Indian Lake Vegetation Mapping 2022

AQUA DOC Lake and Pond Management

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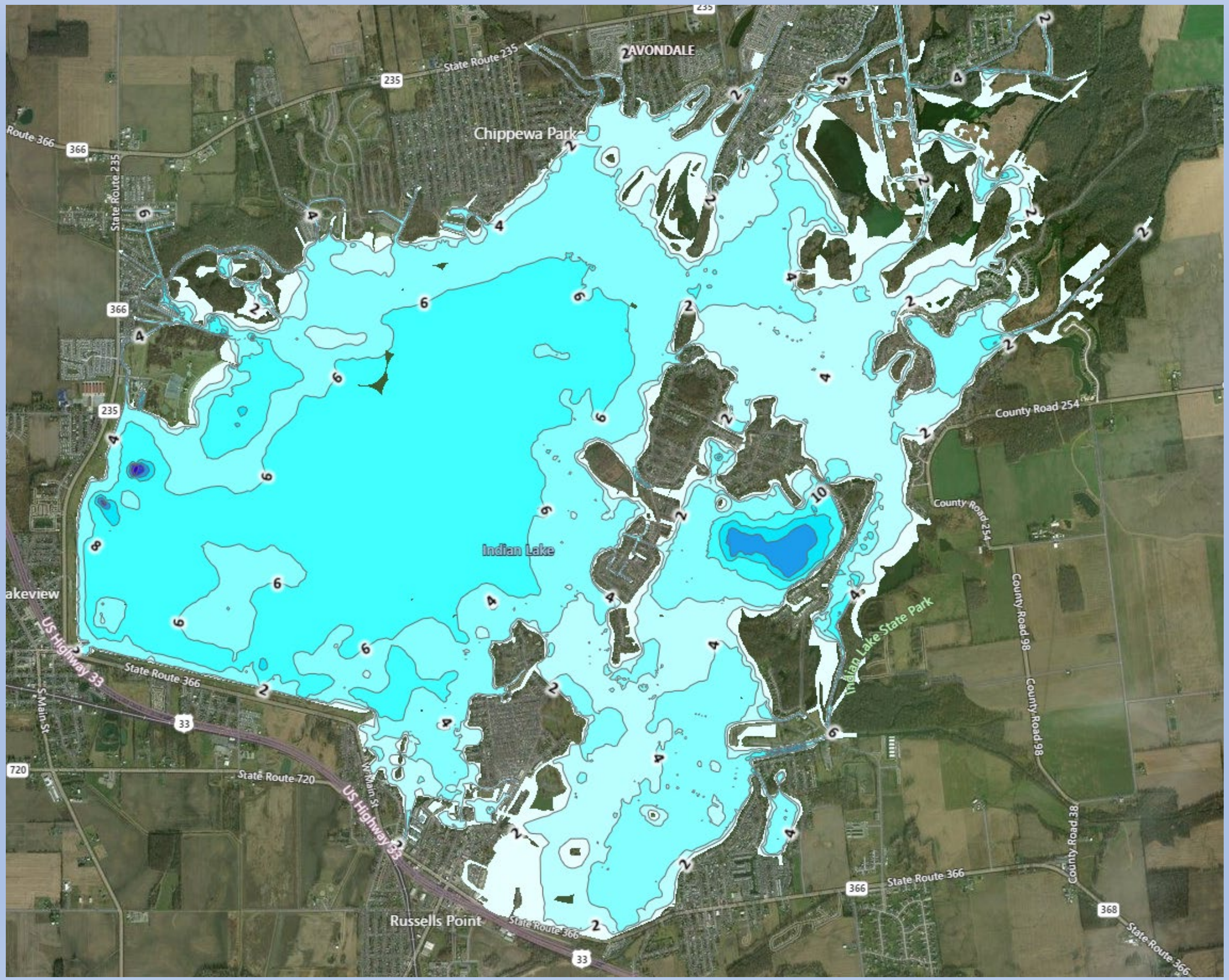
Broad Overview

- An aquatic plant survey was conducted on Indian Lake from July 5 – 15, 2022. The goal of the study was to assess the species richness, relative abundance, and spread of aquatic plants throughout the lake.

- Eurasian watermilfoil and Coontail made up 52% and 39% of the total estimated biomass in the lake, respectively.

- This presentation will discuss a variety of techniques that were looked into to mitigate nuisance growth on the lake, as well as a general management strategy for next year.

Introductory Lake Information



Parameter	Value
Waterbody acreage	5,162.89 acres
Estimated volume	23,745 ac. ft. 7.78×10^9 gallons
Max depth	15.3 ft.
Average depth	5.0 ft.
Watershed area	97.2 sq. miles

Materials and Methods

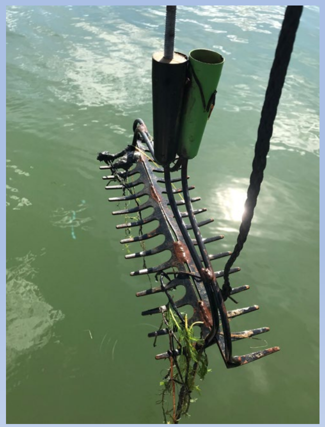
- To estimate species richness, spread, and density in Indian Lake a modified Point Intercept Rake Toss Relative Abundance Method (PIRTRAM) study was performed in conjunction with sonar mapping.
- Modified PIRTRAM followed guidelines incorporating the method described by Lord et al. 2006 to establish richness and spread.
- Sonar mapping was conducted through the use of Bio-Base® plant mapping software.

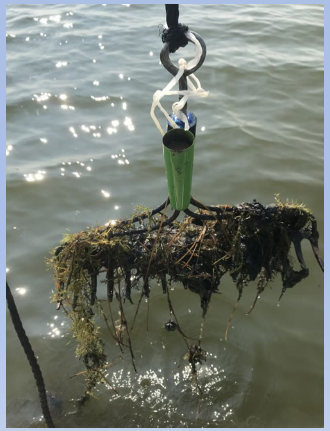
Materials and Methods: PIRTRAM

- A simple, yet effective method of sampling aquatic plants for data collection purposes.

1) A modified rake is tossed at sample locations and slowly brought back to the sampling boat, bringing submersed aquatic plants back with it.
2) A general density number based off the total haul is established (Table below)
3) Individual species are separated, identified, and an estimate of the proportion of each plant is determined.

Rake Toss Density Score	Plant Quantity
0	No Plants
1	"Fingerful" of Plants
2	"Sparce" Amount of Plants
3	"Medium" Amount of Plants
4	"Heavy" Amount of Plants



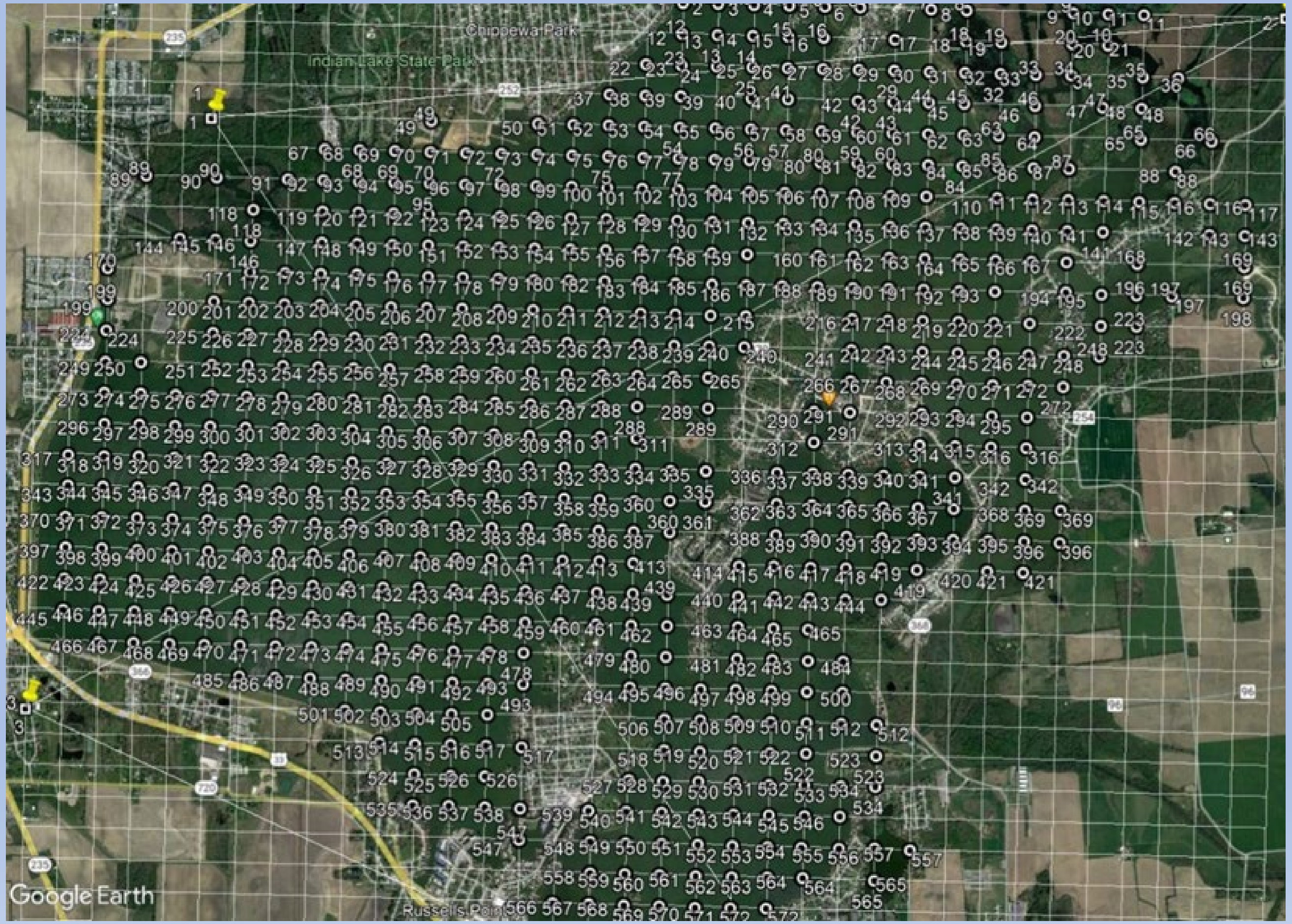


Materials and Methods: PIRTRAM

- Sampling locations were determined through the creation of a gridded map of Indian Lake.
- Initial sampling paradigm of 1 point per 10 acres was suggested but actual sampling included 585 distinct locations after removing unsampleable locations.
- The procedures described in the previous slide were repeated at each location.
- Data compiled into a Microsoft Excel spreadsheet.
- Relatively easy to repeat.

Location #	Abundance Score	# of Spp.	% per Spp: Eurasian watermilfoil	Coontail	Common waterweed	Curly-leaf pondweed	Sago pondweed	Brittle naiad
1	1	3	10	80	0	0	10	0
2	1	1	100	0	0	0	0	0
3	1	3	33	33	0	0	0	33
4	2	2	0	99	0	0	0	1
5	1	2	0	80	20	0	0	0
6	0	0	0	0	0	0	0	0
7	1	1	0	100	0	0	0	0
9	1	1	0	100	0	0	0	0
13	2	3	10	80	10	0	0	0
14	3	1	0	100	0	0	0	0
15	1	2	0	90	10	0	0	0
16	1	4	25	25	25	0	25	0
17	3	4	10	40	40	0	10	0
20	2	1	0	100	0	0	0	0
21	4	1	0	100	0	0	0	0
22	3	2	1	99	0	0	0	0
23	1	2	50	50	0	0	0	0
24	1	4	10	70	0	0	10	10
25	4	3	20	75	0	0	0	0
27	1	3	0	75	20	0	20	0
28	1	3	33	33	0	0	33	0
29	4	1	0	100	0	0	0	0
30	4	2	20	80	0	0	0	0
34	3	1	0	100	0	0	0	0
35	2	1	0	100	0	0	0	0
37	2	2	10	90	0	0	0	0
38	2	1	0	100	0	0	0	0
39	1	2	10	90	0	0	0	0
40	3	3	40	40	20	0	0	0
42	4	4	5	70	20	0	0	0
43	3	3	1	98	0	0	1	0
44	4	2	10	90	0	0	0	0
47	3	1	0	100	0	0	0	0
48	4	1	0	100	0	0	0	0
49	0	0	0	0	0	0	0	0
50	1	2	5	95	0	0	0	0
51	1	2	50	50	0	0	0	0
52	0	0	0	0	0	0	0	0

Spreadsheet example

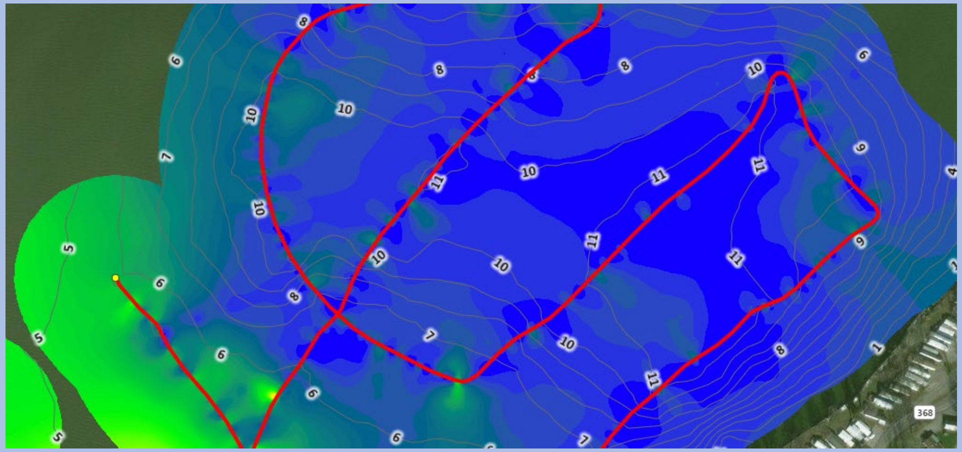


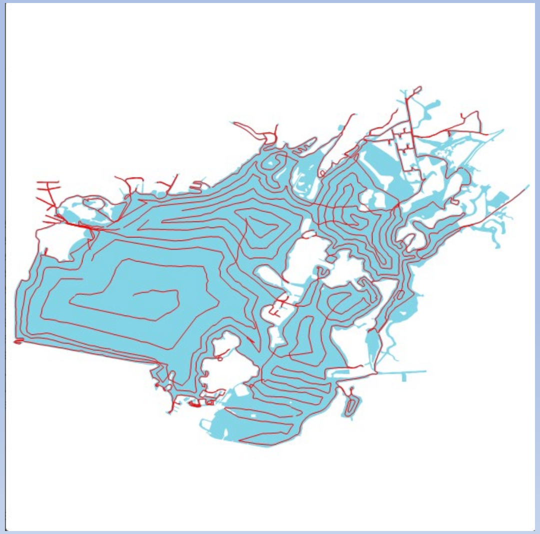
Grid created

Materials and Methods: Sonar Mapping

- Sonar mapping was conducted utilizing a Lowrance Hook readout and transducer.
  - The lake was “traced and filled in” by slowly traveling around the lake and registering sonar pings that distinguish vegetation growth and the bottom.
  - Different areas of the lake were completed in separate chunks due to scale.

Path example



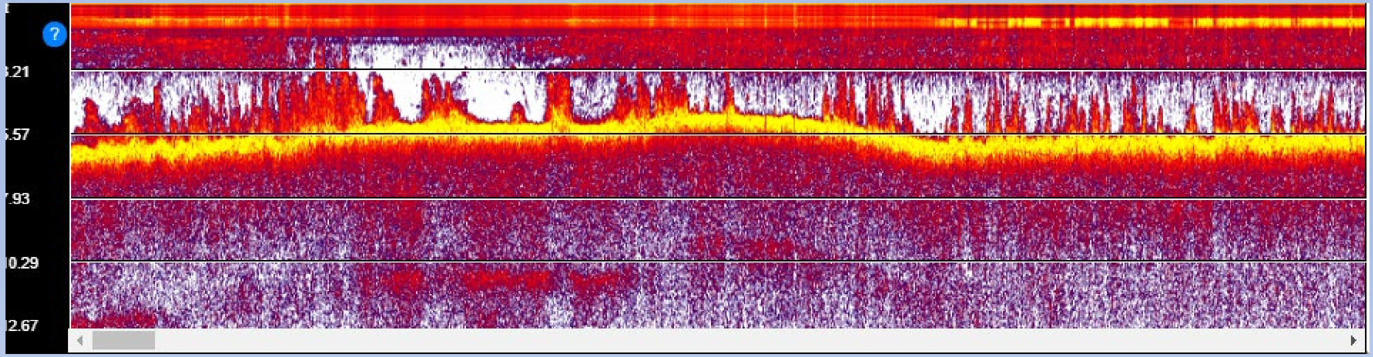


Data collected per ping

Timestamp	Lat	Lon	Depth (ft)	Height (ft)	BV %	Ref No	Modified	Delete
07/06/2022 20:30:07	40.4900912	-83.8700235	-6.12	0	0	0	No	☐
07/06/2022 20:30:08	40.4900848	-83.8700152	-6.11	1.67	27.33	1	No	☐
07/06/2022 20:30:10	40.4900772	-83.8700088	-6.01	0.46	7.65	2	No	☐
07/06/2022 20:30:11	40.4900690	-83.8700036	-5.97	1.22	20.44	3	No	☐
07/06/2022 20:30:13	40.4900602	-83.8699999	-6.10	1.35	22.13	4	No	☐
07/06/2022 20:30:14	40.4900518	-83.8699958	-5.86	0.51	8.7	5	No	☐
07/06/2022 20:30:15	40.4900433	-83.8699911	-6.04	0.96	15.89	6	No	☐
07/06/2022 20:30:15	40.4900338	-83.8699840	-5.86	1.4	23.89	7	No	☐

Showing 1 to 1,392 of 1,392 entries

Sonar visualization



Results

- Species richness
  - 10 individual species of submersed aquatic vegetations (Table 1).
    - 3 are identified as invasive in the United States/Ohio: Eurasian watermilfoil, curly-leaf pondweed, and brittle naiad.
  - 5 individual species of floating-leaf plants also observed (Table 2).

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

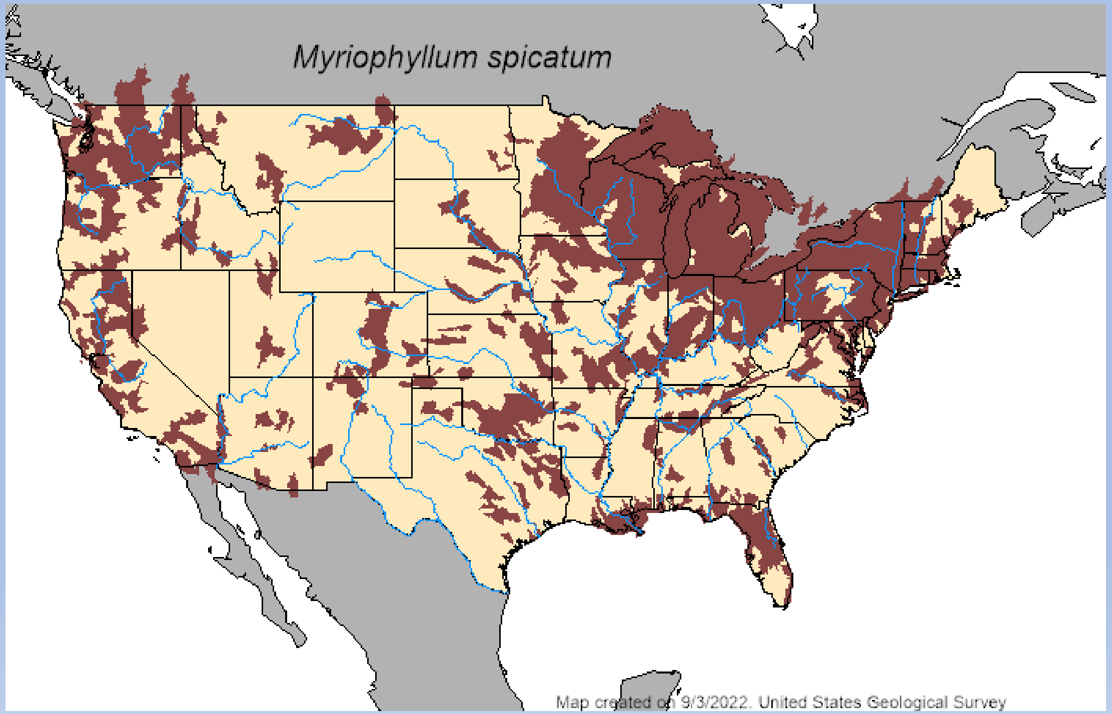
Common Name	Species Name
Eurasian watermilfoil	*Myriophyllum spicatum*
Coontail	*Ceratophyllum dermersum*
Common waterweed	*Elodea canadensis*
Curly-leaf pondweed	*Potamogeton crispus*
Sago pondweed	*Stuckenia pectinata*
Brittle naiad	*Najas minor*
Water stargrass	*Heteranthera dubia*
Narrow-leaf pondweed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

Results: Focus on Invasive aquatic vegetations

- Eurasian watermilfoil (EWM)
  - Common invasive aquatic plant across the state of Ohio and the United States.
  - Easily spreads via fragmentation and can form dense monoculture mats.
  - Growth typically begins in early Spring and shallow growth will reach the surface quickly.
  - Can readily hybridize which may create a more hardy strain of the plant (i.e. Northern watermilfoil; Madsen et al. 2021).
  - Low light may stimulate elongation of the stem to the surface to more quickly produce mats (Spencer and Bowes 1990).



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Results: Focus on Invasive aquatic vegetations

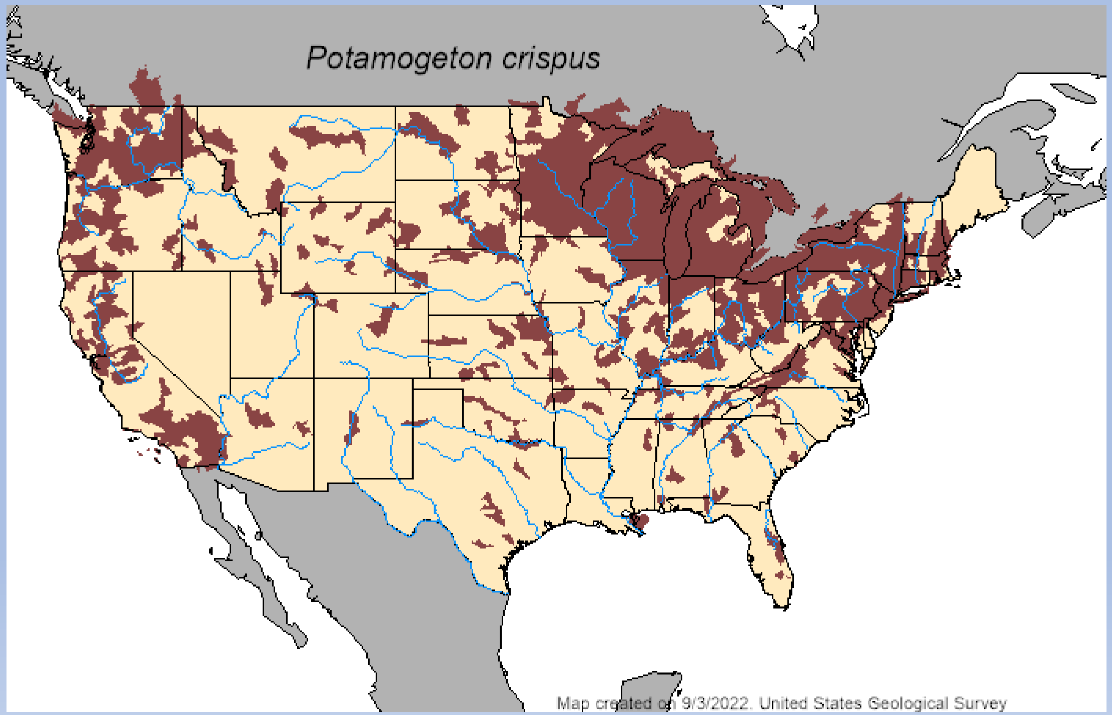
- **Eurasian watermilfoil (EWM)**

Management Technique	Management Type	Details	Pros/Cons
Chemical Applications	Chemical (endothal, diquat, flumioxazin, fluridone, 2,4-D, florpyrauxifen-benzyl)	EWM can be controlled with a range of different chemical products. 2,4-D and florpyrauxifen-benzyl are particularly effective.	Will quickly reduce current biomass; Individual products are selective; Can be used at larger scale; relatively cost-effective; Killing of biomass will increase organic material, and increase oxygen demand
Harvesting	Mechanical	EWM can be mechanically harvested but fragmentation will assist with spread.	Removal of biomass from lake will remove sequestered nutrients in plant; Continuous harvesting will be needed to account for regrowth; Machinery requires constant maint.; Plant fragmentation and spread highly likely
Dredging	Mechanical	Removal of sediment can restrict growth potential; increased depth will slow potential for plant to surface	Removal of deposited sediment reduces eutrophication; Cost can become extreme when considering all necessary moving parts for success
Milfoil weevil (*Euhrychiopsis lecontei*)	Biological	*Euhrychiopsis* will structurally damage milfoil by damaging growth points via feeding and reproduction in the host plant.	Weevil will target milfoil solely; relatively cheap; little maint. or labor requirements; May not completely eradicate plant (look rough); preyed upon by small fish; may not survive overwintering; research is inconclusive

Management Technique	Management Type	Details	Pros/Cons
Lake drawdown	Physical	EWM is considered to be susceptible to exposure and desiccation. Winter freezing could add to success.	Cost is typically a non-factor; Commonly used across the United States; Shift in dominant vegetation likely; Reliant on Spring runoff refill; Need ability to release water AND expose littoral zone
Benthic barriers (small scale)	Physical	Shading of small area milfoil populations possible but not feasible on a larger scale.	Cost is low and shading will impact all biomass under mat; Mat will need consistent maint. in order to be functional
Hand harvesting (small scale)	Physical	Hand pulling milfoil is feasible so long as the plant is pulled from the base to prevent fragmentation.	Removal of plant from the base ensures no fragmentation occurs; Cost can be exceptionally high and little area can typically be covered vs other techniques;
Suction harvesting (medium scale)	Mechanical	Suction harvesting may be able to pull milfoil directly from root if suction is positioned correctly and can work at a faster pace than hand pulling.	Correct use of technique may remove plant and rooted base with minimal fragmentation concern; Cost will become higher than hand harvesting

Results: Focus on Invasive aquatic vegetations

- Curly-leaf pondweed (CLP)
    - Most common early season nuisance aquatic vegetation in Ohio.
    - Prefers the cooler waters of Fall and Spring seasons for maximum growth and is known to regress by the 4th of July in Northern lake environments.
    - They can produce a specialized, seed-like structures called a turion that can remain dormant in lake sediments until conditions are favorable for growth.
    - Growth may persist in the Fall when water temperatures drop and can continue during periods of thick ice.



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Confirmed turion production from Indian Lake

Results: Focus on Invasive aquatic vegetations

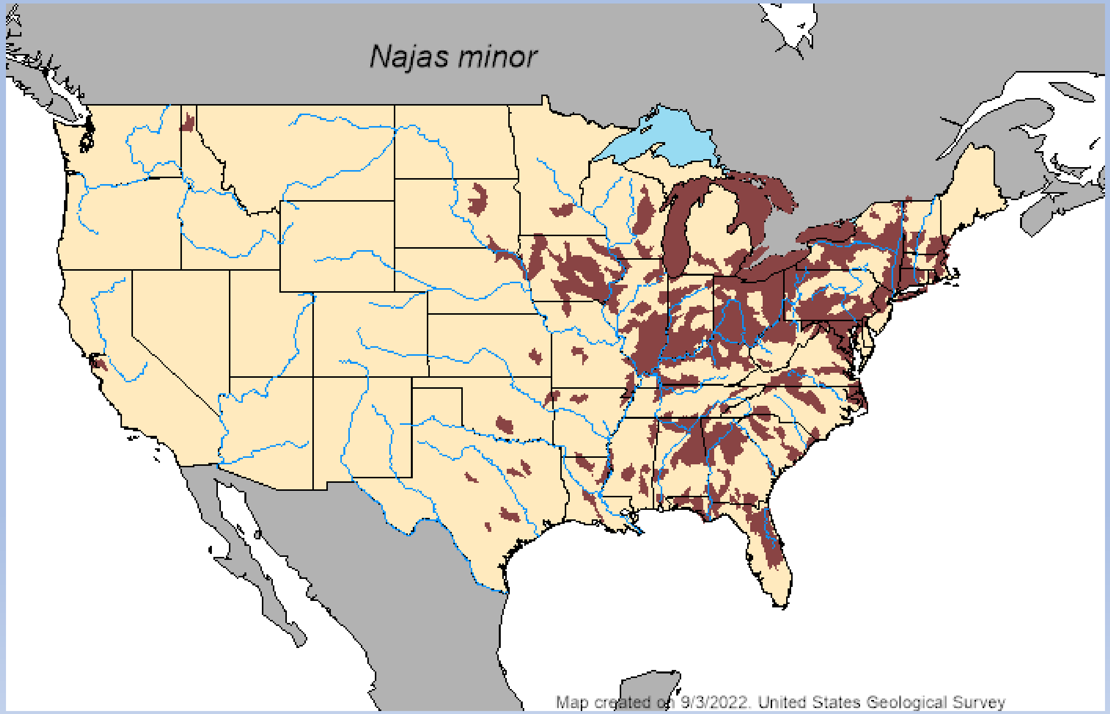
- **Curly-leaf pondweed (CLP)**

Management Technique	Management Type	Details	Pros/Cons
Chemical applications	Chemical (endothal, diquat dibromide, flumioxazin, fluridone)	CLP is highly susceptible to chemical applications at relatively low dosages	Will quickly reduce current biomass; Rate can be low for success; Can be used at larger scale; relatively cost-effective; Will not impact seed/turion base; Killing of biomass will increase organic material and increase oxygen demand
Harvesting	Mechanical	CLP can be mechanically harvested prior to turion formation and surfacing.	CLP is not thought of as a prolific fragmentation-spreading plant; Continual harvesting may slow inflorescence and turion formation; Removal of biomass from lake will also remove sequestered nutrients in plant; Continuous harvesting will be needed to account for regrowth; Machinery requires constant maint.
Dredging	Mechanical	Removal of turion/seed infused sediment can reduce seed bank overtime.	Removal of seed/turion base can reduce the capacity for future population growth; Removal of deposited sediment reduces eutrophication; Increase depth will slow overall growth to surface; Cost can become extreme when considering all necessary moving parts for success
Grass carp	Biological	CLP is highly palatable to grass carp.	NOT FEASIBLE unless containment possible

Management Technique	Management Type	Details	Pros/Cons
Lake drawdown	Physical	CLP may not be susceptible to water level drawdown as turions may survive desiccation and freezing.	Cost is typically a non-factor; Commonly used across the United States; Shift in dominant vegetation likely; Reliant on Spring runoff refill; Need ability to release water AND expose littoral zone; CLP may be unaffected
Benthic barriers (small scale)	Physical	Shading of small-area CLP populations possible but not feasible on a larger scale. Will also not impact turion/seed bank	Cost is low and shading will impact all biomass under mat; Mat will need consistent maint. In order to be functional
Hand-harvesting (small scale)	Physical	Hand pulling CLP is feasible so long as the plant is pulled from the base to prevent fragmentation.	Removal of plant from the base ensures no fragmentation occurs; Cost can be exceptionally high and little area can typically be covered vs other techniques;
Suction harvesting (medium scale)	Mechanical	Suction harvesting may be able to pull plant as well as potential turions.	Correct use of technique may remove plant and rooted base with minimal fragmentation concern; Suctioning of turions from sediment also possible; Cost will become higher than hand harvesting

Results: Focus on Invasive aquatic vegetations

- Brittle naiad/waternymph
  - Another common invasive plant that predominantly becomes a nuisance later in the growing season.
  - Low growing plant that rarely reaches the surface if depth is adequate.
  - May be a good candidate for early detection rapid response in 2023.



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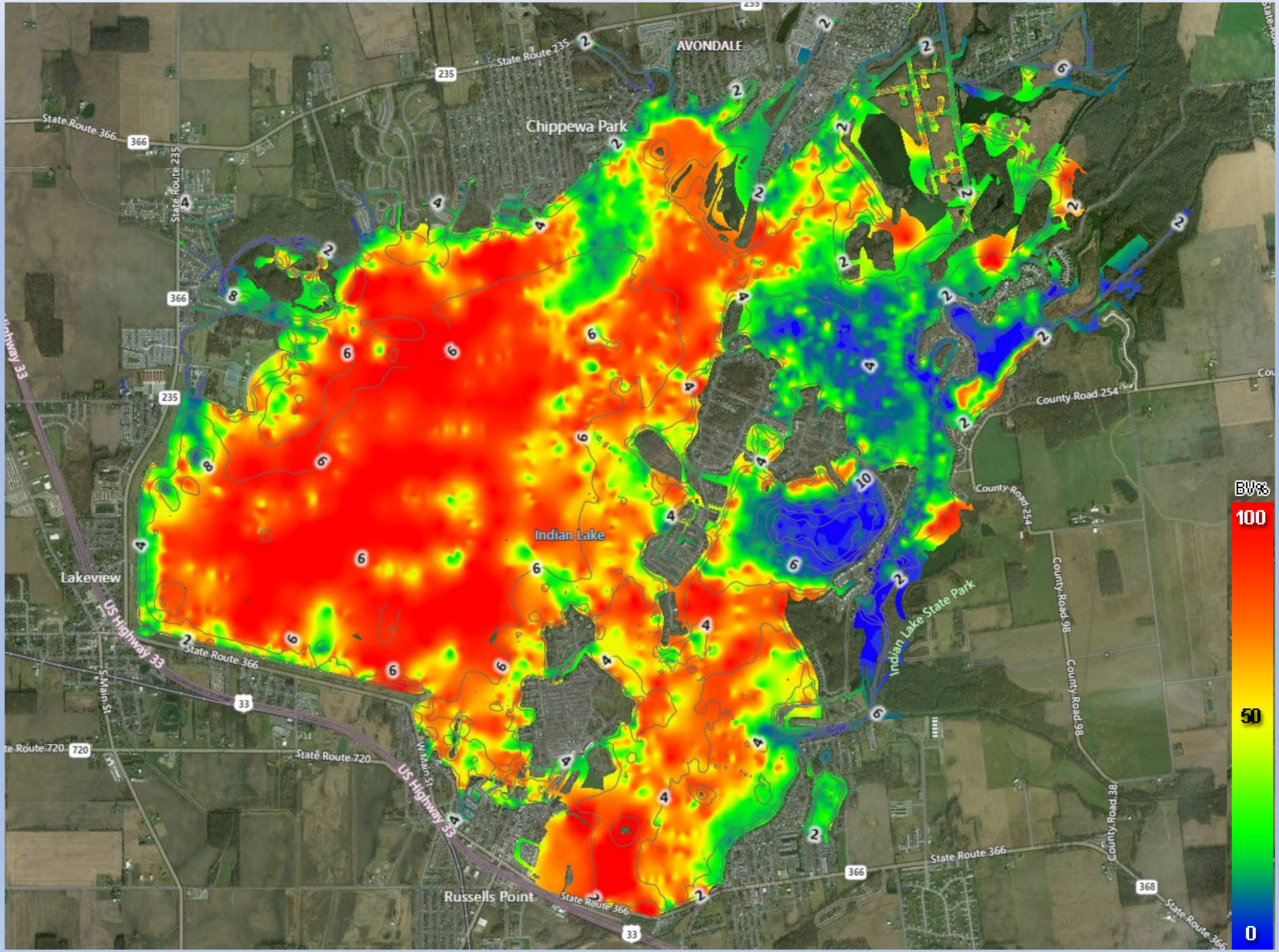
Results:

- **Overall abundance:**

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%

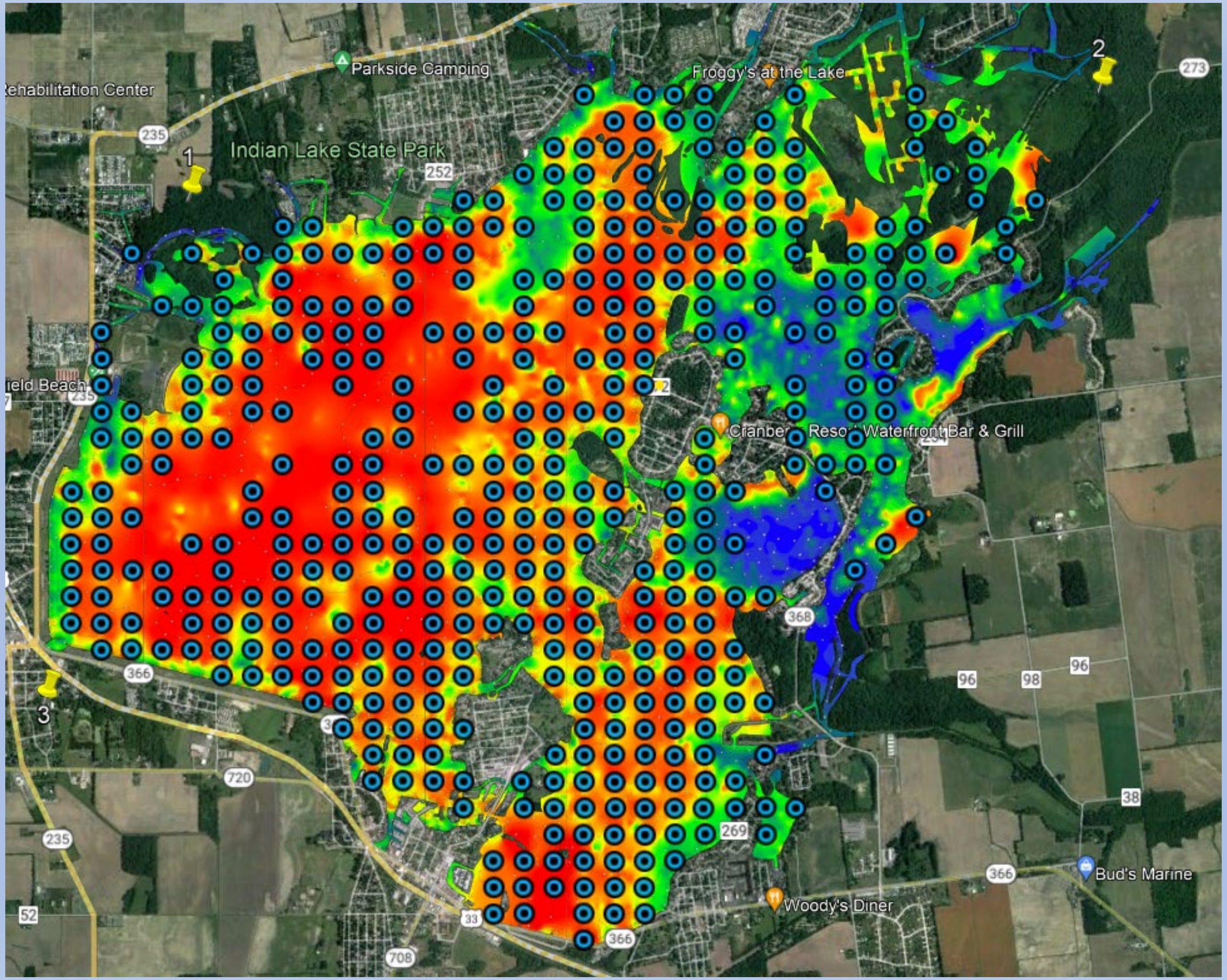
Note: 1 m = 3.3 ft.
*Refers to the average water column percent taken up by aquatic vegetation growth.



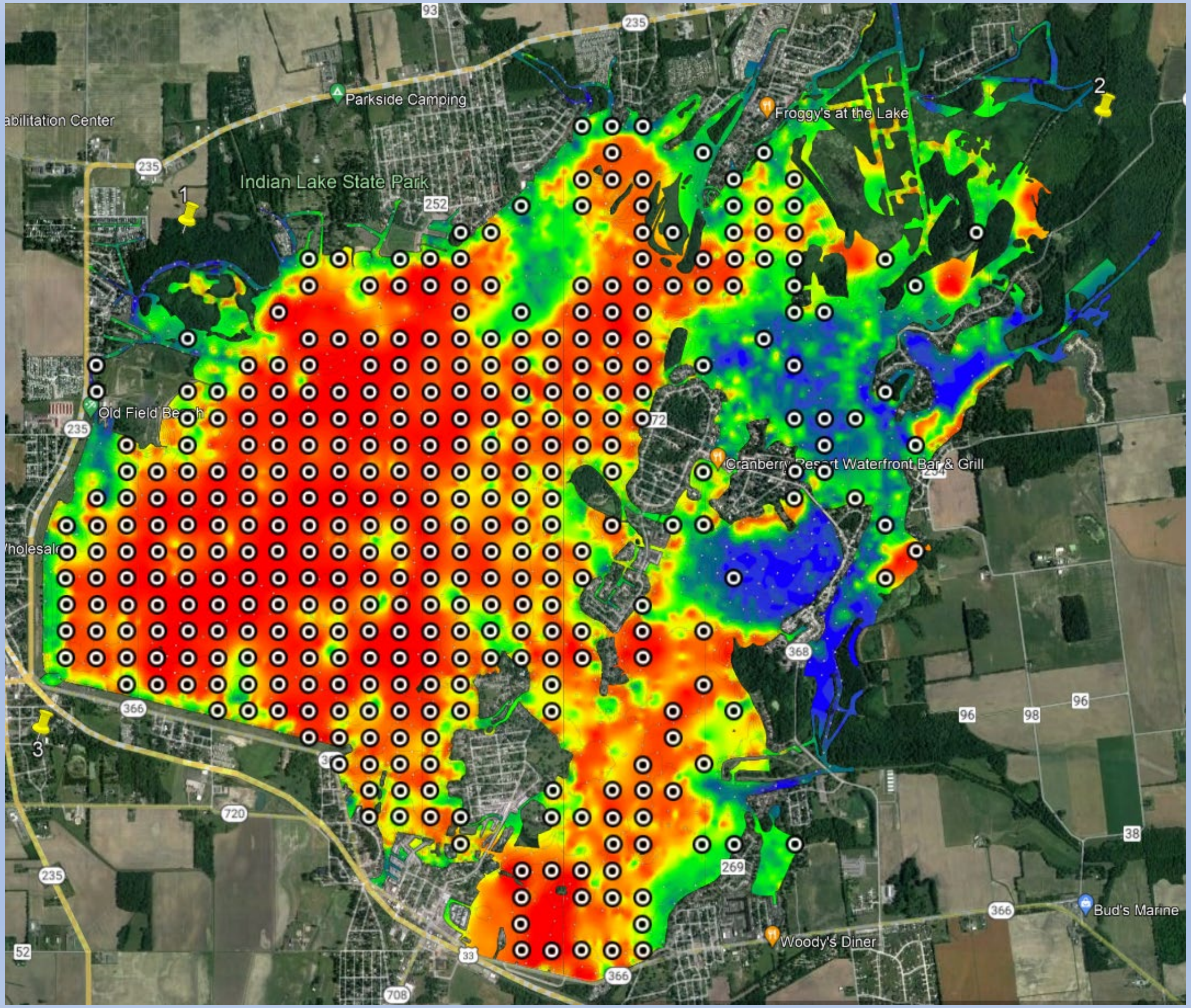
July 6 - 11, 2022

Results:

- Species spread
  - Coontail was the most widely dispersed submersed plant (found in 73.7% of sampled locations; 3,600 acres).
  - Eurasian watermilfoil was a close second (found in 64.6% of sampled locations; 3,150 acres).



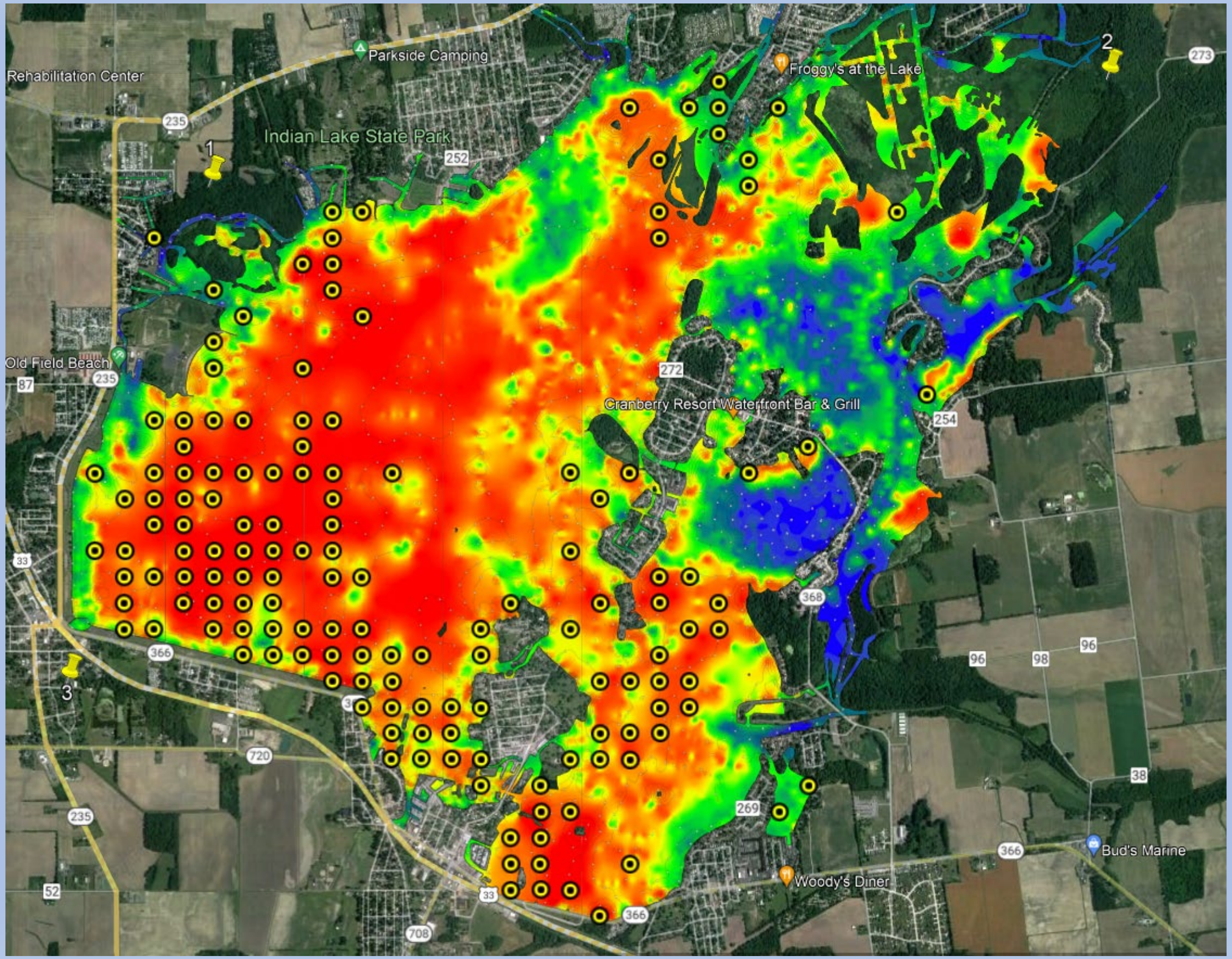
Each dot represents coontail presence on our rake toss.



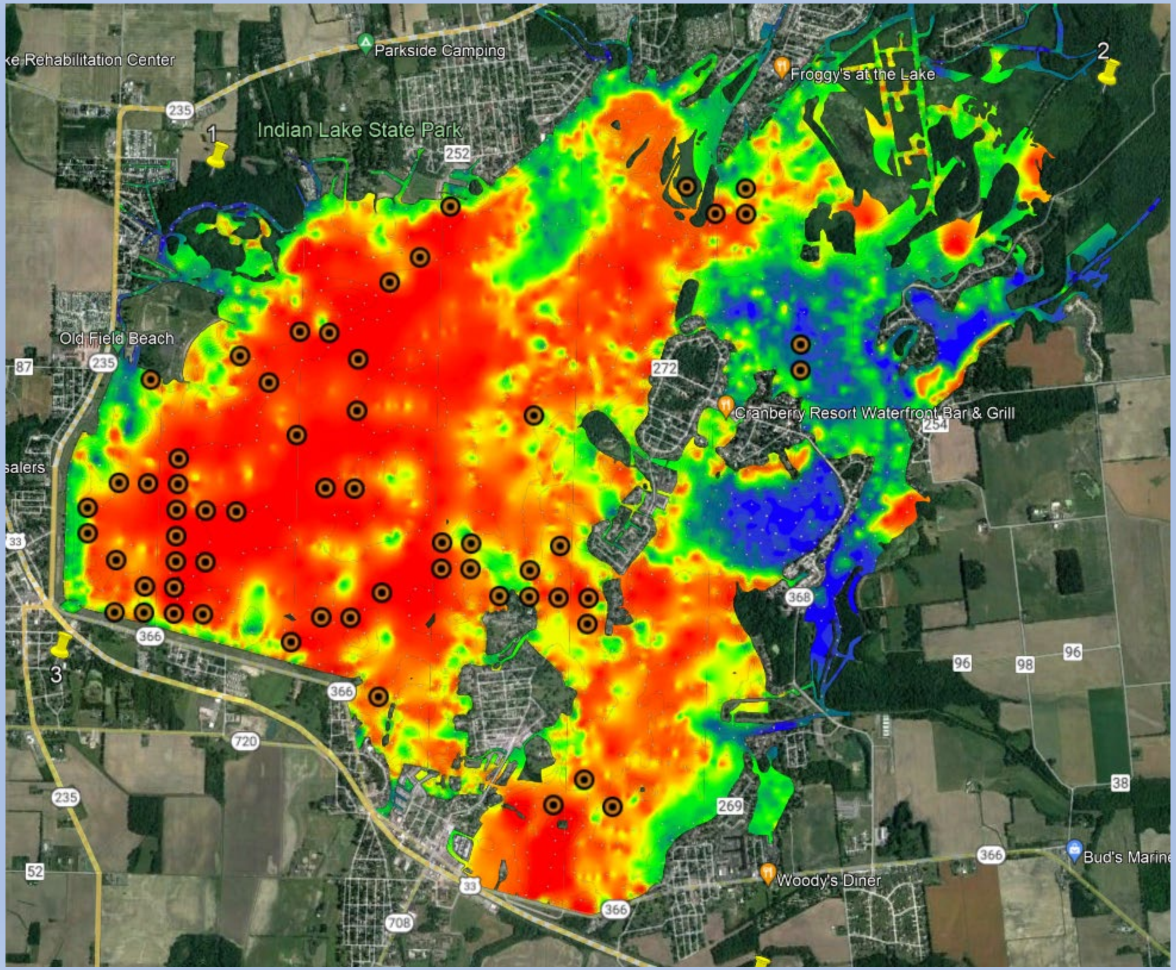
Each dot represents Eurasian watermilfoil presence on our rake toss.

Results:

- Species spread (other common species):
  - Common waterweed (found in 25.9% of sampled locations).
  - Curly-leaf pondweed (found in 9.9% of sampled locations).



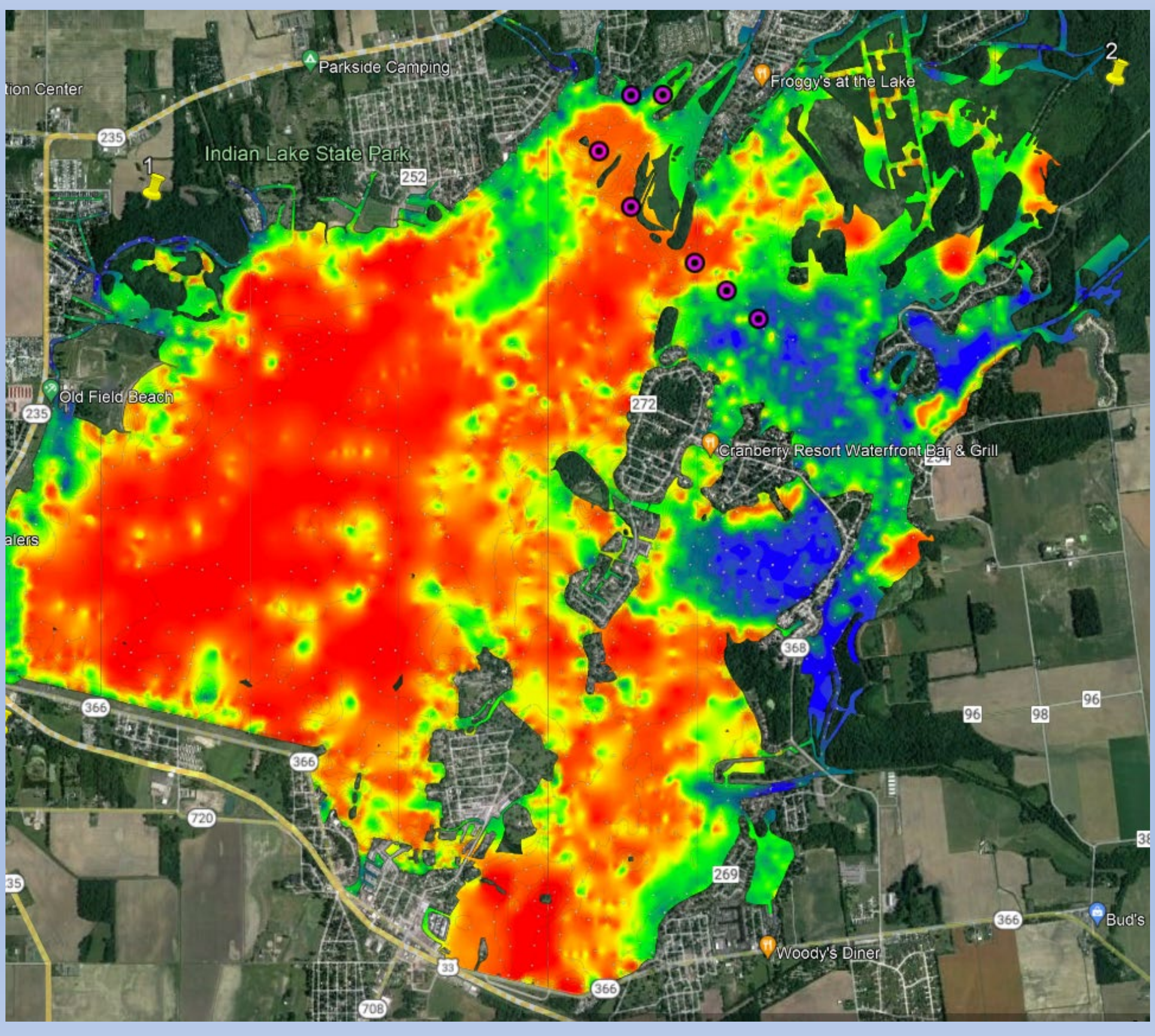
Each dot represents Common waterweed presence on our rake toss.



Each dot represents curly-leaf pondweed presence on our rake toss.

Results:

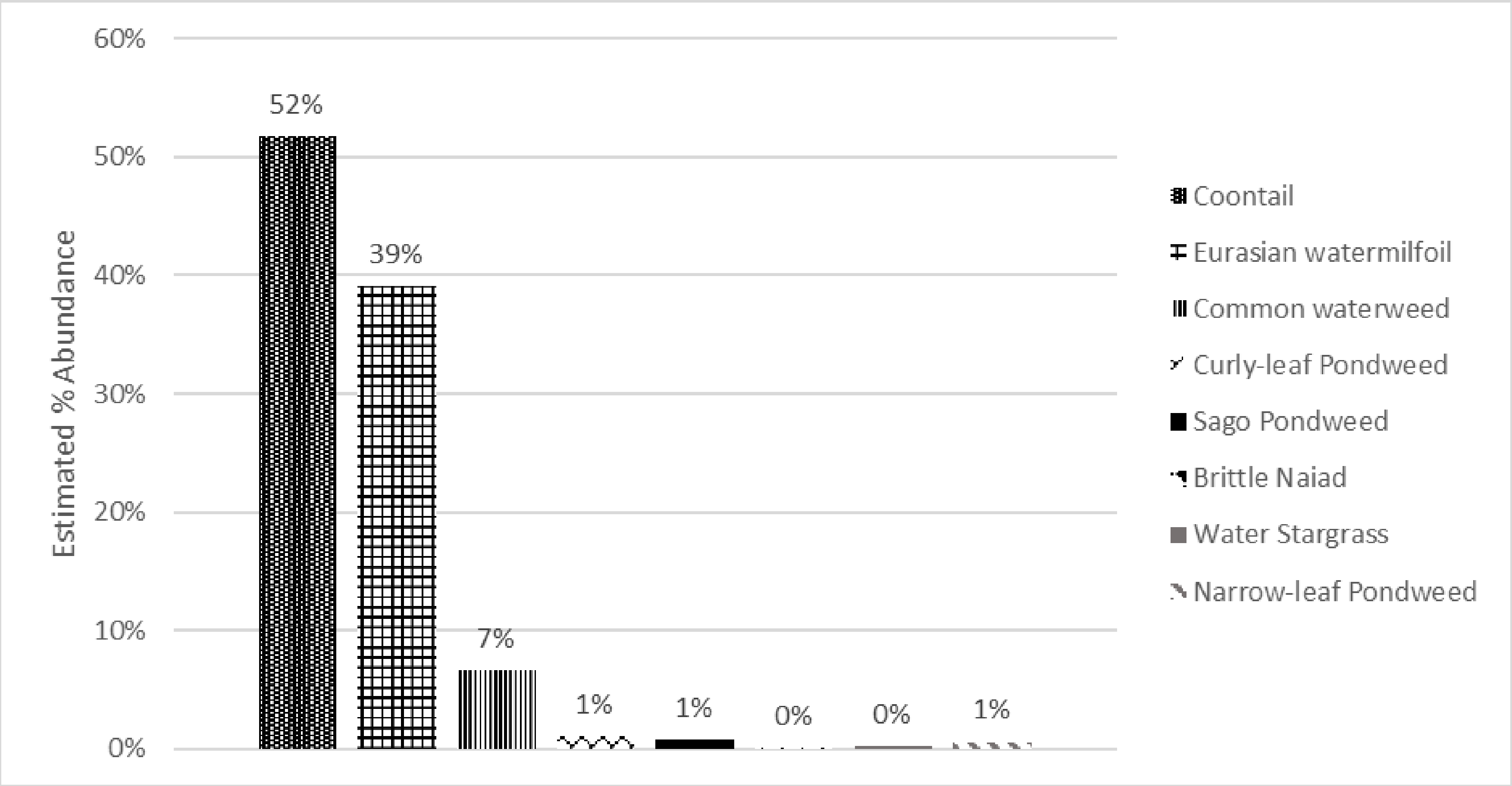
- Species spread (other common species):
  - Brittle naiad (found in 1.2% of sampled locations).



Each dot represents brittle naiad presence on our rake toss.

Results:

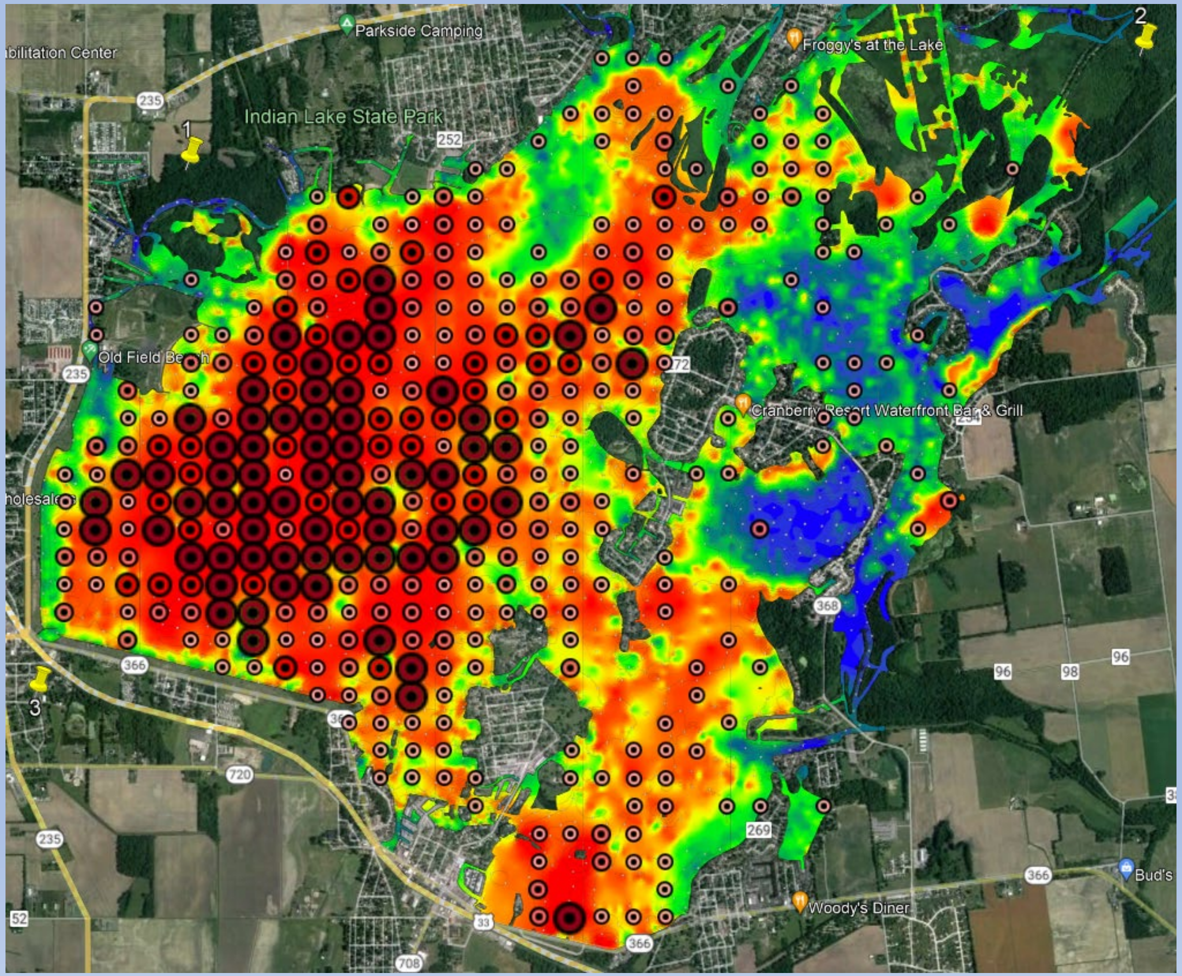
- Species density
  - Coontail was estimated to be the most dense aquatic plant found in Indian Lake at the time of this study (52% of sampled biomass).
  - Eurasian watermilfoil was the second most abundant (39% of sampled biomass).
  - All other species accounted for the remaining 9%.



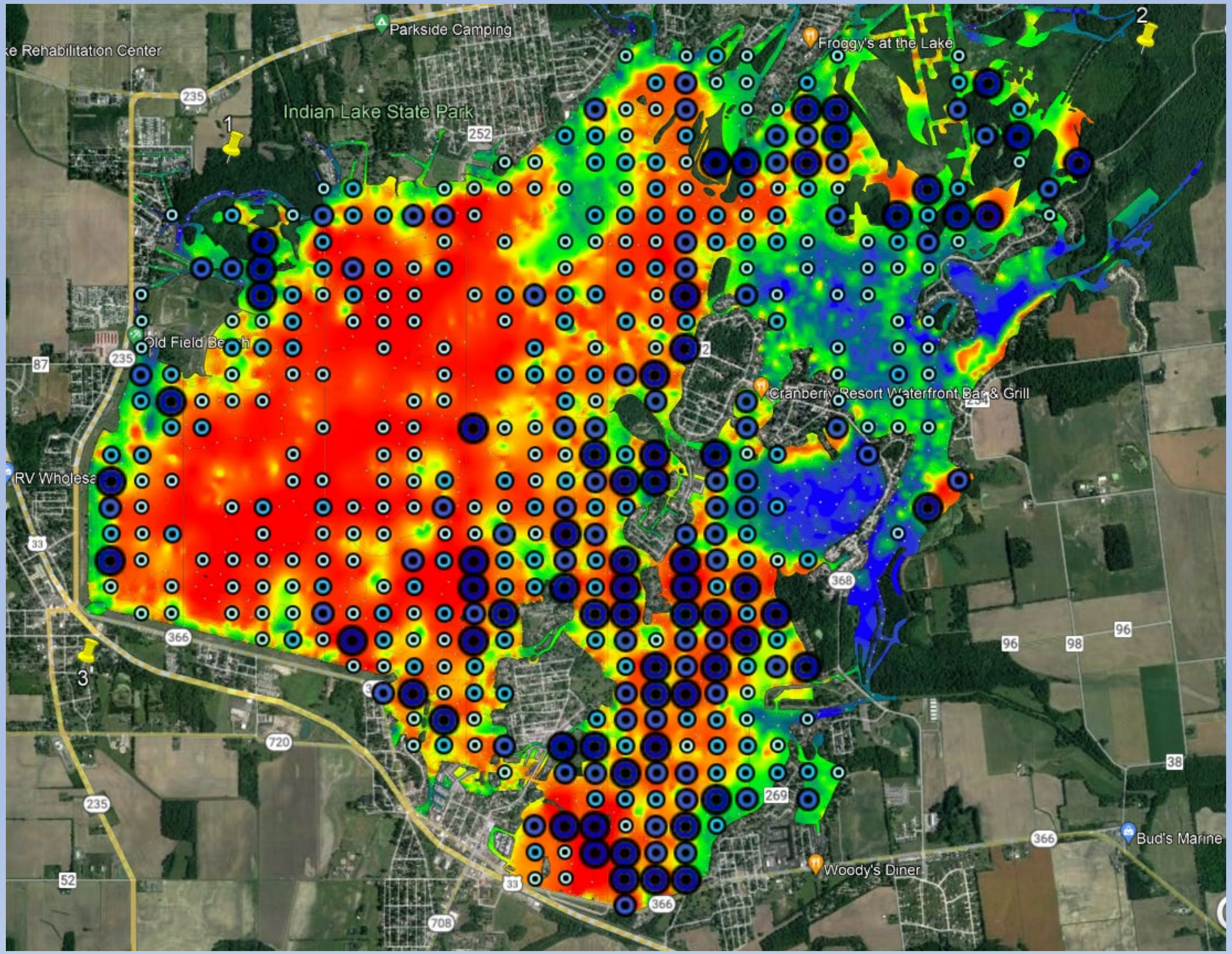
Aquatic vegetation	Estimated density (g/m^2) (Valley 2015)
Coontail	**48,729.92**
Eurasian watermilfoil	**40,966.06**
Common waterweed	7,084.03
Curly-leaf pondweed	1,054.46
Brittle naiad	51.47
All others	1,292.55

Discussion

- **Primary species of concern: Density.**
- **Eurasian watermilfoil (red) and coontail (blue) density shown below. The larger and darker the point, the greater the density observed.**



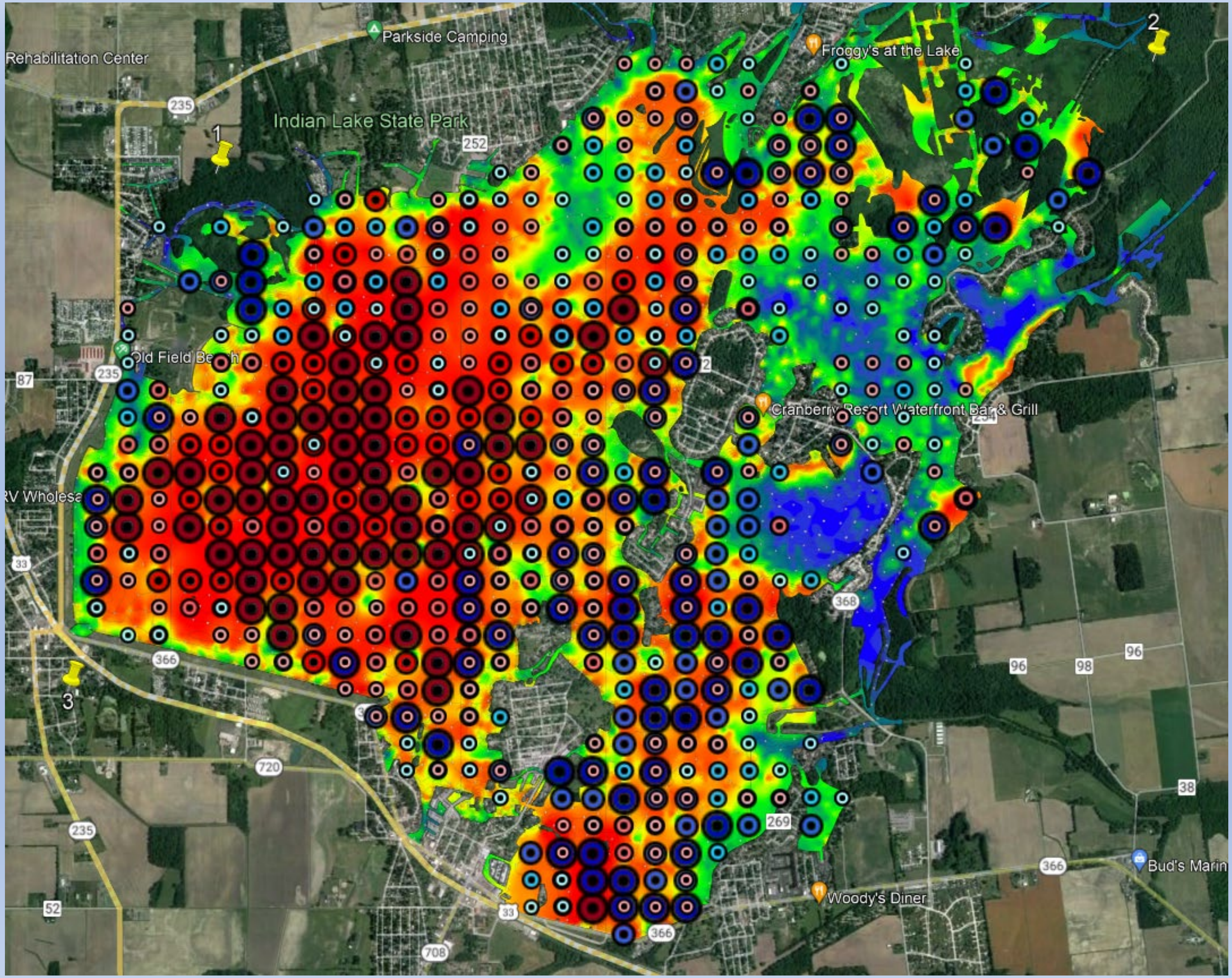
Density map of Eurasian watermilfoil



Density map of coontail

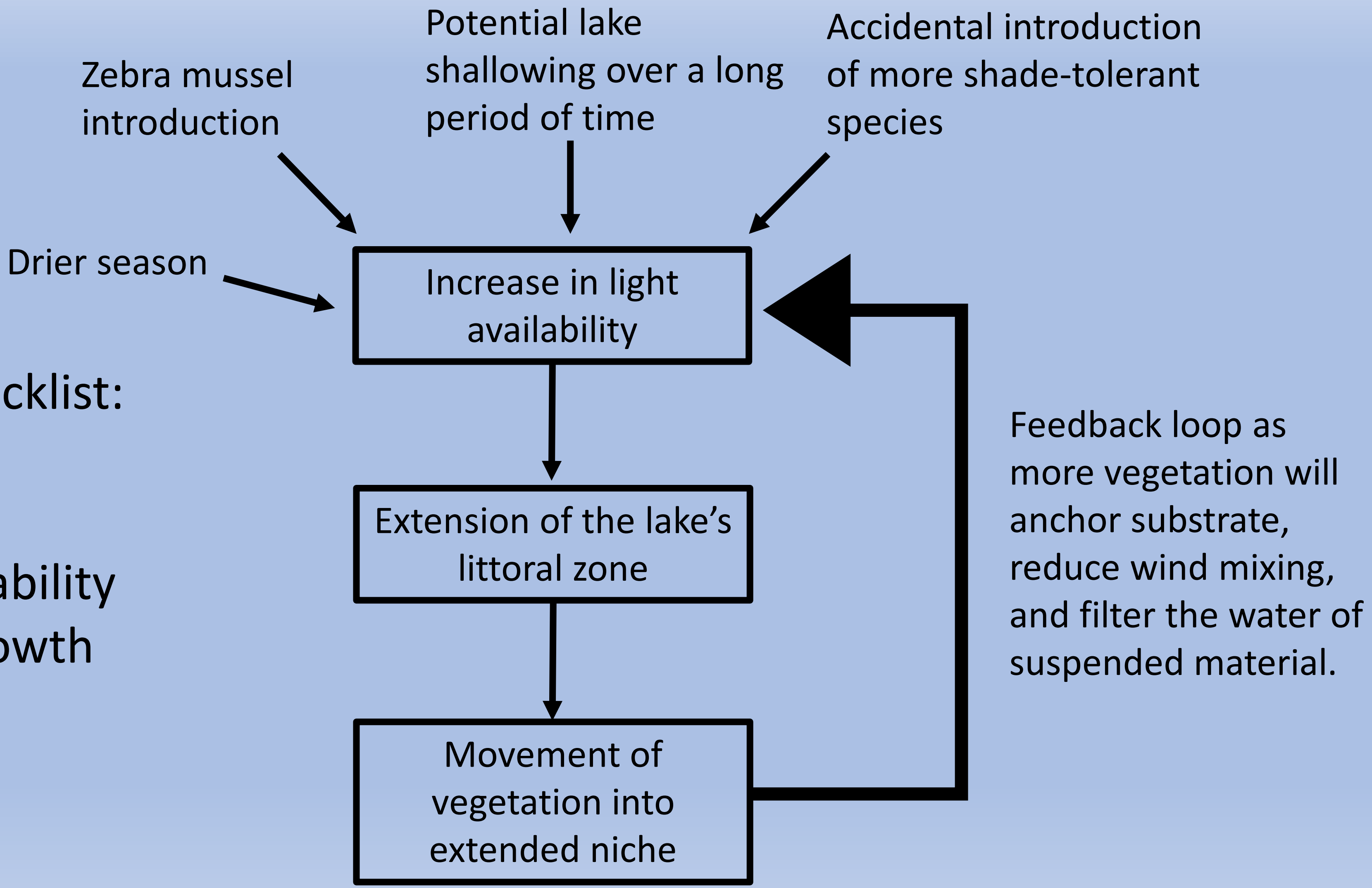
Discussion

- **Previous maps combined.**



Discussion

- **How did the lake become dominated by aquatic vegetation growth?**
- **Aquatic vegetation requires adequate light, nutrients, carbon, substrate, and survivable temperature ranges.**



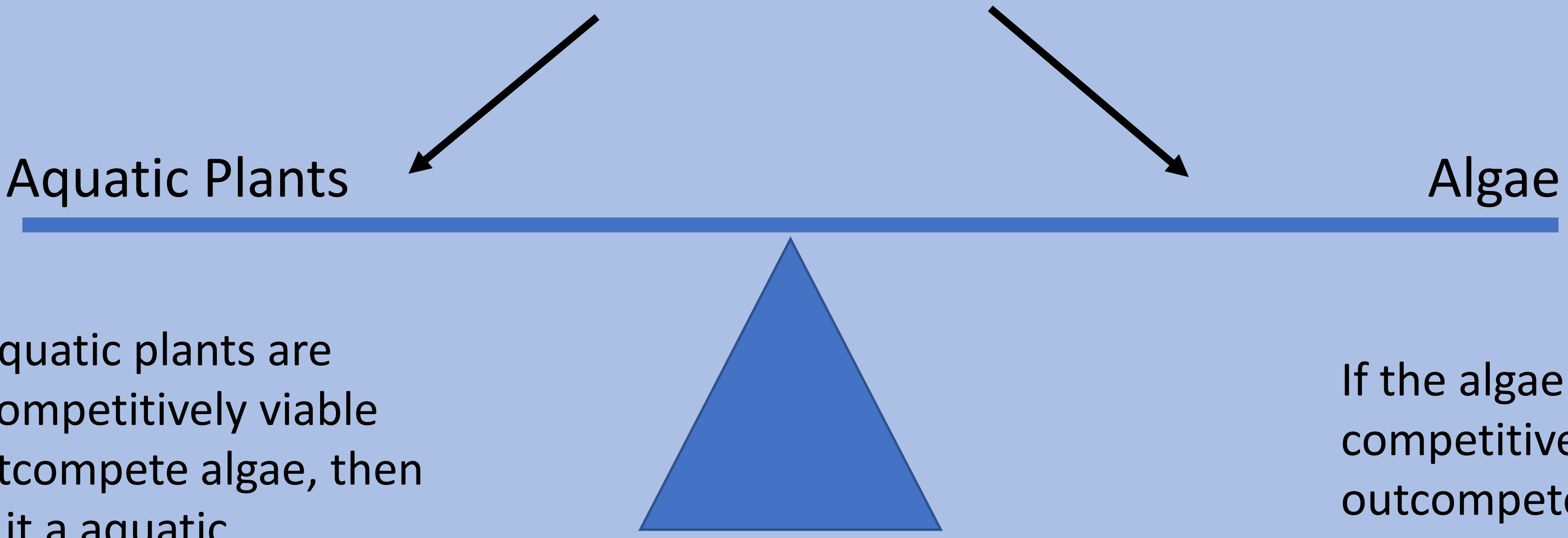
Indian Lake checklist:

✓ Light
✓ Nutrients
✓ Carbon availability
✓ Adequate growth substrate
✓ Temperature

Discussion

- **Indian Lake experienced a “stable state change”. What does this mean?**
  - **Think of a teeter totter:**

These two groups are constantly competing with one another for resources: light, nutrients, space, etc.



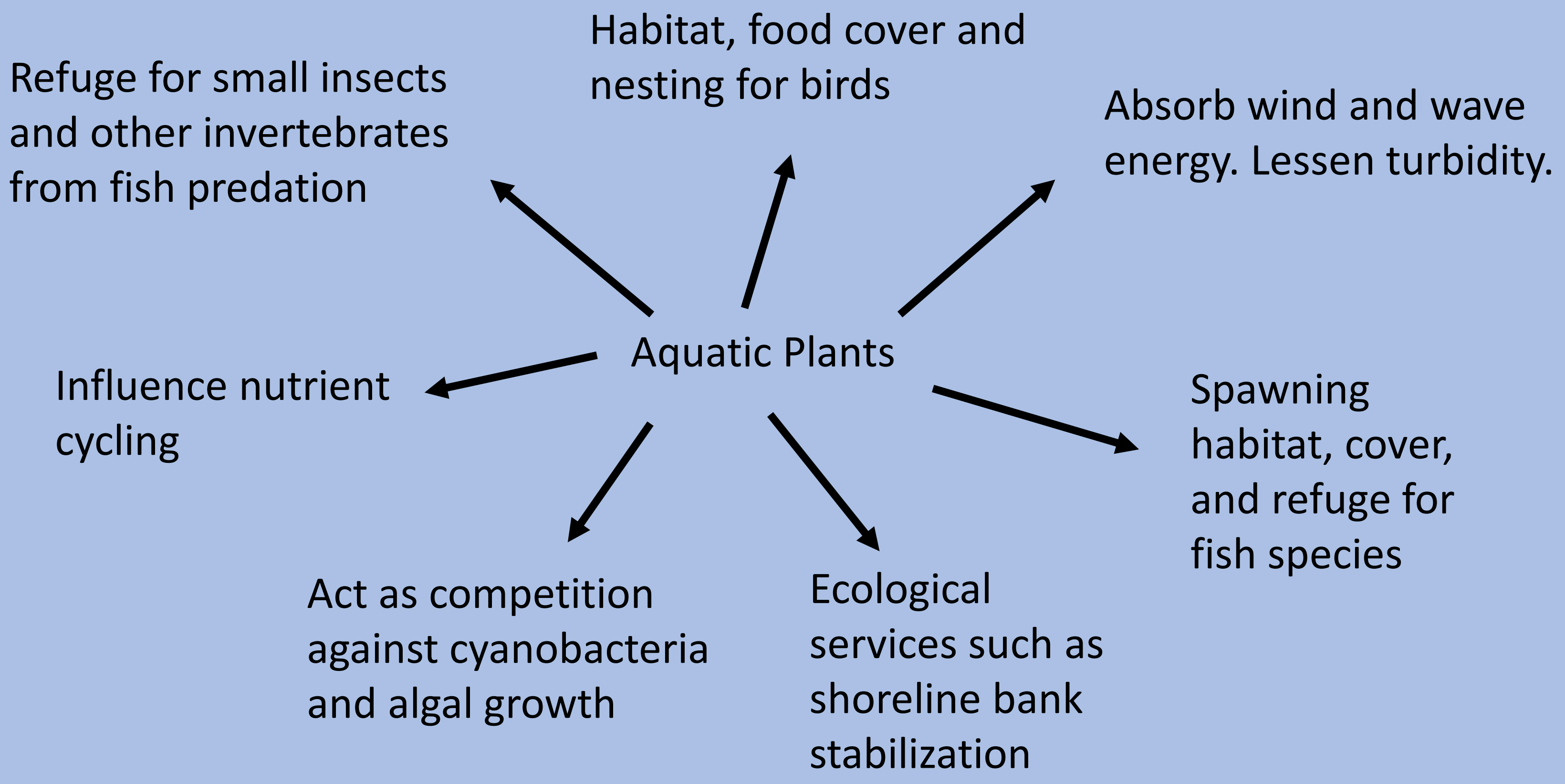
If the aquatic plants are more competitively viable and outcompete algae, then we call it a aquatic vegetation dominated stable state.
Indian Lake currently.

Somewhere in the middle you may have a balanced stable state OR lake-specific stable state.

If the algae is more competitively viable and outcompete aquatic vegetations, then we call it an algal dominated stable state.

Discussion

- **Importance of aquatic vegetation (adapted from Cooke et al. 2005):**

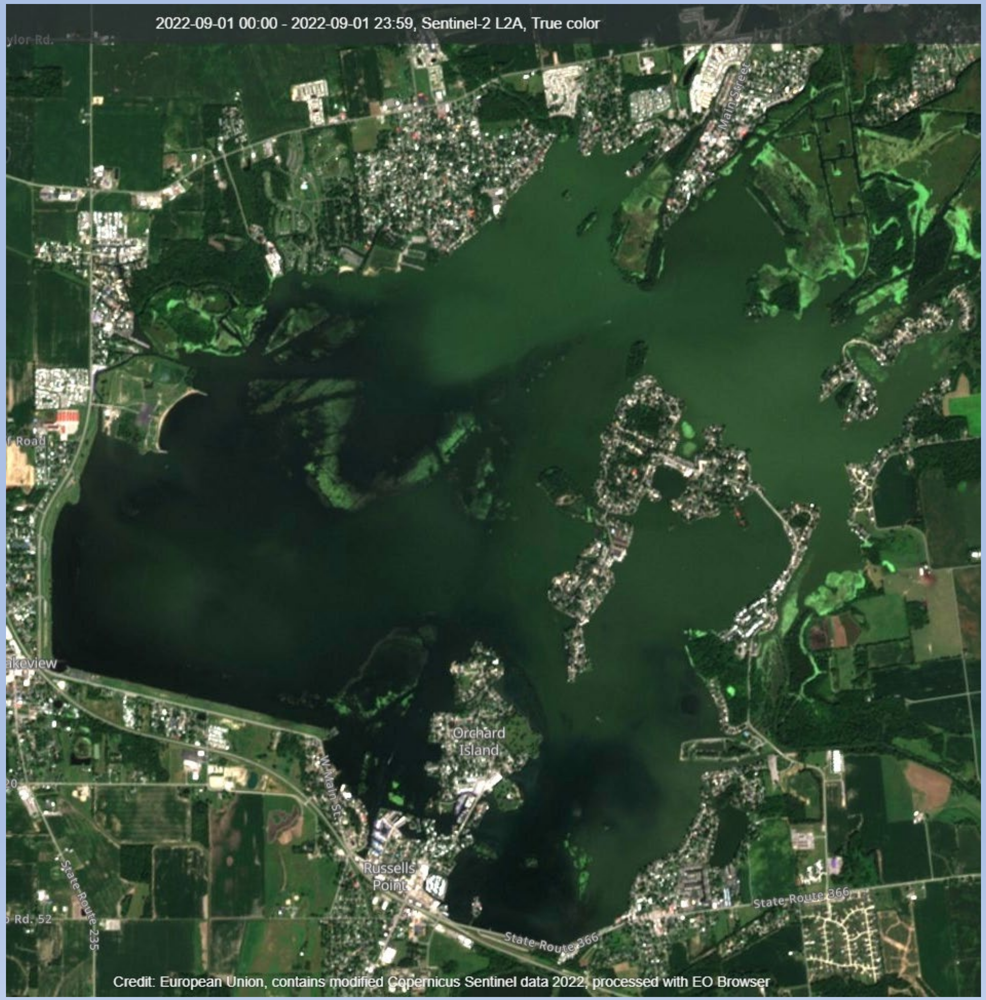


<u>A stable population of non-nuisance vegetation is important for the integrity of the lake.</u>

Discussion

- **Management actions during the 2022 season.**
    - **Harvesting throughout the general use season (70,434 Cu yds; 10,860 [2021]).**
    - **ProcellaCOR application (200 acres) July**
    - **2nd ProcellaCOR application (200 acres) August**

July 3, 2022



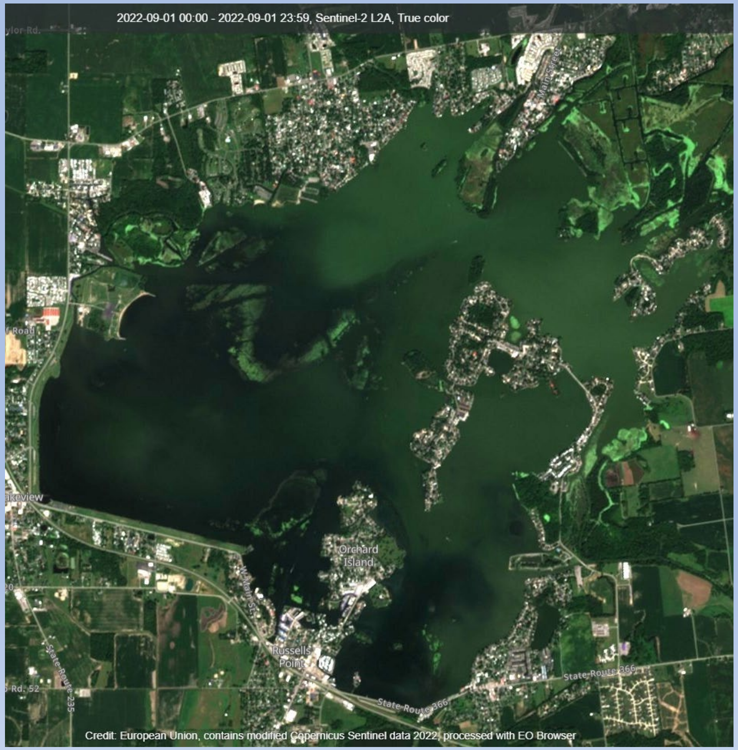
Sept 1, 2022

Discussion

- **Where is Indian Lake based off collected information:**
  1) **Indian Lake will require the use of intensive short-term management techniques in order to maintain its best categorical use as a recreational waterbody.**
     a. **Based on testing success of herbicide usage and mechanical harvesting, these techniques can be carried into 2023 as short term management techniques.**
     b. **Any large-scale (100+ acres) applications should be done early on and in manageable chunks (200 – 300 acres) to reduce potential oxygen issues.**
     c. **Herbicide locations should key in on areas unmanaged in 2022 for maximum effect (post-assessment of last year's treatment zones for longevity analysis).**
     d. **Harvesting should prioritize key recreational/navigational zones and should dominantly target coontail.**

Key Targets
- **Milfoil**
- **Coontail**
- **Curly-leaf pondweed**

Key Areas
- **Outside Blackhawk**
- **Spillway**
- **Navigation Areas**
- **Recreational Zones**
- **Isolated Plots**



Discussion

- **Target/management prioritization:**

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

July 3, 2022

Sept 1, 2022

Discussion

- **<u>Goal development:</u> 70% of the lake navigable for use by the 4th of July (95% of open zone) to maintain its best categorical use as a recreational lake.**

- A simple rake toss assessment in April should yield information pertaining to potential milfoil regrowth to confirm ProcellaCOR EC long-term control success.

- If deemed successful, focus should move to early application of remaining three areas noted with topped-out growth persisting near the end of the 2022 season (previous slide).

- If not, reapplication with granular herbicide should manage growth while milfoil is in its early stages of regrowth.

- Rake-toss survey data can confirm success of management of key areas.

- Harvesters clean surface mats (if applicable) and future channels/coontail.

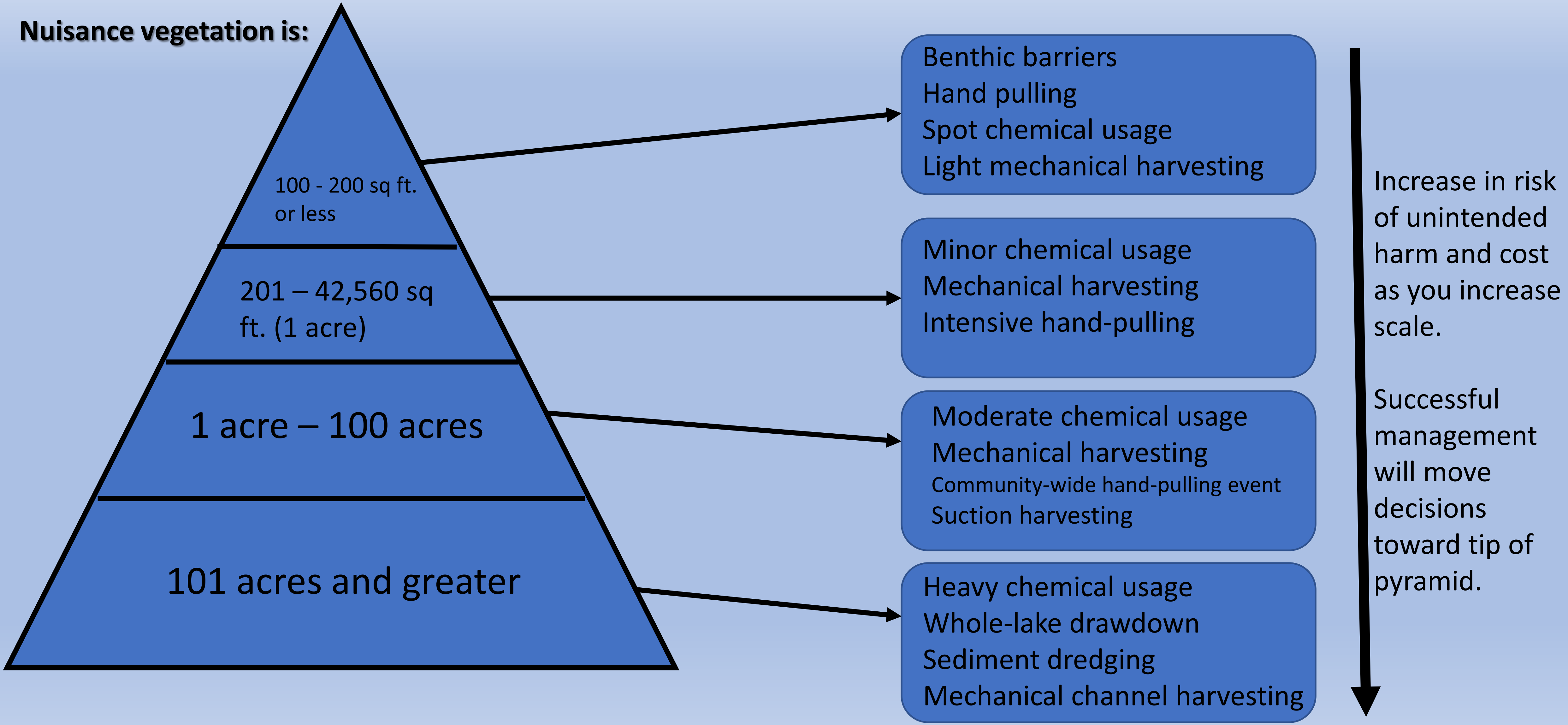
Discussion

- **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).

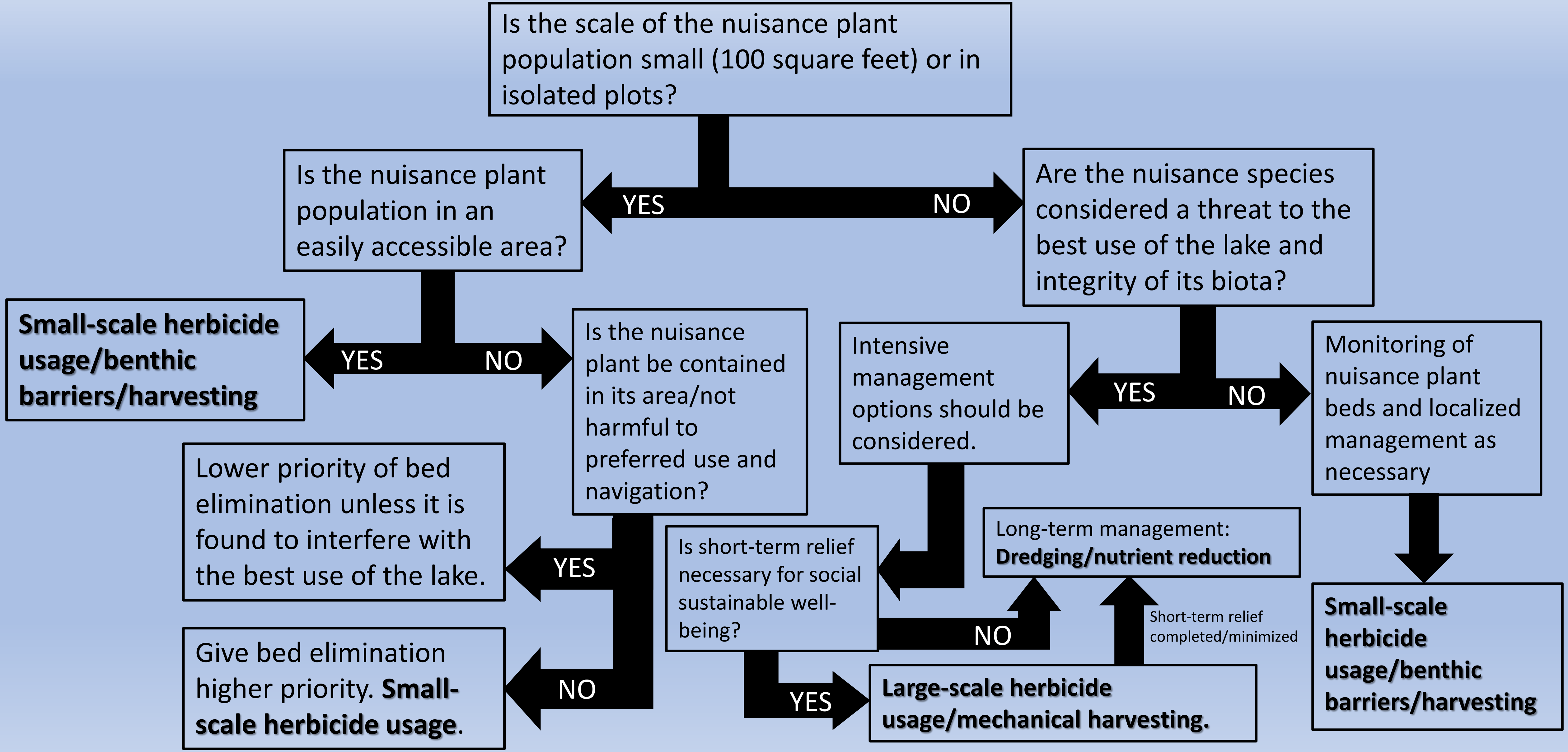
Discussion

- **Management of nuisance vegetation based off scale (thinking framework).**



Discussion

- **Short-term management of nuisance vegetation based off scale (concept adapted from NYSFOLA 2009).**



Discussion

- **Suggested Timeline for 2023 short-term relief:**

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.

Discussion

- Techniques to improve efficiency and reduce risk (Herbicides):

1. **Harvesting an area followed up with granular herbicide applications.**
   - Cut vegetation near the bottom can be treated with granular versions of herbicide products. The granular products will remain in the target zone longer (increasing concentration and contact time) and be less impacted by boat traffic.
   - Less overall biomass means less decomposition which reduces oxygen demand.
   - Harvested areas should experience longer control of nuisance growth.

2. **Utilize granular products in areas of expected high boat traffic or water movement.**
   - Will increase contact time and concentration while reducing potential for drift.
   - Greater likelihood for control success.

3. **Ensure large applications are done in controlled, meaningful chunks.**
   - Reduces risk of increasing biological oxygen demand beyond photosynthetic activity (increase oxygen use beyond what can be added).
   - Treating all the vegetation at once if it becomes extreme (like 2022) is not suggested as the potential for harm is not worth the risk if the same result can be made in a more controlled manner.
   - Ensuring chemical applications are done in a manner that is controlled, monitored, and thoughtful will reduce potential negative impacts and allow us to note success.

4. **Rotate usable chemicals to reduce potential for target resistance.**
   - Many target plants have multiple chemicals that can impact it. Many chemicals have multiple manufacturers.

Discussion

- Techniques to improve efficiency and reduce risk (Harvesting):

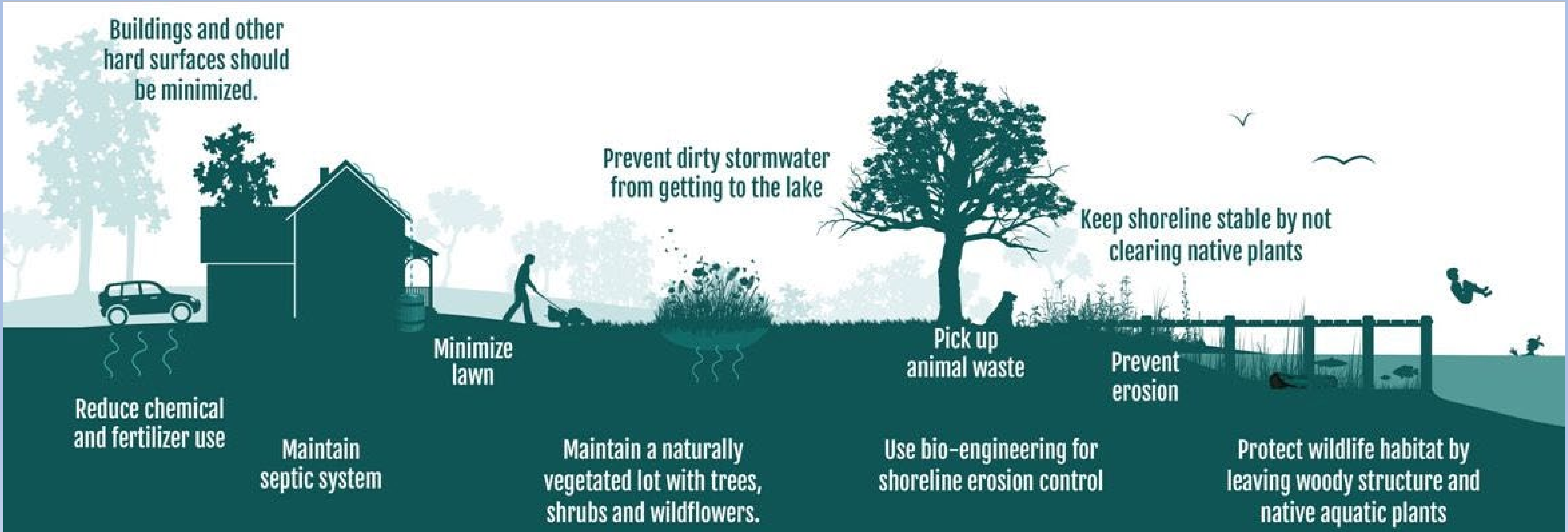
1. **Ensure drop off points are pre-established and reduce overall carry distance or consider a barge.**
    - Less distance for travel means more material can be collected with a reduced overall cost of operation.
    - Lake can be broken into quadrants with established drop-off points based in areas of greatest concern.
    - Already established and improved during the 2022 season.

2. **Be as selective as possible on what is being targeted and where. Focus on coontail removal if it increases in the lake.**
    - Reducing fragmentation is important to consider to reduce respread of nuisance species (e.g. Milfoil).
    - Coontail does not need to be rooted to grow and persist. Harvesting can grab unrooted plants that float around the lake.
    - Chemical control does not work well when plants do not remain in treatment zone.

3. **Utilize harvesting for creation and maintenance of channels.**
    - Maintain navigation from one part of the lake to another.
    - Herbicide management is more efficient for larger chunk removal.

Discussion

- **Long-term suggestions and threshold development.**
  - **In order to best manage Indian Lake into the future, consistent monitoring will be necessary to develop management thresholds and goals.**
  - **Nutrient reduction (phosphorus in particular) overtime will increase the potential for sustainable nuisance plant and algae control.**
  - **How do lakes reduce their nutrient load?**
    - ✓ **Supporting best management practices (BMPs) that reduce nutrients as much as possible (i.e. figure below).**
    - ✓ **Removing nutrient rich sediments.**



Muskegon lake watershed project

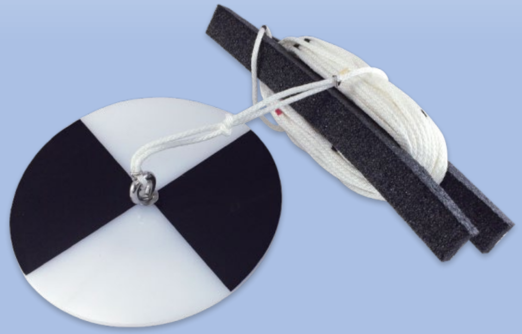
Discussion

- **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.	

Discussion

- **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 α
6) Fecal coliforms/*E. coli*
7) Microcystin

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

(Items 5–7:) Important for human health concerns

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.

Discussion

- **Some notes on dredging**
  - **Maintaining low vegetation growth in Indian Lake may be difficult due to its shallow nature, high nutrient levels, and quantity of soft sediment. Dredging would be useful to reduce these points.**
  - **Large scale dredging operations are complex and expensive. Price will vary due to a large number of variables.**
  - **Early data suggest there is a large quantity of soft substrate material in areas with dense plant growth persists.**

Discussion

- **Costs**
  - **Note that costs for managing lakes are highly variable due to dynamic nature of lakes.**

Technique	Estimated cost *per acre* (Holdren et al 2001; adjusted for inflation)	Estimated cost *per acre* (NYSFOLA 2009; adjusted for inflation)	Considerations
Chemical application 2022 ProcellaCOR ($163,500 per 200 acre application)	$300 - $3,000	$250 - $1,900	What is the chemical and what rates need to be used? What equipment is needed?
Dredging (average sediment depth of 5 ft.)	$60,000 - $120,000	$1,500 - $60,000 (average sediment depth of 3 ft.)	See previous
Harvesting (Mechanical)	$1,500 - $2,250	$124,000 - $248,000 (purchase machine, does not include salary of operator)	How many harvesters are needed? What salary do you pay operators? How often do they run?
Benthic barrier Installation/removal/maint.	$30,000 - $75,000 (Professionally)	$12,500 - $25,000 (Professionally)	What material are you using? Are you maintaining it yourself?
Hand Pulling with biomass removal	$150 - $750	>$1,200 (Professionally)	Are you paying someone else to do it? How dense are the plants and how big is the area of concern?
Suction harvesting	$7,500 - $15,000	$1,200 - $31,000 excluding equipment cost	How many workers are needed? What type of equipment is being run? How dense are the plants and how large is the area of concern?

Conclusions and Summary

Short-term work (2023):

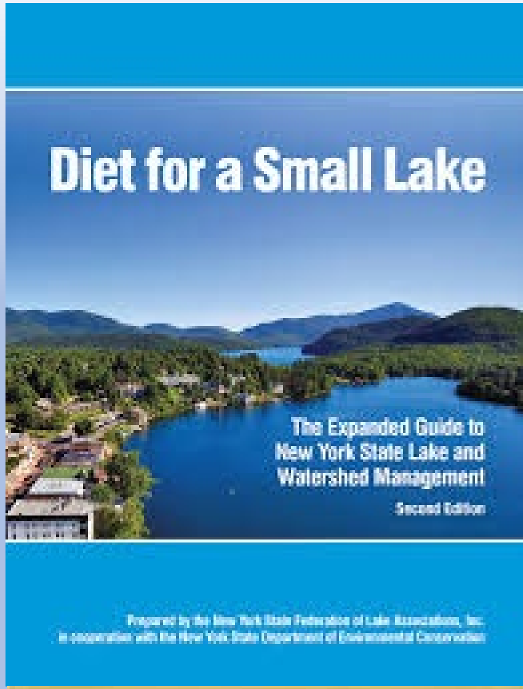
- Assess success of ProcellaCOR EC in treatment zones to determine extent of regrowth if any.
- Based off of the demonstrated successes shown by herbicide usage these products can be used to provide relief against remaining beds of milfoil at scale.
- Harvesting to continue into 2023 to focus on navigation channels and coontail/floating chop removal.
- Prioritize larger-scale areas of concern early to focus on smaller-scale management later. This will reduce future cost and reduce overall environmental impact.
- Continue monitoring work including chemical, physical, and biological data collection.

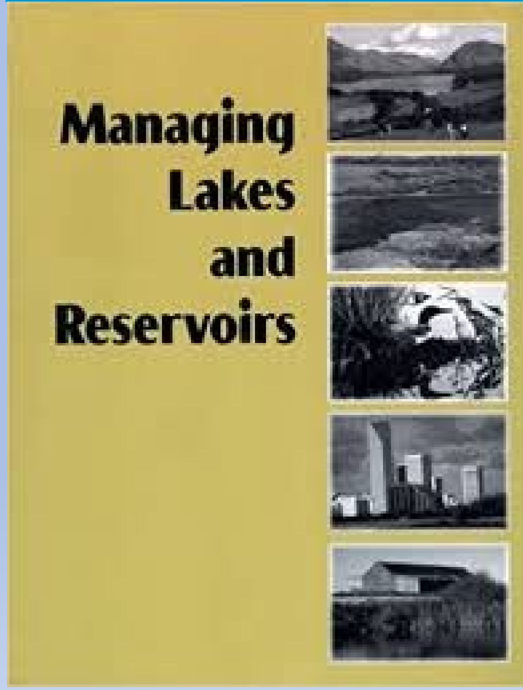
Long-term work (2023 and beyond):

- Establish continual monitoring procedures to collect consistent information for threshold and future goal establishment.
- Enact and support BMPs in order to reduce long-term nutrient loading.
- Dredging will likely need to be incorporated to reduce internal nutrients.
- Continue dynamic management decision making for future short-term needs as time goes on.

Useful resources for those interested:

- “Diet for a Small Lake” (New York State Federation of Lake Associations, 2009) FREE ONLINE
- “Managing Lakes and Reservoirs” (NALMS, 2001) FREE THROUGH THE EPA (Google Search)
- “Restoration and Management of Lakes and Reservoirs” (Cooke et al. 2005)





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