Indian Lake: A case study of how a reservoir stable state change resulted in an extreme invasion of Eurasian watermilfoil (*Myriophyllum spicatum*) and the need for intensive management

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CLM #21-02M

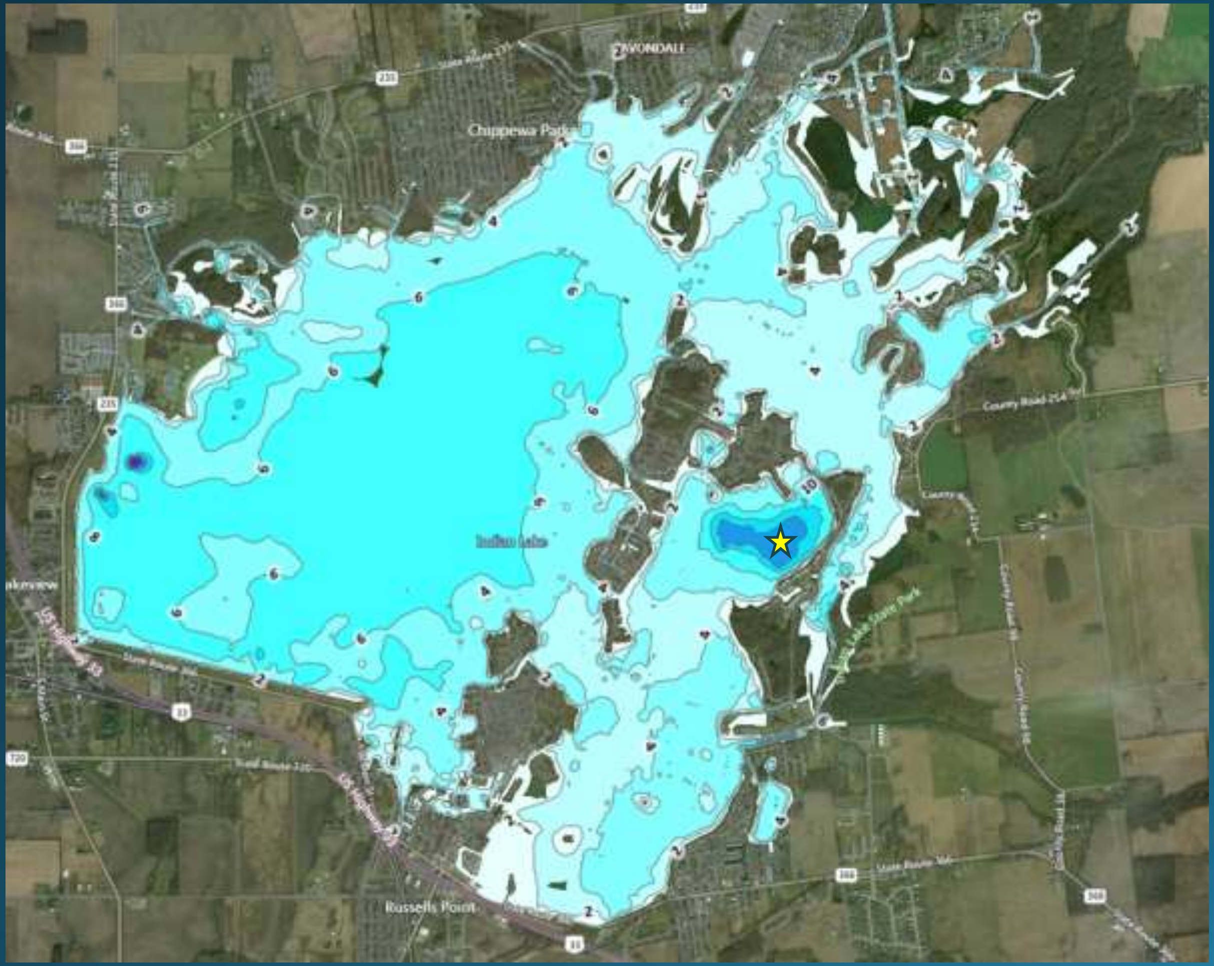
AQUA DOC®
LAKE & POND MANAGEMENT

Overview:

- A look at Indian Lake and its stable state change.
- Results of 2022 point intercept rake toss relative abundance method (PIRTRAM) survey
- 2022 management direction and techniques
- 2023 management direction and techniques

Introduction: Indian Lake Characteristics

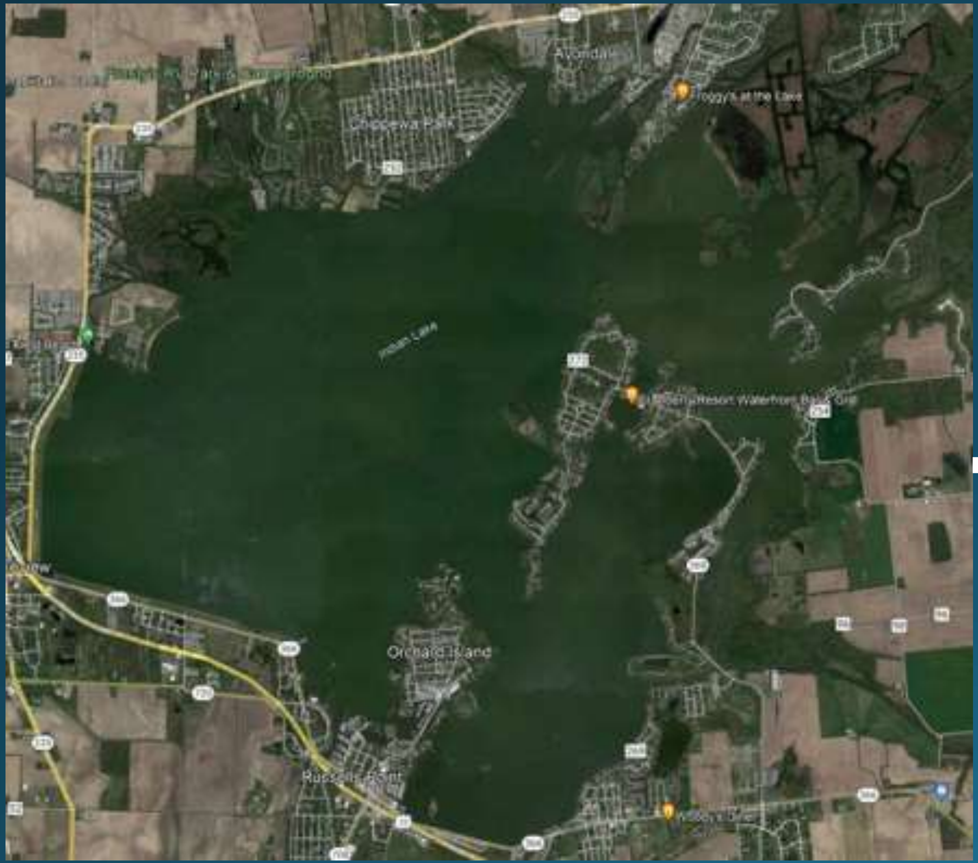
- Represents one of two notably sized reservoirs in Western Ohio.
- Economic pinnacle of the local area (11 different townships relying on tourism).
- Managed by the Ohio Department of Natural Resources (ODNR).



Parameter	Value
Waterbody acreage	5,162.89 acres
Estimated volume	23,745 ac. ft. 7.78 x 10^9 gallons
Max depth (z_{max})	15.3 ft.
Average depth	5.0 ft.
Watershed area	97.2 sq. miles

Introduction: Stable State Change

- The reservoir experienced an incredible stable state change defined by the 2022 lake-use season.
- Normally known for its light-limiting turbidity, Indian Lake rapidly became dominated by submersed vegetation.
- 2022 PIRTRAM survey (next section) found 75.4% of the area of Indian Lake was covered in macrophyte growth encompassing 45.8% of the reservoir's total water column.



July - 2018

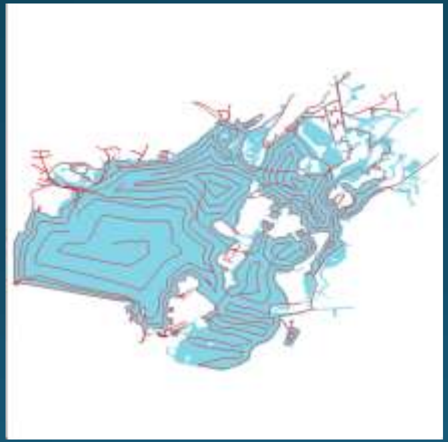
July - 2022

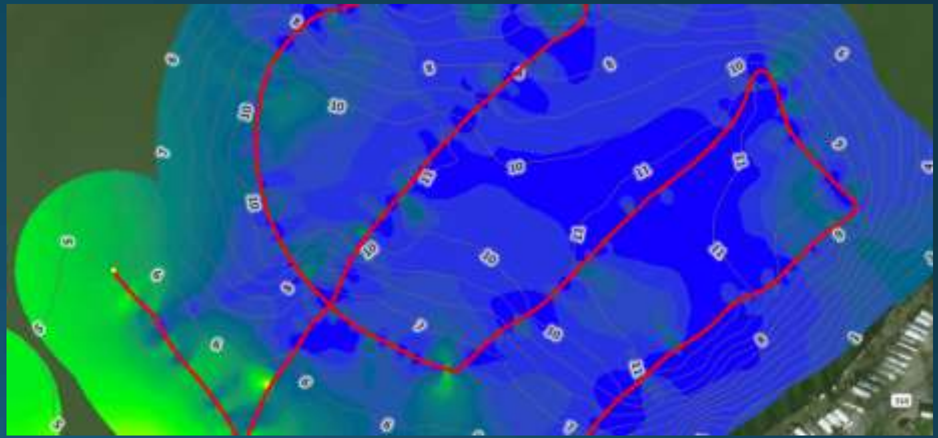
July 2022

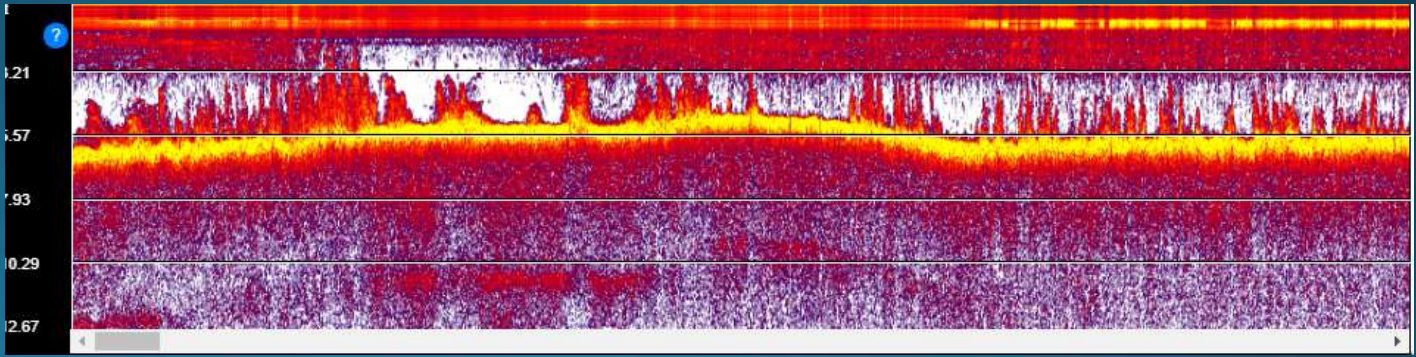
2022 PIRTRAM: Methodology

- Modified PIRTRAM methodology with Biobase® sonar density mapping allowed for estimation of macrophyte species richness, biomass/density, and spread.
- 585 distinctive locations gridded for rake sampling occurring from July 5 – 15, 2022.

Sonar Mapping







2022 PIRTRAM: Species Richness

- 10 individual species of submersed aquatic vegetation identified (Table 1)
  - 3 invasive in Ohio: Eurasian watermilfoil (EWM), curly-leaf pondweed (CLP), and brittle naiad.
  - 5 individual species of floating-leaf plant also observed (Table 2).

Table 1: List of submersed aquatic vegetations identified during study.

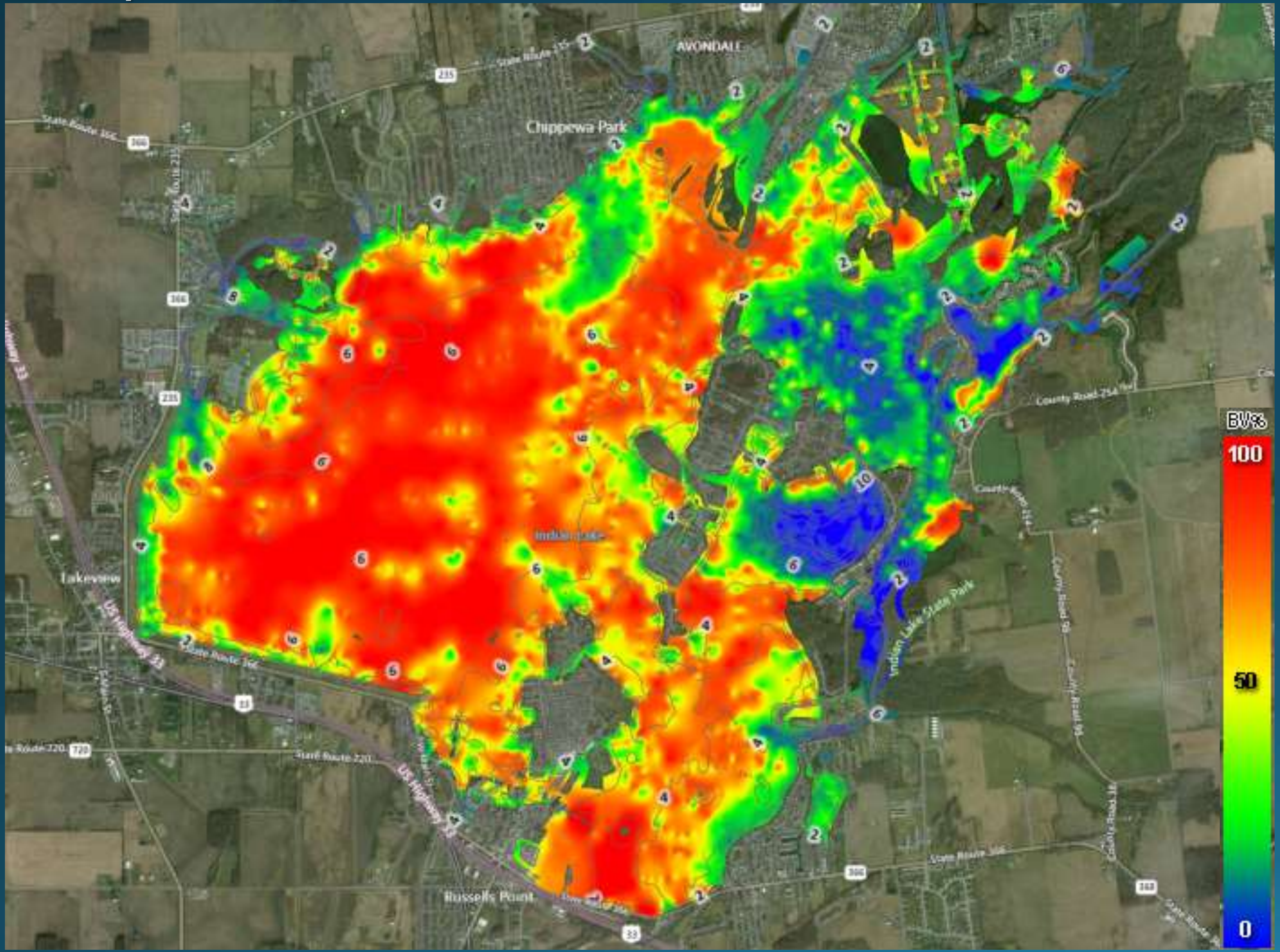
Common Name	Species Name
Eurasian watermilfoil	*Myriophyllum spicatum*
Coontail	*Ceratophyllum dermersum*
Common waterweed	*Elodea canadensis*
Curly-leaf pondweed	*Potamogeton crispus*
Sago pondweed	*Stuckenia pectinata*
Brittle naiad	*Najas minor*
Water stargrass	*Heteranthera dubia*
Narrow-leaf pondweed	*Potamogeton pusillus*
Bladderwort	*Utricularia spp.*
American pondweed	*Potamogeton nodosus*

Table 2: List of floating leaf plants identified during study.

Common Name	Species Name
Spatterdock	*Nuphar spp.*
White water lily	*Nymphea spp.*
Water lotus	*Nelumbo lutea*
Duckweed	*Lemna spp.*
Watermeal	*Wolffia spp.*

2022 PIRTRAM: Overall Macrophyte Abundance

- **Biobase® generated heat map from sonar usage suggested 75.4% of the lake area had macrophyte growth and encompassed 45.8% of the volume of water in Indian Lake.**



July 6 - 11, 2022

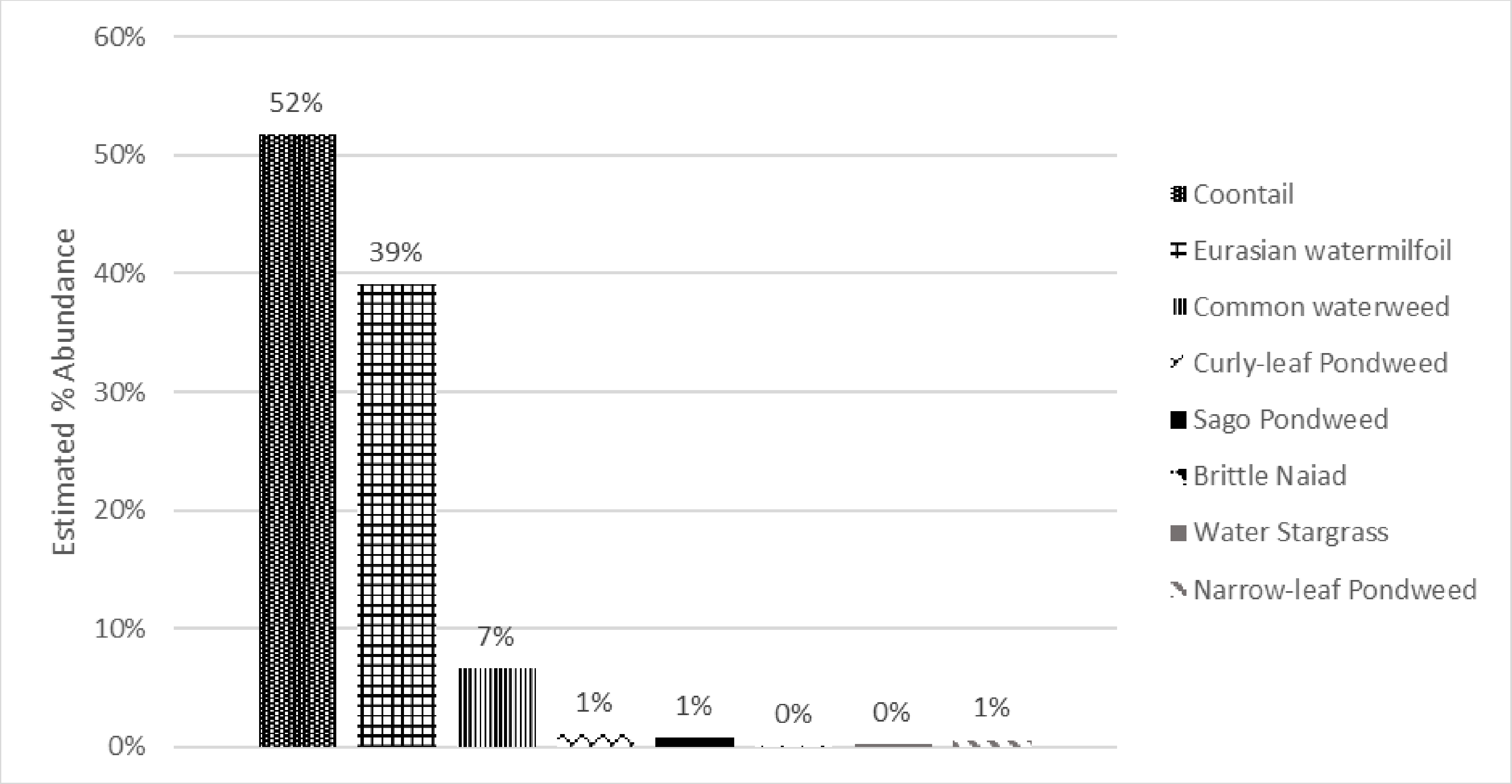
Metric	Value
Area covered as a percent	75.4%
Average biovolume*	45.8%

Depth Range	Area Covered	Average biovolume*
0 - 1 m	95.6%	88.3%
1 - 2 m	76.1%	33.9%
2 - 3 m	50.2%	49.6%
3 - 4 m	14.2%	9.6%

Note: 1 m = 3.3 ft.
*Refers to the average water column percent taken up by aquatic vegetation growth.

2022 PIRTRAM: Overall Macrophyte Abundance

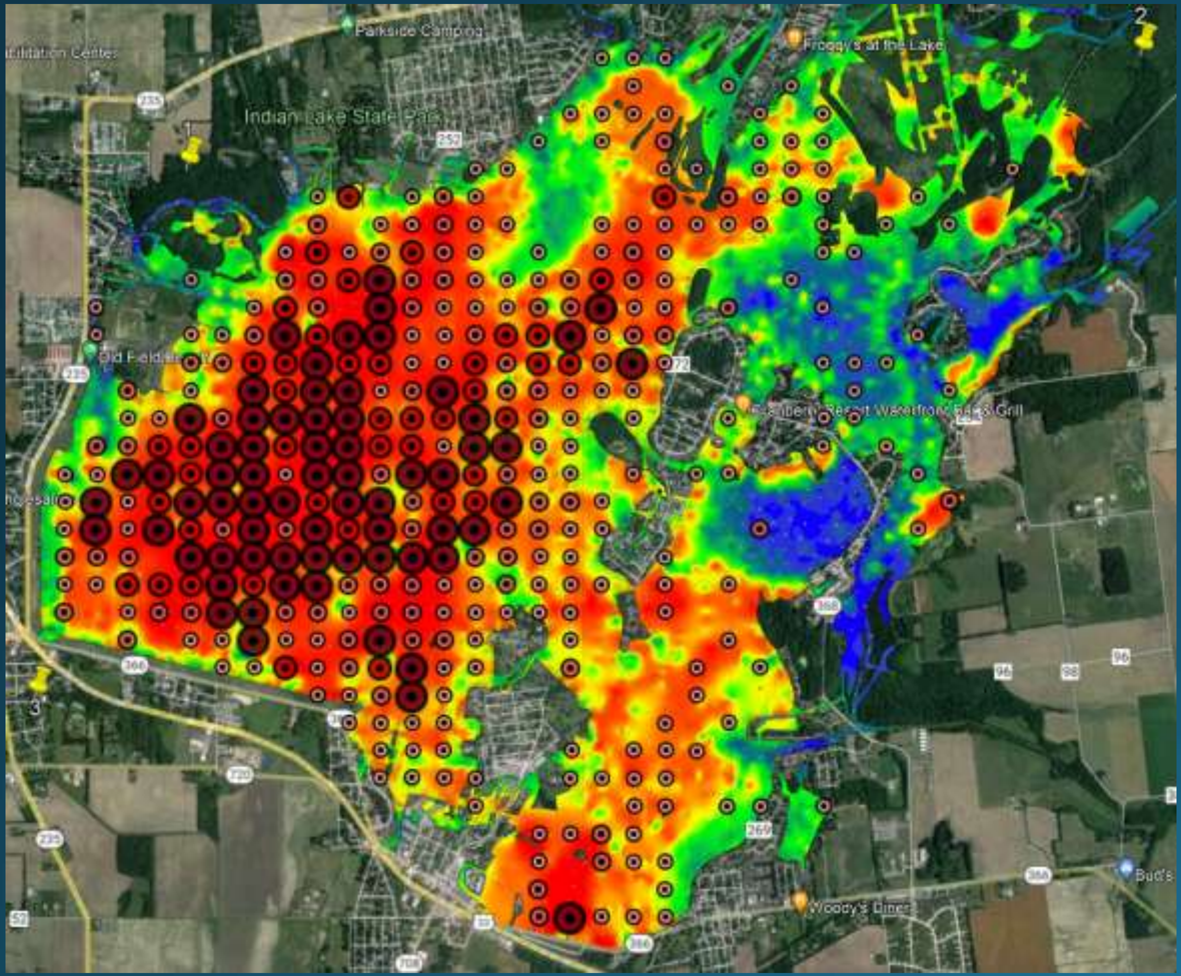
- Individual species density estimates from PIRTRAM/sonar
  - Coontail was estimated as the most dense in the reservoir representing 52% of the sampled biomass.
  - EWM was the second most abundant at 39% of the sampled biomass.
  - All other species accounted for the remaining 9%.



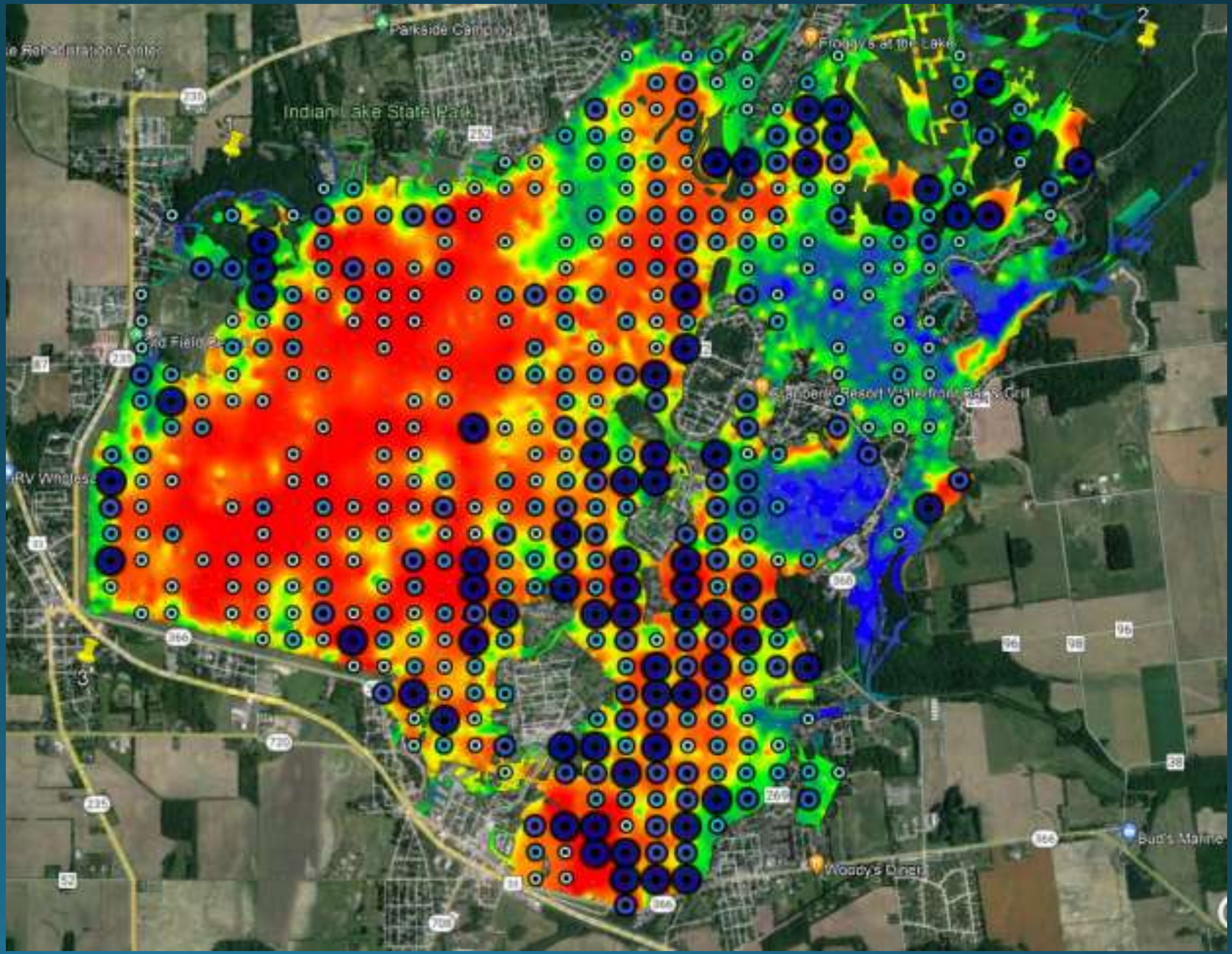
Aquatic vegetation	Estimated density (g/m²) (Valley 2015)
Coontail	**48,729.92**
Eurasian watermilfoil	**40,966.06**
Common waterweed	7,084.03
Curly-leaf pondweed	1,054.46
Brittle naiad	51.47
All others	1,292.55

2022 PIRTRAM: Coontail and EWM Density and Spread

- **Combining PIRTRAM data with sonar mapping allows for the creation of distribution maps that can showcase individual species spread and density.**



Density map of Eurasian watermilfoil

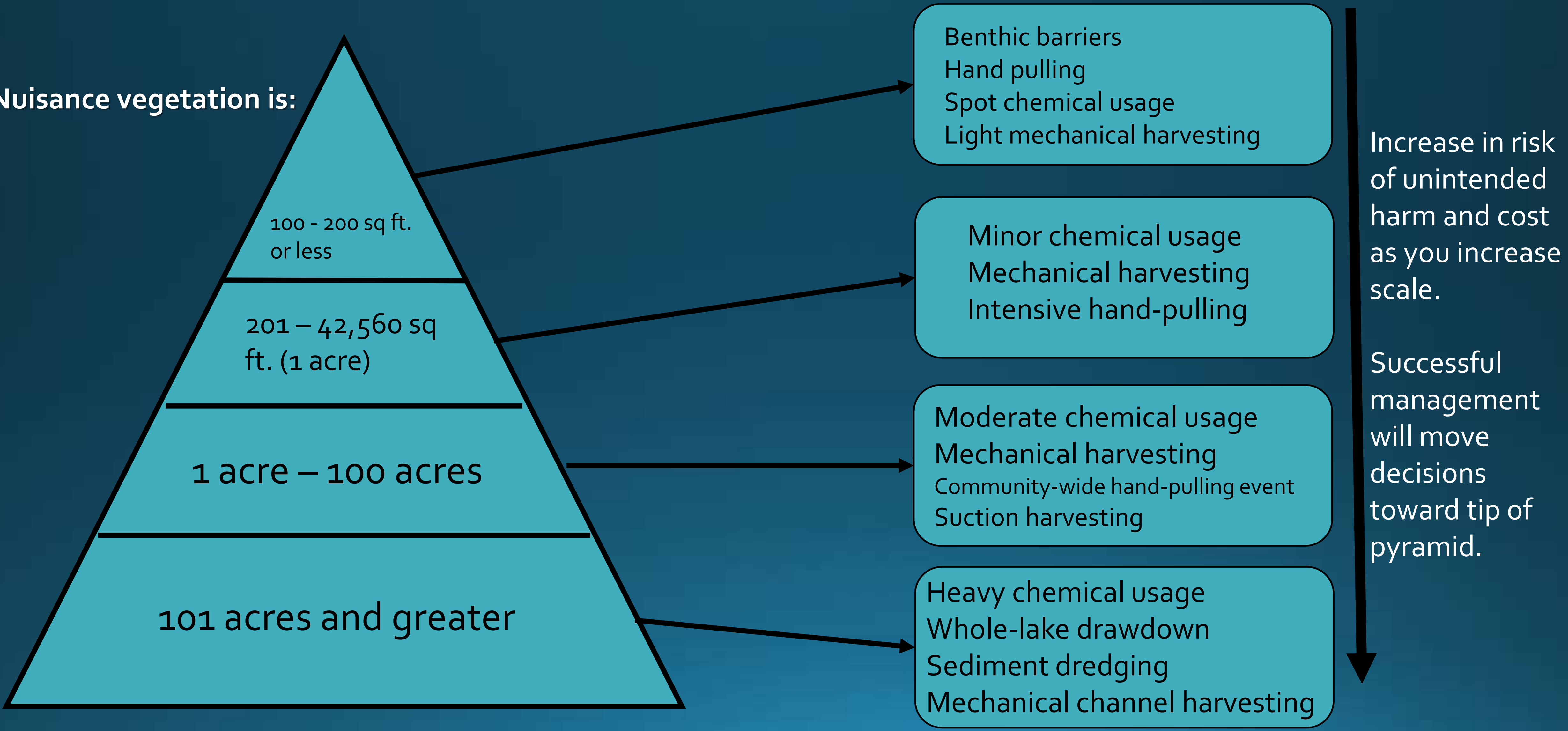


Density map of coontail

2022 Management Direction: Maintaining navigation and test zones

- **Due to sheer scale, selection of acceptable management techniques was limited to restore Indian Lake**

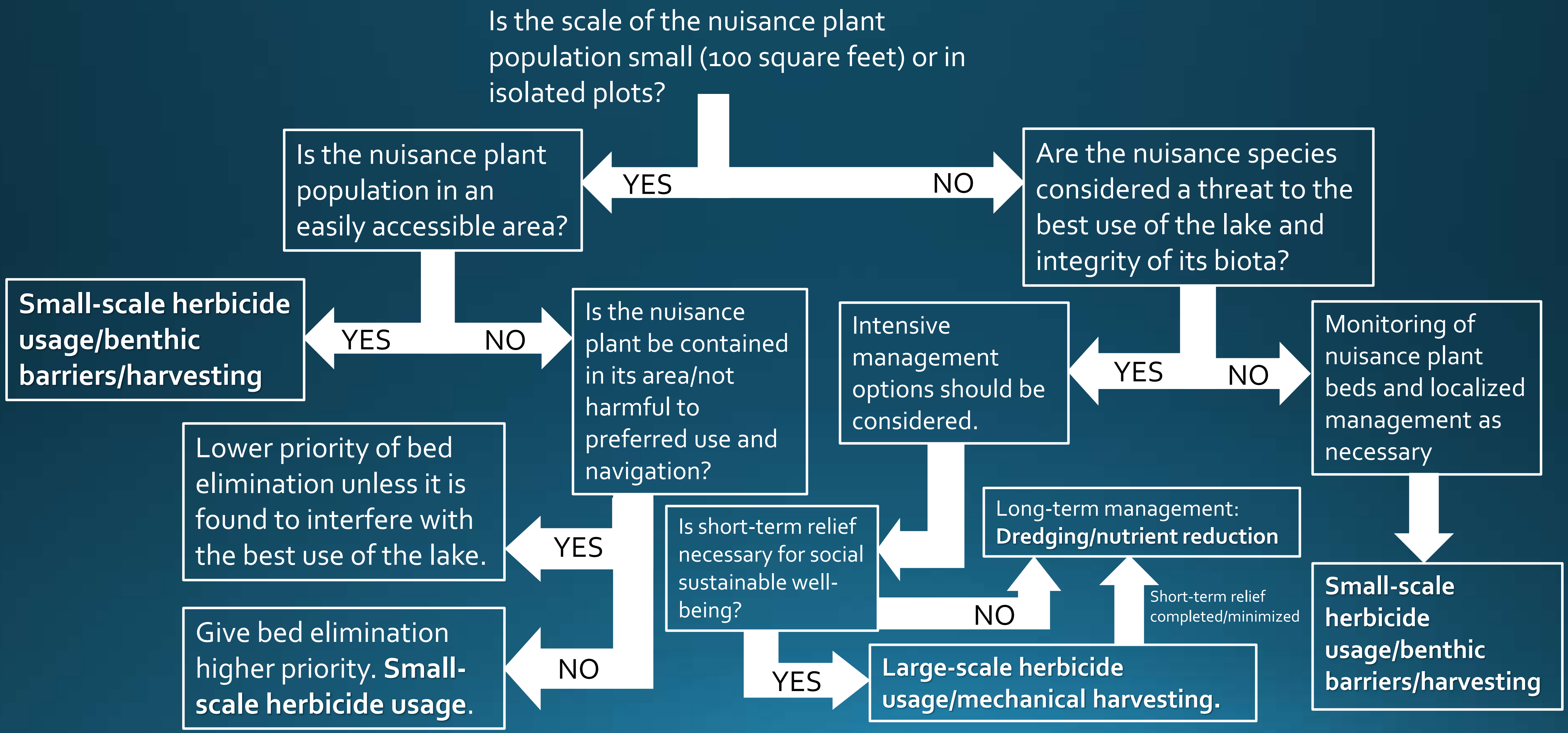
Nuisance vegetation is:



- **Techniques likely inefficient on Indian Lake.**

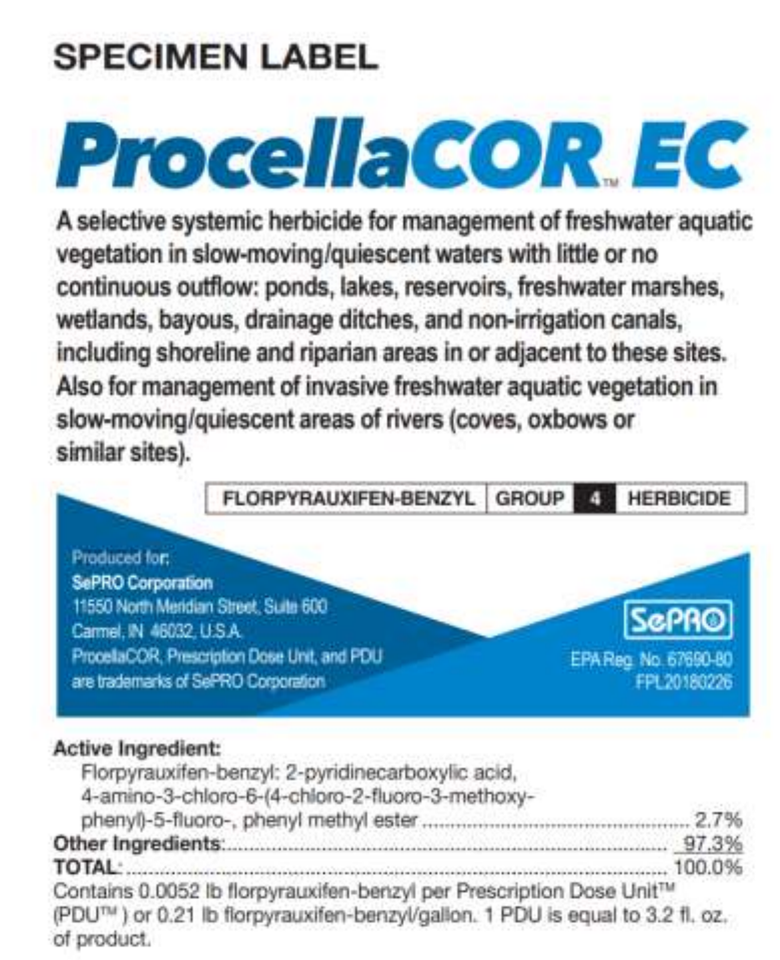
Technique	Reason
Whole-lake drawdown	Lake bathymetry suggests that zones necessary for management may not be drained completely. This may make the technique ineffective. Reliance on Spring refill uncertain if dry weather is persistent.
Sun-shading dye (e.g. aquashade)	Lake water residence time unknown. Dye could flush out rapidly during flow events. Issues could arise downstream since dye doesn't rapidly degrade.
Aeration (large scale)	The shallow nature of the lake makes aeration design impractical. Unlikely to impact current aquatic vegetation biomass.
In-lake alum/nutrient precipitants	Reservoir behavior suggests large watershed inputs may reduce the effectiveness of nutrient precipitants (James et al. 1991; Welch and Cooke 1999) . May also maintain clear water which would result in continued persistent aquatic vegetation growth.
Bacterial additives (e.g. muck digesting products)	Primary literature showcases no consistent results with limited information (Kindervater et al. 2022). Dredging is more consistent and would likely keep up with inlet sedimentation better.
Biocontrol methods (e.g. grass carp, milfoil weevil)	Triploid grass carp should not be added to the lake due to lack of containment ability. Milfoil weevil likely preyed upon by centrarchid fish species and may not reduce milfoil to an acceptable level under unfavorable conditions (Parsons et al. 2011; Sutter and Newman 1997; Havel et al. 2017).

2022 Management Direction: Maintaining navigation and test zones



2022 Management Direction: Maintaining navigation and test zones

- Mechanical harvesting was utilized to maintain navigation pathways through the reservoir.
  - Approximately 1,323,000 cubic feet of material estimated to have been removed in 2022.
- Testing of ProcellaCOR® in two – 200 acre test zones in July and August ("A" and "B" in photo).


SPECIMEN LABEL

ProcellaCOR™ EC

A selective systemic herbicide for management of freshwater aquatic vegetation in slow-moving/quiescent waters with little or no continuous outflow: ponds, lakes, reservoirs, freshwater marshes, wetlands, bayous, drainage ditches, and non-irrigation canals, including shoreline and riparian areas in or adjacent to these sites. Also for management of invasive freshwater aquatic vegetation in slow-moving/quiescent areas of rivers (coves, oxbows or similar sites).

FLORPYRAUXIFEN-BENZYL | GROUP 4 | HERBICIDE

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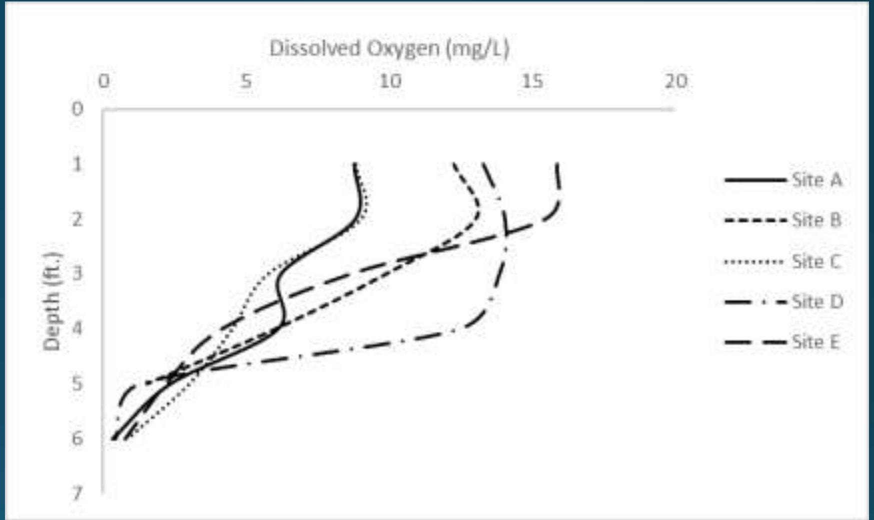
Active Ingredient:
Florpyrauxifen-benzyl: 2-pyridinecarboxylic acid, 4-amino-3-chloro-6-(4-chloro-2-fluoro-3-methoxy-phenyl)-5-fluoro-, phenyl methyl ester 2.7%
Other Ingredients: 97.3%
TOTAL: 100.0%
Contains 0.0052 lb florpyrauxifen-benzyl per Prescription Dose Unit™ (PDU™) or 0.21 lb florpyrauxifen-benzyl/gallon. 1 PDU is equal to 3.2 fl. oz. of product.

Channels through the vegetation visible in satellite imagery.

2022 Management Direction: Maintaining navigation and test zones

- **Harvesting and chemical usage challenges and concerns:**
  - **Harvesting creates prop-chop which floats around the lake and impedes navigation in areas.**
  - **EWM and coontail are both fragmentable species of macrophyte.**
- **Large-scale herbicide usage could come with elevated risk to Indian Lake.**



Pre-Treatment Information Collected Data:
Dissolved Oxygen Levels (DO), Nutrient Data
- DO showcased supersaturation near the surface with decreasing levels as you approach bottom.
- Nutrient levels included total phosphorus and total K nitrogen. Levels were variable but TP was notably high.

	Site A	Site B	Site C	Site D	Site E
TP (a, ppb)	55.9	243.6	174.7	55.1	140.9
TP (b, ppb)	57.1	98.3	125.5	74.2	422.7
TKN (a, mg/L)	1.0	1.7	2.1	1.1	1.3
TKN (b, mg/L)	1.0	0.3	1.7	1.1	2.8

2022 Management Direction: Maintaining navigation and test zones

- ProcellaCOR® Test Zone A information (Zone B similar):

Application Information:

Dates: July 12 – 13, 2022

Product Used: ProcellaCOR EC®

Target Rate: 2.2 – 2.5 PDU/ac ft

Amount of Product: 2,400 PDU

Application Technique: High pressure hose injection off stern of 18' application boat.

Treatment zone denoted by bright buoys for visualization.

Application transects moving in North-South direction utilizing harvested lanes for clearing vegetation off motor.

2022 Management Direction: Maintaining navigation and test zones

- **ProcellaCOR EC® Test Zone A Results:**

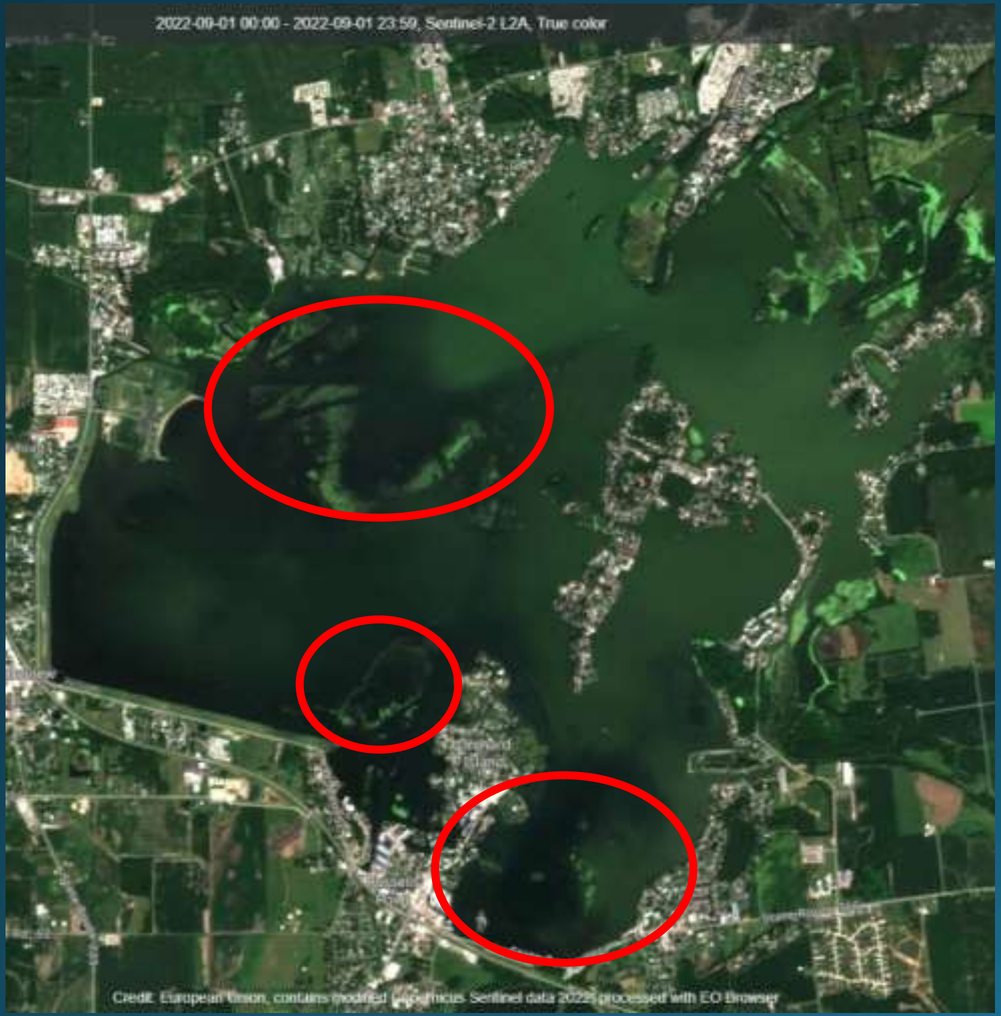
Treatment zone was 200 acres.

Likely impact was greater with estimates between 300 – 350 acres.

No observed negative change to dissolved oxygen levels, TP became less variable once vegetation regressed.

2022 Management Direction: Maintaining navigation and test zones

- Lake outlook at end of 2022 season:



Sept 1, 2022

Target Priorities:

1) Eurasian watermilfoil
2) Nuisance coontail
3) Curly-leaf pondweed

Location Priorities:

1) Unmanaged areas of open zone
2) Spillway
3) Isolated locations

Assess 2022 treatment zones and areas of interest for potential Milfoil regrowth if any.

More than 70% (95% OPEN ZONE) of the main basin of the lake should be navigable by July 4.

Assessment of aquatic vegetation population in lake to gauge success.

2023

April May June July August September October

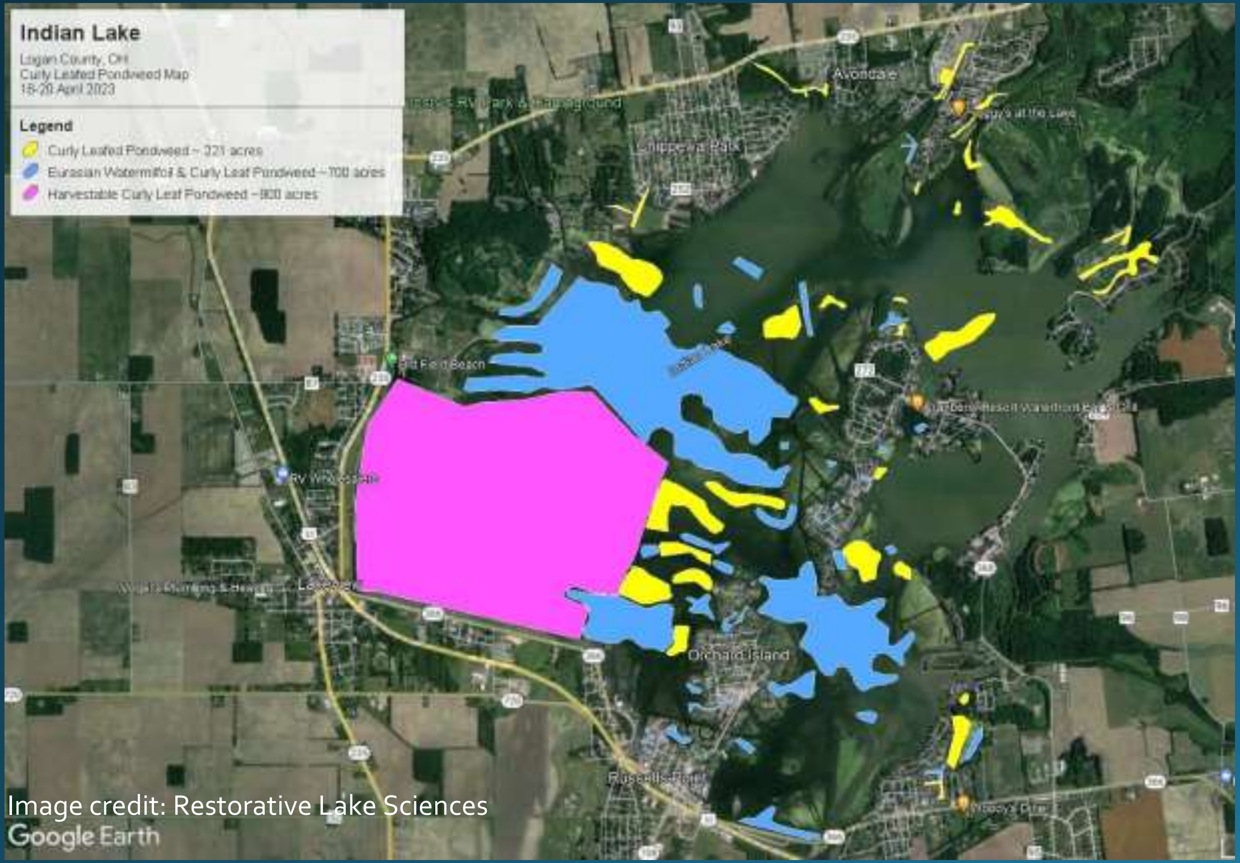
Large scale chemical applications should be conducted early on to reduce oxygen demand and target growth prior to peak use season.

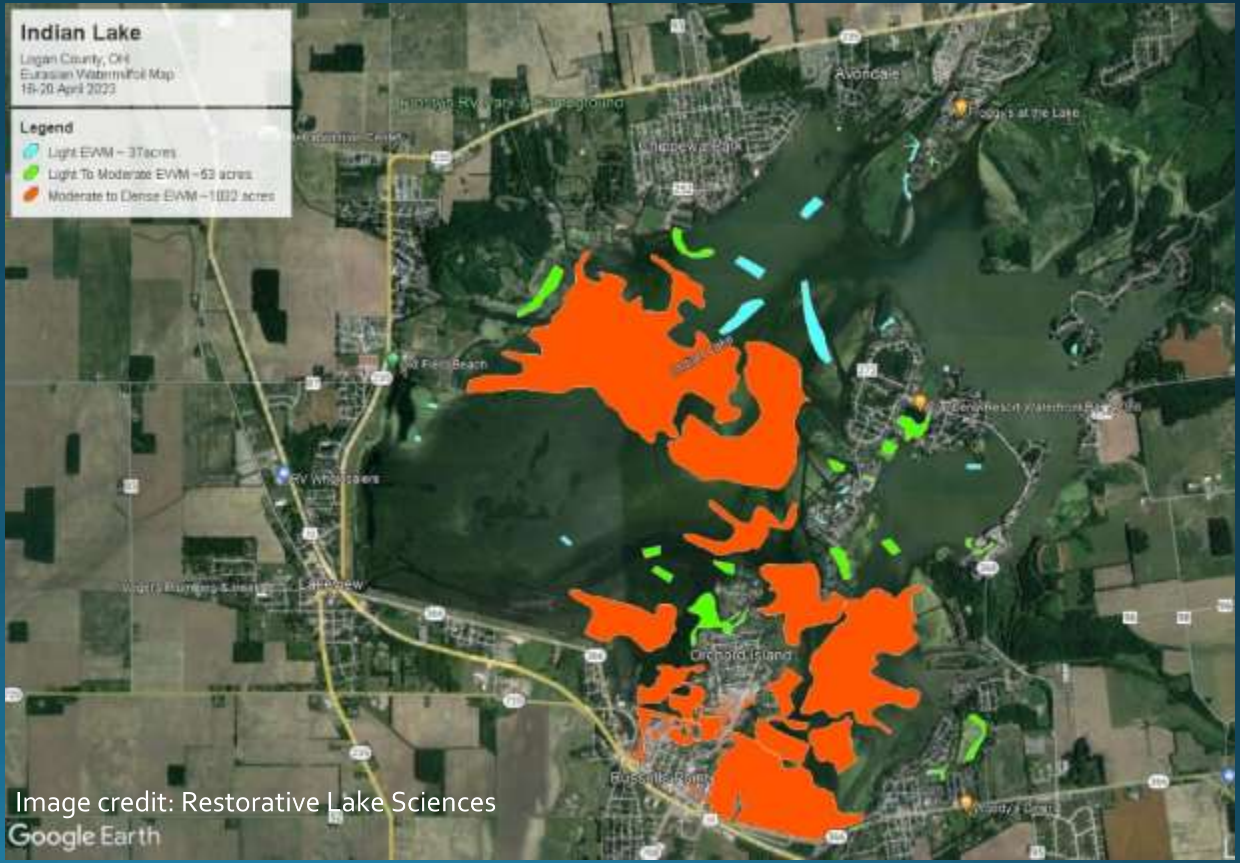
Once large scale control measures have been completed, maintenance procedures can target smaller areas.

Harvesting should continue as necessary where navigation channels are necessary and chemical usage hasn't been utilized.

2023 Lake Conditions:

- April 16 – 20 2023 vegetation survey denoted approximately 1,122 acres of EWM remaining in Indian Lake.
- Curly-leaf pondweed was estimated at 1,821 acres.





2023 Management Direction: Restoring Best Categorical Use of Resource

- 6 total zones (image below) were generated for suggested ProcellaCOR EC® applications following success of 2022.

Zone ID	Size (Acres)	Average Depth (ft.)	Acre Feet	Rate (PDU/ac ft)	Total PDUs Needed
A	500	6	3000	2.2	6600
B	70	6	420	2.2	924
C	66	5.5	363	2.2	798.6
D	160	4	640	2.2	1408
E	235	3.5	822.5	2.2	1809.5
F	35	4.5	157.5	2.2	346.5
Total:	1066			Total:	11886.6

Image credit: Restorative Lake Sciences modified by AQUA DOC

2023 Management Direction: Restoring Best Categorical Use of Resource

- Applications started on May 10, 2023 and ended June 2, 2023.
- Harvesting operation continued through 2023 season and was scaled based on need and focused on coontail growth.

2023 Management Direction: Restoring Best Categorical Use of Resource

- Condition of lake by end of July: 20.7 total acres of EWM noted.

Image credit: Restorative Lake Sciences

Conclusions:

- Lake stable state changes can have a dramatic influence on the impacted system.
- Comprehensive lake management plans are suggested to provide a wholistic perspective to managing individual systems.
- A multi-faceted management approach can be utilized to improve management efficiency.
- ProcellaCOR EC® was an effective tool for the selective control of EWM.

- **Best management practices (BMPs)**
  - **Changes that can reduce nutrients loading over time and support "lake-minded" behaviors.**
  - **Many of these BMPs either directly reduce nutrients/pollutants or slow water movement down.**
  - **BMPs will not directly impact nuisance growth and coincide with direct management practices.**

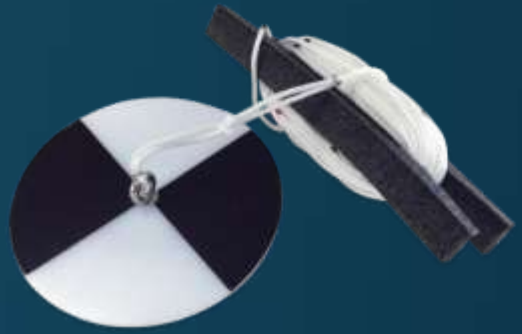
Lake shoreline owners	Construction	Farming/Agricultural	Other
Reduced or no-P fertilizer use.	Use silt fencing on slopes where necessary.	Ensure vegetated buffer strips protect river systems.	Allow for "greenways" to persist to sequester nutrients before they reach the lake.
Ensure septic systems are up-to-date.	Cover or stabilize exposed/barren soils	Enact fertilizer management practices.	Follow wake zone rules to reduce erosion.
Allow for vegetated buffer strips to persist on shore.	Build sedimentation basins if necessary.	Consider contour farming.	Construct rain gardens to take in water before it gets to the lake.
Consider utilizing permeable surfaces where possible.	Install swales into ditches.	Enact crop rotation practices.	
Conserve water usage as much as possible.		Reduce livestock waste movement into moving water.	

- **Long-term monitoring and threshold development.**
  - **In order to establish long-term goals to maintain the lake, a monitoring program and water quality thresholds need to be enacted.**
  - **The following parameters are common for lake monitoring:**

1) Dissolved oxygen
2) Nutrients (phosphorus and nitrogen)
3) pH
4) Secchi transparency
5) Chlorophyll a
6) Fecal coliforms/*E. coli*
7) Microcystin

Important physical, chemical, and biological components of the lake. (1–5)

Important for human health concerns (6–7)



Lake monitoring should be consistent! Information collected in one season is a snap-shot of that season. Information collected over time is a powerful tool to identify what is "typical" for the lake and what is not.

Thanks!

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