PI Data Analysis

Kemp Aquatic Macrophyte Workshop

June 25-26, 2013

PI Data Analysis

So we have all this data…

now what?

Data Analysis and Interpretation

- Analyzing plant distributions
  - Qualitative data (maps)
  - Semi-quantitative data (frequency of occurrence)
- Analyzing changes in plant distributions
  - 2 sampling events
    - Chi Square analysis: Baseline & pre/post treatment assessment
  - more than 2 sampling events
    - Chi Square in series, generalized linear models
- Analyzing plant communities

Qualitative data - maps

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- Visual representation of plant community

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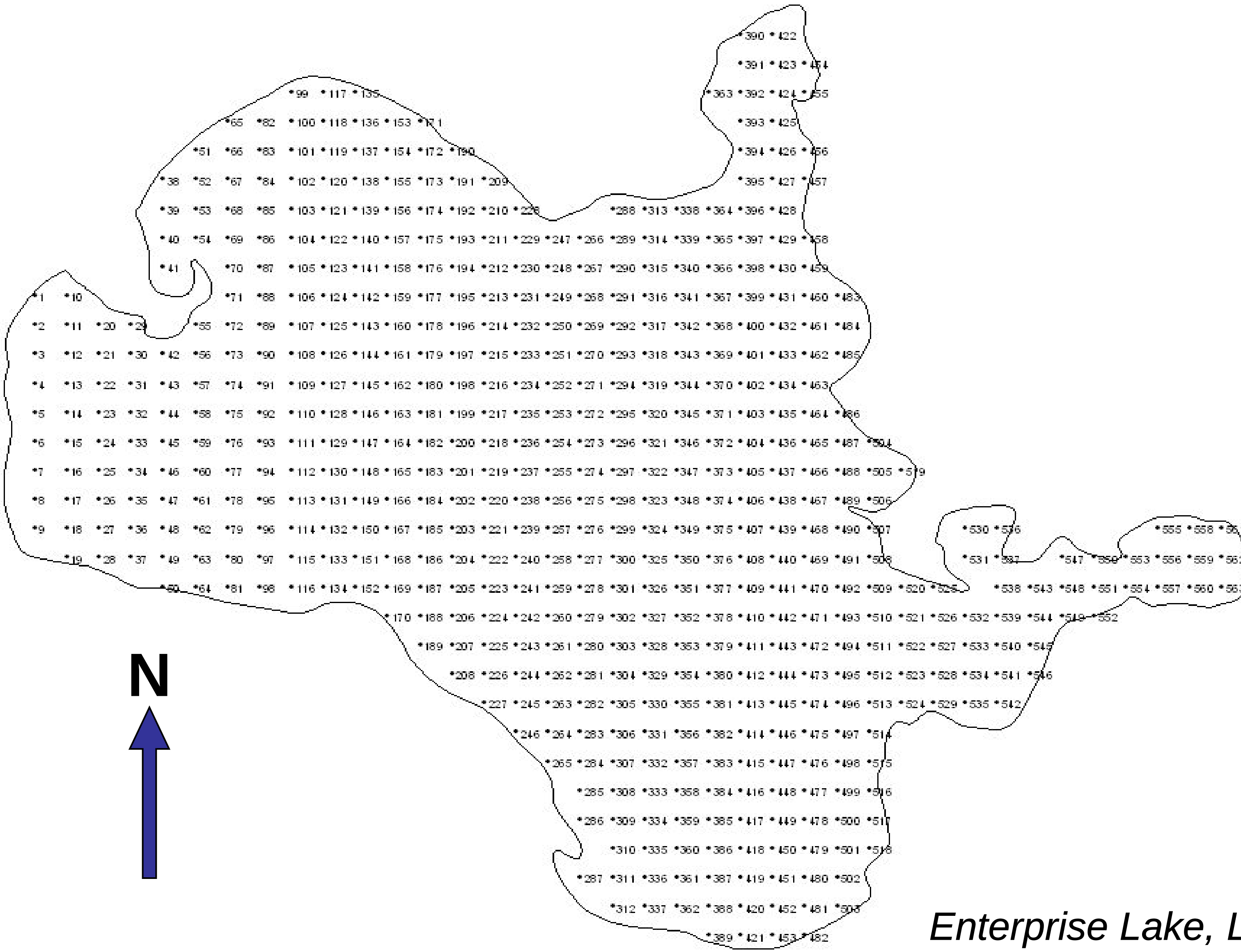
- Species-specific maps

Qualitative data - maps

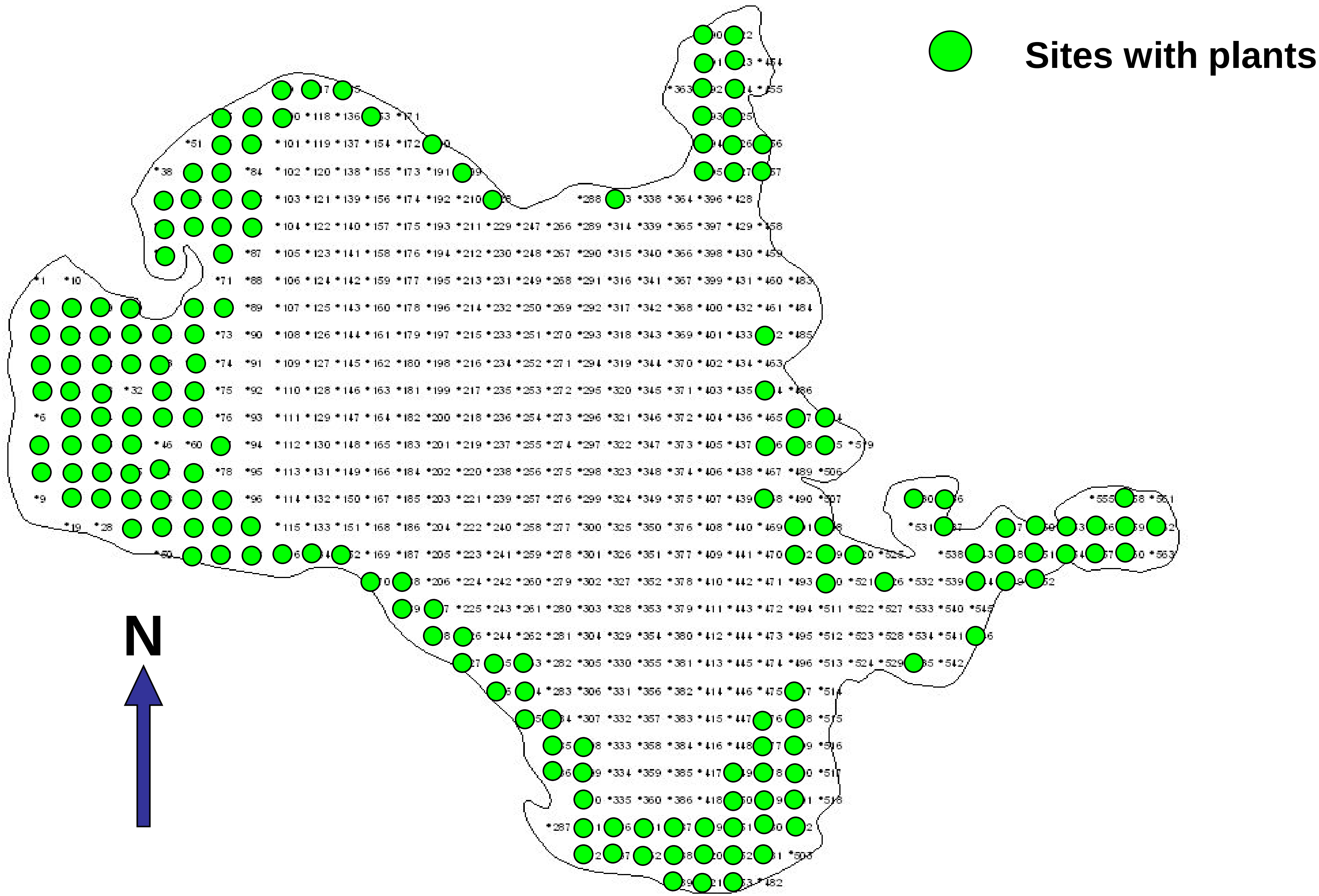
- Visual representation of plant community
- Species-specific maps
- Spatially-informed management decisions

Qualitative data - maps

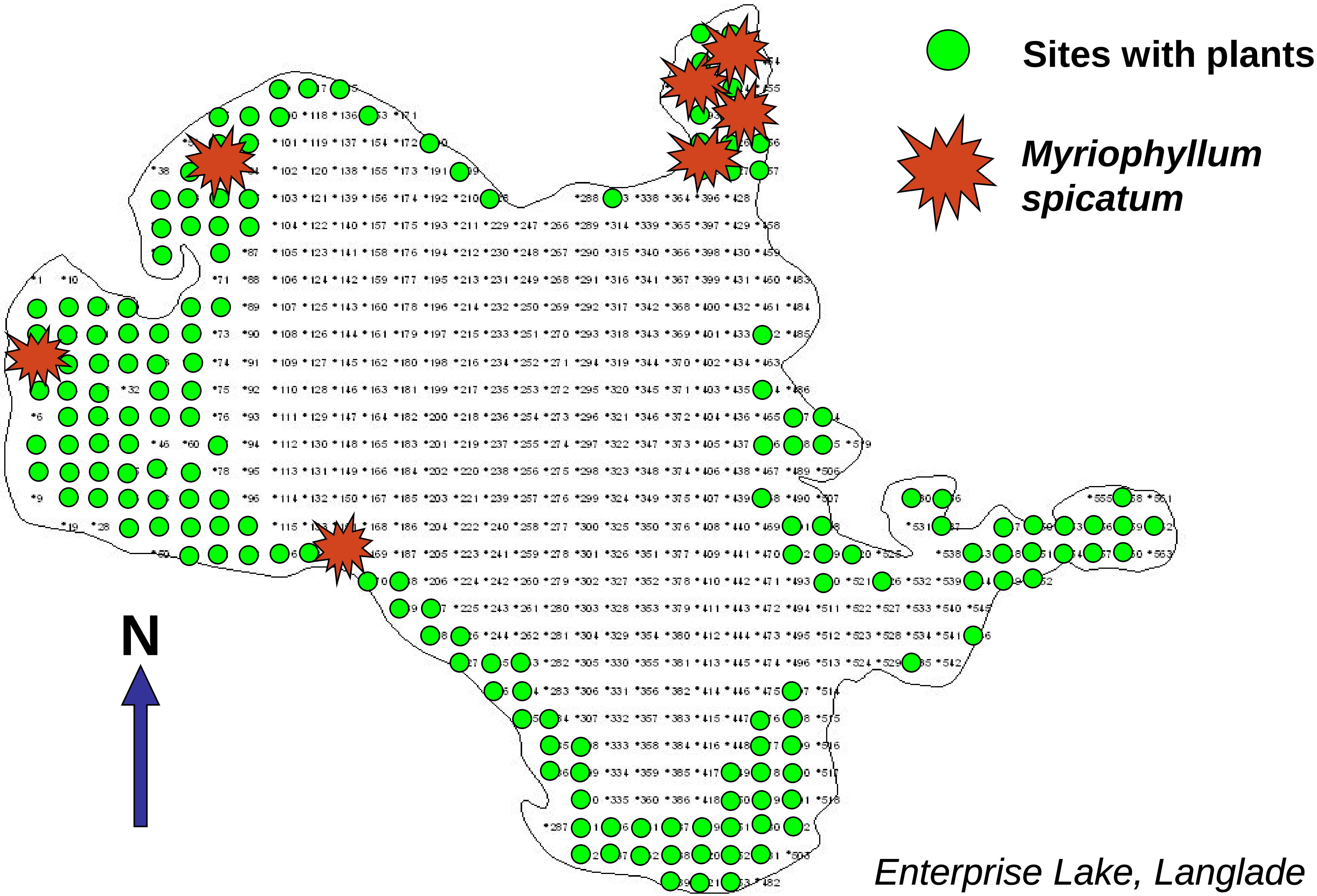


Enterprise Lake, Langlade

Vegetated sites

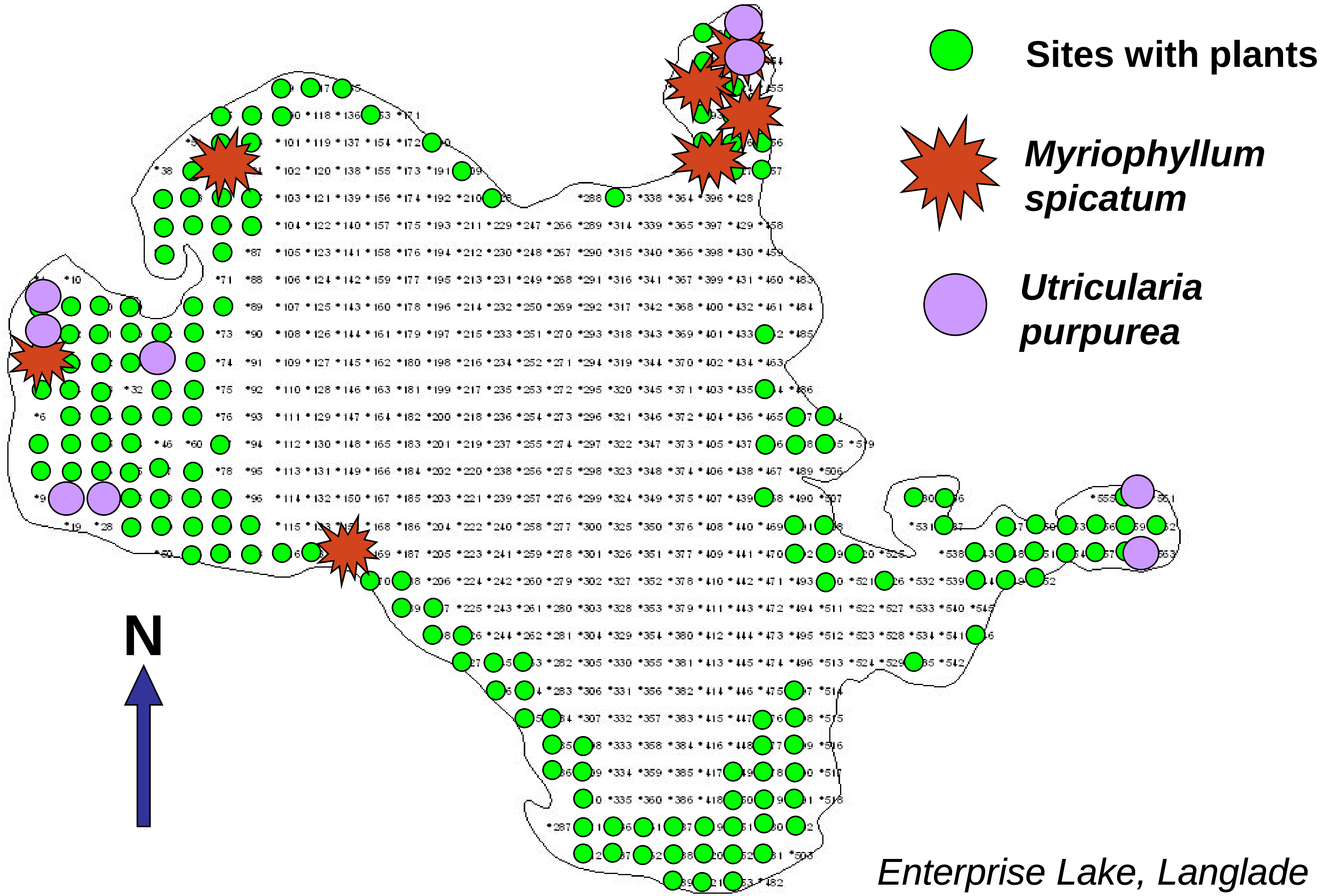


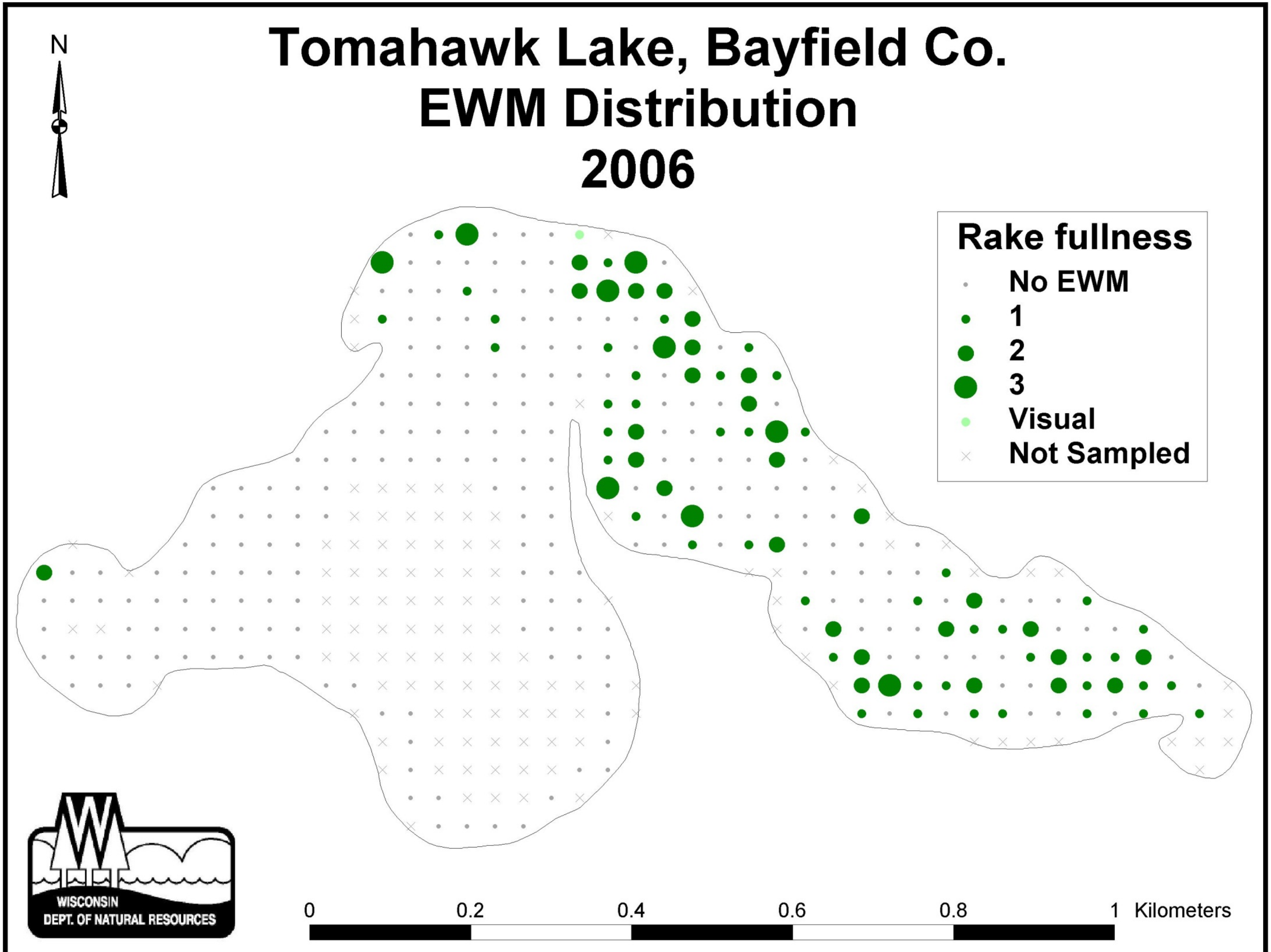
Eurasian Watermilfoil

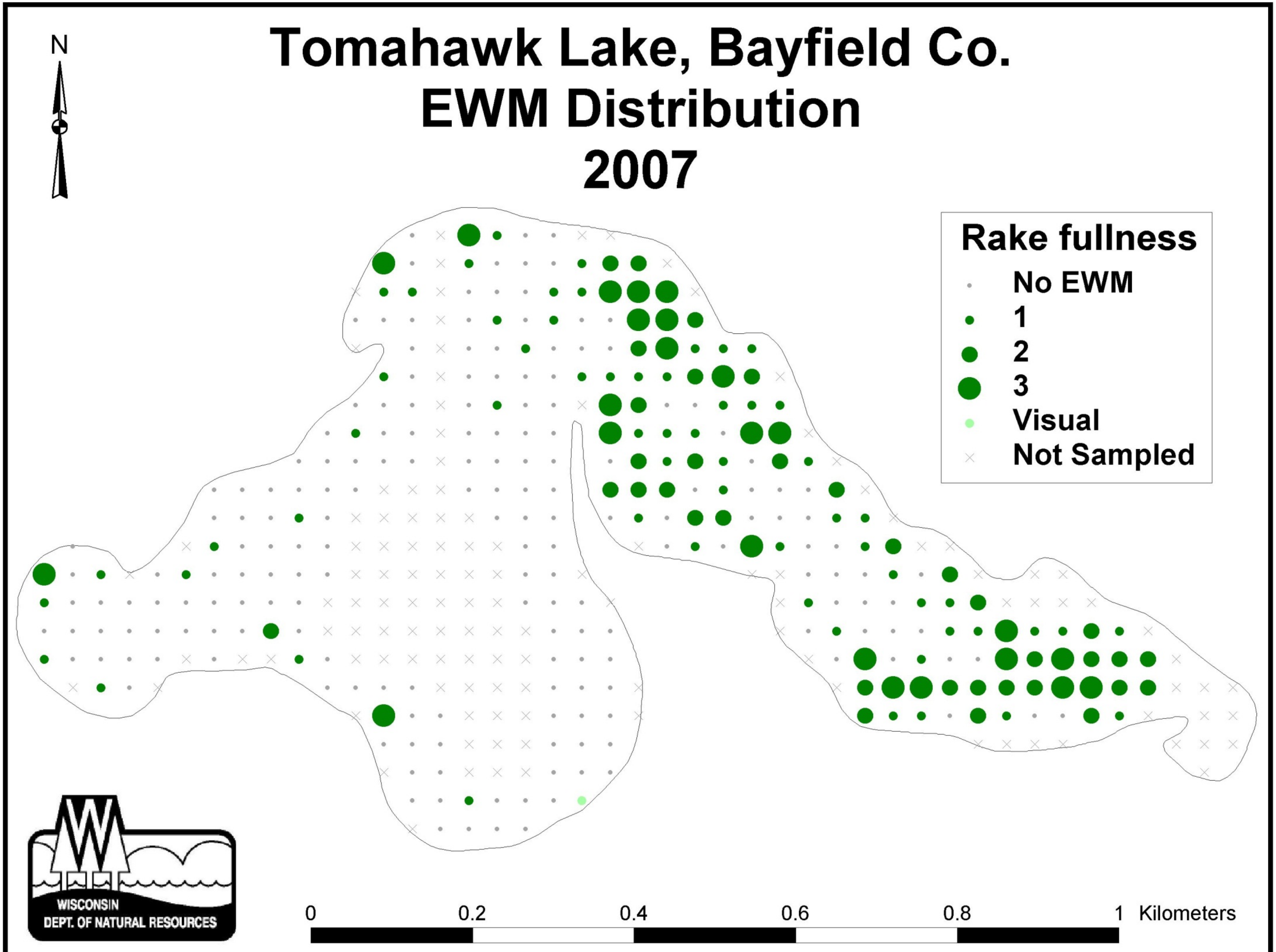


Enterprise Lake, Langlade

Species of Special Concern




N
Tomahawk Lake, Bayfield Co.
EWM Distribution
2006
Rake fullness
No EWM
1
2
3
Visual
Not Sampled
0
0.2
0.4
0.6
0.8
1 Kilometers
WISCONSIN
DEPT. OF NATURAL RESOURCES



Tomahawk Lake, Bayfield Co.
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DEPT. OF NATURAL RESOURCES
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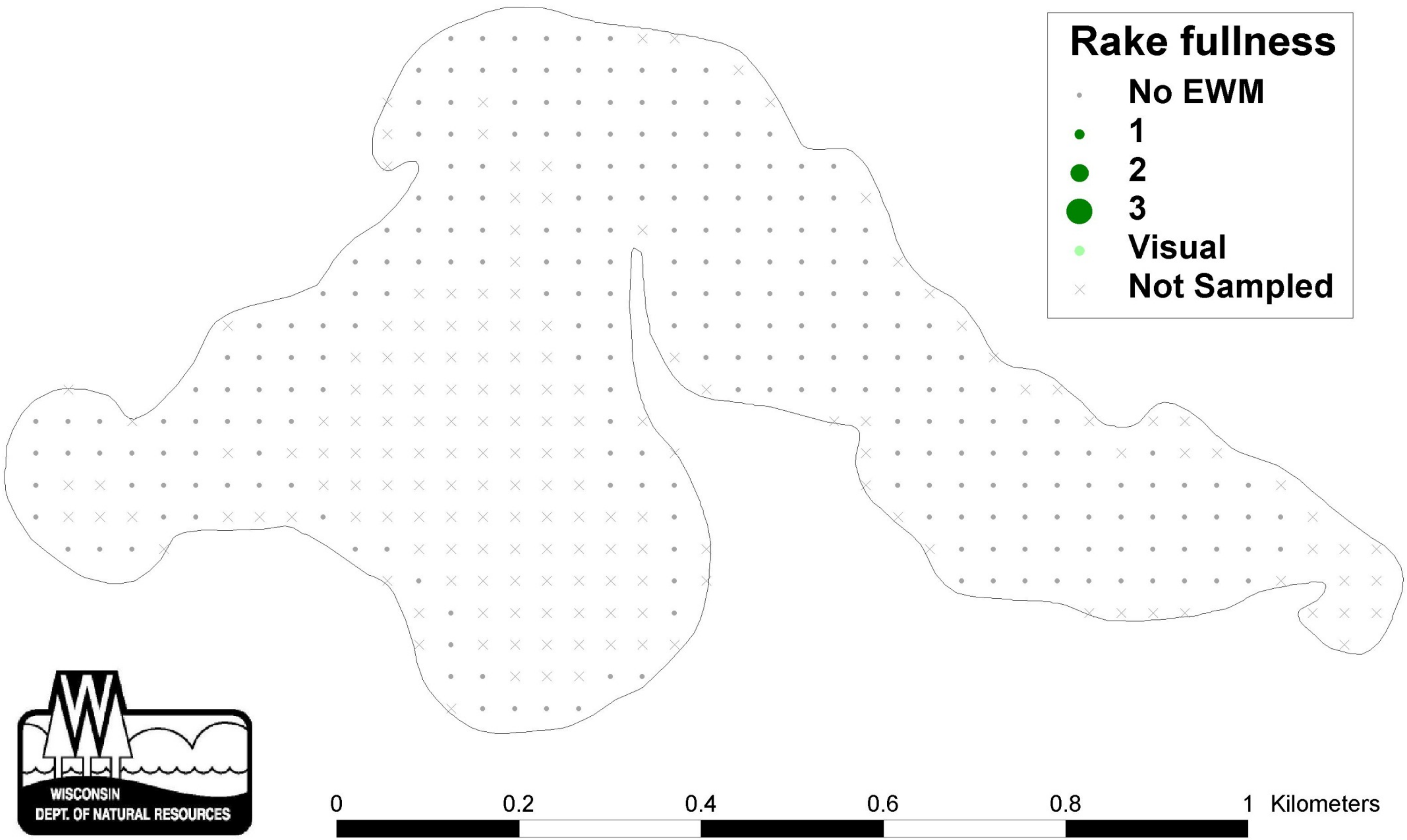
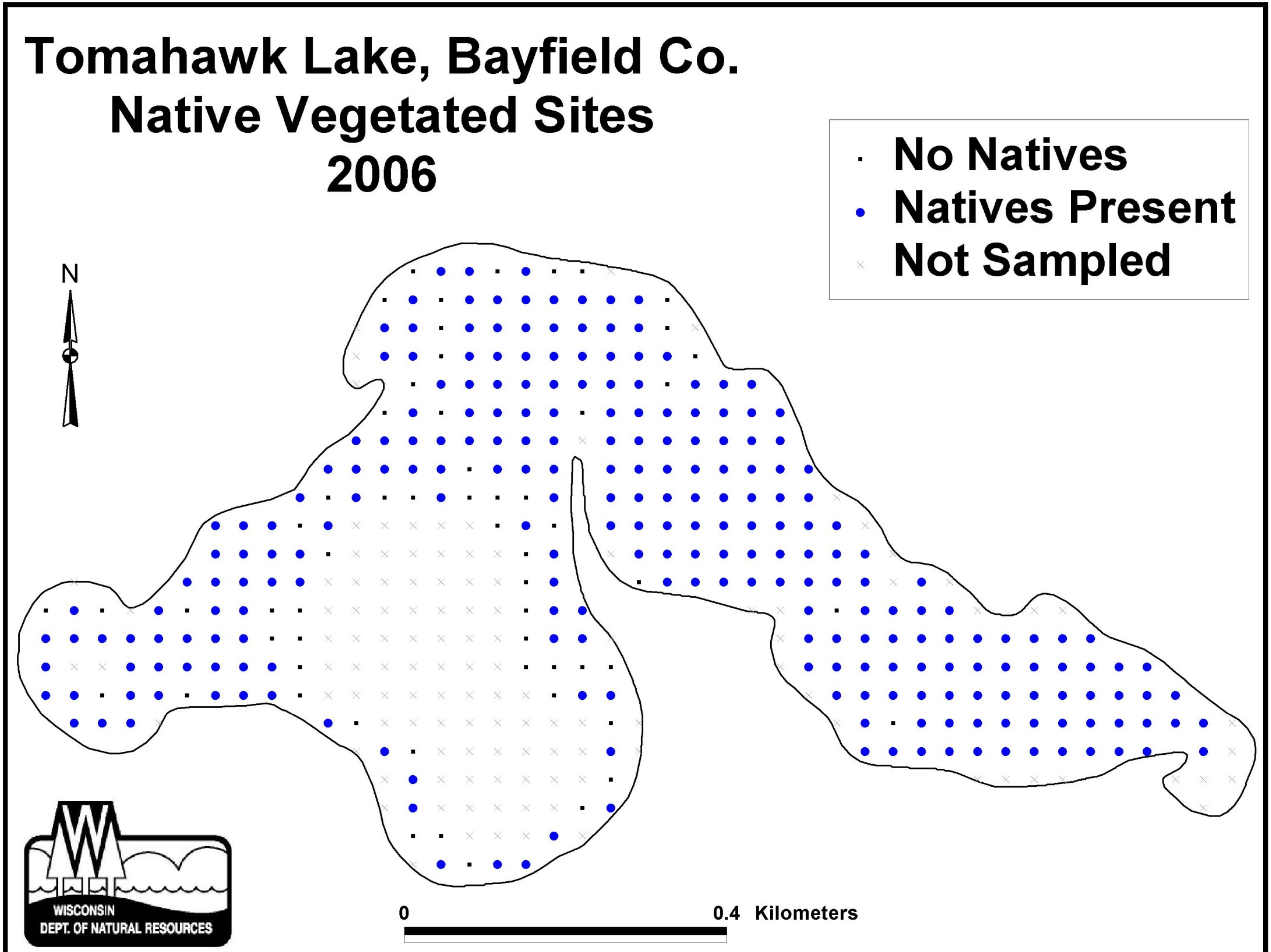
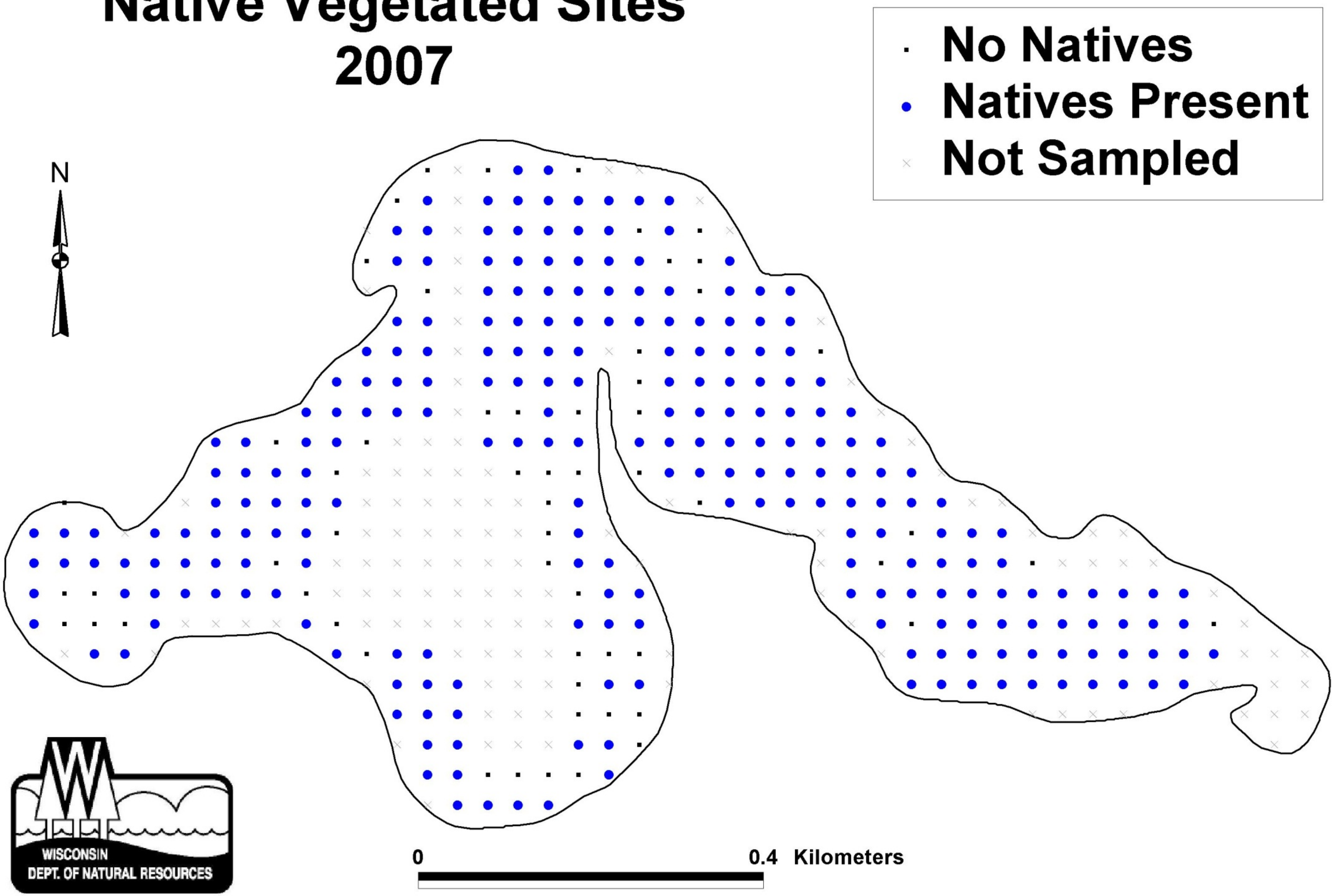
Tomahawk Lake, Bayfield Co.
EWM Distribution
2008

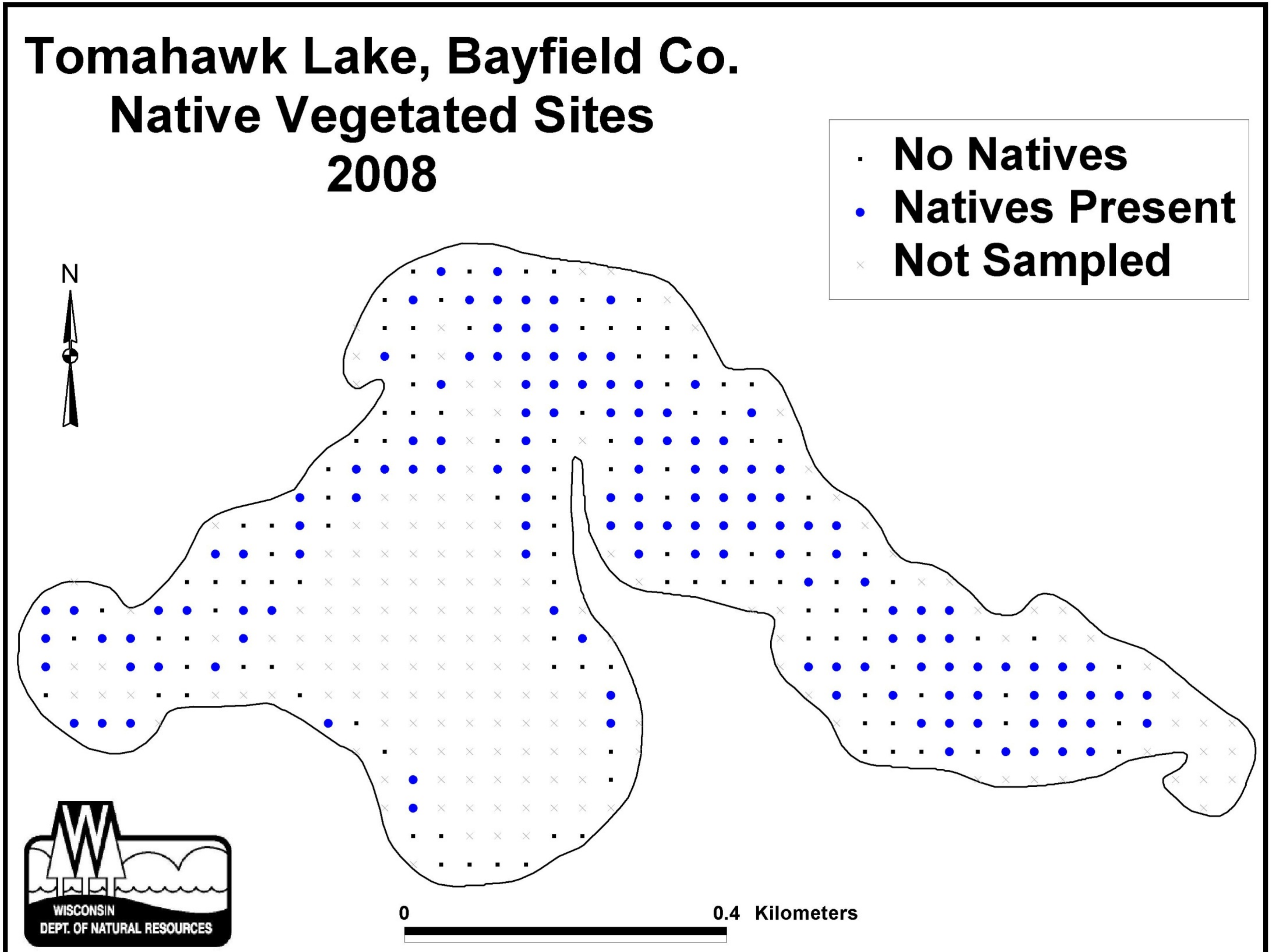




Tomahawk Lake, Bayfield Co.
Native Vegetated Sites
2006
No Natives
Natives Present
Not Sampled
N
0
0.4 Kilometers
WISCONSIN
DEPT. OF NATURAL RESOURCES

Tomahawk Lake, Bayfield Co.
Native Vegetated Sites
2007




Tomahawk Lake, Bayfield Co.
Native Vegetated Sites
2008
No Natives
Natives Present
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0
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WISCONSIN
DEPT. OF NATURAL RESOURCES

Quantitative Data?

- EWM decreased by 45% in the second survey

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- EWM decreased by 45% in the second survey
- 45% decrease in *what* of EWM

Quantitative Data?

- EWM decreased by 45% in the second survey

- 45% decrease in *what* of EWM
  - Acres?
  - g dry weight per m^2?
  - Points?
  - Number of nuisance areas?

Quantitative Data?

- EWM decreased by 45% in the second survey

- 45% decrease in *what* of EWM
- Second survey compared to *what?*

Quantitative Data?

- EWM decreased by 45% in the second survey

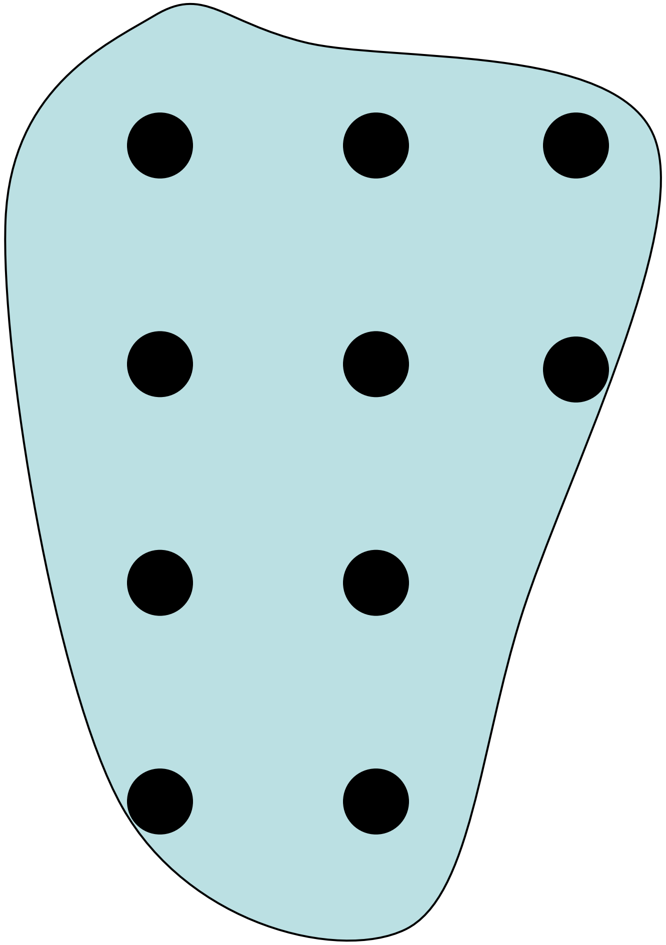
- 45% decrease in *what* of EWM
- Second survey compared to *what?*
  - Pre-treatment year survey, similar timing?
  - An earlier spring survey?
  - Compared to a survey conducted in 1995?

(Semi-) Quantitative data!

- Frequency of occurrence
  - Number of times an event occurs given a finite number of samples

- NUMERATOR: number positive hits
- DENOMINATOR: total number of samples

- Total number of samples??

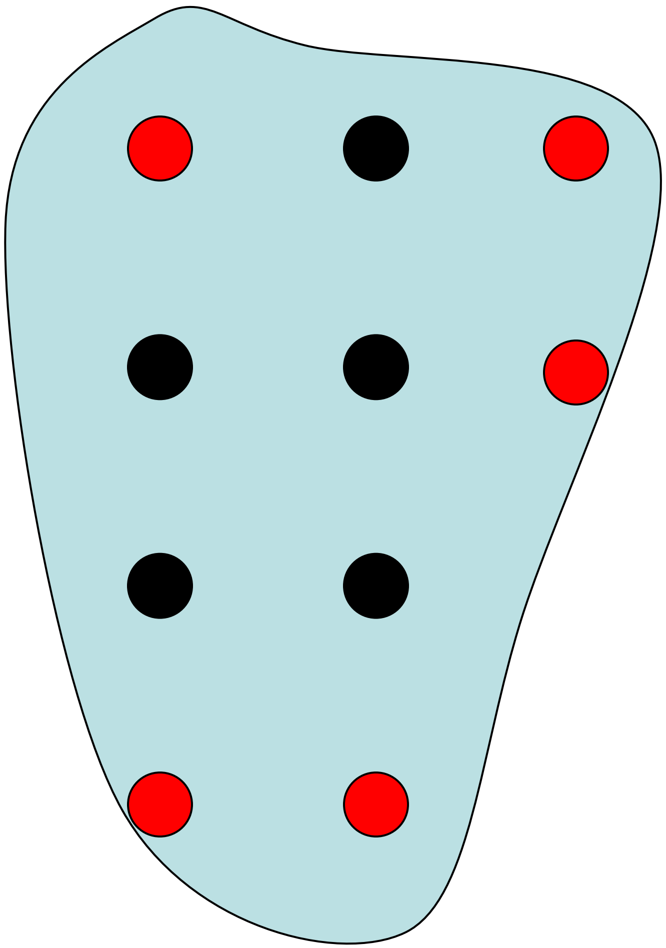


Frequency of occurrence

Number of positive hits:

Number of points:

Frequency of occurrence =

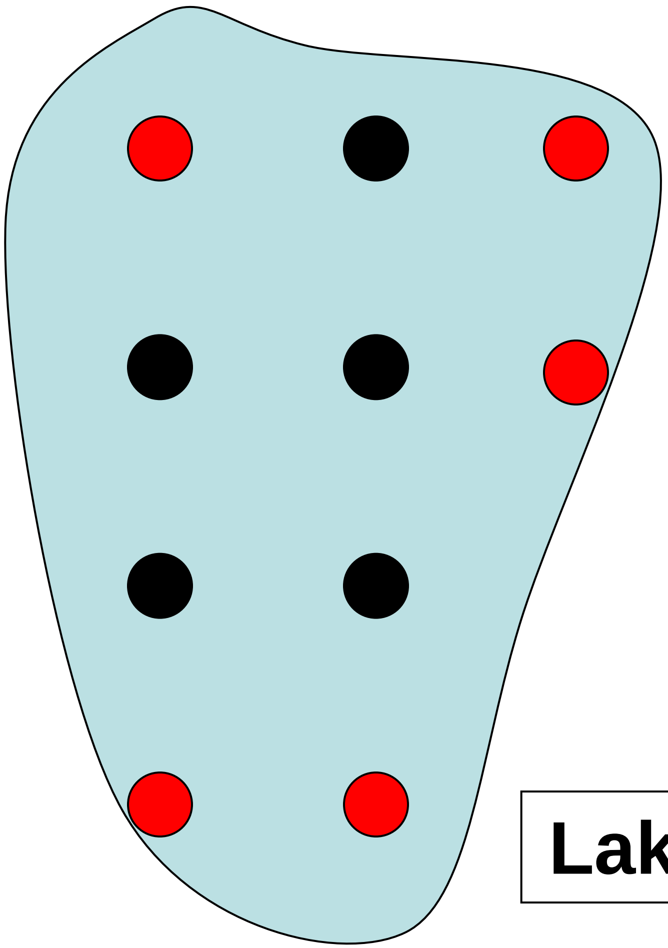


Frequency of occurrence

Number of positive hits: **5**

Number of points: **10**

Frequency of occurrence =



Frequency of occurrence

Number of positive hits: **5**

Number of points: **10**

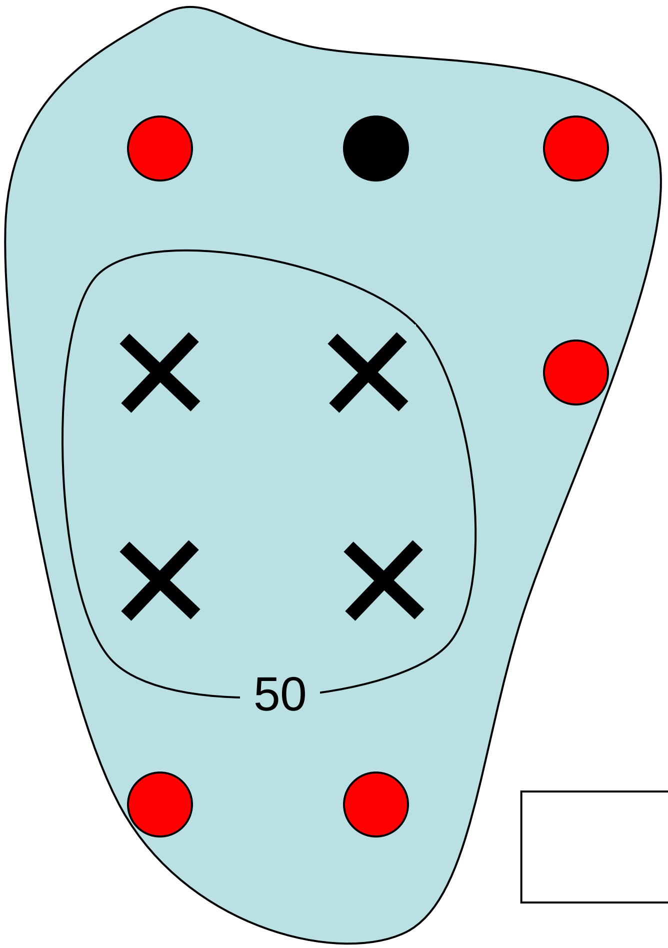
Lakewide Frequency of occurrence =

0.50

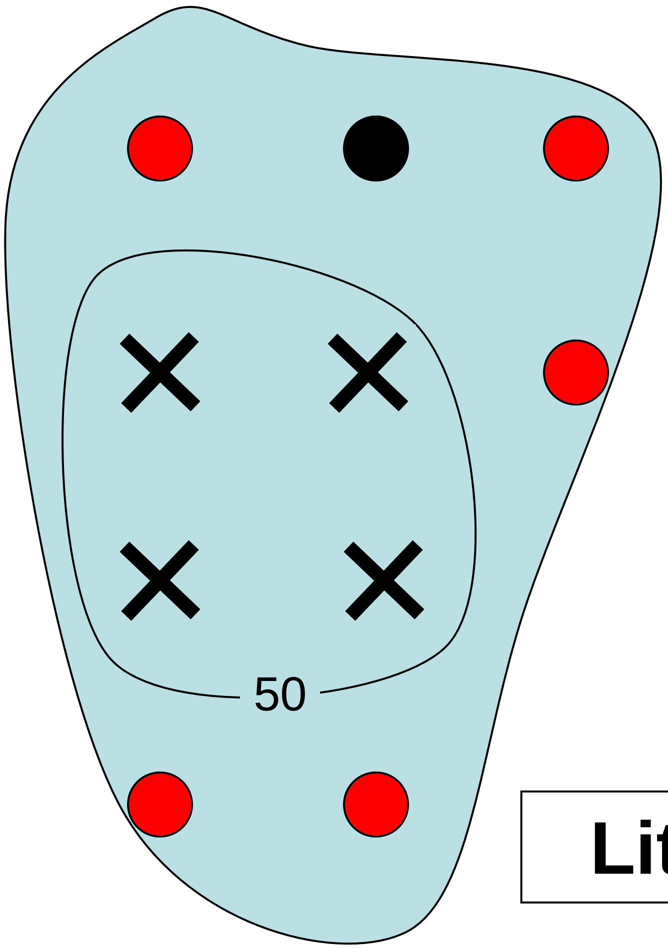
Frequency of occurrence

Number of positive hits: **5**

Number of points:



Frequency of occurrence =



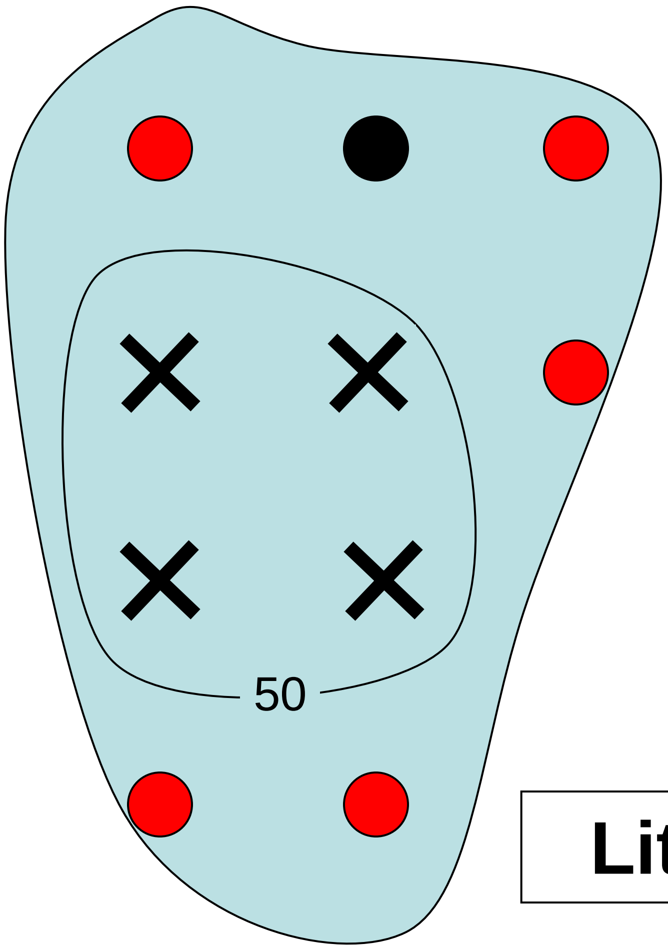
Frequency of occurrence

Number of positive hits: **5**

Number of points: **6**

Littoral

Frequency of occurrence =



Frequency of occurrence

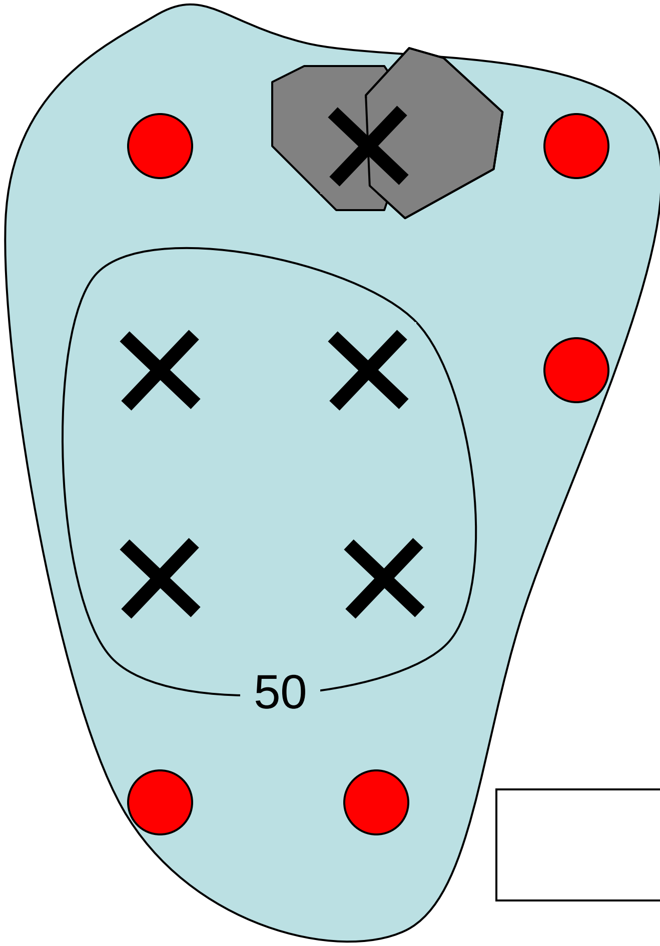
Number of positive hits: **5**

Number of points: **6**

Littoral

Frequency of occurrence =

0.83

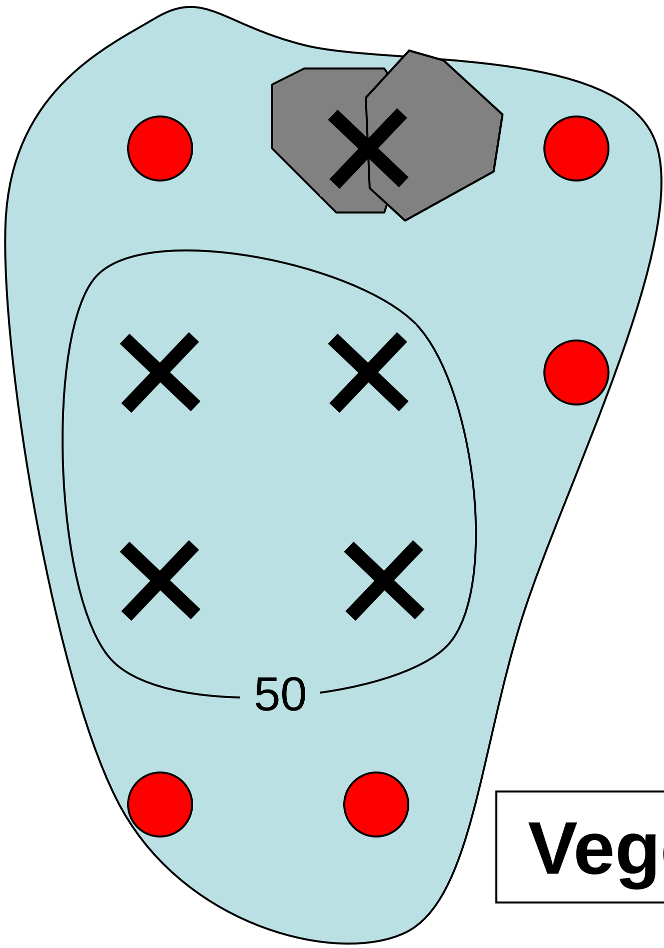


Frequency of occurrence

Number of positive hits: **5**

Number of points:

Frequency of occurrence =

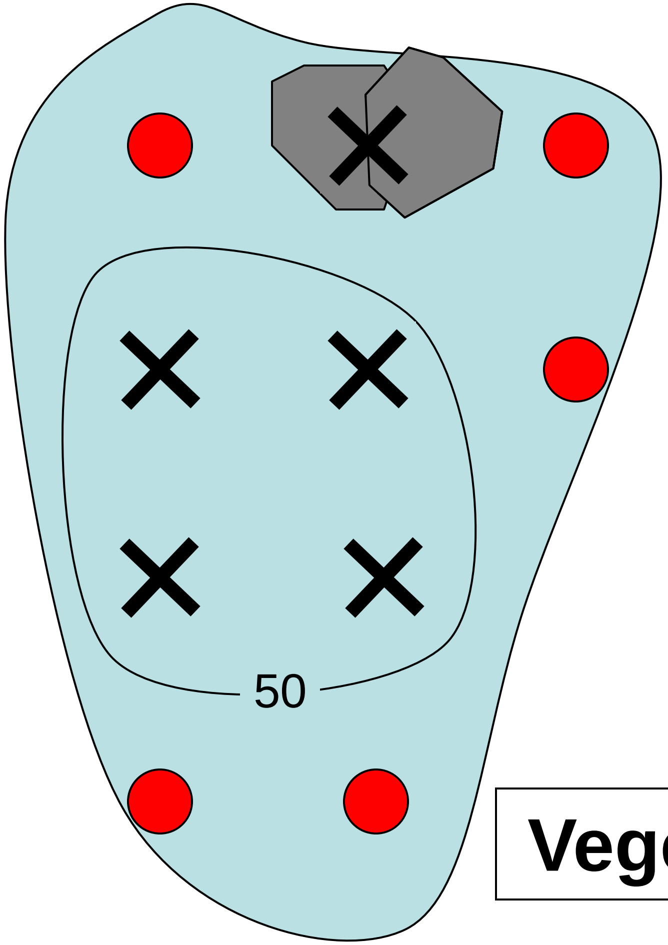


Frequency of occurrence

Number of positive hits: **5**

Number of points: **5**

Vegetated Frequency of occurrence =



Frequency of occurrence

Number of positive hits: **5**

Number of points: **5**

Vegetated Frequency of occurrence =

1.00

EWM frequency of occurrence

N # points with EWM

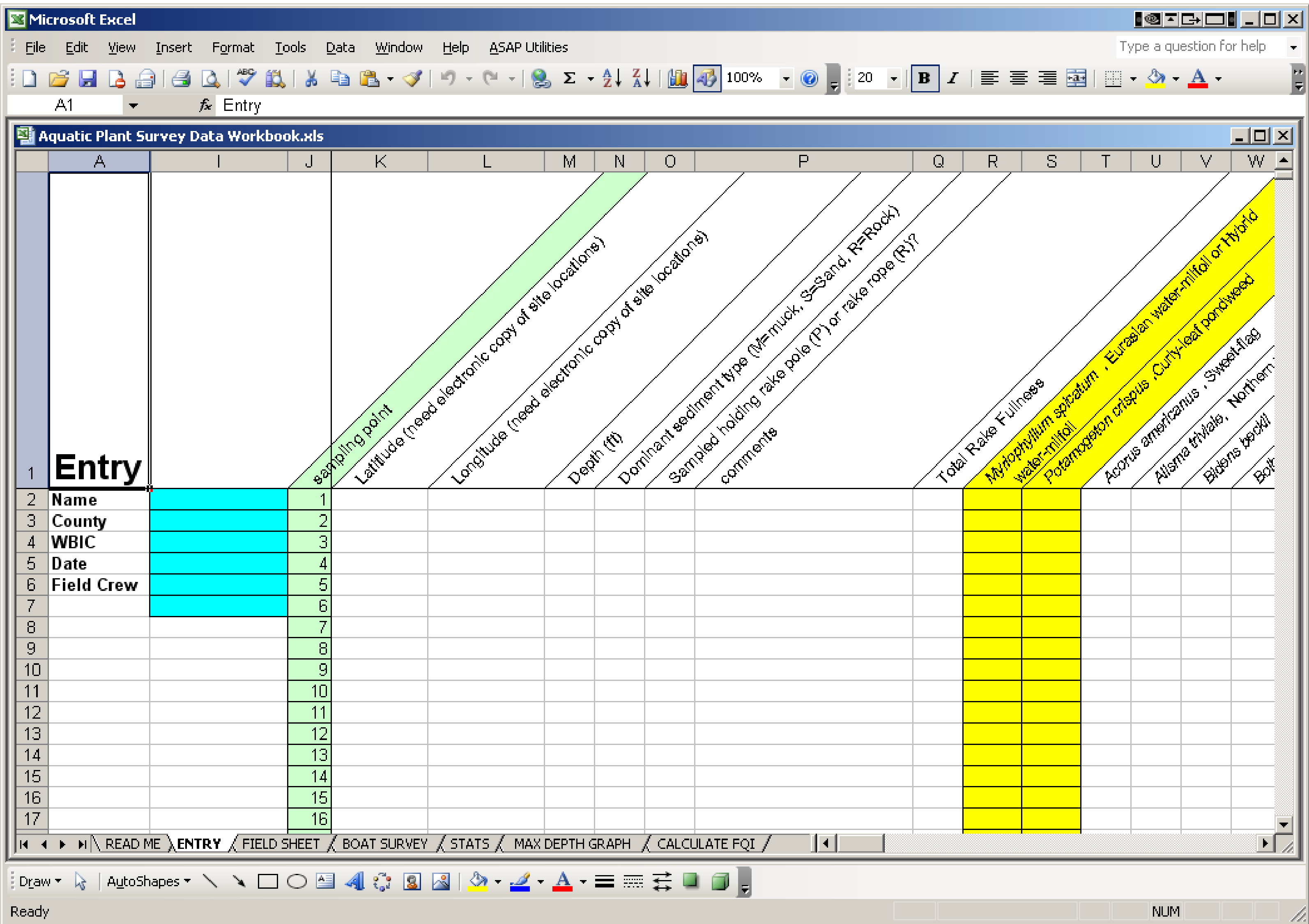
D

Lakewide - total # sample points (50%)

Littoral - # points shallower than max depth of plant growth (83%)

Vegetated - # vegetated points (100%)

Aquatic Plant Survey Data Workbook



The Statistics

Total number of sites visited: Total number of sites where the boat stopped, even if much too deep to have plants.

Total number of sites with vegetation: Total number of sites where at least one plant was found

Total number of sites shallower than maximum depth of plants: Number of sites where the depth was less than or equal to the maximum depth where plants were found.

This value is used for Frequency of occurrence at sites shallower than maximum depth of plants.

Frequency of occurrence within vegetated areas (%): Number of times a species was seen in a vegetated area divided by the total number of vegetated sites.

Frequency of occurrence at sites shallower than maximum depth of plants: Number of times a species was seen divided by the total number of sites shallower than maximum depth of plants

Species Richness: Total number of species collected. Does not include visual sightings.

Species Richness (including visuals): Total number of species collected including visual sightings.

APMstatsUWSP2009.xls

	A	B	C	D	E	F
1		**STATS**	Total vegetation	Myriophyllum spicatum, Euras	Potamogeton cris	Acor
2	Lake					
3	County					
4	WBIC					
5	Survey Date					
6		**INDIVIDUAL SPECIES STATS:**				
7		Frequency of occurrence within vegetated areas (%)				
8		Frequency of occurrence at sites shallower than maximum depth of plants				
		Relative Frequency (%)				
10		Relative Frequency (squared)				
11		Number of sites where species found				
12		Average Rake Fullness				
13		#visual sightings				
14		present (visual or collected)				
15						
16		**SUMMARY STATS:**				
		Total number of sites visited				
		Total number of sites with vegetation				
		Total number of sites shallower than maximum depth of plants				
20		Frequency of occurrence at sites shallower than maximum depth of plants				
21		Simpson Diversity Index				
22		Maximum depth of plants (ft)**				
23		Number of sites sampled using rake on Rope (R)				
24		Number of sites sampled using rake on Pole (P)				
25		Average number of all species per site (shallower than max depth)				
26		Average number of all species per site (veg. sites only)				
27		Average number of native species per site (shallower than max depth)				
28		Average number of native species per site (veg. sites only)				
29		Species Richness				
30		Species Richness (including visuals)				
31						
32		**SEE "MAX DEPTH GRAPH" WORKSHEET TO CONFIRM				
33						

READ ME / ENTRY / FIELD SHEET / BOAT SURVEY / **STATS** / MAX DEPTH GRAPH / CALC

Relative frequency of occurrence

- How common or rare a species is relative to other species
- NUMERATOR: number positive hits
- DENOMINATOR: sum of frequencies of all species observed
- High RFOO = dominant species

Analyzing community change

- Tomahawk Lake - 2,4-D in 2008
  - Littoral frequency of occurrence 2007 – 2008
    - EWM: 40% to 0 %
    - Robbins’ pondweed: 35% to 25%
    - Elodea: 38% to 13%
- Sandbar Lake – not treated
  - Littoral frequency of occurrence 2007 – 2008
    - EWM: 26% to 31%
    - Robbins’pondweed: 7% to 11%
    - Elodea: 35% to 31%

Tomahawk Chi Square

- Presence/Absence data
  - Two outcomes – plant is present, or not
  - Binomial error distribution – non-normal!
- Chi Square test
  - Non-parametric
  - Test difference between expected results and actual observed results

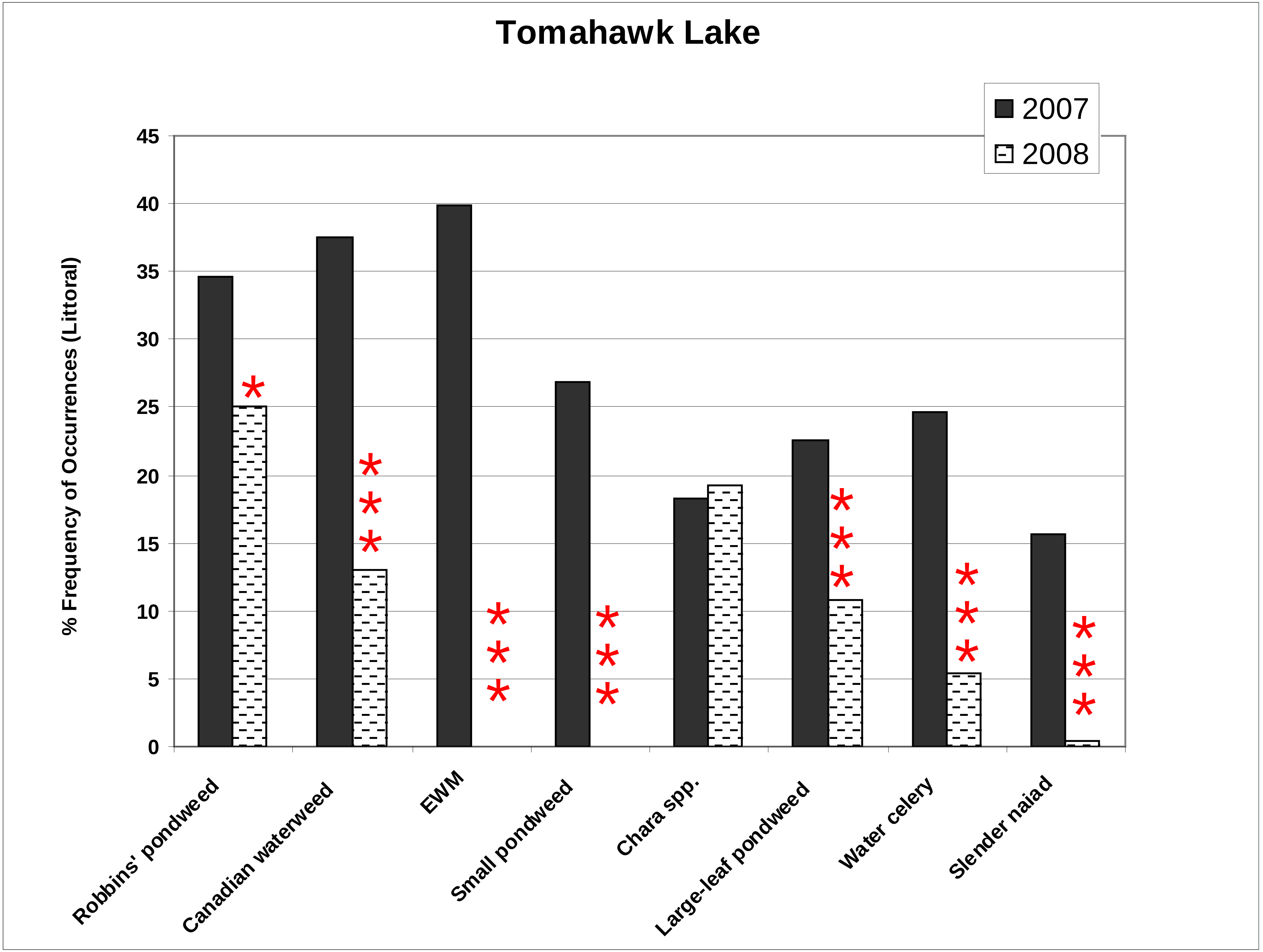
$$X^2 = \sum \frac{(\text{Observed frequency} - \text{Expected frequency})^2}{\text{Expected frequency}}$$

Tomahawk Chi Square

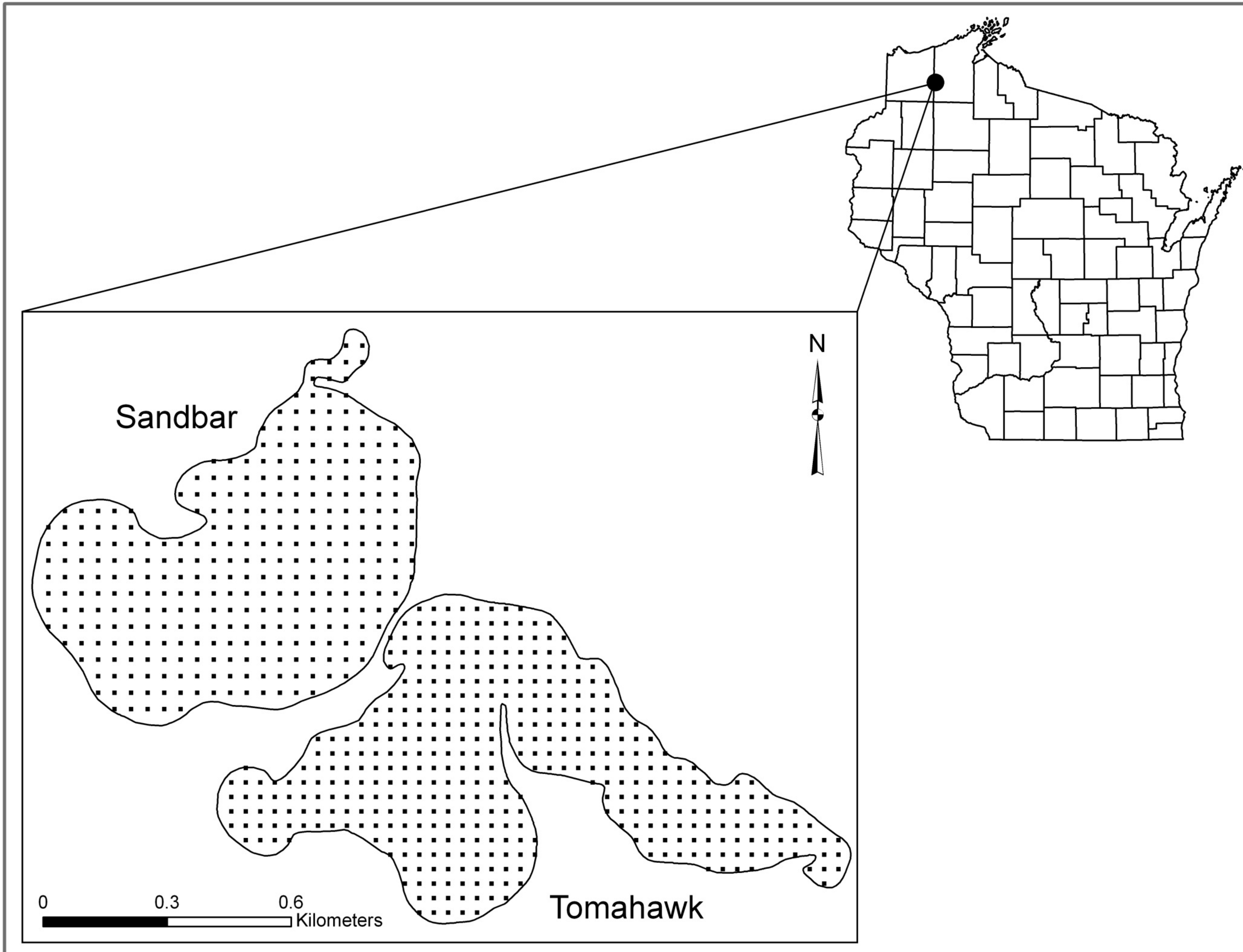
- Example–

Tomahawk Chi Square

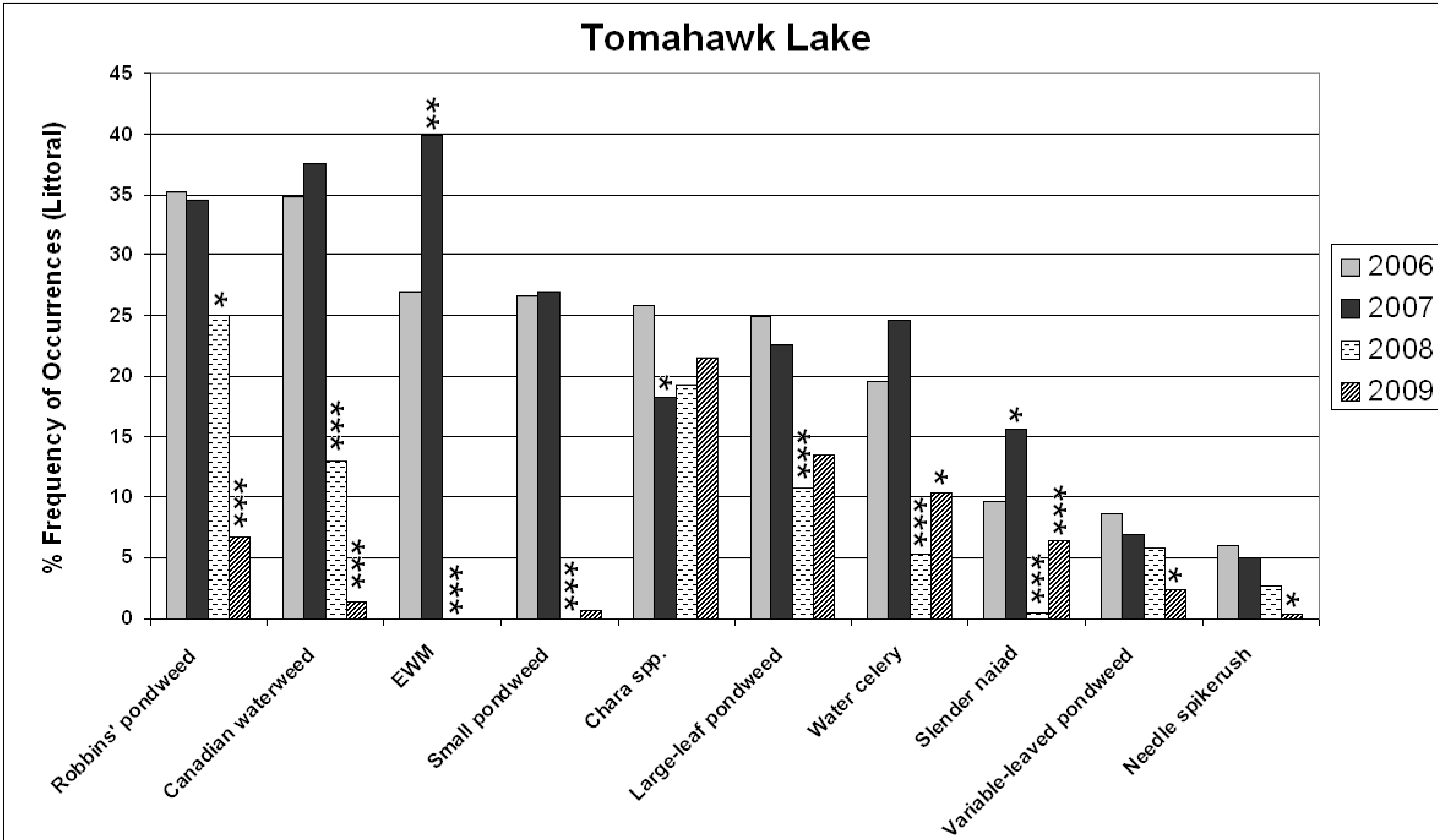
- Graph frequency of occurrence
- Indicate significant changes (***)

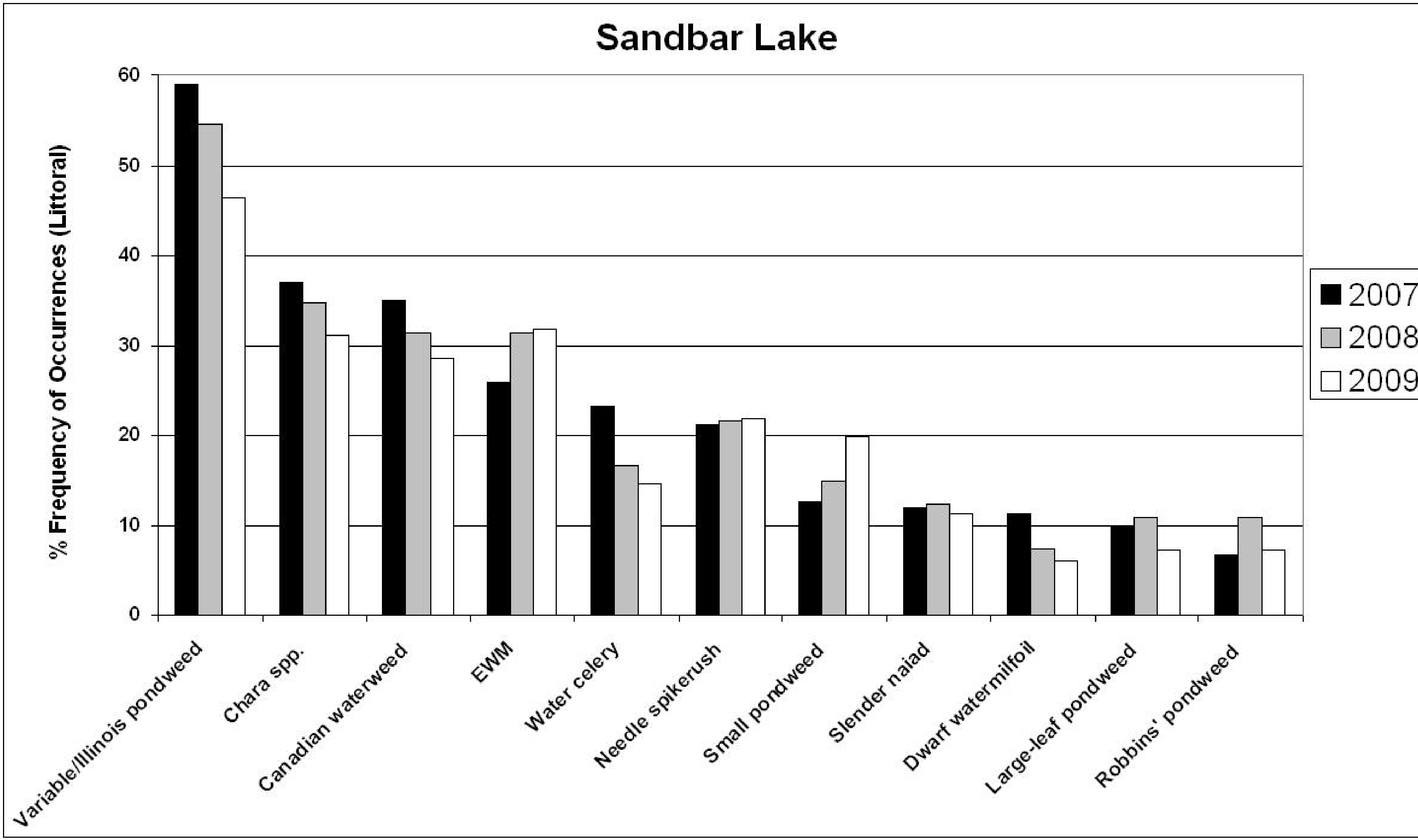


Tomahawk Lake
2007
2008
% Frequency of Occurrences (Littoral)
0
5
10
15
20
25
30
35
40
45
*
***
***
***
***
***
***
Robbins' pondweed
Canadian waterweed
EWM
Small pondweed
Chara spp.
Large-leaf pondweed
Water celery
Slender naiad

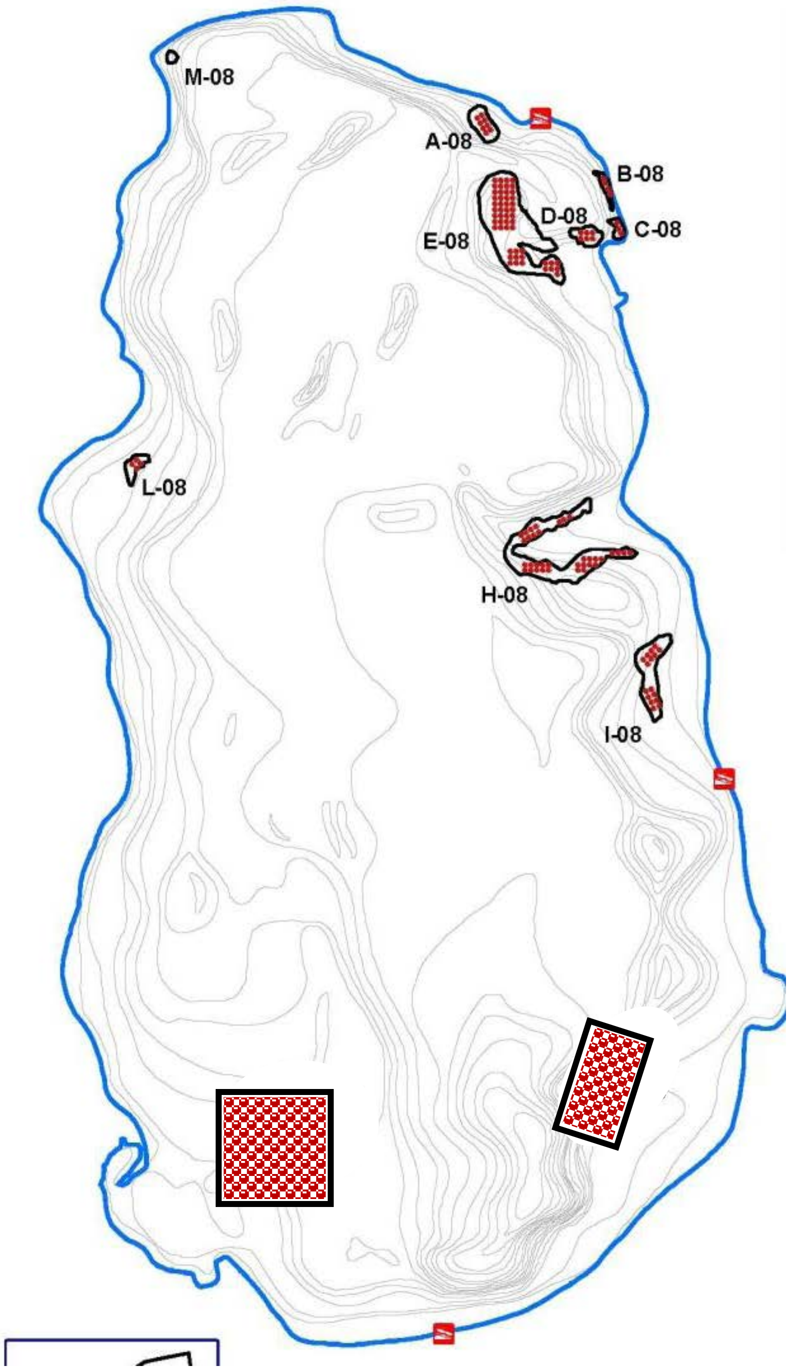


Sandbar
Tomahawk
N
0
0.3
0.6
Kilometers


Tomahawk Lake
% Frequency of Occurrences (Littoral)
45
40
35
30
25
20
15
10
5
0
2006
2007
2008
2009
Robbins' pondweed
Canadian waterweed
EWM
Small pondweed
Chara spp.
Large-leaf pondweed
Water celery
Slender naiad
Variable-leaved pondweed
Needle spikerush



Sandbar Lake
% Frequency of Occurrences (Littoral)
60
50
40
30
20
10
0
Variable/Illinois pondweed
Chara spp.
Canadian waterweed
EWM
Water celery
Needle spikerush
Small pondweed
Slender naiad
Dwarf watermilfoil
Large-leaf pondweed
Robbins' pondweed
2007
2008
2009

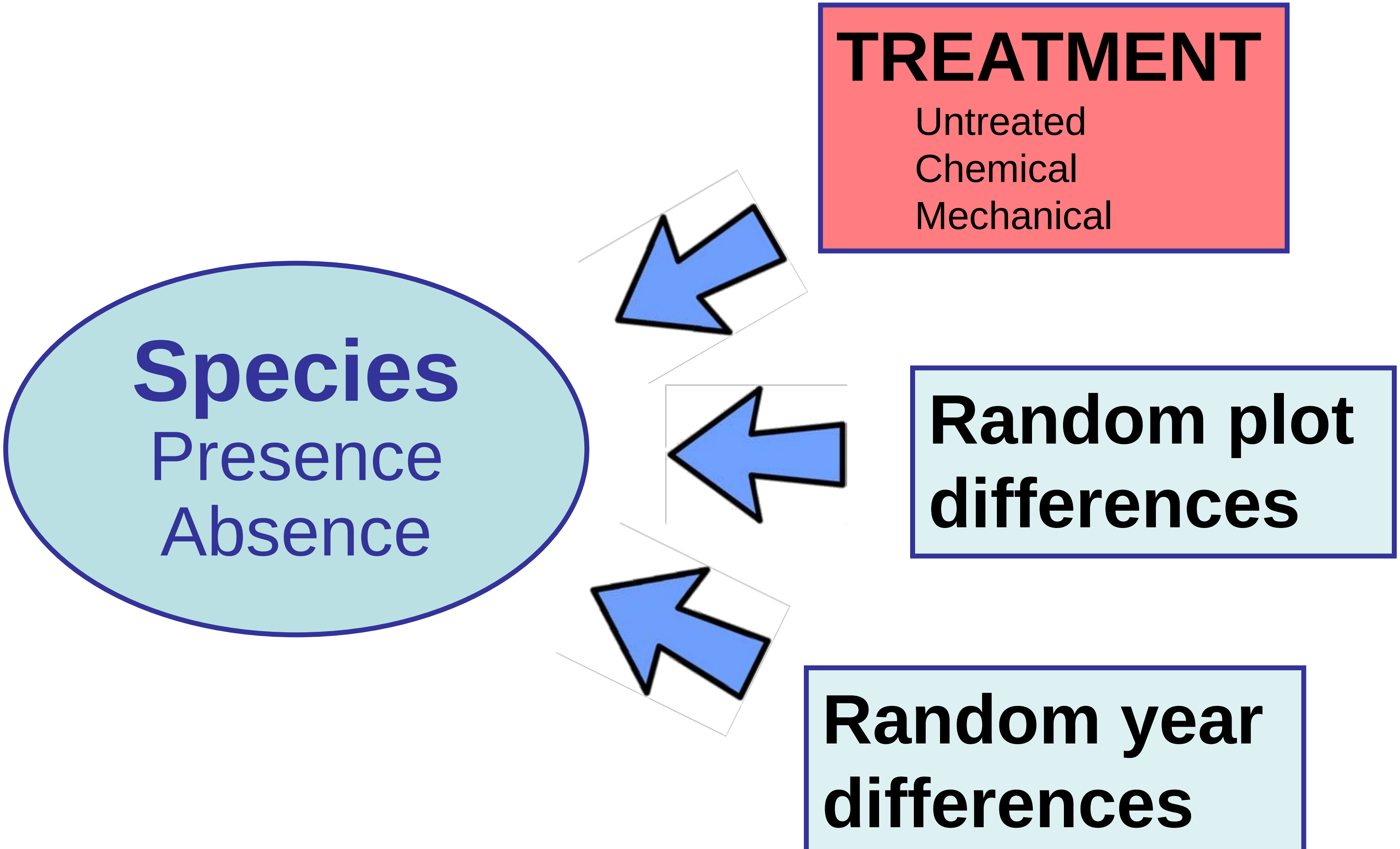


- Pre/Post-treatment monitoring polygons
- If possible – compare to controls!

Detecting change over >2 events

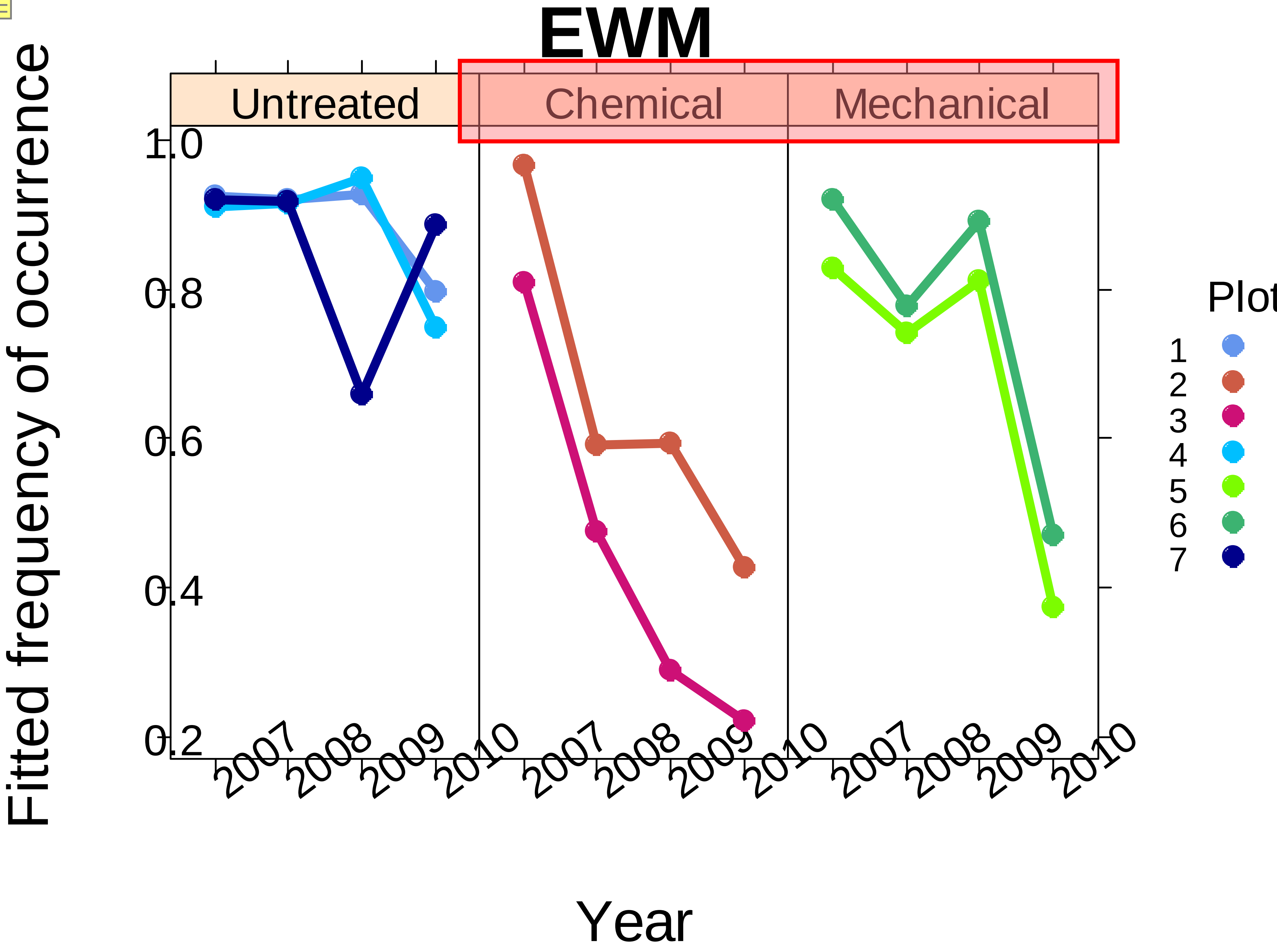
- Chi square analysis, pairwise
  - Nested chi square analyses (caveat!)
    - 2005 v. 2006
    - 2006 v. 2007
    - 2005 v. 2007
  - More complex models
    - Linear mixed models
    - Time series analysis

Predict: **Given:**



Generalized Linear Mixed Model

SPECIES ~ TREATMENT + YEAR + (1 | PLOT) + (YEAR | PLOT)

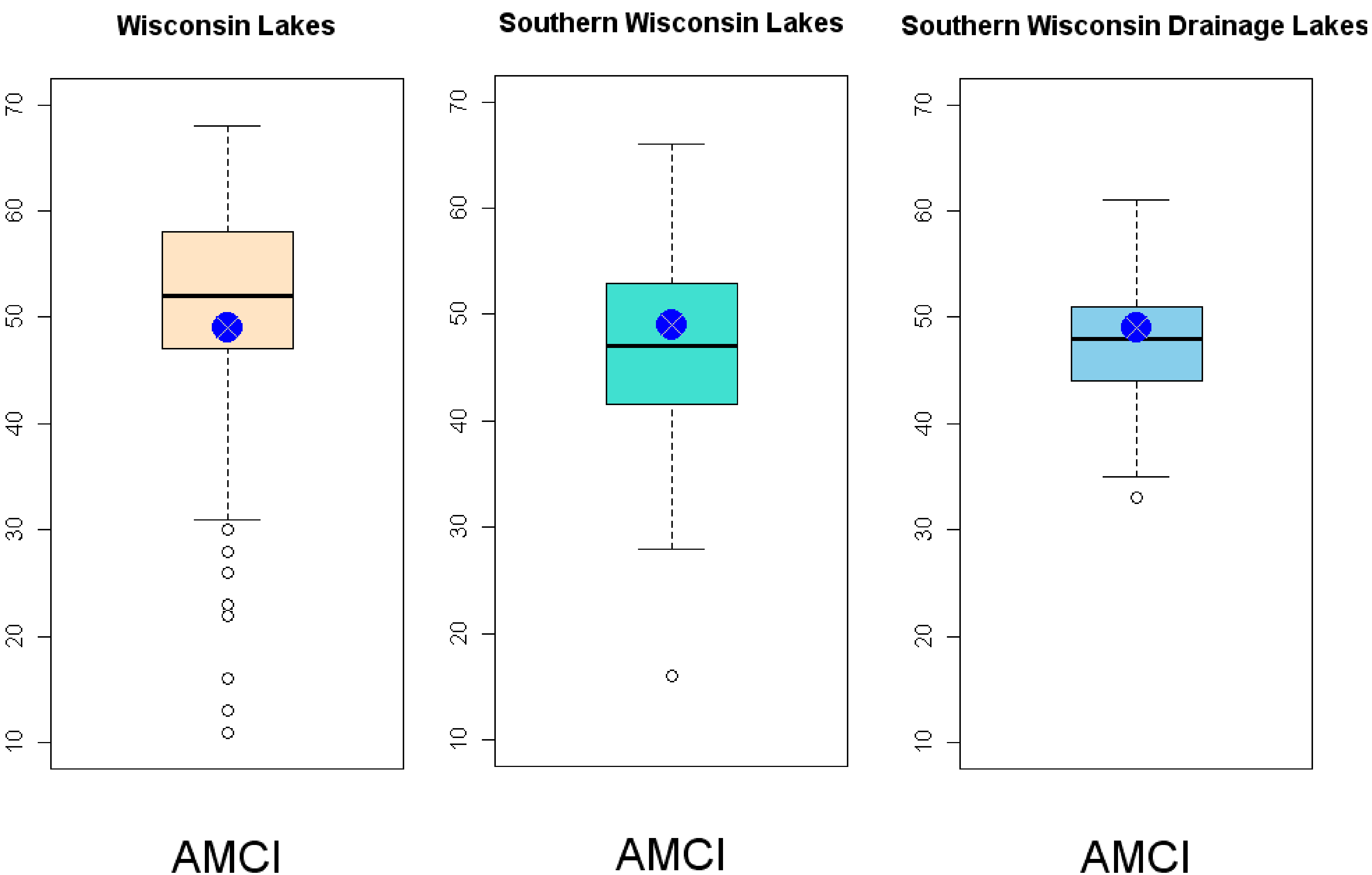

EWM
Untreated
Chemical
Mechanical
Fitted frequency of occurrence
1.0
0.8
0.6
0.4
0.2
2007
2008
2009
2010
Year
Plot
1
2
3
4
5
6
7

Diversity / Quality Indicators

- Natives per vegetated point
- Simpson's diversity index
  - Ranges 0 – 1;   1 = maximally diverse
- FQI
  - Based on conservatism value 1-10
    - 1 is most likely to be in impacted systems
    - 10 is most often found in pristine systems
    - Mean C divided by $\sqrt{N}$
- AMCI
  - Like FQI but incorporates more factors

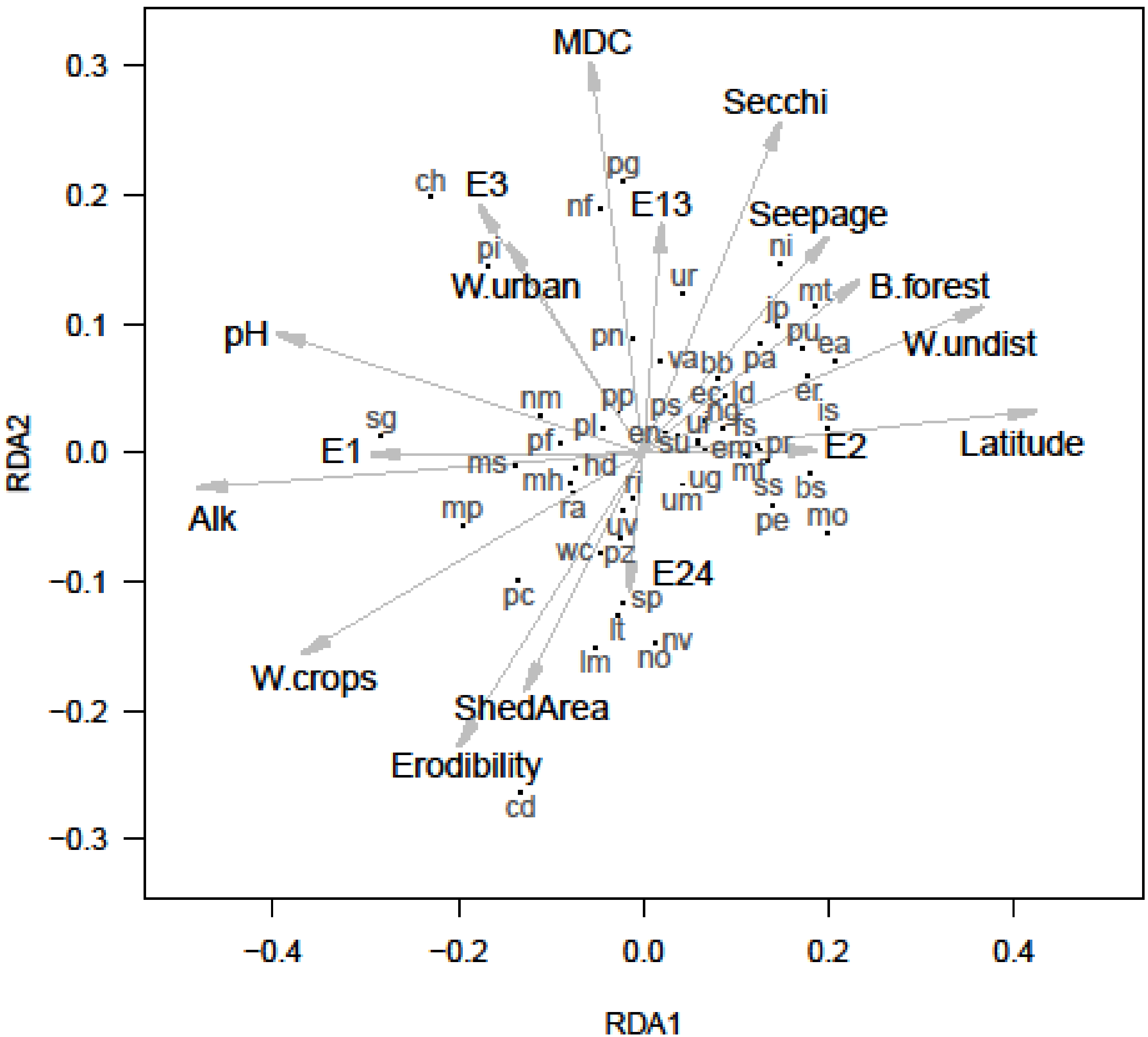
Making comparisons

- How is my lake relative to:
  - Wisconsin lakes
  - Wisconsin lakes in my region
  - Wisconsin lakes of similar type in my region


Wisconsin Lakes
Southern Wisconsin Lakes
Southern Wisconsin Drainage Lakes
10
20
30
40
50
60
70
AMCI
AMCI
AMCI

Analyzing plant communities

- Different species respond to environmental conditions differently
- Analyze each species' response curve
  - Many dimensions – species/sites/environment
- Ordination – force multi-dimensional data into fewer dimensions that are easier to understand


MDC
Secchi
Seepage
B.forest
W.undist
Latitude
E2
E3
E13
E24
E1
W.urban
pH
Alk
W.crops
ShedArea
Erodibility
ch
pg
nf
pi
ur
ni
mt
jp
pu
ea
pn
va
bb
pa
er
is
nm
pp
ps
ec
ld
sg
pl
pf
ms
hd
mh
ra
mp
ri
um
ug
mf
ss
bs
pe
mo
uv
wc
pz
pc
sp
lt
lm
no
nv
cd
RDA1
RDA2
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.3
−0.4
0.4

Water Residue Sampling

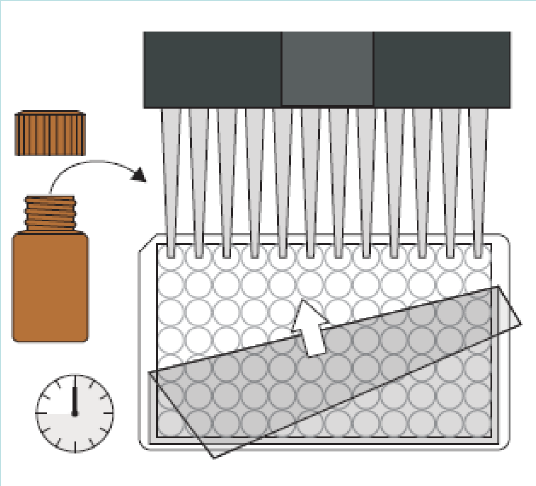
- **2,4-D residues**

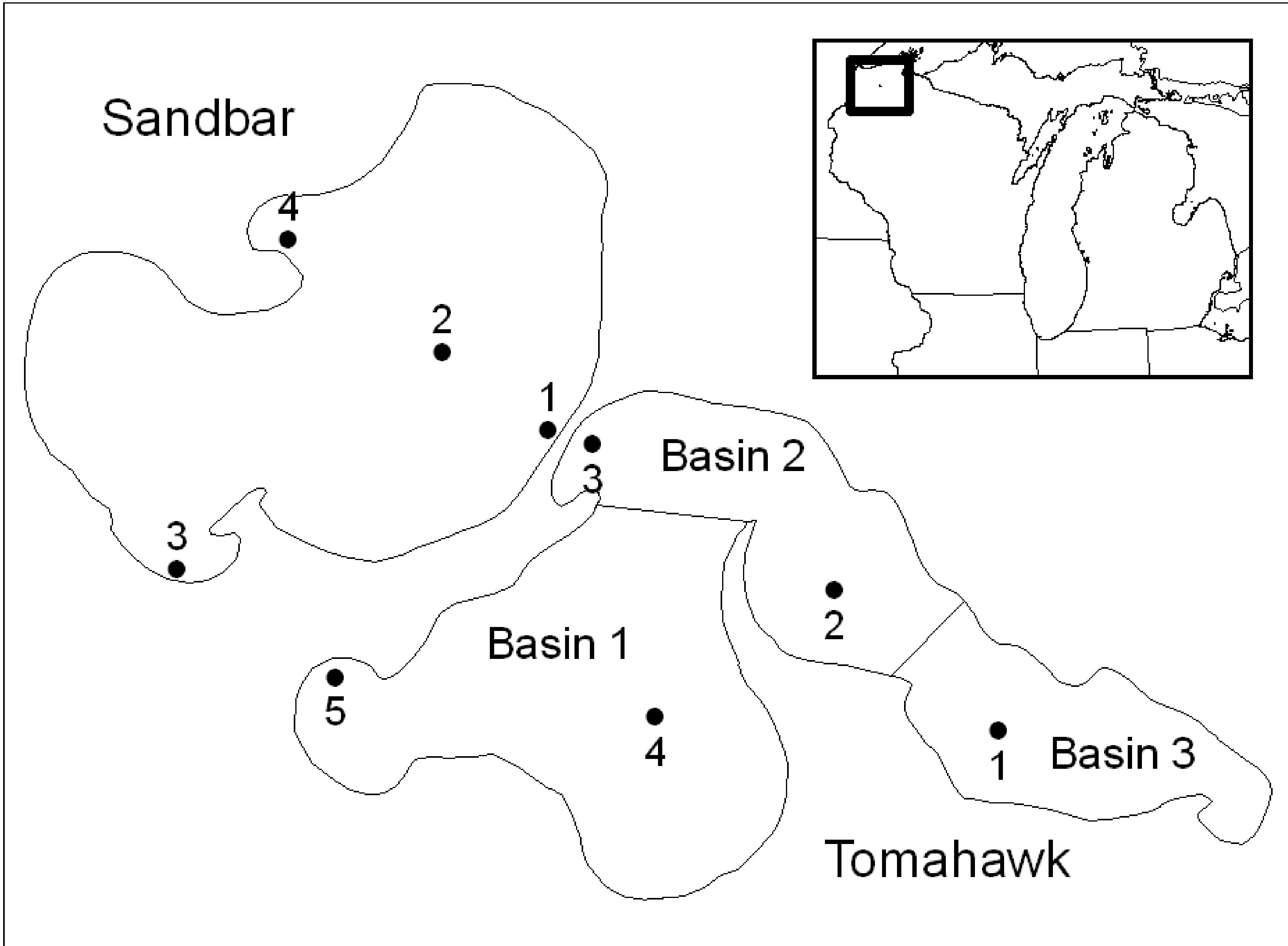
Enzyme-linked immunosorbant assay (ELISA)

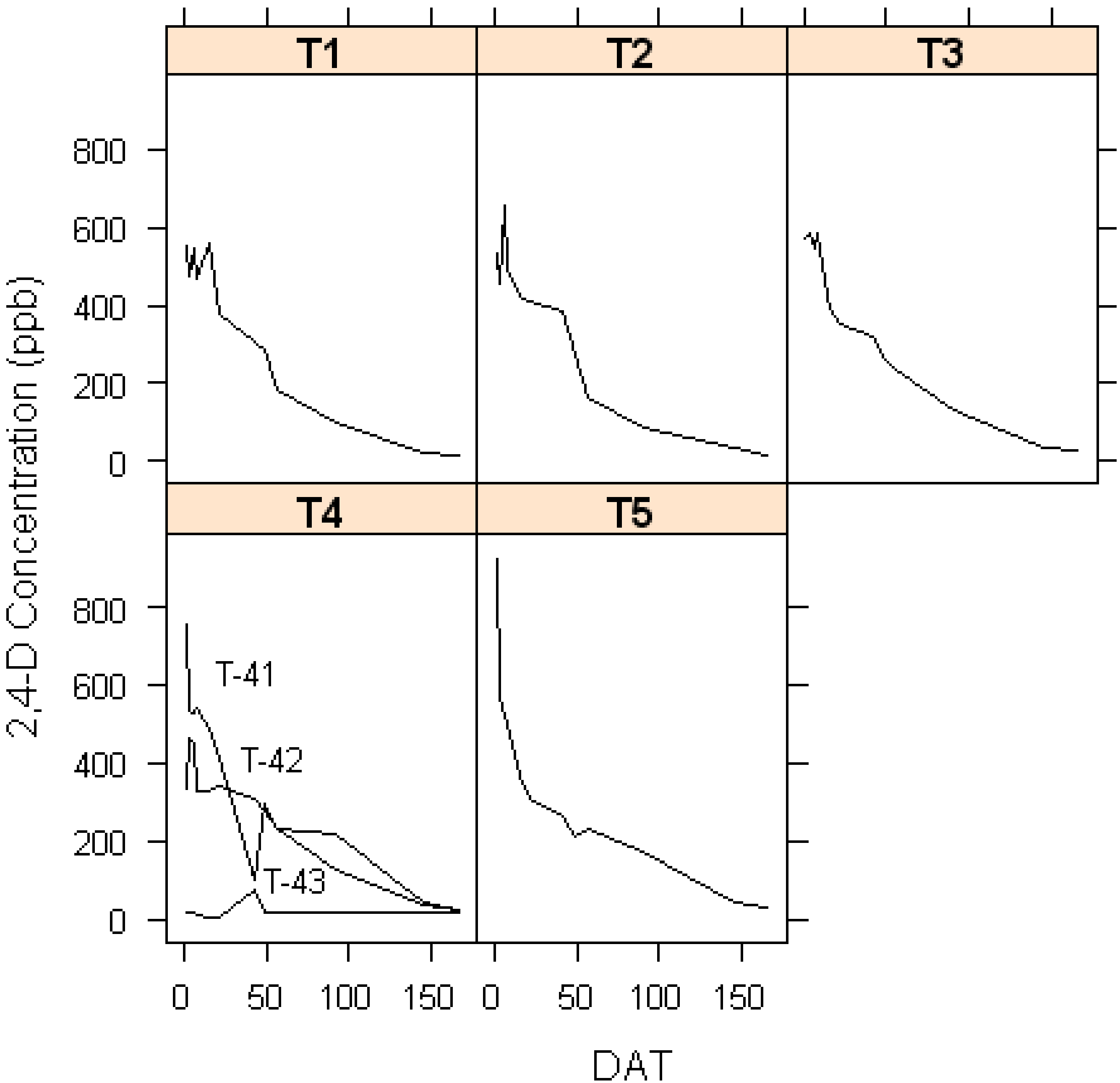
Residuals often reported as 2,4-D acid equivalent

ELISA – for 2,4-D

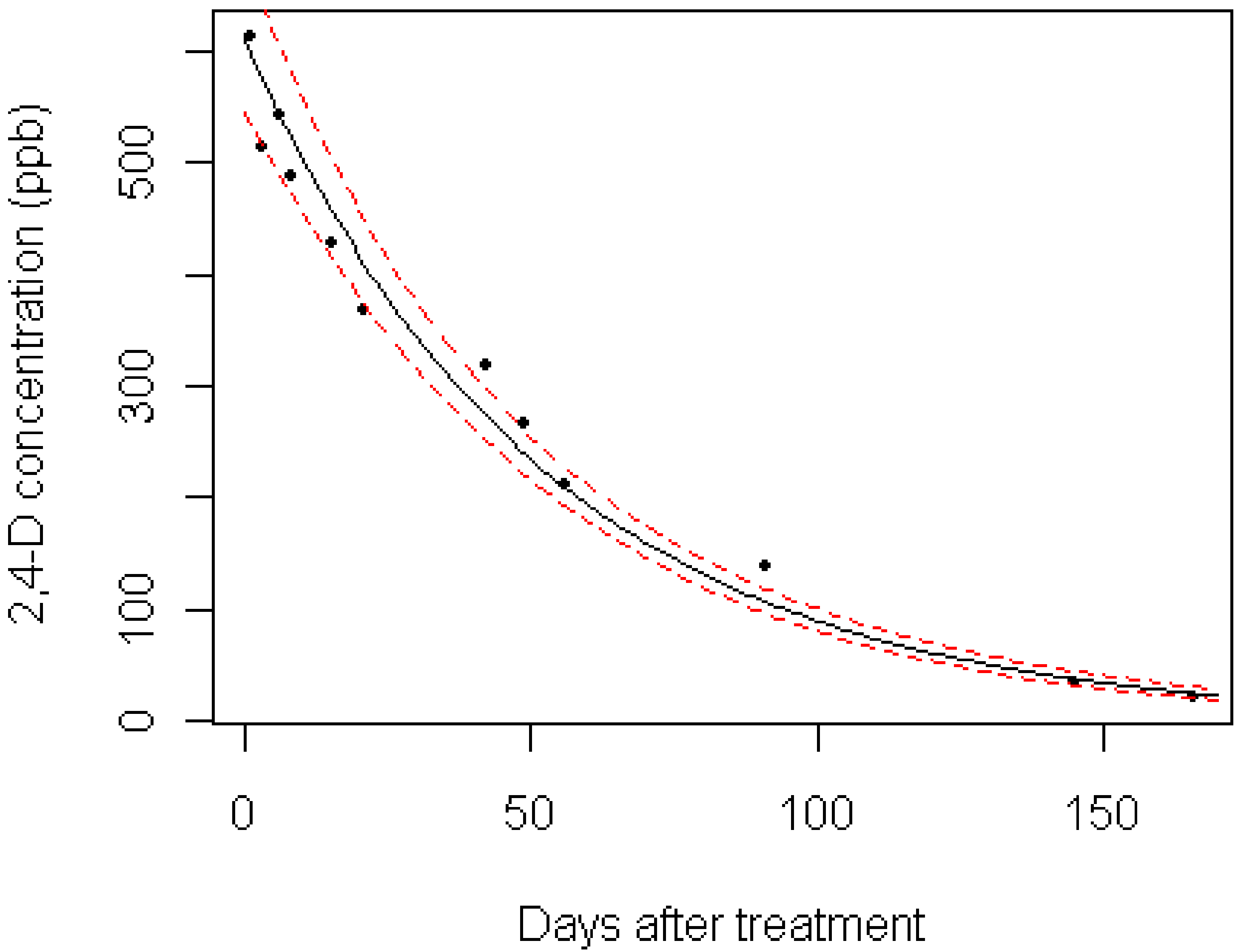
- Add water samples to microtiter plate containing 2,4-D antibody
- Wash plates
- Add color solution
- Measure color with spectrophotometer
  - Quantity of 2,4-D in sample




Sandbar
4
2
1
3
3
Basin 2
2
Basin 1
5
4
1
Basin 3
Tomahawk



T1
T2
T3
T4
T5
T-41
T-42
T-43
2,4-D Concentration (ppb)
DAT
0
200
400
600
800
0
50
100
150


2,4-D concentration (ppb)
0
100
300
500
0
50
100
150
Days after treatment

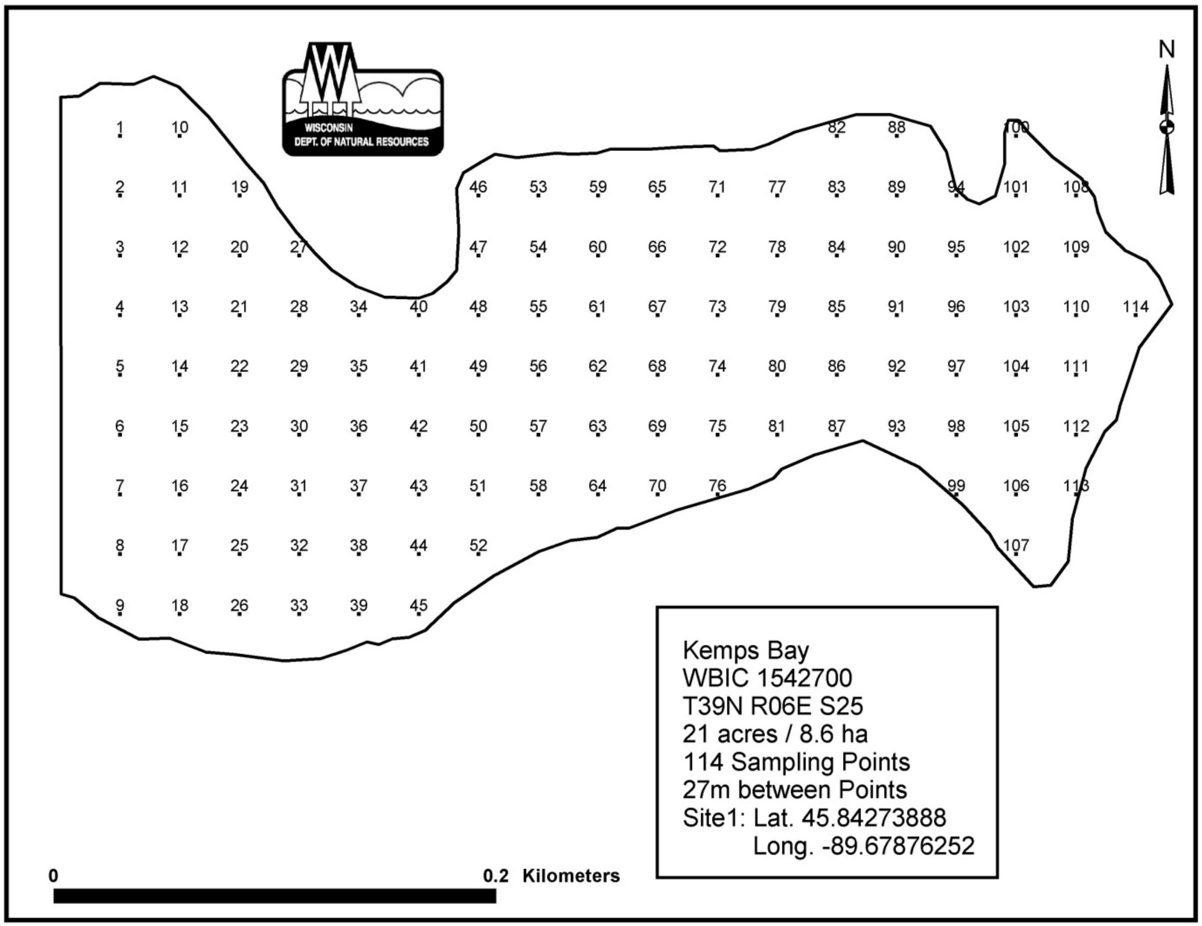
Data Analysis and Interpretation

- Analyzing plant distributions
  - Qualitative data (maps)
  - Semi-quantitative data (frequency of occurrence)
- Analyzing changes in plant distributions
  - 2 sampling events
    - Chi Square analysis: Baseline & pre/post treatment assessment
  - more than 2 sampling events
    - Chi Square in series, generalized linear models
- Analyzing plant communities

Tools

- Making Maps
- Aquatic Plant Survey Data Workbook
  - Datasheets, Data Entry, Stats, MDC check, FQI calculation
- Pre/Post Treatment Guidance
- Chi Square Workbook

Free Map Making Software



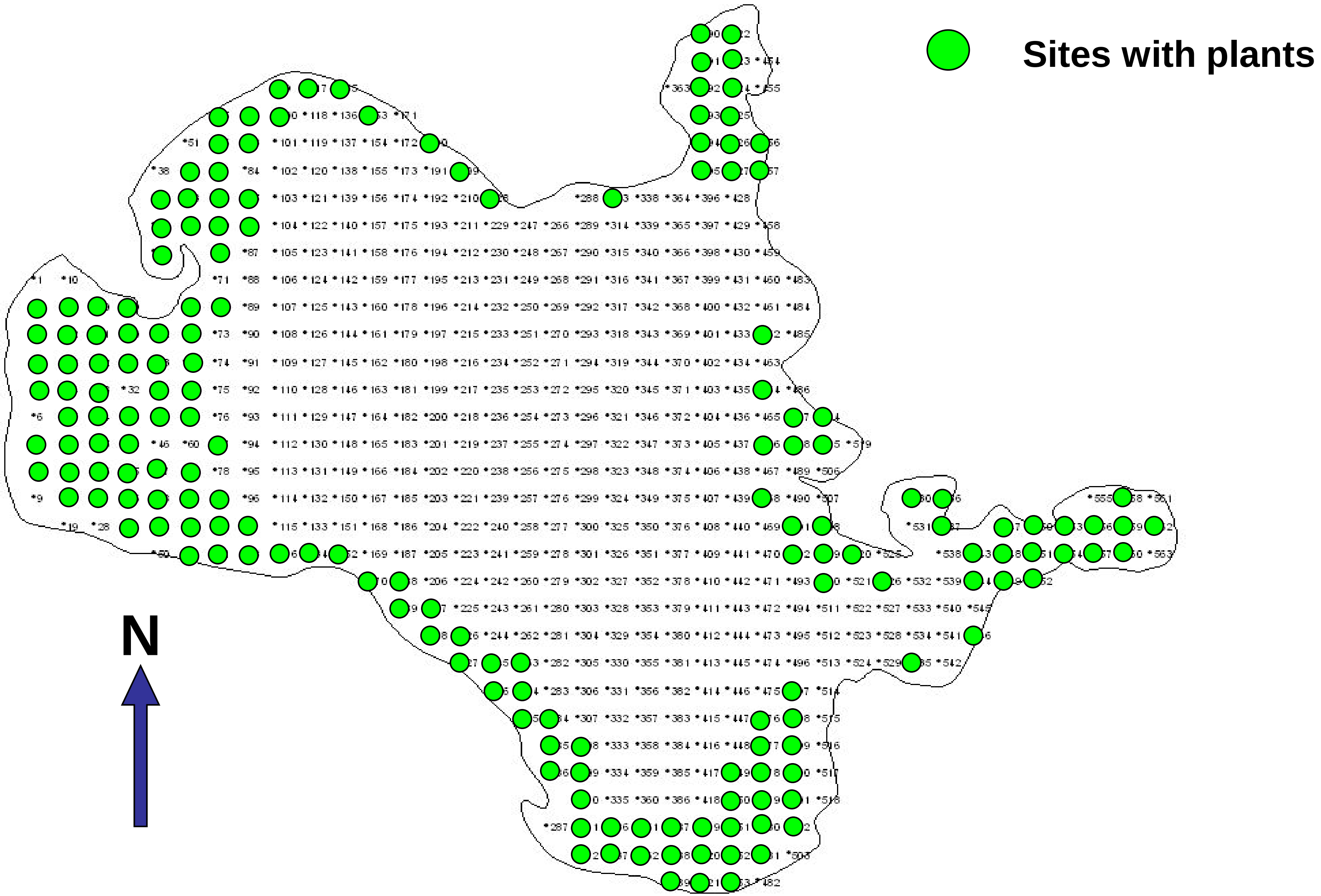
Freeware for map making

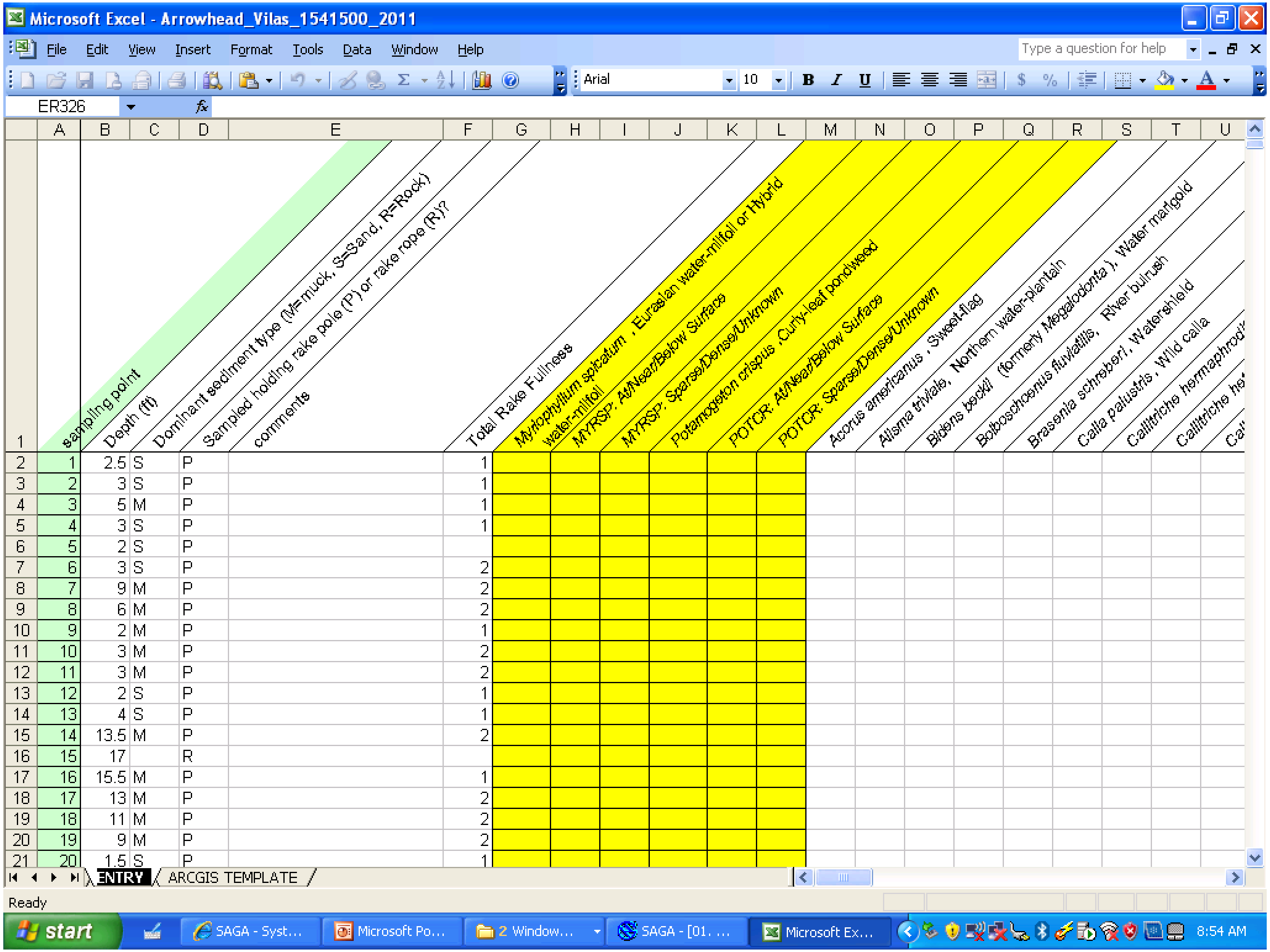
- SAGA
- MapWindow
- GRASS

Map making ideas

- Use to display different species
- Identify invasive locations

Vegetated sites





	sampling point	Depth (ft)	Dominant sediment type (M=muck, S=Sand, R=Rock)	Sampled holding rake pole (P) or rake rope (R)?	comments	Total Rake Fullness	Myriophyllum spicatum , Eurasian water-milfoil or Hybrid water-milfoil	MYRSP: At/Near/Below Surface	MYRSP: Sparse/Dense/Unknown	Potamogeton crispus , Curly-leaf pondweed	POTCR: At/Near/Below Surface	POTCR: Sparse/Dense/Unknown	Acorus americanus , Sweet-flag	Alisma triviale, Northern water-plantain	Bidens beckii (formerly Megalodonta), Water marigold	Bolboschoenus fluviatilis, River bulrush	Brasenia schreberi, Watershield	Calla palustris , Wild calla	Callitriche hermaphrodi	Callitriche he	Cal
2	1	2.5	S	P		1															
3	2	3	S	P		1															
4	3	5	M	P		1															
5	4	3	S	P		1															
6	5	2	S	P																	
7	6	3	S	P		2															
8	7	9	M	P		2															
9	8	6	M	P		2															
10	9	2	M	P		1															
11	10	3	M	P		2															
12	11	3	M	P		2															
13	12	2	S	P		1															
14	13	4	S	P		1															
15	14	13.5	M	P		2															
16	15	17		R																	
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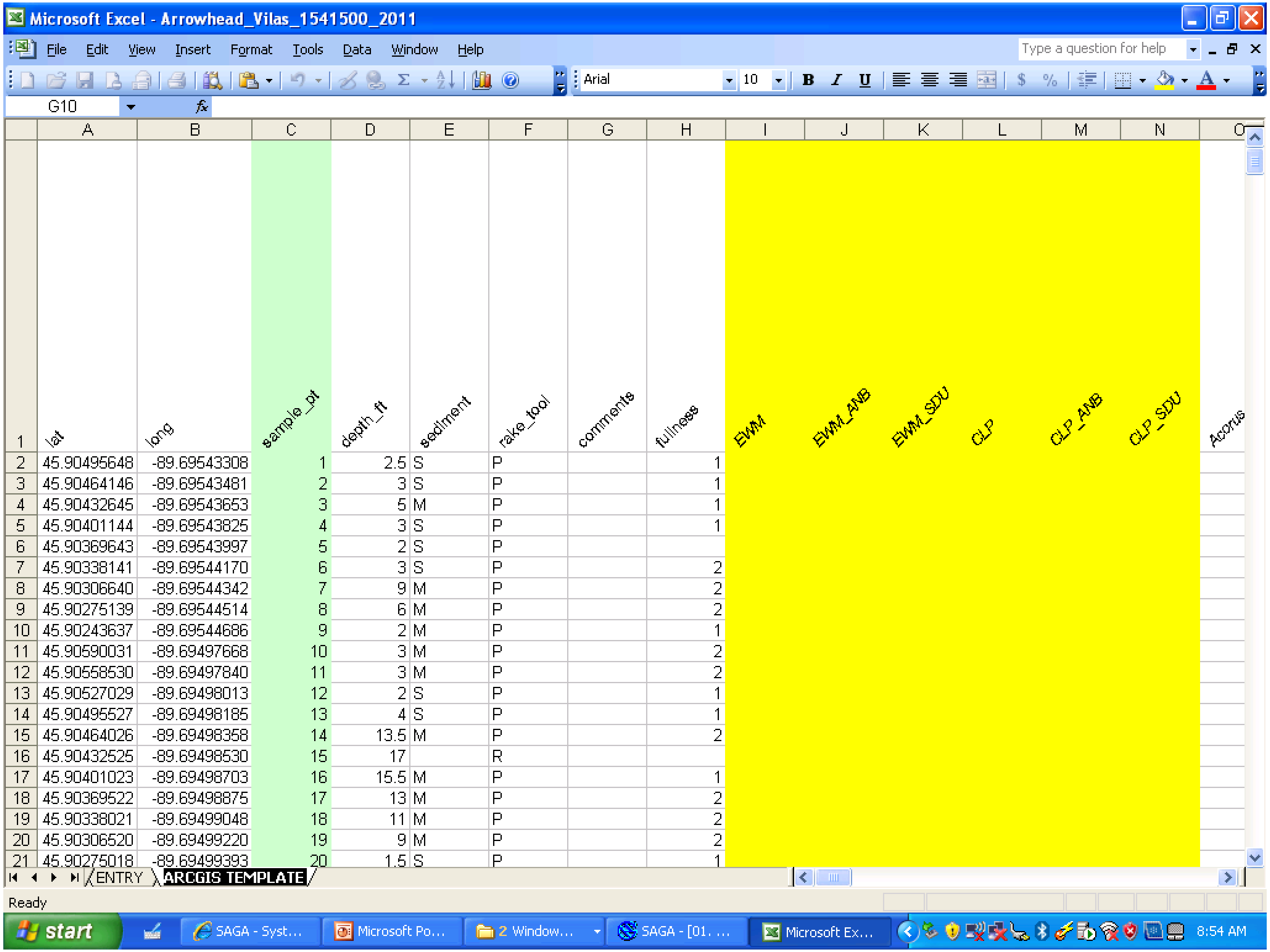

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3	45.90464146	-89.69543481	2	3	S	P		1							
4	45.90432645	-89.69543653	3	5	M	P		1							
5	45.90401144	-89.69543825	4	3	S	P		1							
6	45.90369643	-89.69543997	5	2	S	P									
7	45.90338141	-89.69544170	6	3	S	P		2							
8	45.90306640	-89.69544342	7	9	M	P		2							
9	45.90275139	-89.69544514	8	6	M	P		2							
10	45.90243637	-89.69544686	9	2	M	P		1							
11	45.90590031	-89.69497668	10	3	M	P		2							
12	45.90558530	-89.69497840	11	3	M	P		2							
13	45.90527029	-89.69498013	12	2	S	P		1							
14	45.90495527	-89.69498185	13	4	S	P		1							
15	45.90464026	-89.69498358	14	13.5	M	P		2							
16	45.90432525	-89.69498530	15	17		R									
17	45.90401023	-89.69498703	16	15.5	M	P		1							
18	45.90369522	-89.69498875	17	13	M	P		2							
19	45.90338021	-89.69499048	18	11	M	P		2							
20	45.90306520	-89.69499220	19	9	M	P		2							
21	45.90275018	-89.69499393	20	1.5	S	P		1							


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SAGA's first objective is to give (geo-)scientists an effective but easy learnable platform for the implementation of geoscientific methods. This is achieved by SAGA's unique Application Programming Interface (API). The second is to make these methods accessible in a user friendly way, what is first of all done by its Graphical User Interface (GUI). Together this results in SAGA's true strength: a fast growing set of geoscientifc methods ready to be used in numerous applications.
SAGA is coded in the widespread and powerful C++ programming language and has an object oriented system design. Since version 2 SAGA uses the cross platform GUI library wxWidgets for user interface functionality. Because wxWidgets enables operating system independent software development, you can run SAGA with MS-Windows as well as with Linux.
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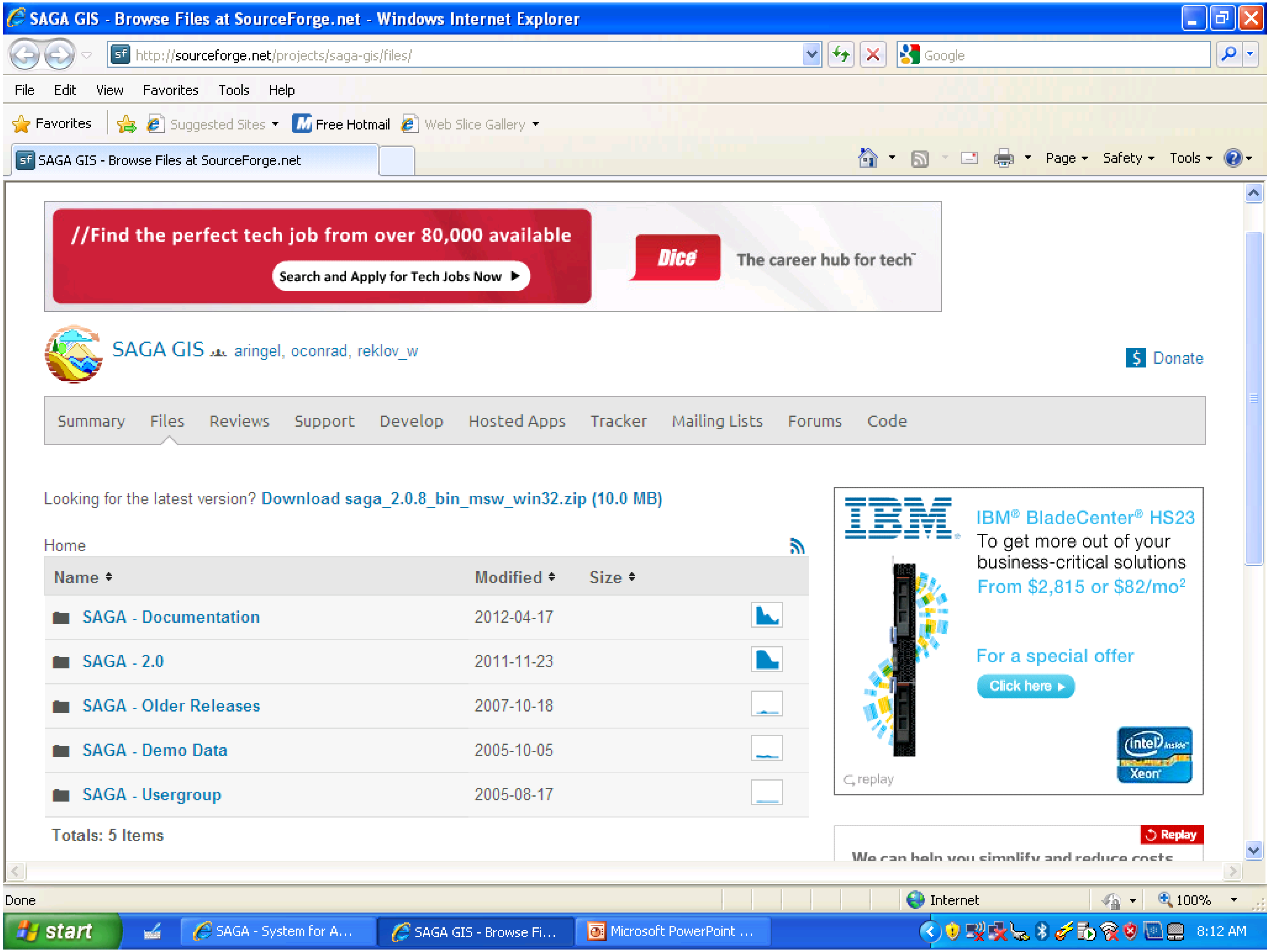
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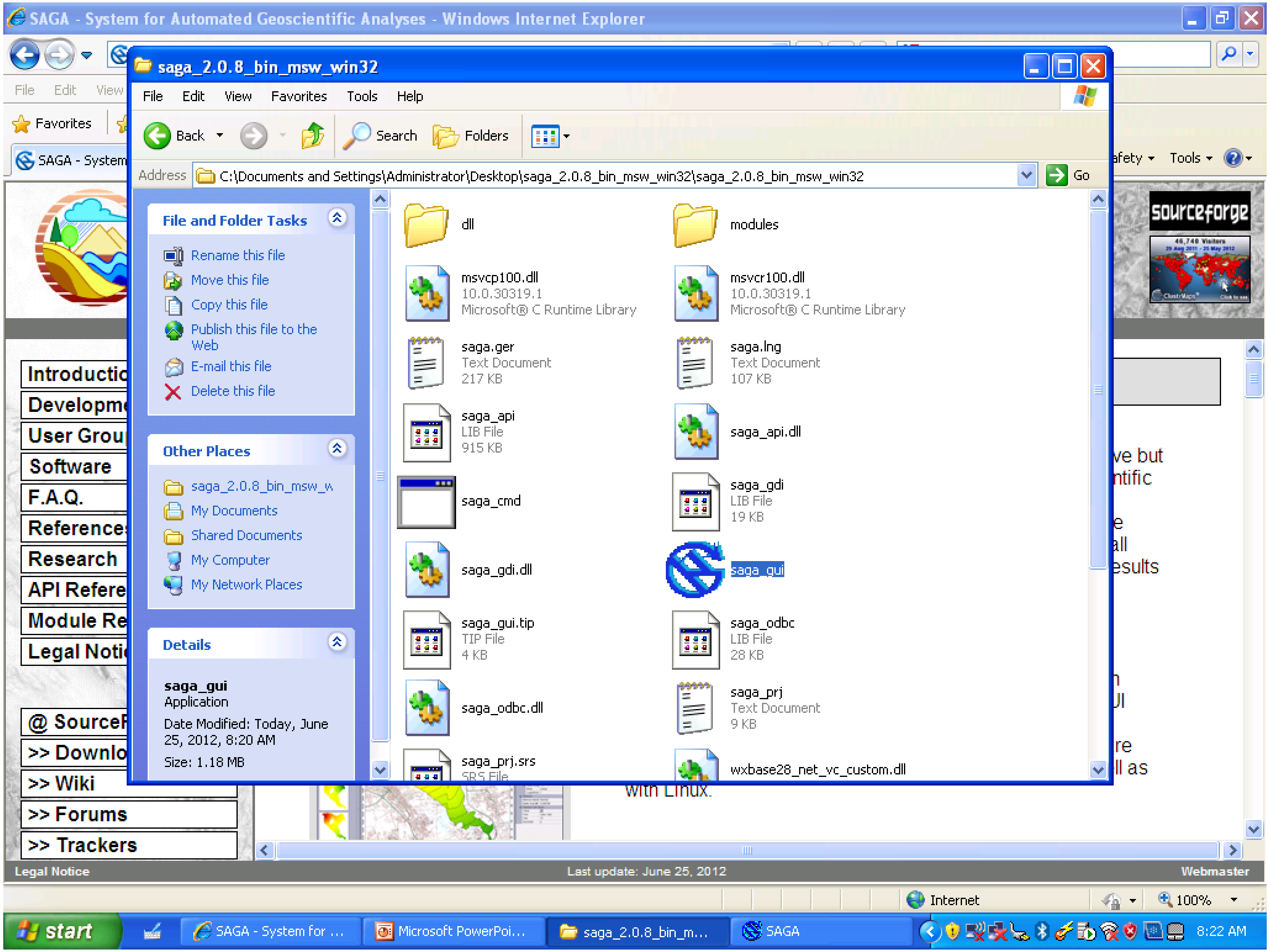
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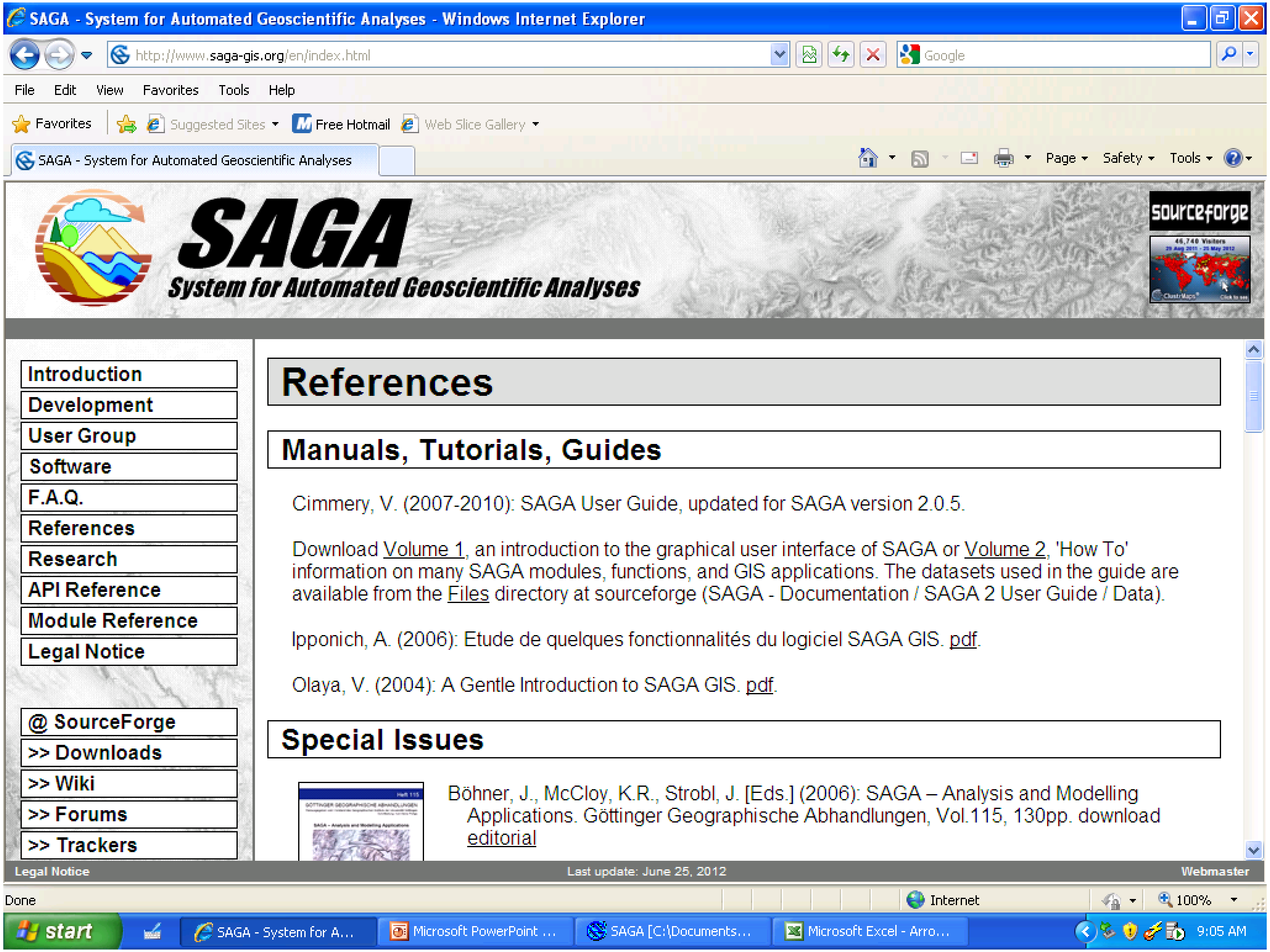
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References
Manuals, Tutorials, Guides
Cimmery, V. (2007-2010): SAGA User Guide, updated for SAGA version 2.0.5.
Download Volume 1, an introduction to the graphical user interface of SAGA or Volume 2, 'How To' information on many SAGA modules, functions, and GIS applications. The datasets used in the guide are available from the Files directory at sourceforge (SAGA - Documentation / SAGA 2 User Guide / Data).
Ipponich, A. (2006): Etude de quelques fonctionnalités du logiciel SAGA GIS. pdf.
Olaya, V. (2004): A Gentle Introduction to SAGA GIS. pdf.
Special Issues
Böhner, J., McCloy, K.R., Strobl, J. [Eds.] (2006): SAGA – Analysis and Modelling Applications. Göttinger Geographische Abhandlungen, Vol.115, 130pp. download editorial
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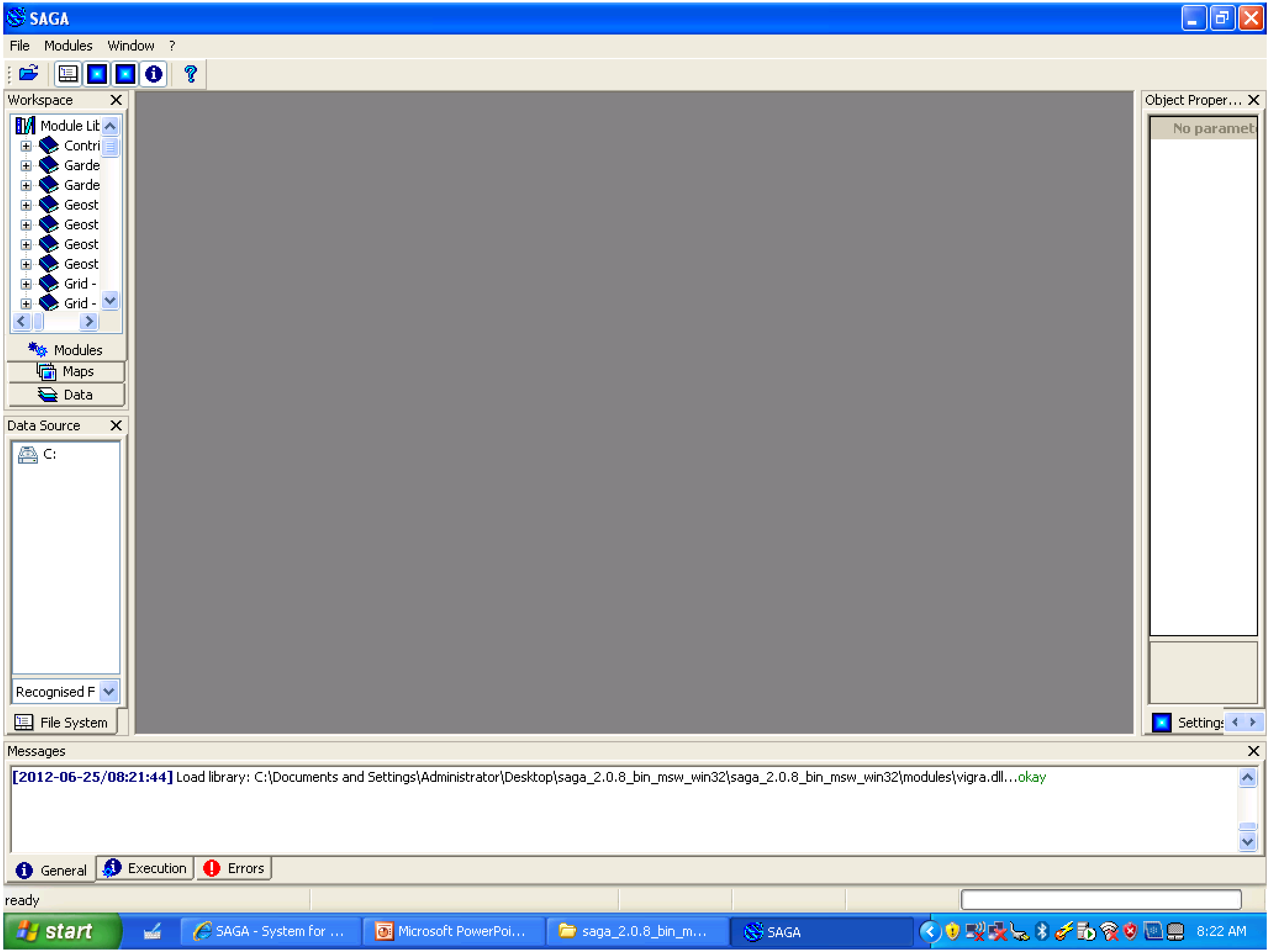
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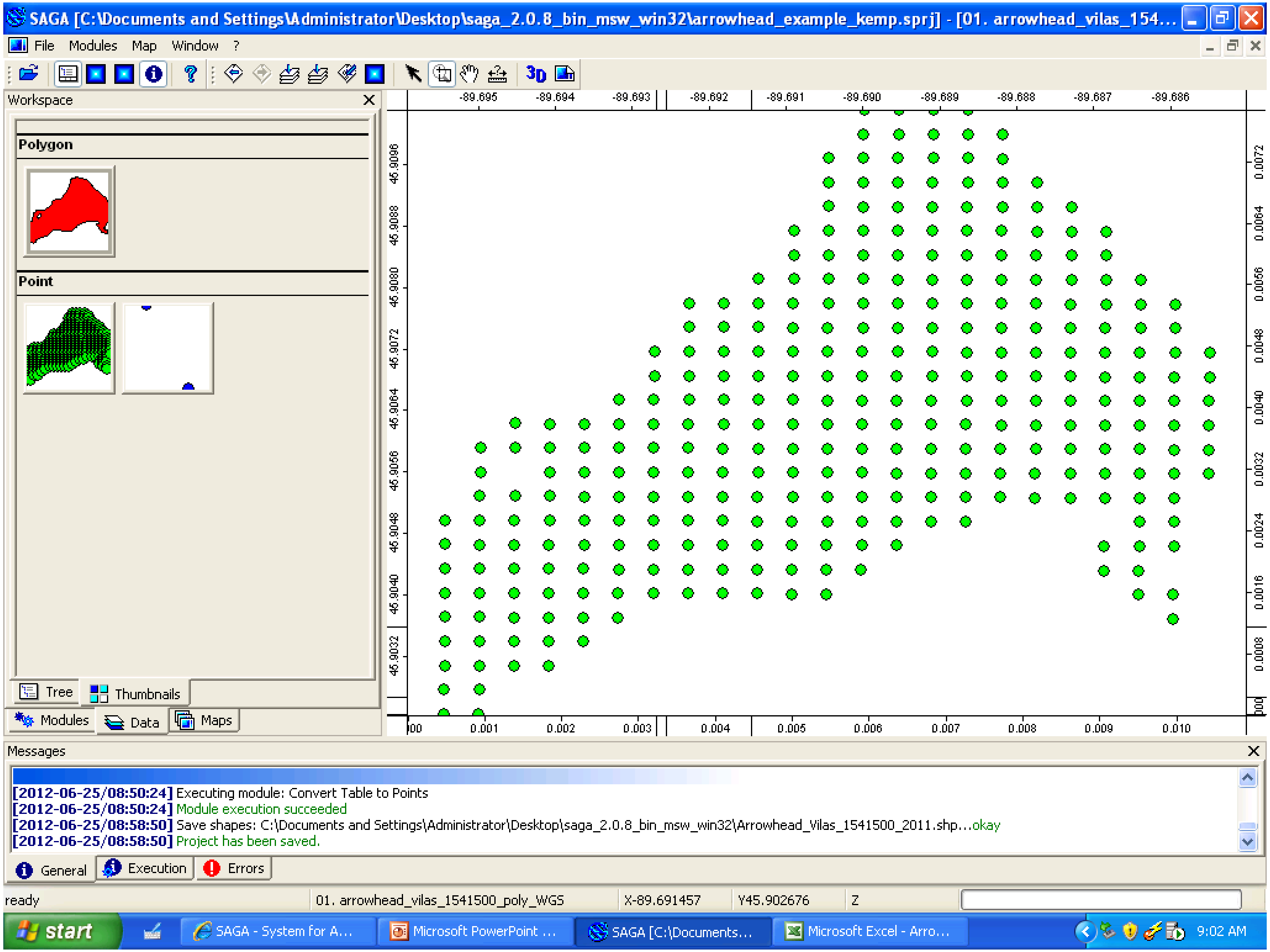
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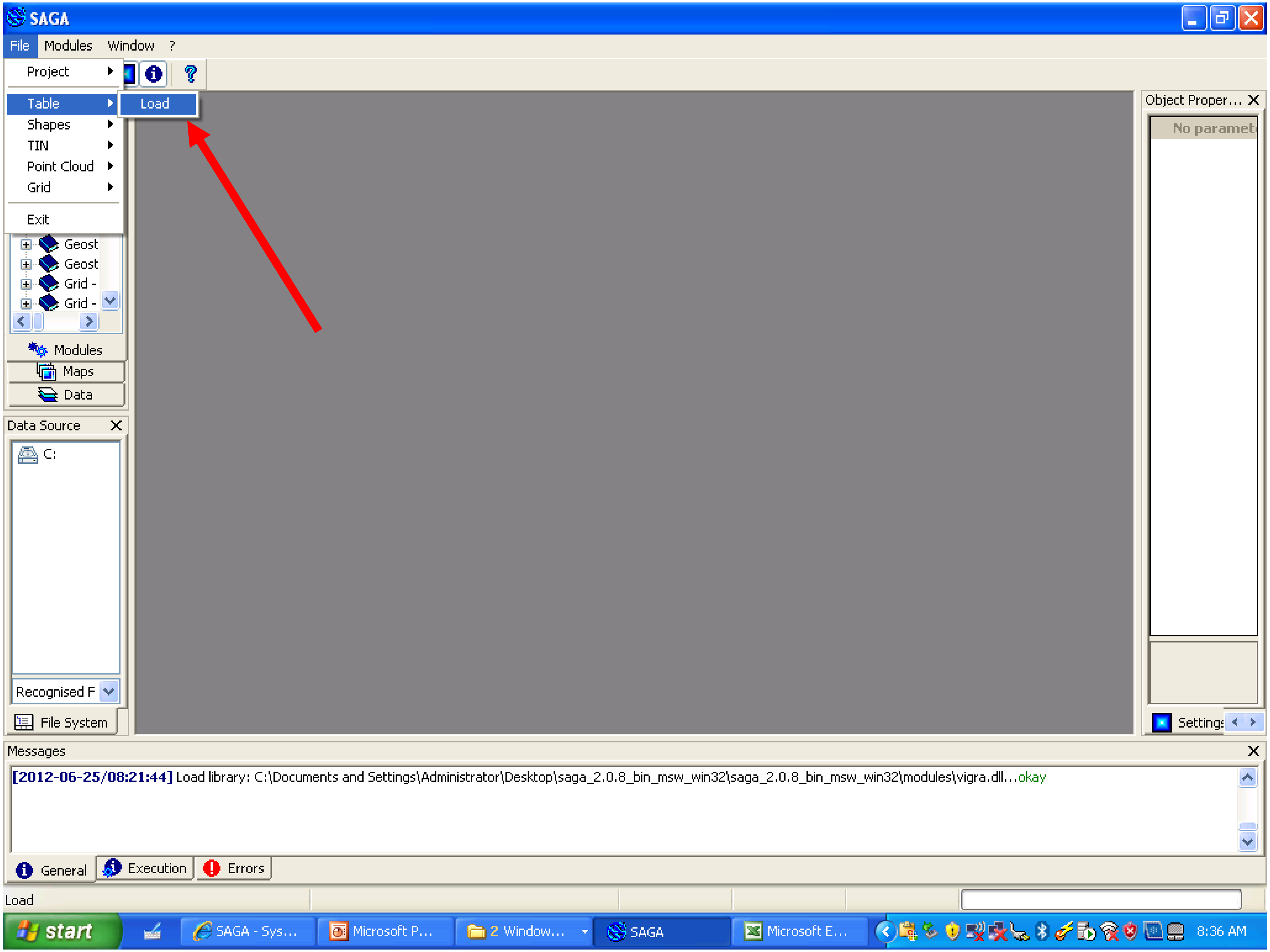
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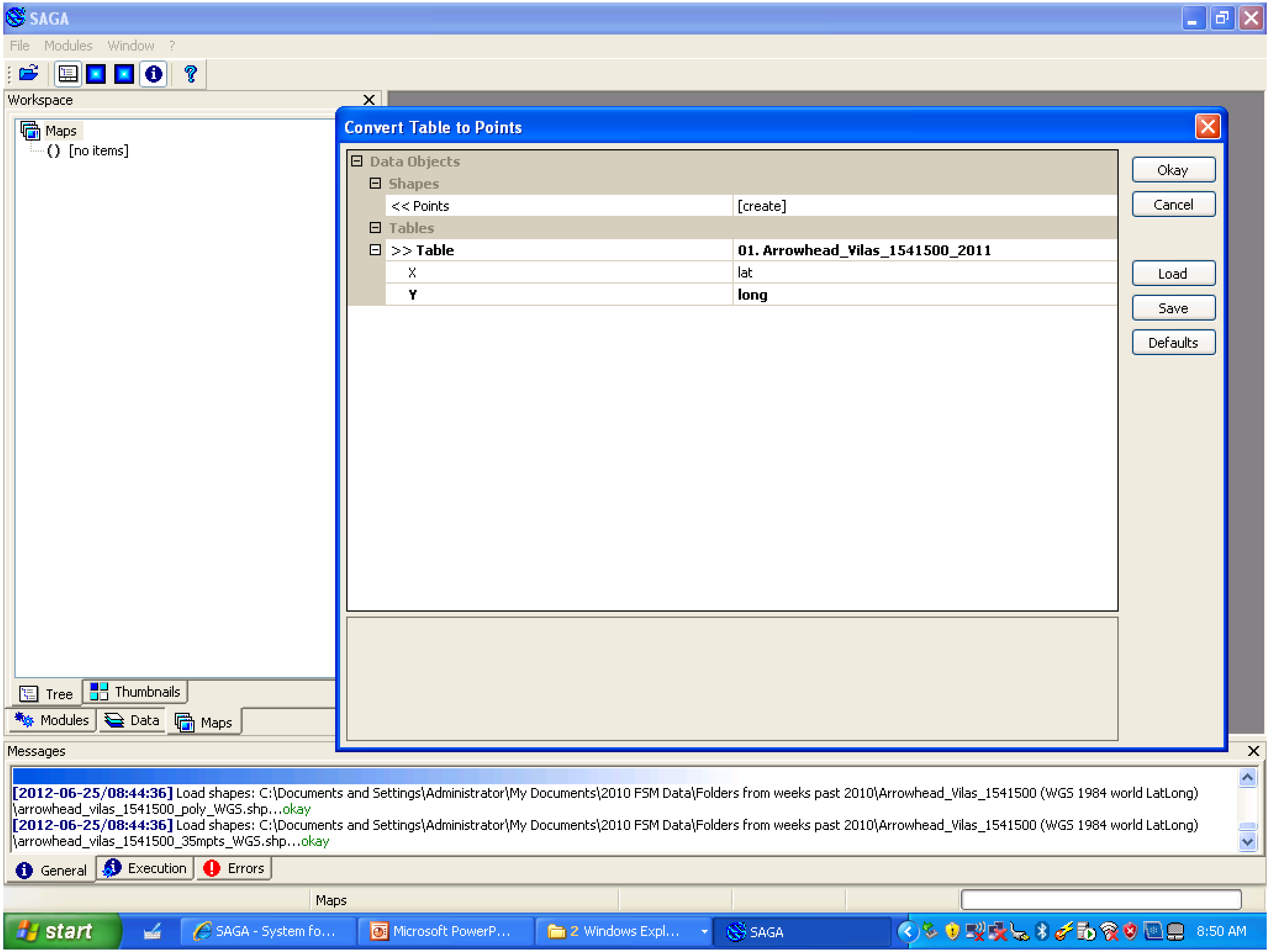

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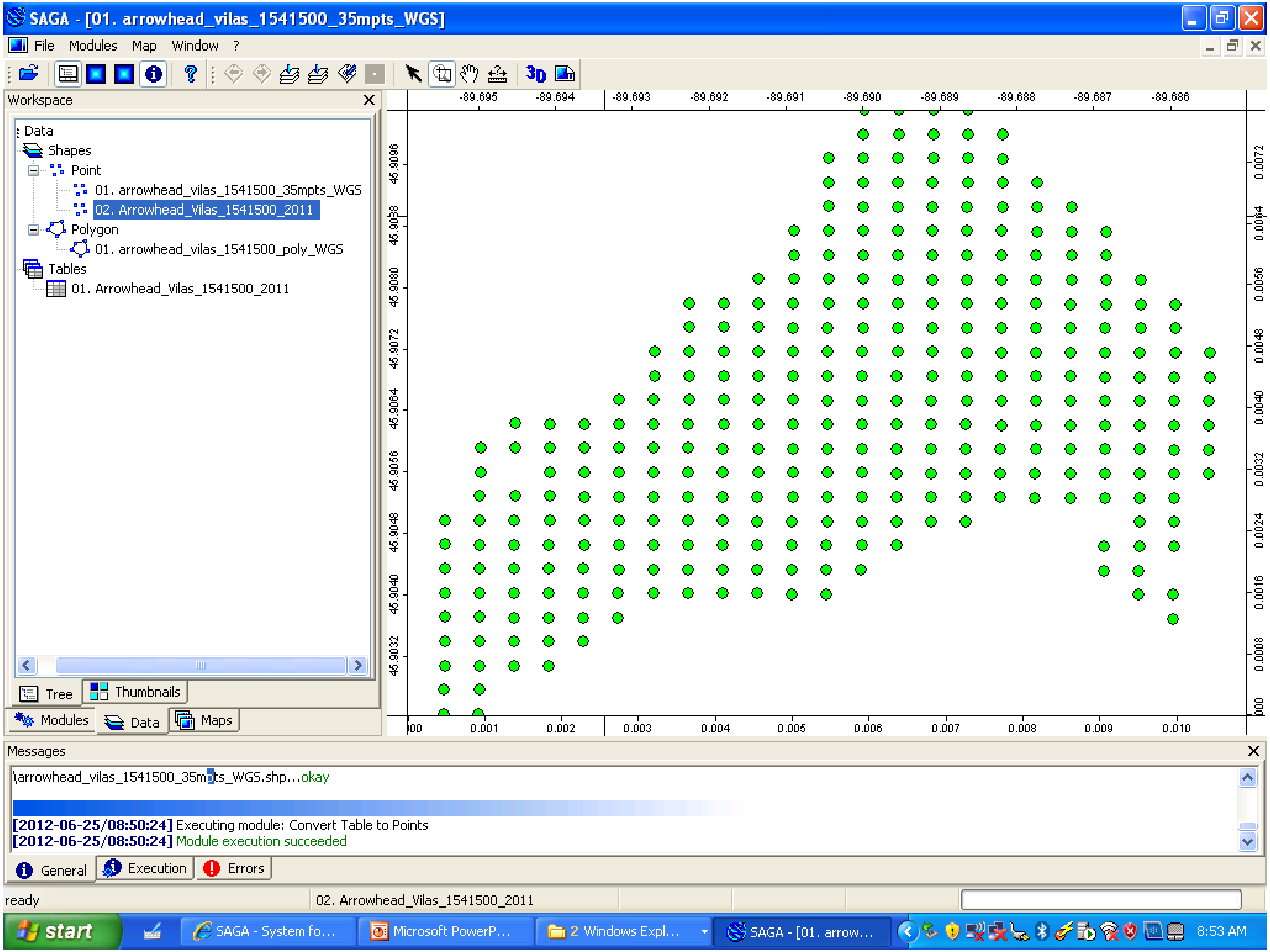
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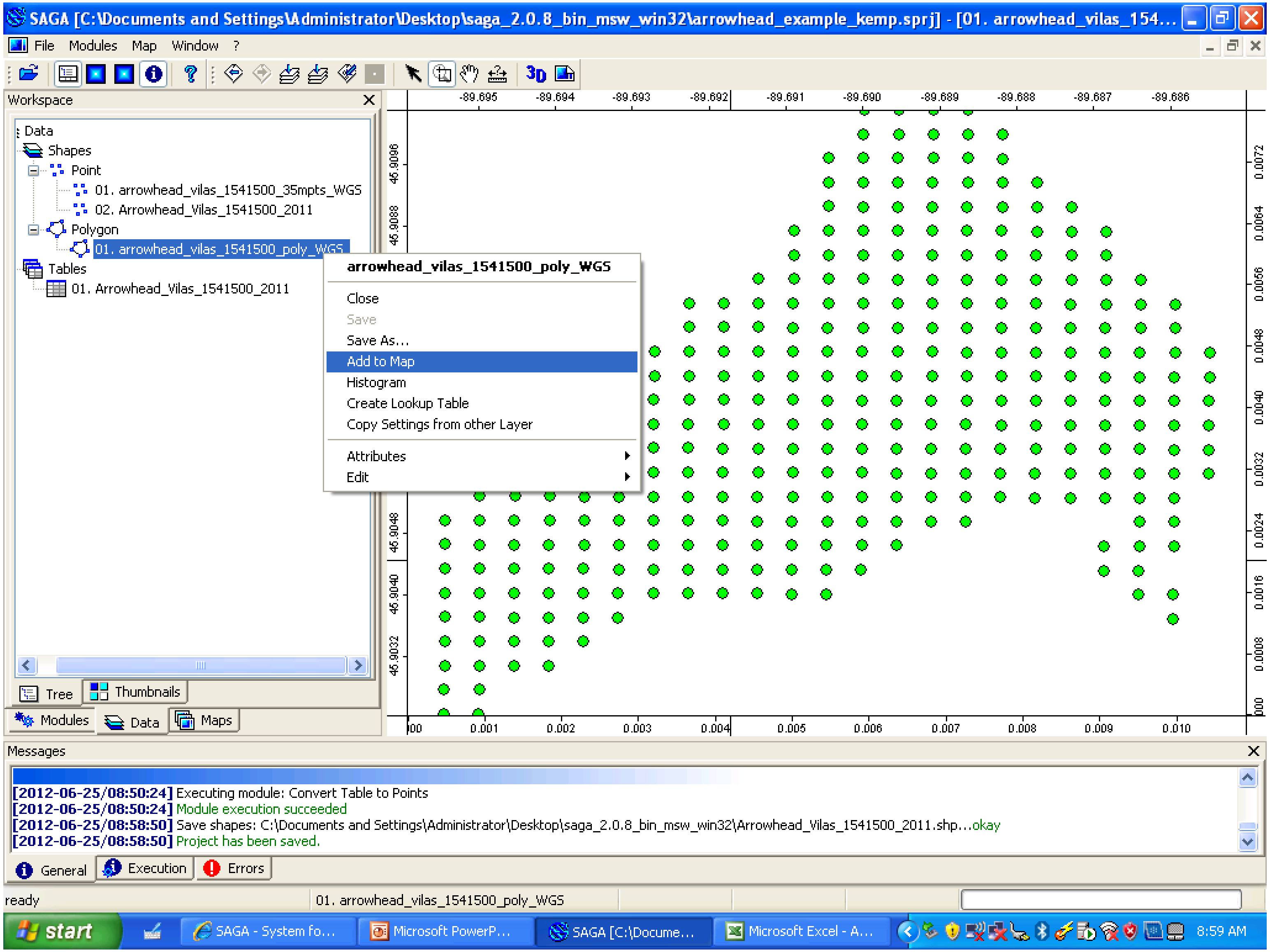
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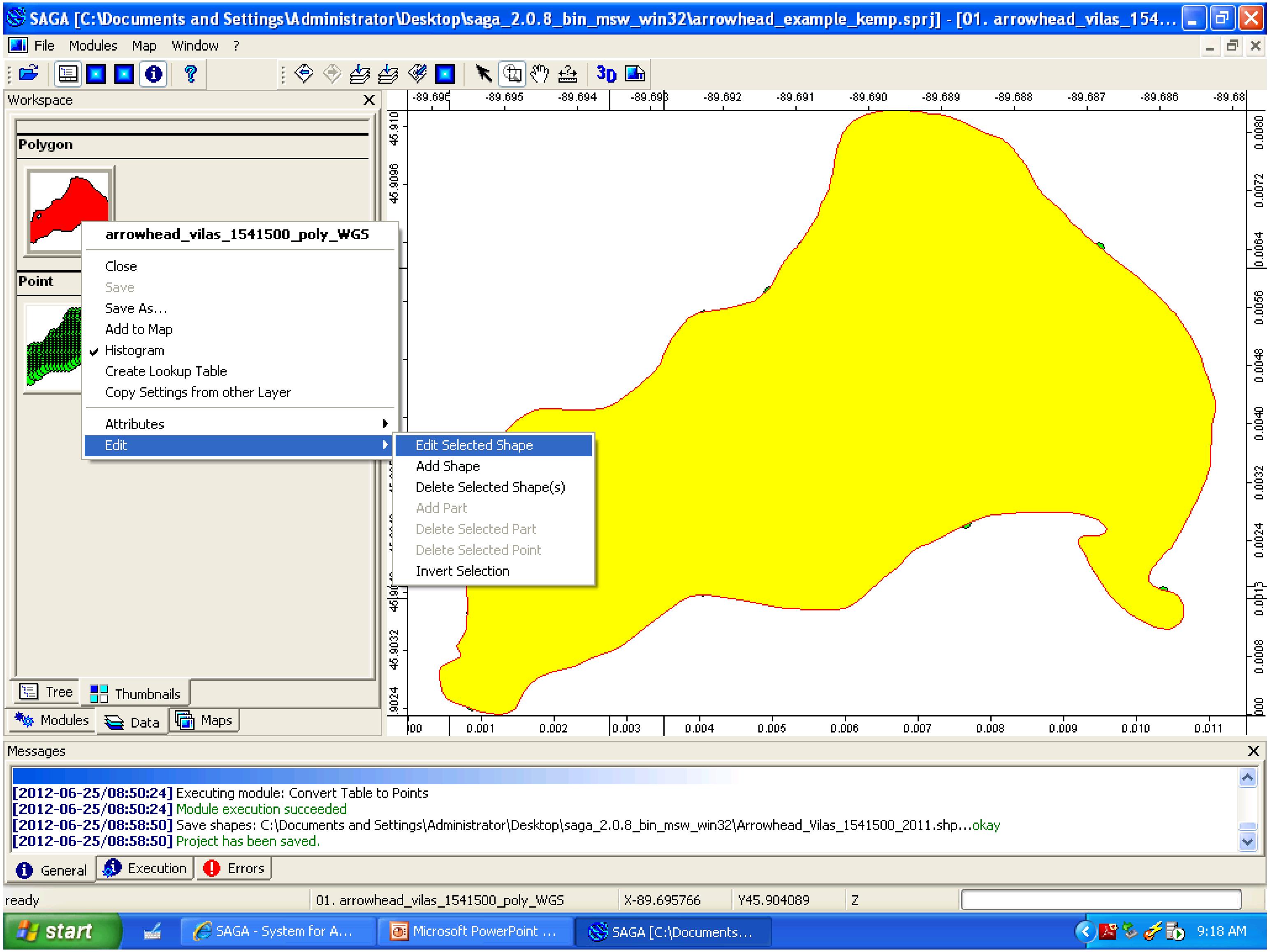
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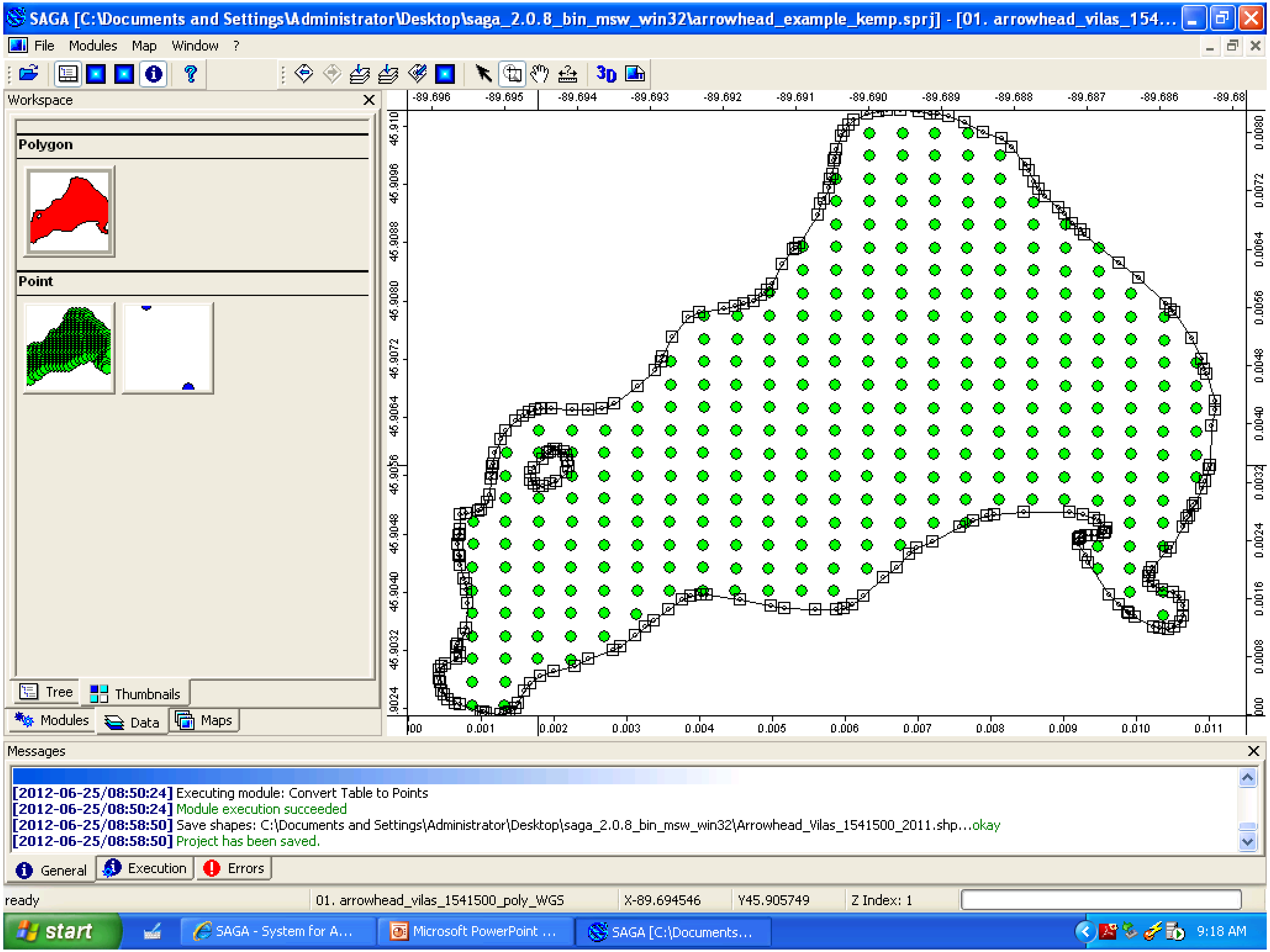
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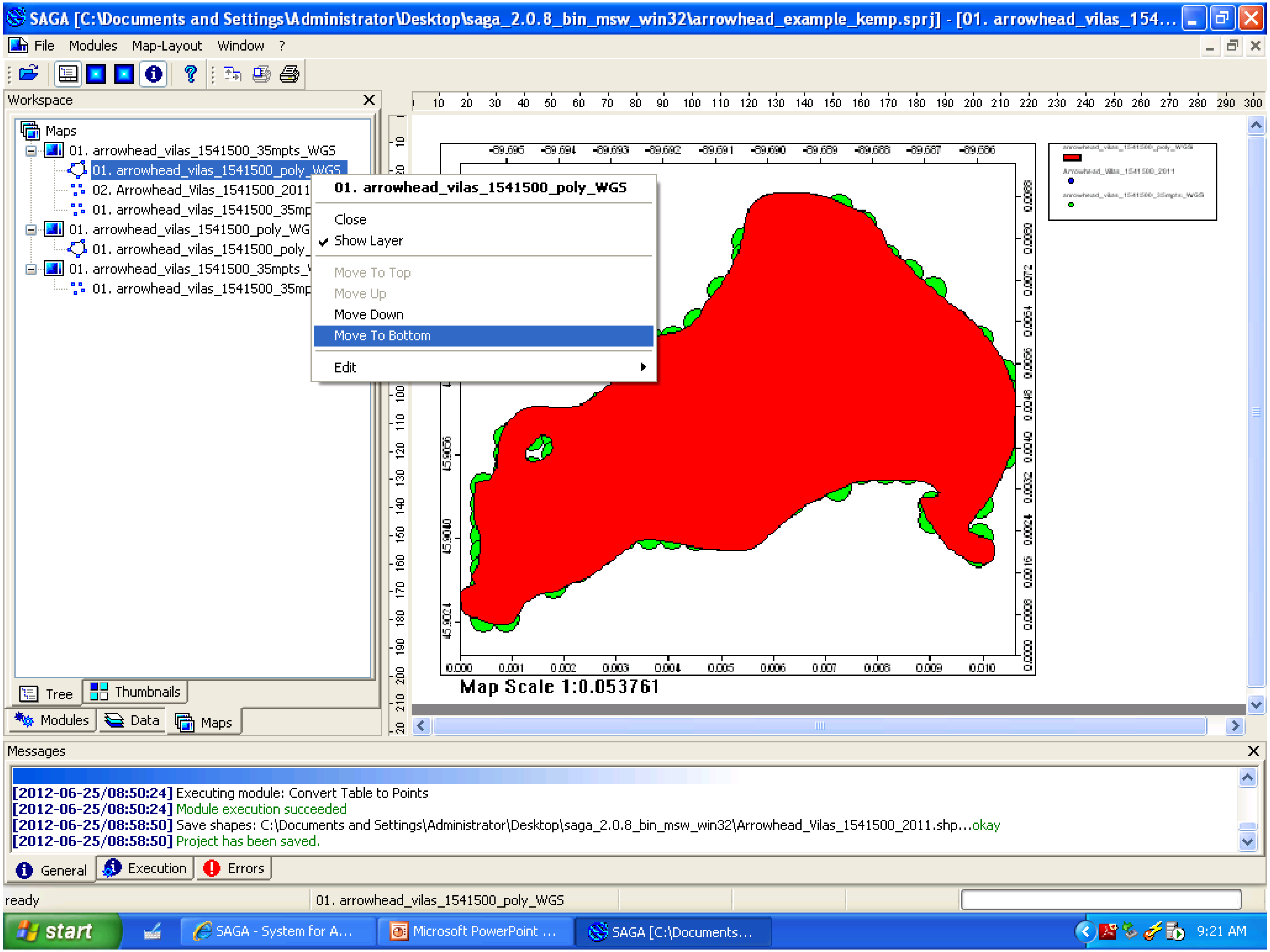
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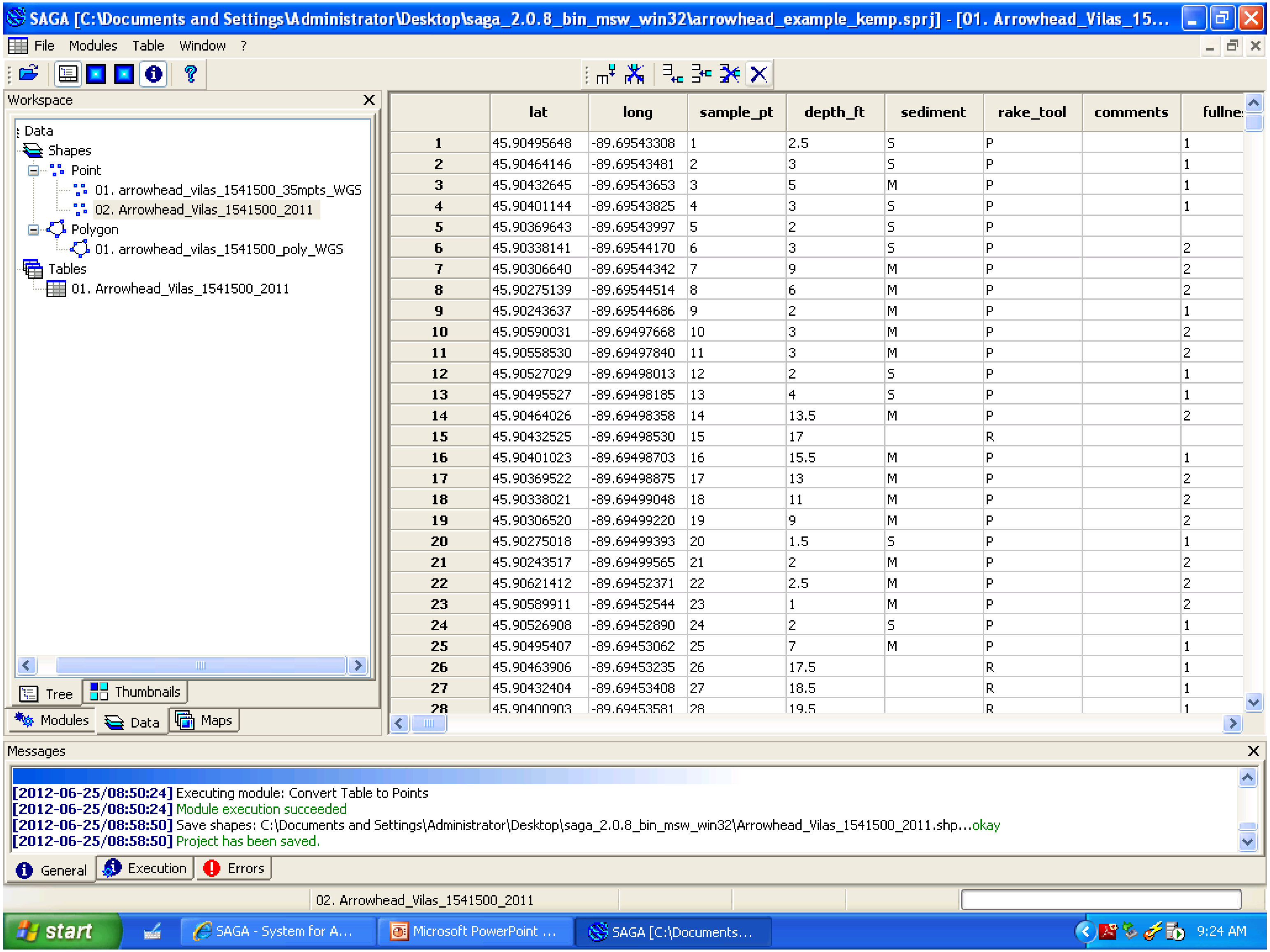

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7	45.90306640	-89.69544342	7	9	M	P		2
8	45.90275139	-89.69544514	8	6	M	P		2
9	45.90243637	-89.69544686	9	2	M	P		1
10	45.90590031	-89.69497668	10	3	M	P		2
11	45.90558530	-89.69497840	11	3	M	P		2
12	45.90527029	-89.69498013	12	2	S	P		1
13	45.90495527	-89.69498185	13	4	S	P		1
14	45.90464026	-89.69498358	14	13.5	M	P		2
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16	45.90401023	-89.69498703	16	15.5	M	P		1
17	45.90369522	-89.69498875	17	13	M	P		2
18	45.90338021	-89.69499048	18	11	M	P		2
19	45.90306520	-89.69499220	19	9	M	P		2
20	45.90275018	-89.69499393	20	1.5	S	P		1
21	45.90243517	-89.69499565	21	2	M	P		2
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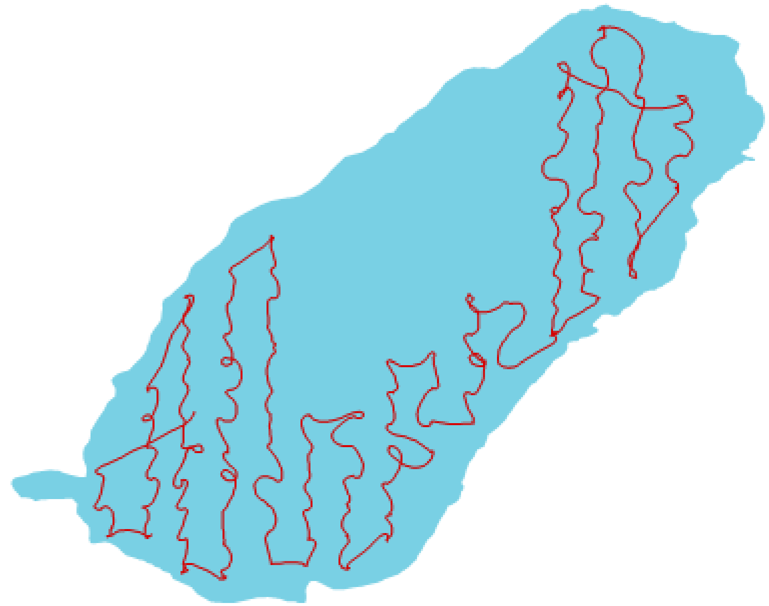
25	45.90495407	-89.69453062	25	7	M	P		1
26	45.90463906	-89.69453235	26	17.5		R		1
27	45.90432404	-89.69453408	27	18.5		R		1
28	45.90400903	-89.69453581	28	19.5		R		1

Hydroacoustic Mapping

- Change in vegetation biovolume following
  - Herbicide treatment
  - Invasive species invasion
    - EWM
    - Zebra mussels
    - Rusty Crayfish
- Bathymetry Mapping
- Predictive Drawdown Maps
- Fish Habitat



Start Lat/Lon: 42.58302689, -88.34655762
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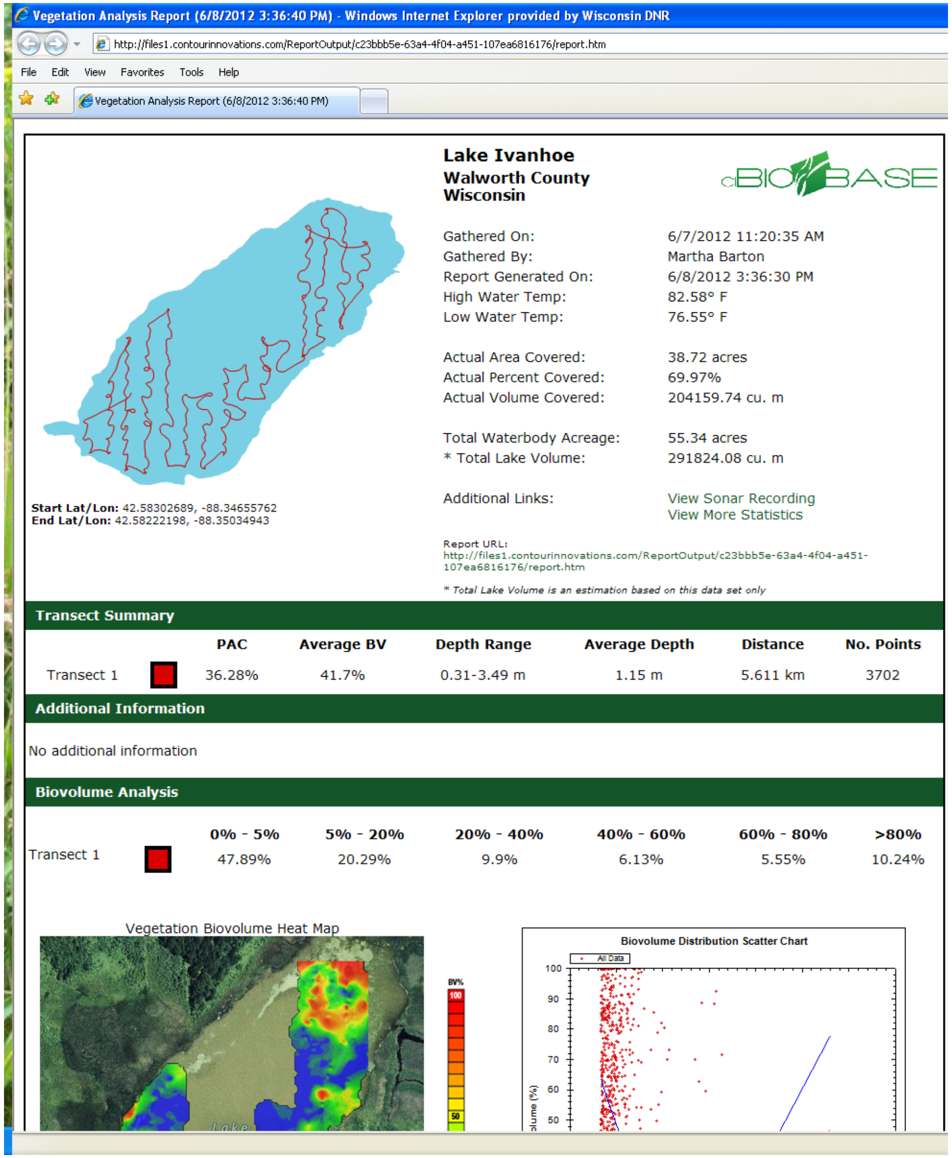
Vegetation Analysis Report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Lake Ivanhoe
Walworth County
Wisconsin

Gathered On:	6/7/2012 11:20:35 AM
Gathered By:	Martha Barton
Report Generated On:	6/8/2012 3:36:30 PM
High Water Temp:	82.58° F
Low Water Temp:	76.55° F
Actual Area Covered:	38.72 acres
Actual Percent Covered:	69.97%
Actual Volume Covered:	204159.74 cu. m
Total Waterbody Acreage:	55.34 acres
* Total Lake Volume:	291824.08 cu. m
Additional Links:	View Sonar Recording View More Statistics

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Report URL:
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* Total Lake Volume is an estimation based on this data set only

Transect Summary

	PAC	Average BV	Depth Range	Average Depth	Distance	No. Points
Transect 1	36.28%	41.7%	0.31-3.49 m	1.15 m	5.611 km	3702

Additional Information

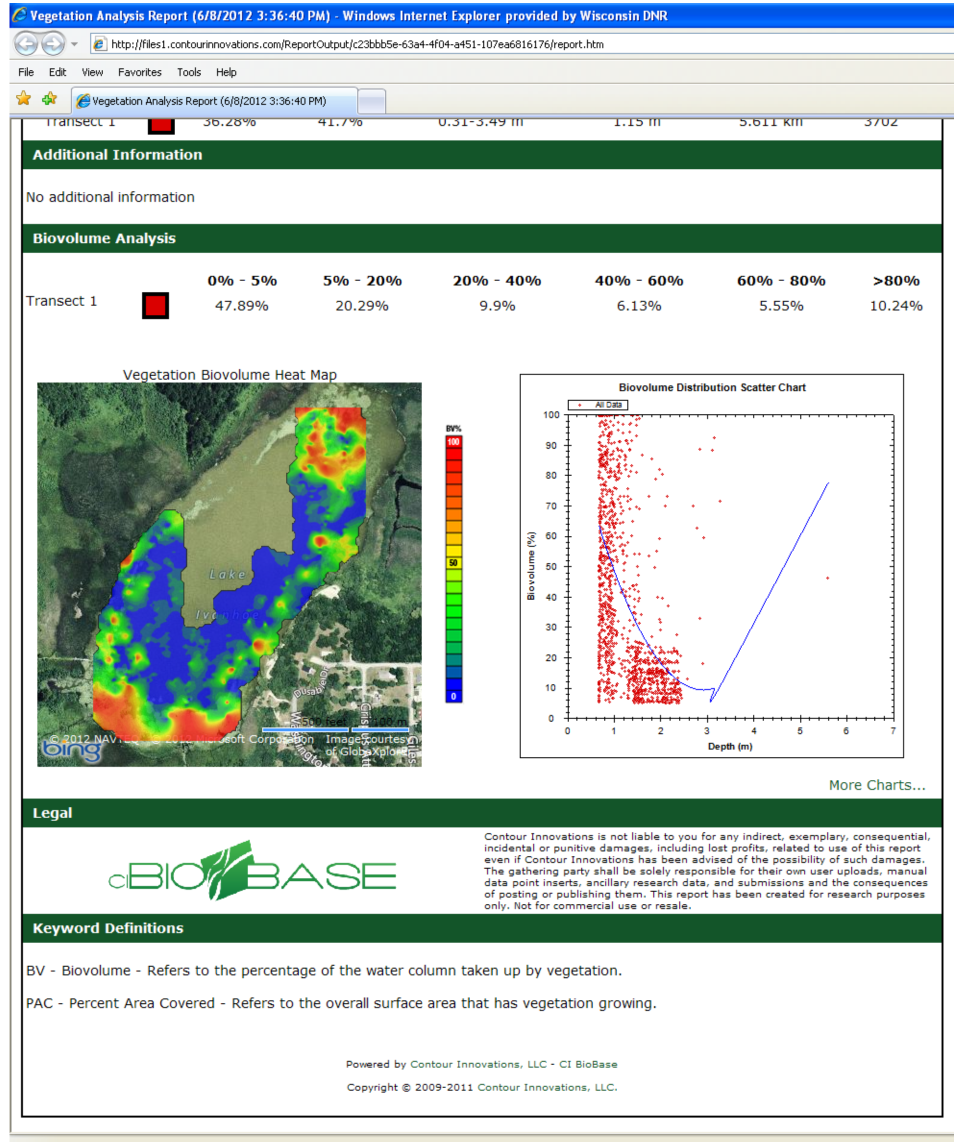
No additional information

Biovolume Analysis

	0% - 5%	5% - 20%	20% - 40%	40% - 60%	60% - 80%	>80%
Transect 1	47.89%	20.29%	9.9%	6.13%	5.55%	10.24%

Vegetation Biovolume Heat Map

Biovolume Distribution Scatter Chart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Additional Information

No additional information

Biovolume Analysis

	0% - 5%	5% - 20%	20% - 40%	40% - 60%	60% - 80%	>80%
Transect 1	47.89%	20.29%	9.9%	6.13%	5.55%	10.24%

Vegetation Biovolume Heat Map

Biovolume Distribution Scatter Chart

Depth (m)

Biovolume (%)

More Charts...

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Keyword Definitions

BV - Biovolume - Refers to the percentage of the water column taken up by vegetation.

PAC - Percent Area Covered - Refers to the overall surface area that has vegetation growing.

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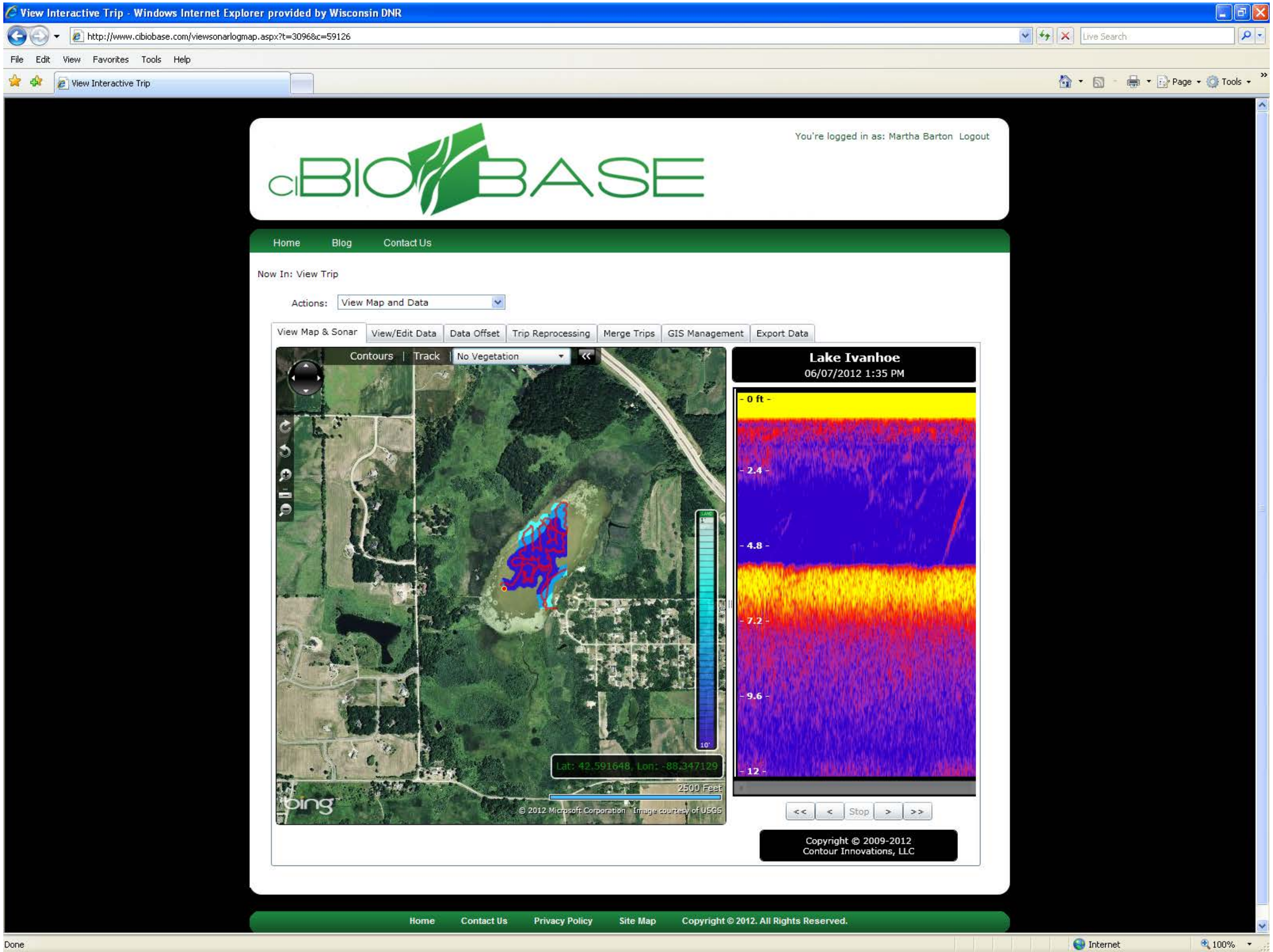

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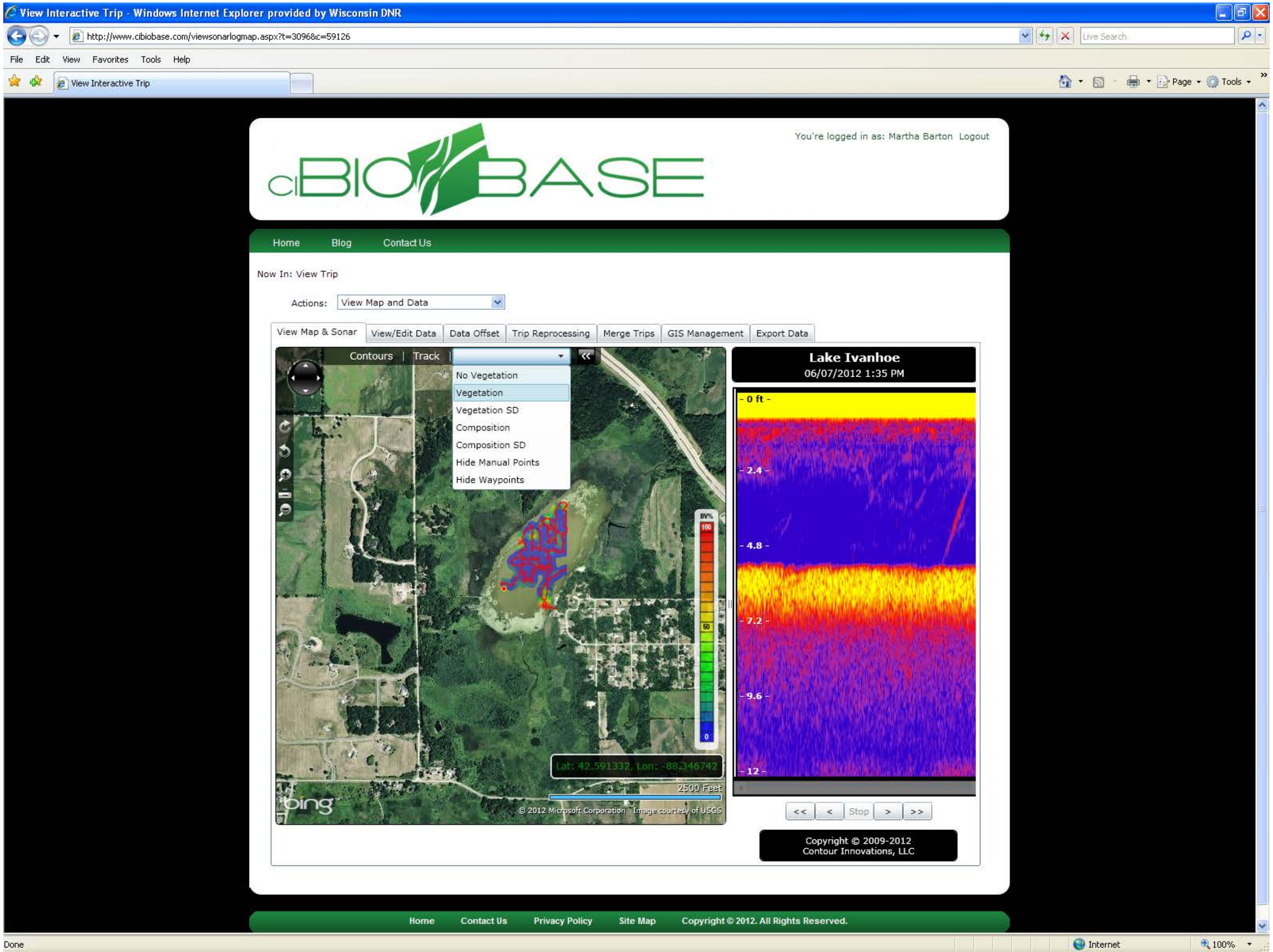

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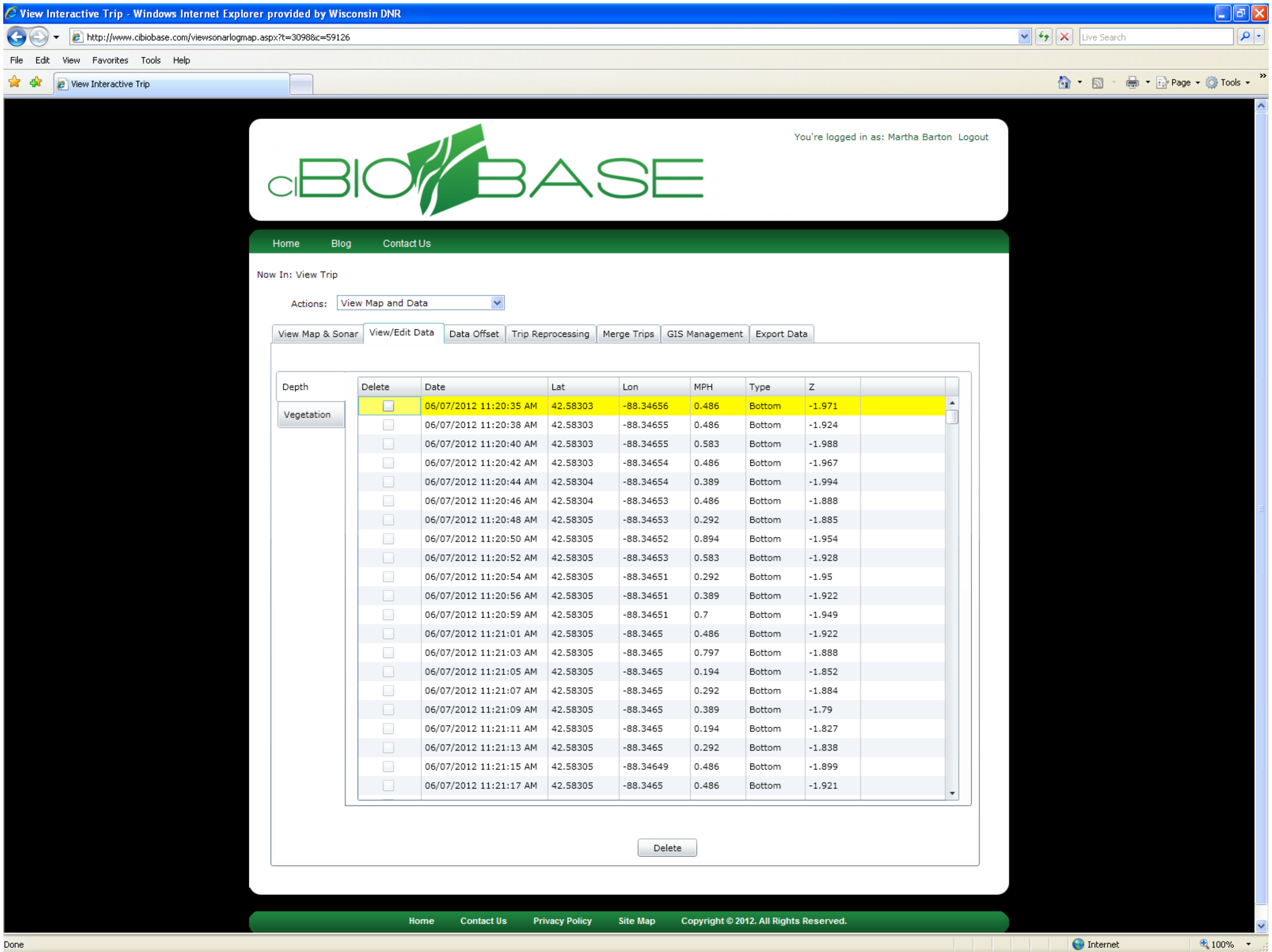

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	06/07/2012 11:20:44 AM	42.58304	-88.34654	0.389	Bottom	-1.994
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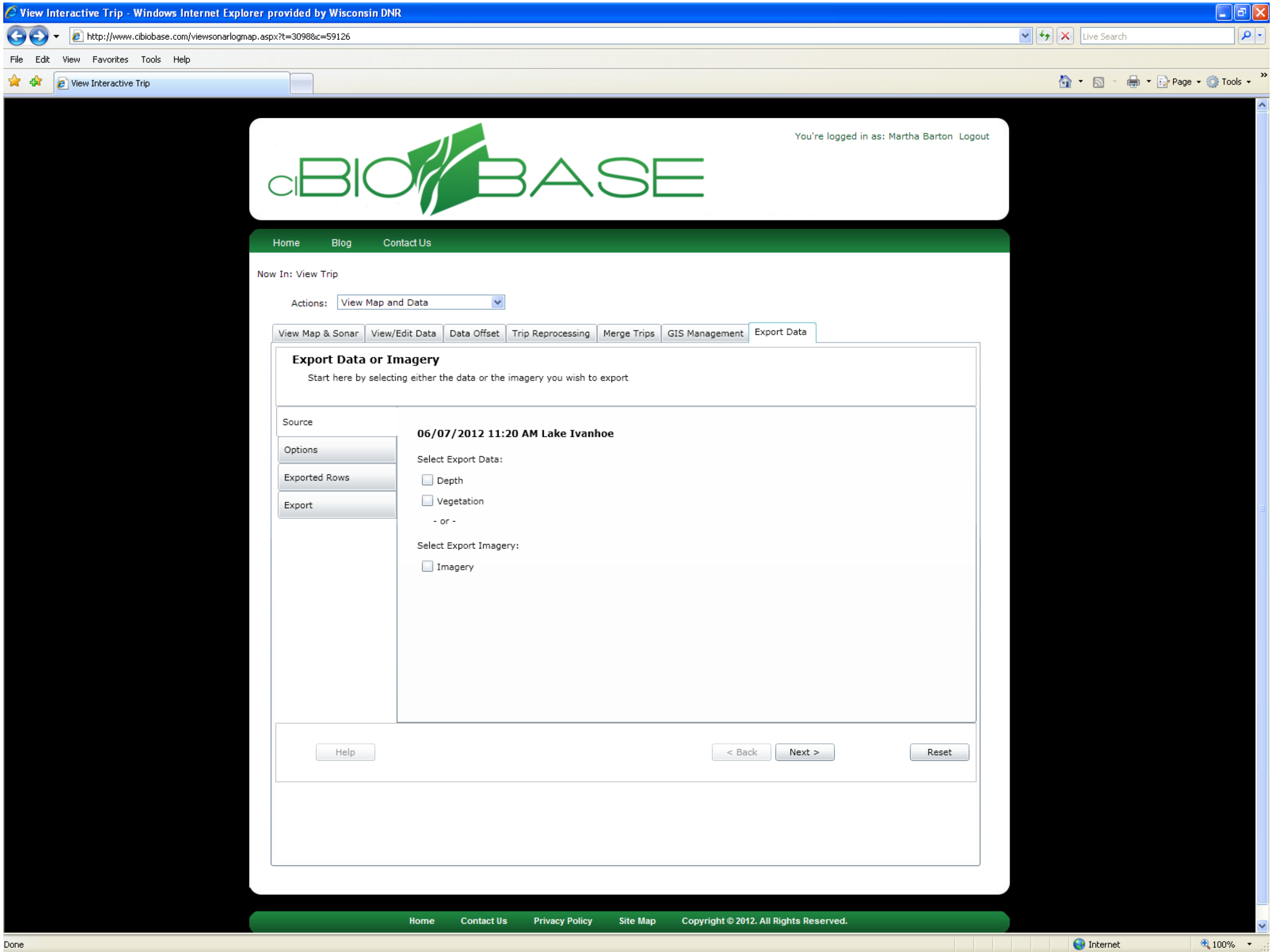

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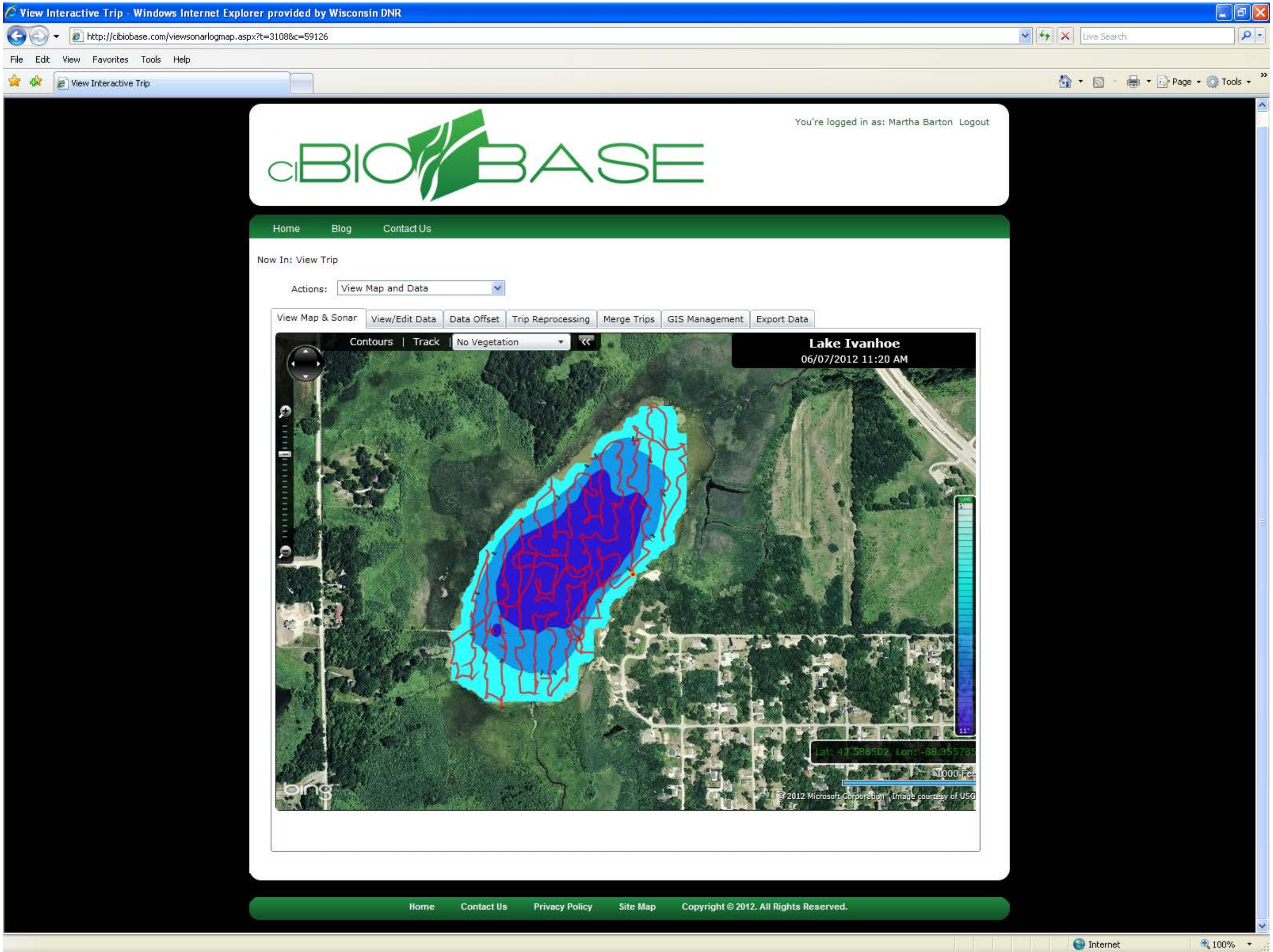

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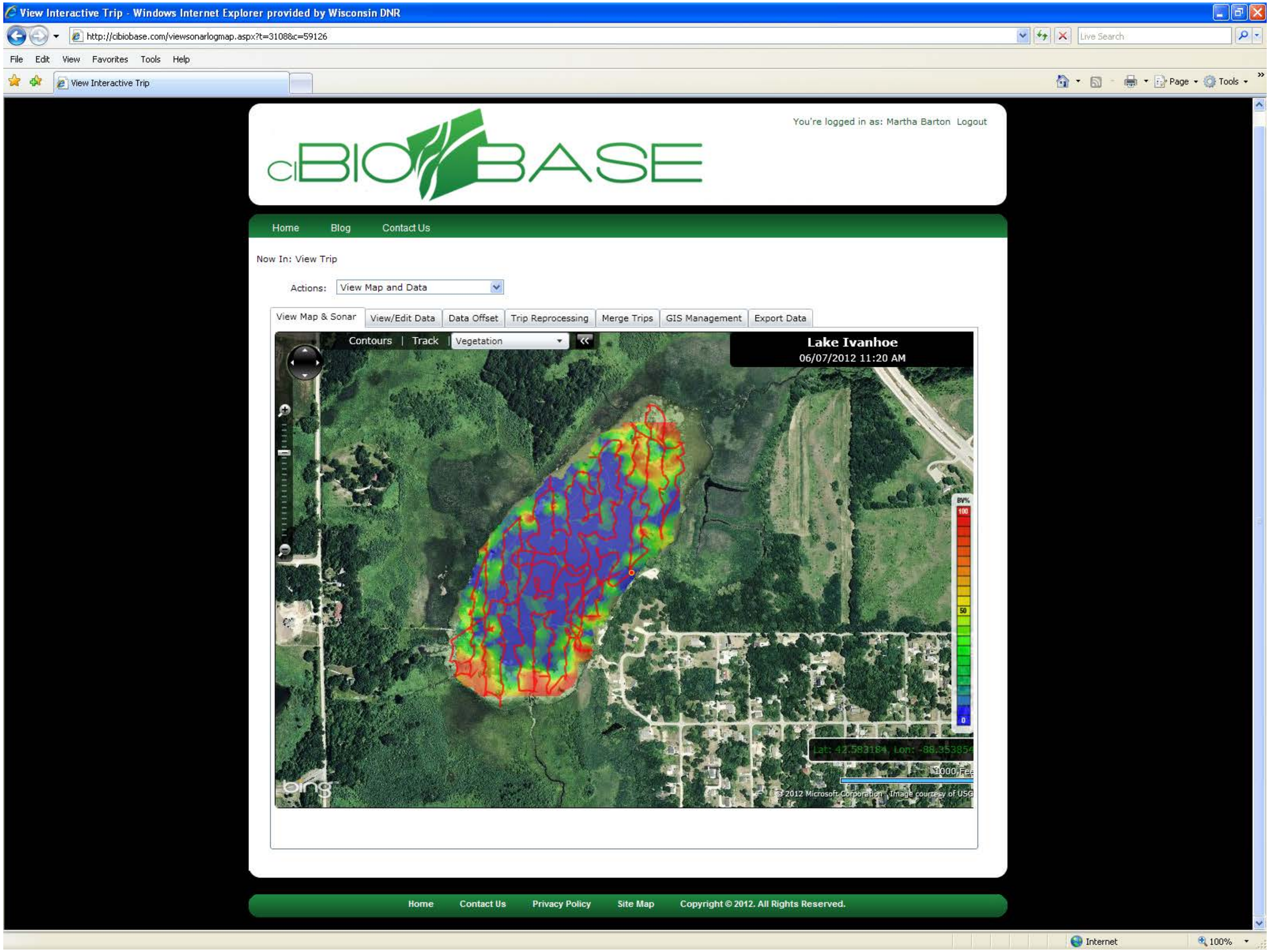

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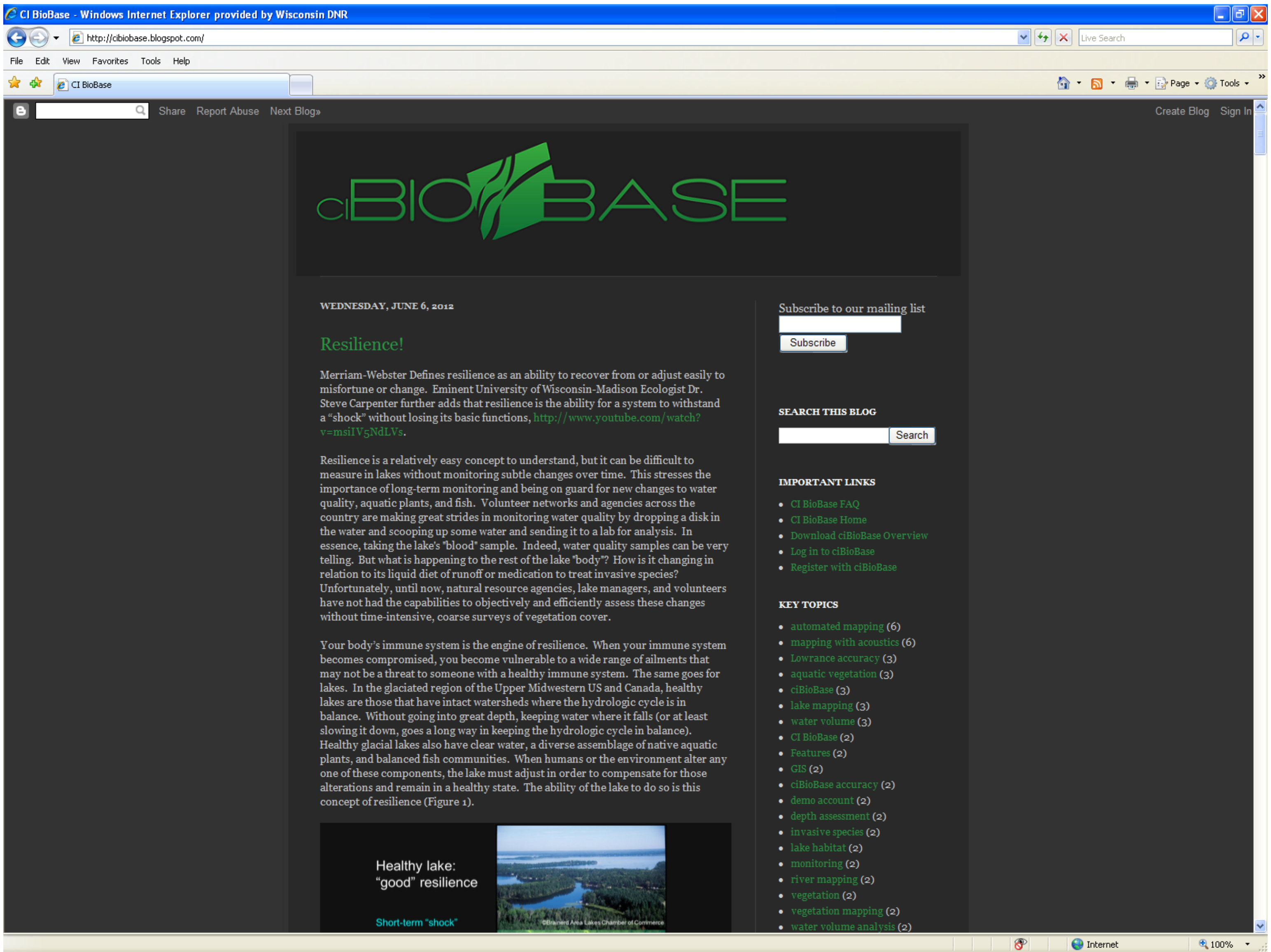

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WEDNESDAY, JUNE 6, 2012

Resilience!

Merriam-Webster Defines resilience as an ability to recover from or adjust easily to misfortune or change. Eminent University of Wisconsin-Madison Ecologist Dr. Steve Carpenter further adds that resilience is the ability for a system to withstand a "shock" without losing its basic functions, http://www.youtube.com/watch?v=msiIV5NdLVs.

Resilience is a relatively easy concept to understand, but it can be difficult to measure in lakes without monitoring subtle changes over time. This stresses the importance of long-term monitoring and being on guard for new changes to water quality, aquatic plants, and fish. Volunteer networks and agencies across the country are making great strides in monitoring water quality by dropping a disk in the water and scooping up some water and sending it to a lab for analysis. In essence, taking the lake's "blood" sample. Indeed, water quality samples can be very telling. But what is happening to the rest of the lake "body"? How is it changing in relation to its liquid diet of runoff or medication to treat invasive species? Unfortunately, until now, natural resource agencies, lake managers, and volunteers have not had the capabilities to objectively and efficiently assess these changes without time-intensive, coarse surveys of vegetation cover.

Your body's immune system is the engine of resilience. When your immune system becomes compromised, you become vulnerable to a wide range of ailments that may not be a threat to someone with a healthy immune system. The same goes for lakes. In the glaciated region of the Upper Midwestern US and Canada, healthy lakes are those that have intact watersheds where the hydrologic cycle is in balance. Without going into great depth, keeping water where it falls (or at least slowing it down, goes a long way in keeping the hydrologic cycle in balance). Healthy glacial lakes also have clear water, a diverse assemblage of native aquatic plants, and balanced fish communities. When humans or the environment alter any one of these components, the lake must adjust in order to compensate for those alterations and remain in a healthy state. The ability of the lake to do so is this concept of resilience (Figure 1).

Healthy lake:
"good" resilience

Short-term "shock"

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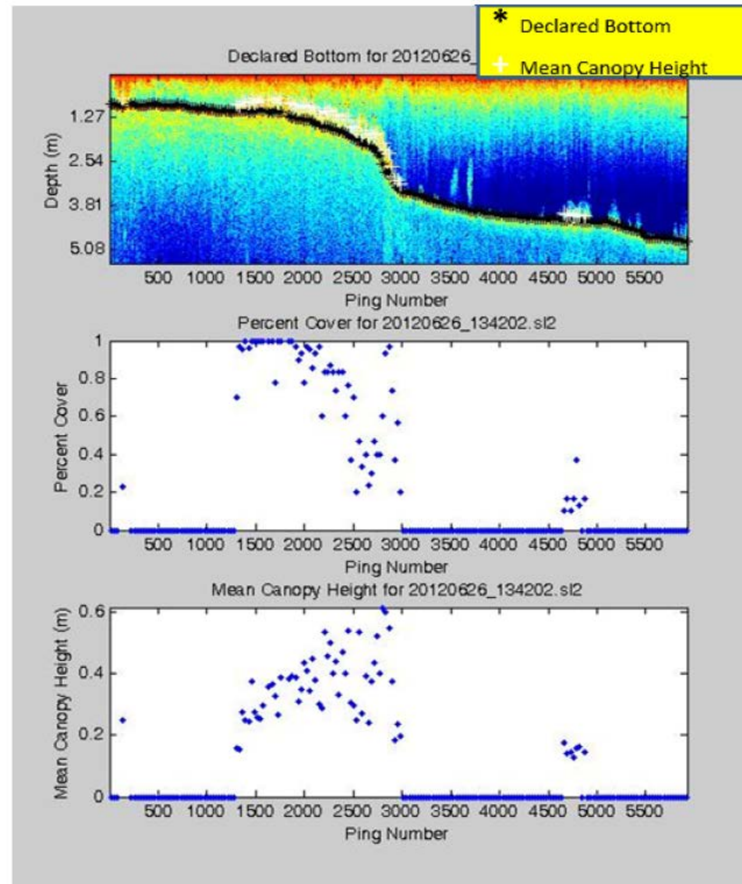

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