Ecological Effects of Whole-Lake Fluridone Treatments for Eurasian Watermilfoil Control

Summary of Available Data

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WISCONSIN
DEPT. OF NATURAL RESOURCES

Outline

- Background on fluridone
- Results of our national technical review on efficacy and additional ecological effects
- What happened in the 4 Wisconsin treatments?
- What happened in Houghton Lake, MI?
- Preliminary data on the Madison lakes

Fluridone Overview

- Marketed as Sonar® and Avast!®
- Systemic herbicide
- Kills plants in 60-90 days (6 ppb)
- Whole-lakes or coves,
  partial treatments possible
- Semi-selective control of Eurasian Watermilfoil and Hydrilla

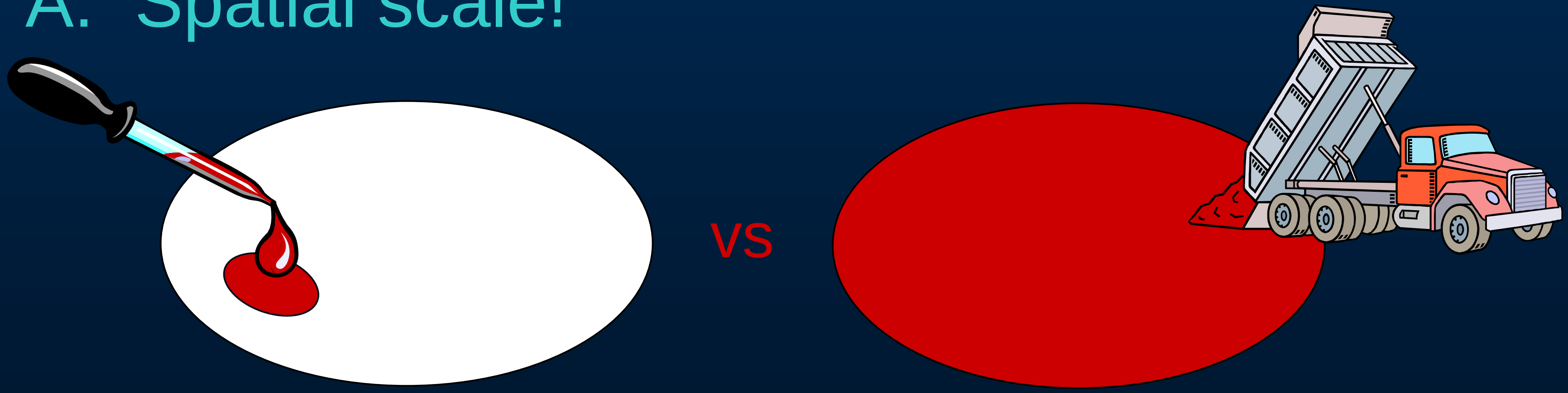
Eurasian water milfoil
Myriophyllum spicatum
Photo by A. Murray
Copyright 2001 Univ. Florida

Recent interest in WI for whole-lake treatments

-The WDNR has authority over the use of chemical treatment in public waters (but does not initiate chemical treatments or apply chemicals – permit approval)

-Detailed regulatory procedures are outlined in Ch. NR 107, Wis. Adm. Code Includes DNR's legal responsibility to understand effectiveness of chemical treatments not only as tool for nuisance relief, but also potential ecosystem effects* before approving permit applications

Q: So what's the big deal with fluridone?
A: Spatial scale!



Whole lake treatment = Whole ecosystem manipulation

Need to be reasonably certain that "the proposed treatment" will NOT:

(3)(d) …result in a hazard to humans, animals or other nontarget organisms;

(3)(e) …result in a significant adverse effect on the body of water;

(3)(g) …significantly injure fish, fish eggs, fish larvae, essential fish food organisms or wildlife, either directly or indirectly through habitat destruction;

(4) New applications will be reviewed with consideration given to the cumulative effect of applications already approved for the body of water…

(Wisconsin Adminstrative Code, NR 107.05)

Why do we care?

Plants → Nutrient uptake, erosion control, habitat (fish, birds, wildlife, invertebrates)

Too much algae → Poor water clarity, aesthetics (odors), health, affect fish

Fish → Important component of ecosystem, important to WI economy and legacy

Questions

1) What are the primary and secondary ecological effects (both intended and unintended)?

-Vegetation (exotic and native)

-Water quality (algae)

-Fisheries

2) What has been done already to address those questions?

→

Technical review of DATA

N > 1, generalize effects

Fluridone Use in U.S.

States with no State monitoring or permitting requirements: KY, MO, VA
States contacted with no reply: AR, CO, NC, NJ, NV, OH, PA, TX,
LA, AL, GA, SC, *IL*, *NY*

Whole-lake treatments, public waterbodies > 30 acres

- FL ~ 75-80 y^{-1}
- MI ~ 20 y^{-1}
- MA $\geq$ 40-50 treatments
- WA ~ 27
- MN ~ 10 (2) (+2 for CLP expt.)
- IA ~ 6
- WI 4 (2)
- VT ~ 4
- IN ~ 4 (2)
- OR ~ 2
- ME 1 (hydrilla)
- CA 0

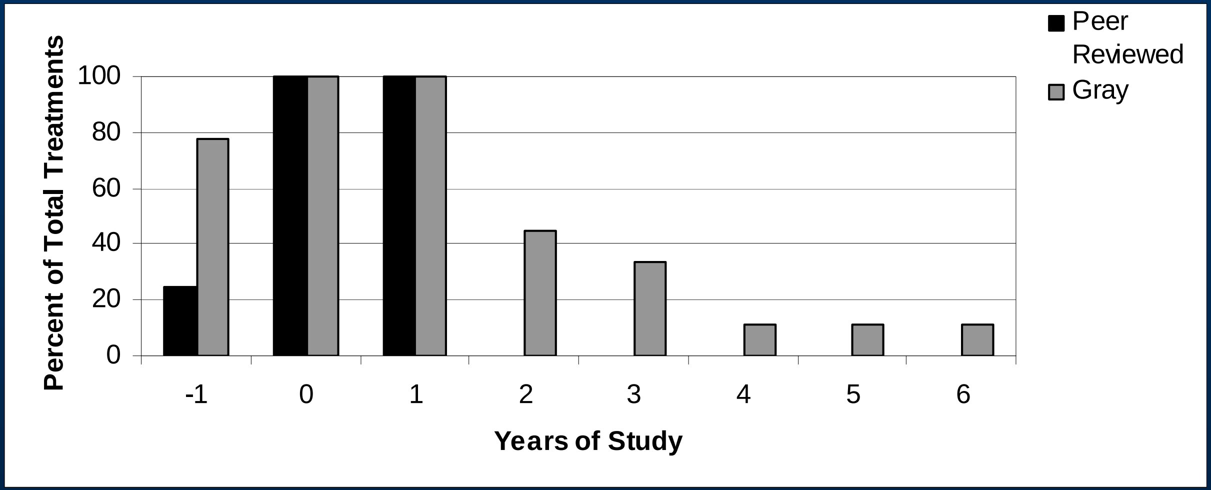
Fluridone Studies

- Despite widespread use in some states, very few peer-reviewed papers (3 on vegetation, 0 on water quality, 4 on fish)
- Army Corps technical reports
- Michigan has published information as well as reliable unpublished data
- Minnesota DNR shared data from research lakes
- Additional data from WI, VT, WA, NY, IN, ME, OR

Most studies focus on vegetation

Limitations of Data

1) Study length often only 1-2 years post-treatment



2) Methods vary
   – Sampling design, data collection, statistics

3) Inadequate sampling frequency or timing
   – Early spring or late fall vegetation samples

4) Lack of pretreatment data or reference lakes
   (effect of treatment vs interannual variation?)

Data Reliability

- Plant and Water Quality Data
  - Include at least one year pre-treatment data or reference lake
  - Sampling during peak biomass or at least two samples per year
  - Had to be quantitative
- Fish Data
  - Limited to specific examples due to lack of information

National Plant Results

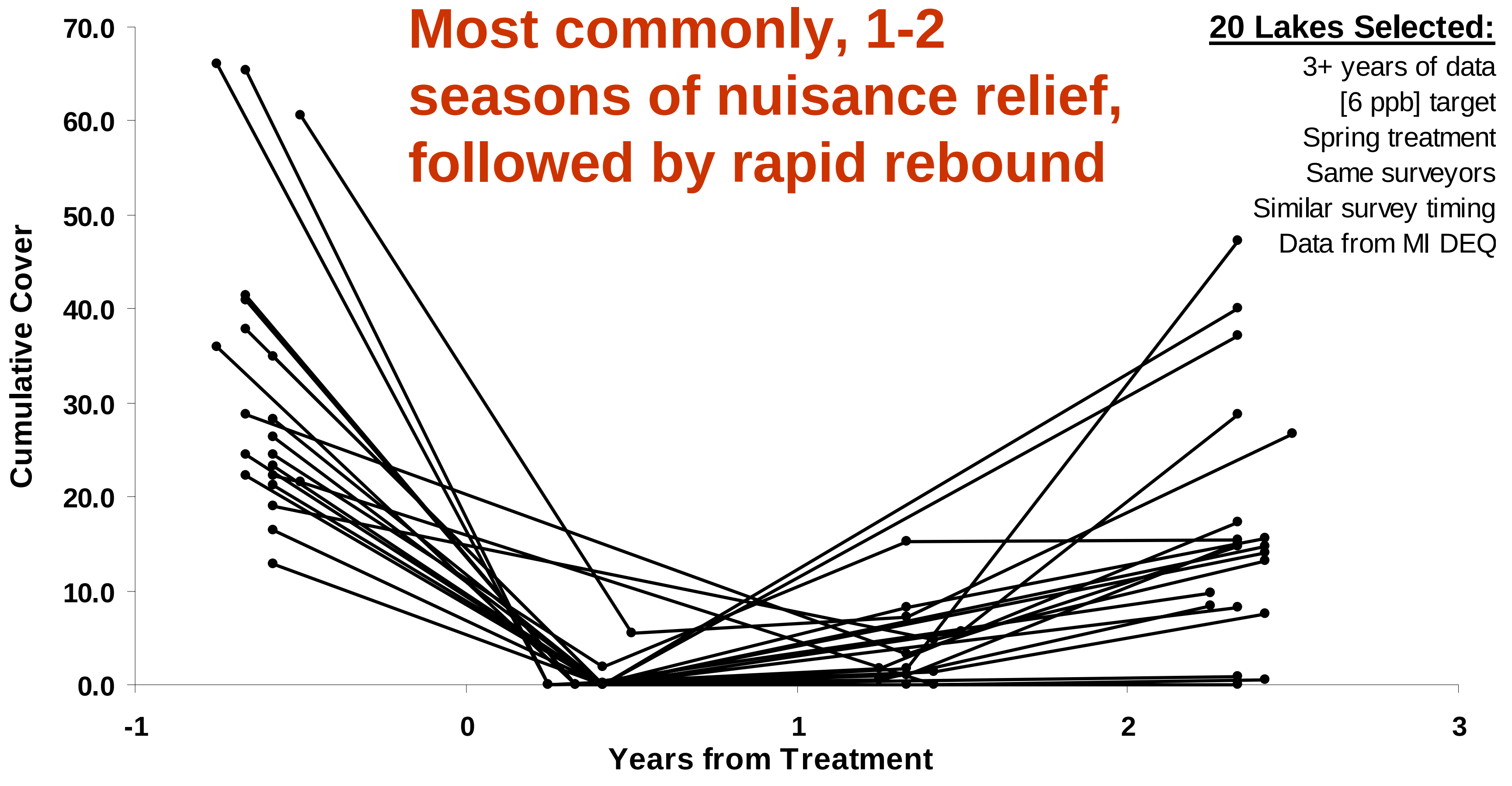
n ≥ 4 WHOLE LAKE TREATMENTS
Had to be initially present at >10% frequency (or 10% cumulative cover – MI data)
Change = >10% difference in frequency of occurrence from pretreatment data

Tables indicate the % of cases in which the species increased or decreased by at least 10% (not the magnitude)

Species	Year	% of Decreases	% of Increases	% w/ No Change	n
Eurasian watermilfoil	1	98	2	0	54

EWM
-Decrease in 98% of cases
-Large decrease, regardless of dosage (see next slide)
-Always returns, often rapidly (see next slide)

Long-term effects on EWM (3+ year data sets):



*Cumulative cover – indicates coverage and density of plants in lake

Native WI species listed as susceptible by SePro[1]

[1]From SePRO's Sonar® Guide to Aquatic Habitat Management

Floating plants
Duckweed
Watermeal
Pond-lilies
Water-lilies

Emergent
Northern water-plantain
Cattail species
Spike rush species
Reed-canary grass*

Submerged
Watermilfoil species
Coontail
Waterweed
Bladderwort species
Southern water naiad
Sago pondweed
Curly-leaf pondweed*
6 Potamogeton pondweed species
Horned pondweed

DNR has all WI species information (susceptible, tolerant, or unknown) available to anyone upon request, including species listed on label, laboratory studies, and field studies

Short-term effects on native plants:

-Susceptible species:

Species	Year	% of Decreases	% of Increases	% w/ No Change	n
Northern milfoil	1	100	0	0	4
Slender naiad	1	90	0	10	10
Elodea (waterweed)	1	85	0	15	13
Clasping leaf pondweed	1	67	0	33	9
Thin leaf pondweed	1	54	8	38	24
White-stem pondweed	1	60	0	40	5
Water crowfoot	1	57	0	43	7
Coontail	1	50	5	45	20
Variable pondweed	1	43	0	57	7
Large leaf pondweed	1	41	9	50	22
Bulrush	1	33	0	67	6
Illinois pondweed	1	33	7	60	15
Pond lily - Nuphar spp.	1	28	8	64	25
Cattail	1	27	0	73	11

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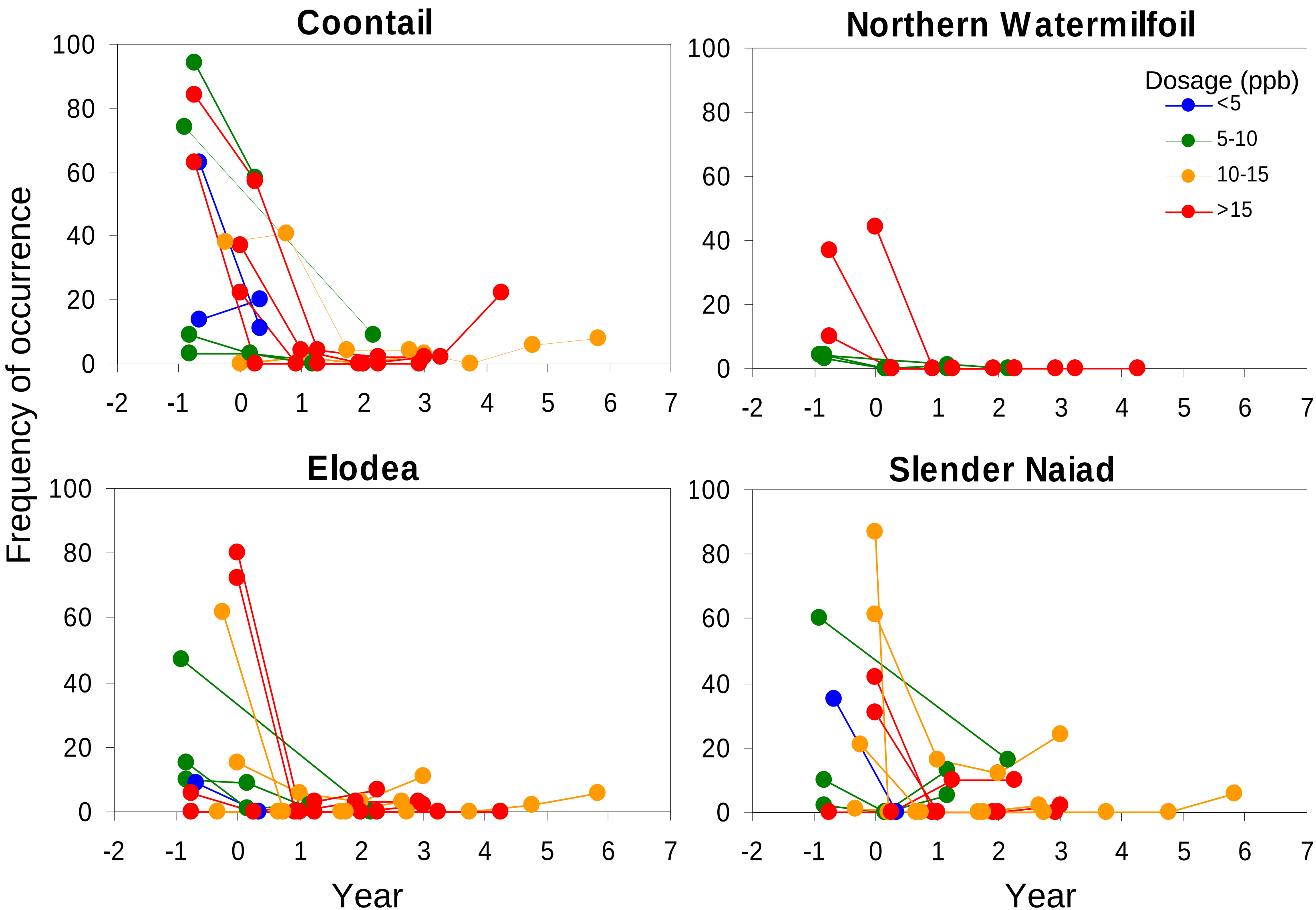
Decreases in 30% – 100% of the cases

Response dependent on dose and duration

Long-term effects on susceptible native plants

(common, abundant species):



-Potential large decreases, regardless of dosage

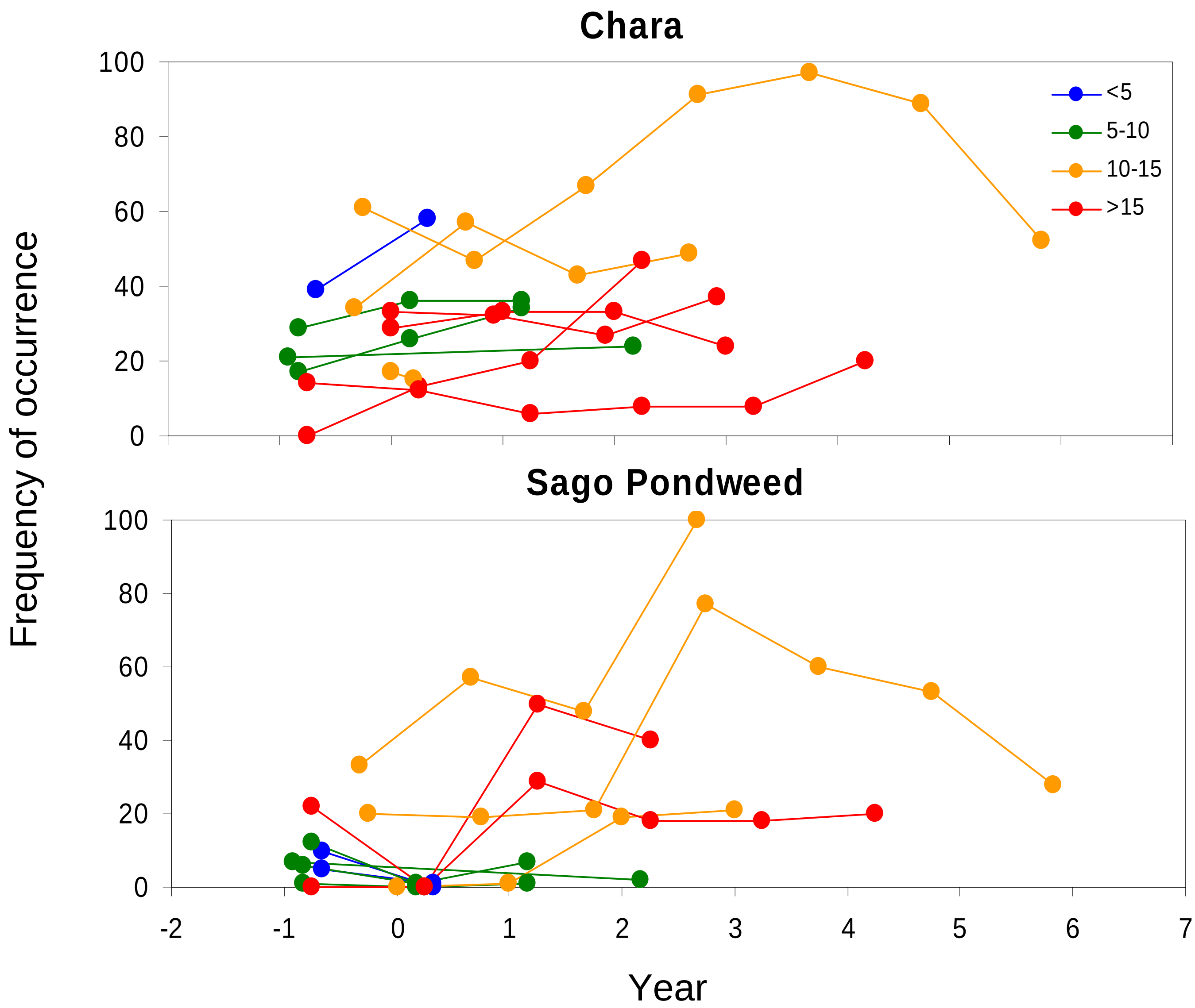
Short-term effects on native plants:

-Tolerant species:

Species	Year	% of Decreases	% of Increases	% w/ No Change	n
Southern naiad	1	0	0	100	5
White water lily	1	8	8	84	25
Fern pondweed	1	0	20	80	10
Common bladderwort	1	0	20	80	5
Wild celery	1	25	20	55	20
Chara spp.	1	8	33	59	49
Flat-stem pondweed	1	18	35	47	17
Water stargrass	1	11	42	47	19
Sago pondweed	1	22	44	33	18

Mixed results - no change or mixed increases/decreases

Long-term effects on tolerant native plants:



-Potential large increases, mixed results

Another exotic – curly leaf pondweed

-May inhibit recreation
-May contribute to degraded water quality due to unique biology – dies off in early summer, can fuel algal growth

Species	Year	% of Decreases	% of Increases	% w/ No Change	n
Curly-leaf pondweed	1	35	35	29	17

<u>Curly-leaf pondweed (poor timing for monitoring)</u>

-Cook et al. 2005 - Often increases

-Don't trade one exotic for another- needs concurrent management

Overall long-term effects on plants:

EWM

Most often, 2 seasons of nuisance relief (1-4)

Natives

Dependent on:

1) Plant community
   - -% of natives susceptible to chemical vs tolerant species
   - -Reproductive strategy (seed producers return more often)

2) EWM response
   With 2+ seasons of EWM relief certain species sometimes increase (chara, sago), until EWM returns

Effects on Algae / Water Clarity

-Since they compete for nutrients, trade-off between plants and algae
-Plant decay also provides nutrients for algal growth, resuspension of sediments

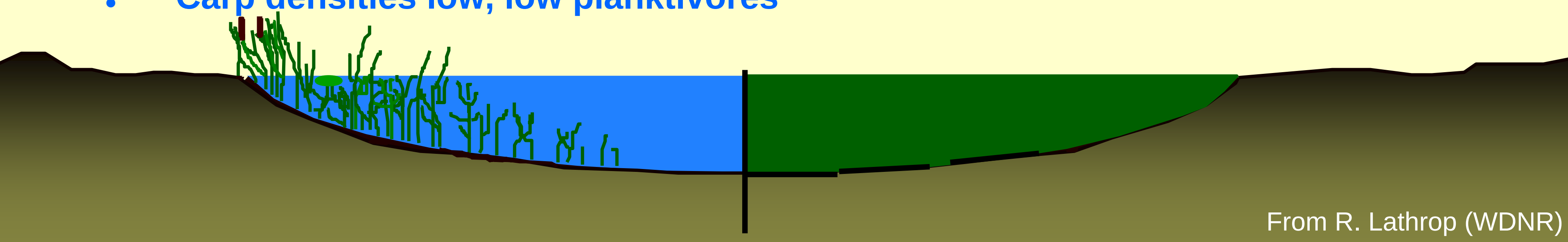
Alternative States in Shallow Lakes:

Clear-Water, Aquatic Plant State

- **Clear water**
- **Aquatic plants abundant (with high biodiversity?)**
- **Bottom sediment resuspension & phosphorus recycling low**
- **Algae densities low (low blue-green algal toxins)**
- **Carp densities low, low planktivores**

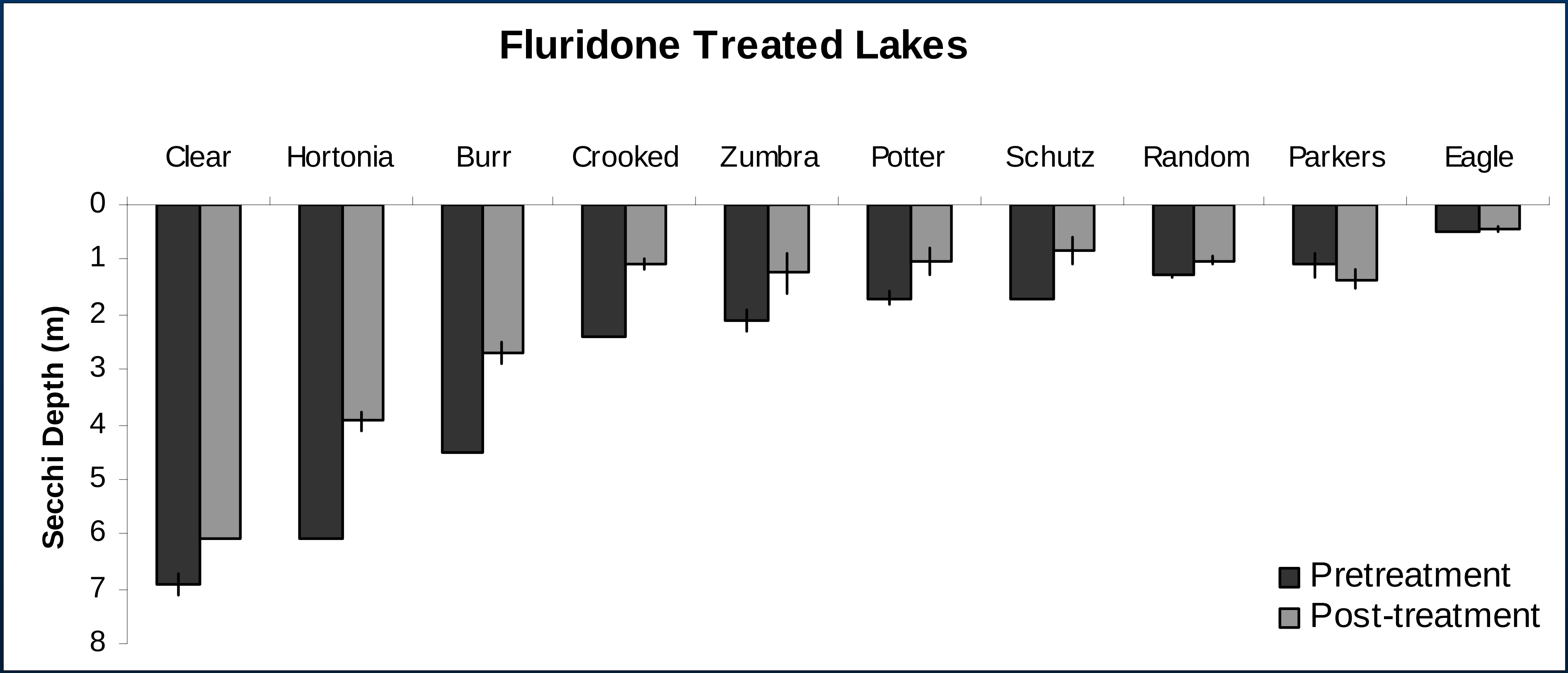
Turbid Algal State

- **Turbid green water**
- **Aquatic plants sparse**
- **Bottom sediment resuspension & phosphorus recycling high**
- **Algae densities high (high blue-green algal toxins?)**
- **Carp densities high, high planktivores**



From R. Lathrop (WDNR)

National Water Clarity Results



-Reductions in secchi depth in 80% of treated lakes ($P = 0.003$) due to increased algae (late summer samples, 1 yr pretreatment vs averaged year of treatment and 1 year post)

-Long term effects?

Overall effects on algae/water clarity:

Depends on the lake:

- Biomass of susceptible vegetation
- External and internal nutrient loads
- Morphology and bathymetry of lake (% of lake area that is vegetated)

Shallow, eutrophic lake with high biomass of EWM, coontail, and elodea throughout

VS

Deep, oligotrophic lake with some EWM, and high biomass of tolerant natives

From a Fisheries Standpoint:

- Submersed aquatic vegetation provides services to multiple fish species at multiple life stages

  Game fish – sunfish, largemouth bass,
  northern pike, muskellunge

  Nongame fish – darters, minnows, killifishes

- Losses to fish recruitment are probable with loss of habitat
- Extent of impact depends on the lake (fish, plants, physical characteristics, water quality)

From Valley et al. 2004

National Fish Results

- No acute or chronic toxic effects on Trout, Bluegill, Catfish, Fathead Minnows, Sheepshead Minnows[1], or fry of Walleye, SMB, and LMB[2]

[1]Hamelink et. al 1986, [2]Paul et. al 1994

- Secondary effects of vegetation removal (recruitment, growth, condition, mortality)?
  - Population structure[1-6]
  - Behavior[2,5]
  - Reproduction[6]

[1]Pothoven et al. 1999, [2]Pothoven 1996 (gray), [3]Valley and Bremigan 2002, [4]Schneider 2000 (gray), [5]Welling et. al 1997 (gray), [5]Sammons et. al 2003, [6]Schneider 2000

- Long-term effect on fisheries? Need data!

Summary

Deciding whether a whole-lake treatment is appropriate:

1) Quantify the perceived problem! Data, data, data…

2) Set reasonable expectations (ecological and economical)

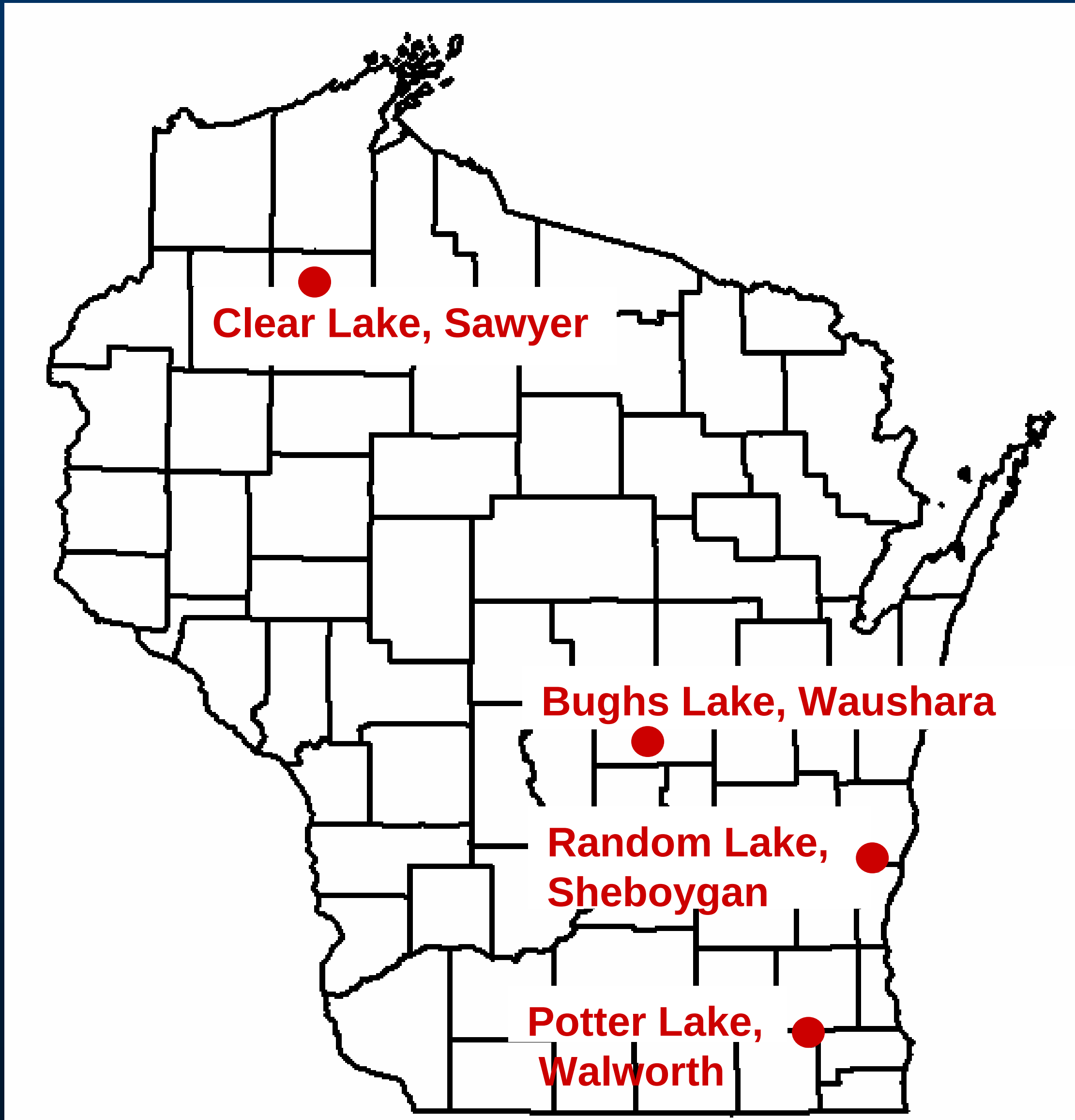
-Whole lake treatments generally do not eradicate EWM, repeat treatments would probably be requested
-Usually provide 2 seasons of nuisance relief, need to manage in interim
-Can incur unintended ecological effects – need to evaluate data **lake by lake** (physical features, plants, algae/water clarity, fisheries)

3) Weigh the benefit with the risks

4) Recognize that managing invasives is a long-term commitment with any tool (action based on data)

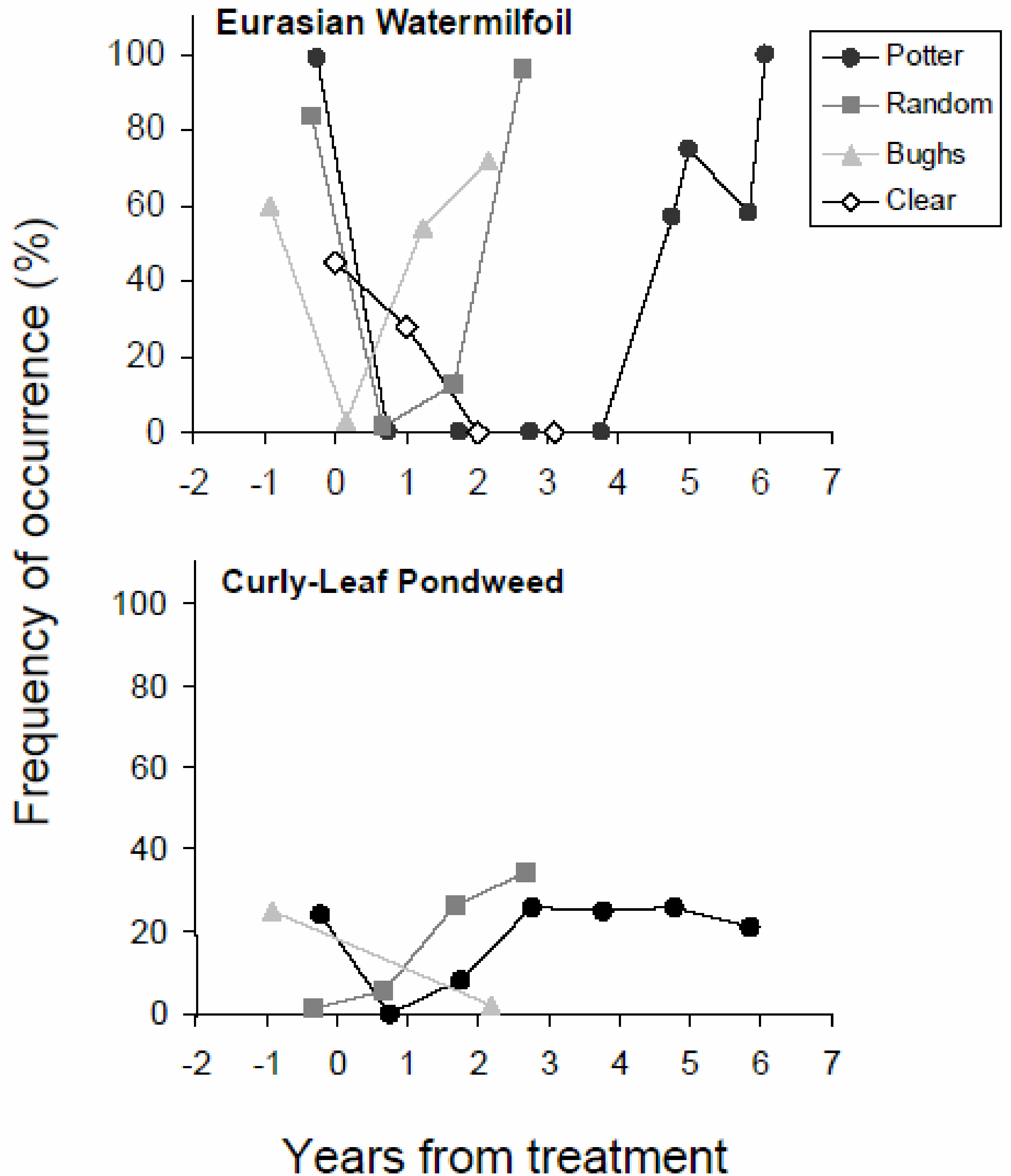
What happened in WI lakes?

- 4 lakes treated
- 30-200 acres
- >95% littoral
- 1997-2001
- 6-16 ppb
- Fall or spring

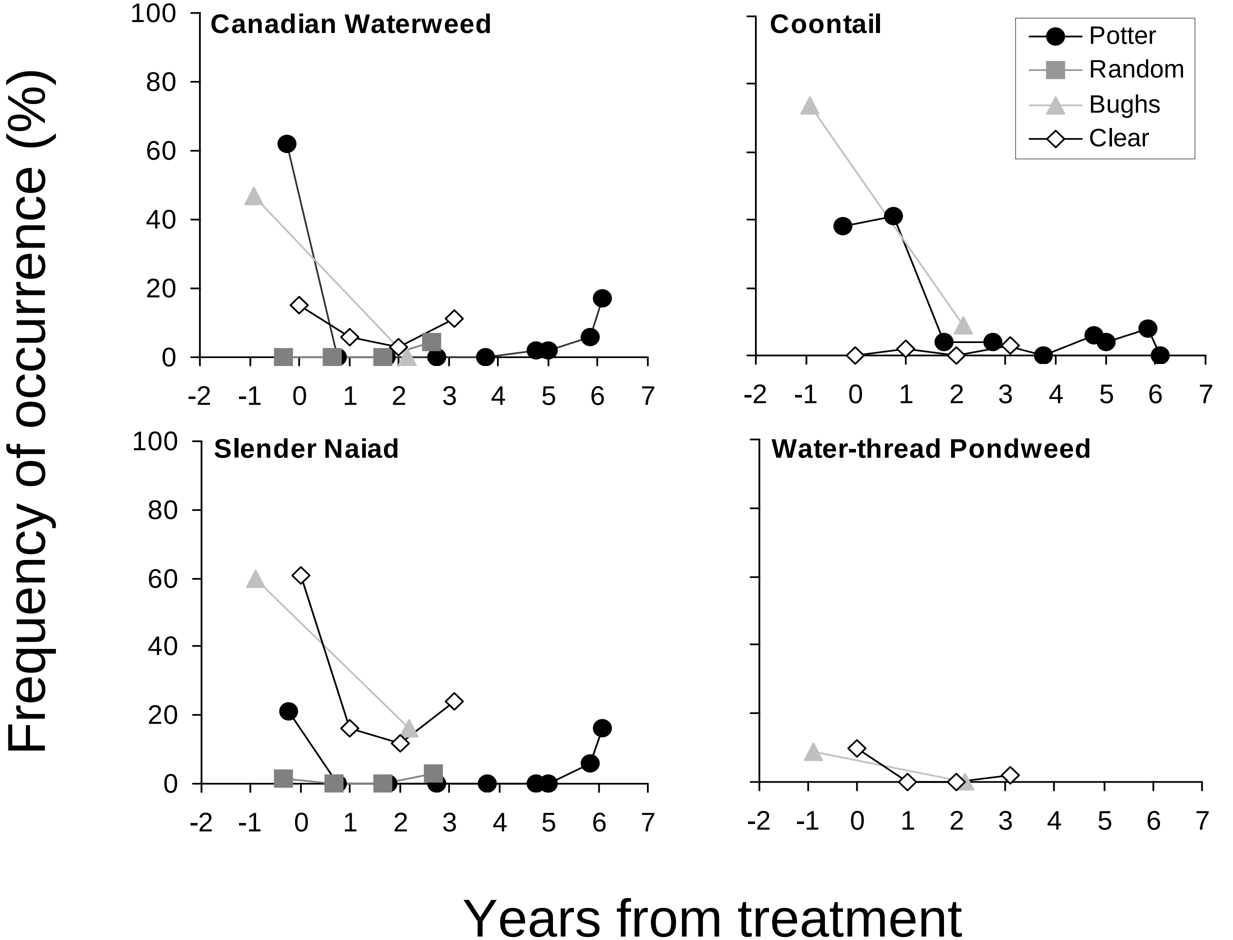


Effect on exotics:

- 1-4 seasons significant reduction
- Concurrent small-scale treatments
- Rapid return
- Potter retreated in 2004 and 2005
- Random retreated in 2005



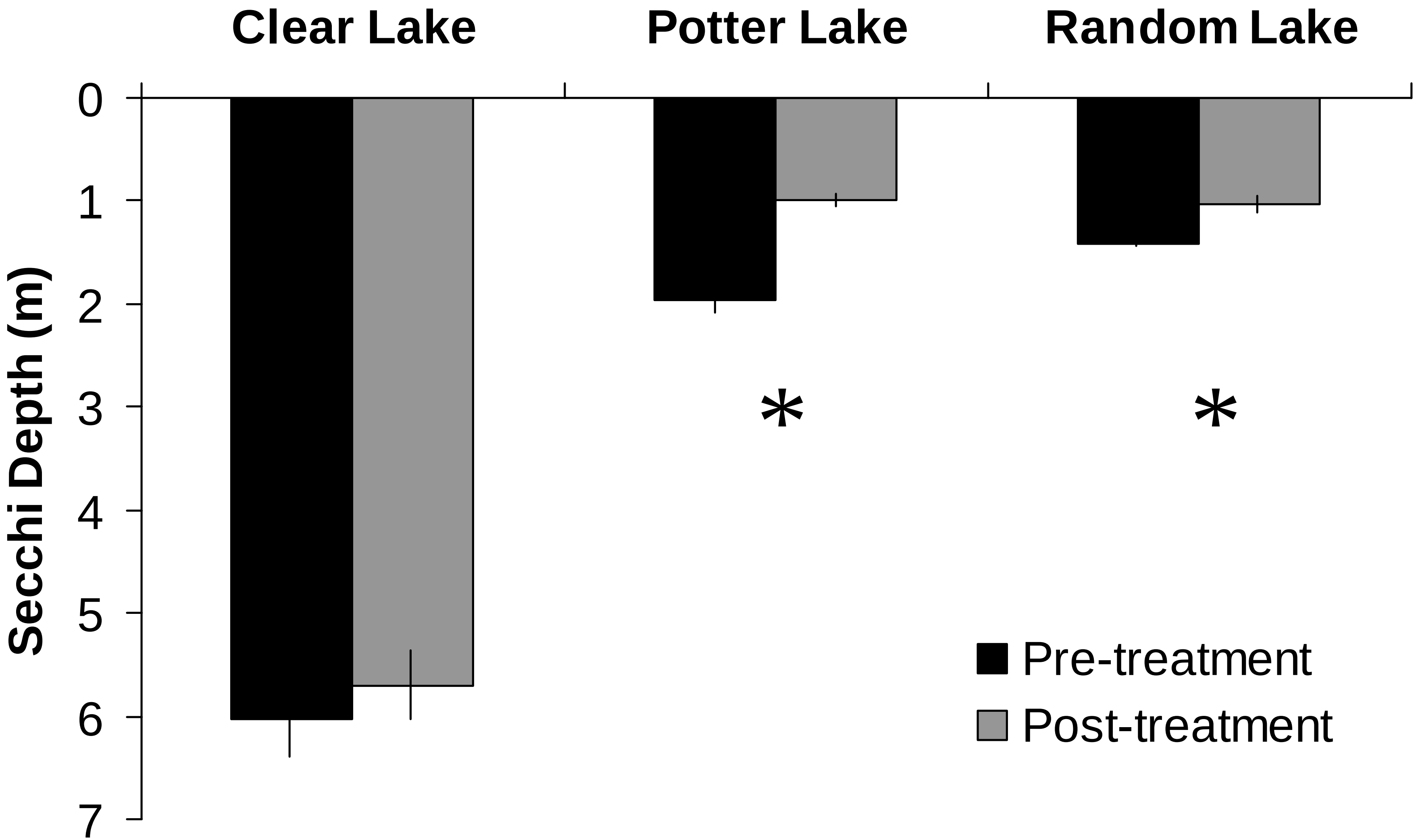
Effect on natives:



-Elodea, coontail, slender naiad, and water-thread pondweed decreased
-Where present, chara and sago increased until EWM returned

*In Clear Lake, additional natives increased

Effect on water clarity:



*Bughs Lake – no data, aerator installed because of crashes in dissolved oxygen

Potter Lake 9/30/05

What happened in Houghton lake, MI?

Size = 8100 ha
Primarily forested watershed
Mean depth < 3 m
Near 100% littoral
54% EWM
Volume (treated) = 200 million m^3
$1.4 million to SePro for chem. and app.
Additional annual costs
Riparian owners assessed $200/yr (per lakeshore unit) for 3 yrs, then reduction

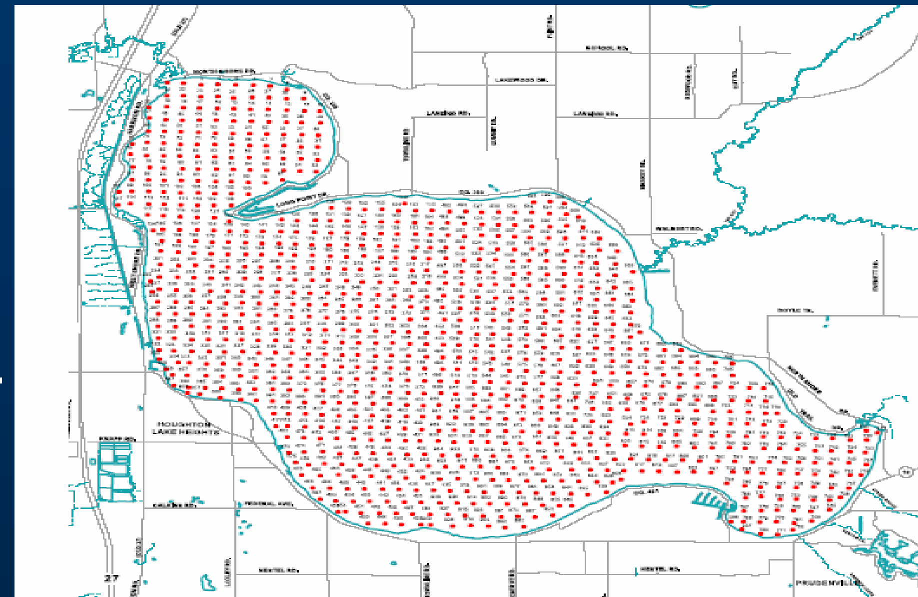


TABLE 2
HOUGHTON LAKE PLANT CONTROL HISTORY

	Sonar® (acres treated)	Reward® (acres treated)	Renovate® (acres treated)	Acres Harvested	Milfoil Weevils (# Stocked)
2002	20,044	17			
2003			32		
2004			44	81	2,000

Data and figures from Progressive AE

Effect on plants:

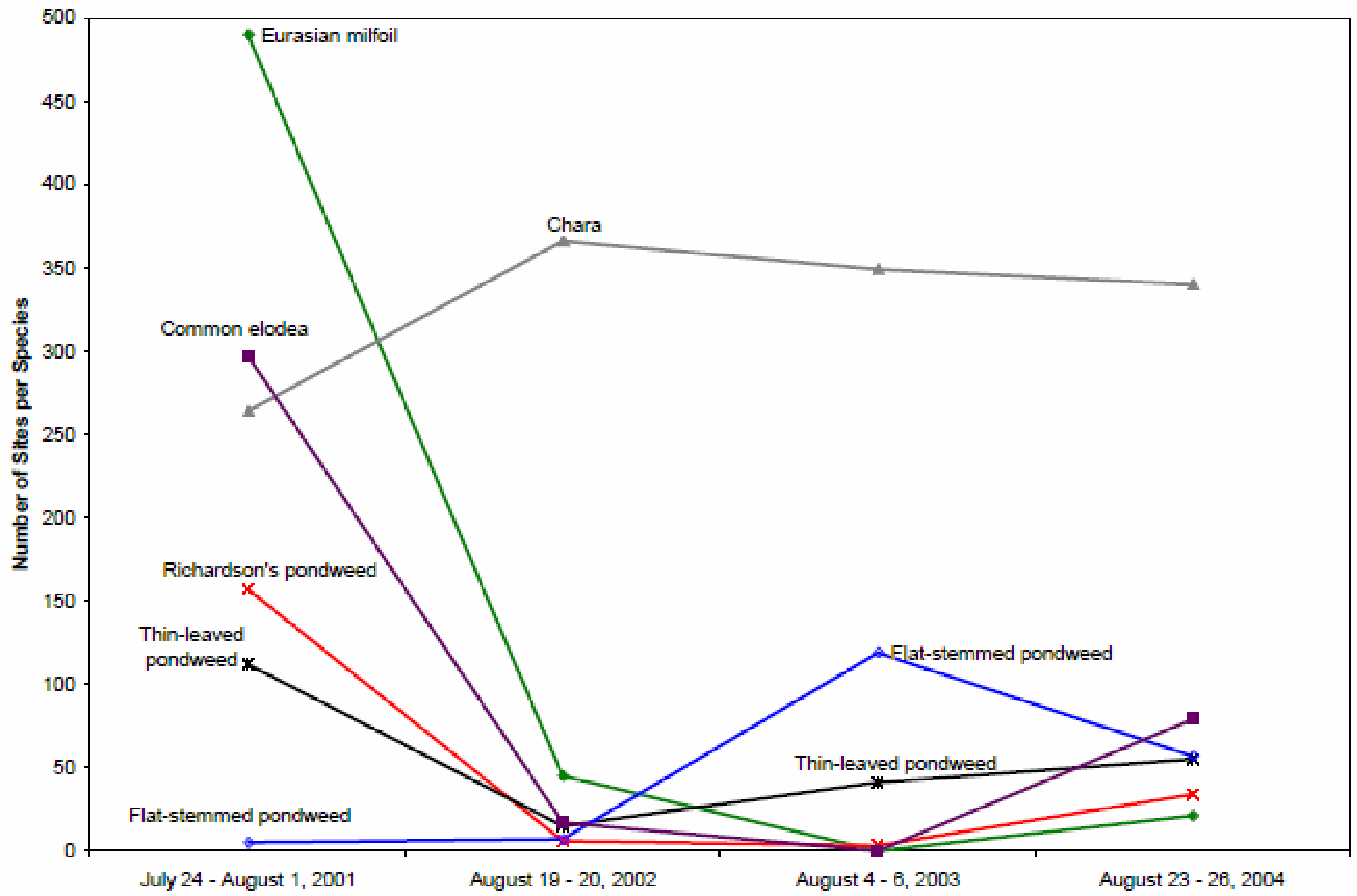
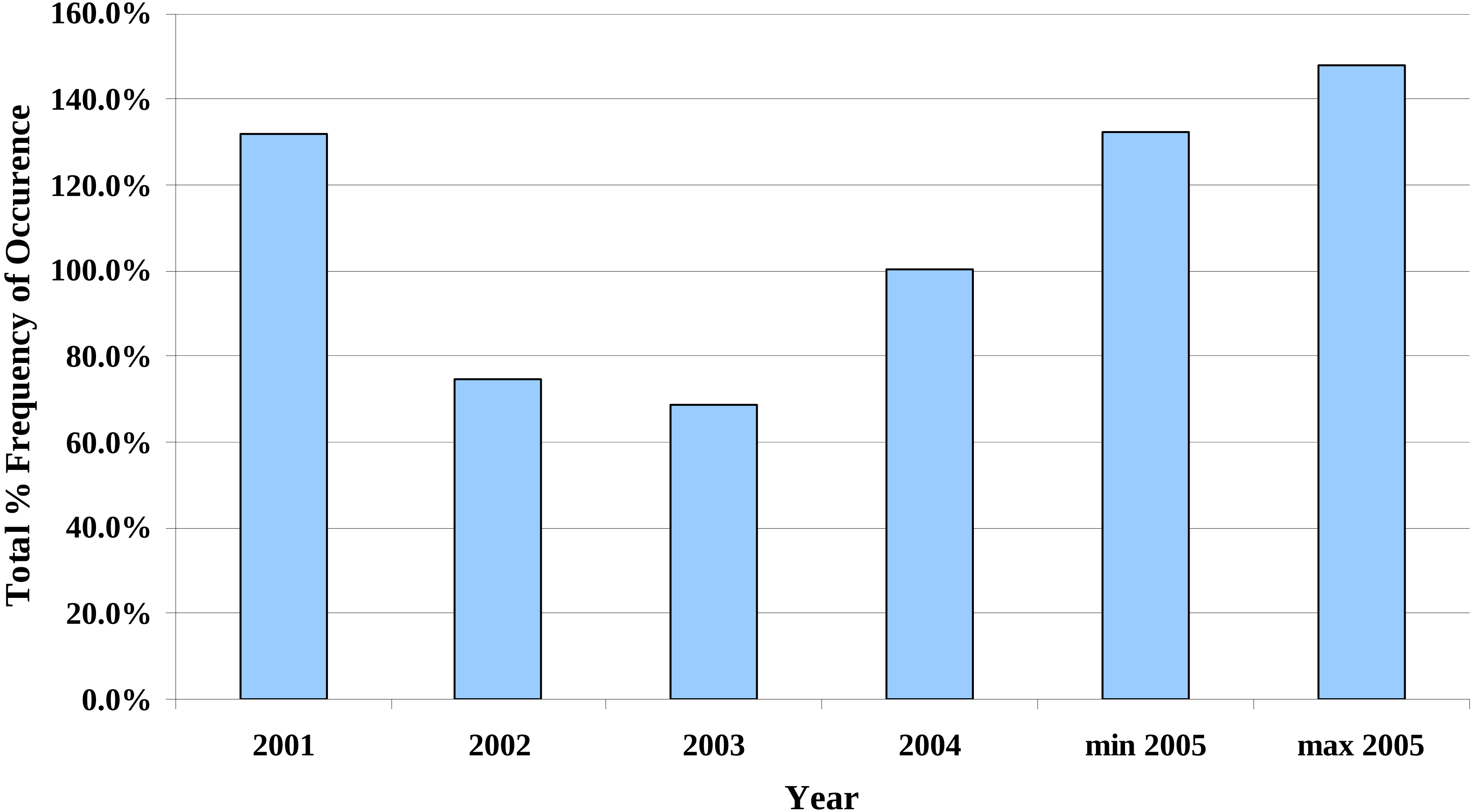


Figure 4. Population changes in common Houghton Lake species, 2001 - 2004.

Data from Progressive AE

Total % Frequency of Occurrence: Native Species on Houghton Lake



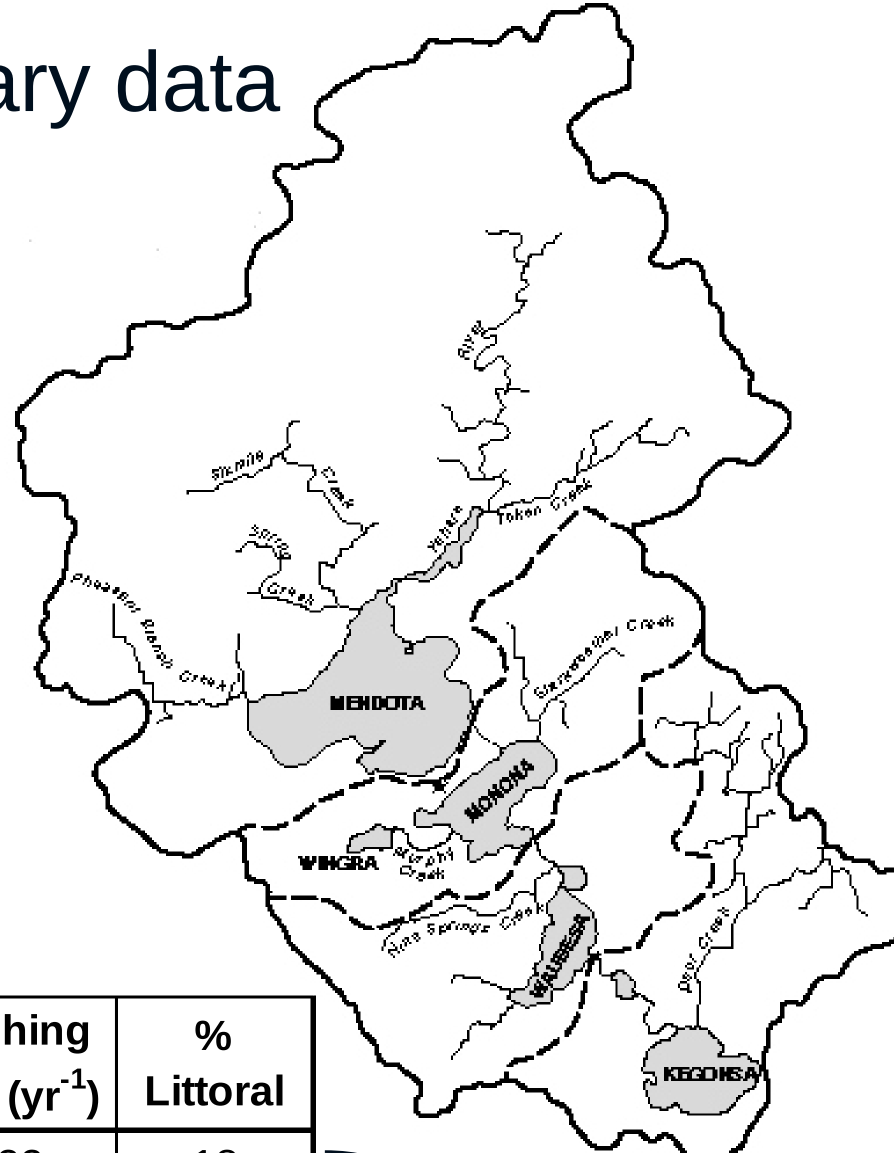
Data from Progressive AE

Houghton Lake Summary

- Four seasons EWM control (with additional efforts)
- Significant Decreasers – 8 native species
  - 5 species still less abundant in 2005 than pretreatment:
    Elodea, Richardson's pondweed, Vallisneria, coontail, nitella
  - 3 species exhibited initial decrease with rebound:
    Thin leaf pondweed, naiad, whitestem pondweed
- Significant Increasers – 6 native species
  - Chara, flatstem pondweed, variable-leaf pondweed, Illinois pondweed, ribbon leaf pondweed
- Undesirable species increased
  - Curly leaf pondweed, co-managed by herbicides/harvesting
  - Spirogyra (filamentous algae, from 0 to 4%)

Data from Progressive AE

Madison lakes – preliminary data



Madison lakes watershed

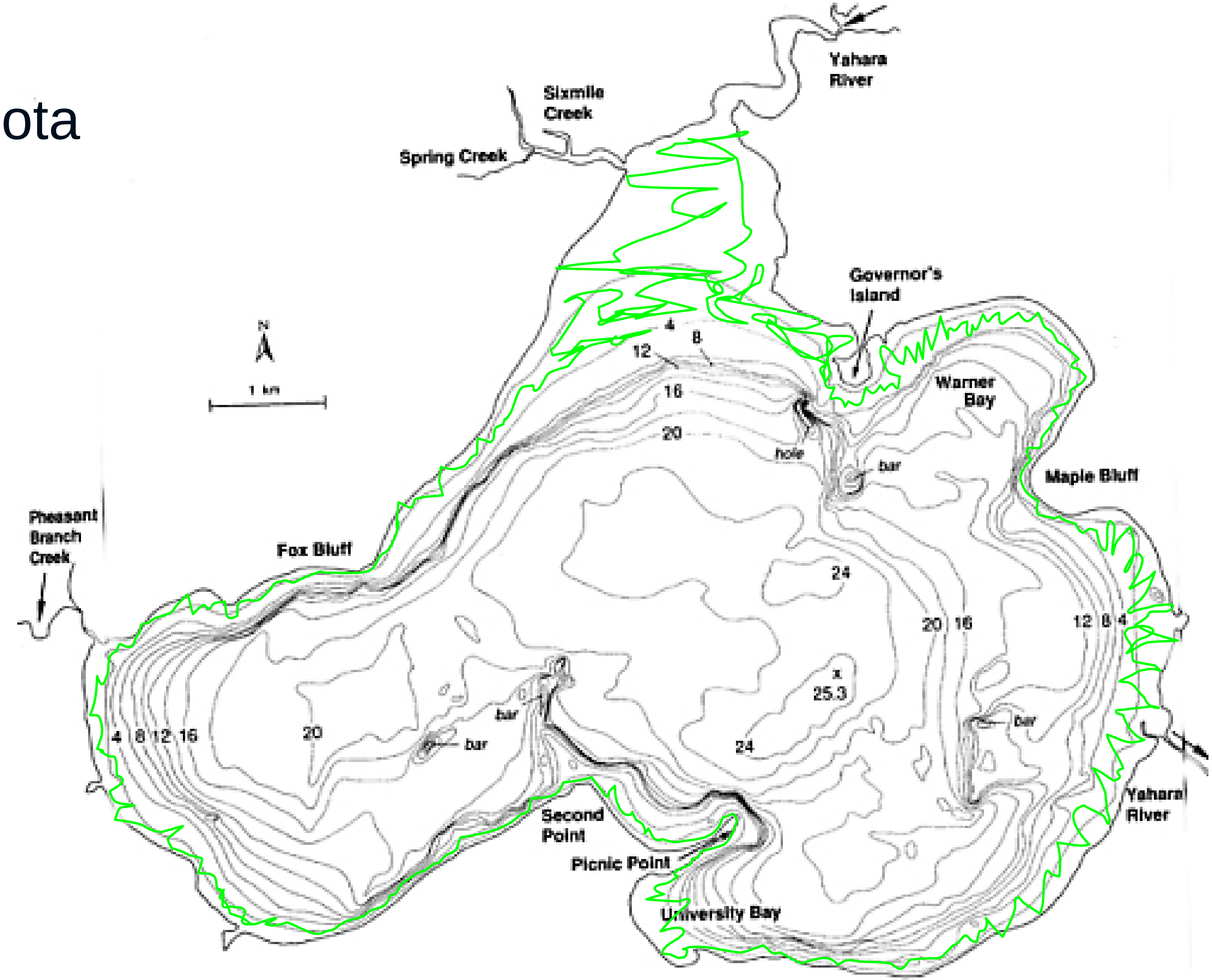
-primarily URBAN & AGRIC.

Lake	Surface Area (ha)	Volume (million m^3)	Max Depth (m)	Flushing Rate (yr^{-1})	% Littoral
Mendota	3,985	505	25.3	0.22	18
Monona	1,326	110	22.6	0.91	30
Waubesa	843	40	11.6	3.2	35
Kegonsa	1,299	67	9.8	2.2	50

Used the 4 m contour as proxy, may overestimate for lower lakes

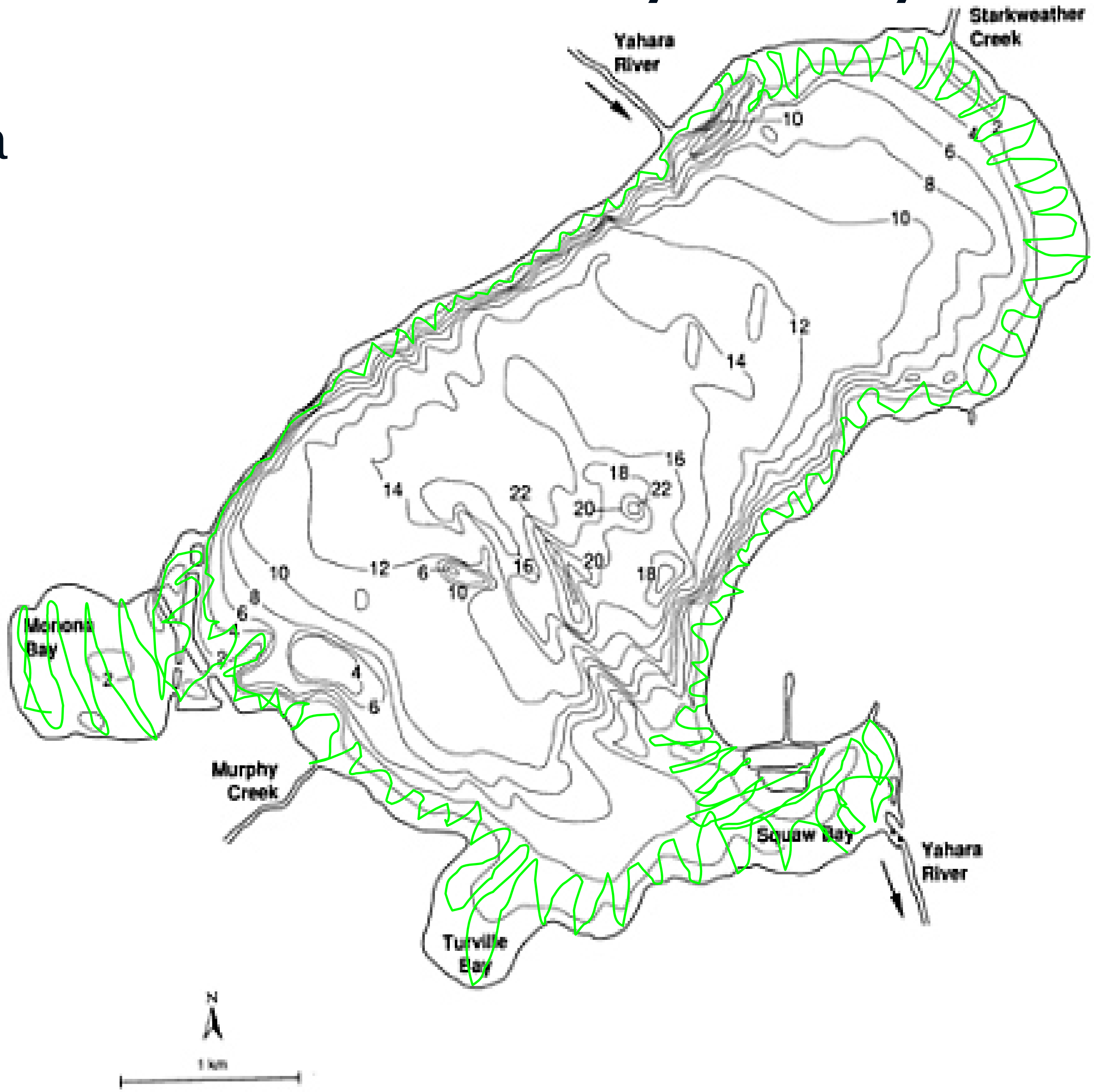
Madison lakes bathymetry

-Mendota



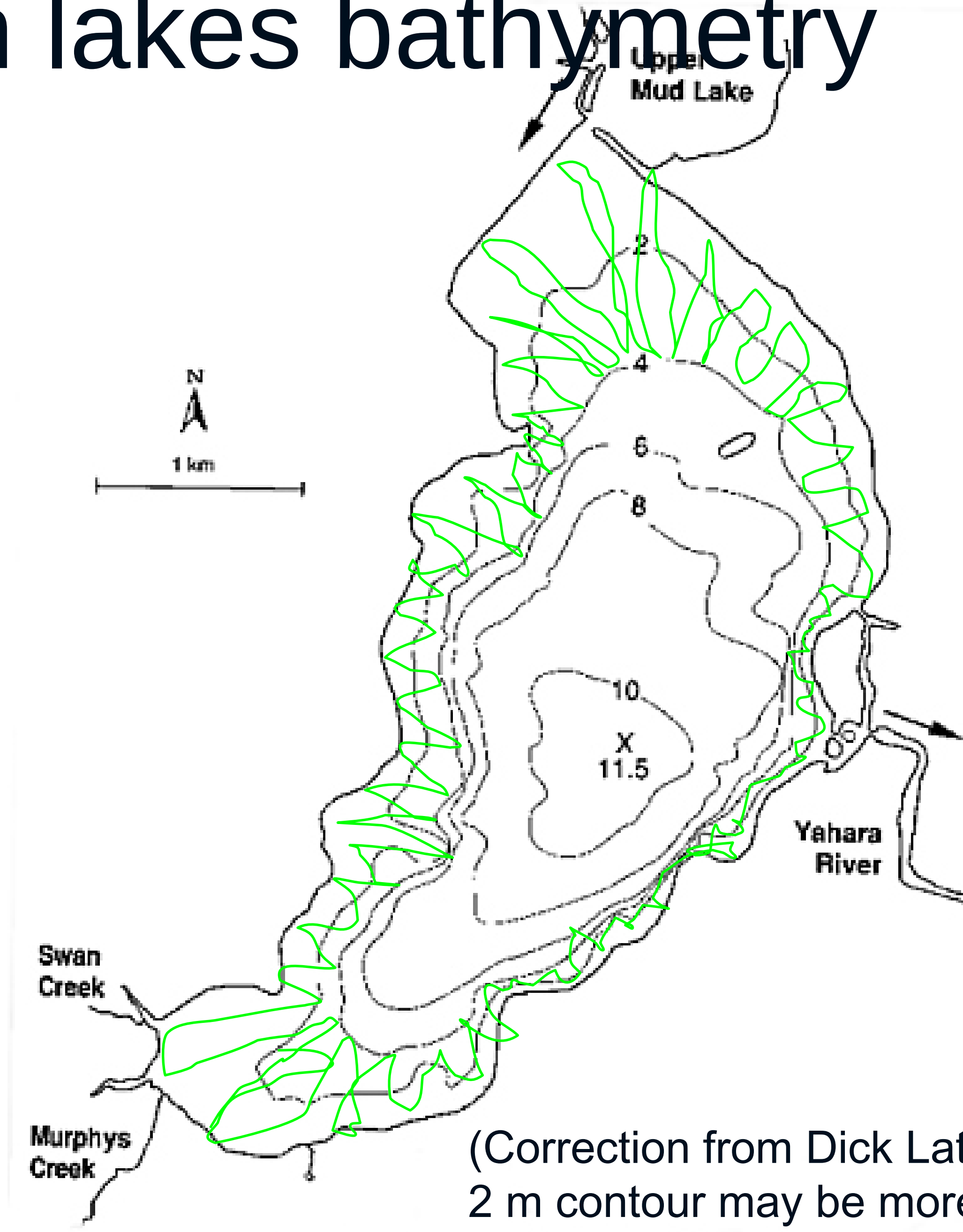
Madison lakes bathymetry

-Monona



Madison lakes bathymetry

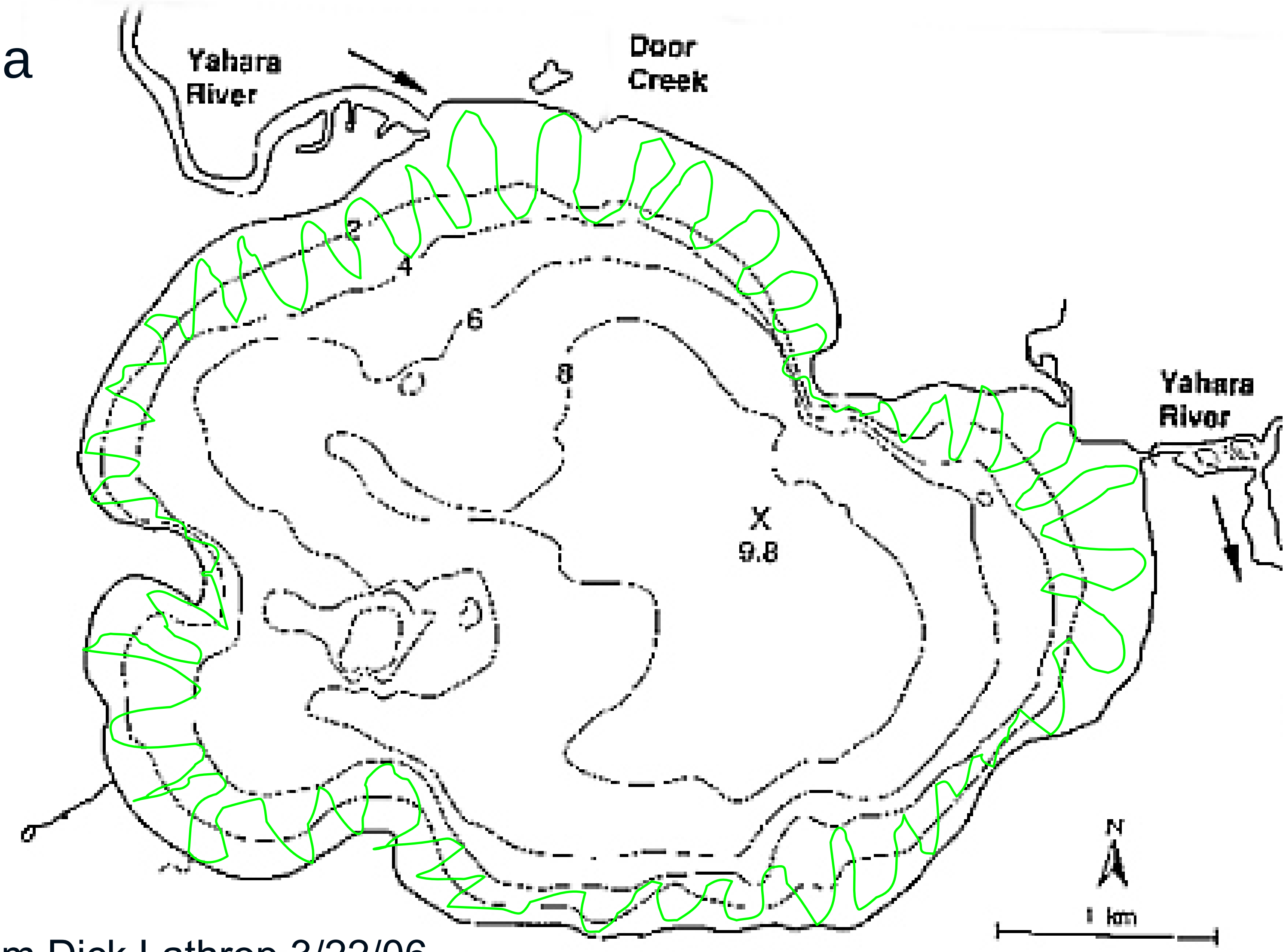
-Waubesa



(Correction from Dick Lathrop 3/22/06–
2 m contour may be more accurate)

Madison lakes bathymetry

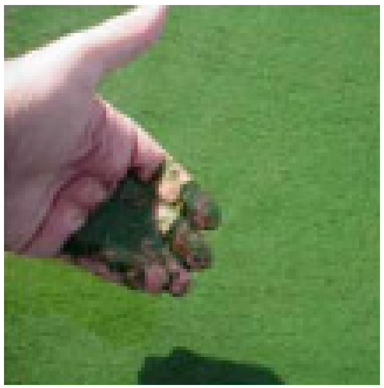
-Kegonsa



(Correction from Dick Lathrop 3/22/06– 2 m contour may be more accurate)

Madison lakes – preliminary data

Biology – History of algae and/or "weed" problems:



**"Every season a greenish-yellow scum occurs…are collected into fleecy massess, and driven ashore…,
forming a slimy scum which quickly putrifies, giving off a very disagreeable odor…"**

-occasionally prevented boating
-noticeable odor within 1-2 blocks from lake

Source:
1889. William Trelease. *Transactions of the WI Academy Sciences*, *Arts and Letters*, Vol VII

Madison lakes – preliminary data

Biology – History of algae and/or "weed" problems:

Max depth of plant growth dependent on algae
Algae high – fewer plants
Algae low – more plants

MENDOTA

Year	max depth of plant growth
1912-1920	about 5.5 m (25% of lake area!)
1951	about 4.8 m
1966	4.0 m
1980	3.0 m
1984	plants sparse between 2 and 3 m
1989	3.5-4m

MONONA

Year	max depth of plant growth
1920'S	3.0m (>20% of lake area, continuous belt around lake) (sewage effluent caused a lot of algae)
1925	3-5.5 (increased clarity due to extensive chemical treatment for planktonic algae)
'48 & '51	1.7 m (planktonic algae treatments discontinued)
1961	1.8m
1984	3.0m

UPPER MUD

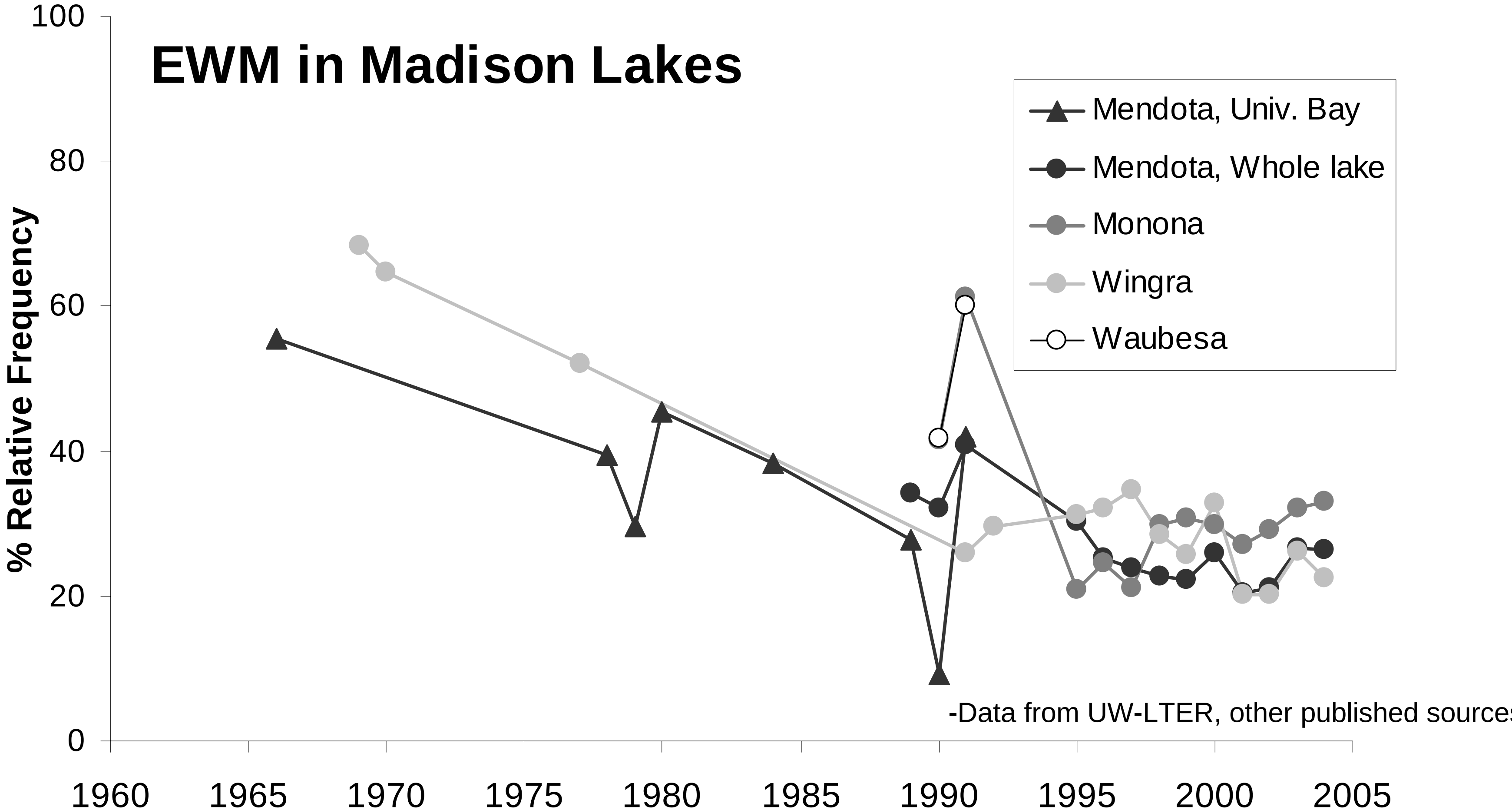
Year	max depth of plant growth
1887	dense growths
1930	no submersed macrophytes (loss probably caused by algae caused by sewage effluent)

WAUBESA -- Sago was the only important species through 1936, before that, wild celery had been abundant.

Year	max depth of plant growth
1939	0.6-1.5m (<3% of lake) (sewage effluent discharge began in 1936)
1951	1.2m
1955 + '61	very little macrophyte growth
'72-'75	milfoil growth abundant; "a nuisance"
1976	dramatic decline in plant growth (dense algae blooms)
1987	extensive growth of EWM; high density

-Data from *Fisheries of the Yahara Lakes*

Madison lakes – preliminary data



-EWM made up the largest component of the vegetation in 1960s
-Leveled off lakewide over recent decade
-Provides historical perspective – not to minimize nuisance for homeowners or discourage discussion on alternative management

Madison lakes - preliminary data

-Data from UW-LTER

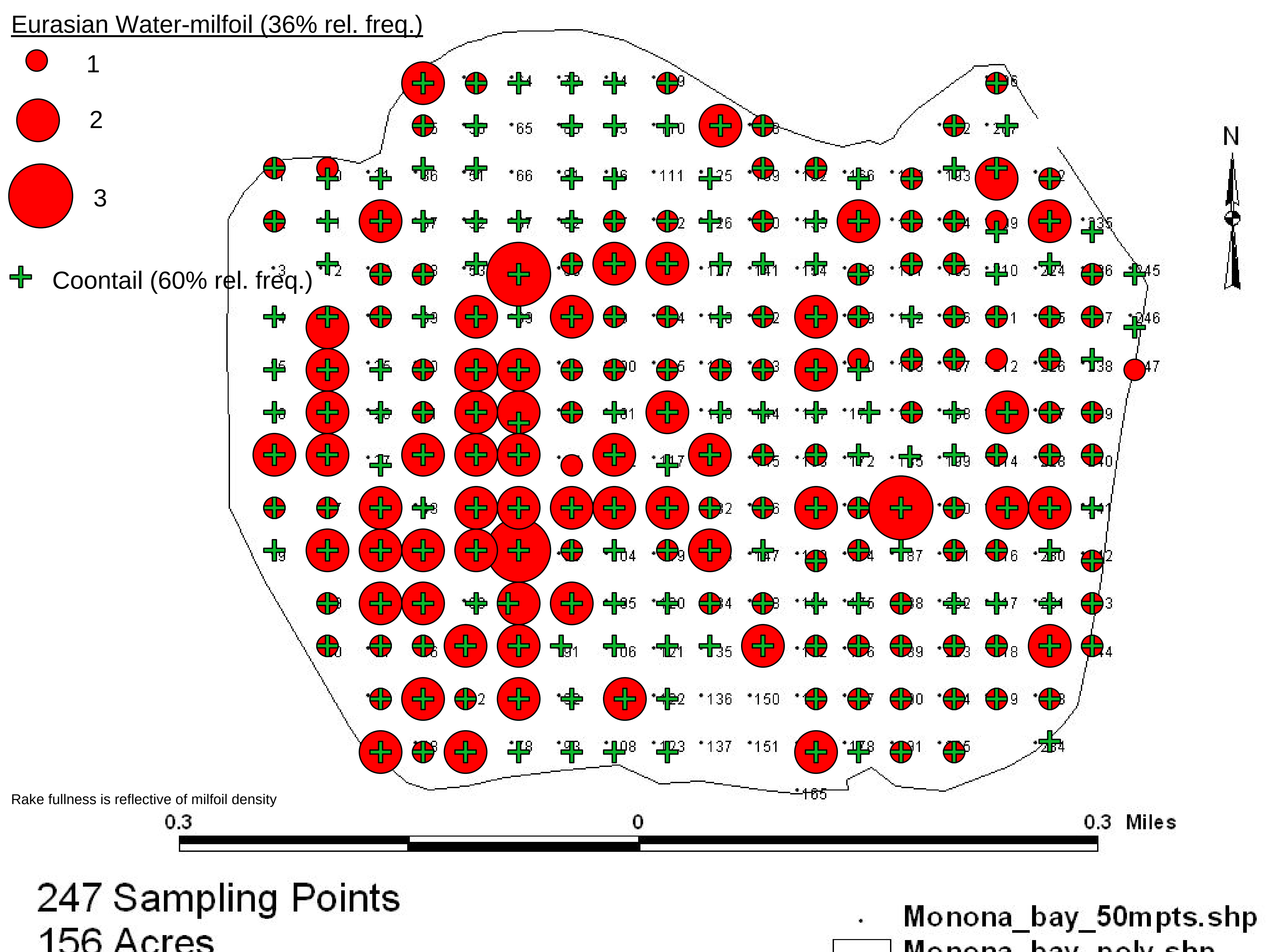
=susceptible to fluridone

Species	Mendota	Monona	Waubesa
EWM	27	33	60
Coontail	27	36	10
Elodea	19	1	
Northern milfoil			4
Clasping leaf pw	3	7	
Illinois pw		5	
Sago pw	2	5	2
White water lily	0.2		
Flat-stem pw	0.2	2	
Wild celery	11	5	
Water stargrass	9	3	6
Curlyleaf pw	1	4	18
Filamentous algae	X	X	X

60-80% of plant community susceptible

40-50% of native plant species richness likely affected

CLP/Filamentous algae/Sago/other spp. may increase



Eurasian Water-milfoil (36% rel. freq.)
1
2
3
Coontail (60% rel. freq.)
N
Rake fullness is reflective of milfoil density
0.3
0
0.3 Miles
247 Sampling Points
156 Acres
Monona_bay_50mpts.shp
Monona_bay_poly.shp

Madison lakes - preliminary data

Potential to support toxic blue-green blooms exists:

Need to balance recreational use with other uses, in addition to human health aspect

Dog dies after swimming in Kegonsa
11:08 PM 6/10/04
Beth Williams Wisconsin State Journal

Wisconsin teen's death a wake-up call about toxic algae
Posted on Wed, Feb. 11, 2004
BY RAMSEY CAMPBELL AND ROBERT SARGENT
The Orlando Sentinel
-Golf course pond

State monitoring lakes for toxic blue-green algae
By TOM HELD
theld@journalsentinel.com
Last Updated: Aug. 7, 2003
-Wingra and Monona

Summary

- All ecosystem components are interrelated, major change in vegetation affects all aspects of lake ecology

  Because of spatial scale, whole lake herbicide treatments need to be evaluated lake by lake
- We have several tools for managing invasive aquatic plants (see table), each with its own benefits and drawbacks
- We don't yet know how to eradicate aquatic invasives (any approach requires long-term commitment)
- Adaptive management approach – evaluate success/drawbacks scientifically (employ good monitoring designs)