
- *8-100% of lake surface area treated*
- *Early season (spring) treatments*
- *Monitored from 2008-2015*

2,4-D Degradation

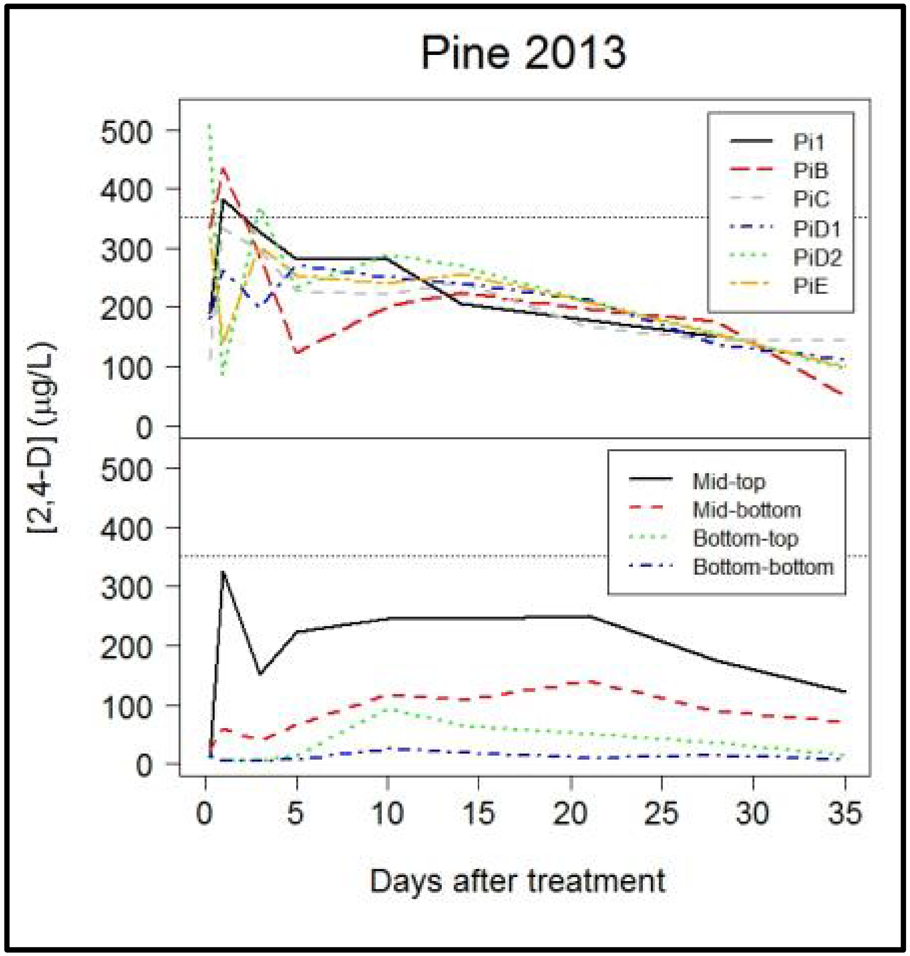
- *Majority of models highly significant (p <0.001)*
- *Mean 1-7 DAT ranged from 127-584 ppb*
- *2,4-D half-lives ranged from 4-59 days*
- *Irrigation restriction (<100 ppb by 21 DAT) exceeded in over half the treatments*
- *Analysis in progress to determine what variables affect degradation rates (lake type, trophic status, pH, etc.)*

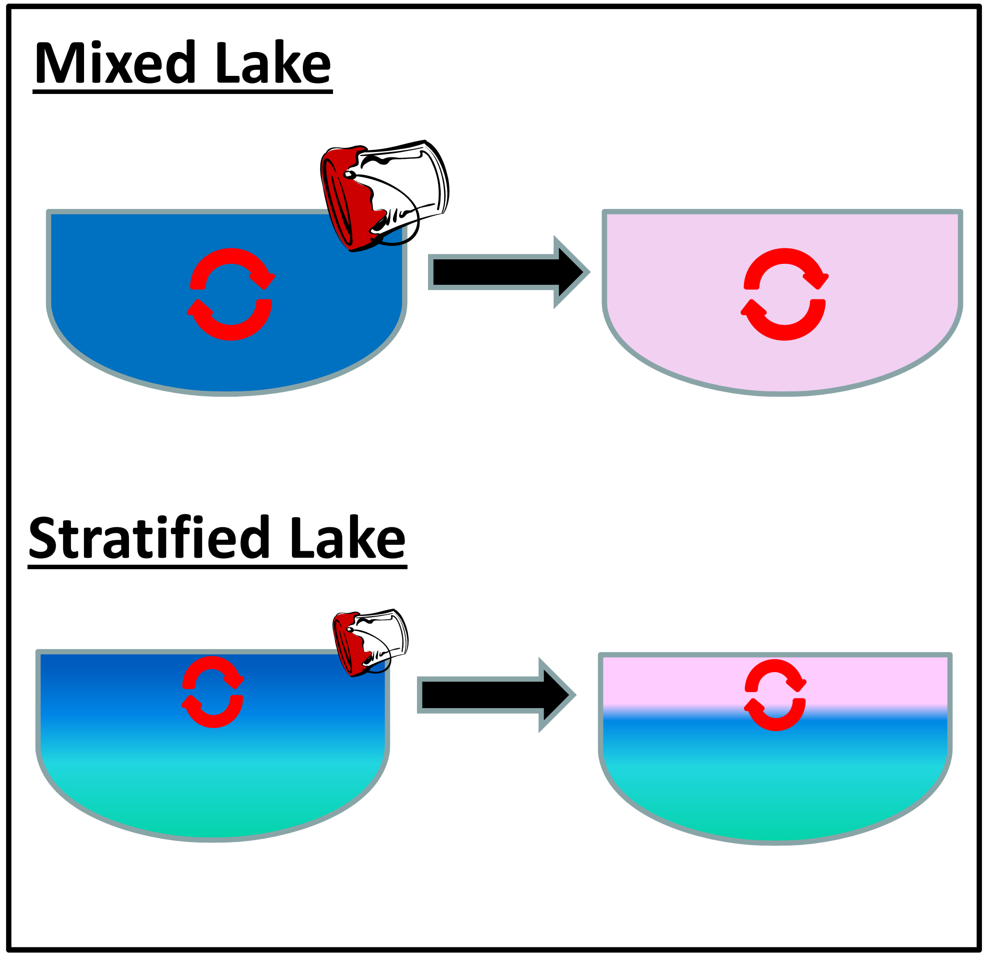




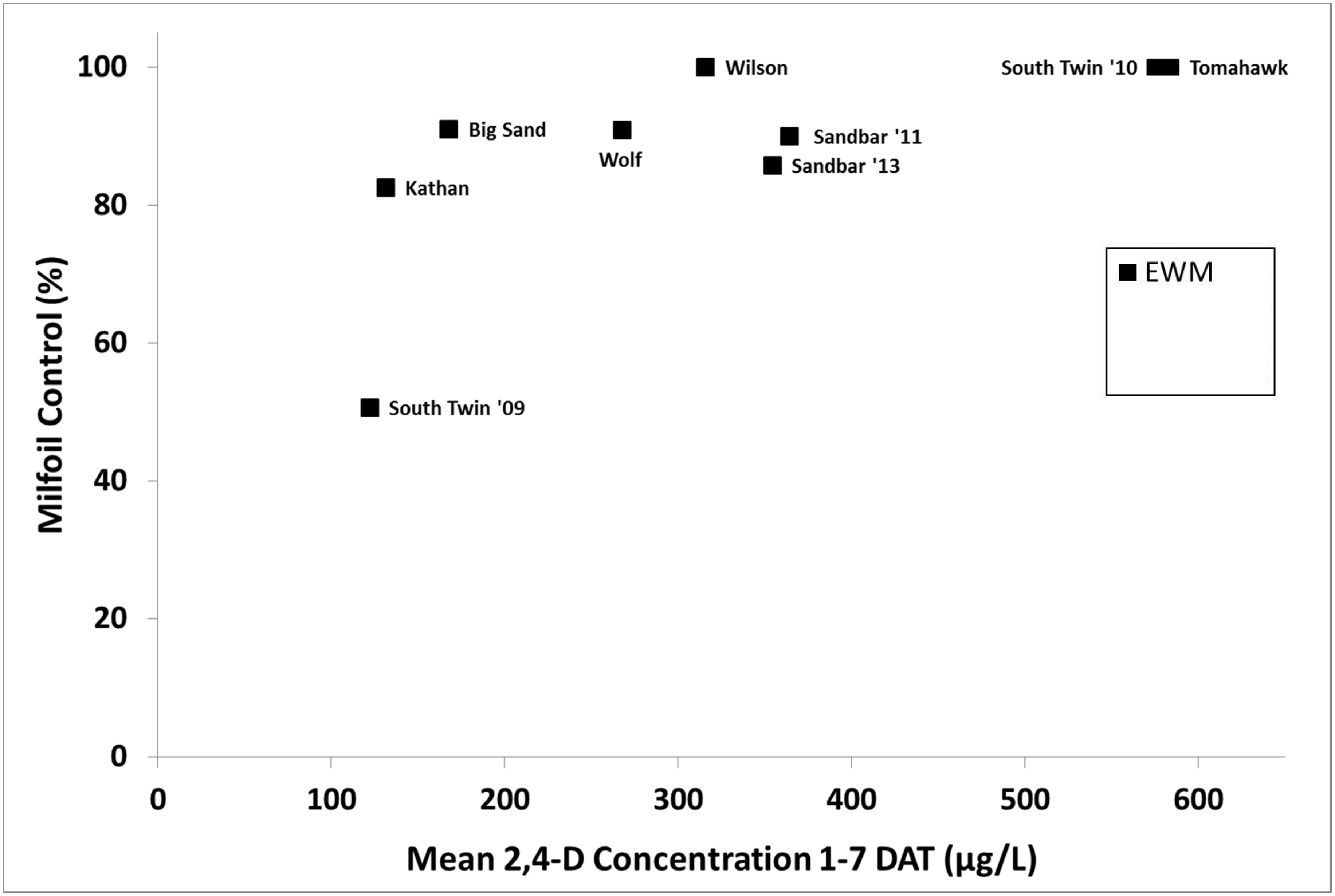


2,4-D Vertical Dissipation

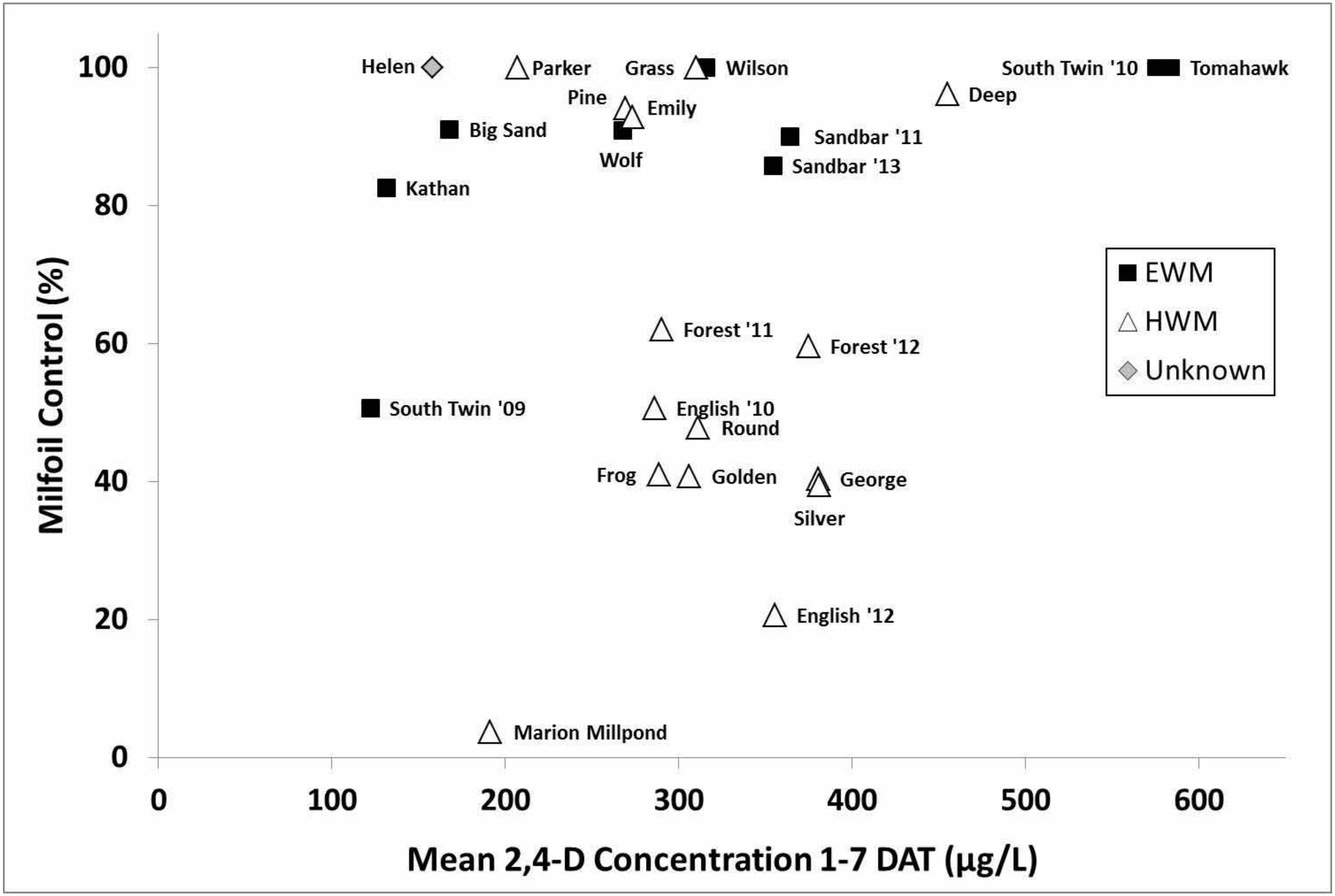




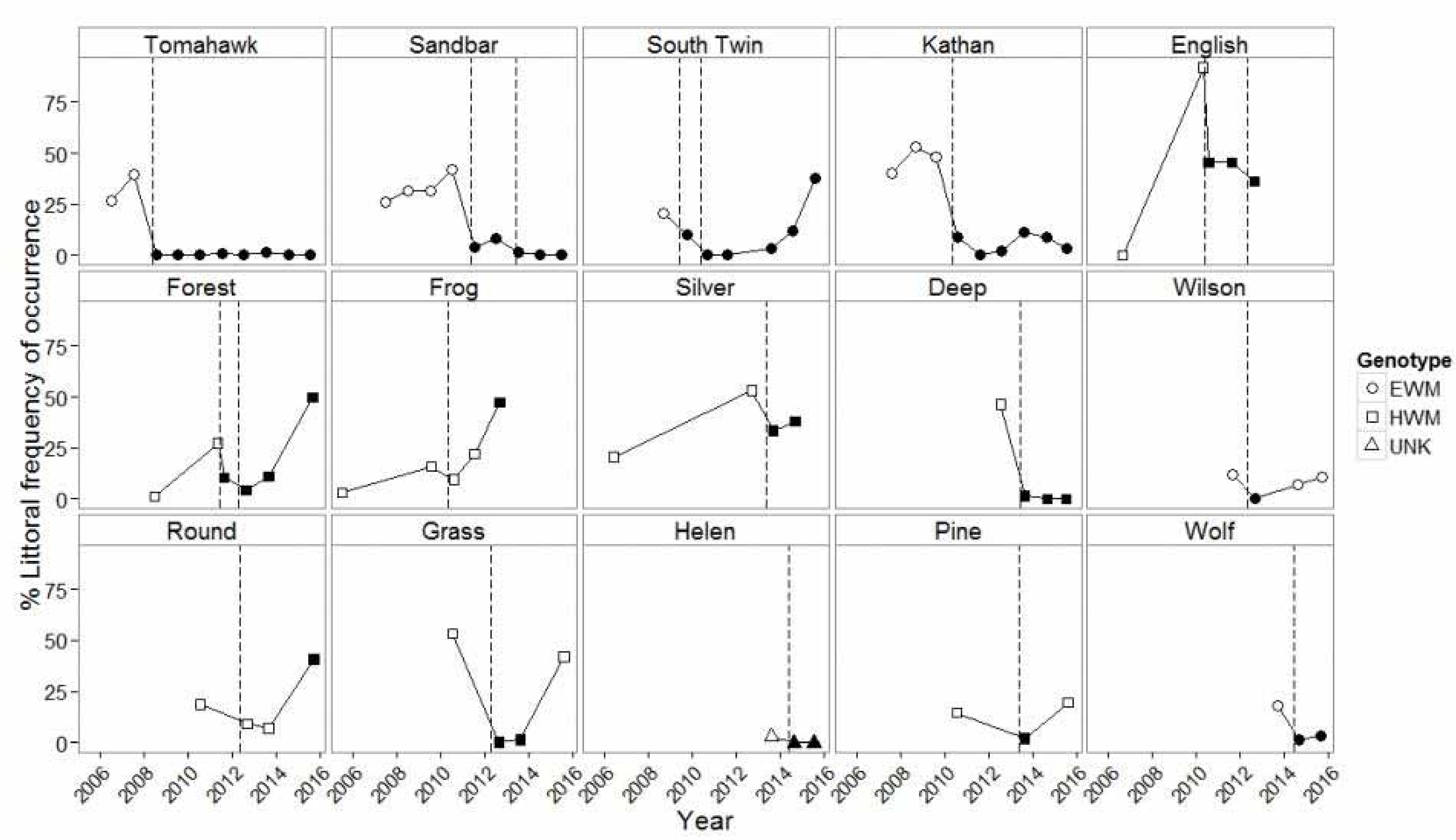
Milfoil Control



Milfoil Control



Long-Term Milfoil Control



Native Plant Community

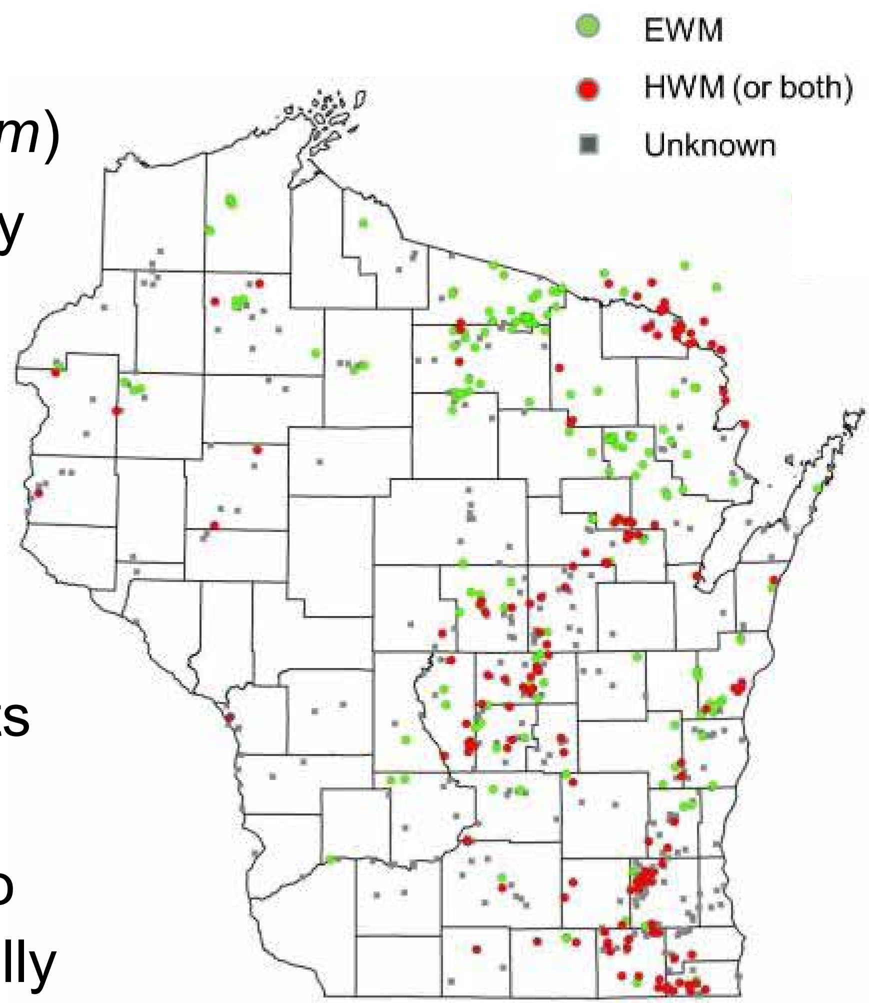
	Tomahawk	Sandbar '11	South Twin '09	Kathan	Wilson	Frog	Silver	Deep	Marion	Helen	Wolf	Emily	Parker
B. beckii	-	-	< 0.001	-	-	-	-	-	-	-	-	-	-
B. schreberi	-	-	-	0.408	-	-	-	-	-	-	-	-	-
C. demersum	-	-	0.421	0.242	< 0.001	-	0.093	-	0.081	-	0.262	-	-
Chara spp.	0.772	0.943	< 0.001	0.825	-	0.619	0.205	0.953	-	0.023	0.025	0.045	0.098
E. acicularis	-	0.693	-	-	-	-	-	-	-	-	-	-	-
E. canadensis	< 0.001	0.807	0.659	0.394	-	-	-	-	< 0.001	-	-	-	-
H. dubia	-	-	< 0.001	-	-	-	-	-	-	-	-	-	-
M. sibiricum	-	-	< 0.001	-	-	-	-	0.003	-	< 0.001	-	-	-
N. flexilis	< 0.001	0.003	0.525	< 0.001	-	< 0.001	< 0.001	-	< 0.001	< 0.001	-	< 0.001	< 0.001
N. guadalupensis	-	-	-	-	-	-	-	-	-	< 0.001	-	-	< 0.001
Nitella spp.	-	-	-	< 0.001	-	-	-	0.699	< 0.001	-	-	0.011	-
P. amplifolius	< 0.001	-	-	-	-	0.629	-	0.275	-	-	-	-	-
P. epihydrus	-	-	-	< 0.001	-	-	-	-	-	-	-	-	-
P. friesii	-	-	-	-	-	-	-	-	< 0.001	-	-	< 0.001	-
P. gramineus	0.038	0.036	0.841	-	-	-	0.074	-	-	0.069	-	0.985	< 0.001
P. illinoensis	-	-	-	-	-	-	-	-	-	< 0.001	-	-	-
P. praelongus	-	-	0.778	-	-	-	-	-	0.010	-	-	-	-
P. pusillus	< 0.001	< 0.001	0.042	< 0.001	-	0.171	-	-	-	-	-	-	-
P. richardsonii	-	-	0.053	-	-	-	-	-	-	-	-	-	-
P. robbinsii	0.014	-	0.749	-	< 0.001	-	-	-	-	-	-	-	-
P. strictifolius	-	-	-	< 0.001	-	< 0.001	-	-	-	-	-	-	-
P. zosteriformis	-	-	0.144	0.032	< 0.001	-	-	< 0.001	-	-	-	< 0.001	-
S. pectinata	-	-	-	-	-	-	0.334	-	< 0.001	< 0.001	-	-	< 0.001
U. vulgaris	-	-	-	0.249	-	-	-	-	-	-	-	-	-
V. americana	< 0.001	< 0.001	< 0.001	0.041	-	-	0.016	-	-	-	0.443	0.252	0.537

# native spp sig increase	0	0	0	2	0	0	2	0	1	1	0	2	1
# native spp sig decrease	7	4	6	5	3	2	0	2	5	5	1	3	3

net increase/decrease	-7	-4	-6	-3	-3	-2	+2	-2	-4	-4	-1	-1	-2

Hybrid Watermilfoil

- Many misconceptions and misinformation regarding hybrid watermilfoils (*M. spicatum* X *sibiricum*)
- Milfoil populations tested for hybridity through ITS genetic sequencing
- ~140 lakes in WI have HWM confirmed
- There is not one 'single' hybrid watermilfoil, but it is rather a genetically diverse group that reflects recurrent hybridization
- Not all HWM appear to be tolerant to herbicides, but many show statistically significant differences in % control when compared to pure EWM

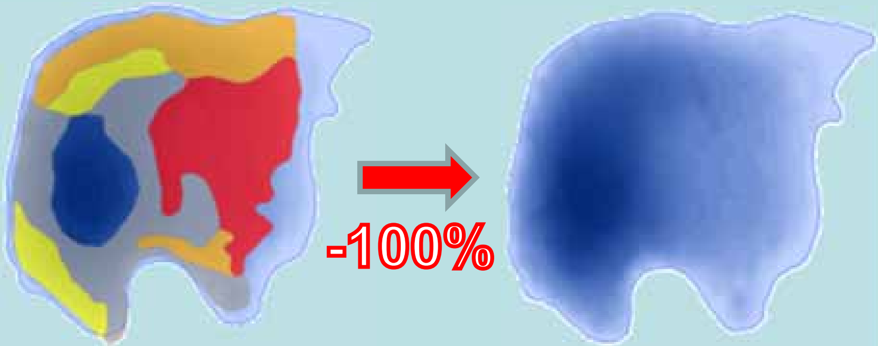


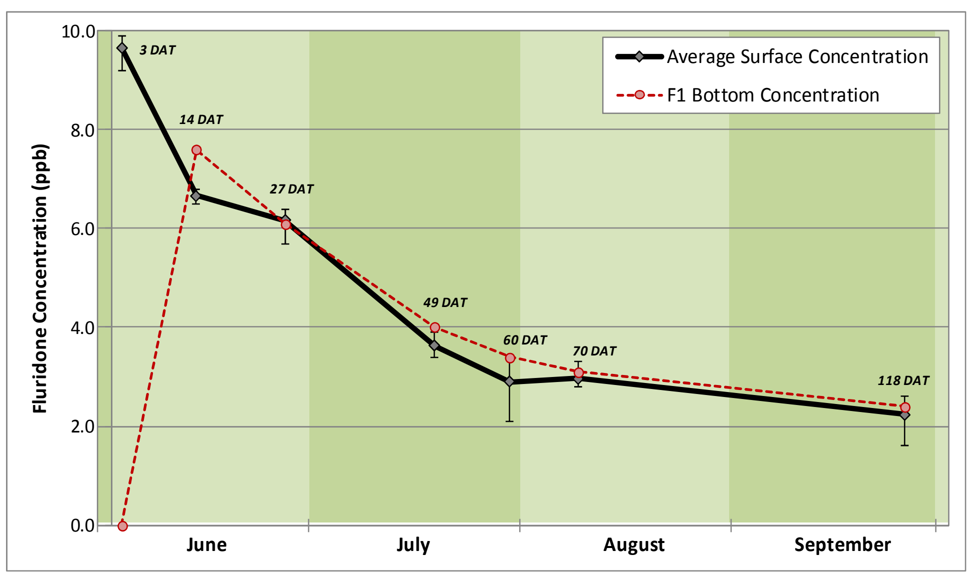
"Alternative" Large-Scale Treatments

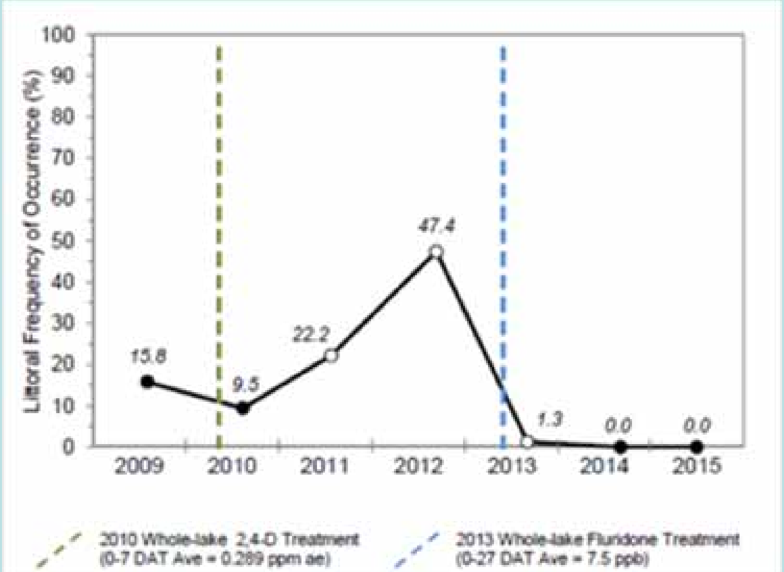
- Explore use of other herbicides (i.e. fluridone, triclopyr) and combos (2,4-D/endothall) for large-scale treatments.
- These herbicides may be good alternatives for milfoil populations which have demonstrated lack of susceptibility to 2,4-D in the field and/or laboratory.
- Need to balance out efficacy for milfoil with selectivity towards natives.
  - Frog Lake, Florence Co. – Fluridone
  - English Lake, Manitowoc Co. – 2,4-D & Endothall

Large-Scale Treatments - Fluridone

- **Frog Lake**: 6-bump-6 liquid fluridone treatment
  - 9.6 ppb (3 DAT),
  - 7.5 ppb (0-27 DAT), no bump
  - 2.2 ppb (118 DAT)

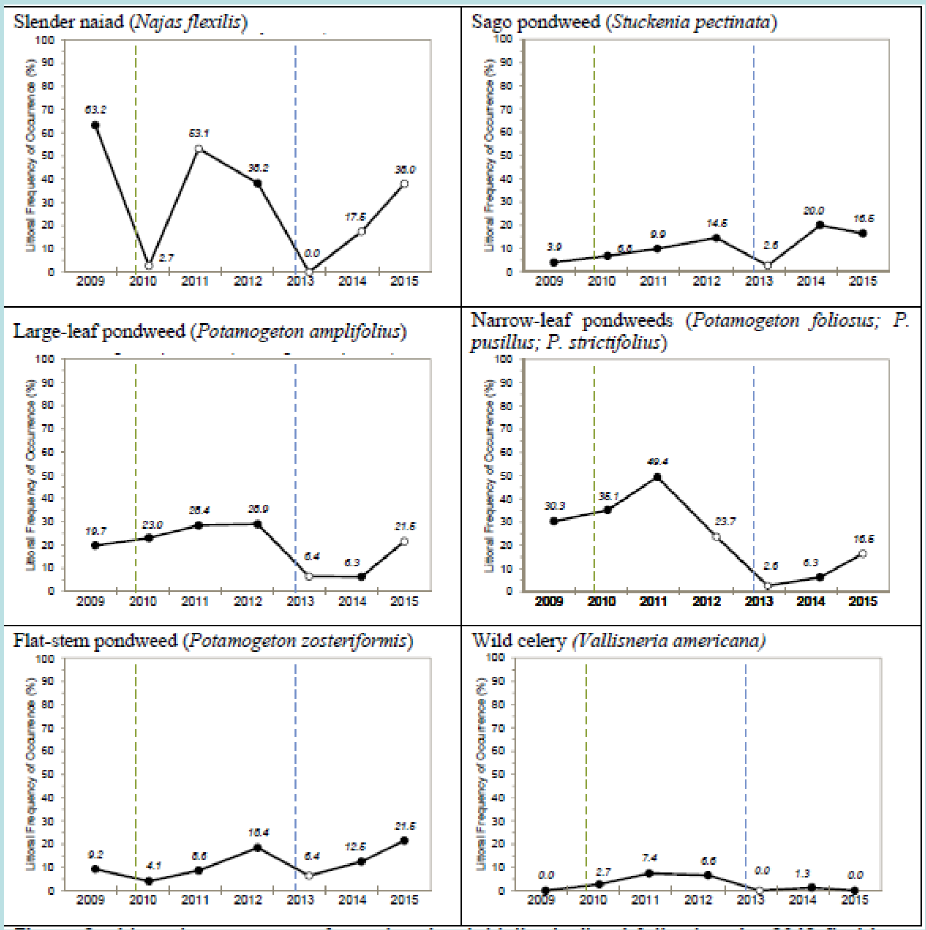






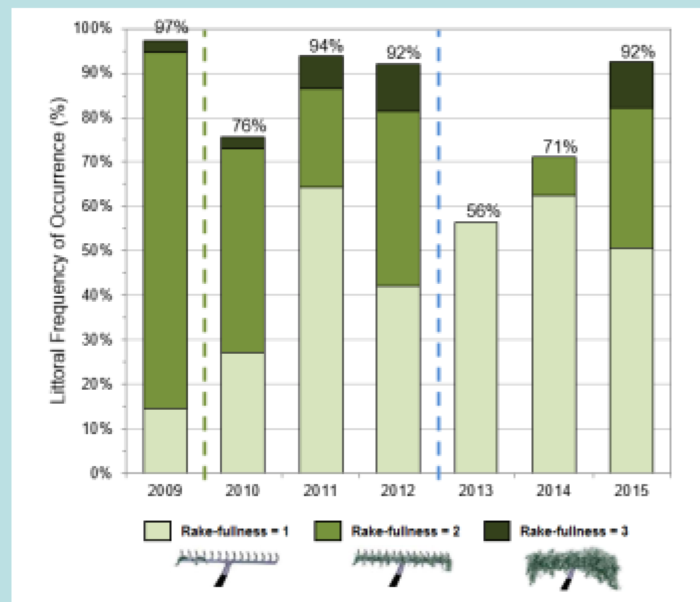
Large-Scale Treatments - Fluridone

- **Frog Lake**: 6-bump-6 liquid fluridone treatment



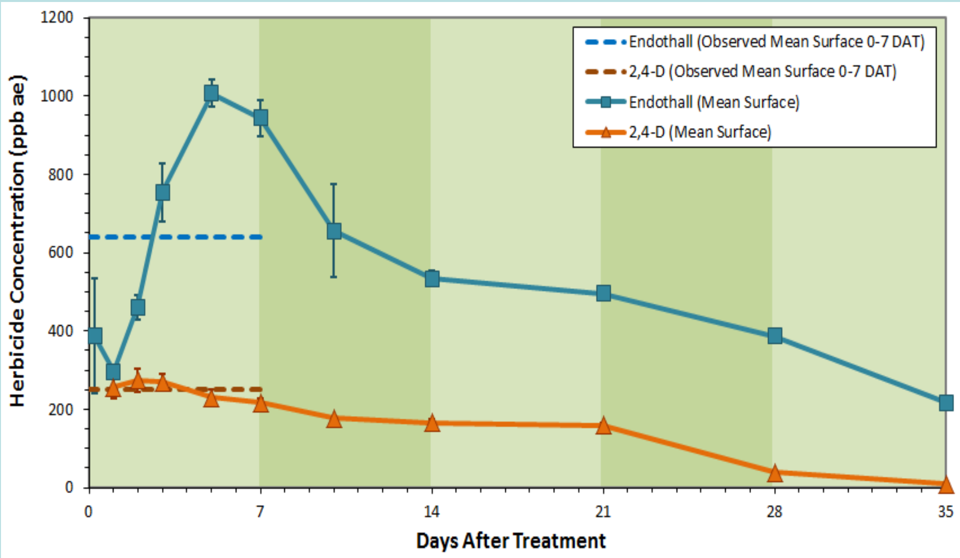
Selectivity

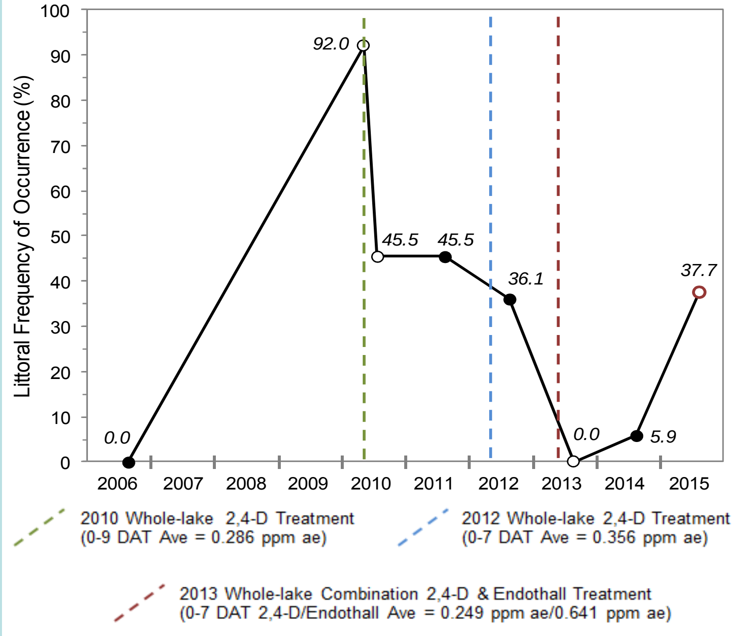
- 6 species statistically declined during year of treatment
- 3 species did not change
- Recovery of many natives observed within 1-2 years



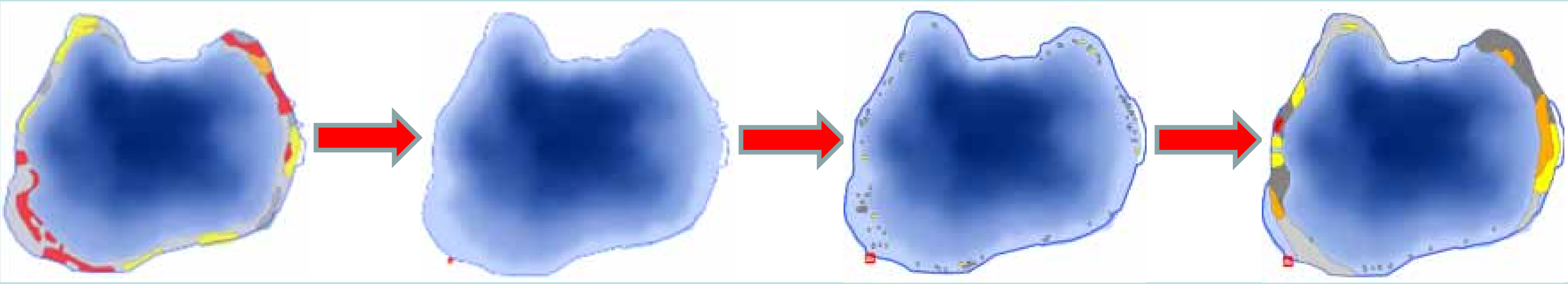
Large-Scale Treatments – 2,4-D/Endothall

- **English Lake**: 2,4-D (0.25 ppm) & endothall (0.53 ppm)



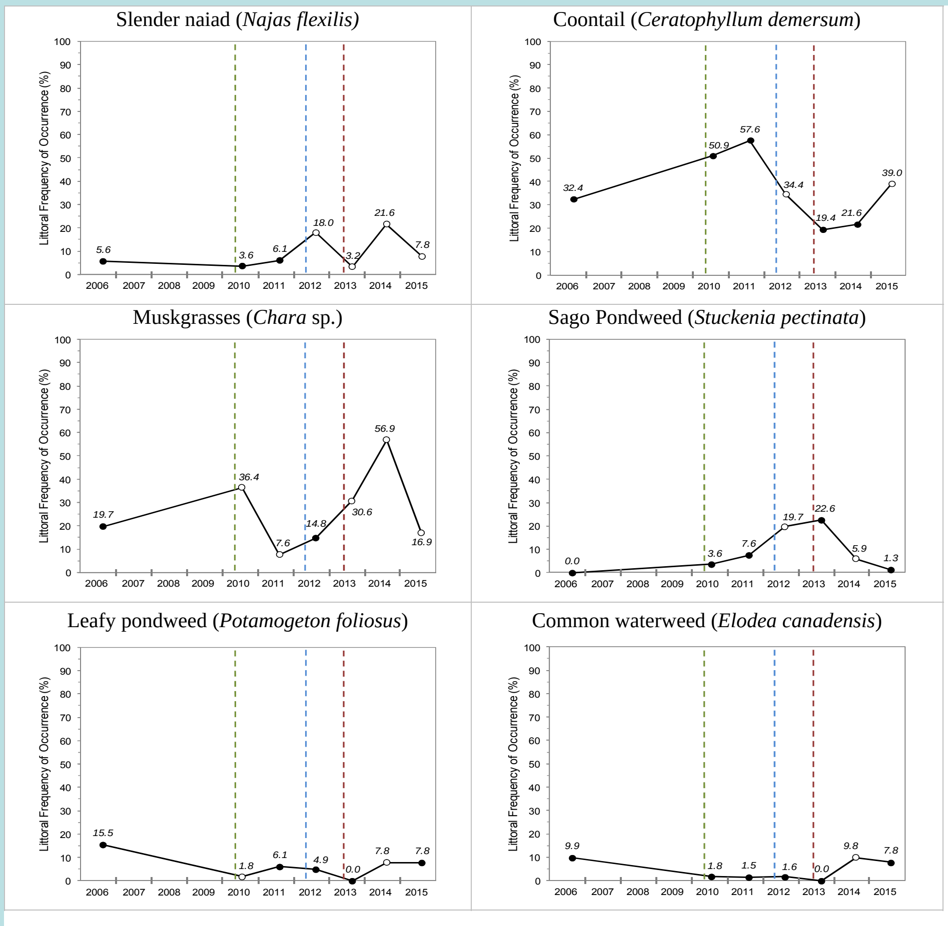


  - 0.25 2,4-D ppm ae (0-7 DAT)
  - 0.64 endothall ppm ae (0-7 DAT)



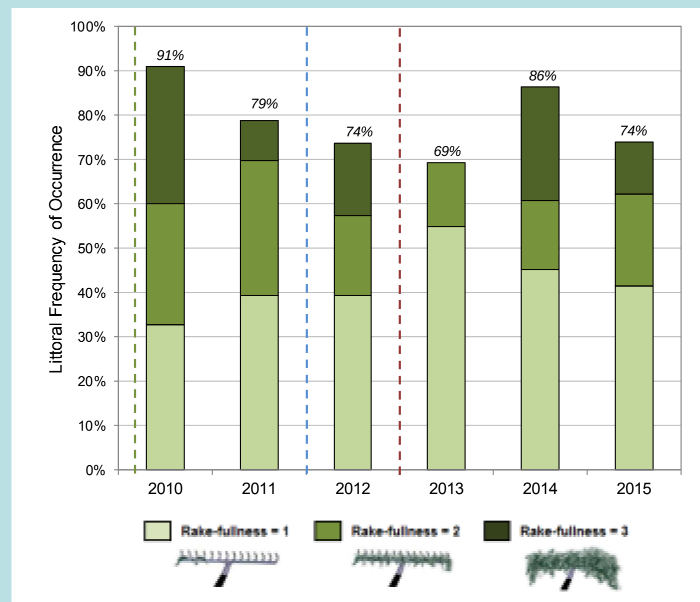
Large-Scale Treatments – 2,4-D/Endothall

- **English Lake**: 2,4-D (0.25 ppm) & endothall (0.53 ppm)



<u>Selectivity</u>

- 2 species statistically declined during year of treatment
- 1 species increased
- Recovery of natives observed within 1 year



Large-Scale Treatment Summary

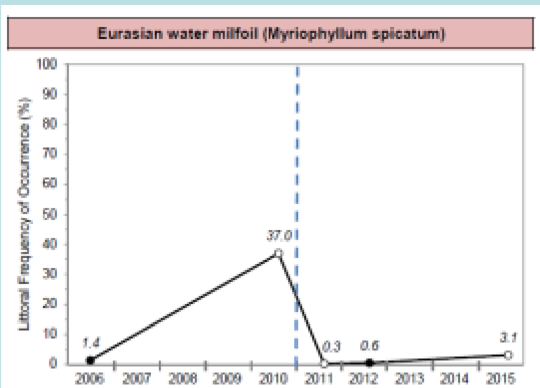
- Herbicide dissipation is rapid and large scale treatments can result in a whole-lake treatment if the scale of the treatment area is large compared to the overall lake epilimnetic volume
- Lake stratification and water temperature are very important to consider when calculating volume
- Early spring, large scale 2,4-D treatments may result in longer persistence of herbicides than expected; may exceed 100 ppb (0.1 ppm) 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
- Herbicide monitoring is important, both to understand treatment efficacy, as well as ecological risks

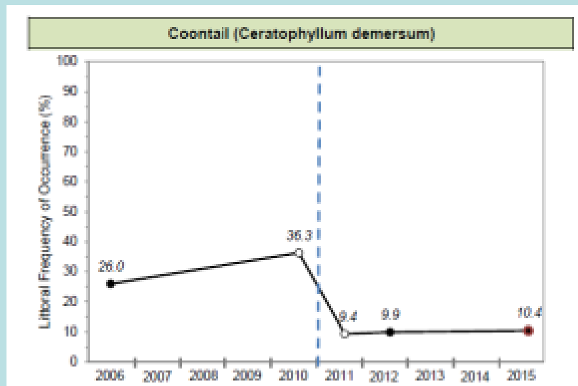
Drawdown Studies

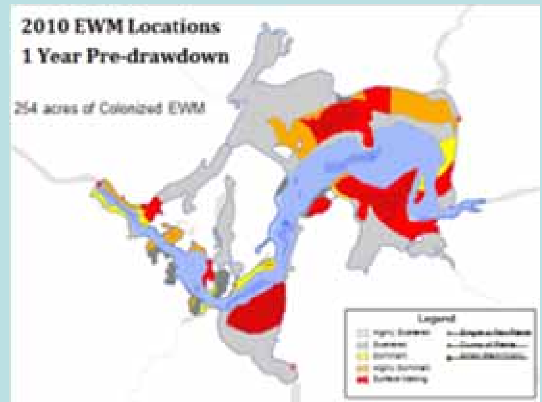
- How do water level drawdowns affect EWM/CLP population levels?
  - Soo (Lac Sault Dore) Lake, Price Co.
  - Musser Lake, Price Co.

Drawdown Studies

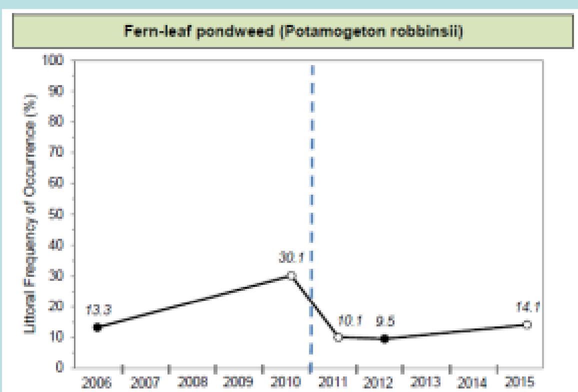
- **Soo Lake**: Winter drawdown (6ft) to control EWM

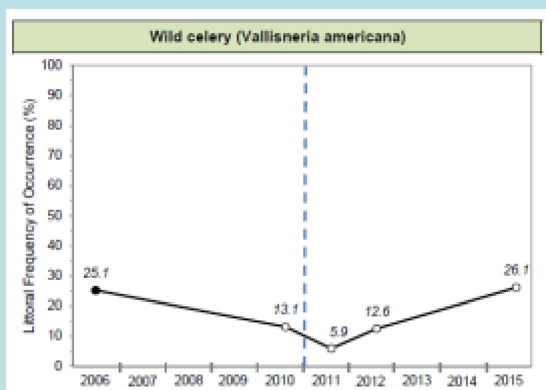


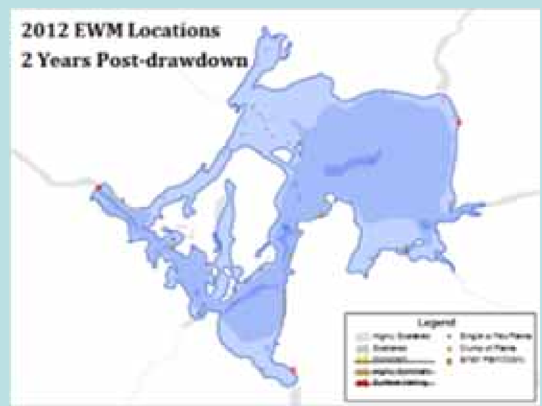




-98%



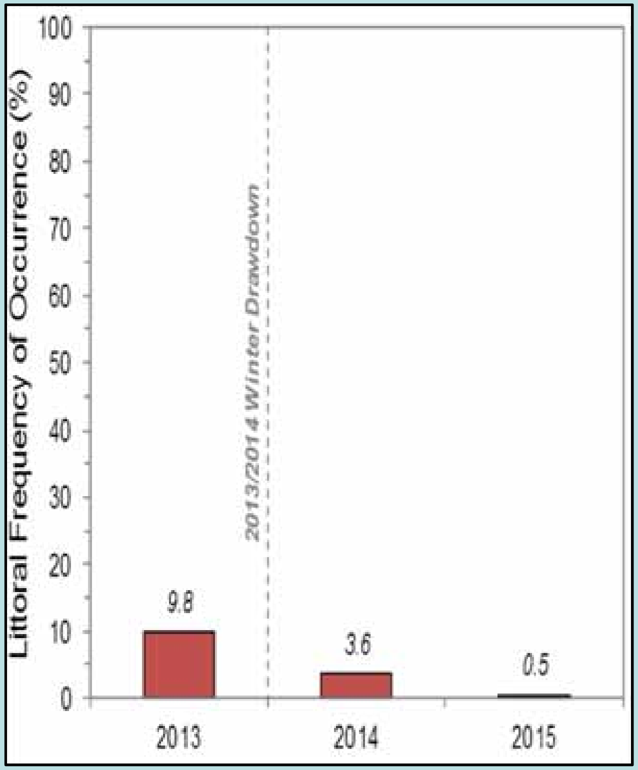




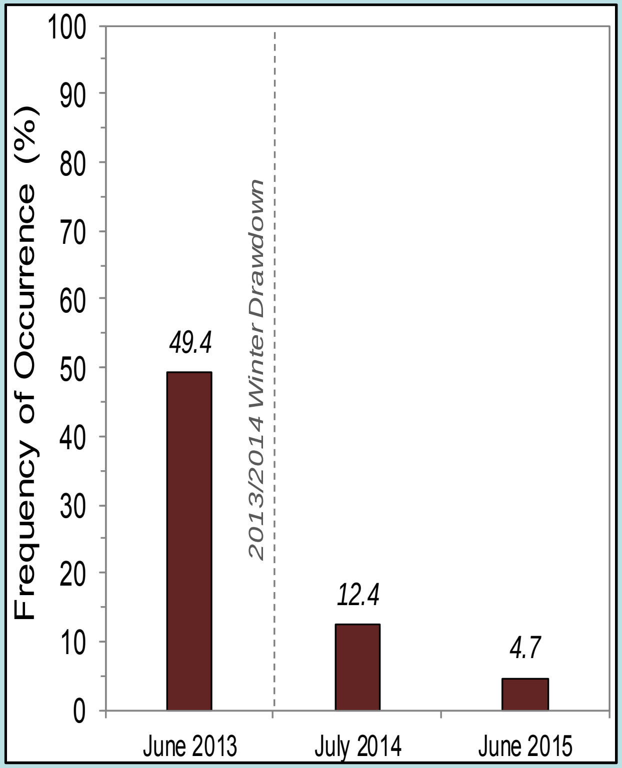
Drawdown Studies

- **Musser Lake**: Winter drawdown (~5-6ft) to control CLP

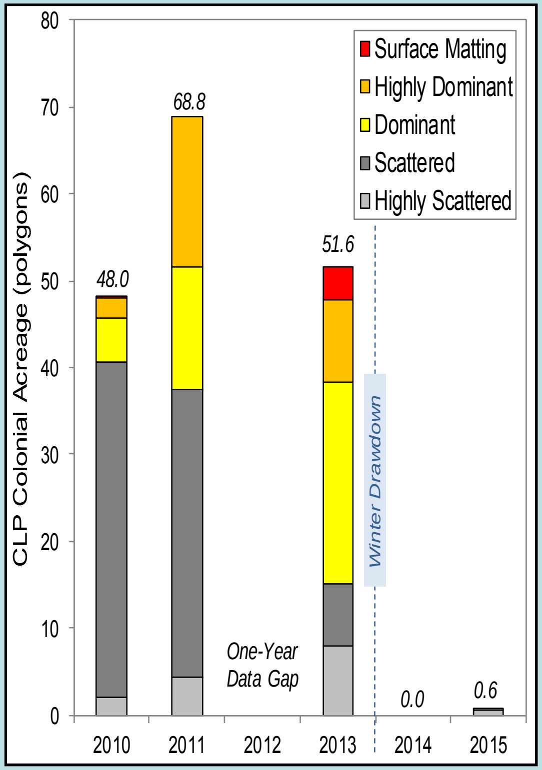
Lakewide PI



Sub-Sample PI



Mapped Acres



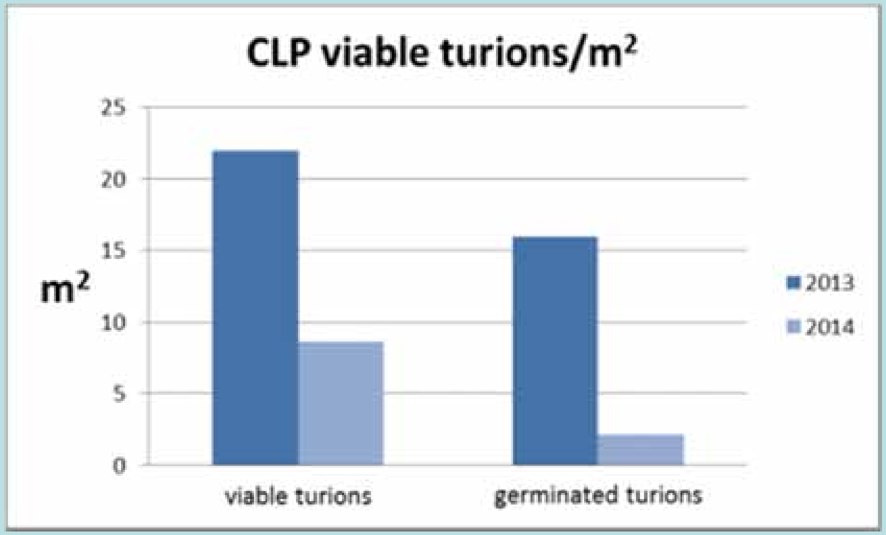
Drawdown Studies

- **Musser Lake**: Winter drawdown (~5-6ft) to control CLP

Species	2013	2015	p value	Significant change	
Curly-leaf Pondweed	54	2	0.0000	***	-
Coontail	98	35	0.0000	***	-
Small Duckweed	16	0	0.0004	***	-
Flat-stem Pondweed	12	0	0.0021	**	-
Common Bladderwort	6	0	0.0299	*	-
Aquatic Moss	5	13	0.0144	*	+
Nitella sp.	6	17	0.0033	**	+
Small Pondweed	6	16	0.0058	**	+
Filamentous algae	3	23	0.0000	***	+
Floating-leaf Pondweed	19	37	0.0006	***	+

Drawdown Studies

- **Musser Lake**: Winter drawdown (~5-6ft) to control CLP



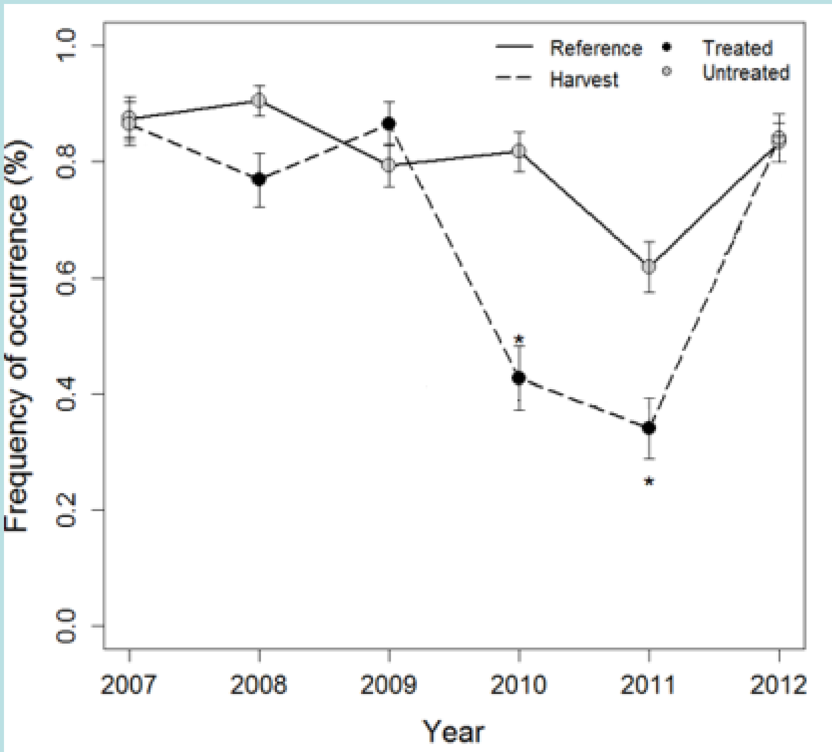
Mechanical Harvesting Studies

- How does selective mechanical harvesting affect EWM/CLP population levels?
  - Turville Bay, Dane Co.
  - Mid Lake, Oneida Co.

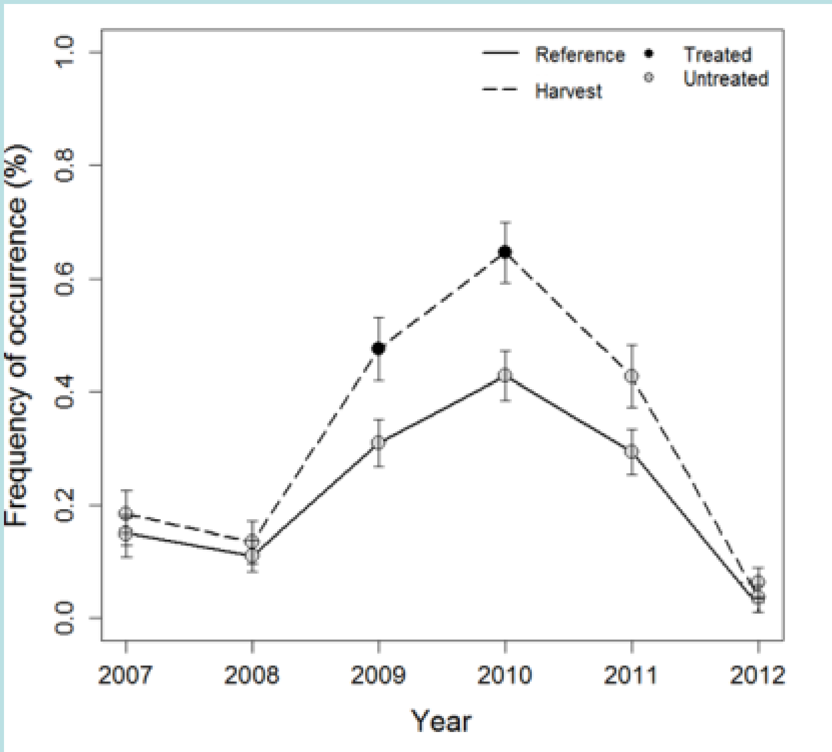
Mechanical Harvesting Studies

- **Turville Bay**: Several years of early season, single ‘deep’ cut mechanical harvesting for EWM/CLP control

EWM

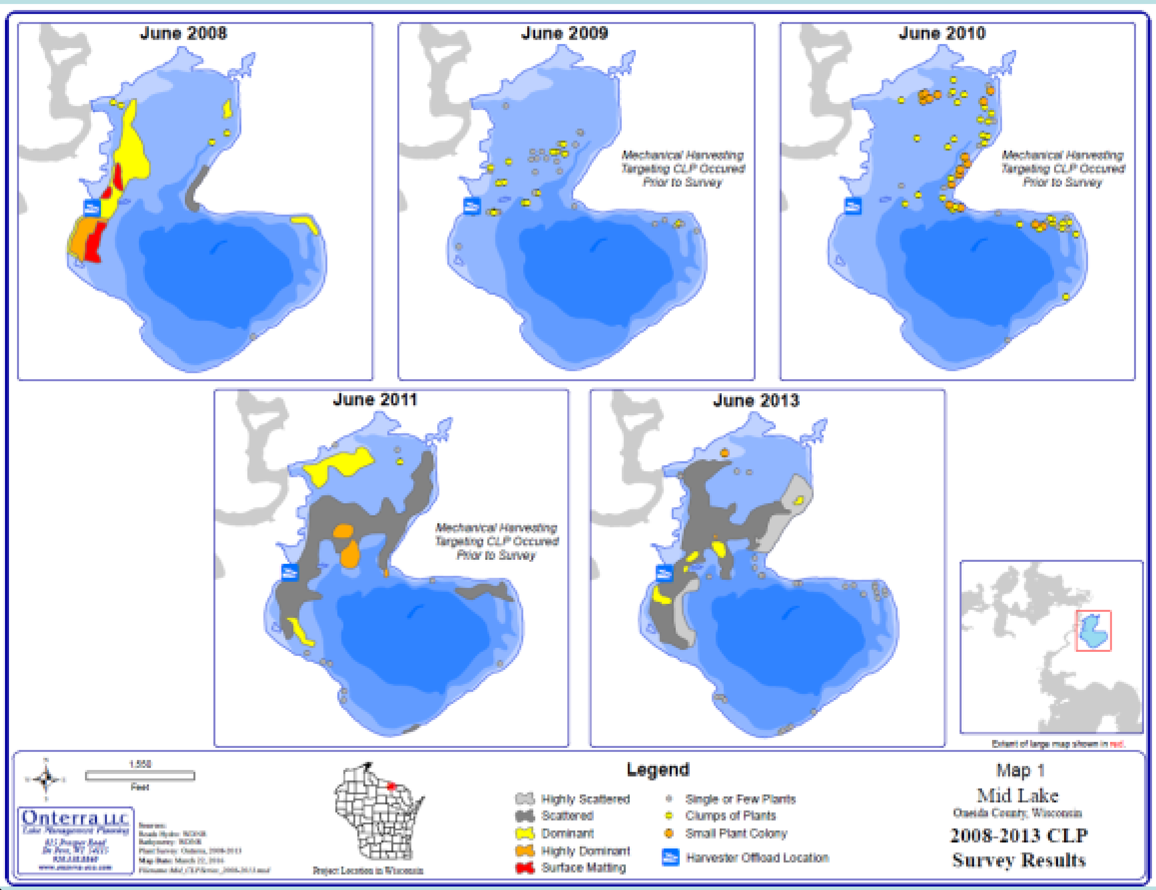


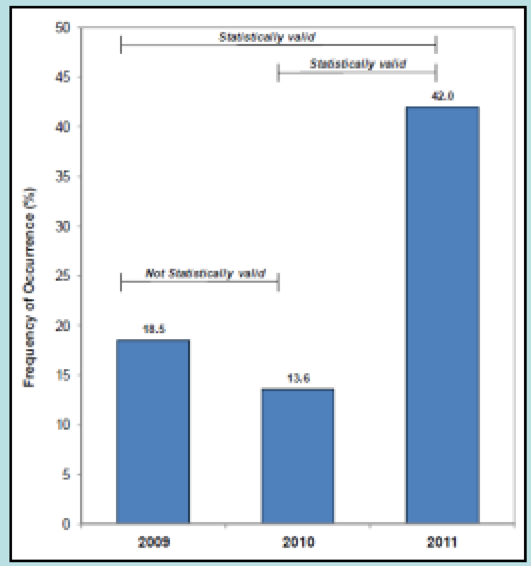
CLP

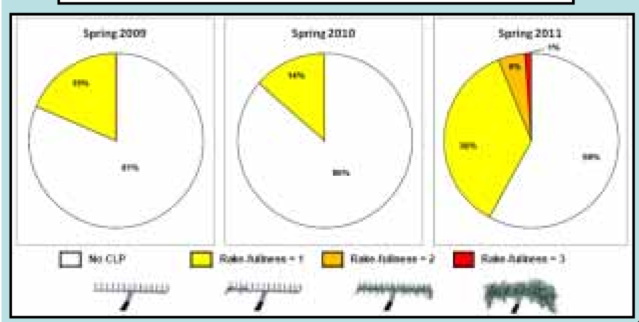


Mechanical Harvesting Studies

- **Mid Lake**: Several years of early season, multiple cut mechanical harvesting for CLP control







Integrated Pest Management

- Utilize quantitative monitoring to understand the distribution and extent of AIS in the waterbody
- Set a realistic management goal
- Pick the best set of tools to reach that goal
- Evaluate progress periodically to see if goals are being meet
- Alter management tools if goals are not being achieved


Implementing Integrated Pest Management In Wisconsin
Scott Provost
Statewide APM Coordinator
Wisconsin Department of Natural Resources

Historical Perspective

- <1989 Aquatic Nuisance Control
- 1989 Aquatic Plant Management
- 2001 Aquatic Plant Management
  - First regulated approach to IPM

Present Day IPM Implementation

- Active research in a collaborative approach
- Implementation of new techniques/methods
- Holistic management is becoming the norm
- AIS focused/protect native species
- Comprehensive plans
- Revision of code(s) to reflect new technologies and philosophy

Definition of IPM (UC)

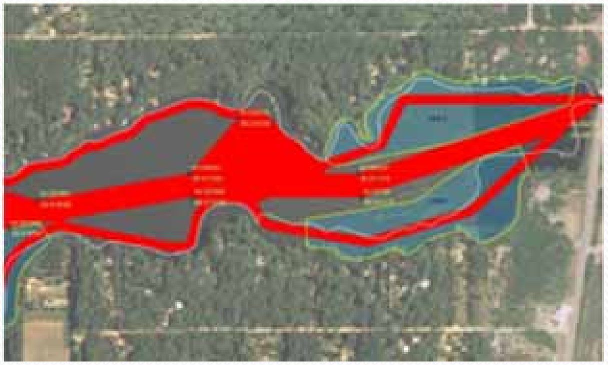
Integrated pest management (IPM) is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Pest control materials are selected and applied in a manner that minimizes risks to human health, beneficial and nontarget organisms, and the environment.

3 Main Concepts of IPM

- Decision making process
- Use all available pest management techniques
- Prevent damage from pests while reducing the risk to human health and the environment

Decision Making Process

- Use Scientific Research
  - Science based evaluations
  - Minimize anecdotes
- Social Impacts
  - Safety impacts
  - Economics
- Detailed Plans
  - Explain management options
  - How, when and where they will be implemented



Use all available techniques

- Mechanical
- Manual
- Chemical
- Biological
- Observation
- Prevention
- Water Levels

Hybridized (integrated) approach




Control While Minimizing Risks

- Use best management practices
- Use the right tools
- Robust evaluation
- Inform and educate – Share information!
- Policy

Making IPM Work

- Include in management plans
  - Consultants and sponsors work with agencies
  - Details
  - Follow plan with action
- Required in permits by WDNR
  - Obligated to IPM in WPDES
  - Embedded in NR 198.43 (grants)
- Monitor efficacy
  - Learn and employ (adaptive management)
  - Plan for future management

Aquatic Invasive Plant Control
AIS Grants

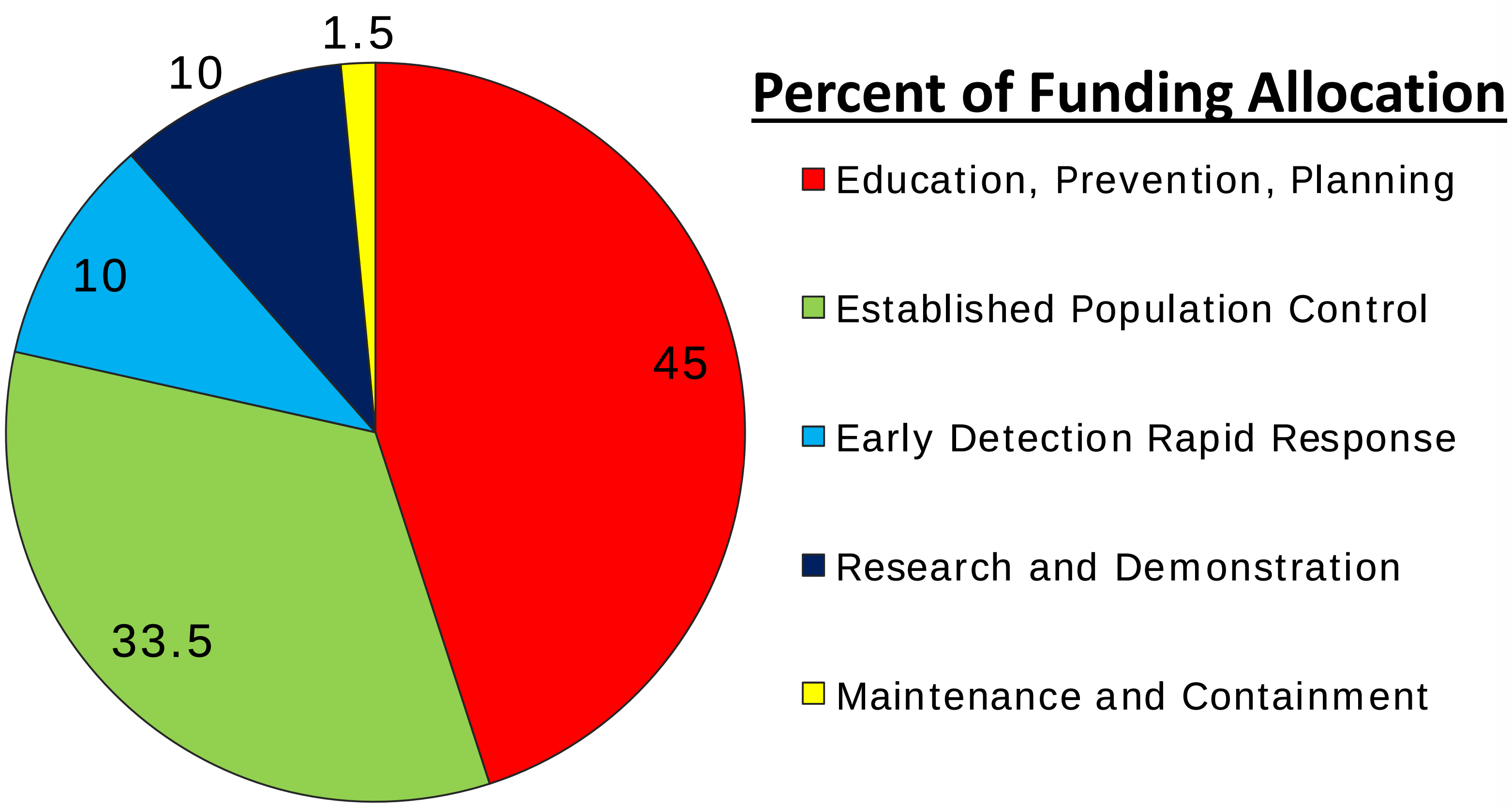
Scott Van Egeren
Lake and Reservoir Ecologist
Wisconsin Department of Natural Resources

Types of AIS Control Grants

- Early Detection, Rapid Response
- Established Population Control
- Maintenance and Containment
- Education, Prevention and Planning
- Research and Demonstration

AIS Grant Funding Allocation

Total funding = $5 million/year



Early Detection, Rapid Response

- Highest priority for funding
- $20K grant maximum
- Detection and control of relatively new and low coverage occurrences of AIS
  - <5% frequency and present less than five years
- Early detection monitoring for a new AIS in a region.
- A high likelihood of significant reduction and subsequently lower management costs.
- Activities likely include monitoring, hand removal, DASH or herbicide treatments.

Education, Prevention and Planning

- Grant caps range depending on activities.
  - $10K – education or plan updates
  - $50K – development of AIS plans
  - $200K – regional AIS coordination/planning
- **Create AIS control plans**
- Watercraft inspection for AIS containment or prevention.
- Monitoring of AIS **(including management evaluation).**

Established Population Control

- $200K grant maximum
- Goal: Control substantial AIS populations.
- Funds management recommendations from an approved AIS/lake management plan.
- Maximize AIS control and minimize damage to native aquatic plants.
- Activities likely include whole-lake or large-scale herbicide treatments or drawdown.

Established Population Control

- Good projects will include:
  - Clean Boats, Clean Waters for containment
  - Target levels of control needed to restore lake uses
  - Quantitative surveys the year before management
  - Large-scale or whole-lake AIS management
  - Herbicide concentration monitoring for evaluation
  - Quantitative surveys following management
  - Report comparing pre and post surveys…
    - Were target levels of control met?
    - What were the impacts to native species?
  - A strategy for maintaining suppressed population after control target is reached.

Maintenance and Containment

- Cover the cost of APM permit fees.
- Ongoing control of a suppressed population following substantial control.
  - Target level of control from plan has been met.
  - Prevent population from…
    - re-establishing throughout the lake.
    - spreading to other lakes (containment).
    - impairing lake uses (swimming, fishing, boating)
- Activities may include spot treatments, DASH or hand pulling.
- Good projects will follow whole-lake management and spend the funding on management activities.
- The control areas will likely be too small to monitor for effectiveness.

Grants Code Revision

- Opportunities for involvement

DNR Surface Water Grants: What's on the Horizon?

Thursday 2:35-3:15 pm

Q&A Panel