Eurasian watermilfoil research & management in Wisconsin

Wisconsin Lakes Convention
Stevens Point, WI
April 23-25, 2015

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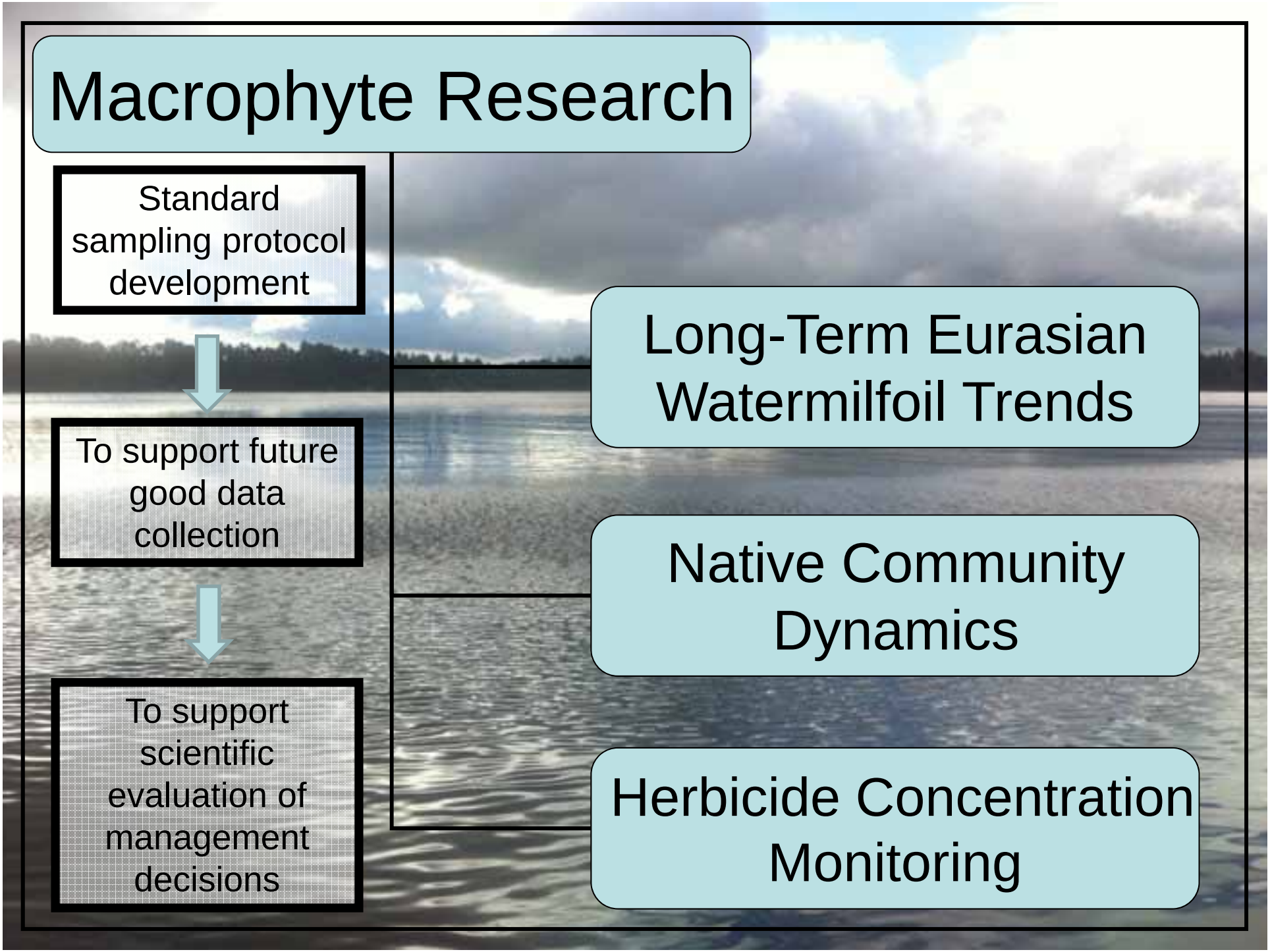
Wisconsin Department of Natural Resources


Macrophyte Research
Standard sampling protocol development
To support future good data collection
To support scientific evaluation of management decisions
Long-Term Eurasian Watermilfoil Trends
Native Community Dynamics
Herbicide Concentration Monitoring

Eurasian Watermilfoil Study

What:

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

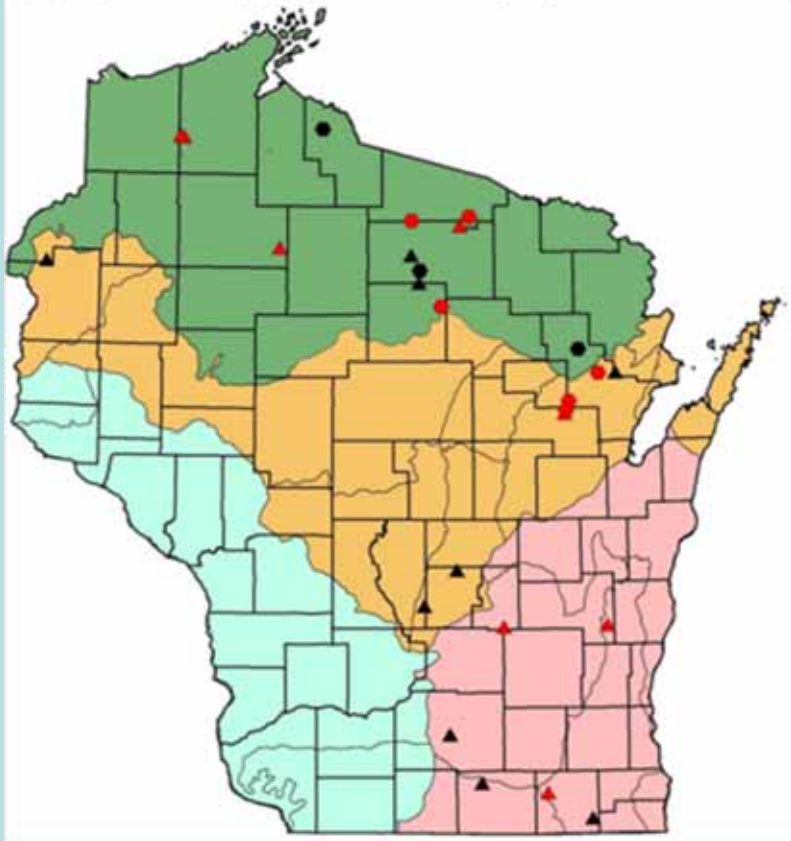
Purpose:

Create a baseline long-term dataset on EWM populations over time

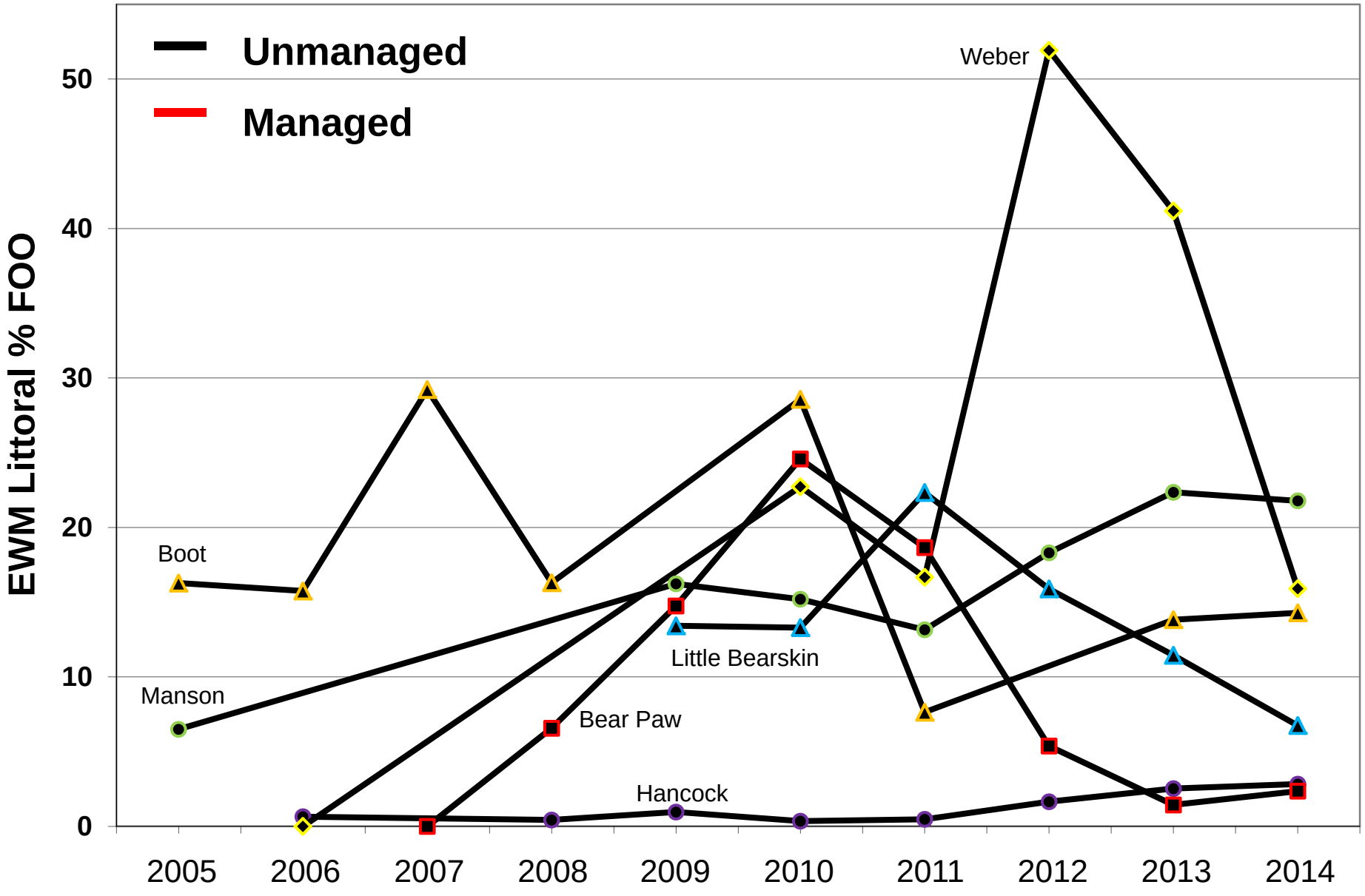
Output:

Long-term temporal and spatial EWM & natives trends

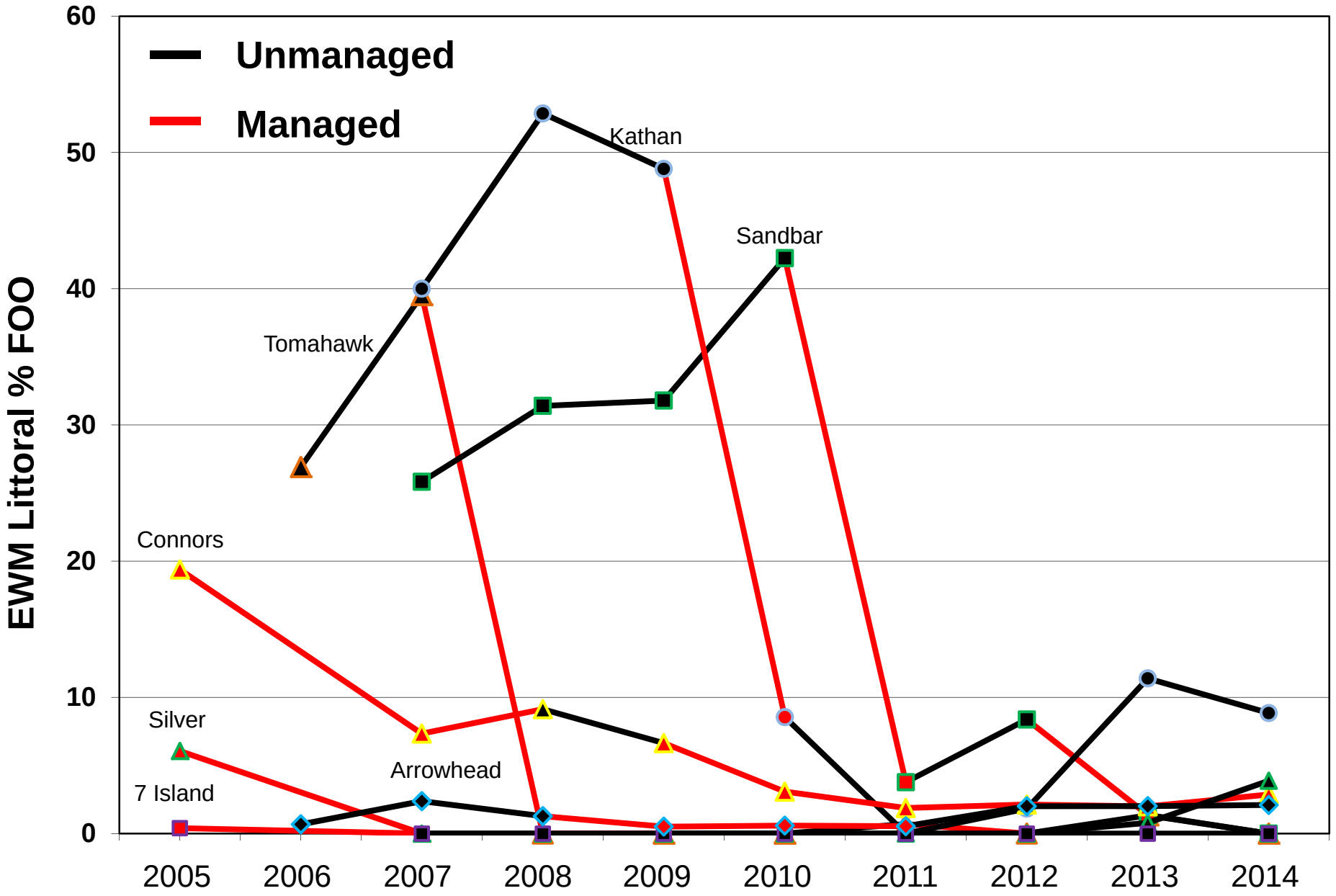
- Annual aquatic plant survey & biomass collection on 24 lakes over time
- 3 ecoregions, established and new populations, managed and unmanaged



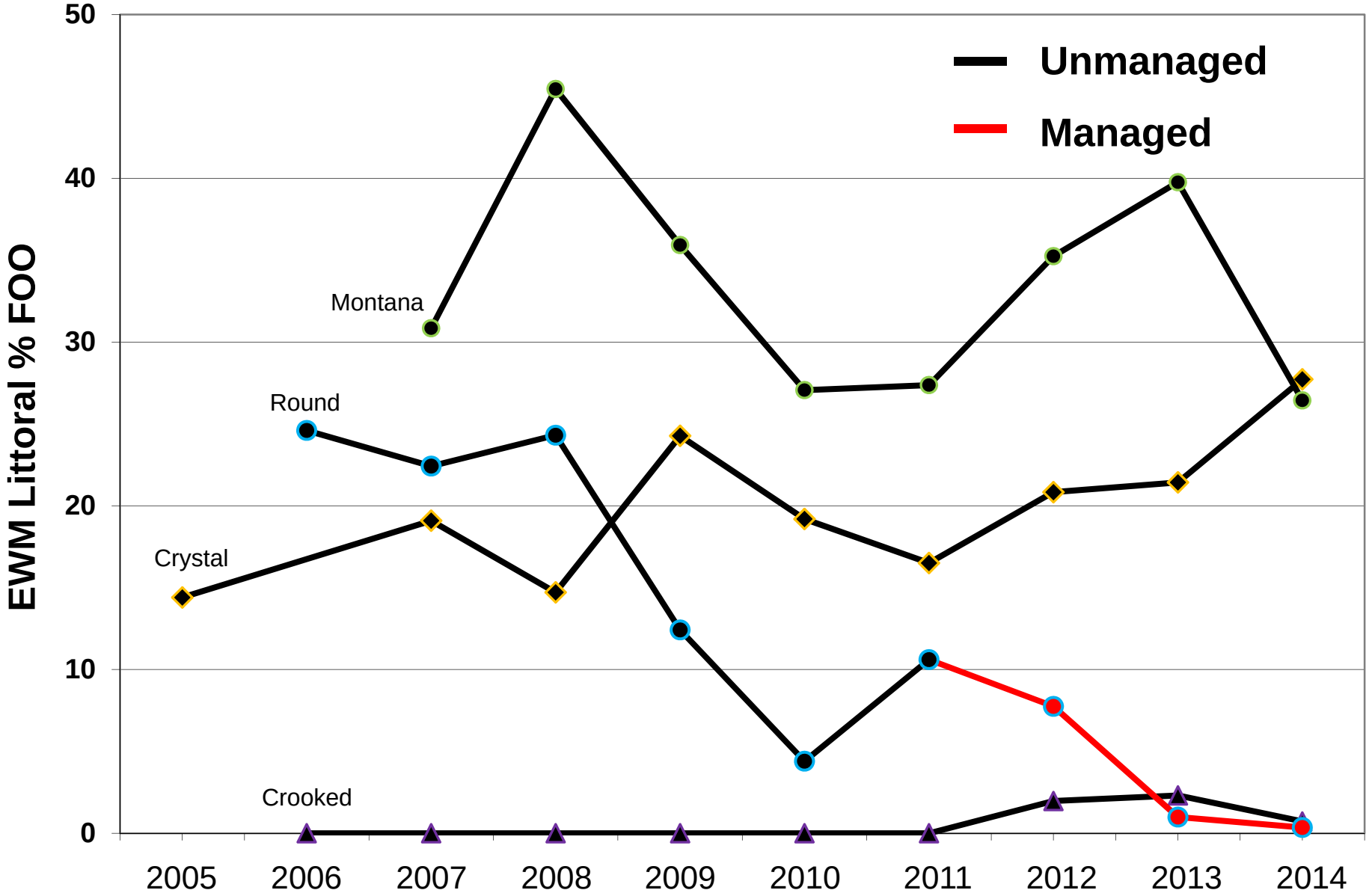
Northern Lakes & Forests



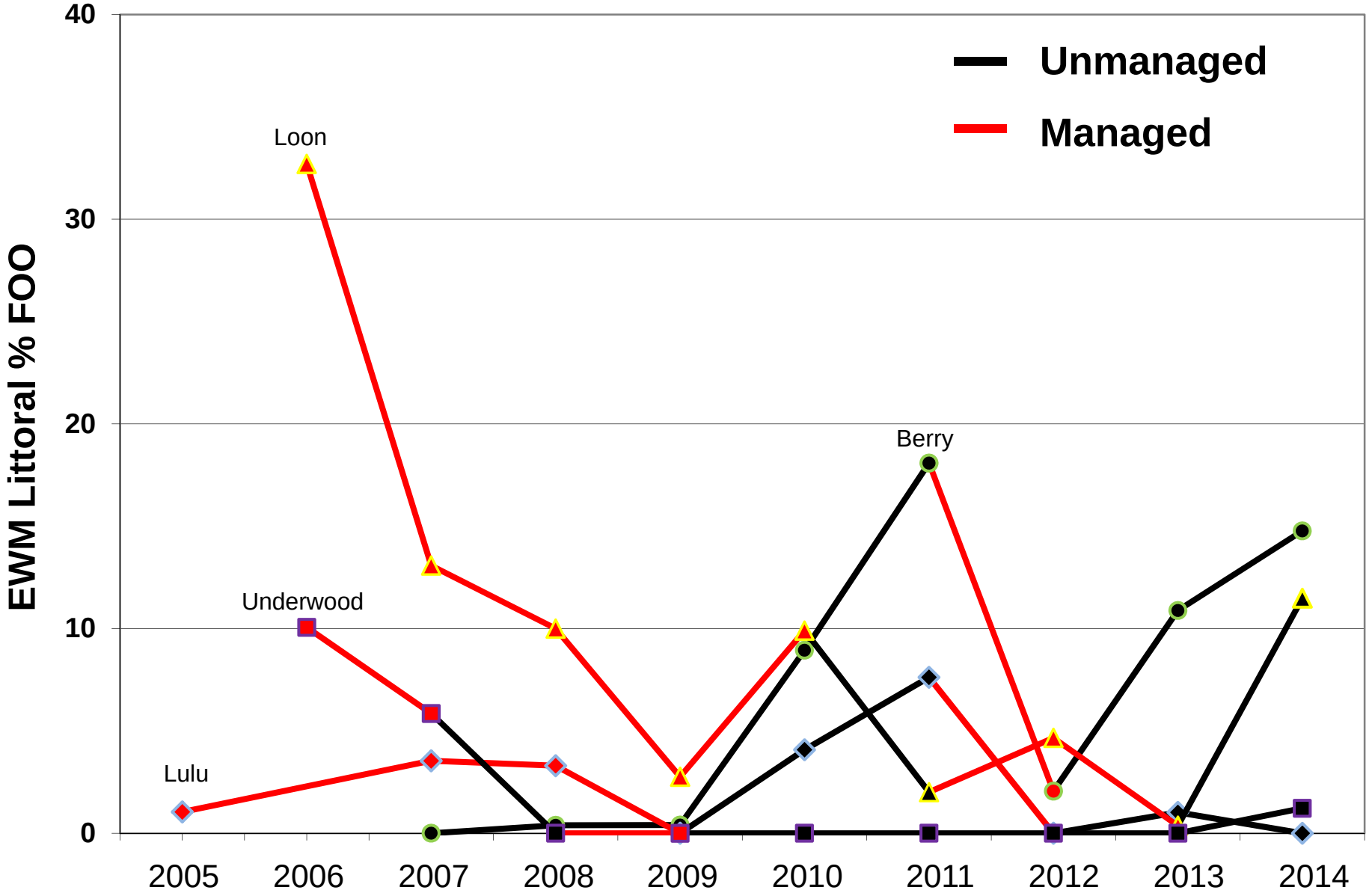
Northern Lakes & Forests



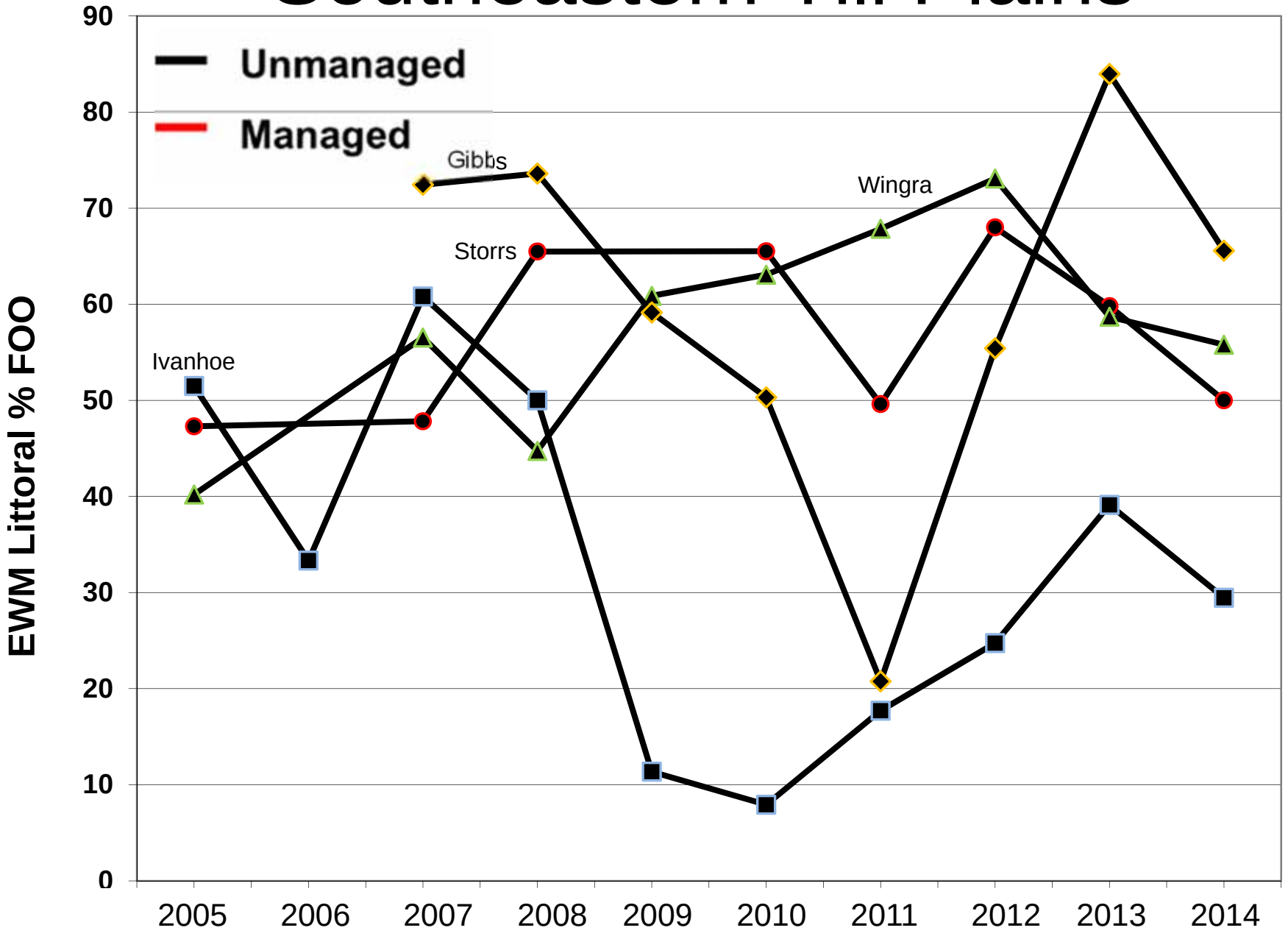
North Central Hardwood Forest



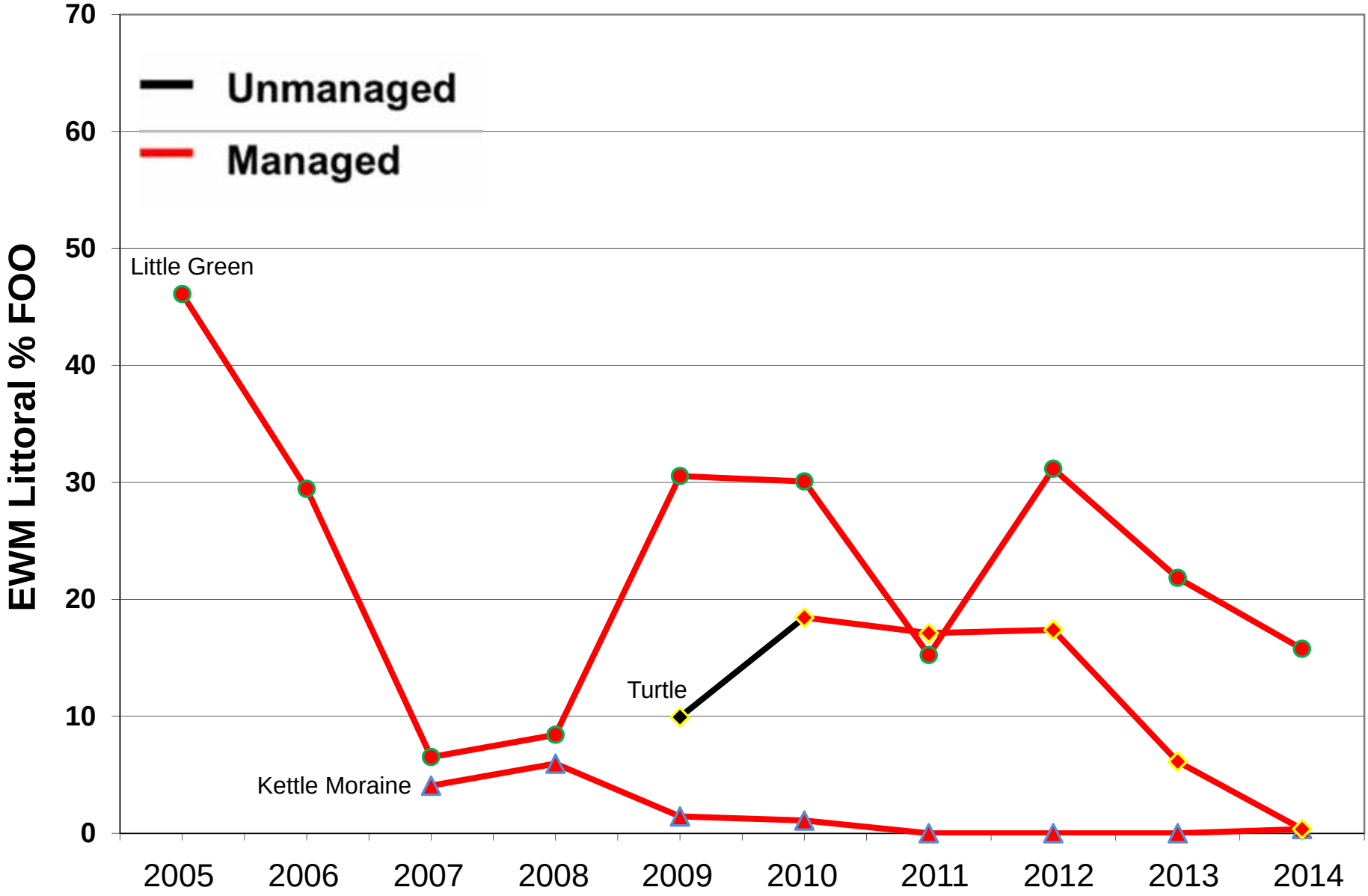
North Central Hardwood Forest



Southeastern Till Plains

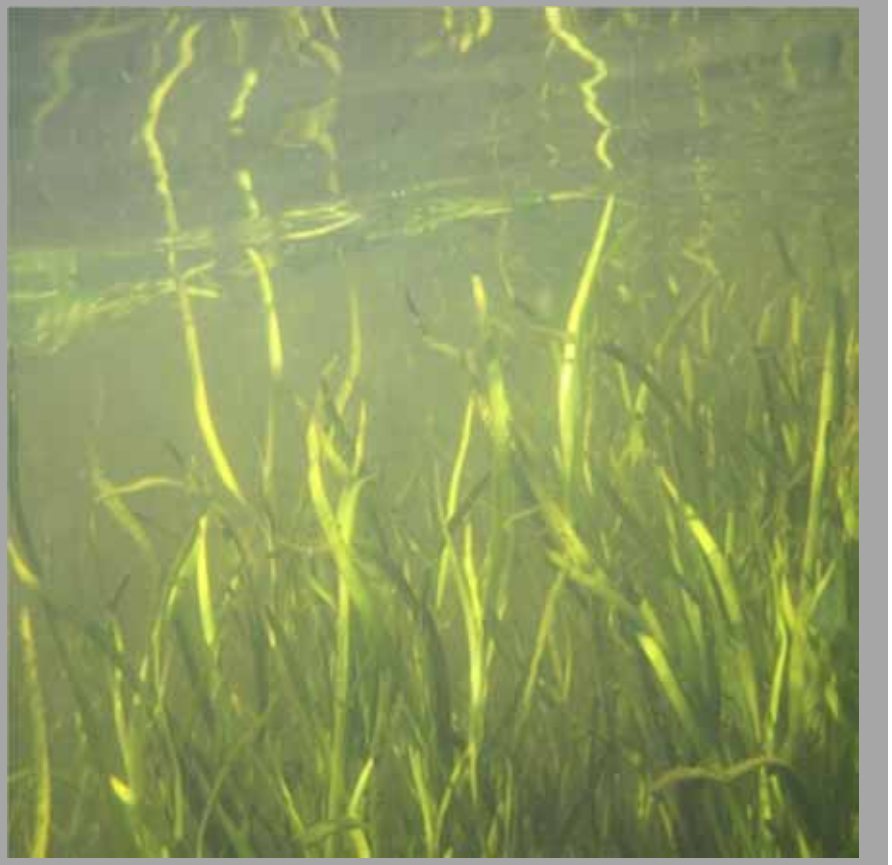


Southeastern Till Plains

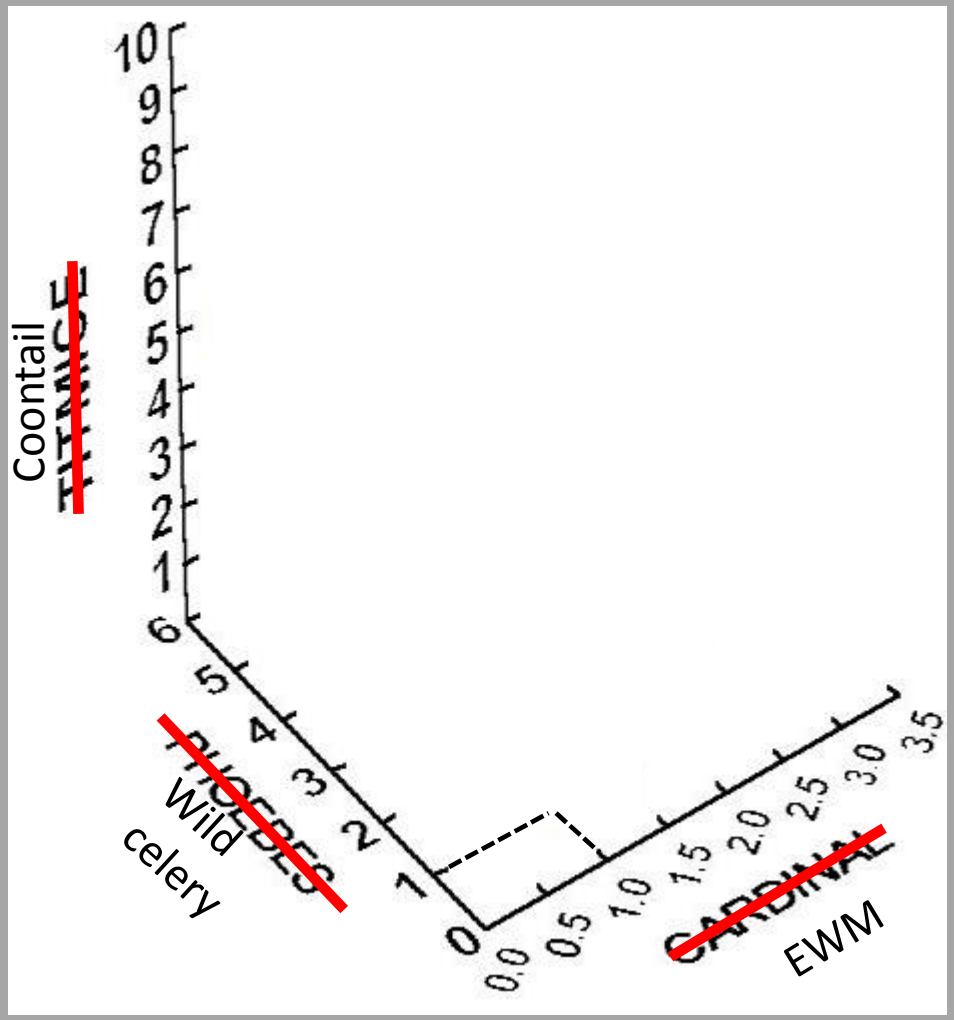


Methods of Assessing Native Communities

- Close to 100 species of aquatic plants in WI
- A lake often contains 20-30 species
- Analyzing single species is "inefficient, awkward, and unsatisfying." (McCune and Grace, 2002)



Community Distance



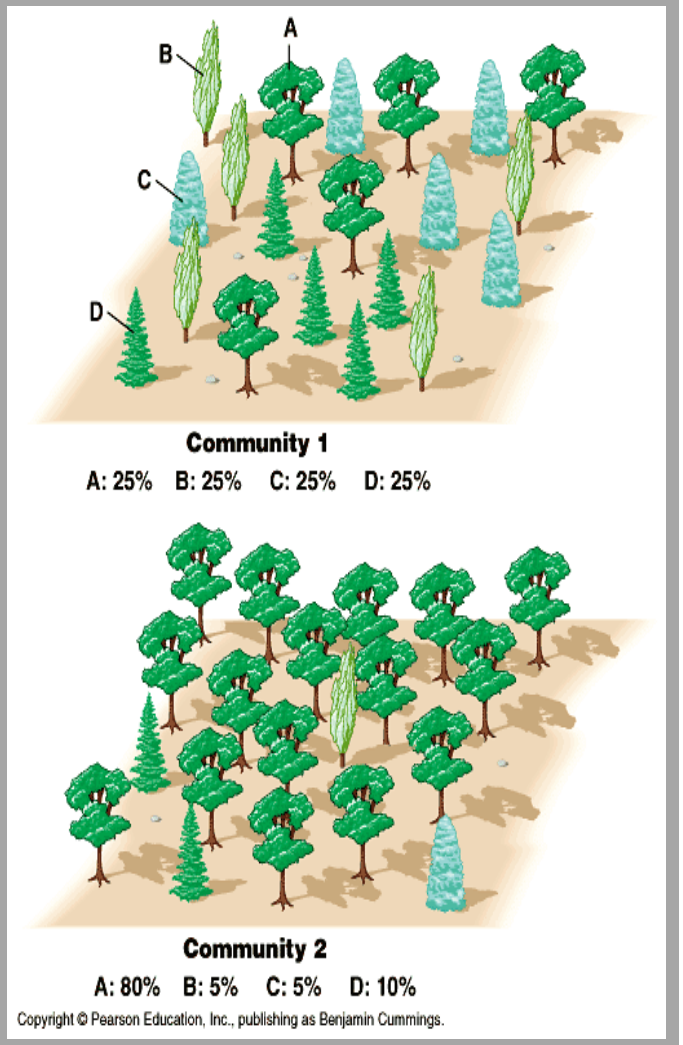
Community Similarity / Dissimilarity

- Looks at species and abundance in common

$D = 1 – (2 * sum(C) / S_1 + S_2)$

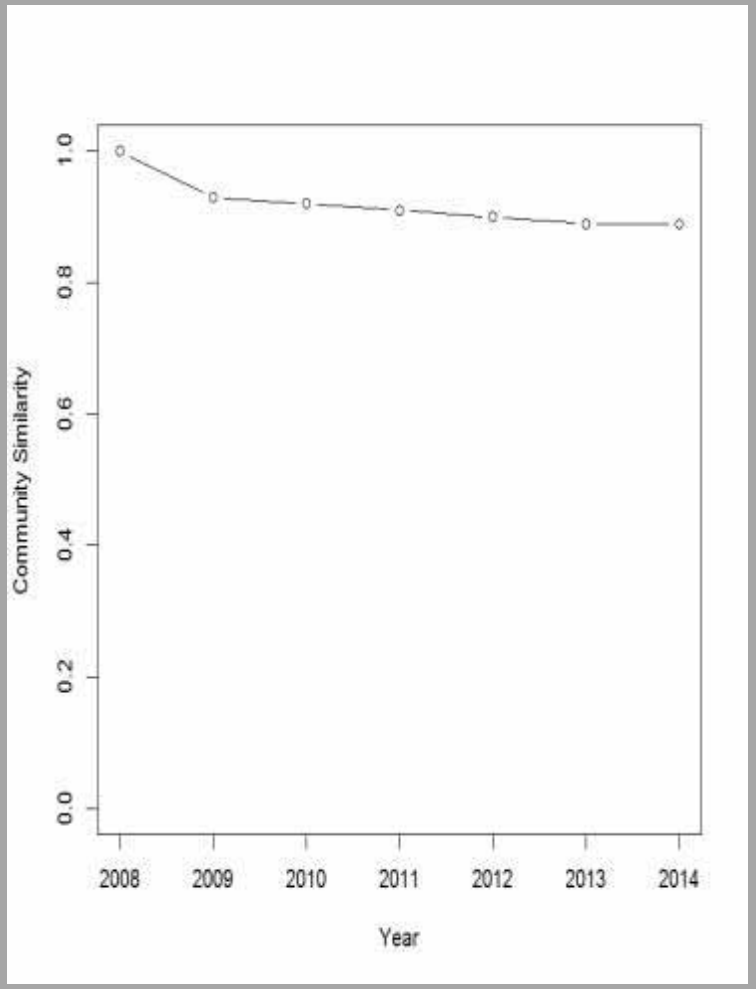
$D = 1 – [2 * (5 + 1 + 1 + 2) / (20 + 20)]$

$= 0.55$



Similarity / Dissimilarity Across Time

- Can perform this for lakes across time
- Should indicate major shifts in overall community



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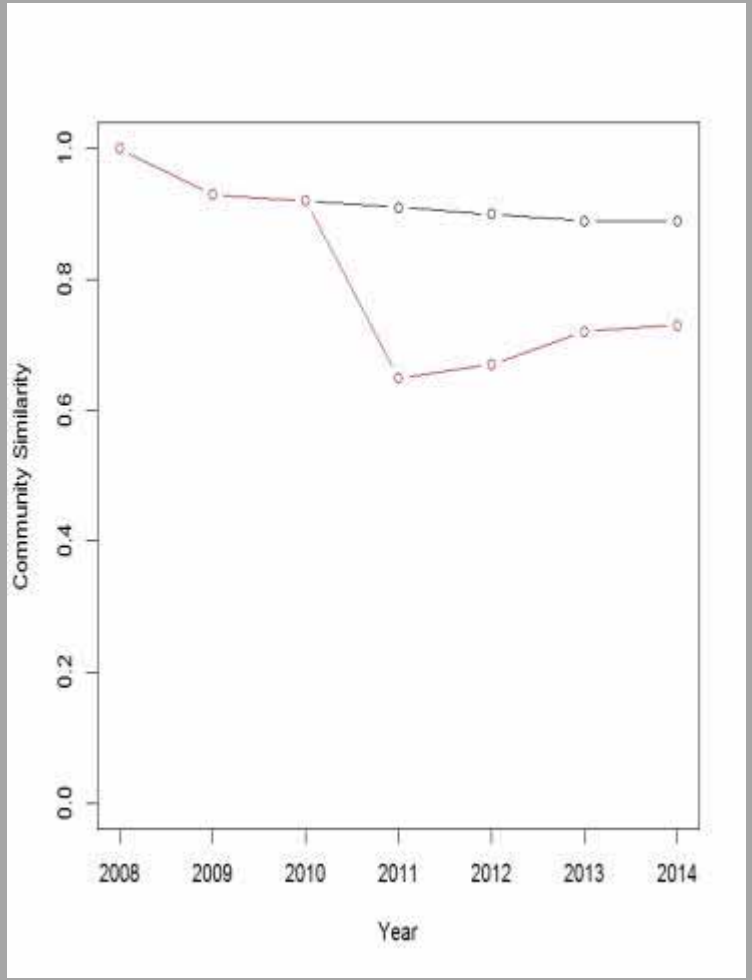
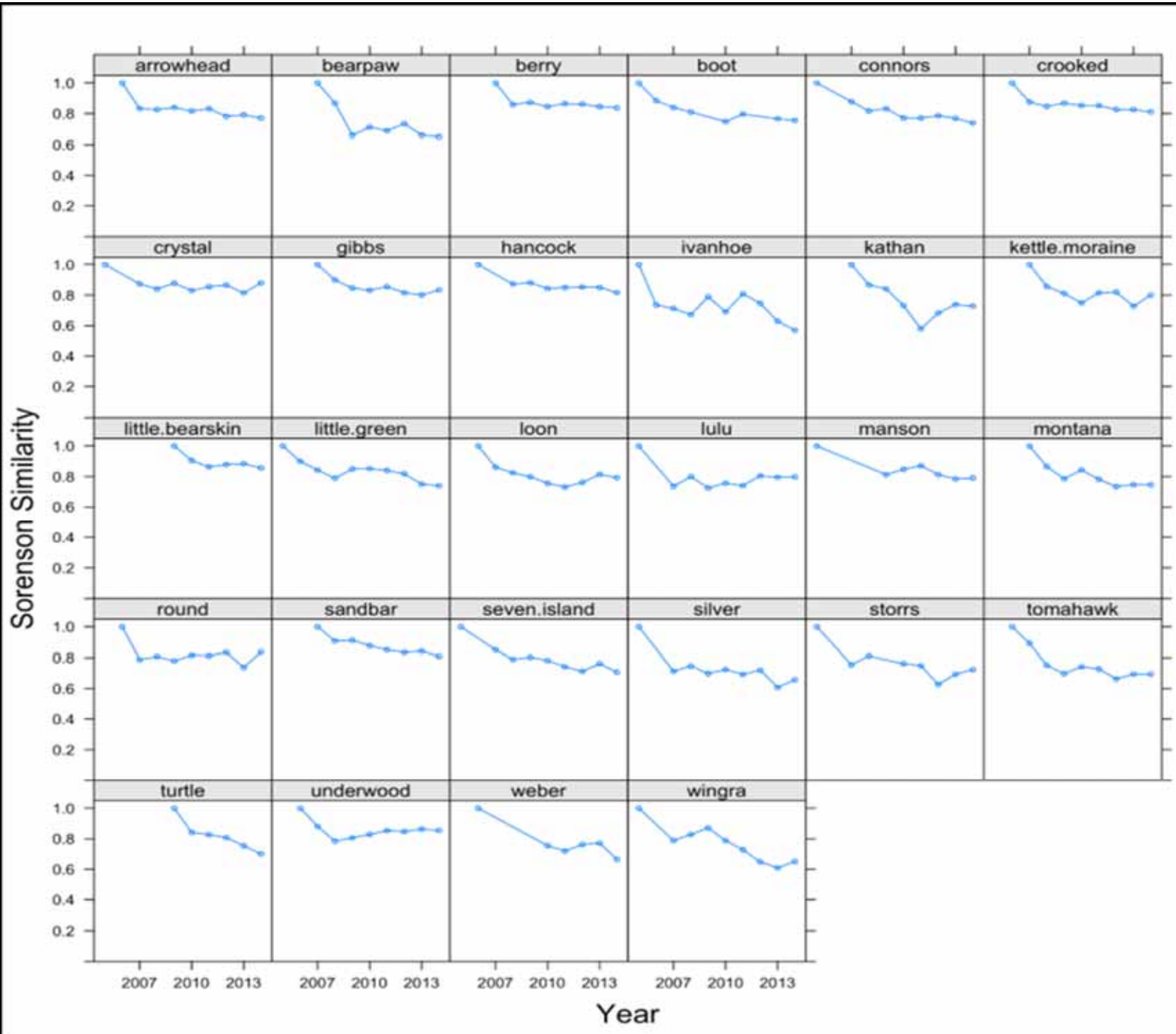
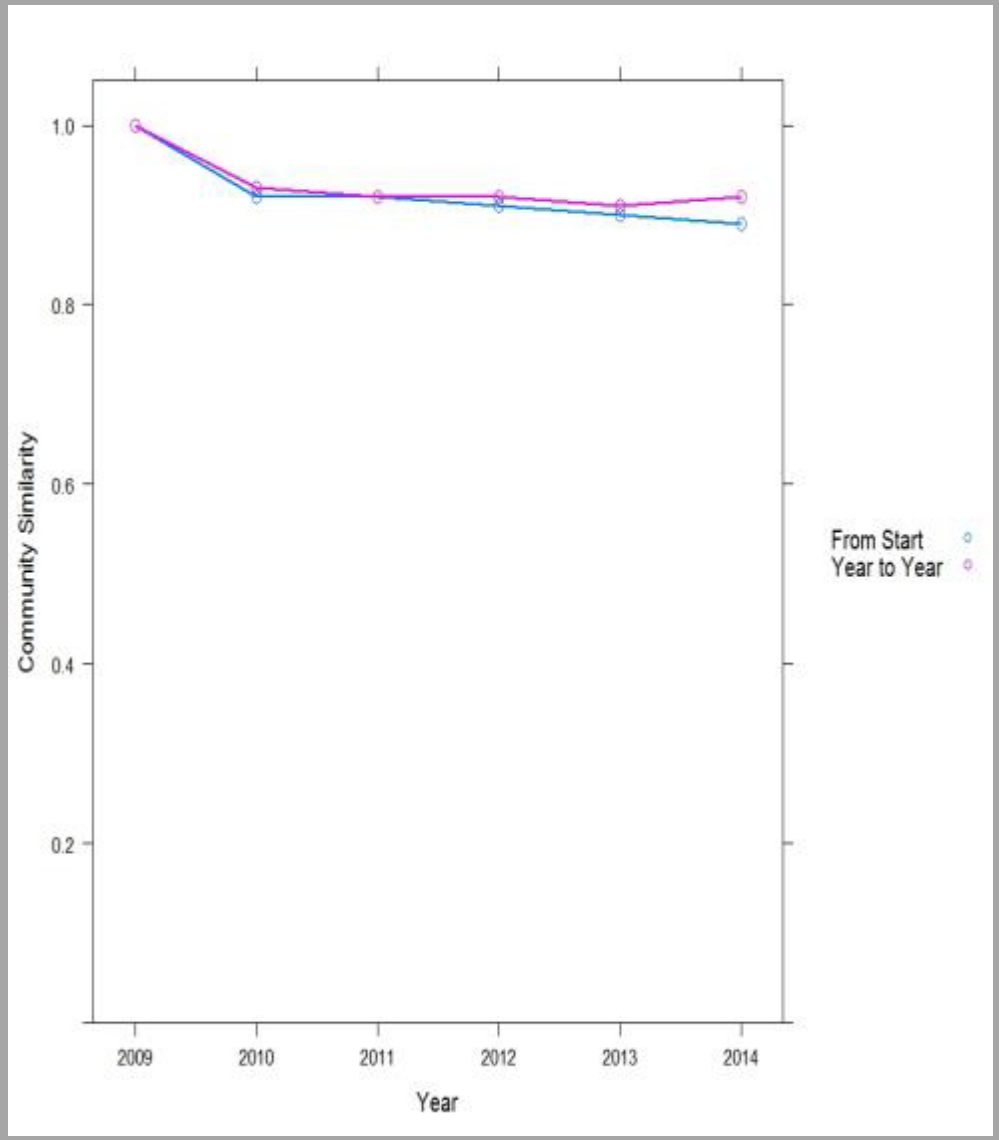


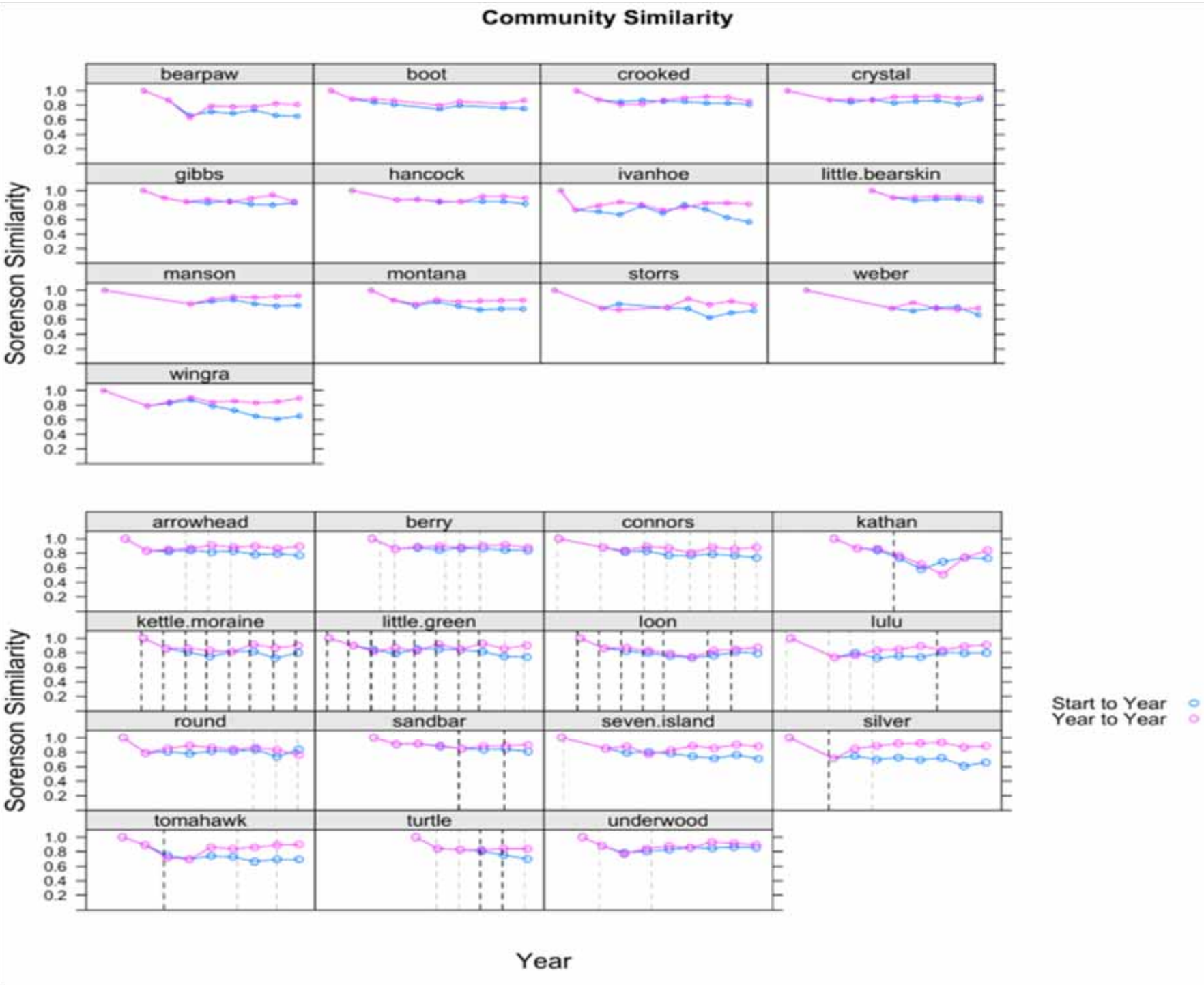

arrowhead
bearpaw
berry
boot
connors
crooked
crystal
gibbs
hancock
ivanhoe
kathan
kettle.moraine
little.bearskin
little.green
loon
lulu
manson
montana
round
sandbar
seven.island
silver
storrs
tomahawk
turtle
underwood
weber
wingra
Sorenson Similarity
1.0
0.8
0.6
0.4
0.2
2007
2010
2013
Year

Community Similarity Matrix

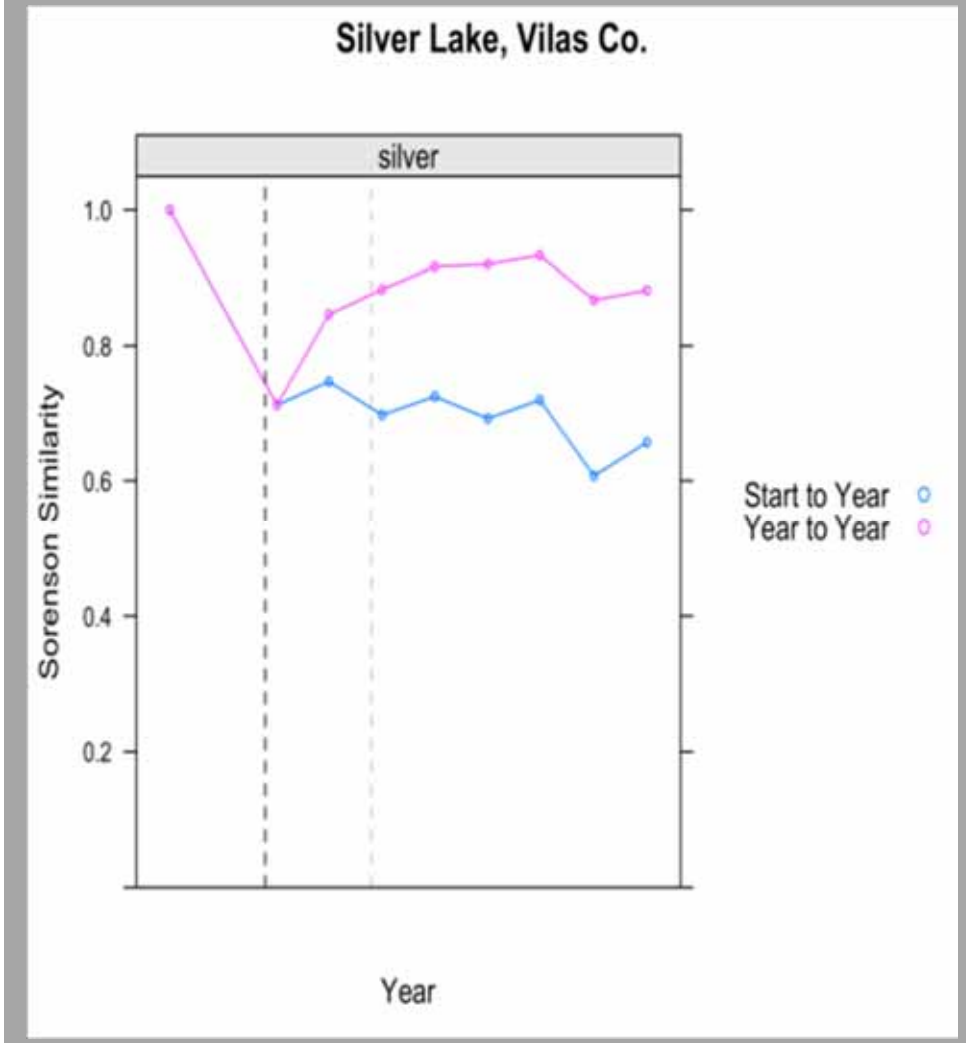
	2010	2011	2012	2013	2014
2010	1.00				
2011	.93	1.00			
2012	.92	.95	1.00		
2013	.90	.87	.93	1.00	
2014	.88	.85	.88	.93	1.00

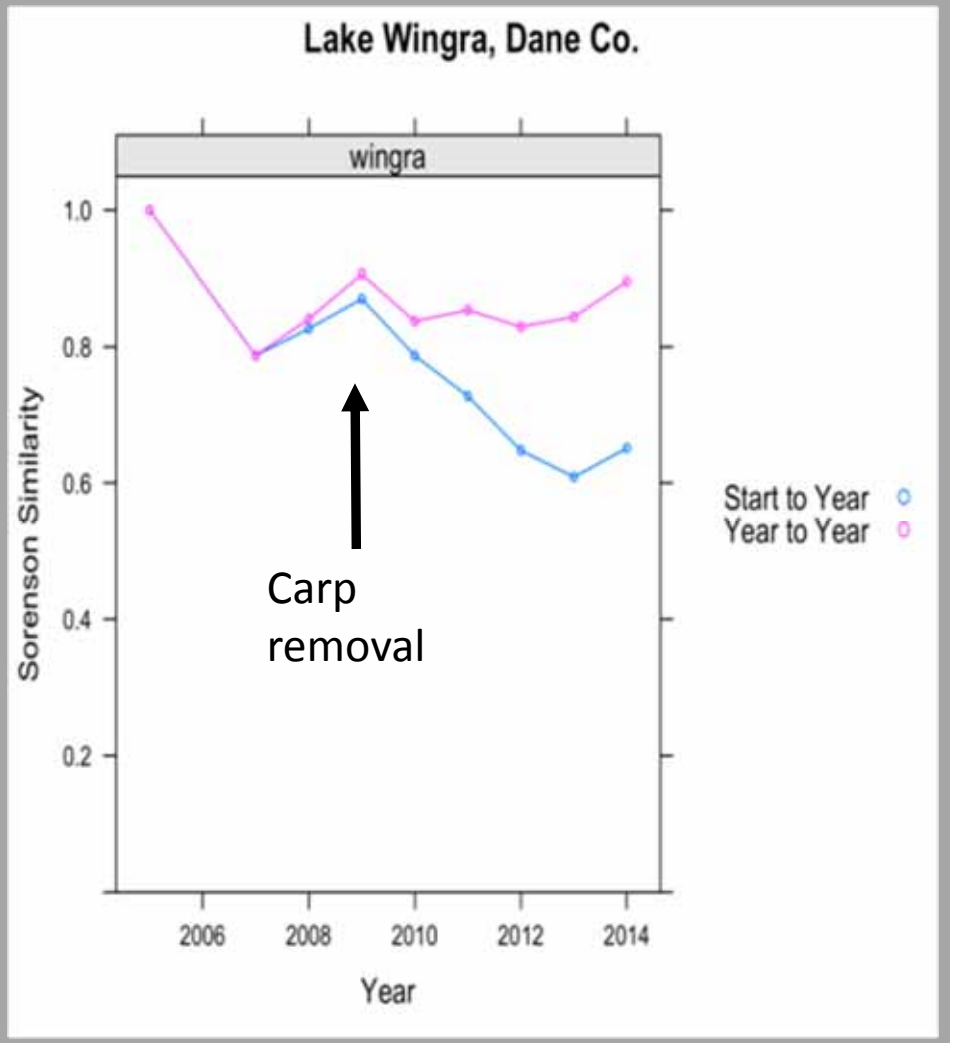
Similarity / Dissimilarity Across Time




Community Similarity
bearpaw
boot
crooked
crystal
gibbs
hancock
ivanhoe
little.bearskin
manson
montana
storrs
weber
wingra
arrowhead
berry
connors
kathan
kettle.moraine
little.green
loon
lulu
round
sandbar
seven.island
silver
tomahawk
turtle
underwood
Sorenson Similarity
1.0
0.8
0.6
0.4
0.2
Year
Start to Year
Year to Year

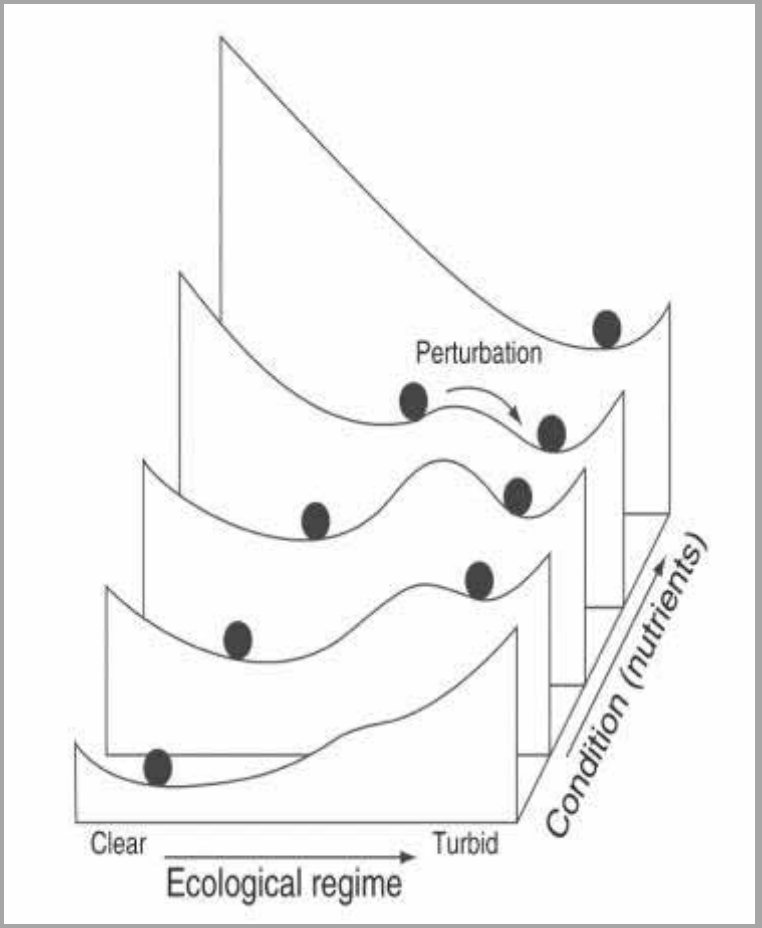
Long-term vs. Yearly Change





Alternative Stable States

- A shift from one state to another (May 1977)
- Due to perturbation of system

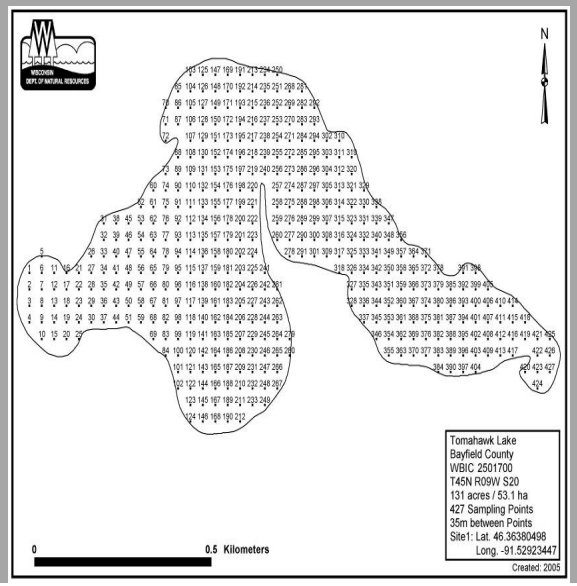


Tomahawk and Sandbar Lakes

Study design

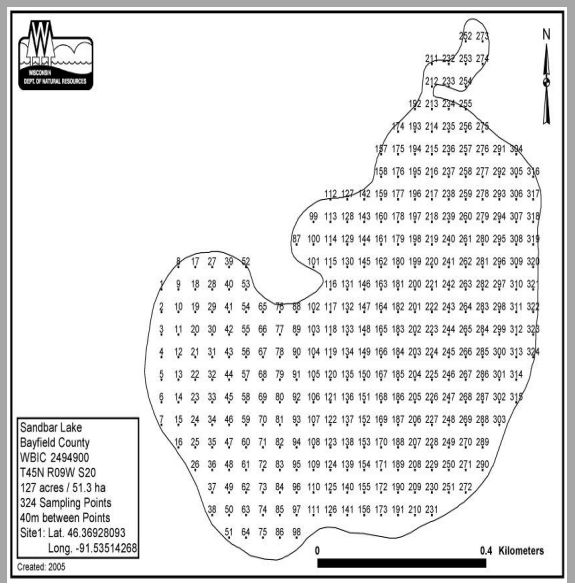
Tomahawk

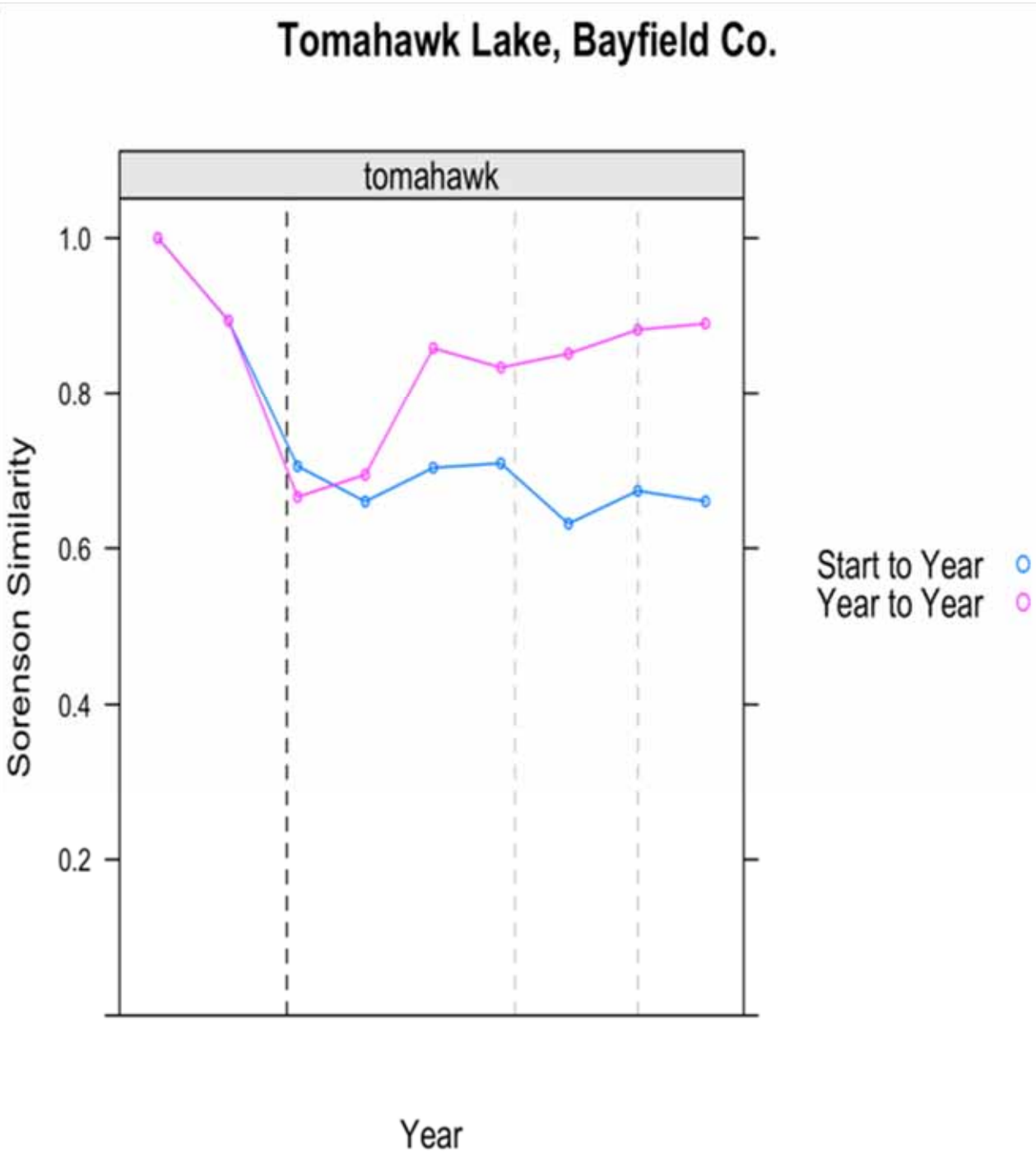
- Low dose liquid 2,4-D (0.5 ppm) treatment to whole lake (May 20, 2008)
- Aquatic plant surveys conducted 2006-2014
- Biomass collected during 2007-2014 surveys

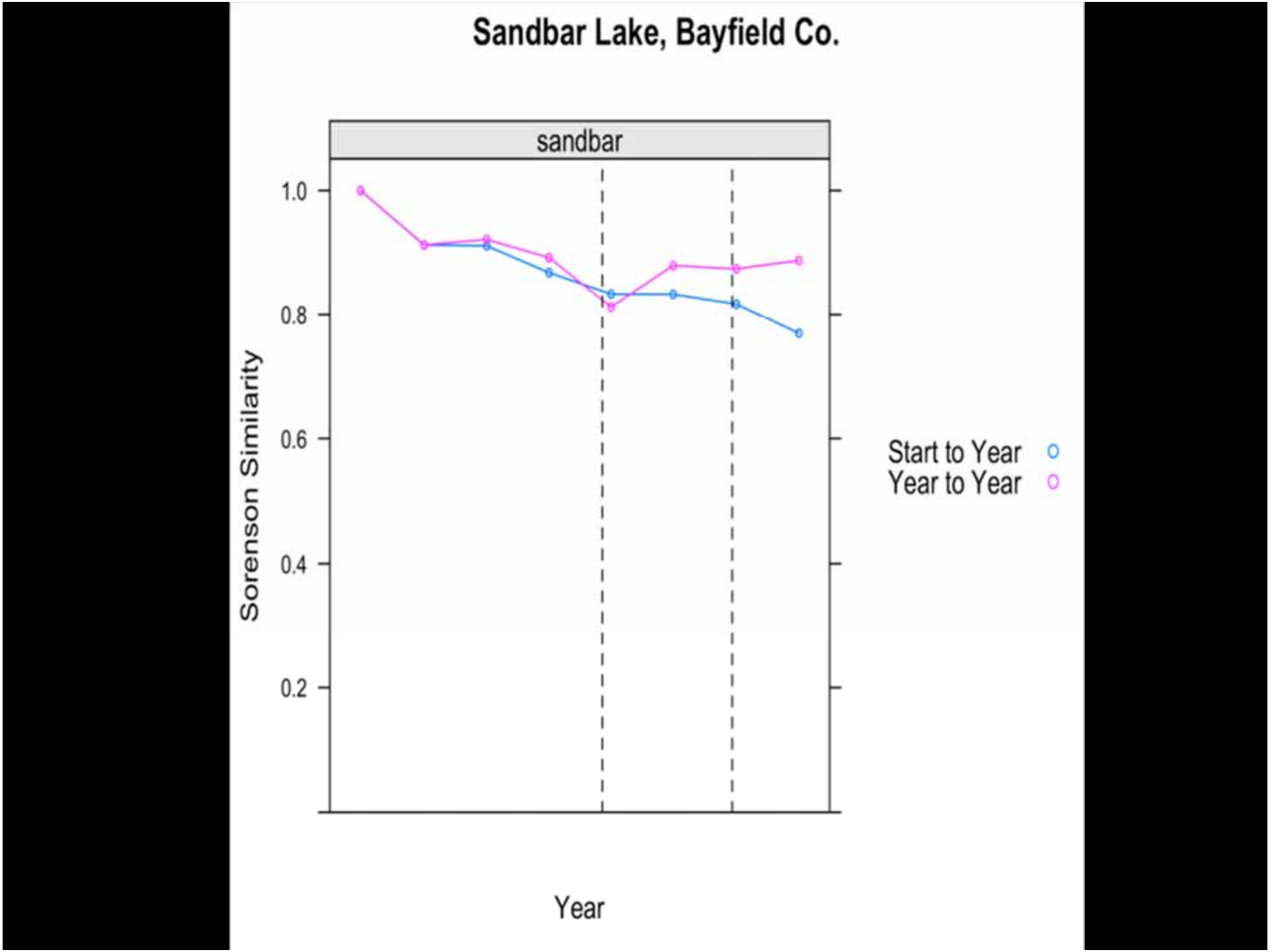


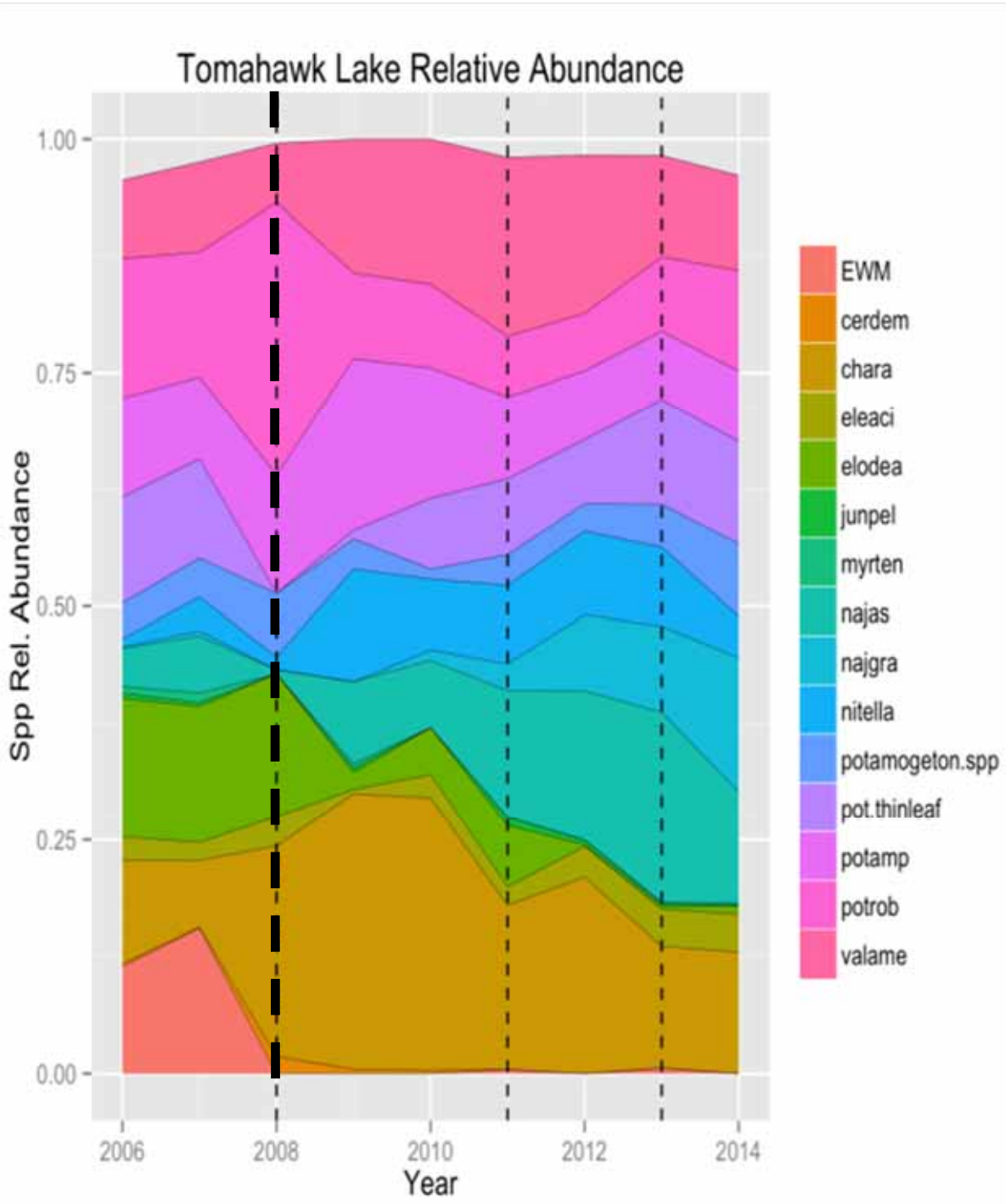
Sandbar

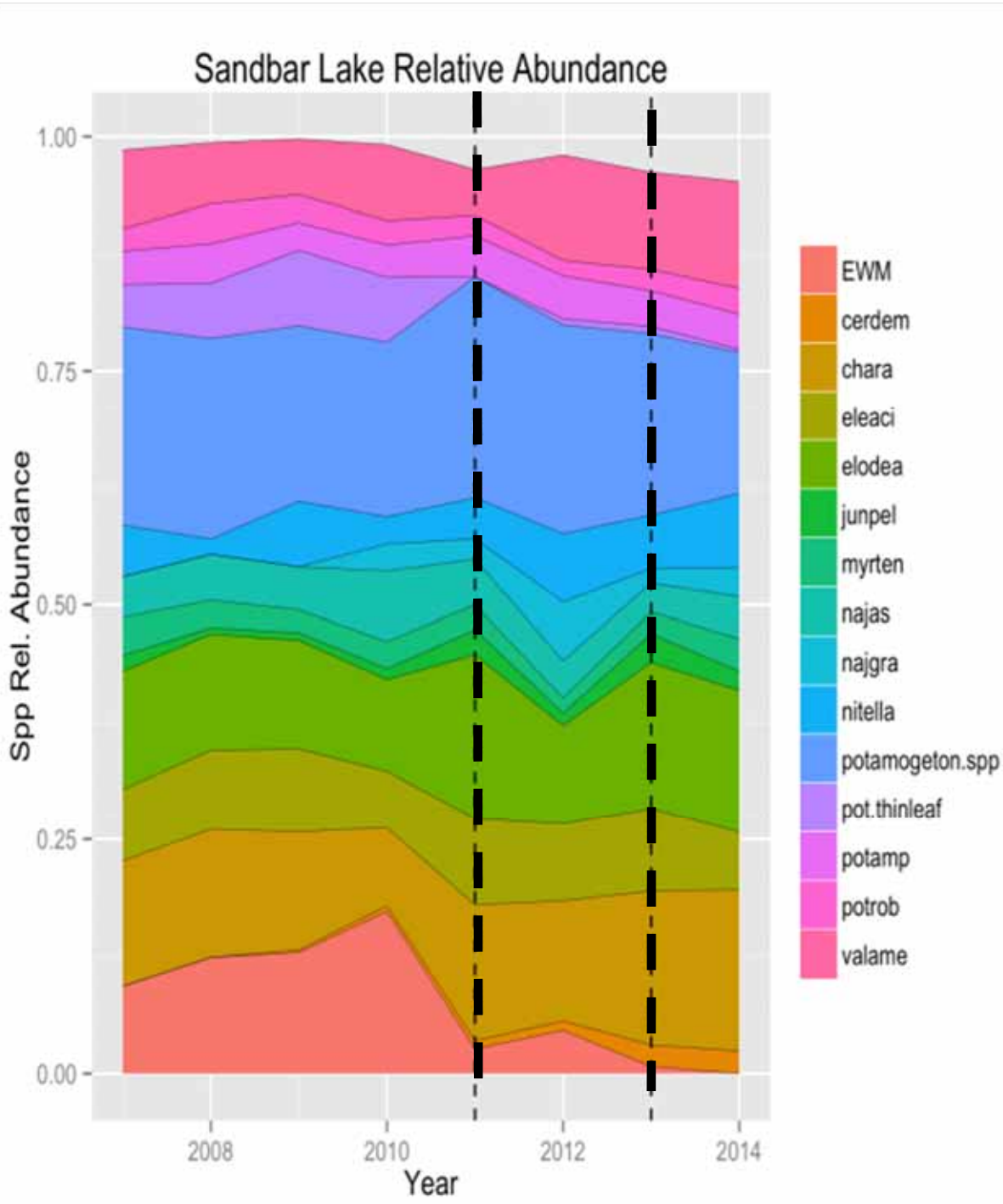
- Reference lake – no treatment (2007 - 2010)
- Low dose liquid 2,4-D (0.275 ppm) treatment to whole lake epilimnion (spring 2011 & 2013)
- Aquatic plant surveys and biomass collected during 2007-2014




Tomahawk Lake, Bayfield Co.
tomahawk
1.0
0.8
0.6
0.4
0.2
Sorenson Similarity
Year
Start to Year
Year to Year


Sandbar Lake, Bayfield Co.
sandbar
1.0
0.8
0.6
0.4
0.2
Sorenson Similarity
Year
Start to Year
Year to Year


Tomahawk Lake Relative Abundance
Spp Rel. Abundance
1.00
0.75
0.50
0.25
0.00
2006
2008
2010
2012
2014
Year
EWM
cerdem
chara
eleaci
elodea
junpel
myrten
najas
najgra
nitella
potamogeton.spp
pot.thinleaf
potamp
potrob
valame


Sandbar Lake Relative Abundance
1.00
0.75
0.50
0.25
0.00
Spp Rel. Abundance
2008
2010
2012
2014
Year
EWM
cerdem
chara
eleaci
elodea
junpel
myrten
najas
najgra
nitella
potamogeton.spp
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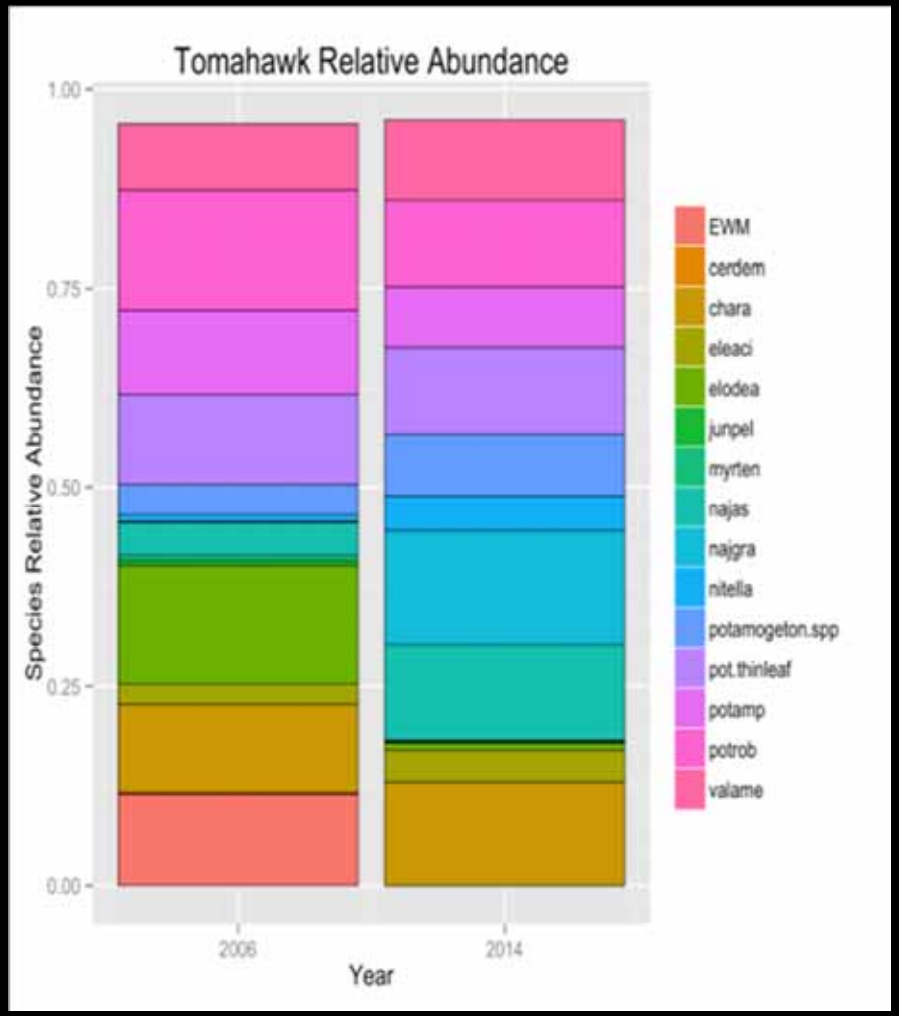
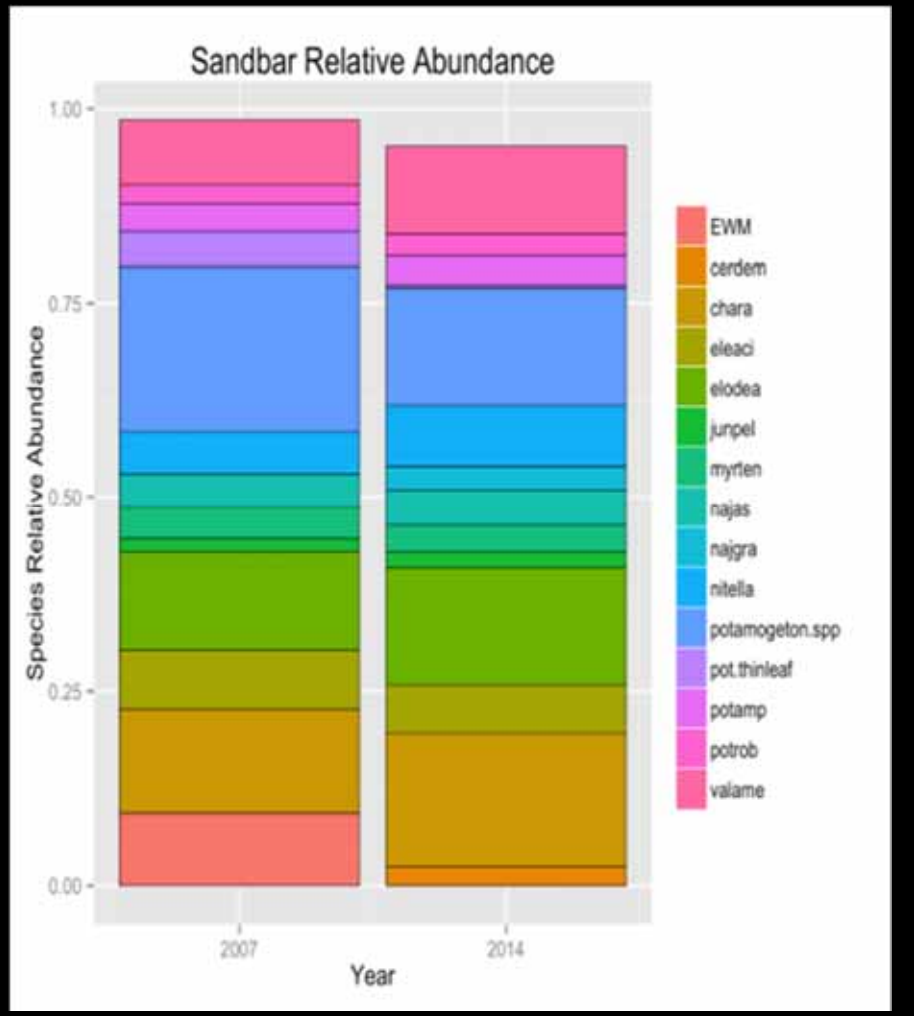
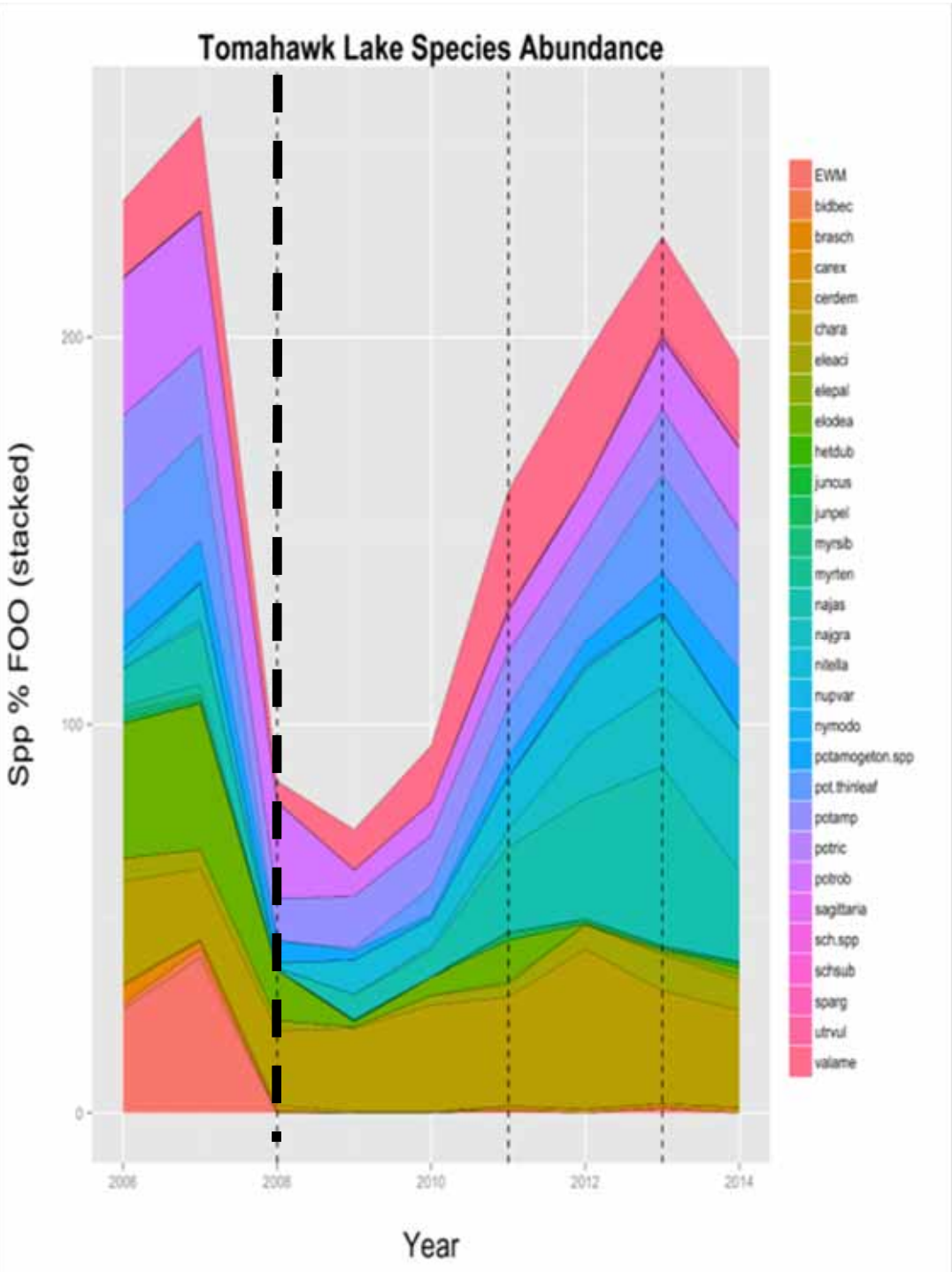
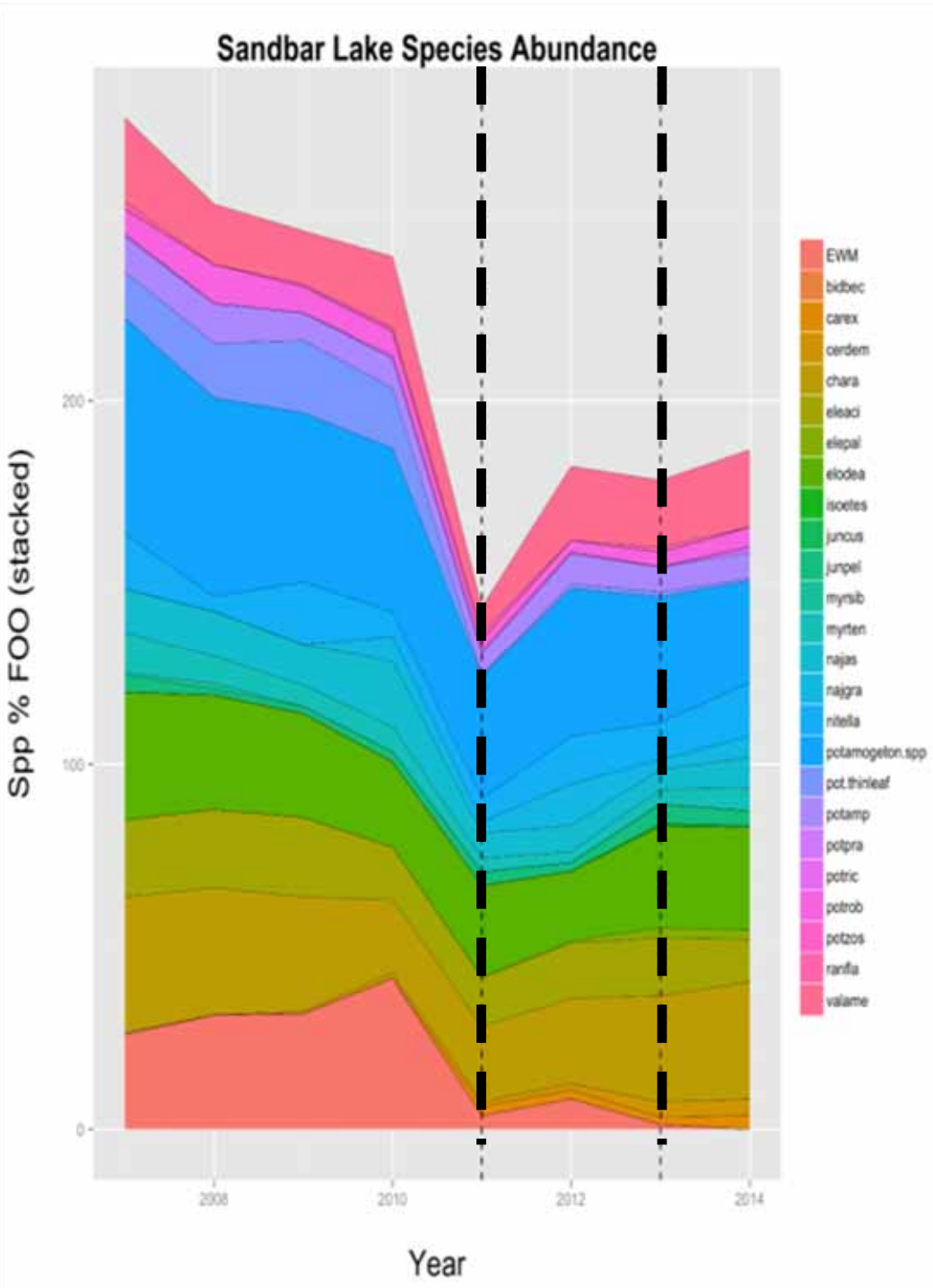
potamp
potrob
valame

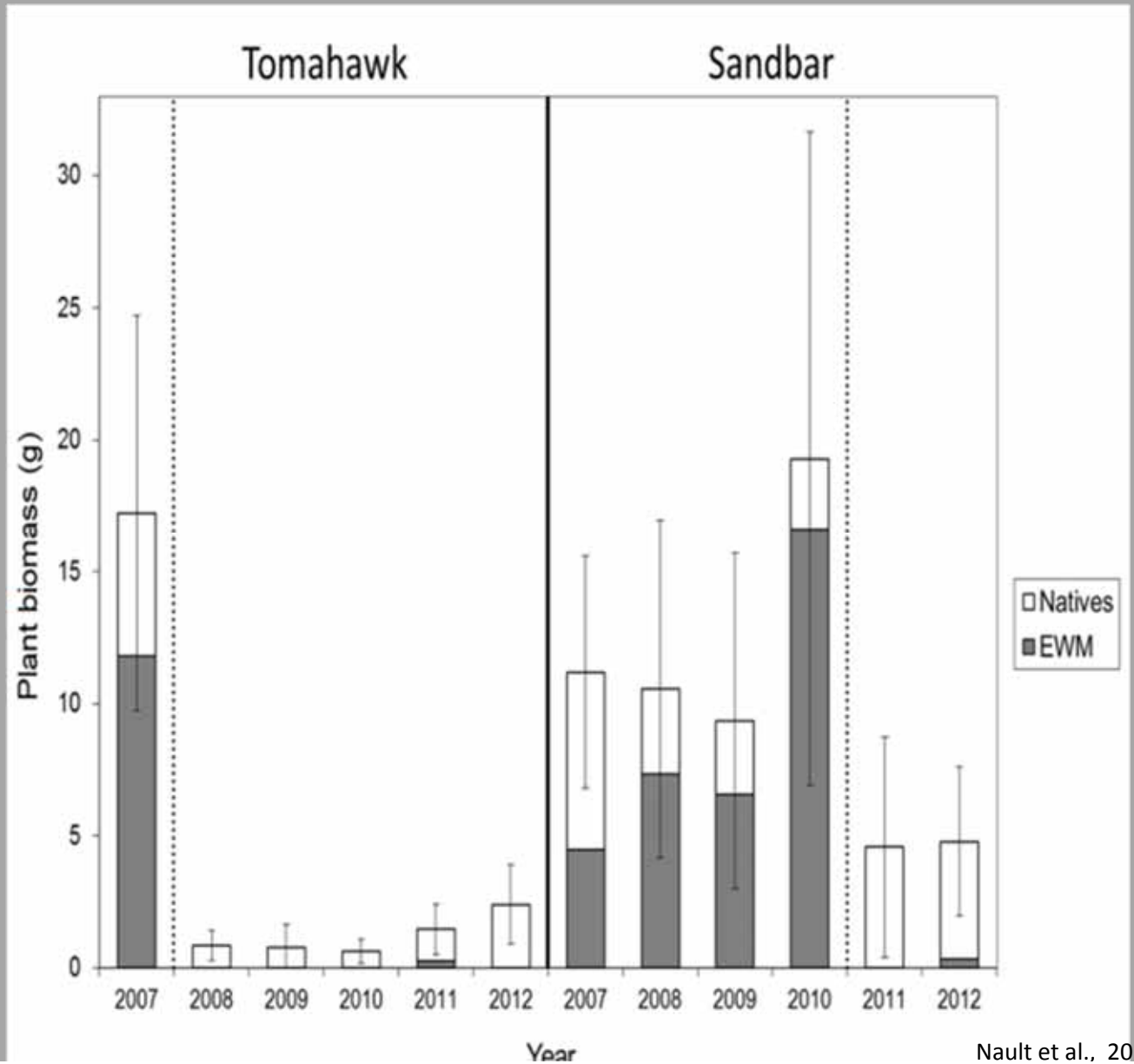

Tomahawk Relative Abundance
Species Relative Abundance
1.00
0.75
0.50
0.25
0.00
2006
2014
Year
EWM
cerdem
chara
eleaci
elodea
junpel
myrten
najas
najgra
nitella
potamogeton.spp
pot.thinleaf
potamp
potrob
valame


Sandbar Relative Abundance
Species Relative Abundance
1.00
0.75
0.50
0.25
0.00
2007
2014
Year
EWM
cerdem
chara
eleaci
elodea
junpel
myrten
najas
najgra
nitella
potamogeton.spp
pot.thinleaf
potamp
potrob
valame


Tomahawk Lake Species Abundance
Spp % FOO (stacked)
200
100
0
2006
2008
2010
2012
2014
Year
EWM
bidbec
brasch
carex
cerdem
chara
eleaci
elepal
elodea
hetdub
juncus
junpel
myrsib
myrten
najas
najgra
nitella
nupvar
nymodo
potamogeton.spp
pot.thinleaf
potamp
potric
potrob
sagittaria
sch.spp
schsub
sparg
utrvul
valame


Sandbar Lake Species Abundance
Spp % FOO (stacked)
200
100
0
2008
2010
2012
2014
Year
EWM
bidbec
carex
cerdem
chara
eleaci
elepal
elodea
isoetes
juncus
junpel
myrsib
myrten
najas
najgra
nitella
potamogeton.spp
pot.thinleaf
potamp
potpra
potric
potrob
potzos
ranfla
valame

Tomahawk/Sandbar Biomass



Nault et al., 2014. Lake & Res. 30:1-10

Conclusions

- Native aquatic plant communities change over time due to variable factors
- It is difficult to assert these changes to "management"; some cases exist where this likely is the reason (e.g. Tomahawk)
- The possibility exists of an alternative stable state in some of these systems
- Scale of "management" is important

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)

Barton et al. 2013. Turville Bay Report. (PUB-SS-1120 2013)

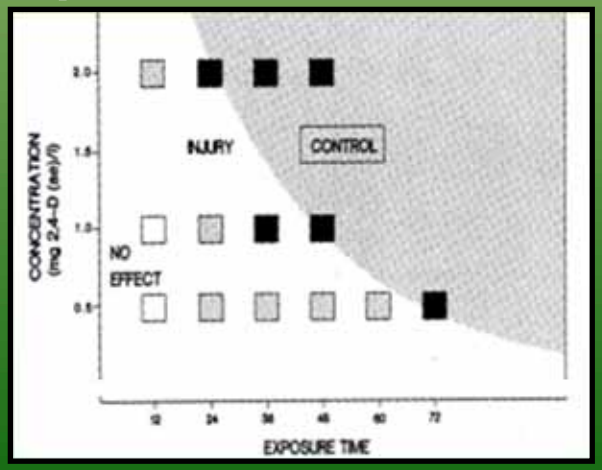
Nault et al. 2015. Small-scale treatments. NALMS LakeLine. *In press*.

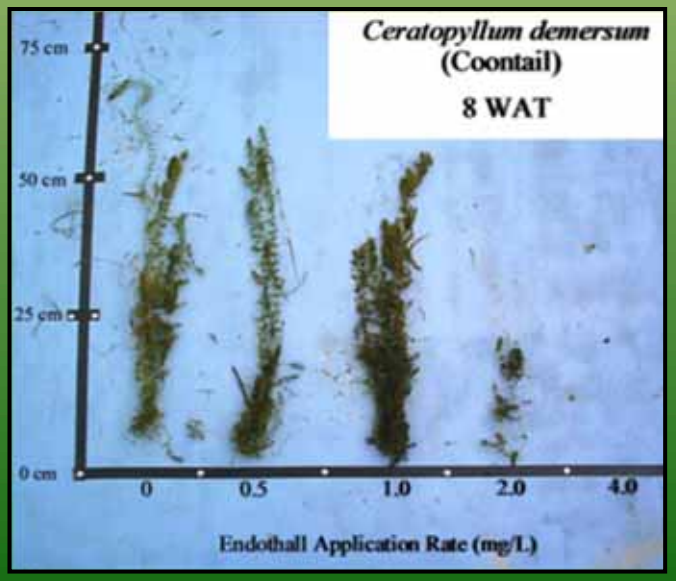
CET Experiments

Indoor Growth Chambers

Outdoor Mesocosm Tanks

- Wide range of herbicide concentrations and exposure times (CET)
- Replicated studies
- Species sensitivity
- Controlled setting





‘Real World’ Management

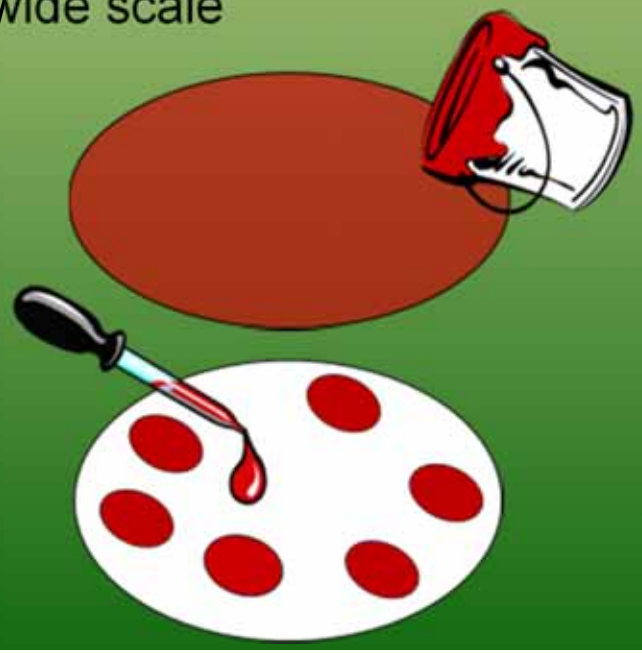
Implementation Considerations

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

Scale of Treatment

Large

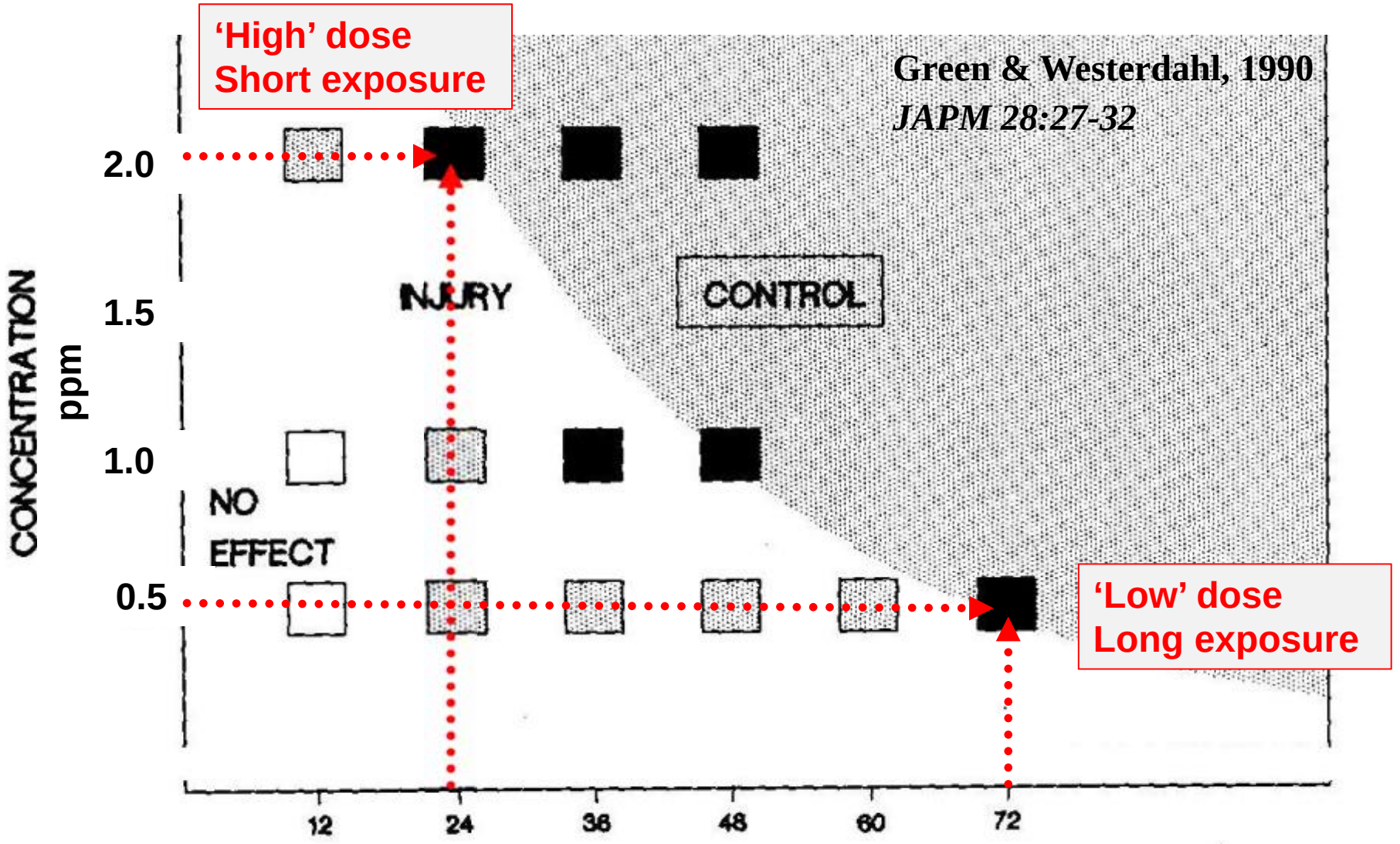
- *WI Admin. Code*: >10 acres or >10% of littoral zone
- *Ecological*: Herbicide will be applied at a scale where dissipation will result in significant lakewide concentrations and effects are anticipated on a lakewide scale



Small

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

2,4-D Concentration/Exposure Time



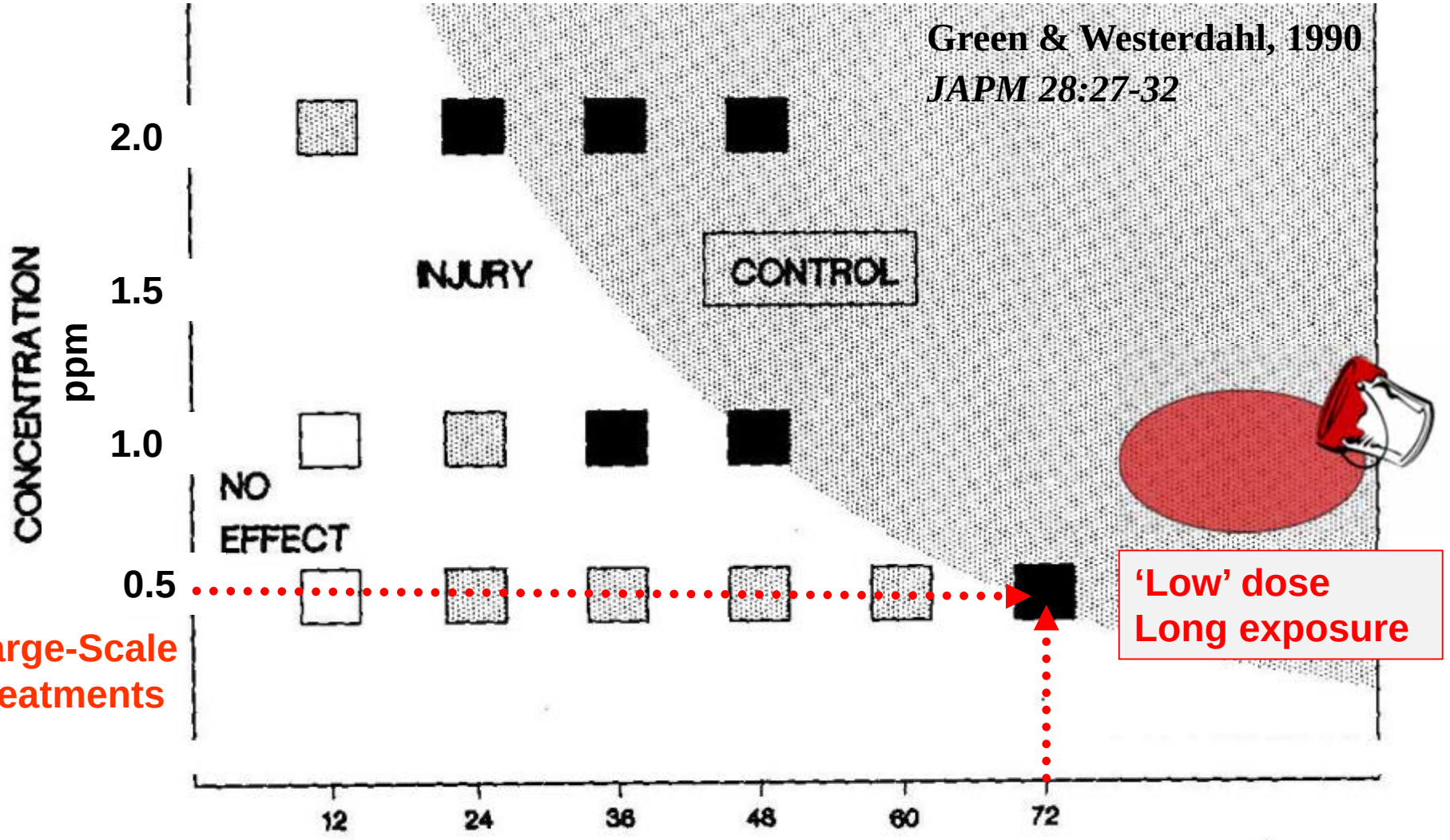
Recommended label rate:
2.0 – 4.0 ppm

1.0 ppm = 1.0 mg/L = 1000 ppb

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 label rate: 2.0 – 4.0 ppm

1.0 ppm = 1.0 mg/L = 1000 ppb

Study Lakes

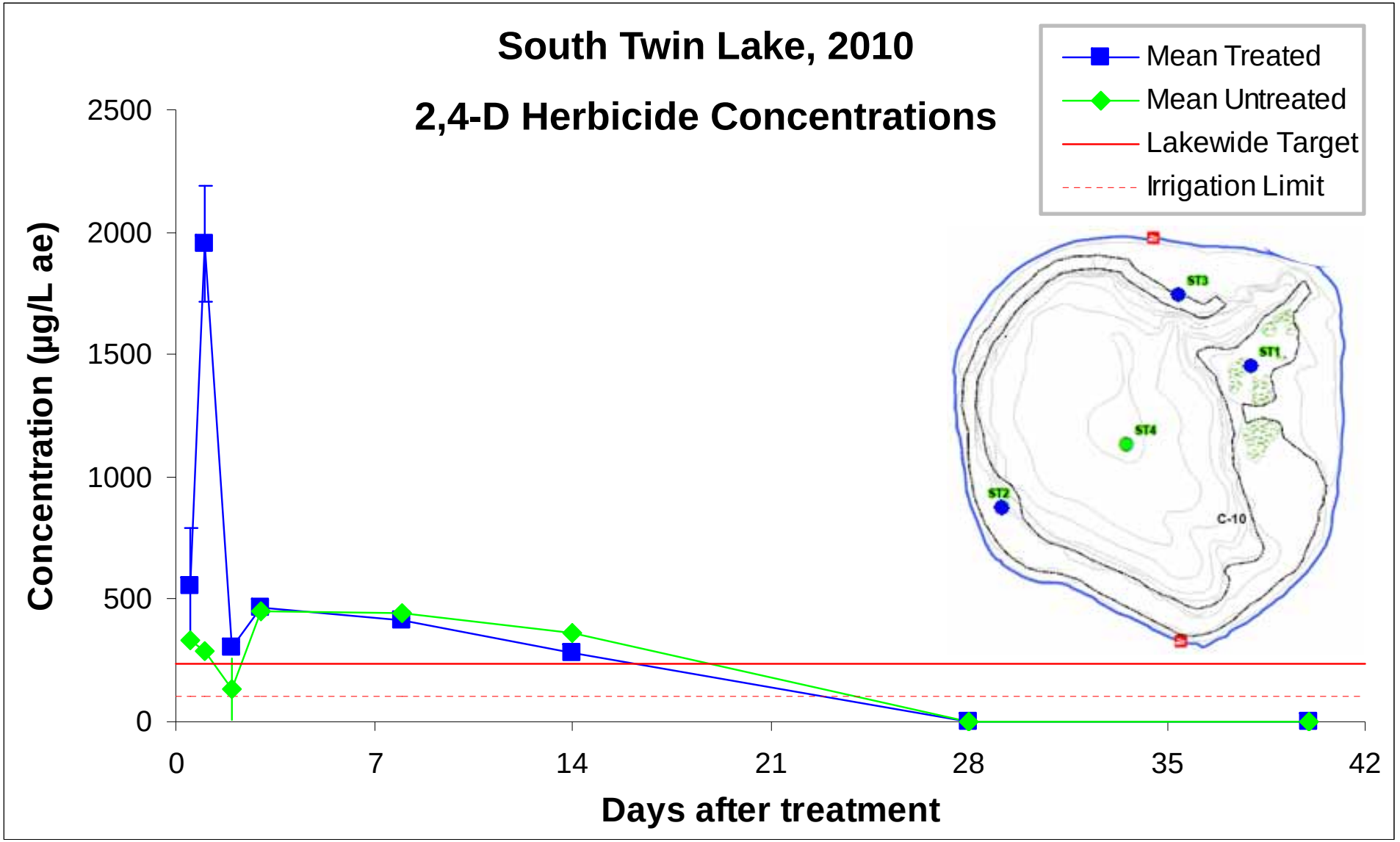
- *20 lakes*
- *Variety of lake types*
- *Range of sizes and depths*
- *Range of trophic status*

Treatments

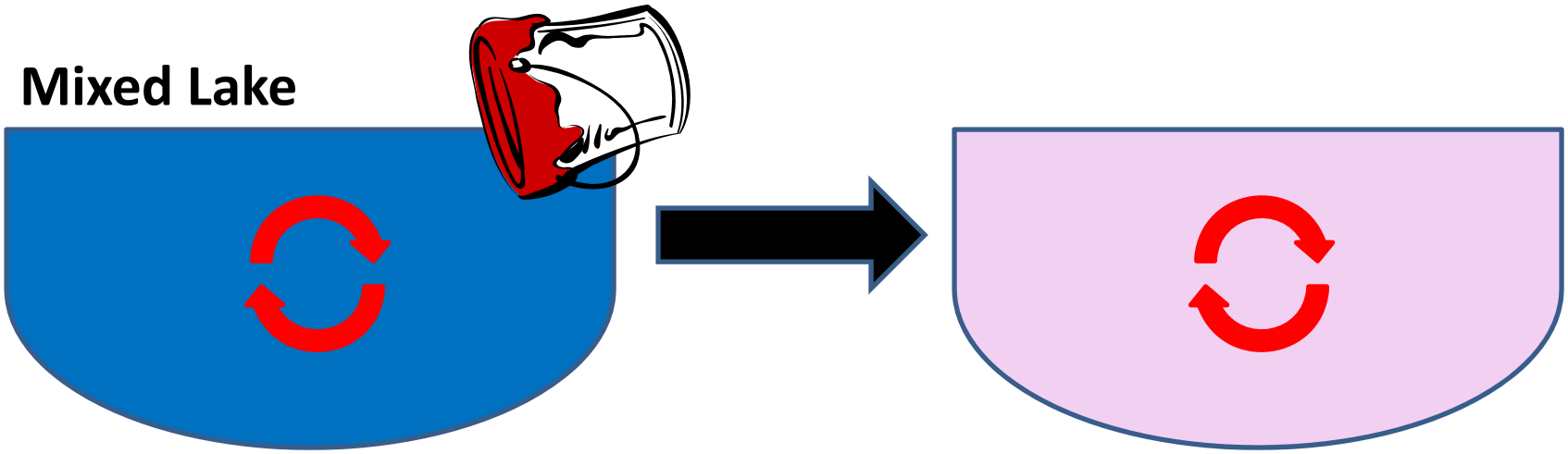
- *Lakewide liquid 2,4-D targets of 0.073 - 0.5 ppm (epilimnetic)*
- *Application rates of 0.25 - 4.0 ppm*
- *8-100% of lake surface area treated*
- *Early season (spring) treatments*
- *Monitored from 2008-2014*

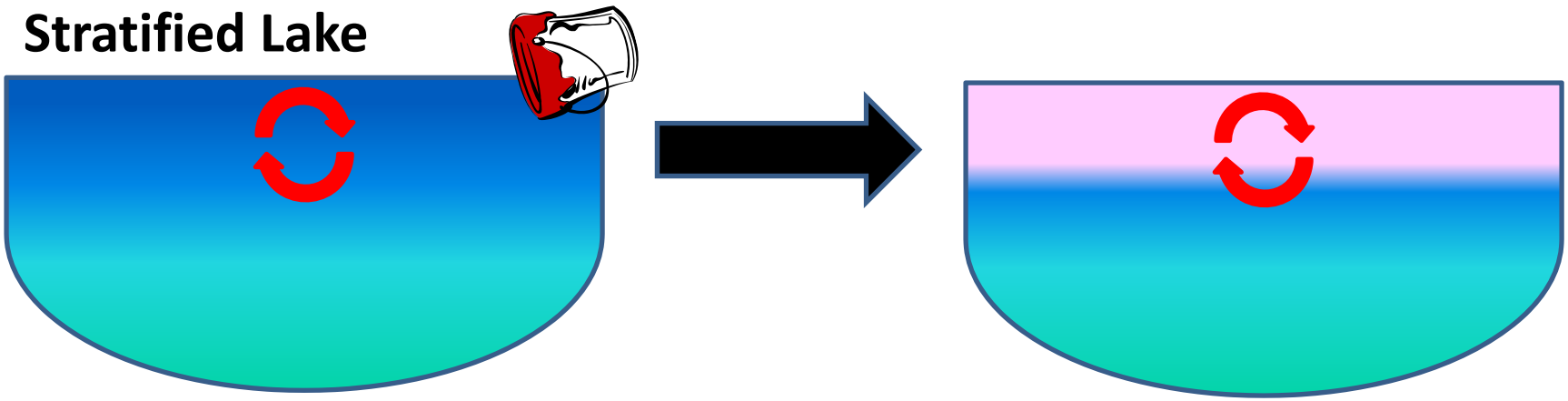
Lakewide Dissipation

26% of lake treated

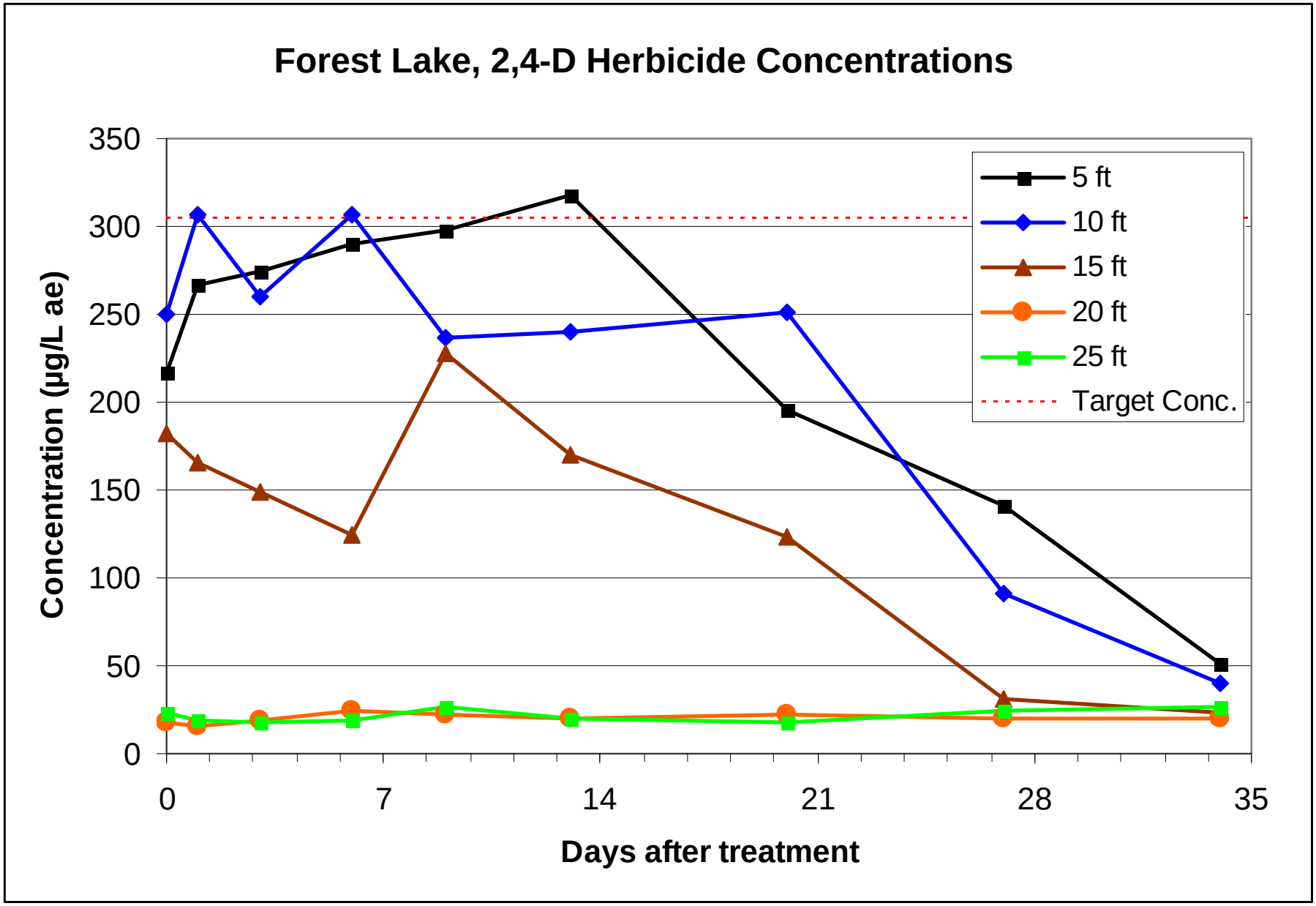


Lakewide Dissipation



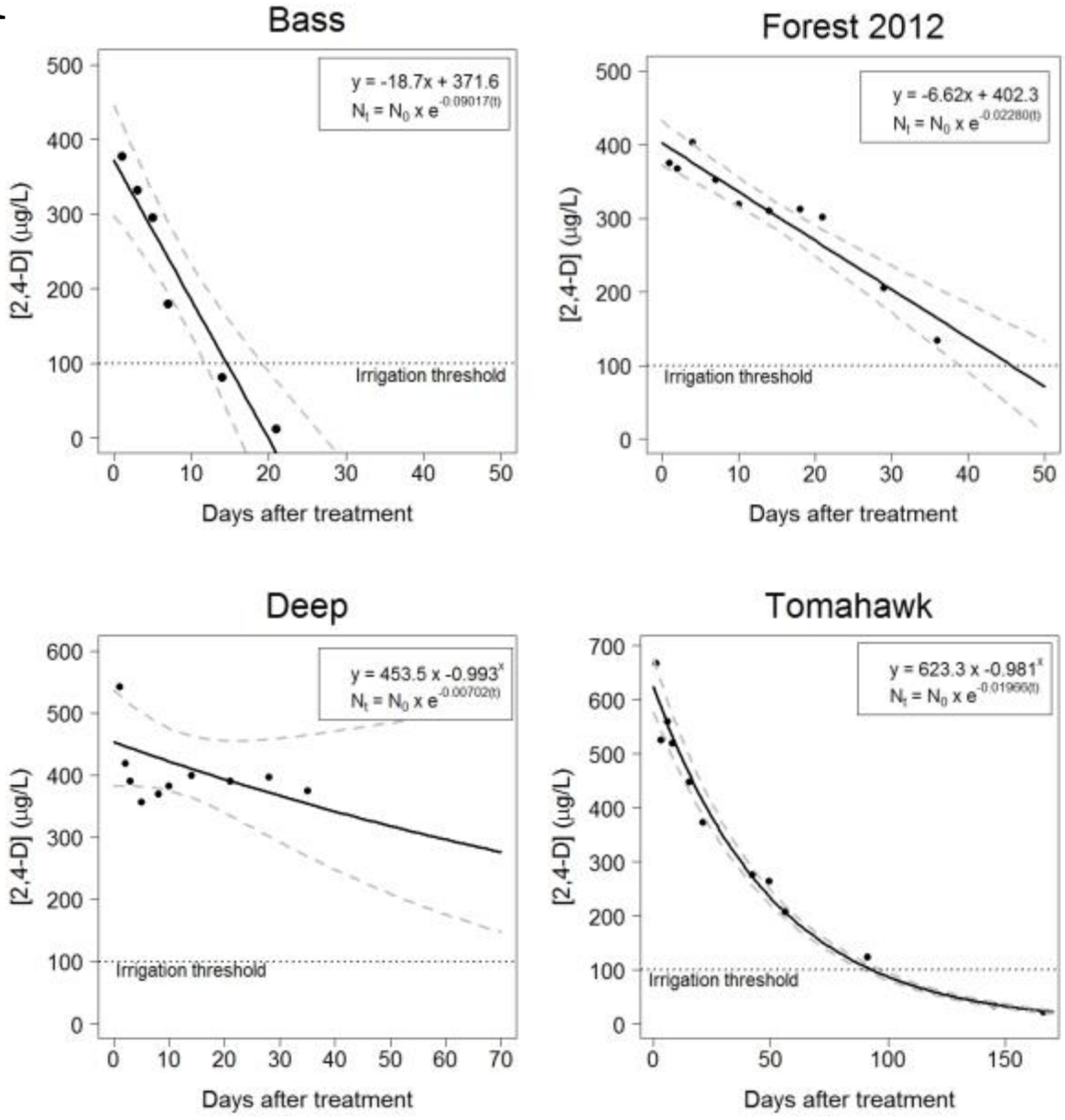


Lakewide Dissipation

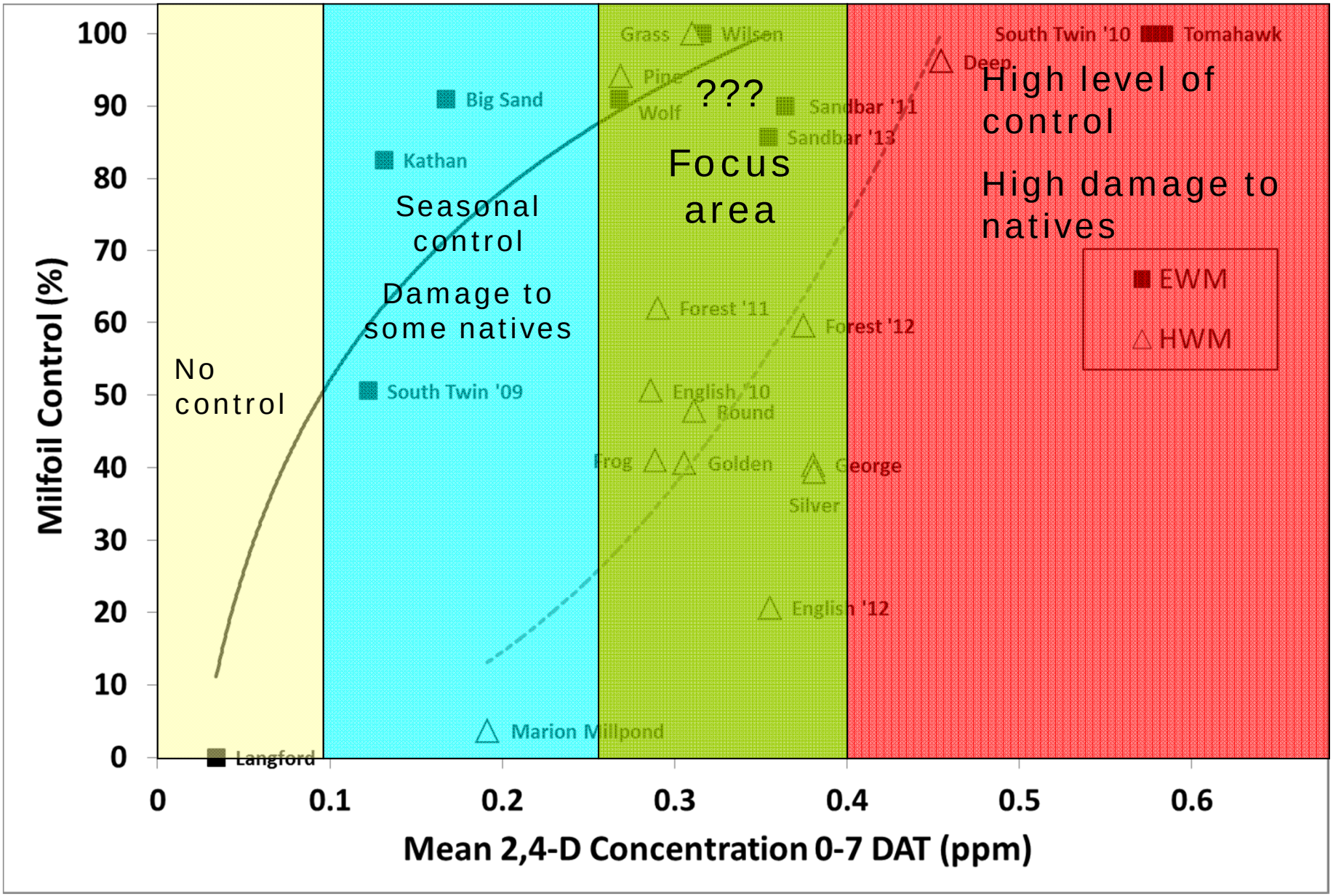


Degradation Models

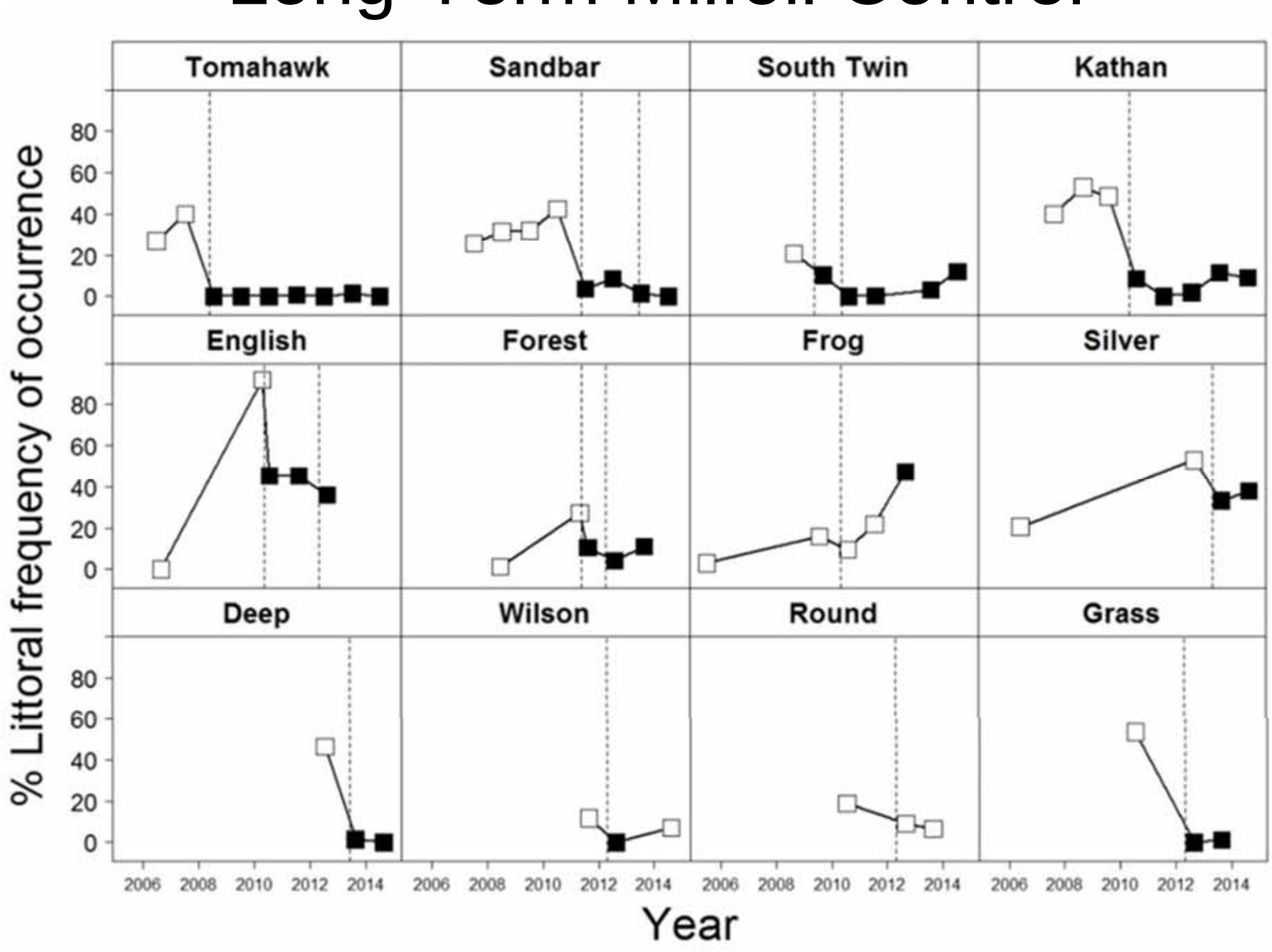
- Majority of models highly significant ($p < 0.001$)
- Mean 1-7 DAT ranged from 0.127-0.584 ppm
- Calculated 2,4-D half-lives ranged from 4-57 days
- Irrigation restriction (<0.1 ppm by 21 DAT) exceeded in over half the treatments



Milfoil Control



Long-Term Milfoil Control



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

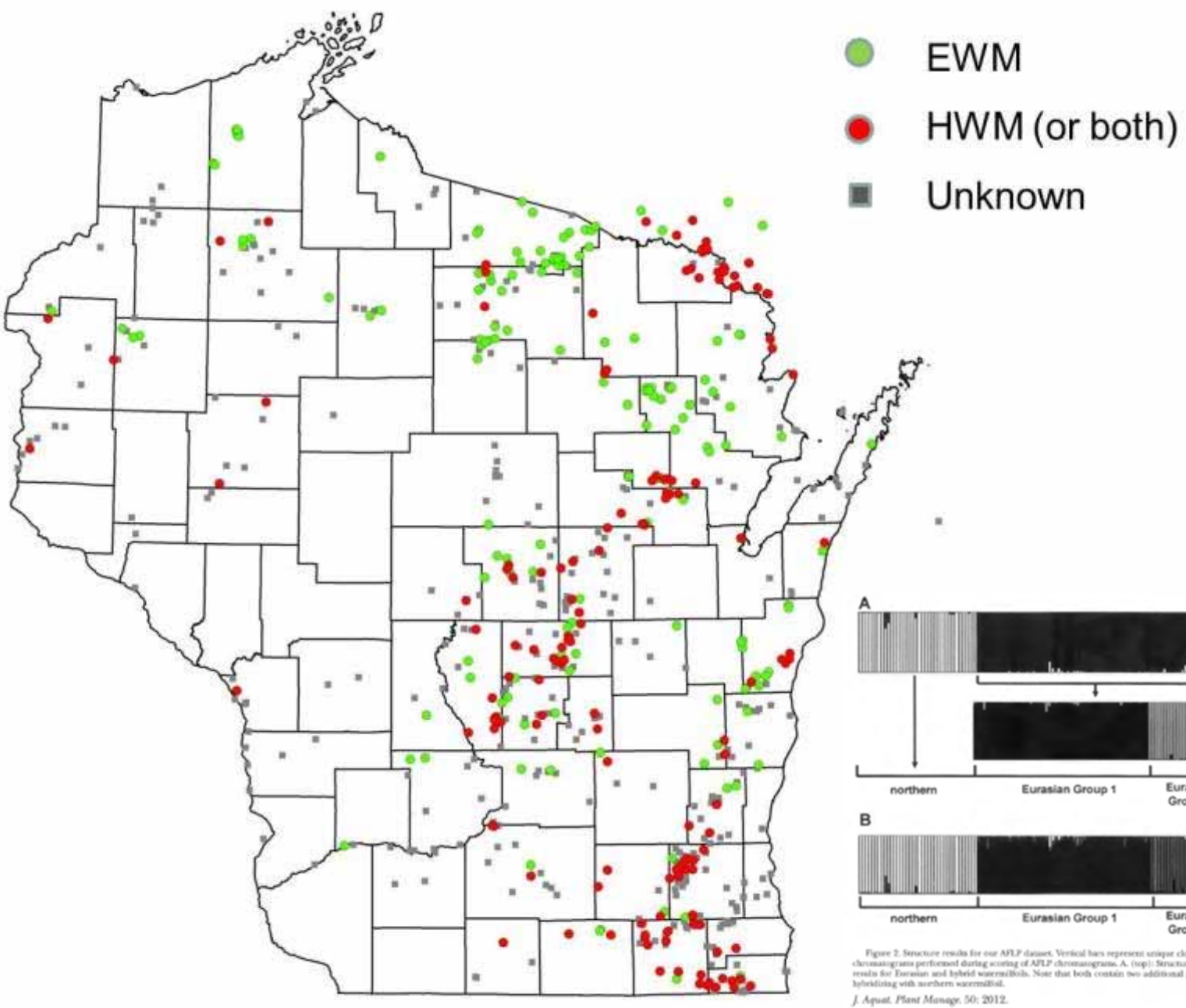
* = negative
+ = positive

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

Hybrid Watermilfoil

- Many misconceptions and misinformation regarding hybrid watermilfoils (*M. spicatum* X *sibiricum*; HWM)
- Statewide analysis of confirmed or suspected milfoil populations tested through ITS sequencing for hybridity
- ~130 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 (Zuelling & Thum 2012, JAPM)
- Further exploration of hybrid water milfoils and effectiveness of various herbicide treatments
- Collaboration with GVSU on variation in lakewide milfoil populations and selection pre vs post treatment
- Not all HWM appear to be tolerant to herbicides, but majority show statistically significant differences in % control when compared to pure EWM

Confirmed Hybrid Watermilfoil



Zuelling & Thum, 2012

Figure 2. Structure results for our AFLP dataset. Vertical bars represent unique clones from each population identified with a visual inspection of AFLP chromatograms performed during scoring of AFLP chromatograms. A. (top): Structure results for the full dataset at K = 2; (bottom): Hierarchical Structure results for Eurasian and hybrid watermilfoils. Note that both contain two additional groups. B. Entire AFLP dataset at K = 3, shows both Eurasian groups hybridizing with northern watermilfoil.

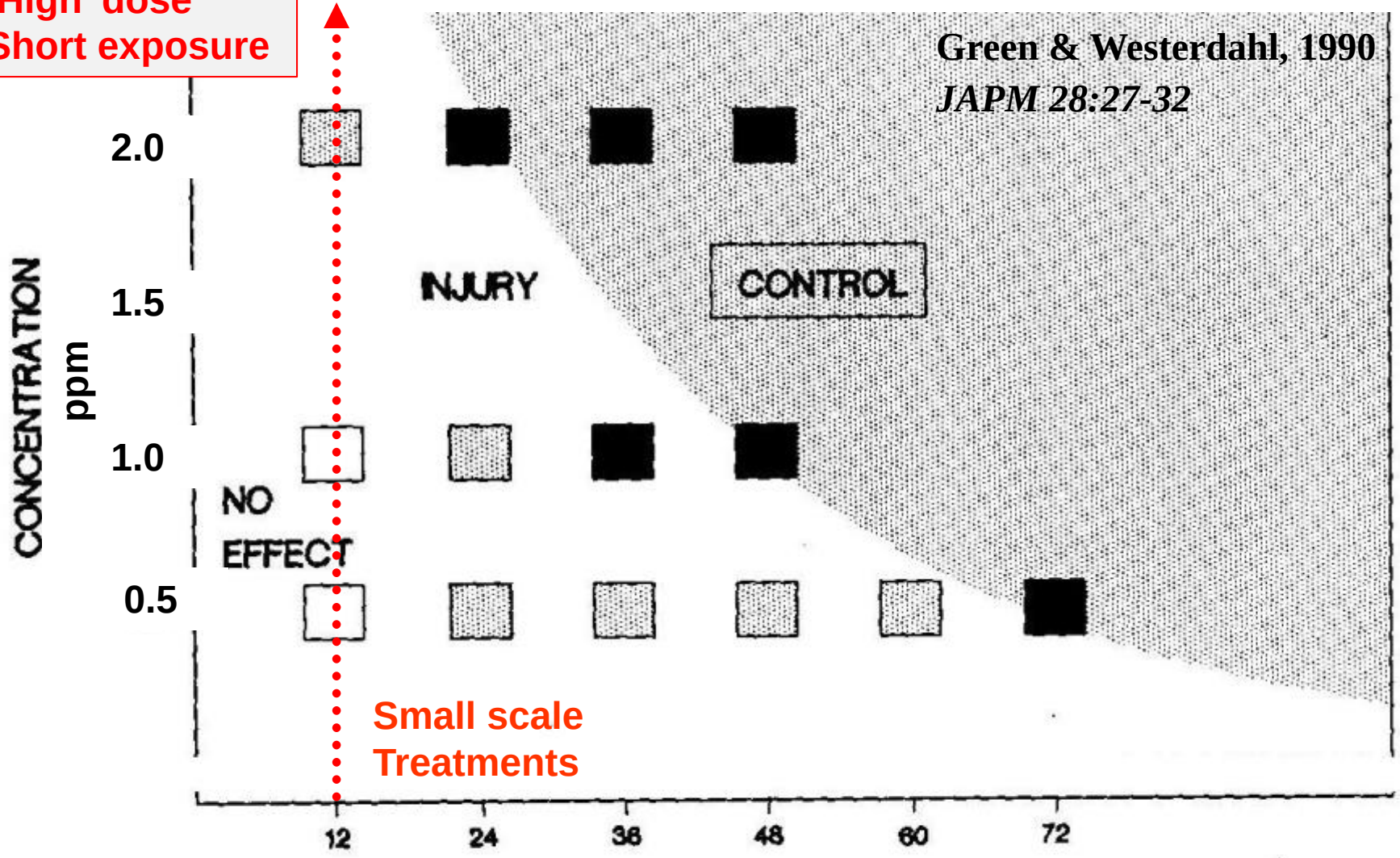
J. Aquat. Plant Manage. 50: 2012.

Preliminary Findings

- 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
- 2,4-D degradation rates and half-lives are variable across different lakes; analysis currently in progress…
- Early spring, large scale 2,4-D treatments may result in longer persistence of herbicides than expected; may exceed 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
- Future research into other herbicides (combos, triclopyr, fluridone)
- Herbicide monitoring is important, both to understand treatment efficacy, as well as ecological risks

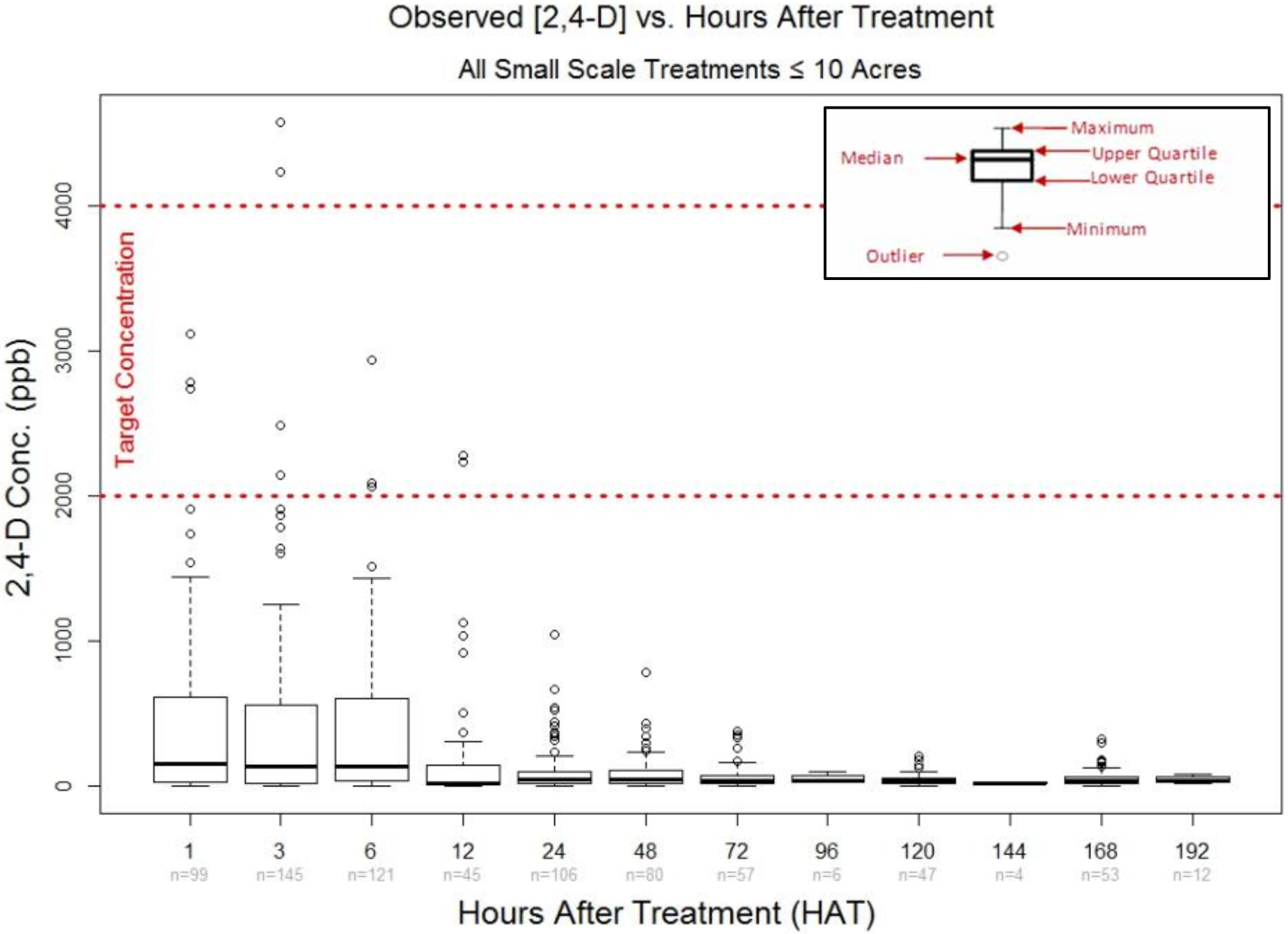
2,4-D Concentration/Exposure Time

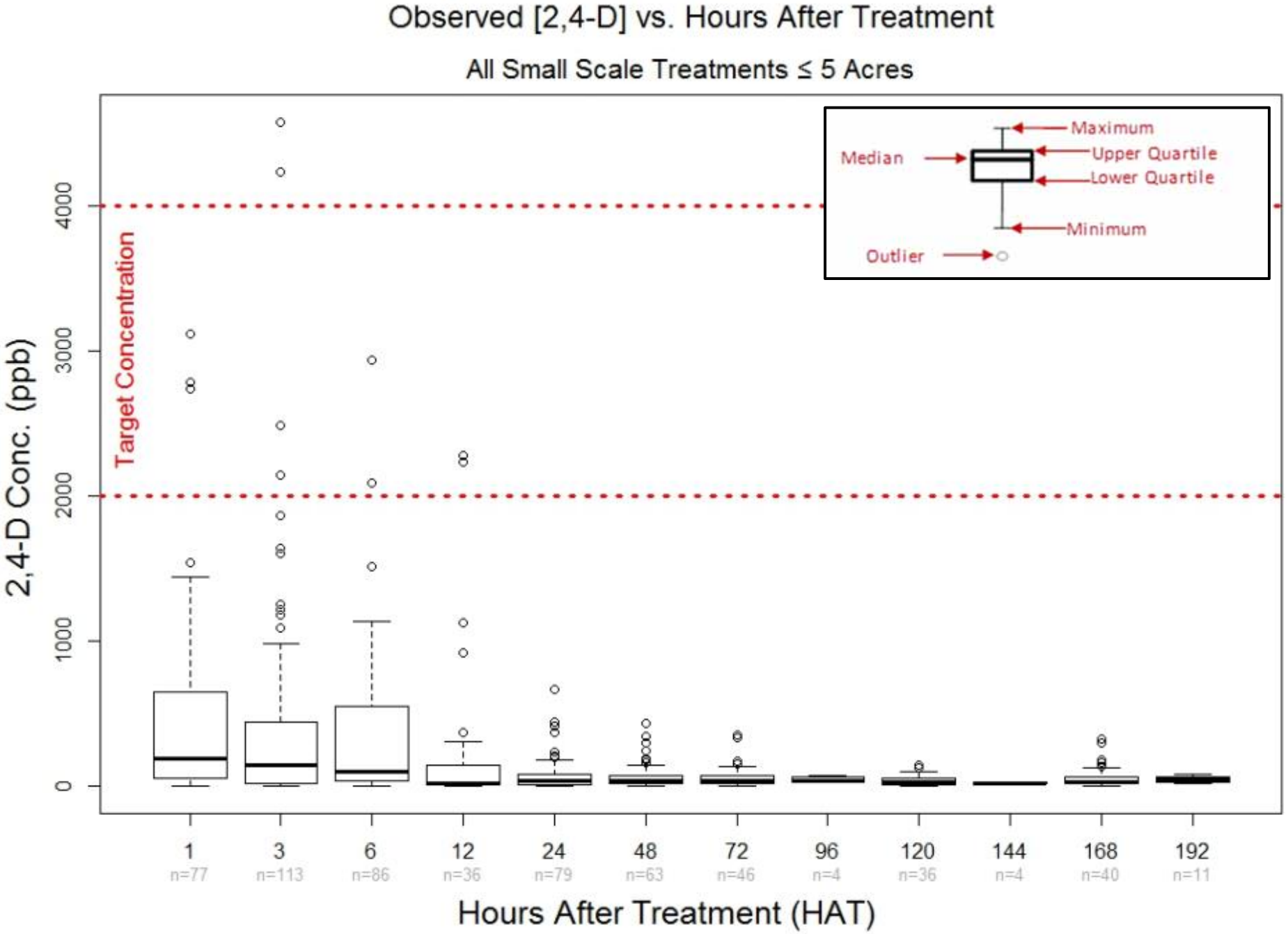
'High' dose
Short exposure

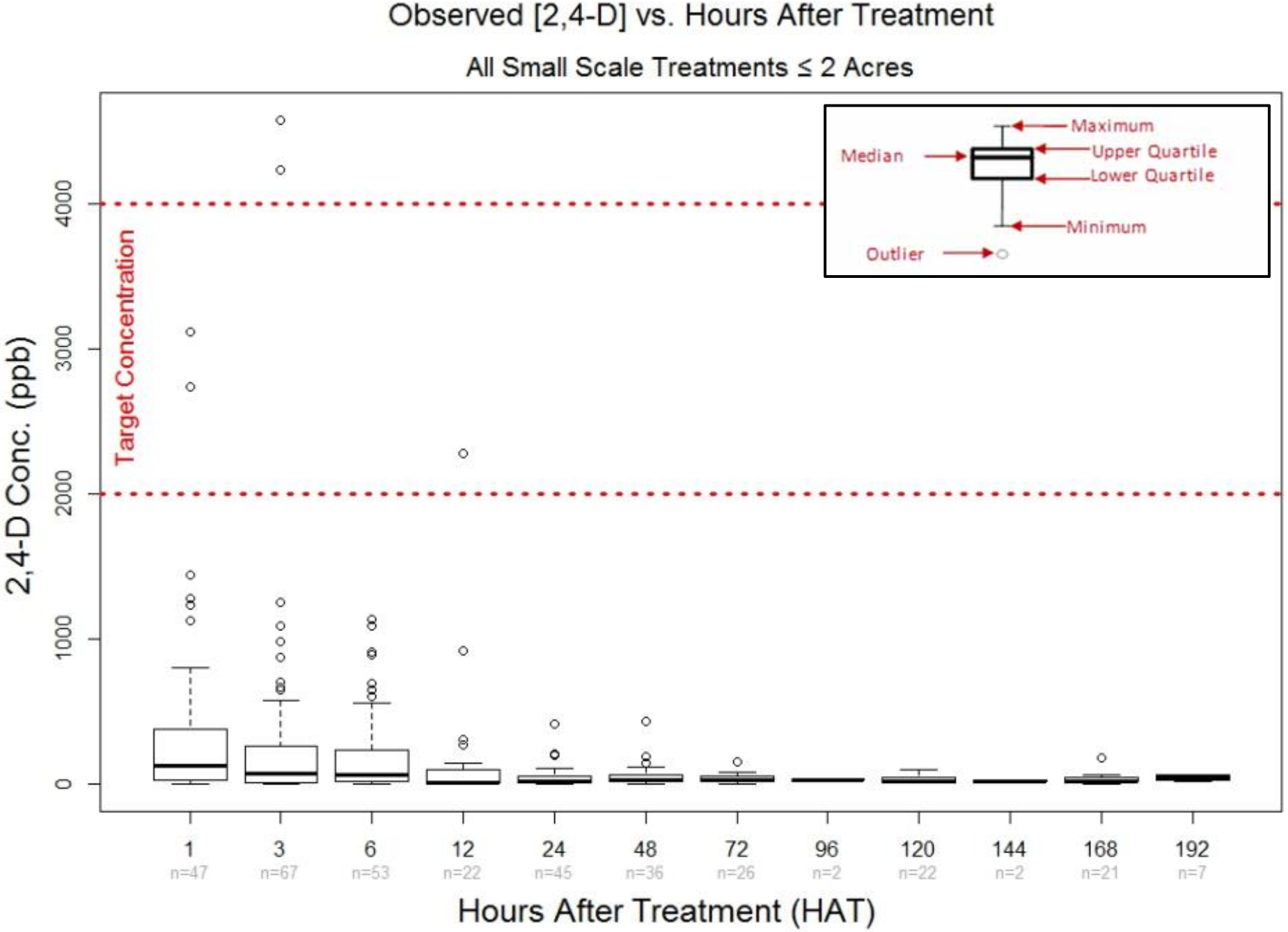


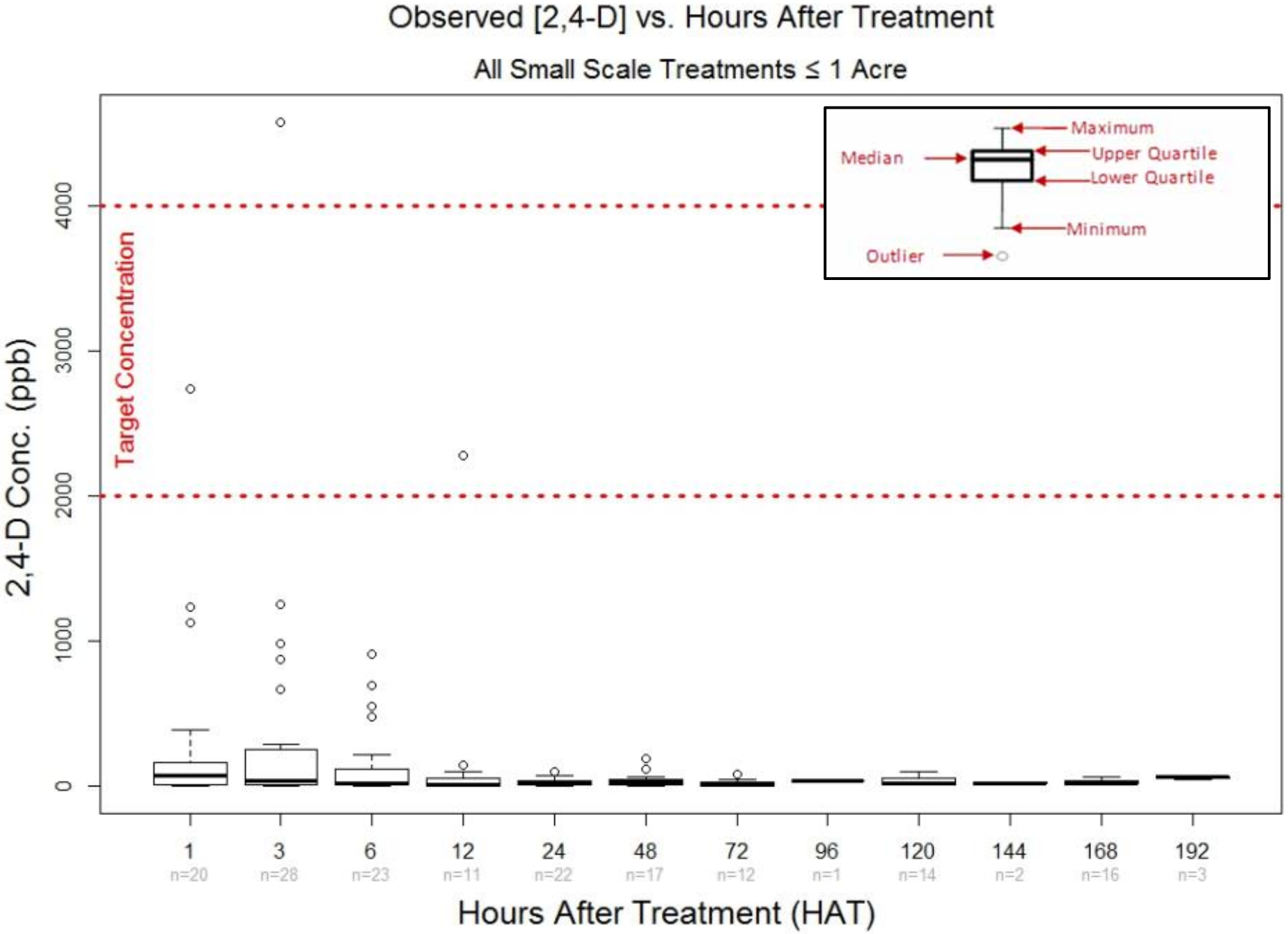
Recommended label rate:
2.0 – 4.0 ppm

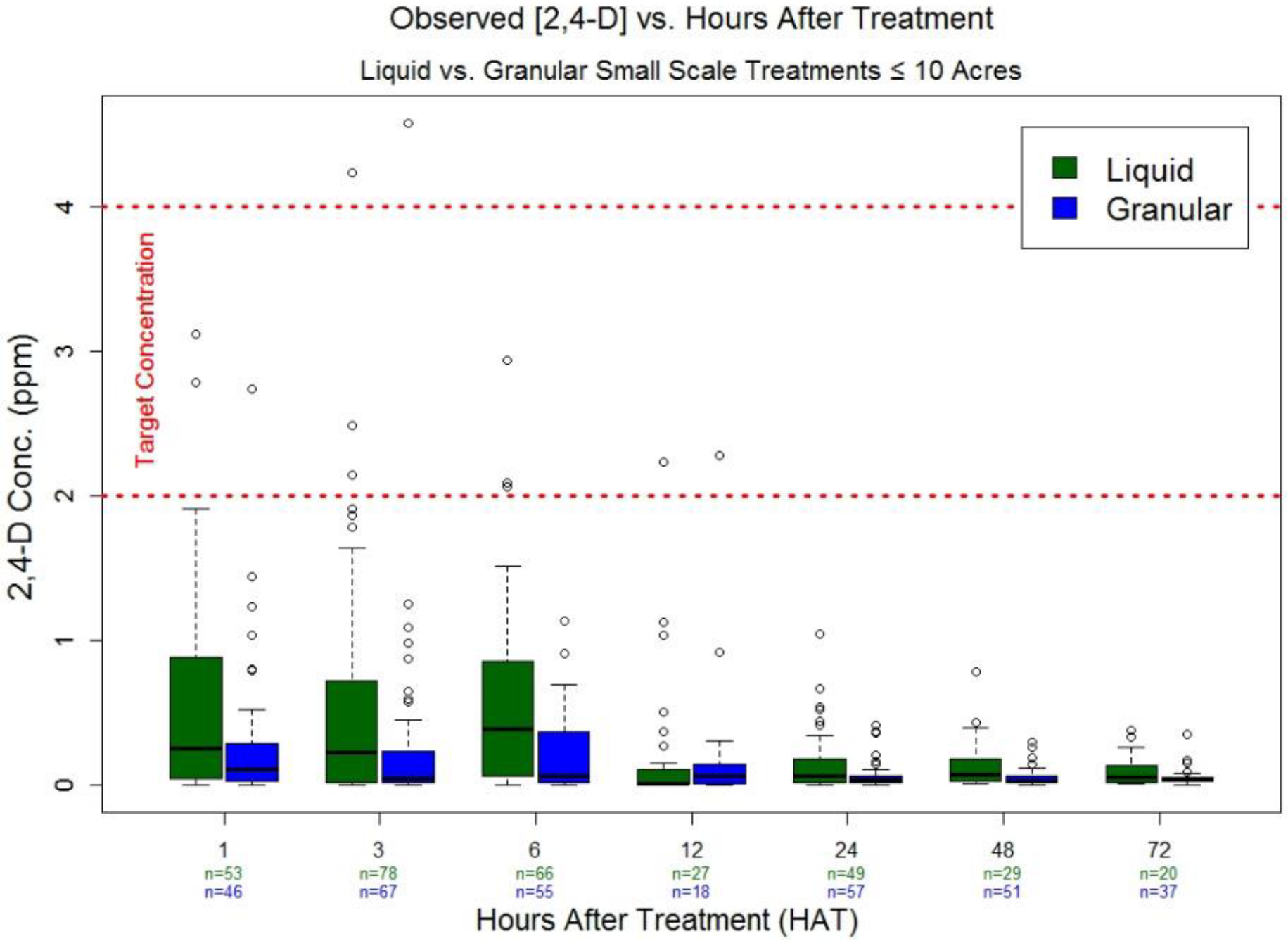
1.0 ppm = 1.0 mg/L = 1000 ppb


Observed [2,4-D] vs. Hours After Treatment
All Small Scale Treatments ≤ 10 Acres
Maximum
Upper Quartile
Median
Lower Quartile
Minimum
Outlier
Target Concentration
2,4-D Conc. (ppb)
0
1000
2000
3000
4000
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
Upper Quartile
Median
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
Upper Quartile
Median
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
Maximum
Upper Quartile
Median
Lower Quartile
Minimum
Outlier
Target Concentration
2,4-D Conc. (ppb)
0
1000
2000
3000
4000
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
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)

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 – efficacy of control is variable
- Rapid dissipation occurs with both granular and liquid 2,4-D formulations and concentrations were below what laboratory CET analysis recommend for effective control
- Future research into sediment porewater and herbicide uptake mechanisms
- No “one size fits all” solution - future research into other herbicides (diquat, triclopyr, combos)
- 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)

Bureau of Science Services!

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