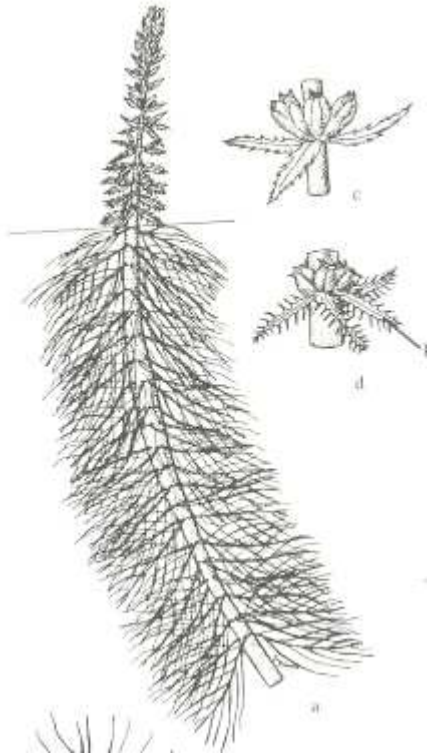
Using Aquatic Herbicides to Control Variable Watermilfoil (*Myriophyllum heterophyllum*) in New Hampshire Lakes



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Aquatic Herbicides

- Risk = Toxicity x Exposure
- Products re-registered by EPA under FIFRA, also registered in each State
- 20 active ingredients for aquatics in 1976 – now only 8 in US
- Many target proteins or photosynthetic pathways
- No aquatic herbicides have a swimming restriction on the label

USEPA Herbicide Registration – what's involved?

- 120 toxicity tests required in every category minimum
- 8-13 years typically required from when a new compound is introduced to when it is registered
- $50-$80 million (or more) to register a product in aquatics

Aquatic Herbicides Currently Available

TRADE NAME	ACTIVE INGREDIENT	MANUFACTURER	
Navigate	2,4-D	Applied Biochemists	www.appliedbiochemists.com
Aquathol K	Endothall	United Phosphorus	www.upi-usa.com
Komeen / Nautique	Copper	SePRO	www.sepro.com
Renovate	Triclopyr	SePRO	www.sepro.com
Reward	Diquat	Syngenta	www.syngentaprofessional products.com
Rodeo & generics	Glyphosate	Dow AgroSciences	www.dowagro.com
Sonar	Fluridone	SePRO	www.sepro.com
Habitat	Imazapyr	BASF	www.vmanswers.com

Registered Aquatic Herbicides

Compound	Year Registered	Mode of Action
2,4-D Ester	1959	Auxin – Systemic
2,4-D Amine	1976	
Copper	1950's	Contact – phs – membrane
Diquat	1962	Contact – PSII – membrane
Endothall	1960	Contact – Resp. – membrane
Glyphosate	1982	Growth – protein synthesis
Fluridone	1986	Growth – Enzyme inhibitor
Triclopyr	2002	Auxin Systemic
Imazapyr	2003	Growth – AHAS inhibitor
Carfentrazone	2004	Contact – Enzyme- membrane

Source: USACE, ERDC

New Aquatic Herbicides…
Registration Pending or issued EUP

Compound	Company	Mode of Action
Penoxsulam	SePRO	Growth – ALS enzyme inhib.
Imazamox	BASF	Growth – AHAS enzyme inhib.
Flumioxazin	Valent	Contact- Protox Enzyme
Bis-pyrobac	Valent	Growth – ALS enzyme inhib.

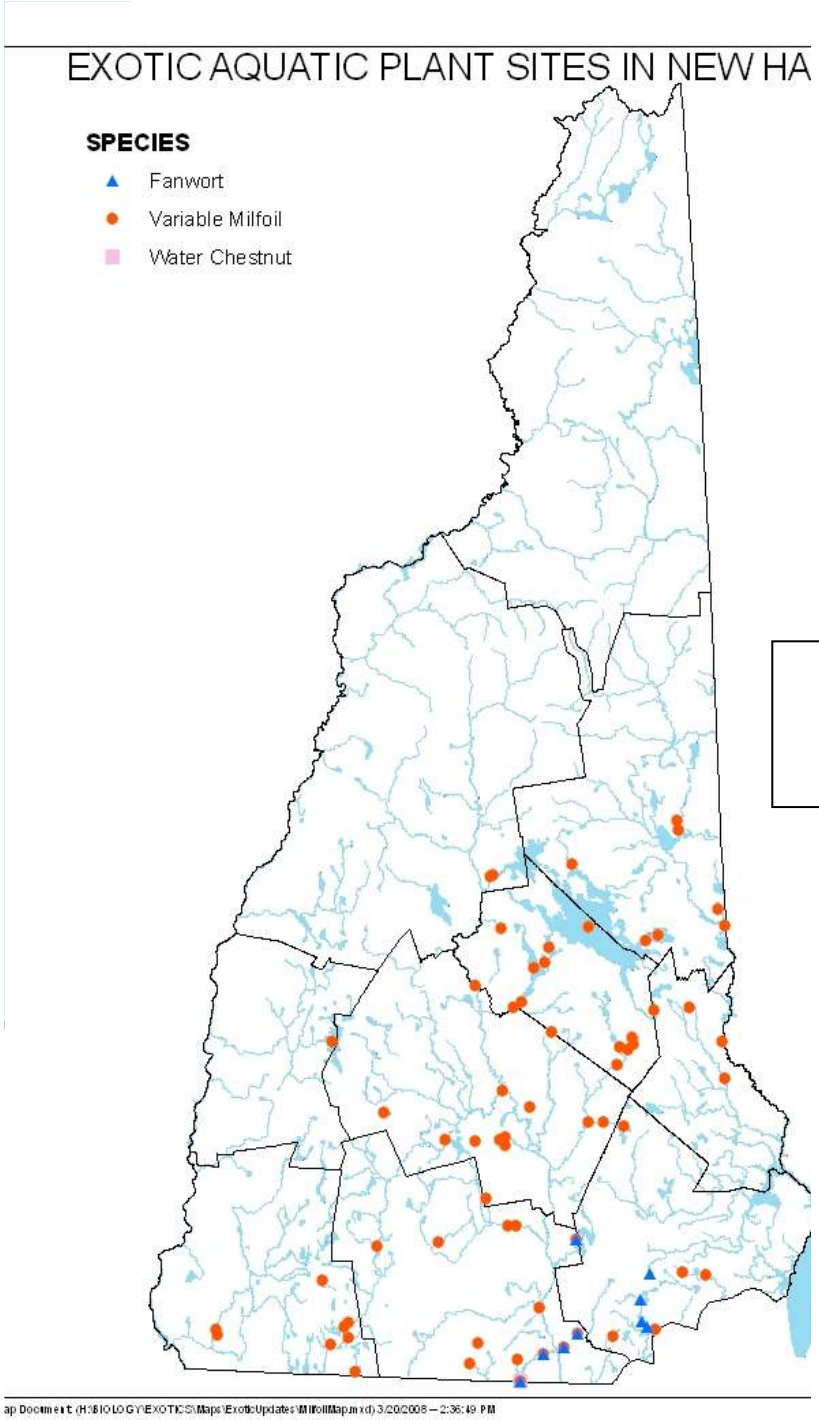
Source: USACE, ERDC

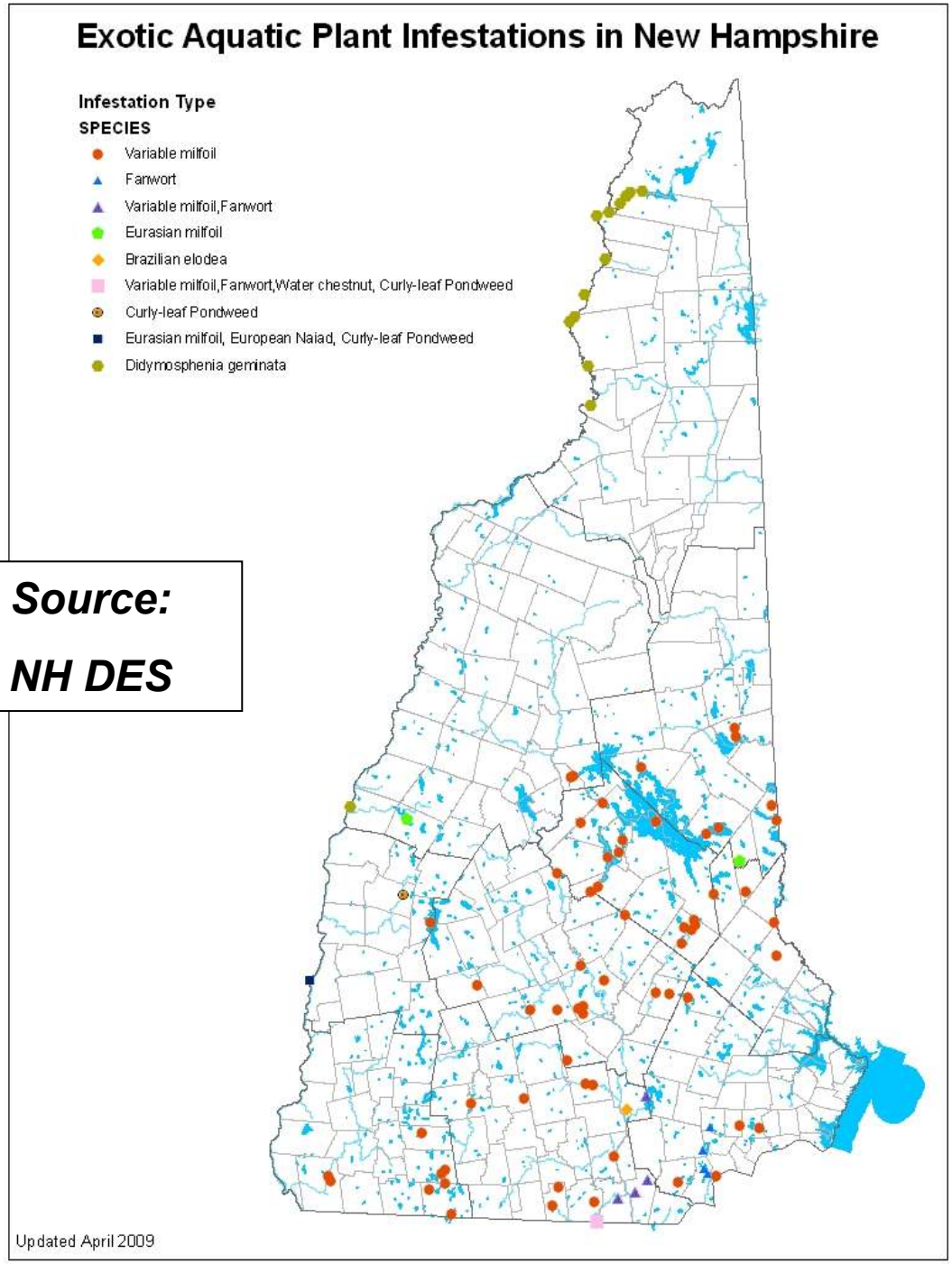
EXOTIC OR INVASIVE AQUATIC PLANTS

- Eurasian Watermilfoil
- Variable Watermilfoil
- Fanwort
- Water Chestnut
- Curlyleaf Pondweed
- Common Reed / Phragmites
- Purple Loosestrife
- Hydrilla

Native Plants That Can be Invasive

- Watermeal
- Duckweed
- Bladderwort
- Coontail
- Elodea
- Pondweeds
- Waterlilies





Source:

NH DES

POTENTIAL IMPACTS OF EXOTIC OR INVASIVE PLANTS

FISH, WILDLIFE & NATIVE PLANTS

- Displacement of native plants
- Displacement of endangered, threatened or rare aquatic plants
- Habitat loss for fish & wildlife
- Change in spawning site availability
- Change in fish distribution
- Reduction in feeding success of predatory fish
- Reduction of open-water

WATER QUALITY

- Temperature & oxygen fluctuations
- Increased phosphorus (nutrient) loading
- Alteration in plant and algae communities
- Accelerated eutrophication rates

Source: A report from the Milfoil Study Committee on the Use of Aquatic Herbicides to Control Eurasian Watermilfoil in Vermont. VTDEC, March 1993

POTENTIAL IMPACTS OF EXOTIC OR INVASIVE PLANTS (continued)

RECREATION

- Risk of swimmer entanglement
- Reduced access for boating & fishing
- Reduced aesthetics

LOCAL COMMERCE & REAL ESTATE

- Reduced property taxes
- Declining property values
- Renters fail to return for a second season
- Slowed business for marinas, etc.
- Declining attendance at lakefront beaches and parks

Source: A report from the Milfoil Study Committee on the Use of Aquatic Herbicides to Control Eurasian Watermilfoil in Vermont. VTDEC, March 1993

Invasive Aquatic Plants

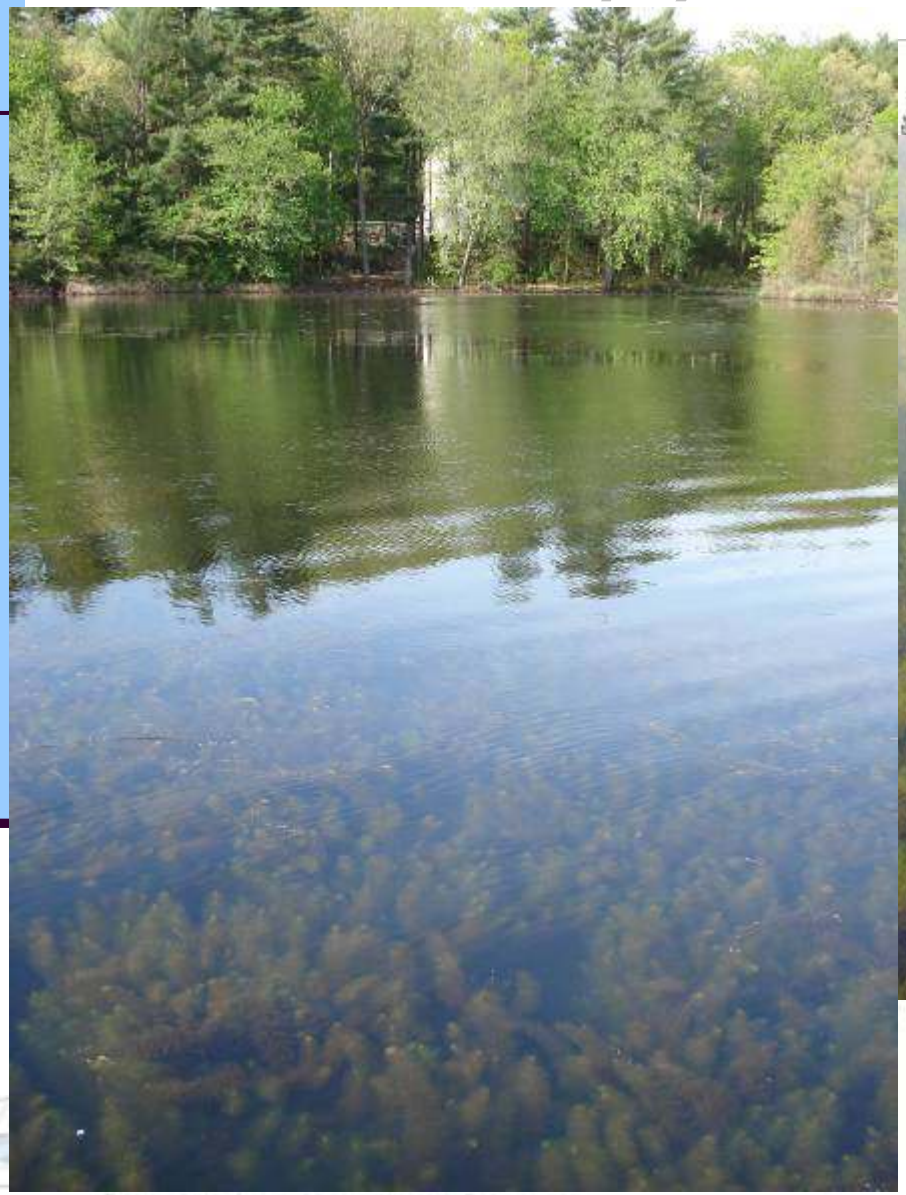
Invade or disrupt native plant communities

- rapid growth
- multiple reproductive methods
- wide dispersal and survival
- broad environmental tolerance
- resistance to management

No natural native control agents or competitors

Variable Watermilfoil

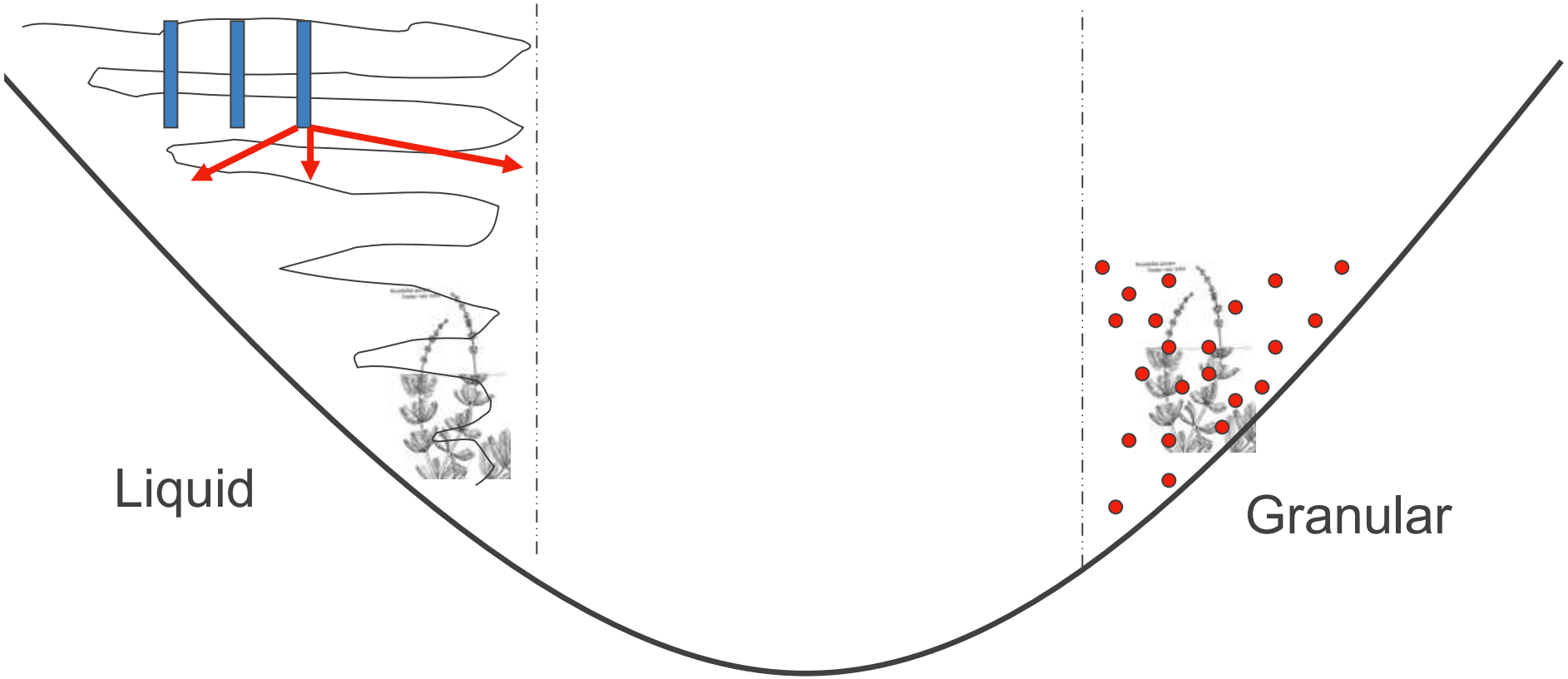
Myriophyllum heterophyllum



Factors for herbicide selection

- Target species
- Non-target species trying to protect
- Size and configuration of treatment area – potential for dilution
- Water flow
- Concentration Exposure Time (CET)
- Water uses

Different Formulations



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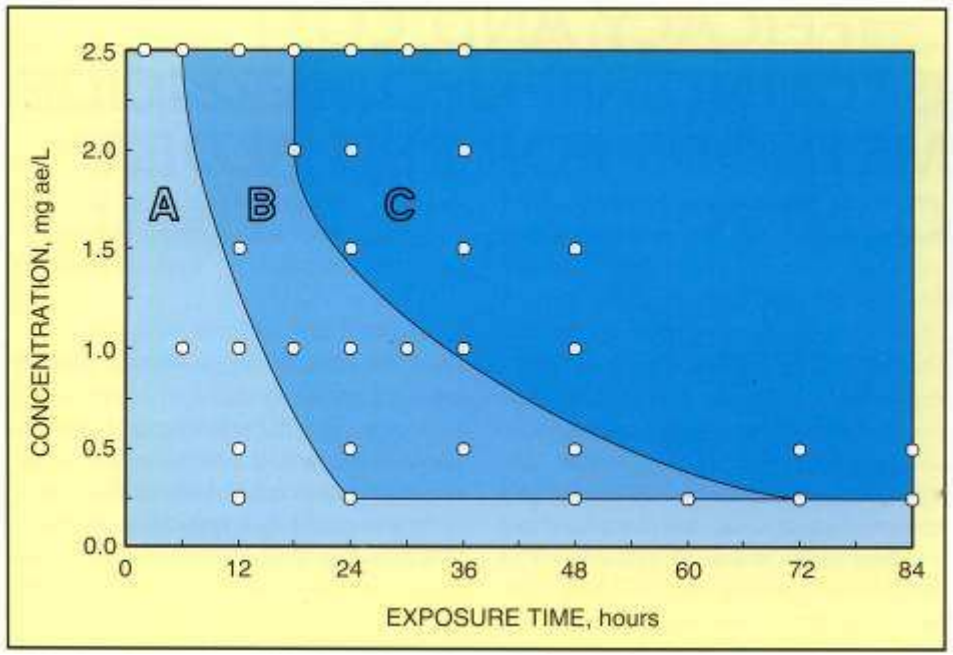
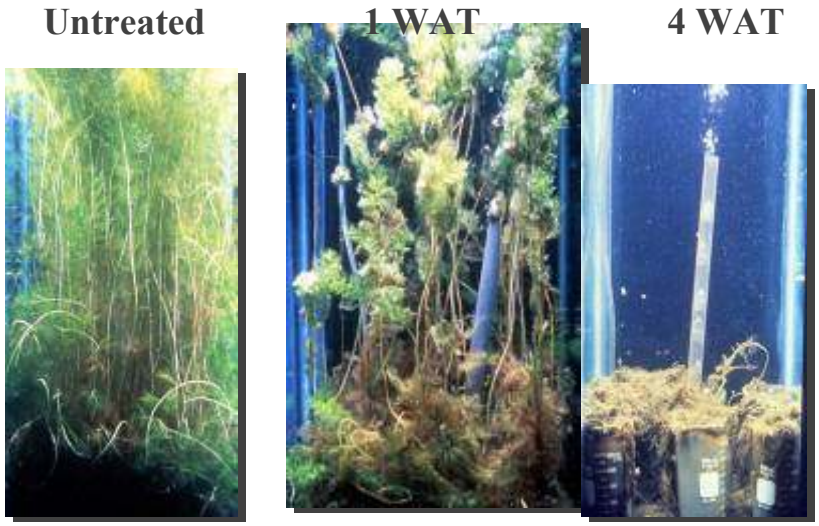
Concentration Exposure Time (CET)

Source: US Army Engineers – ERDC





Control Predictions

A: 0 - 70 % (regrowth likely)

B: 70 - 85 % (regrowth potential subject to site conditions)

C: >85 % (limited regrowth potential)

Navigate (2,4-D)

- Formulation: Granular (BEE)
- Mode of Action: Systemic – auxin mimic, inhibits cell division in new tissue and stimulates growth of existing tissue
- Environmental Fate: Hydrolosis, microbial degradation, photolysis
- Water Use Restrictions: Drinking < 70 ppb, Irrigation < 100 ppb
- Advantages: fairly selective for broad-leaf (dicot) species, multiple year control, effective for spot-treatments
- Limitations: prohibited in Zone II areas, negative public perception
- Plants Controlled: Milfoil, Water Chestnut, Waterlilies, Watershield

Reward (Diquat)

- Formulation: Liquid
- Mode of Action: Contact – interferes with photosynthesis
- Environmental Fate: Sediment absorption, photolysis
- Water Use Restrictions: Drinking 1-3 days, Irrigation 1-5 days, Watering Livestock 1 day
- Advantages: Rapid action effective for partial lake or shoreline treatments
- Limitations: Annual control does not kill roots
- Plants Controlled: Milfoil, Curlyleaf Pondweed, Elodea, Hydrilla, Coontail, Pondweeds, Naiad, Duckweed, Bladderwort, Algae

Sonar (Fluridone)

- Formulation: Liquid (AS) and Pellet (SRP, PR, Q, One)
- Mode of Action: Systemic – inhibits carotenoid synthesis
- Environmental Fate: phytolysis
- Water Use Restrictions: Irrigation 7-30 days or until <5-10 ppb
- Advantages: Systemic action kills entire plant including roots, provides multiple years of control, favorable toxicology profile, species selectivity at low doses
- Limitations: Highly soluble not effective for partial lake or shoreline treatments, requires long contact time
- Plants Controlled: Eurasian Watermilfoil, Fanwort, Curlyleaf Pondweed, Hydrilla, many others at higher doses

Renovate (Triclopyr)

- Formulation: Liquid and Flake/Pellet (OTF)
- Mode of Action: Systemic – auxin mimic interferes with plant growth processes
- Environmental Fate: Phytolysis
- Water Use Restrictions: Irrigation 120 days or until non-detect, Drinking set-back distances based on dose
- Advantages: Rapid action effective for partial lake or shoreline treatments, Systemic kills entire plant including roots, multiple years of control
- Limitations: Expensive, Demonstrated effectiveness on only a few aquatic species
- Plants Controlled: Milfoil, Purple Loosestrife

Registered Aquatic Herbicides

Compound	Year Registered	Mode of Action
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Source: USACE, ERDC

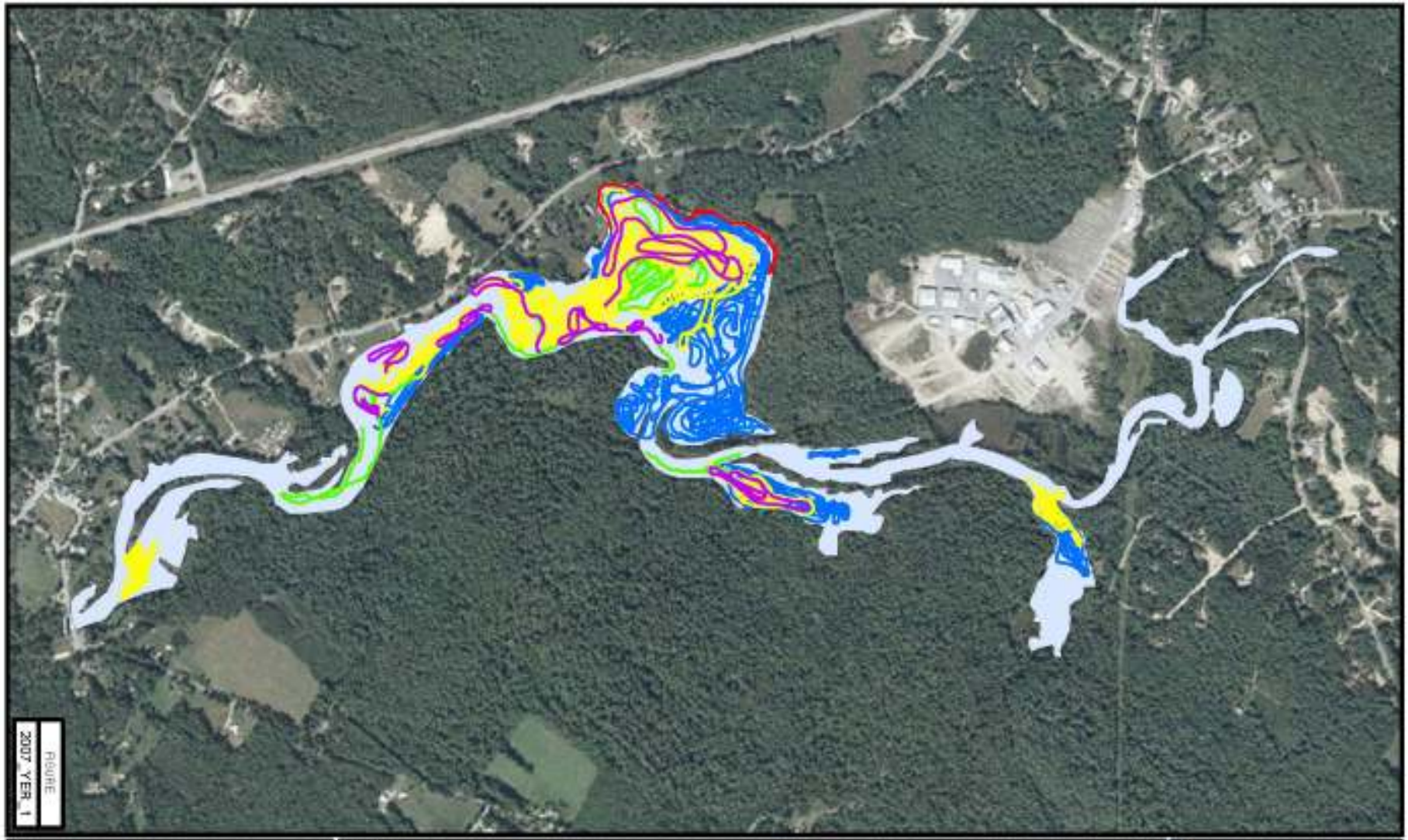
Methods of Application


Classic


malibu

Lower Suncook Lake – Barnstead, NH

- Variable watermilfoil infestation
- Reward (diquat) treatment in 2002 only provided seasonal control
- Association coordinated a grant funded research project and worked with legislators to get 2,4-D approved
- Treated 132 acres with 2,4-D in 2004, surveys and treatment guided by GPS



SUNCOOK RIVER

Barnstead, NH

2007 VARIABLE WATERMILFOIL HERBICIDE TREATMENT PROJECT DGPS TREATMENT TRACKS

FIGURE	SURVEY DATE	MAP DATE
2007_YER_1	09/24/07	10/11/07

Legend:

- 05/30/07 - 5.5 ac treated with Navigate
- 05/16/07 - 1.5 ac treated with DMA 4 IVM
- 05/16/07 - 23.0 ac treated with Navigate
- 05/09/07 - 32.0 ac treated with Navigate
- 05/02/07 - 2.0 ac treated with Navigate

2003naip01_40.sid
2003naip01_41.sid

N

0 200 400 800 1,200 1,600 2,000 Feet

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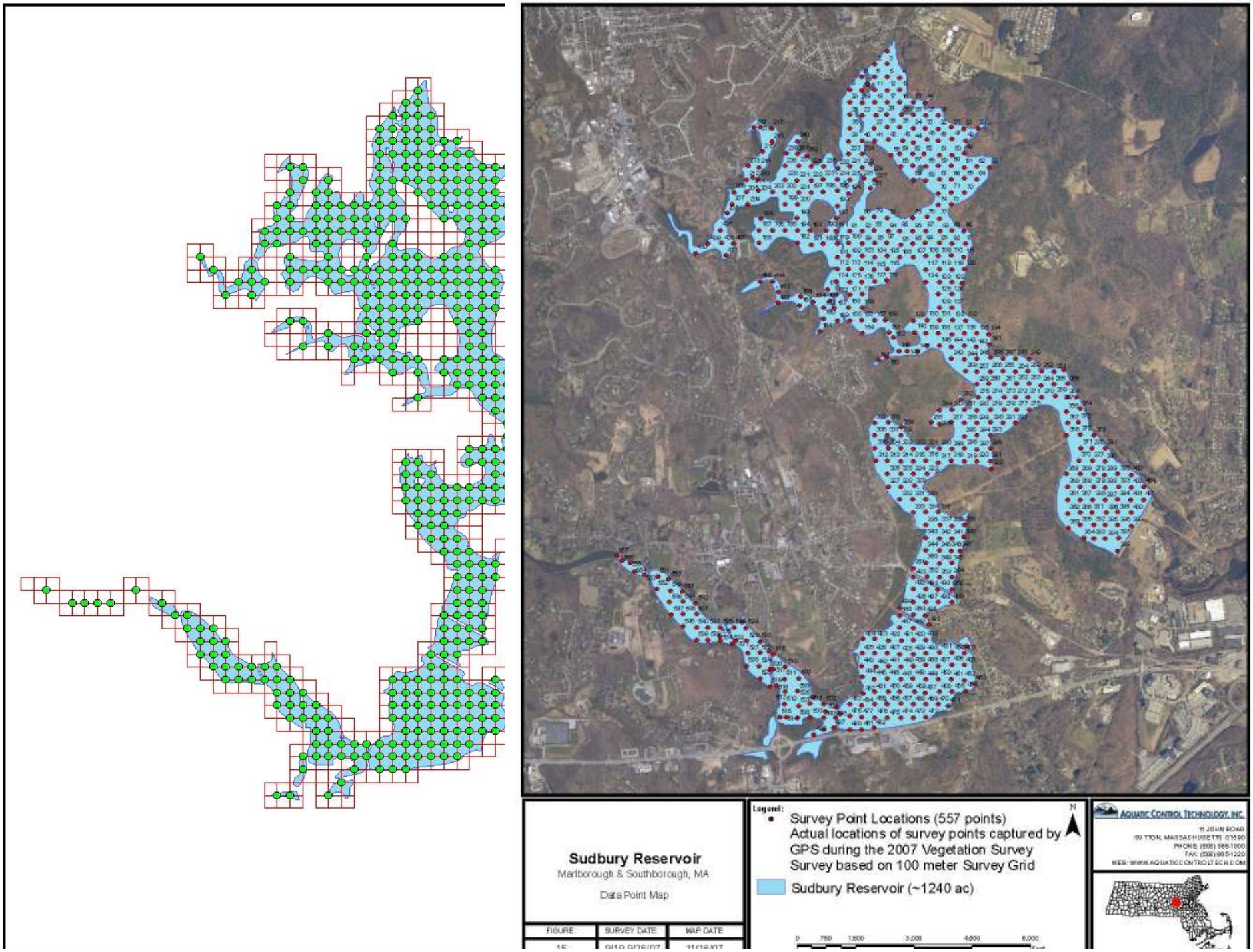
Sudbury Reservoir
Marlborough & Southborough, MA
Data Point Map
FIGURE
SURVEY DATE
MAP DATE
Legend:
Survey Point Locations (557 points)
Actual locations of survey points captured by GPS during the 2007 Vegetation Survey
Survey based on 100 meter Survey Grid
Sudbury Reservoir (~1240 ac)
N
0
750
1,500
3,000
4,500
6,000
Feet
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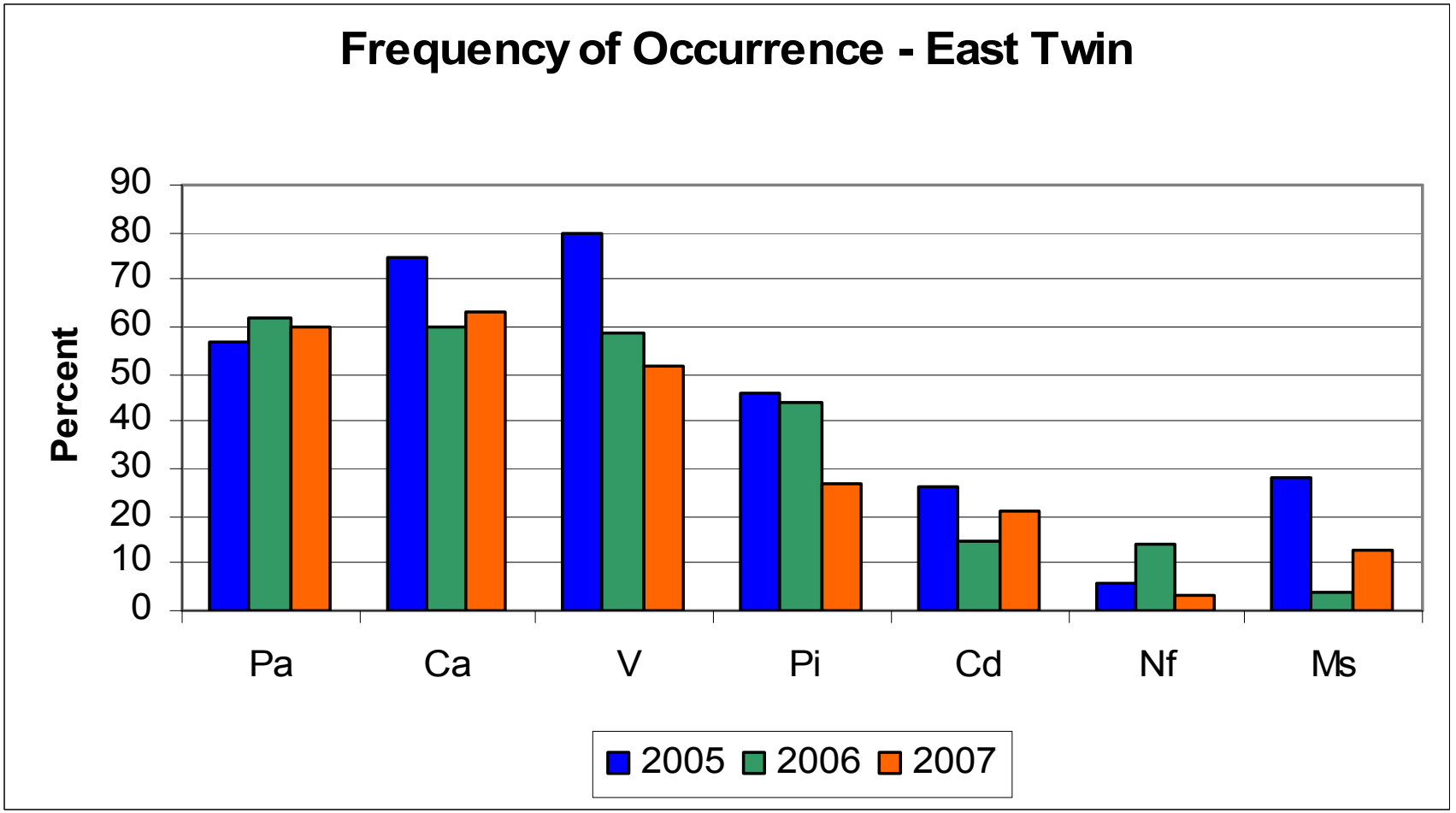
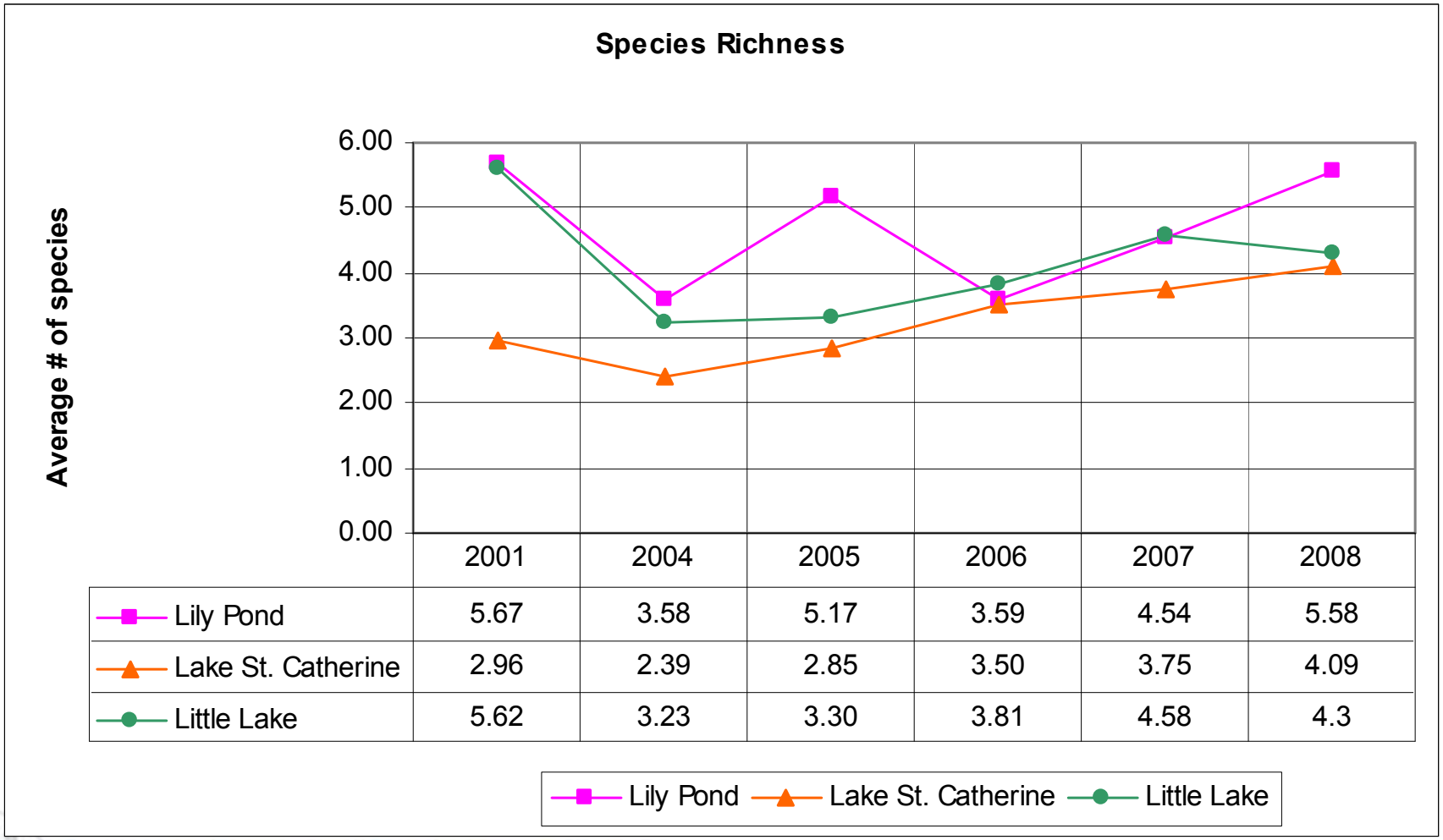
Pre and Post Vegetation Monitoring

Macrophyte Species	Common Name	2001 pre	2004 YOT	2005 YAT	2006 2YAT	2007 3YAT	2008 4YAT
Myriophyllum spicatum	Eurasian watermilfoil	94%	44%	17%	33%	74%	65%
Potamogeton robbinsii	Pondweed	52%	76%	88%	74%	77%	68%
Potamogeton amplifolius	Large-leaf	33%	38%	43%	49%	52%	53%
Elodea canadensis	Waterweed	32%	1%	1%	1%	5%	43%
Valisneria americana	Wild celery/Tapegrass	29%	13%	2%	4%	9%	8%
Potamogeton zosteriformis	Flat-stem pondweed	28%	3%	29%	29%	23%	19%
Potamogeton gramineus	Variable pondweed	23%	1%	6%	6%	2%	4%
Najas flexilis	Naiad	22%	0%	8%	39%	34%	22%
Ceratophyllum demersum	Coontail	20%	8%	11%	12%	21%	18%
Nitella / Chara	Stonewort	17%	6%	36%	40%	14%	14%
Nymphaea odorata	White waterlily	16%	5%	11%	10%	11%	11%
Utricularia vulgaris	Common bladderwort	8%	9%	2%	6%	7%	7%
Potamogeton illinoensis	Illinois pondweed	4%	1%	2%	9%	23%	39%
Zosterella dubia	Water stargrass	1%	1%	9%	8%	23%	17%

Pre and Post Vegetation Monitoring

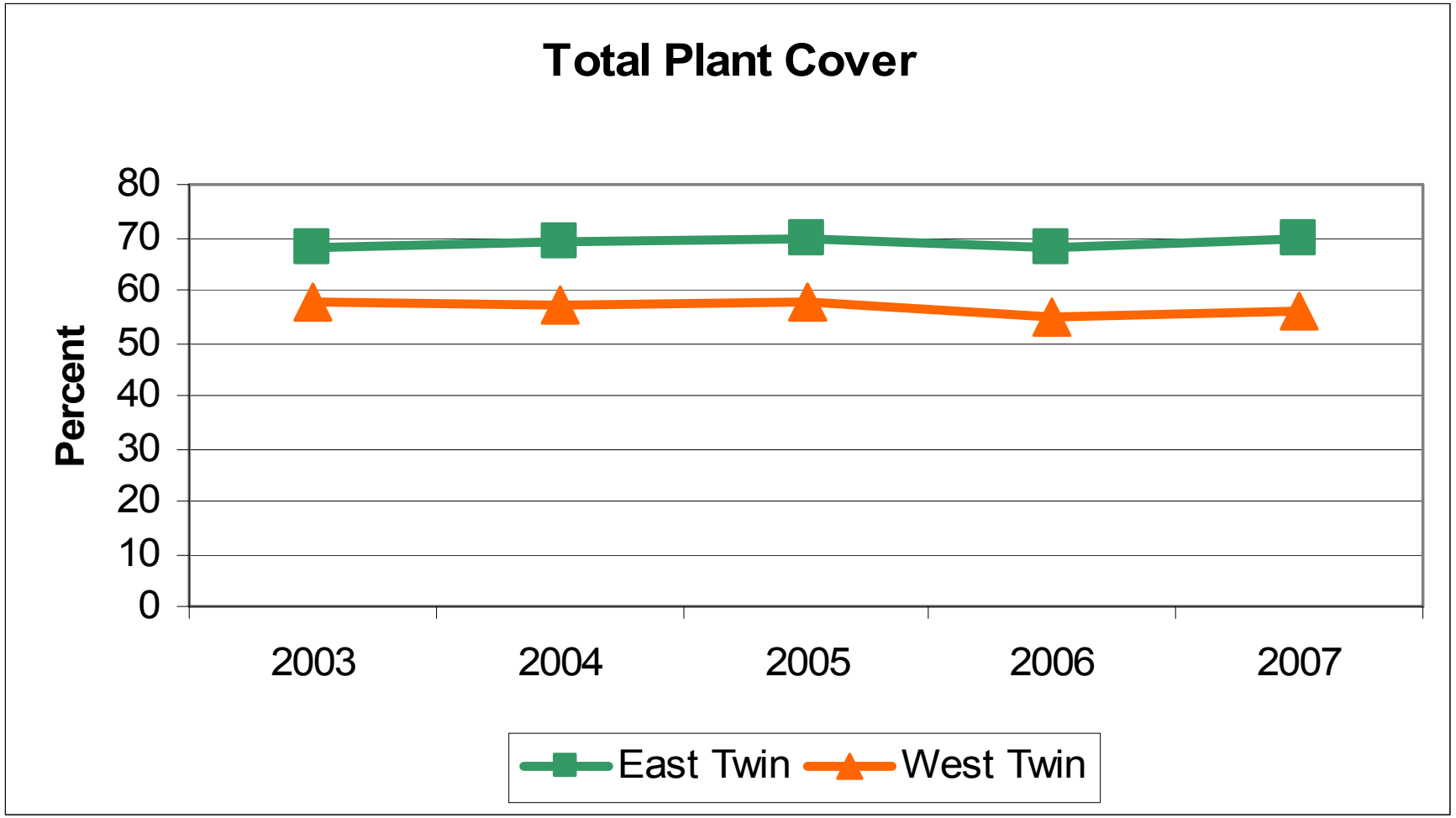


Pre and Post Vegetation Monitoring

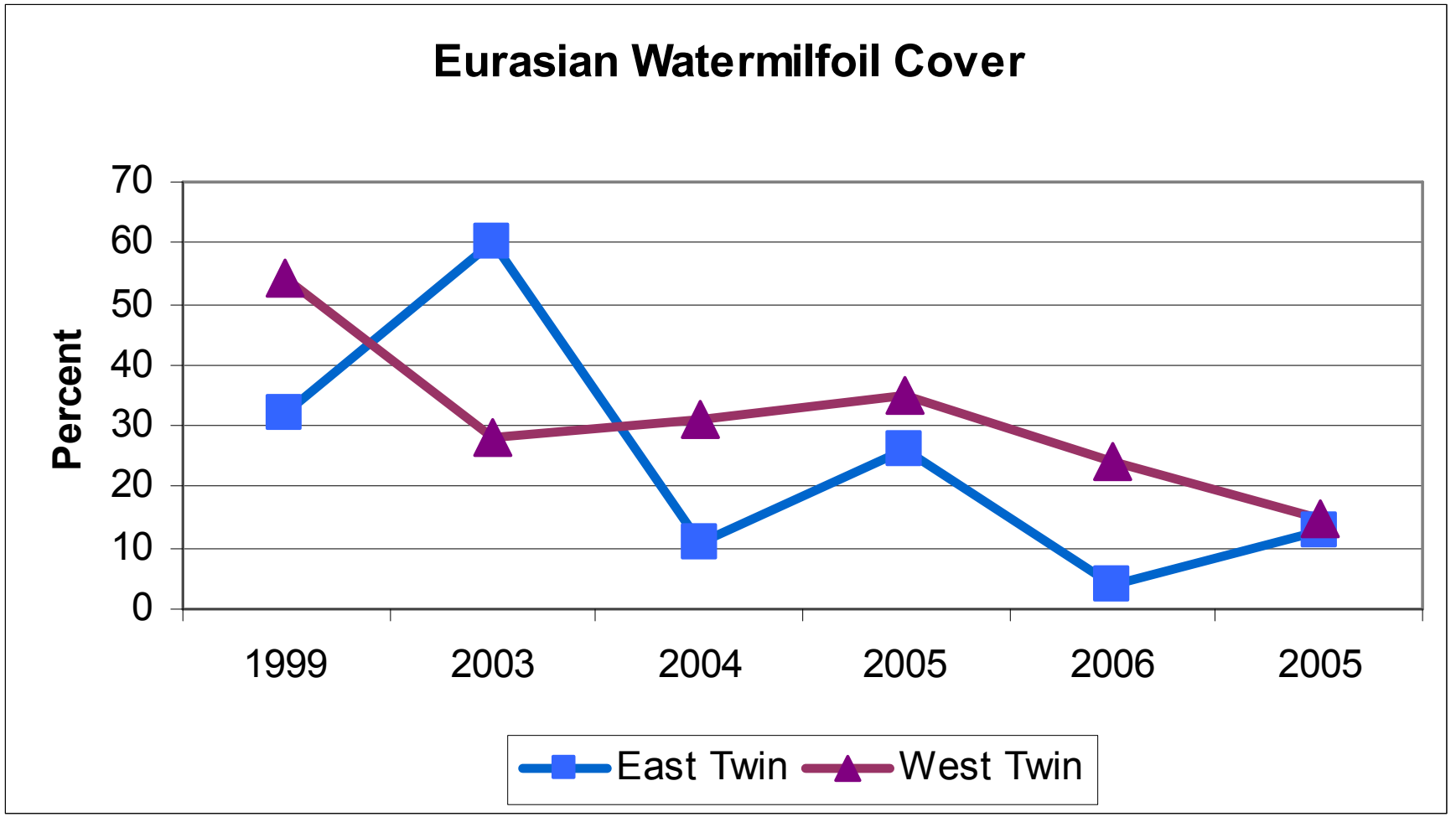


	2001	2004	2005	2006	2007	2008
Lily Pond	5.67	3.58	5.17	3.59	4.54	5.58
Lake St. Catherine	2.96	2.39	2.85	3.50	3.75	4.09
Little Lake	5.62	3.23	3.30	3.81	4.58	4.3

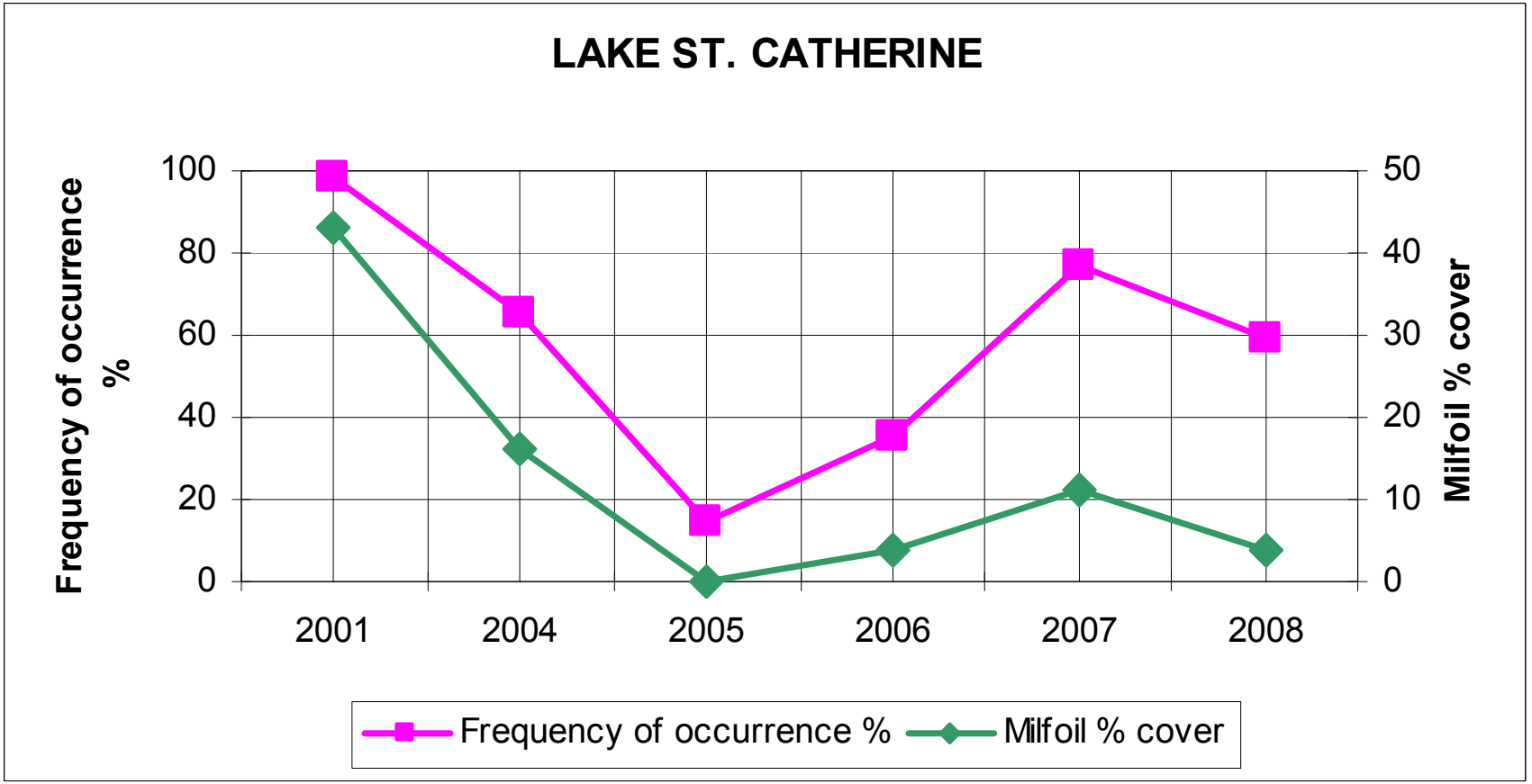
Pre and Post Vegetation Monitoring



Pre and Post Vegetation Monitoring



Pre and Post Vegetation Monitoring



Summary…

- Aquatic Herbicides (2,4-D, Diquat, Fluridone and Triclopyr) herbicides can be used to achieve control of variable watermilfoil
- Very good non-target species selectivity can be achieved, particularly with 2,4-D
- Ongoing monitoring is needed to evaluate treatment efficacy, guide future management efforts, and document impacts to non-target species

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