Aquatic Macrophyte Survey-Point Intercept Method

Grindstone Lake (WBIC: 2391200)

Sawyer County Wisconsin

June/August 2021

Sponsored by: Wisconsin DNR and Grindstone Lake Association

Conducted by: Ecological Integrity Service, LLC

Survey summary

The 2021 Grindstone Lake Aquatic Macrophyte Survey revealed a healthy and diverse plant community. There were 34 species of native aquatic plants sampled in the survey. The Simpson's diversity index was 0.92. The plant coverage was limited, with 48.8% of the littoral zone (defined by the maximum depth of plants) having plants sampled. Numerous sensitive plants were sampled, resulting in an FBI of 39.2. The mean conservatism value for plants sampled was 6.82. There were no invasive plant species sampled or viewed. Three invasive species were observed around the lake. These three species were: aquatic forget me not (*Myosotis scorpioides*), reed canary grass (*Phalaris arundinacea*), and purple loosestrife (*Lythrum salicaria*). A chi-square analysis of the frequency in 2006 vs. 2021 showed a statistically significant increase in 10 species. Five species had a statistically significant decrease between 2006 and 2021. The number of species sampled increased from 24 to 34 between 2006 and 2021.

Introduction

In June and August 2021, an aquatic macrophyte survey was conducted on Grindstone Lake (WBIC: 2391200) in Sawyer County, Wisconsin, using the point intercept method developed by the Wisconsin Department of Natural Resources. Grindstone Lake is a 3176-acre lake with a maximum depth of 60 feet and a mean depth of 30 feet. The lake is designated a drainage lake with an oligotrophic/low mesotrophic trophic status. Development around the lakes is moderate (no quantitative designation, just a basic observed description).

This report summarizes and analyzes data collected in 2021 and compares the 2006 baseline aquatic macrophyte survey. The survey's primary goal is to conduct long-term monitoring of aquatic plant populations and evaluate any changes that may occur from human impact. Invasive species presence and locations are critical components to a survey of this type. This survey is acceptable for aquatic plant management planning purposes in Wisconsin.

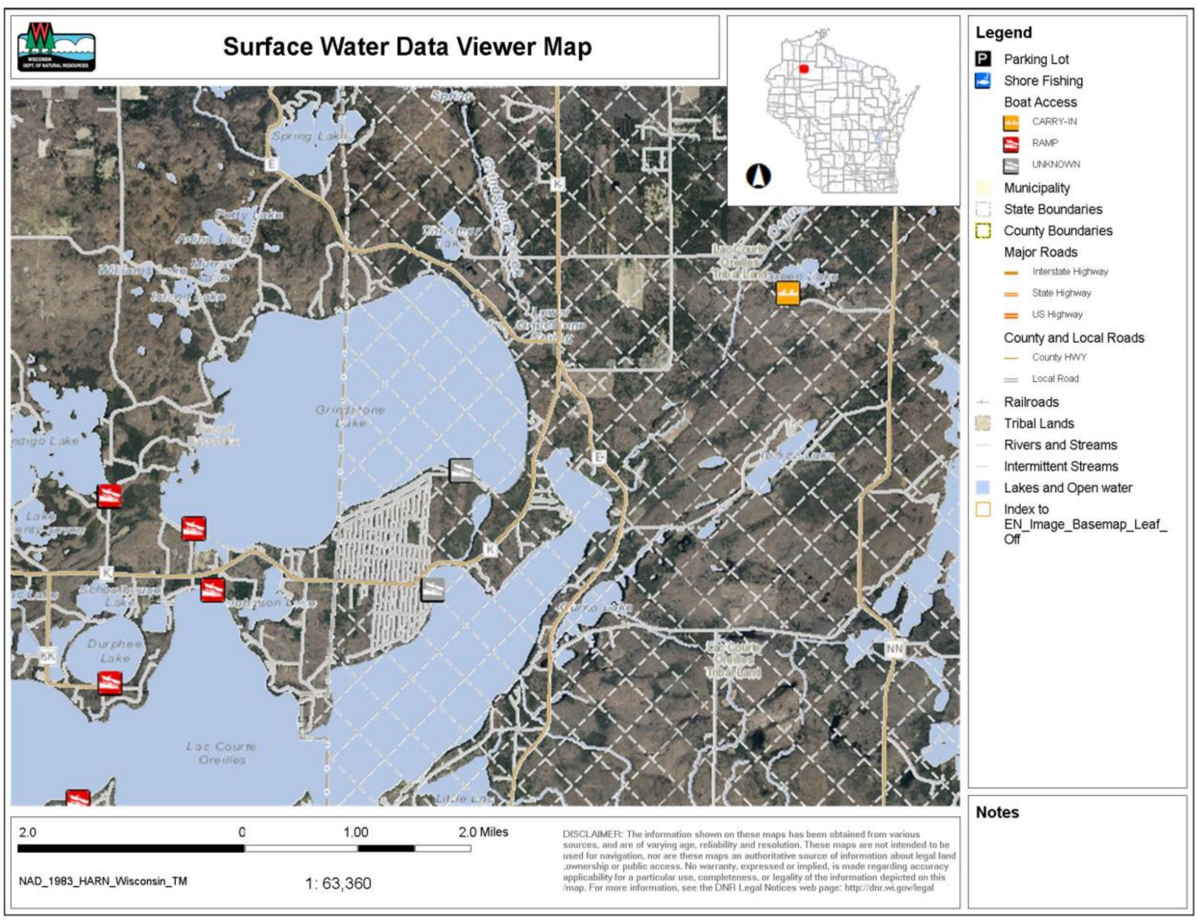


Figure 1: Map of Grindstone Lake located within Wisconsin and public landing.[1]

[1] Map generated from the Wisconsin DNR surface water viewer: https://dnrmaps.wi.gov/H5/?Viewer=SWDV

Field Methods

A point intercept method was employed for the aquatic macrophyte sampling. The Wisconsin Department of Natural Resources (Wisconsin DNR) generated the sampling point grids for each lake. All points were initially sampled for depth only. Once the maximum depth of plant growth was established, only points at that depth (or less) were sampled. If no plants were sampled, one point beyond that was sampled. In areas such as bays that appear to be under-sampled, a boat or shoreline survey was conducted to record plants that may have otherwise been missed. The process involved surveying that area for plants and recording the species viewed or sampled. The type of habitat is also recorded. These data are not used in the statistical analysis, nor is the density recorded. Only plants sampled at predetermined points were used in the statistical analysis. Any plant within 6 feet of the boat was recorded as "viewed." A handheld Global Positioning System (GPS) located the sampling points in the field. The Wisconsin DNR guidelines for point location accuracy followed a 50-foot resolution window and the location arrow touching the point.

The sample grid was surveyed twice in 2021. The early season survey mainly watched for the invasive species Potamogeton crispus (curly-leaf pondweed) in June. This plant grows early and has typically senesced when the late-season survey is conducted, which occurred in early August when most aquatic plants are actively growing.

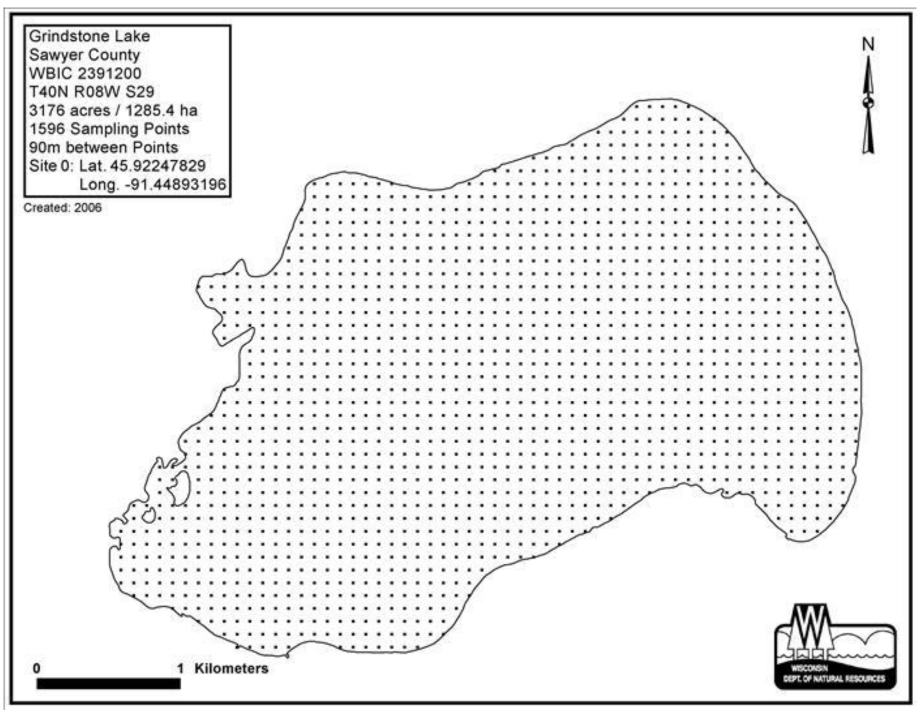


Figure 2: Point-intercept sample grid for Grindstone Lake.[2]

A double-sided fourteen-tine rake was used at each sample location to rake a 1-meter tow off the boat's bow. All plants present on the rake and those that fell off the rake were identified and rated for rake fullness. The rake fullness value was used based on the criteria contained in figure 3 and table 1 below. The plants within 6 feet were recorded as "viewed," but no rake fullness rating was given. Any under-

[2] Sampling grid was generated by the Wisconsin Dept. of Natural Resources.

surveyed areas, such as bays and areas with unique habitats, were monitored. These areas are referred to as a "boat survey or shoreline survey."

The rake density criteria used:

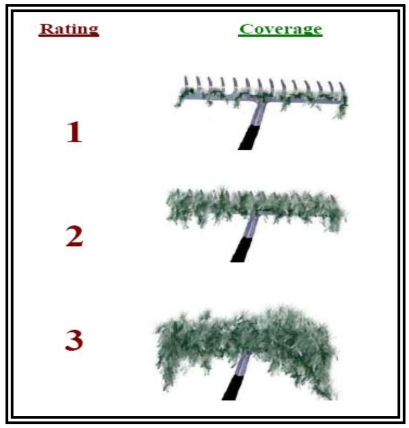


Figure 3: Rake fullness diagram

Rake fullness rating	Criteria for rake fullness rating
1	Plant present occupies less than ½ of tine space
2	Plant presence occupies more than ½ tine space
3	Plant present occupies all or more than tine space
v	Plant not sampled but observed within 6 feet of boat

Table 1: Rake fullness criteria descriptions.

The depth and predominant sediment types were also recorded for each sample point. Caution must be used in determining the sediment type data in deeper water as it is difficult to discern between muck and sand with a rope rake. All plants needing verification were bagged and cooled for later examination. Each species was mounted and pressed for a voucher collection and submitted to the Freckmann Herbarium (UW-Stevens Point) for review.

Data analysis methods

Data collected and analyzed resulted in the following information:

- Frequency of occurrence (FOO) in sample points with vegetation (littoral zone)
- Relative frequency
- Total points in sample grid
- Total points sampled
- Sample points with vegetation
- Simpson's diversity index
- Maximum plant depth
- Species richness
- Floristic Quality Index

An explanation of each of these data is provided below.

Frequency of occurrence for each species- Frequency is expressed as a percentage by dividing the number of sites the plant is sampled by the total number of sites, which calculates to two possible values. The first value is the percentage of all sample points of a particular plant that were sampled at depths less than maximum depth plants (littoral zone), regardless of vegetation was present. The second is the percentage of sample points of a particular plant at only points containing vegetation. The first value shows how often the plant would be present in the defined littoral zone (by depth), while the second value indicates the frequency of the plant in vegetated areas. The greater this value, the more frequent the plant is present in the lake in either case. When comparing frequency in the littoral zone, plant frequency is observed at maximum depth. This frequency value is used to analyze the occurrence and location of plant growth based on depth. The frequency of occurrence is usually reported using sample points where vegetation was present.

Frequency of occurrence example:

Plant A sampled at 35 of 150 littoral points = 35/150 = 0.23 = 23%

Plant A's frequency of occurrence = 23% considering littoral zone depths.

Plant A sampled at 12 of 40 vegetated points = 12/40 = 0.3 = 30%

These two frequencies will show how common the plant was sampled in the littoral zone or how common the plant was sampled at points plants actually grow. Generally, the second will have a higher frequency since that is where plants are actually growing as opposed to where they could grow. This analysis will consider vegetated sites for frequency of occurrence (FOO) in most cases.

Relative frequency-This value shows a percentage of the frequency of a particular plant relative to other plants. This is not dependent on the number of points sampled. The relative frequency of all plants totals 100%. If plant A had a relative frequency of 30%, it occurred 30% of the time or made up 30% of all plants sampled. This value demonstrates which plants are the dominant species in the lake. The higher the relative frequency, the more frequent the plant is compared to the other plants.

Relative frequency example:

Suppose 10 points were sampled in a very small lake and got the following results:

	Frequency sampled
Plant A present at 3 sites	3 of 10 sites
Plant B present at 5 sites	5 of 10 sites
Plant C present at 2 sites	2 of 10 sites
Plant D present at 6 sites	6 of 10 sites

Results show Plant D is the most frequent sampled plant at all points with 60% (6/10) of the sites having plant D. However, the relative frequency displays what the frequency is compared the other plants, without taking into account the number of sites. It is calculated by dividing the number of times a plant is sampled by the total of all plants sampled. If all frequencies are added (3+5+2+6), the sum is 16. In this case, the relative frequency calculated by dividing the individual frequencies by 16.

Plant A = 3/16 = 0.1875 or 18.75%
Plant B = 5/16 = 0.3125 or 31.25%
Plant C = 2/16 = 0.125 or 12.5%
Plant D = 6/16 = 0.375 or 37.5%

In comparing plants, Plant D is still the most frequent, but the relative frequency tells us that of all plants sampled at those 10 sites, 37.5% of them are Plant D. This is much lower than the frequency of occurrence (60%) because although Plant D was sampled at 6 of 10 sites, many other plants were sampled too, thereby giving a lower frequency when compared to those other plants. This shows the true value of the dominant plants present.

Total points in the sample grid- The Wisconsin DNR establishes a sample point grid covering the entire lake. Each GPS coordinate is mapped and used to locate the points.

Sample sites less than the maximum depth of plants-The maximum depth at which a plant is sampled is recorded. This defines the depth plants can grow (littoral zone). Any sample point with a depth less than or equal to this is recorded as a sample point less than the maximum depth of plants. This depth is used to determine the potential littoral zone.

Sample sites with vegetation- The number of sites where plants were sampled gives a projection of plant coverage on the lake. Vegetation in 10% of all sample points implies about 10% coverage of plants in the whole lake, assuming an adequate number of sample points have been established. The littoral zone is observed for the number of sample sites with vegetation. If 10% of the littoral zone had sample points with vegetation, then the estimated plant coverage in the littoral zone is 10%.

Simpson's diversity index-Simpson's diversity index is used to measure the diversity of the plant community. This value can run from 0 to 1.0. The greater the index value, the more diverse the plant community. In theory, the value is the chance that two species sampled are different. An index of "1" indicates that the two will always be different (diverse), and a "0" means that the species will never be other (only one found). The higher the diversity in the native plant community, the healthier the lake ecosystem.

Simpson's diversity example:

If a lake was sampled and observed just one plant, the Simpson's diversity would be "0" because if two plants were randomly sampled, there would be a 0% chance of them being different, since there is only one plant.

If every plant sampled were different, then the Simpson's diversity would be "1." This is because if two plants were randomly sampled, there would be a 100% chance they would be different since every plant is different.

These are extreme and theoretical scenarios, but they demonstrate how this index works. The greater the Simpson's index for a lake, the more likelihood two plants sampled are different.

Maximum depth of plants-This depth indicates the greatest depth that plants were sampled. Generally, clear lakes have a greater depth of plants, while lower water clarity limits light penetration and reduces the depth at which plants are found.

Species richness-The number of different individual species found in the lake. There is a value for the species richness of plants sampled and another value that documents plants viewed but not sampled during the survey.

Floristic Quality Index- The Floristic Quality Index (FQI) was developed by Dr. Stanley Nichols of the University of Wisconsin-Extension. This index measures the plant community in response to development (and human influence) on the lake. It considers the species of aquatic plants sampled and their tolerance for changing water quality and habitat quality. The index uses a conservatism value assigned to various plants ranging from 1 to 10. A higher conservatism value indicates that a plant is intolerant, while a lower value indicates tolerance. Those plants with higher values are more apt to respond adversely to water quality and habitat changes, mainly due to human influence (Nichols, 1999). The FQI is calculated using the number of species and the average conservatism value of all species used in the index.

The formula is: $FQI = \text{Mean } C \cdot \sqrt{N}$

Where C is the conservatism value, and N is the number of species (sampled on rake only).

Therefore, a higher FQI indicates a healthier aquatic plant community, which means a better plant habitat. This value can then be compared to the median for other lakes in the assigned eco-region. Four eco-regions are used throughout Wisconsin: Northern Lakes and Forests, Northern Central Hardwood Forests, Driftless Area, and Southeastern Wisconsin Till Plain. This analysis also compares the 2013 and 2019 macrophyte surveys.

Summary of Northern Lakes and Forests for Floristic Quality Index:

(Nichols, 1999)

	Northern Lakes and Forests
Median species richness	13
Median conservatism	6.7
Median Floristic Quality	24.3

*Floristic Quality has a significant correlation with area of lake (+), alkalinity(-), conductivity(-), pH(-) and Secchi depth(+). In a positive correlation, as that value increases so will FQI, while with a negative correlation, as a value decreases, the FQI will decrease.

Results

The 2021 aquatic macrophyte survey showed that the plant community in Grindstone has limited coverage throughout the lake, with less than 50% of the defined littoral zone (depth plants can grow in the lake) and only 16.9% of the entire lake with plant growth (see Figure 4 for rake fullness showing where plants were sampled and the density). The diversity is relatively high with 34 species sampled on the rake, especially considering that Grindstone Lake has limited aquatic plant habitat (substrate is dominated by rock and sand, limiting species that can flourish). The Simpson's diversity index at 0.92 shows high diversity within the lake.

Total number of sites in entire lake survey	1596
Total number of sites with vegetation	270
The total number of sites is shallower than the maximum depth of plants	553
Frequency of occurrence at sites shallower than the maximum depth of plants	48.82%
Frequency of occurrence for entire lake bed	16.92%
Simpson Diversity Index	0.92
Mean rake fullness (all samples with plants) (scale of 1-3)	1.19
Maximum depth of plants (ft)	25.60
Mean depth of plants (ft)	7.54
The average number of all species per site (shallower than max depth)	1.10
The average number of all species per site (veg. sites only)	2.25
The average number of native species per site (shallower than max depth)	1.10
The average number of native species per site (veg. sites only)	2.25
Species Richness (sampled on rake only)	34
Species Richness (including visuals)	35

Table 3: Summary statistics from 2021 full-lake aquatic macrophyte survey.

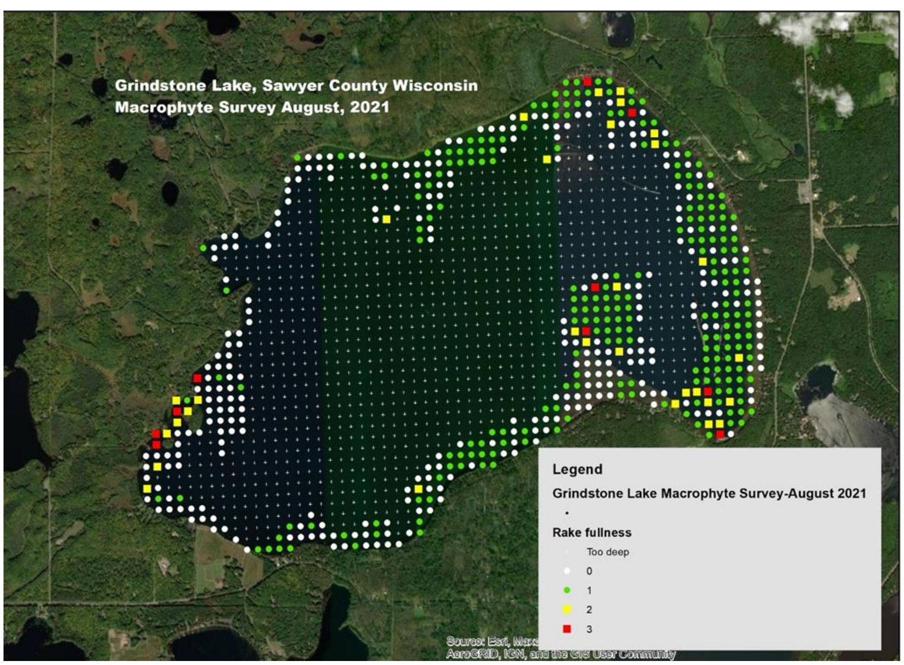


Figure 4: Map showing sample points with plants sampled and the total density (rake fullness).

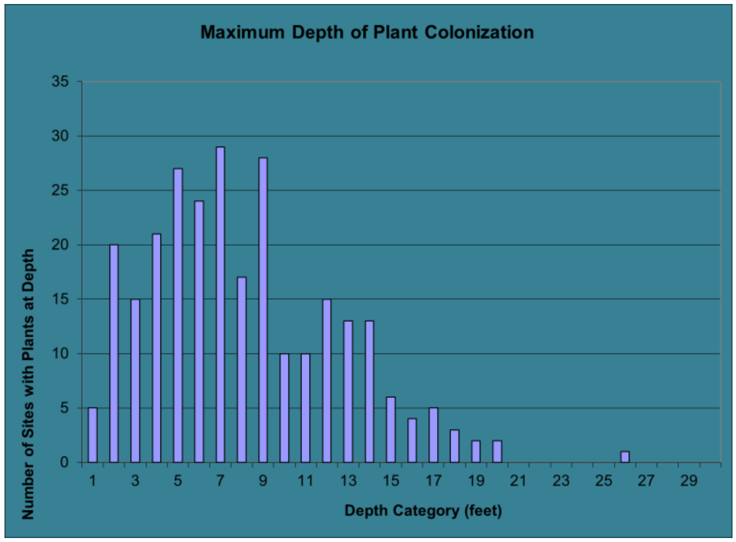


Figure 5: Depth analysis graph showing amount of growth at various depths.

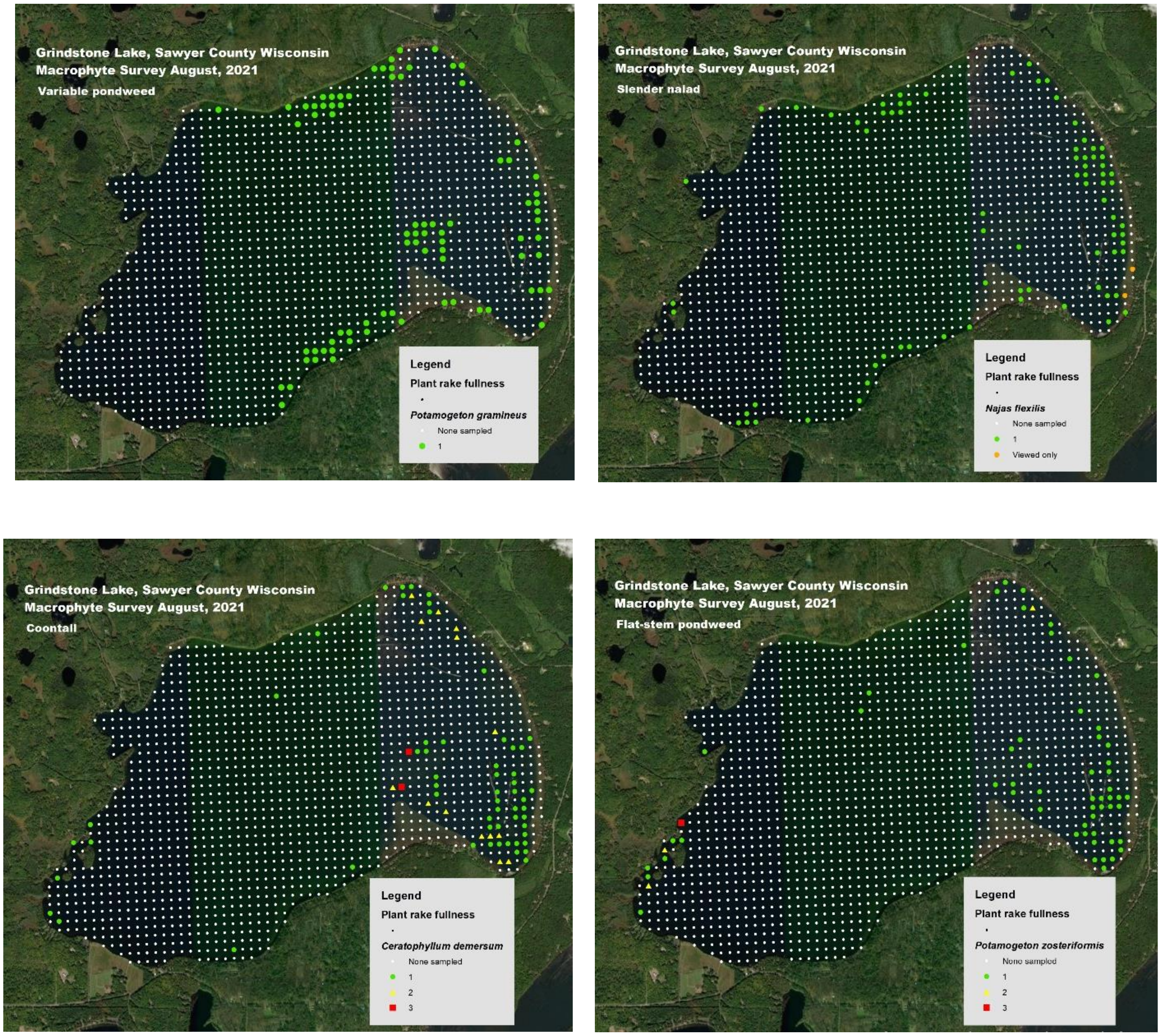
The greatest depth in Grindstone with plants growing was 25.6 ft. This supports the high-water clarity observed in the lake. More clear water allows enough light intensity in deeper water to facilitate photosynthesis. Figure 5 shows that plants mostly grow in 2-9 feet depths.

Species	FOO[1] veg	FOO[2] littoral	Rel.[3] freq.	# Sampled	Mean Rake Fullness	# viewed
Potamogeton gramineus, Variable pondweed	29.63	14.47	13.20	80	1.00	
Najas flexilis, Slender naiad	27.78	13.56	12.38	75	1.00	2
Ceratophyllum demersum, Coontail	27.04	13.20	12.05	73	1.25	
Potamogeton zosteriformis, Flat-stem pondweed	22.22	10.85	9.90	60	1.08	
Chara sp., Muskgrasses	16.30	7.96	7.26	44	1.00	
Vallisneria americana, Wild celery	12.22	5.97	5.45	33	1.00	2
Elodea canadensis, Common waterweed	10.74	5.24	4.79	29	1.00	
Myriophyllum sibiricum, Northern water-milfoil	10.37	5.06	4.62	28	1.14	
Potamogeton richardsonii, Clasping-leaf pondweed	10.37	5.06	4.62	28	1.04	3
Eleocharis acicularis, Needle spikerush	8.89	4.34	3.96	24	1.04	1
Potamogeton pusillus, Small pondweed	7.78	3.80	3.47	21	1.10	
Potamogeton robbinsii, Fern pondweed	7.78	3.80	3.47	21	1.00	
Myriophyllum alterniflorum, Alternate-flowered water-milfoil	7.04	3.44	3.14	19	1.00	
Potamogeton praelongus, White-stem pondweed	3.33	1.63	1.49	9	1.00	
Myriophyllum tenellum, Dwarf water-milfoil	2.96	1.45	1.32	8	1.00	
Potamogeton amplifolius, Large-leaf pondweed	2.96	1.45	1.32	8	1.00	
Nitella sp., Nitella	2.22	1.08	0.99	6	1.00	
Elodea nuttallii, Slender waterweed	1.85	0.90	0.83	5	1.00	
Sagittaria cristata, Crested arrowhead	1.85	0.90	0.83	5	1.00	
Sagittaria cuneata, Arum-leaved arrowhead	1.85	0.90	0.83	5	1.00	1
Juncus pelocarpus f. submersus, Brown-fruited rush	1.48	0.72	0.66	4	1.00	
Potamogeton friesii, Fries' pondweed	1.48	0.72	0.66	4	1.00	
Bidens beckii, Water marigold	1.11	0.54	0.50	3	1.00	
Potamogeton illinoensis, Illinois pondweed	1.11	0.54	0.50	3	1.00	1
Elatine minima, Waterwort	0.74	0.36	0.33	2	1.00	1
Ranunculus aquatilis, White water crowfoot	0.74	0.36	0.33	2	1.00	
Heteranthera dubia, Water star-grass	0.37	0.18	0.17	1	1.00	
Isoetes echinospora, Spiny spored-quillwort	0.37	0.18	0.17	1	1.00	
Lobelia dortmanna, Water lobelia	0.37	0.18	0.17	1	1.00	
Nuphar variegata, Spatterdock	0.37	0.18	0.17	1	1.00	
Nymphaea odorata, White water lily	0.37	0.18	0.17	1	1.00	1
Ranunculus flammula, Creeping spearwort	0.37	0.18	0.17	1	1.00	
Schoenoplectus pungens, Three-square bulrush	0.37	0.18	0.17	1	1.00	
Stuckenia pectinata, Sago pondweed	0.37	0.18	0.17	1	1.00	
Eleocharis palustris, Creeping spikerush	viewed	only				1
Filamentous algae	8.52	4.16		23	1.04	
Aquatic moss	0.74	0.36		2	1.00	

Table 4: Species list with frequency and rake fullness data. (FOO[1] is the frequency of occurrence where plant growth occurs; FOO[2] is the frequency of occurrence in the littoral zone defined by depth only; Rel.[3] is the relative frequency of the plant.)

The most common plants sampled in Grindstone Lake are common plants found in Wisconsin lakes, and all serve essential roles in the lake ecosystem. The most frequently sampled plant in the 2021 survey was variable pondweed (*Potamogeton gramineus*), followed by slender naiad (*Najas flexilis*), coontail (*Ceratophyllum demersum*), and flat-stem pondweed (*Potamogeton zosteriformis*).

Figure 6: Distribution maps of the four most commonly sampled plants during the 2021 survey.



Variable pondweed is often associated with low nutrient substrates, common in Grindstone Lake. It is a reasonably sensitive plant with a conservatism value of "7" (scale of 1-10). This plant can provide suitable habitat and cover for aquatic organisms in areas that may otherwise be limited in plant growth.

Slender naiad is less sensitive with a conservatism value of "6". Slender naiad is considered an essential plant for waterfowl, with the stems and leaves being consumed by many species of ducks. It also provides good cover and feeding areas for fish in low nutrient substrates.

Coontail and flat-stem pondweed are lesser sensitive plants are can be found growing in a wide array of lake habitats. Although these two can grow in many conditions, they still provide critical habitat for invertebrates and fish.

Figure 7: The four most commonly sampled plants in Grindstone Lake. From left to right: variable pondweed, slender naiad, coontail, and flat-stem pondweed. (photo from Paul Skawinski, Aquatic Plants of the Upper Midwest, used with permission).

FQI and Sensitive plants

One way to evaluate the status of the aquatic plant community is by using the Floristic Quality Index (FQI). The FQI is calculated using the number of species and the mean conservatism value for the plants sampled. The conservatism values define how sensitive the plant is to changes in habitat and water quality, mostly related to human activity. The higher the conservatism value, the more sensitive the plant. More sensitive plants will tend to decrease in frequency as habitat degradation occurs. Table 5 summarizes FQI results from the 2021 survey.

The floristic quality index parameter	Grindstone Lake 2021	Median for Northern Lakes and Forests Eco-region
Number of species in FQI	33	13
Mean Conservatism value	6.82	6.7
FQI	39.2	24.3

Table 5: Floristic quality index summary and comparison to eco-region lakes median.

As the data shows, the FQI is substantially higher than the median for lakes studied in the same eco-region. This is due to the higher number of species sampled, and a higher mean conservatism value. This shows that the aquatic plants in Grindstone Lake have not been adversely affected by human activity in and around Grindstone Lake.

There were no endangered, threatened, or species of special concern sampled or viewed in Grindstone Lake. However, several plants sampled are sensitive and have a high conservatism value. The scale for conservatism is 1-10, with the higher value representing more susceptible plants. Sensitive plants are more prone to reductions from habitat changes, often linked to human activity. Table 5 lists five plant species with high conservatism values (9 and 10) and the frequency of occurrence of the plant within vegetated areas of the lake.

Species	Conservatism value	FOO in 2021
Water lobelia (*Lobelia dortmanna*)	10	0.18%
Alternate flowered watermilfoil (*Myriophyllum alternaflorum*)	10	3.44%
Dwarf watermilfoil (*Myriophyllum tenellum*)	10	1.45%
Waterwort (*Elatine minima*)	9	0.36%
Creeping spearwort (*Ranunculus flammula*)	9	0.18%

Table 5: List of sensitive species and the frequency of occurrence.

Aquatic invasive plant species

No invasive species were sampled or viewed in the June or August surveys. The June survey focused on the invasive species curly-leaf pondweed (*Potamogeton crispus*) since its peak is in June and dies off in July. One location had curly-leaf pondweed in 2006 but was not sampled, viewed, or observed in June 2021.

Three invasive species were observed on the shoreline. These plants were: aquatic forget me not (*Myosotis scorpioides*), purple loosestrife (*Lythrum salicaria*), and reed canary grass (*Phalaris arundinacea*). All three of these plants can spread in wetlands and become dominant.

Figure 8: Location of the aquatic forget me not observed during the boat surveys in June and August 2021.

The aquatic forget-me-not observed was just two plants. This was the only location observed, but others could be located around the lake (Figure 8). At this point, there does not appear to be a major infestation, but monitoring of this plant should occur annually.

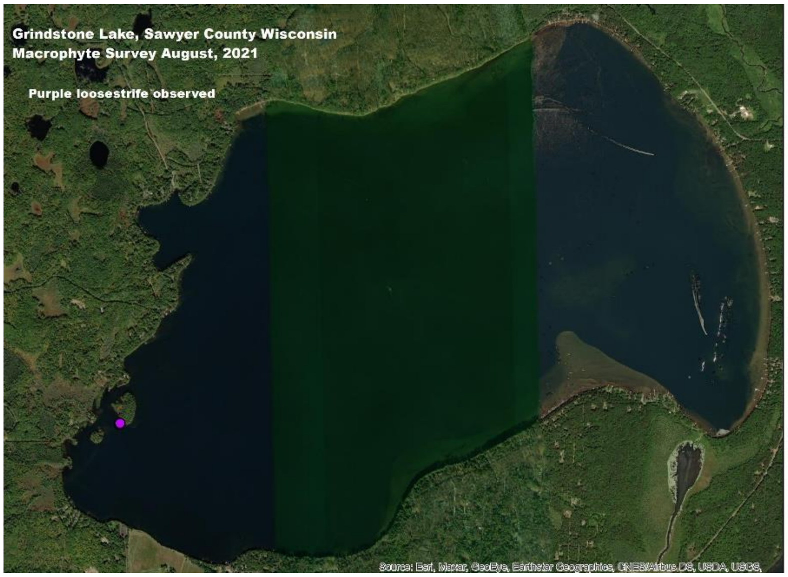


Figure 9: The purple loosestrife was observed during the boat survey in August 2021.

The purple loosestrife was a small clump of plants on the end of the northeast island in the southwest corner of Grindstone Lake (Figure 9). Other locations may be present around the lake, so this plant should be monitored annually.

Reed canary grass occurred at various locations around the lake and was not recorded. It is common for reed canary grass to infiltrate disturbed areas. Mitigation of this plant is typically when restored areas have reed canary grass becomes present. Otherwise, it is widespread in disturbed areas; mitigation is not implemented.

Comparison of 2006-2021 Data

Comparing periodic aquatic macrophyte surveys is essential to determine if any changes in the plant community have occurred. An aquatic macrophyte survey was conducted on Grindstone Lake in 2006. This allows for a comparison between 2006 and 2021. No known plant management activities have occurred on Grindstone Lake, so most changes could be natural variability in the plant community or human activity that negatively affects more sensitive plants.

Statistic	Grindstone Lake 2006	Grindstone Lake 2021
Species richness	24*	34
Simpson's diversity index	0.93	0.92
Maximum depth with plants	27.4 ft*	25.6 ft
Mean conservatism value	6.61	6.82
FQI	31.7	39.2
Sample points with plants	235*	270

*These numbers are adjusted from the 2006 macrophyte survey since Wisconsin DNR no longer included filamentous algae in the species richness or statistics.

Table 6: Comparison statistics for 2006 and 2021 surveys.

The general statistics of 2006 and 2021 are similar. The species richness is higher in 2021, but Simpson's diversity index is slightly lower (0.93 vs. 0.92). The maximum depth of plants was 1.8 feet deeper in 2006 compared to 2021. The mean conservatism was the same, and the FQI was somewhat higher in 2021. There were significantly more sample sites with plants in 2021 than in 2006. This is in part due to the adjustment of removing filamentous algae from the 2006 survey since filamentous algae is no longer included in the plant species richness. There is no indication of any changes to be concerned within the plant community over the past fourteen years.

For a more in-depth analysis of change, the frequency of occurrence of individual species was analyzed using a chi-square analysis. If the frequency change is statistically significant, the p-value derived from the chi-square will be less than 0.05. The lower the p-value, the more statistically significant the difference.

There are various sources for the frequency of occurrence change. Those possible sources are as follows:

1. Management practices, such as herbicide treatments, can cause reductions. Typically, if herbicide treatments of invasive species are utilized, a pretreatment and post-treatment analysis is conducted in those specific areas. The treatment areas would need to be evaluated using the point-intercept sample grid to determine if this is a cause of a reduction in the full lake survey. Furthermore, if herbicide reduces the native species, it depends on the type and concentration of the herbicide. A single species reduction is unlikely. Since no known plant management has occurred, Grindstone Lake should not be a factor.

2. Sample variation can also occur. The sample grid is entered into a GPS unit. The GPS allows the surveyor to get close to the same sample point each time, but there is a possible error of 20 feet or more (the arrow icon is 16 feet in real space). Since the distribution of various plants is not typically uniform but more likely clumped, sampling variation could result in that plant not being sampled in a particular survey. Plants with low frequency could give significantly different values with surveys conducted within the same year.

3. Each year, the timing for aquatic plants coming out of dormancy can vary widely. A late or early ice-out may affect the size of plants during a survey from one year to the next. For example, a lake with a high plant density one year could have a very low density another year. The type of plant reproduction can affect this immensely. If the plant grows from seed or a rhizome each year, the timing can be paramount to the frequency and density are shown in a survey.

4. Identification differences can lead to frequency changes. The small pond weeds such as *Potamogeton pusillus, Potamogeton foliosus, Potamogeton friesii,* and *Potamogeton strictifolious* can easily be mistaken for one plant or another. It may be best to look at the overall frequency of all of the small pondweeds to determine if an actual reduction has occurred. All small pondweeds collected were magnified and closely scrutinized in the 2019 survey.

5. Habitat changes and plant dominance changes can lead to plant declines. If an area receives a large amount of sediment from human activity (runoff), the plant community may respond. If a plant emerges as a more dominant plant over time, that plant may reduce another plant's frequency and density.

6. Large plant coverage reduction that is not species-specific can occur from an infestation of the non-native rusty crayfish or common carp.

Table 9 lists all species that showed a statistically significant increase in frequency from 2006 to 2021. The p-value from the chi-square indicates the significance of any change (the number of * indicates more importance; *** is high, ** is moderate and * is low).

Species with Significant Increase	FOO-2006	FOO-2021	P-value	Significance
Potamogeton gramineus, Variable pondweed	14.96%	14.5%	0.003	**
Najas flexilis, Slender naiad	16.79%	13.6%	0.04	*
Ceratophyllum demersum, Coontail	7.67%	13.2%	2.3×10^{-9}	***
Potamogeton zosteriformis, Flat-stem pondweed	15.33%	10.85%	0.04	*
Eleocharis acicularis, Needle spikerush	0.00%	4.34%	4.5×10^{-7}	***
Potamogeton pusillus, Small pondweed	0.73%	3.8%	2.3×10^{-4}	***
Myriophyllum alterniflorum, Alternate-flowered water-milfoil	0.00%	3.4%	4×10^{-5}	***
Elodea nuttallii, Slender waterweed	0.00%	0.9%	0.04	*
Sagittaria cristata, Crested arrowhead	0.00%	0.9%	0.04	*
Sagittaria cuneata, Arum-leaved arrowhead	0.00%	0.9%	0.04	*

Table 9: List of species with a statistically significant increase in frequency (littoral points) between surveys in 2006 and 2021. The green highlighted species had very low frequency, making the change invalid.

As the data shows, there was a statistically significant increase in the frequency of 10 plant species. Three of those ten had low-frequency values. Seven of the ten had high enough frequency values that the increases are likely statistically valid. The most profound changes were variable pondweed, coontail, and needle spikerush. These increases are potential natural variations for the variable pondweed and coontail. Needle spikerush is a small plant that grows in low nutrient sediment and can be challenging to notice on the rake unless in high enough density and with fewer other species of plants present. Therefore, it may be natural and sampling variations.

Table 10 lists the species with a statistically significant frequency reduction from 2006 to 2021.

Species with Significant Increase	FOO-2006	FOO-2021	P-value	Significance
Vallisneria americana, Wild celery	12.8%	6%	0.0001	***
Potamogeton robbinsii, Fern pondweed	7.7%	3.8%	0.007	**
Myriophyllum tenellum, Dwarf water-milfoil	7.9%	1.45%	4.8×10^{-6}	***
Bidens beckii, Water marigold	2.5%	0.54%	0.009	**
Eriocaulon aquaticum, Pipewort	1.0%	0%	0.02	*

Table 10: List of species with a statistically significant decrease in frequency (littoral points) from 2006 to 2021. The green highlighted species had a low-frequency value, so the change indicated may be invalid.

The cause for the statistically significant decrease in the frequency of five species (four of which had higher frequency values) is unknown. The wild celery frequency nearly decreased by a factor of two. Since there have been no plant management practices and wild celery is a relatively hardy plant, it is likely a natural variation in growth. Dwarf watermilfoil had the most significant reduction. This plant is quite sensitive so human-caused habitat changes could be a factor, but no data or observations have been collected to support this as a potential cause.

Overall, the significant increases outnumber the significant decreases. This indicates that the aquatic plant community in Grindstone Lake remains stable and does not show signs of degradation.

Critical plant habitat

Plants play a critical role in the lake ecosystem. They provide habitat for plankton and invertebrates, which provide food for fish. Plants provide cover for baitfish, which predatory fish can forage on. Floating and emergent vegetation (plants that penetrate the water surface, such as cattails) provide sediment and shoreline stability by reducing energy in waves. Emergent plants also offer cover and nesting areas for amphibians, reptiles, birds, and mammals. Sensitive plants inhabit low nutrient sediments where other plants are not adapted for this substrate.

Since Grindstone Lake has limited plant coverage, the areas with plants are critical. Areas with high species richness, floating and emergent vegetation, and sensitive plants should be considered essential plant habitats. A map showing these areas was generated in reviewing locations of plant habitats that reflect these criteria. These areas should be monitored for changes and scrutinized in a broader critical habitat analysis.

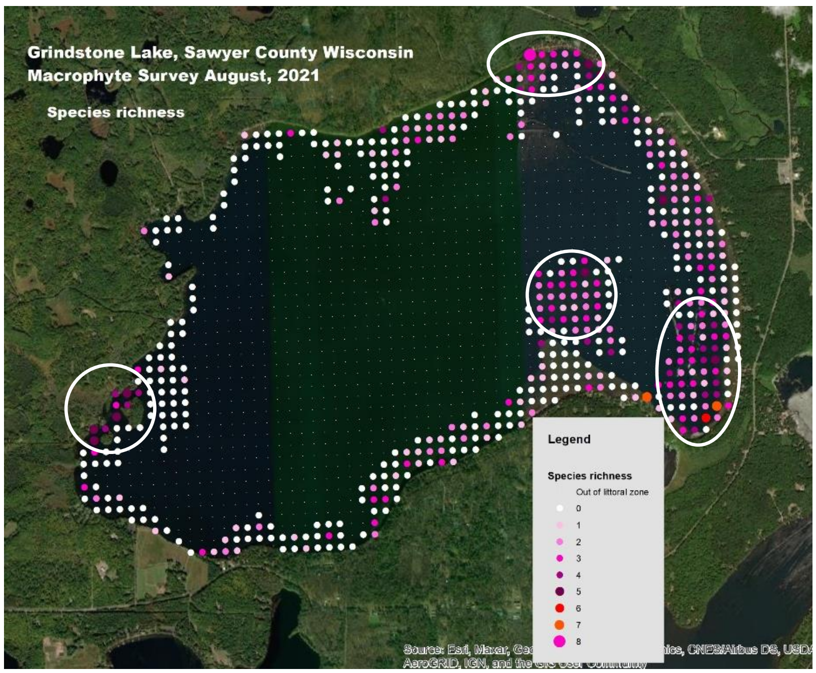


Figure 10: Map showing critical plant habitats based upon diversity. The circled areas show the highest species richness and areas that have good plant coverage.

Discussion

As stated, the 2021 Grindstone Lake aquatic macrophyte survey results show a healthy, diverse aquatic plant community that has numerous sensitive plants present in the lake. The coverage of aquatic plants in Grindstone Lake is limited, so preserving native aquatic plants in Grindstone Lake is paramount. Numerous aquatic organisms rely on these plants for food and habitat, and if the plant coverage decreases, it could be detrimental to the lake ecosystem.

There were three invasive species observed. There was only one location observed with aquatic forget me not and purple loosestrife. There are likely other locations, but it would likely have been observed if the populations were extensive. Reed canary grass is more common around the lake. Still, as mentioned in the invasive species portion of this analysis, it is typically not mitigated due to the common occurrence (unless infesting a restoration area).

Since the nature of invasive species is that they can spread quickly, it is recommended that an AIS survey is conducted one or more times annually during the growing season, either by trained volunteers or through a professional contractor.

The susceptibility of Grindstone Lake to AIS, such as Eurasian water-milfoil (EWM), is likely somewhat lower than other lakes. This is due to the limited prime habitat for a wide range of plants, which could include EWM. Much of Grindstone Lake contains large rock, gravel, or pure sand. Higher nutrient sediments (muck or sand/muck mix) in shallow water regions are where a wide array of plants tend to thrive. Furthermore, Grindstone Lake has a limited depth-defined littoral zone in many areas of the lake. Since the majority of the plant growth in Grindstone Lake occurs in the limited habitat conducive to plant growth, introducing AIS plants into these limited plant areas would be detrimental to the lake ecosystem. Native plants can reduce the success of AIS taking hold in the lake. Therefore, it is essential to help maintain a diverse, native plant community in Grindstone Lake. Figure 11 shows a map designating areas of deep concern due to the susceptibility of AIS plant species. These areas are highlighted due to present plant growth, sediment type, boat traffic, and proximity to boat launches.

Figure 11: Designated AIS risk areas in Grindstone Lake.

Comparing the 2006 results to the 2021 results makes it possible to evaluate major changes occurring in the aquatic plant community. This comparison shows that the plant community has changed little in 15 years. Most of the differences in the survey results are positive changes (meaning the plant community looks healthier). These results are encouraging that the plant community in Grindstone Lake does not appear to be negatively impacted by human activity in and around Grindstone Lake.

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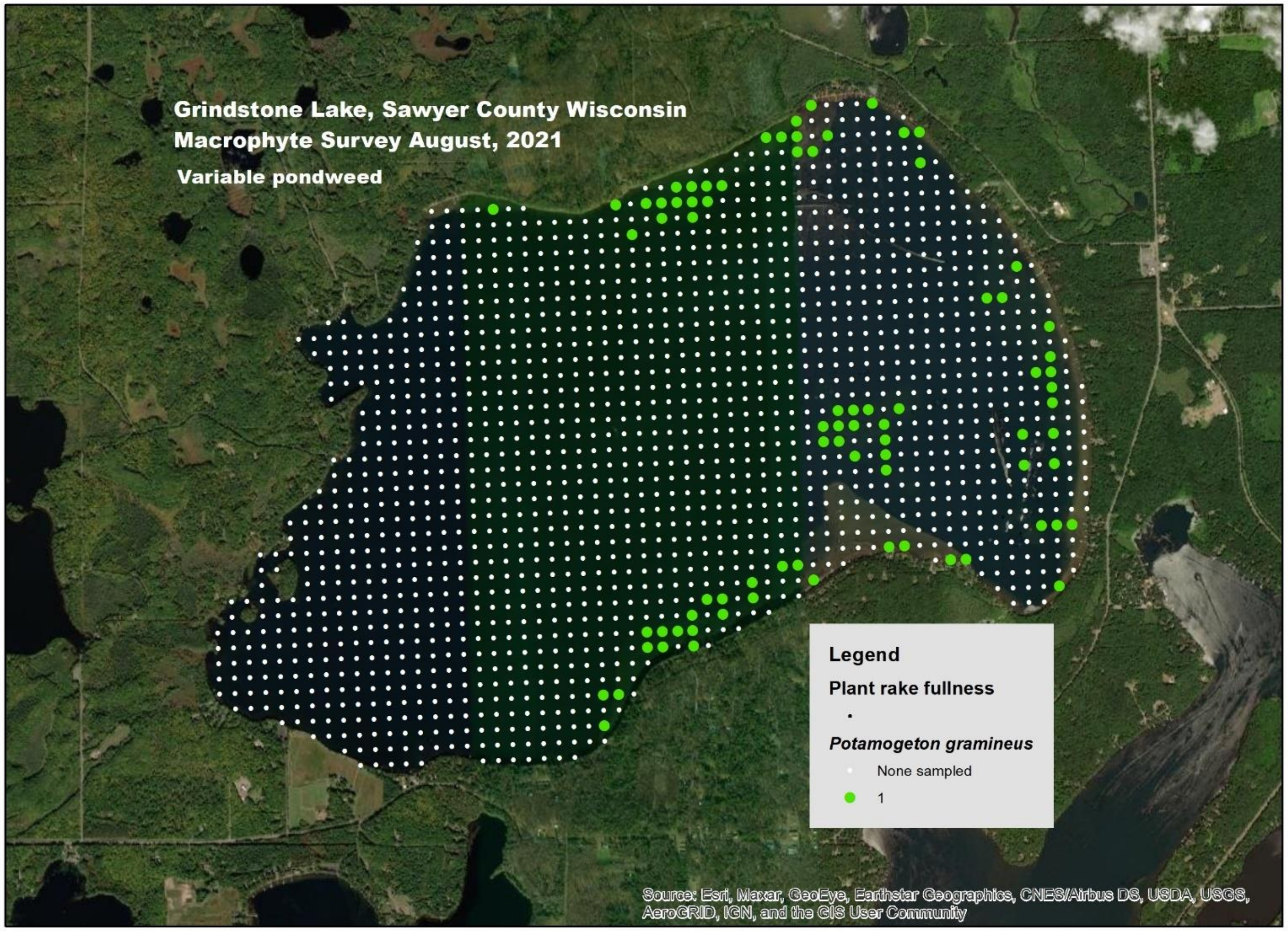
Plant distribution maps (list with frequency and page contained)

Species/Map	**FOO[1] veg**	**Page**
Potamogeton gramineus, Variable pondweed	29.63	21
Najas flexilis, Slender naiad	27.78	22
Ceratophyllum demersum, Coontail	27.04	23
Potamogeton zosteriformis, Flat-stem pondweed	22.22	24
Chara sp., Muskgrasses	16.30	25
Vallisneria americana, Wild celery	12.22	26
Elodea canadensis, Common waterweed	10.74	27
Myriophyllum sibiricum, Northern water-milfoil	10.37	28
Potamogeton richardsonii, Clasping-leaf pondweed	10.37	29
Eleocharis acicularis, Needle spikerush	8.89	30
Potamogeton pusillus, Small pondweed	7.78	31
Potamogeton robbinsii, Fern pondweed	7.78	32
Myriophyllum alterniflorum, Alternate-flowered water-milfoil	7.04	33
Potamogeton praelongus, White-stem pondweed	3.33	34
Myriophyllum tenellum, Dwarf water-milfoil	2.96	35
Potamogeton amplifolius, Large-leaf pondweed	2.96	36
Nitella sp., Nitella	2.22	37
Elodea nuttallii, Slender waterweed	1.85	38
Sagittaria cristata, Crested arrowhead	1.85	39
Sagittaria cuneata, Arum-leaved arrowhead	1.85	40
Juncus pelocarpus f. submersus, Brown-fruited rush	1.48	41
Potamogeton friesii, Fries' pondweed	1.48	42
Bidens beckii, Water marigold	1.11	43
Potamogeton illinoensis, Illinois pondweed	1.11	44
Elatine minima, Waterwort	0.74	45
Ranunculus aquatilis, White water crowfoot	0.74	46
Heteranthera dubia, Water star-grass	0.37	47
Isoetes echinospora, Spiny spored-quillwort	0.37	48
Lobelia dortmanna, Water lobelia	0.37	49
Nuphar variegata, Spatterdock	0.37	50
Nymphaea odorata, White water lily	0.37	51
Ranunculus flammula, Creeping spearwort	0.37	52
Schoenoplectus pungens, Three-square bulrush	0.37	53
Stuckenia pectinata, Sago pondweed	0.37	54
Eleocharis palustris, Creeping spikerush	viewed	55
Filamentous algae	8.52	56
Aquatic moss	0.74	57
Rake fullness	n/a	58

Species/Map	FOO[1] veg	Page
Number of species	n/a	59
Littoral zone	n/a	60
Sediment	n/a	61
Depth	n/a	62


Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Variable pondweed
Legend
Plant rake fullness
Potamogeton gramineus
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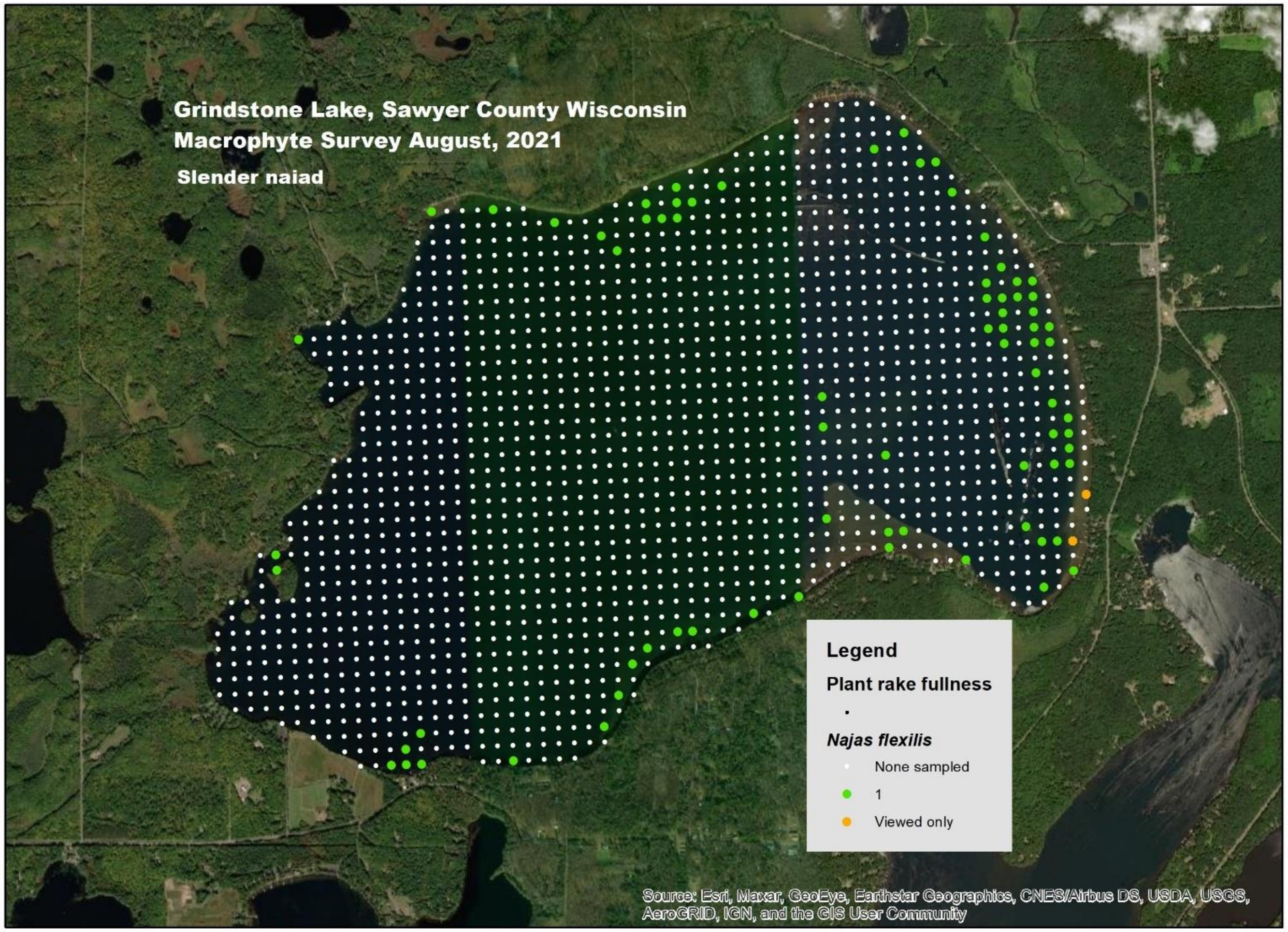
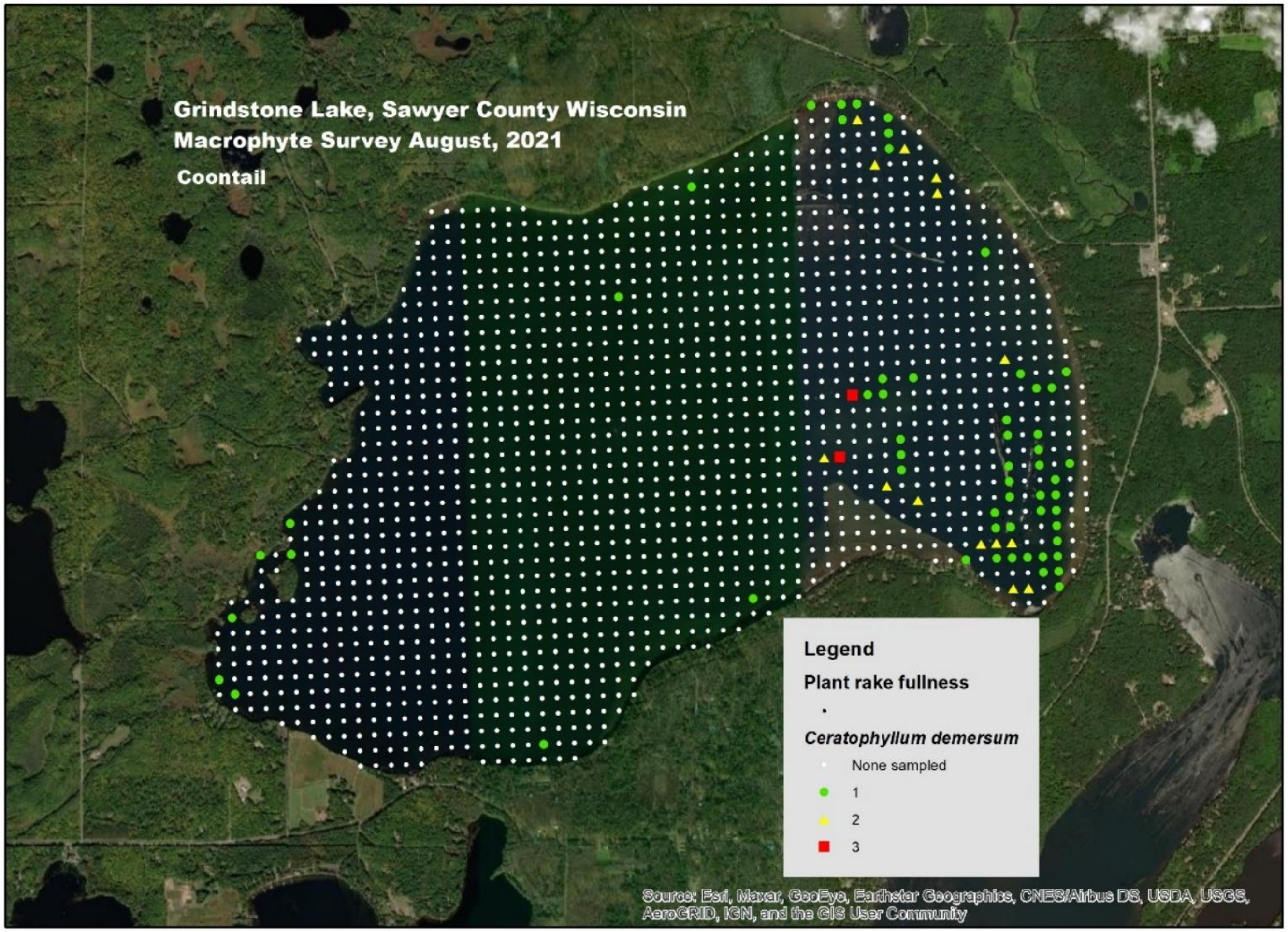
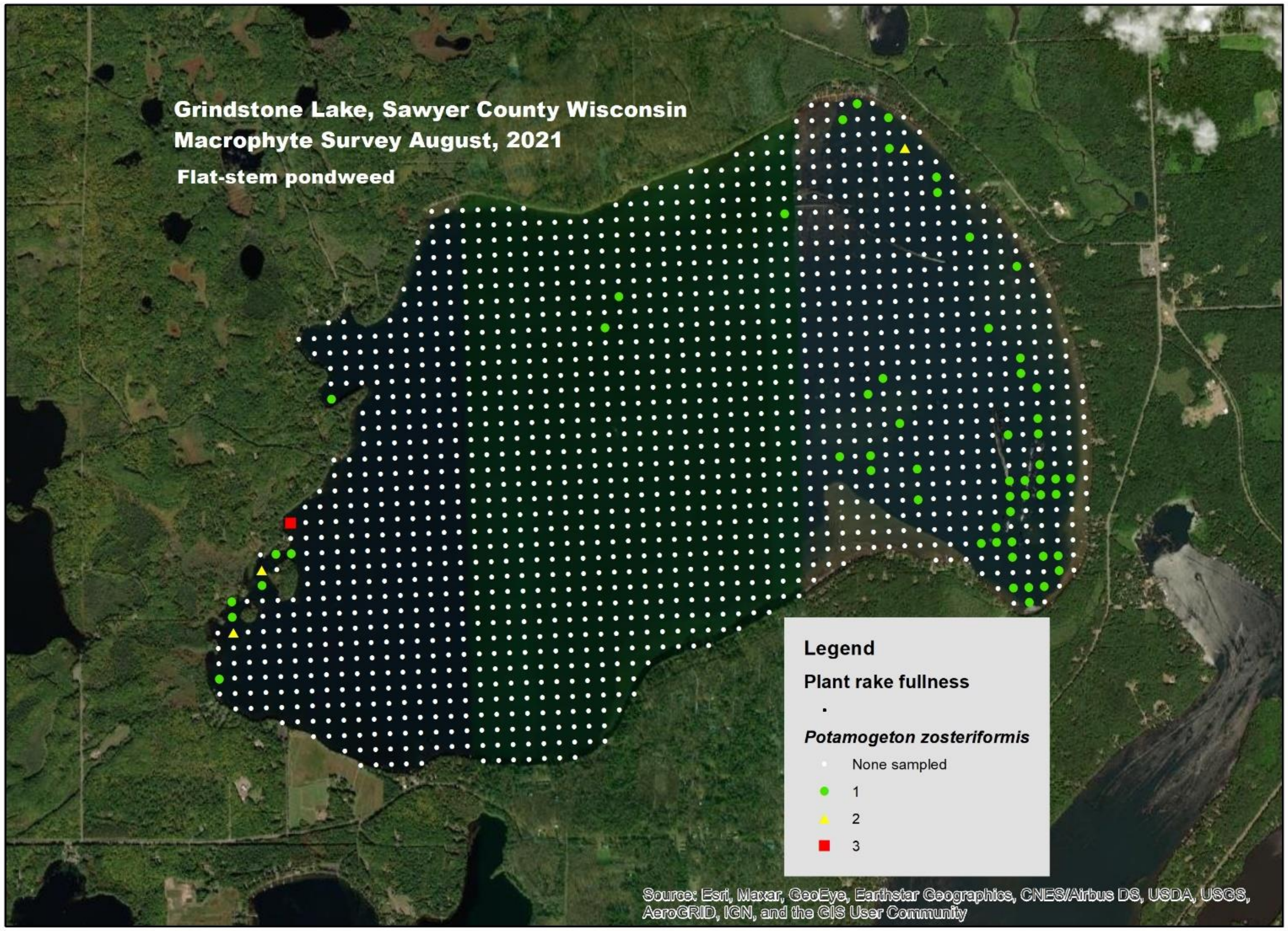
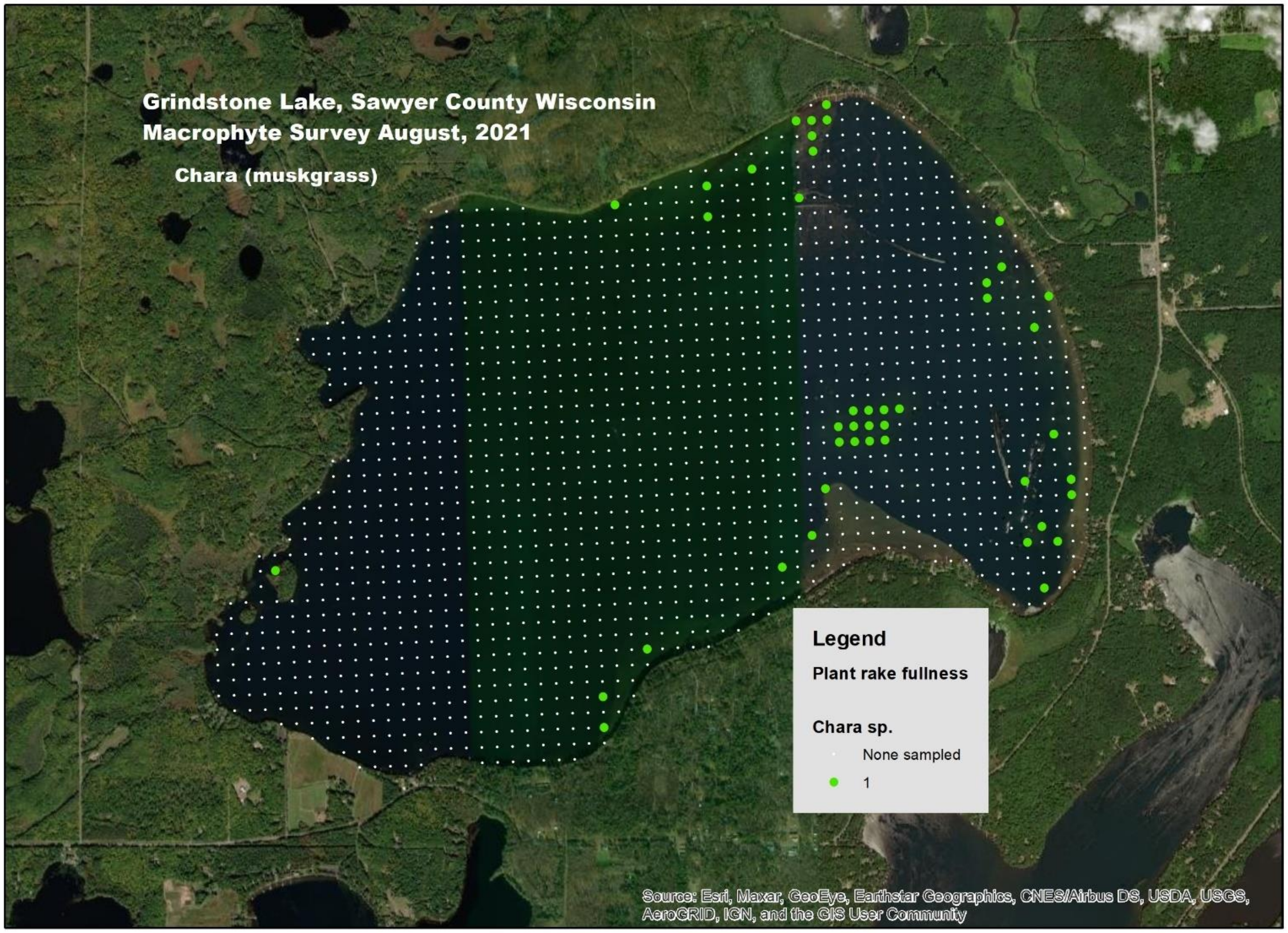
1
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

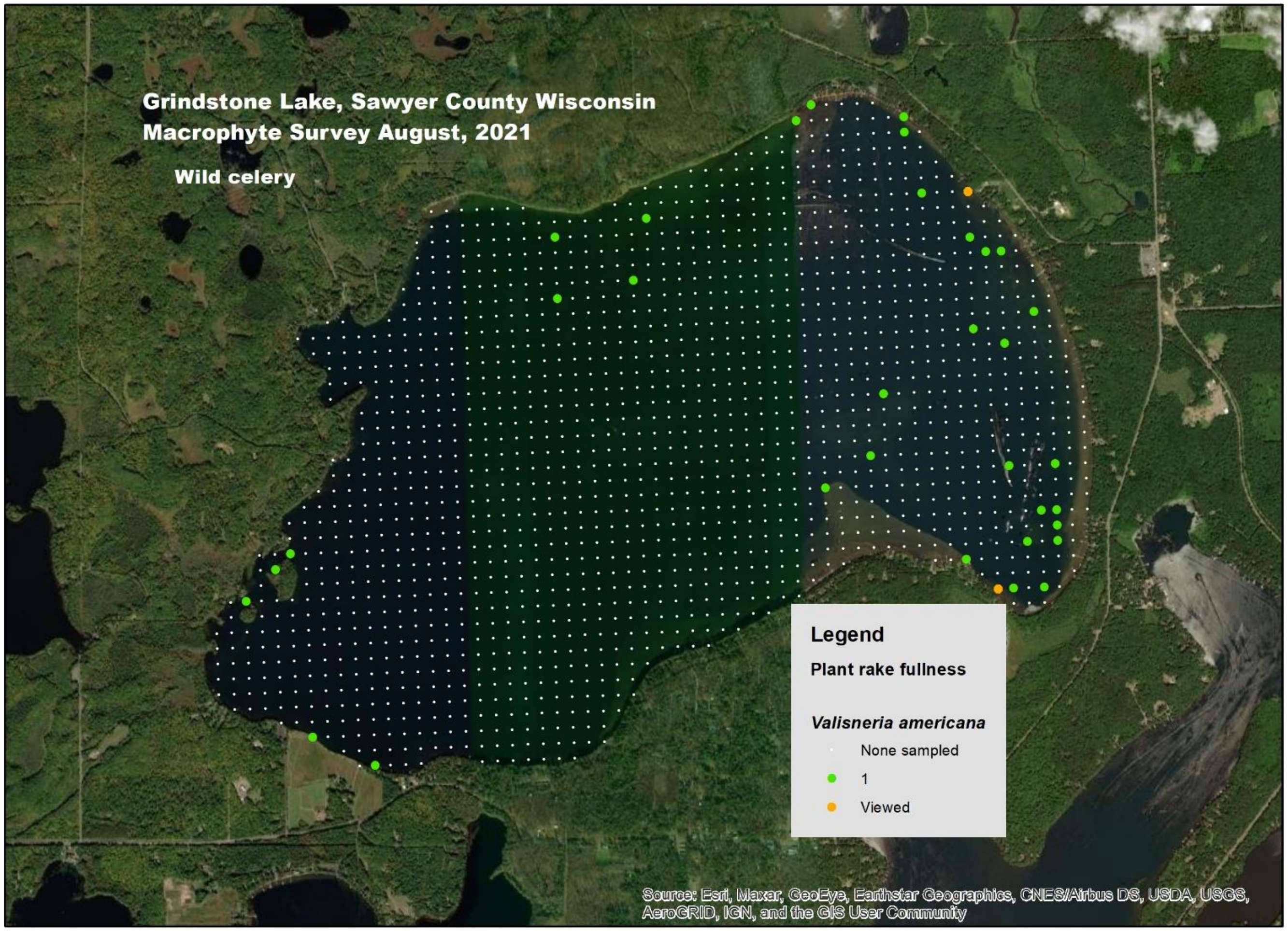

Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Slender naiad
Legend
Plant rake fullness
Najas flexilis
None sampled
1
Viewed only
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Coontail
Legend
Plant rake fullness
Ceratophyllum demersum
None sampled
1
2
3
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Flat-stem pondweed
Legend
Plant rake fullness
Potamogeton zosteriformis
None sampled
1
2
3
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Chara (muskgrass)
Legend
Plant rake fullness
Chara sp.
None sampled
1
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Wild celery
Legend
Plant rake fullness
Valisneria americana
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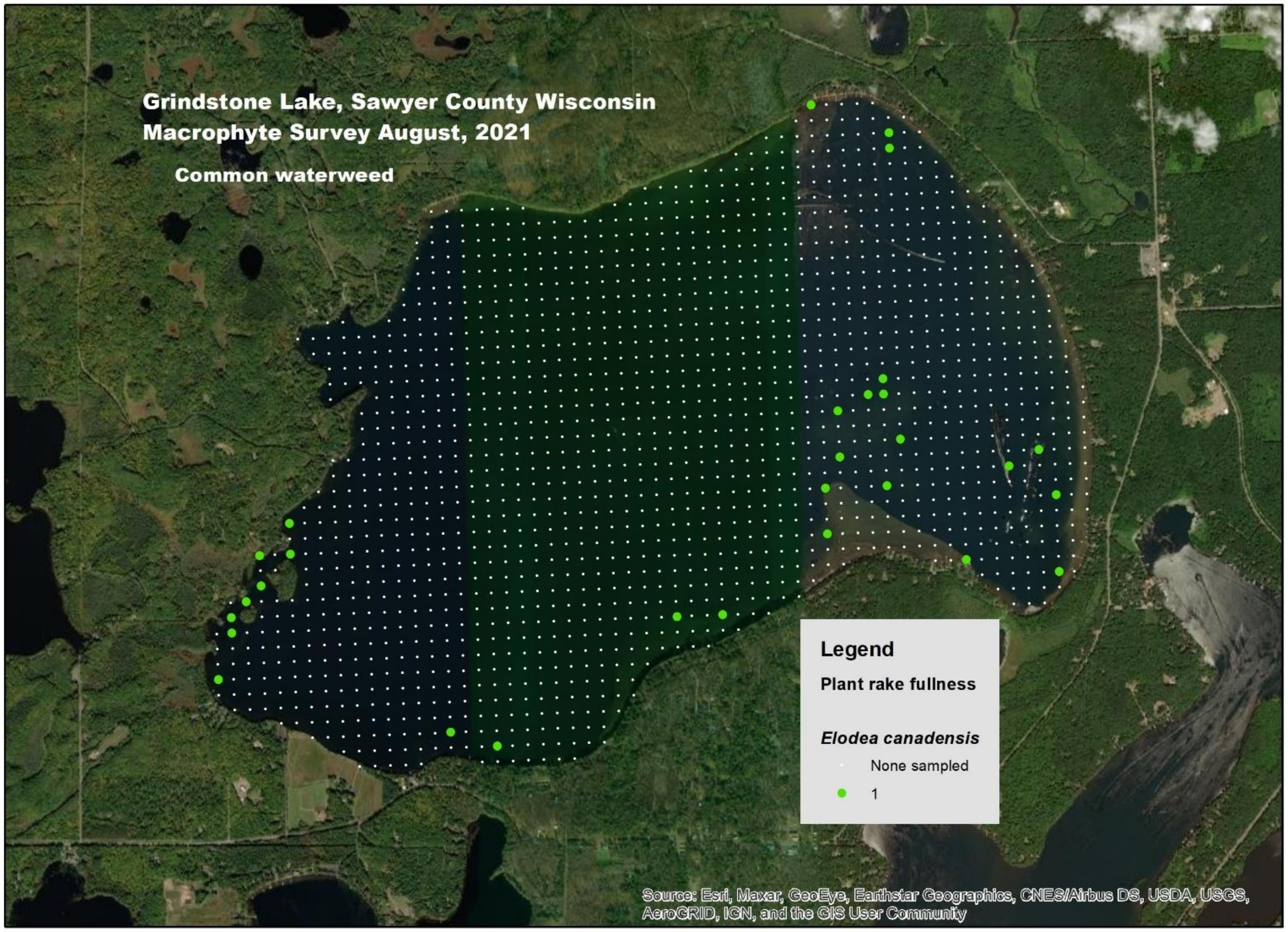
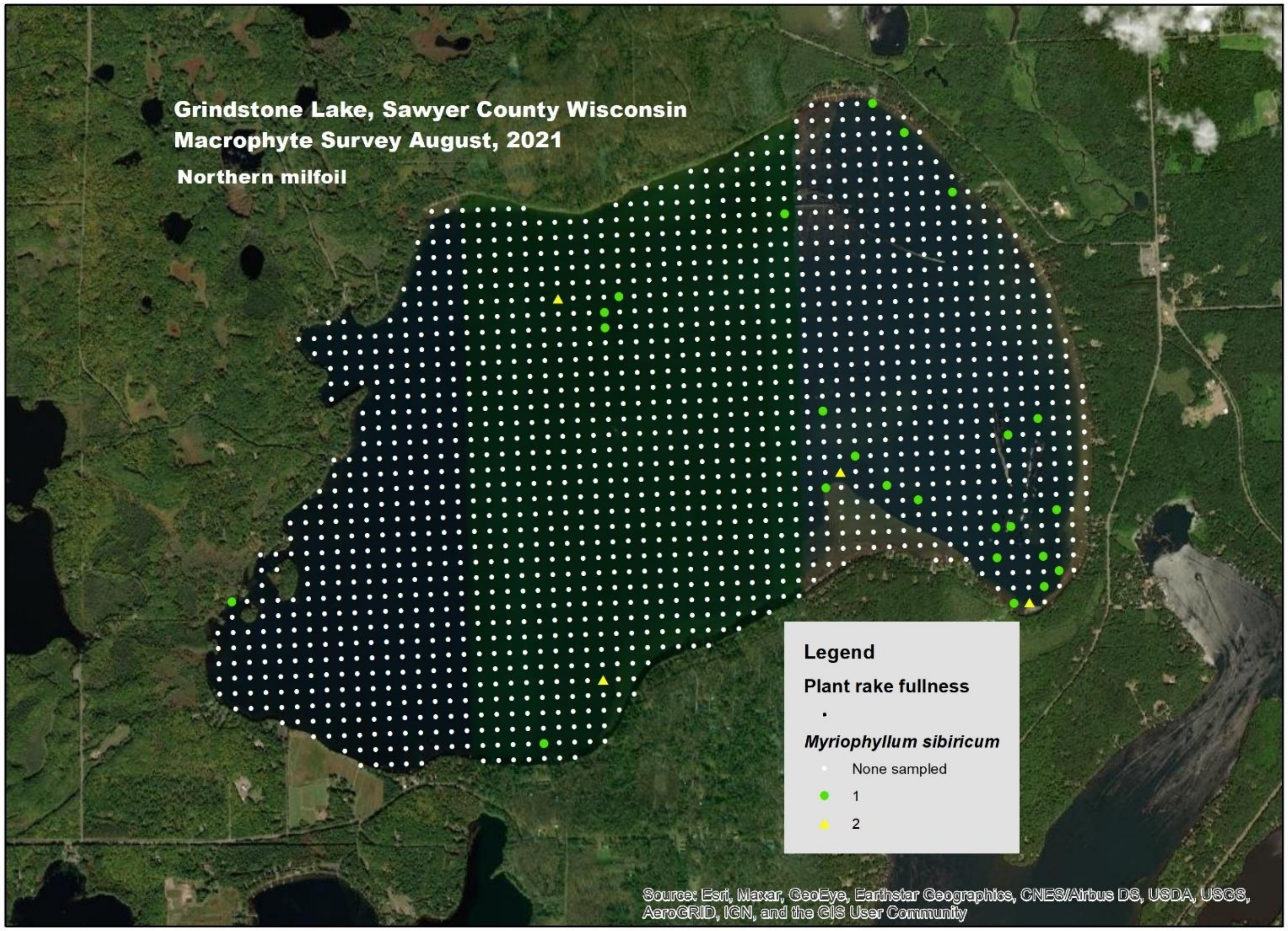
1
Viewed
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Common waterweed
Legend
Plant rake fullness
Elodea canadensis
None sampled
1
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Northern milfoil
Legend
Plant rake fullness
Myriophyllum sibiricum
None sampled
1
2
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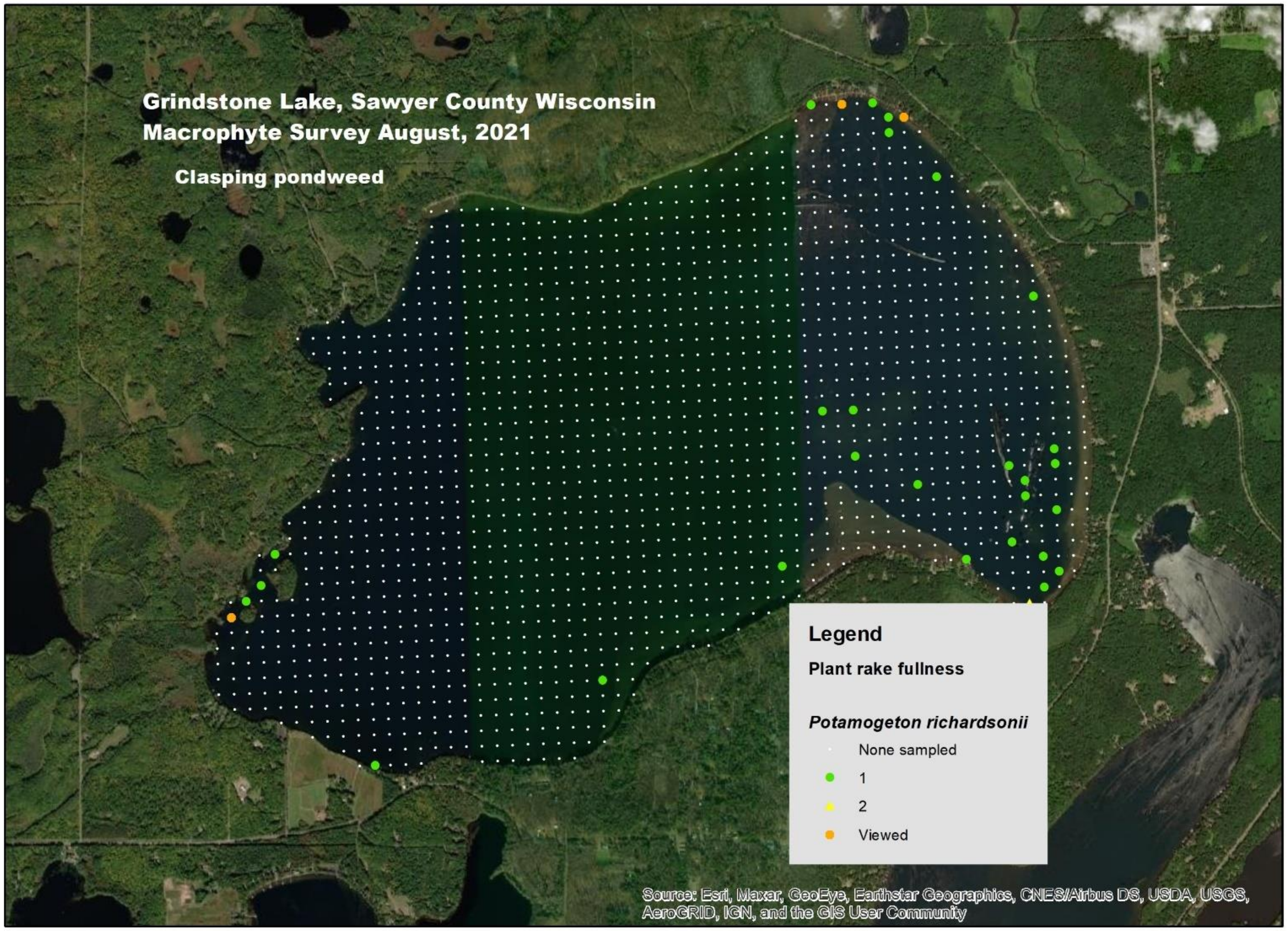
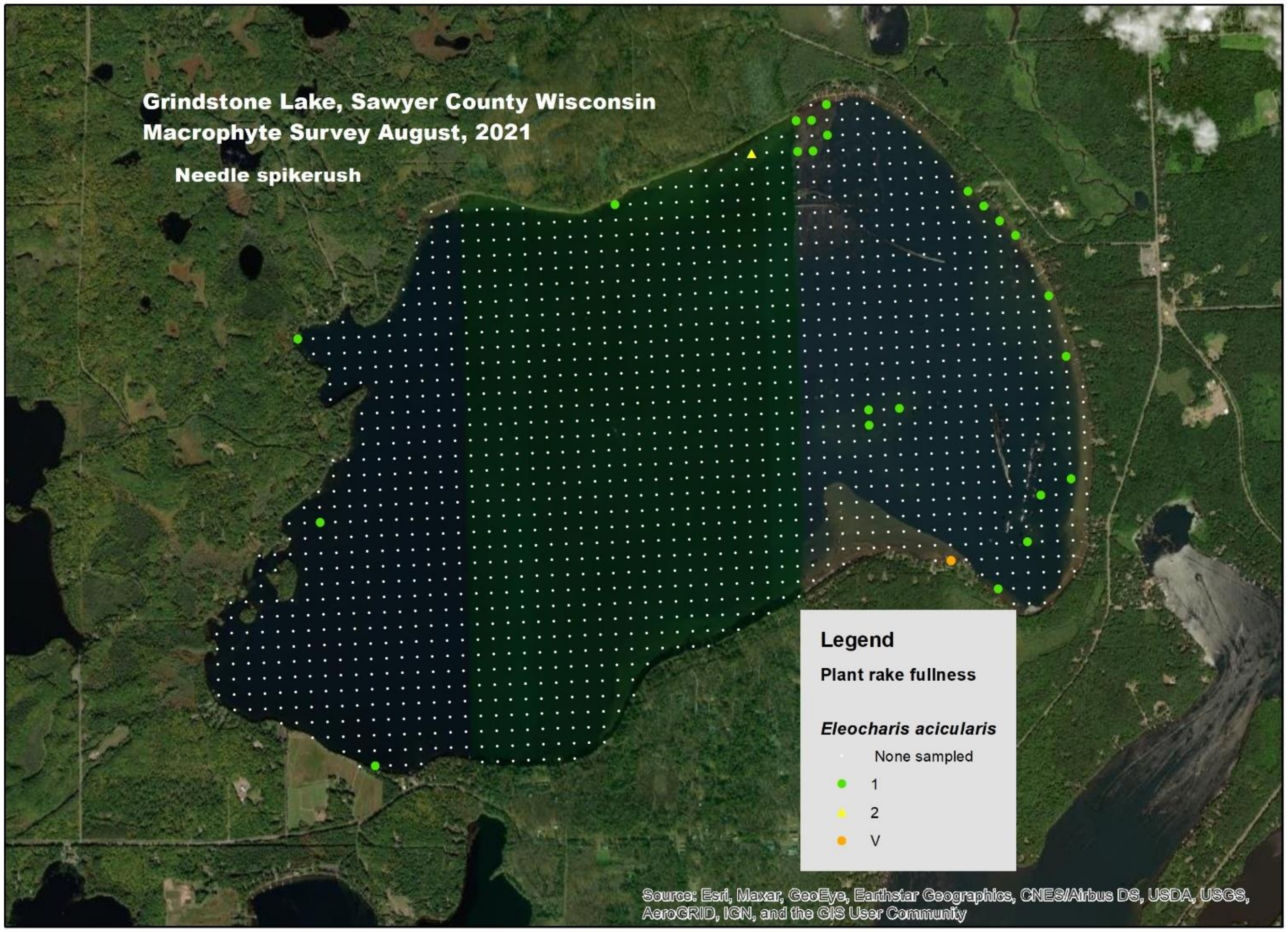
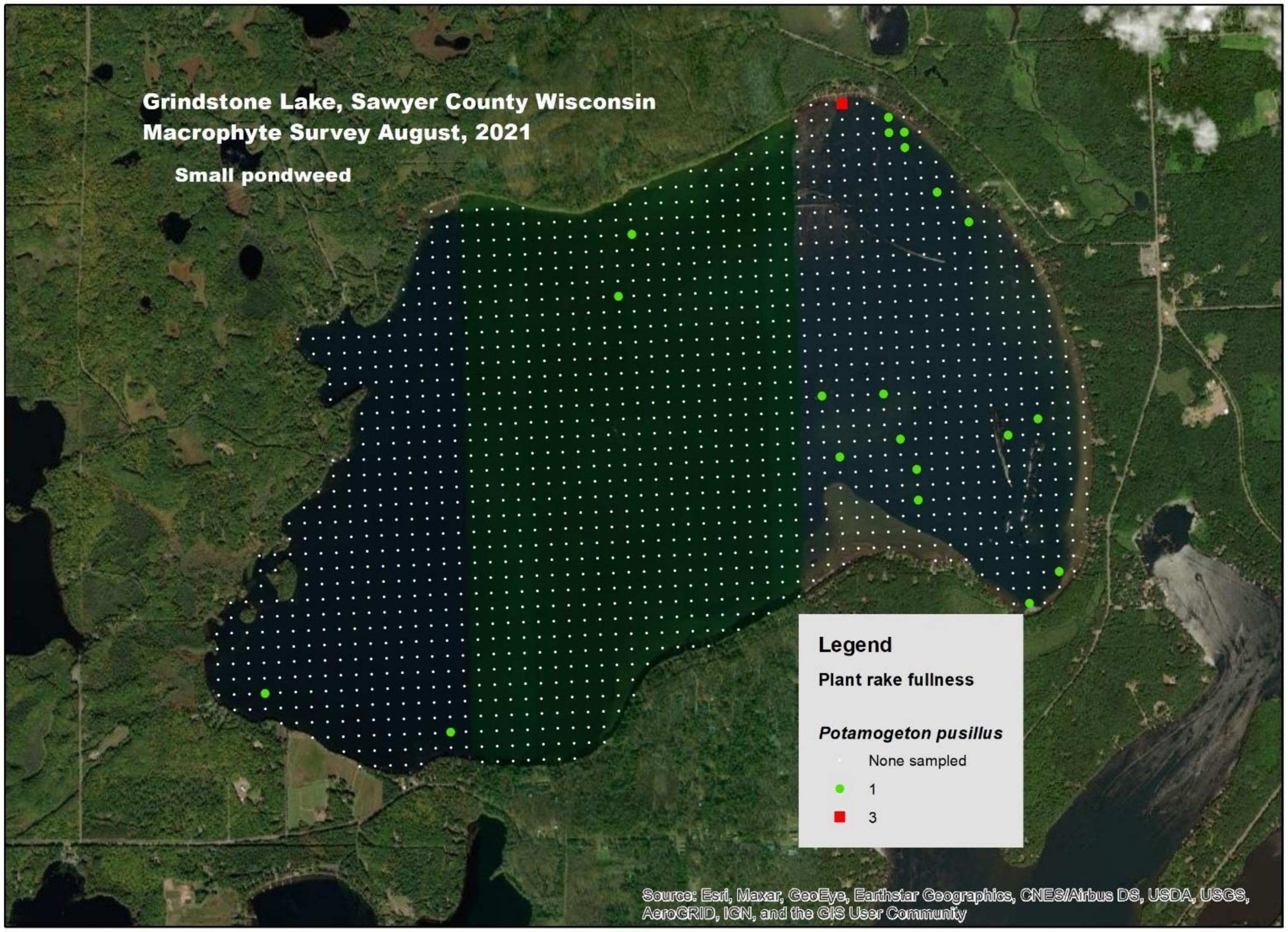
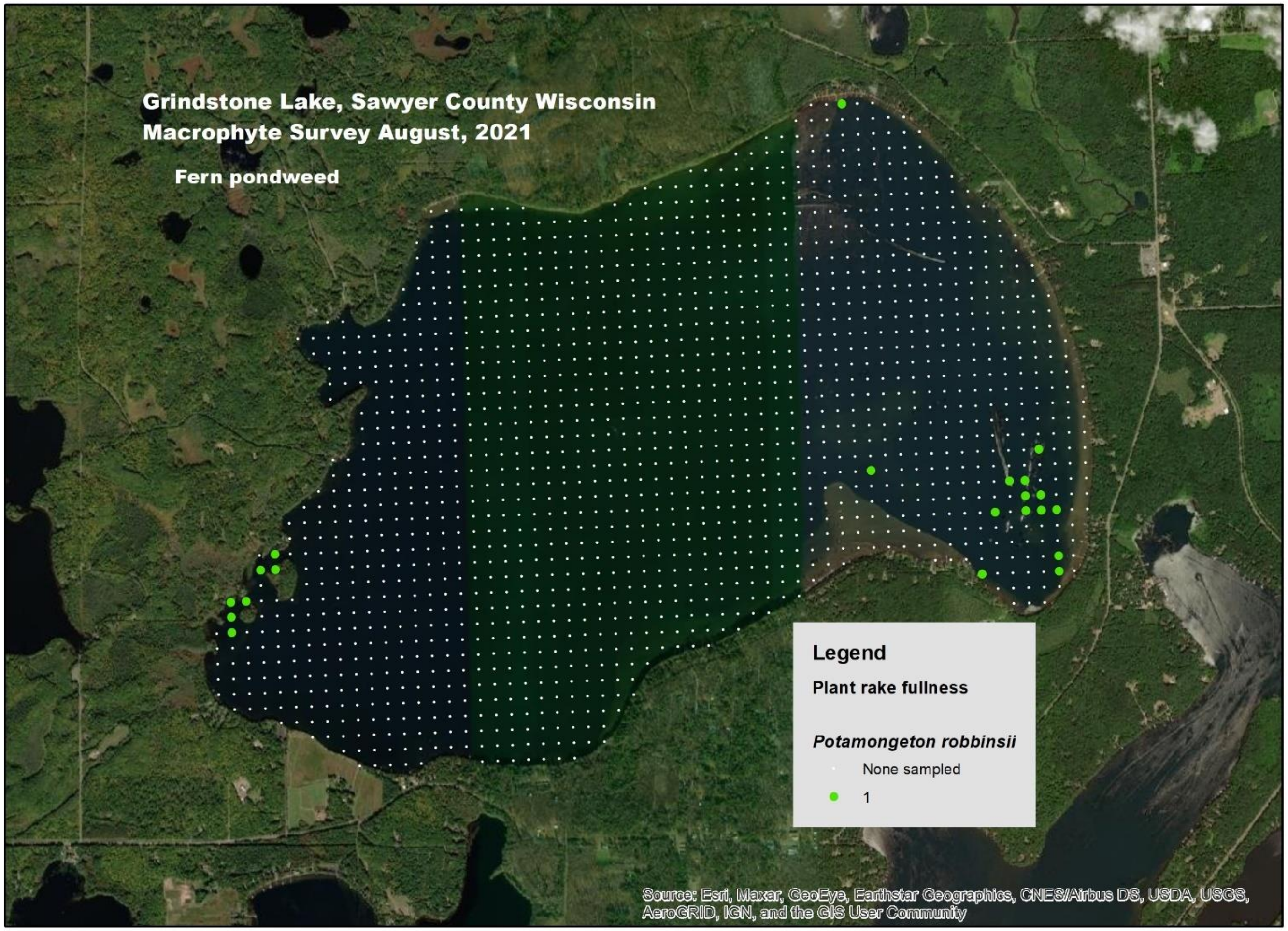
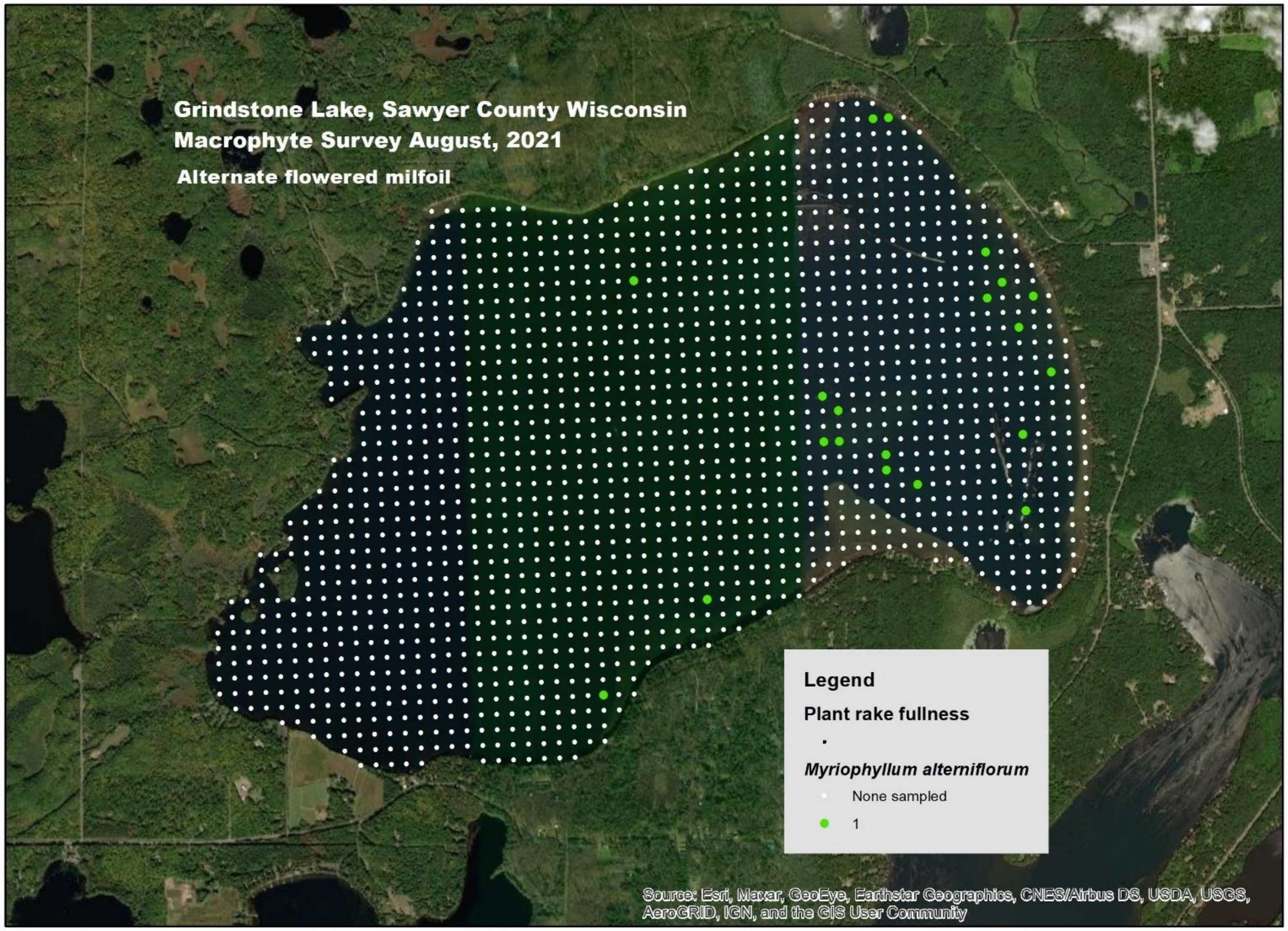

Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Clasping pondweed
Legend
Plant rake fullness
Potamogeton richardsonii
None sampled
1
2
Viewed
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

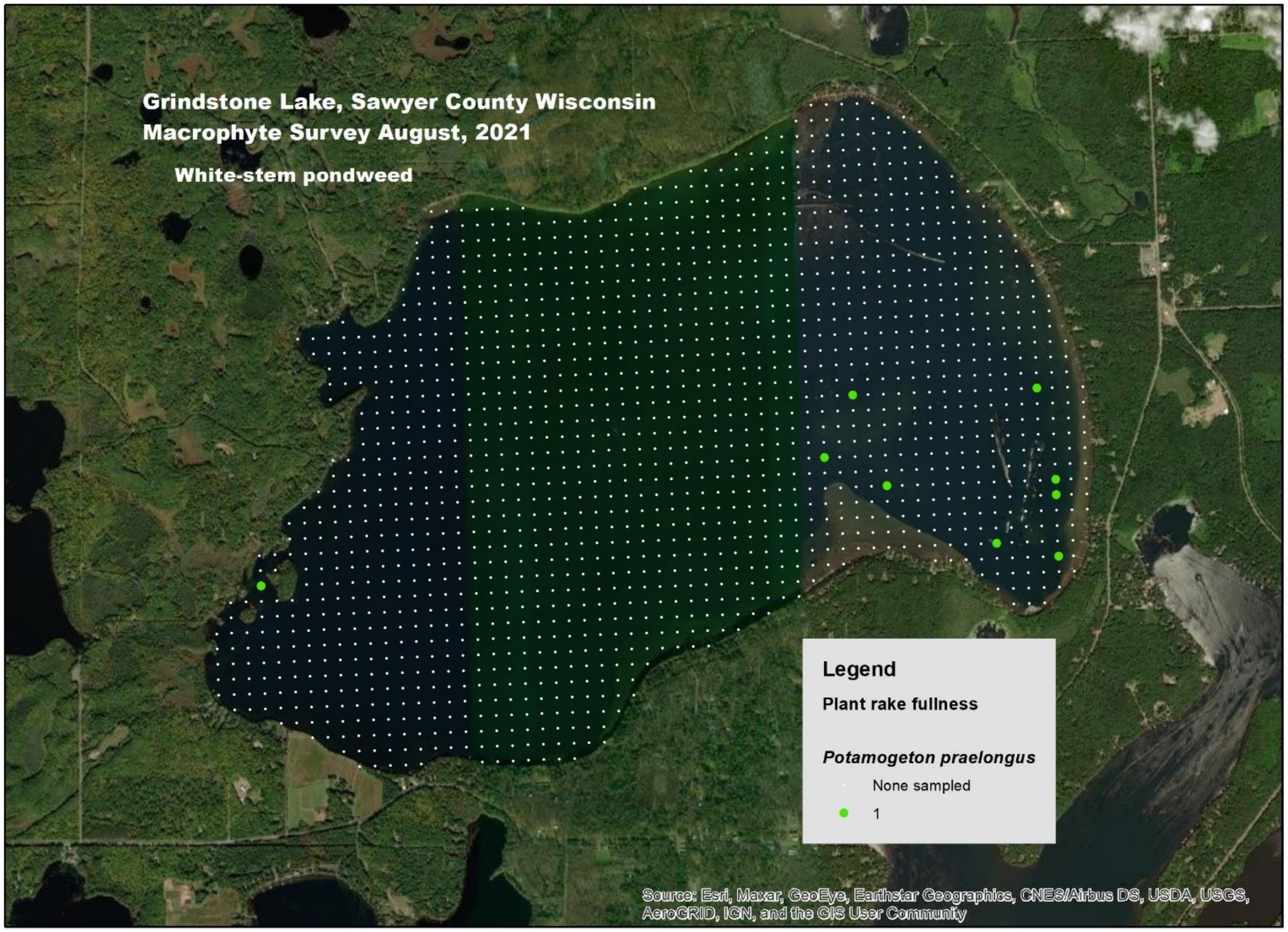

Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Needle spikerush
Legend
Plant rake fullness
Eleocharis acicularis
None sampled
1
2
V
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

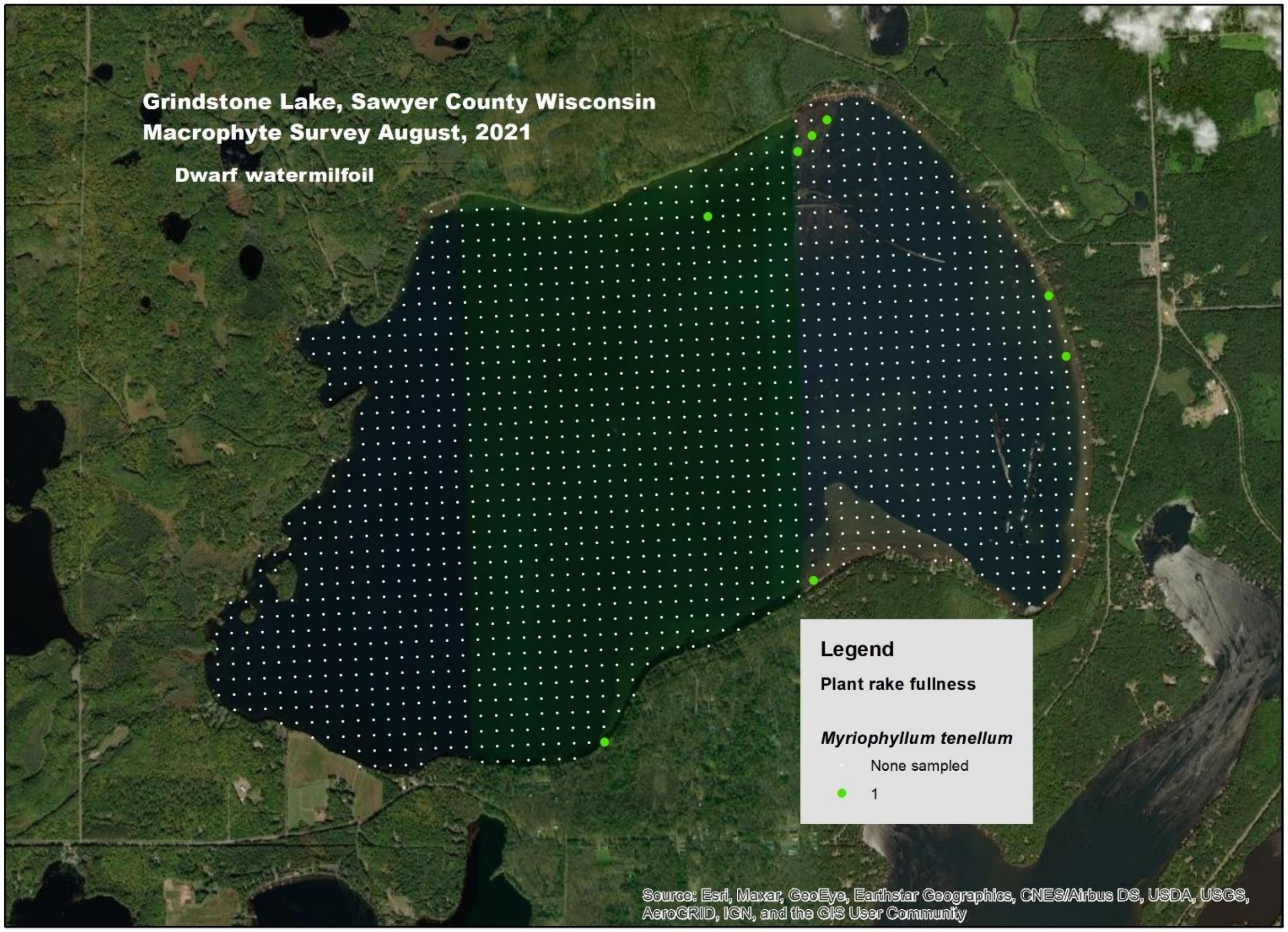

Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Small pondweed
Legend
Plant rake fullness
Potamogeton pusillus
None sampled
1
3
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Fern pondweed
Legend
Plant rake fullness
Potamongeton robbinsii
None sampled
1
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Alternate flowered milfoil
Legend
Plant rake fullness
Myriophyllum alterniflorum
None sampled
1
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
White-stem pondweed
Legend
Plant rake fullness
Potamogeton praelongus
None sampled
1
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Dwarf watermilfoil
Legend
Plant rake fullness
Myriophyllum tenellum
None sampled
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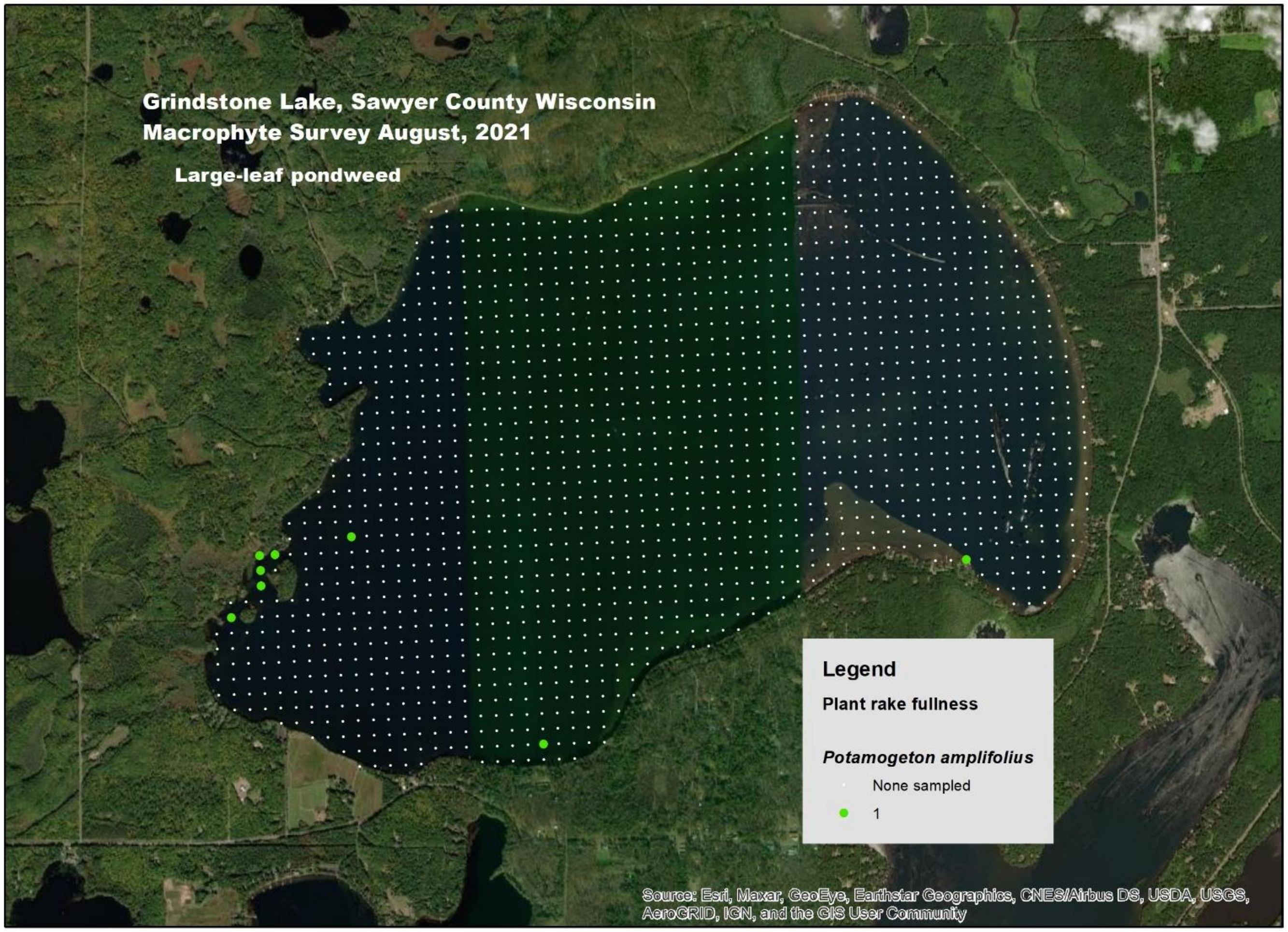
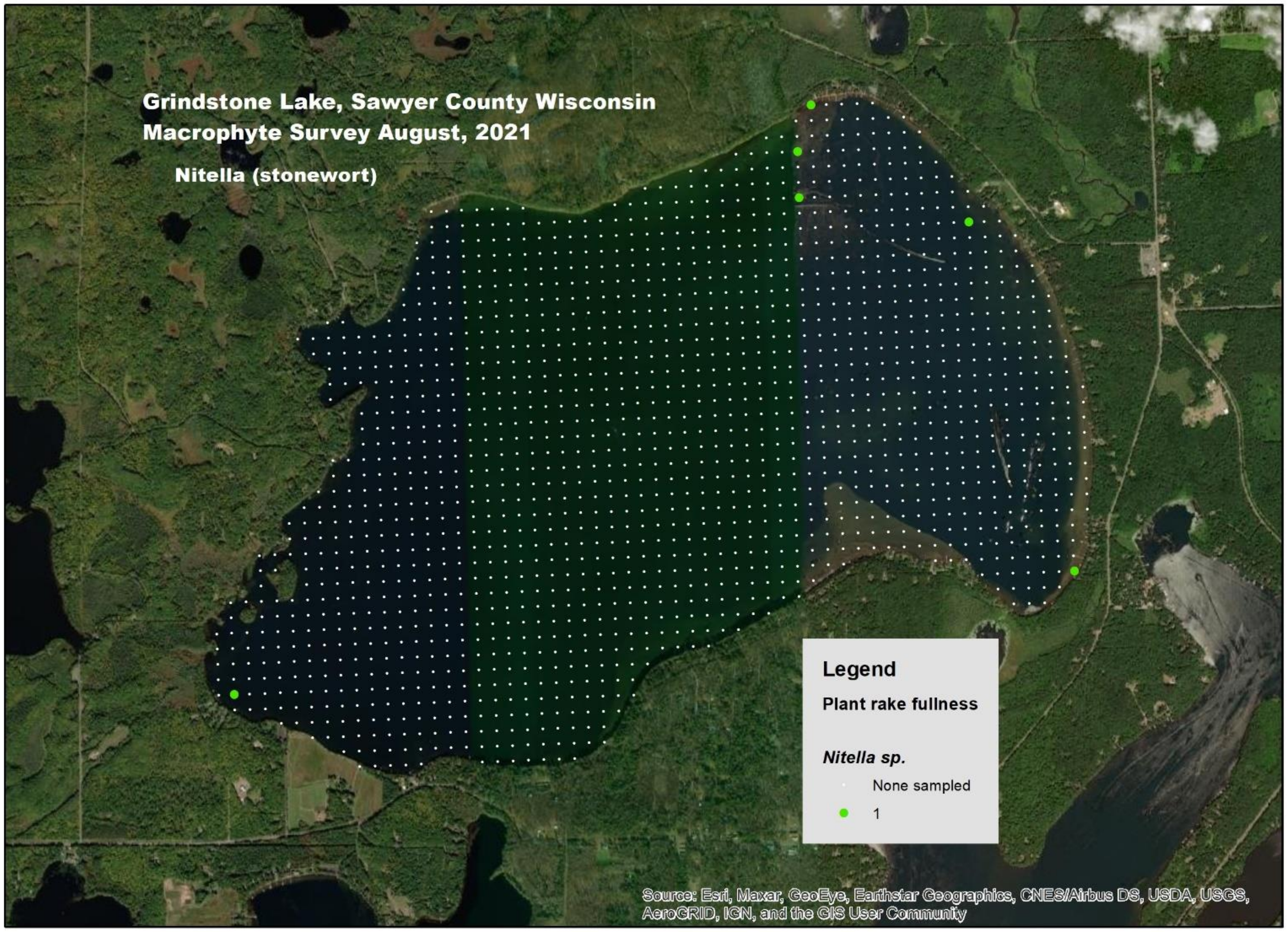
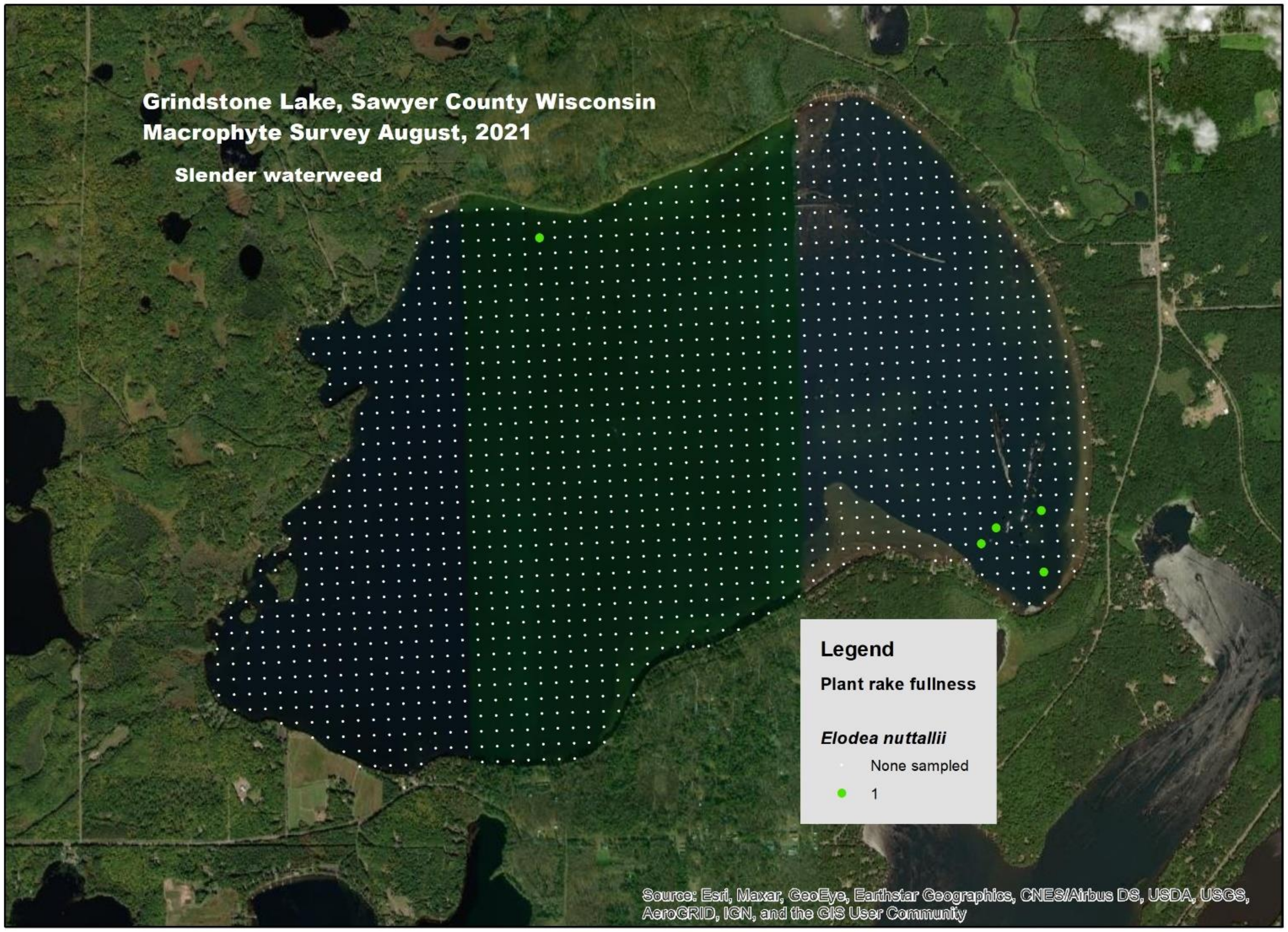
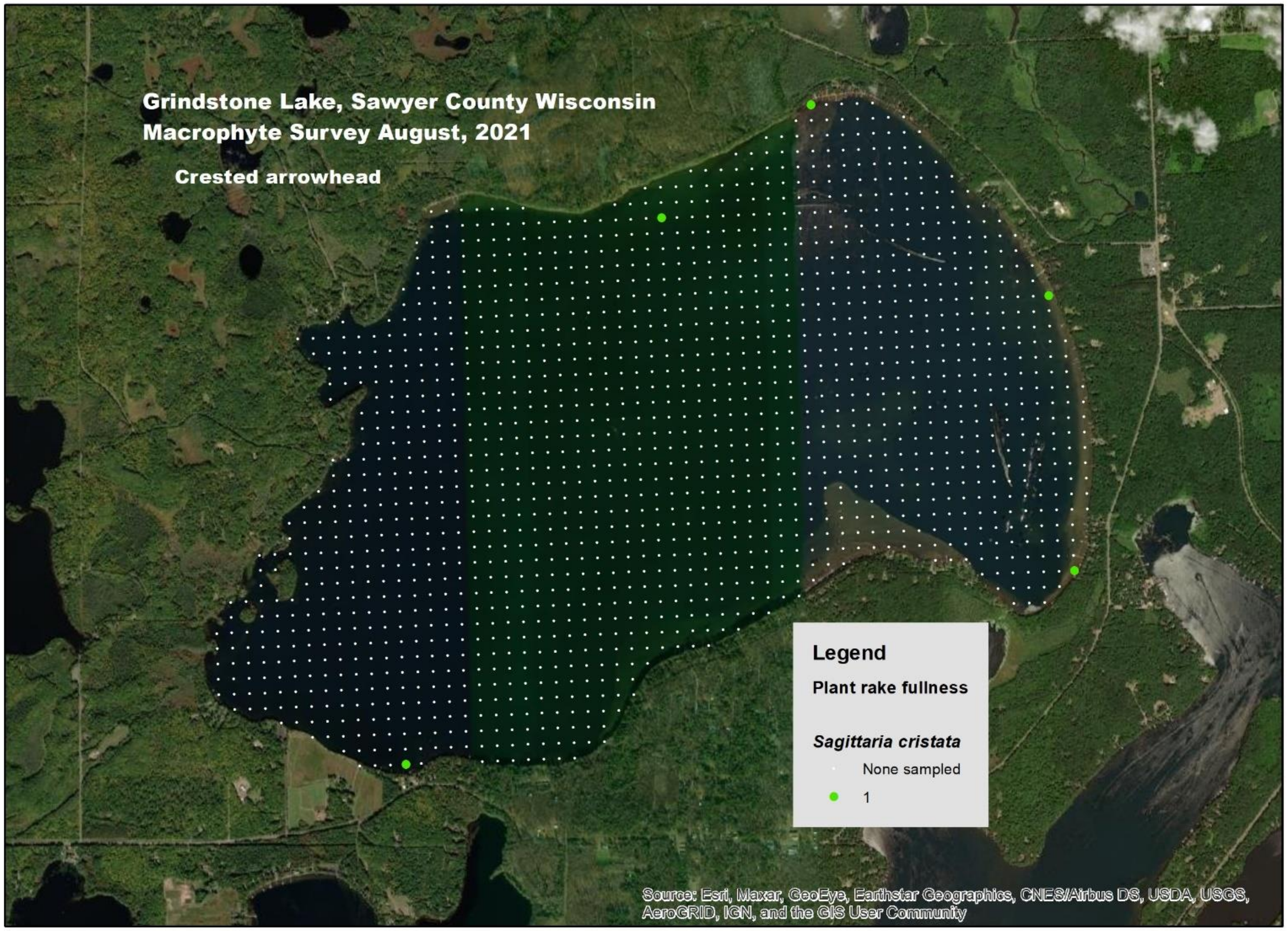

Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Large-leaf pondweed
Legend
Plant rake fullness
Potamogeton amplifolius
None sampled
1
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Nitella (stonewort)
Legend
Plant rake fullness
Nitella sp.
None sampled
1
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Slender waterweed
Legend
Plant rake fullness
Elodea nuttallii
None sampled
1
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Crested arrowhead
Legend
Plant rake fullness
Sagittaria cristata
None sampled
1
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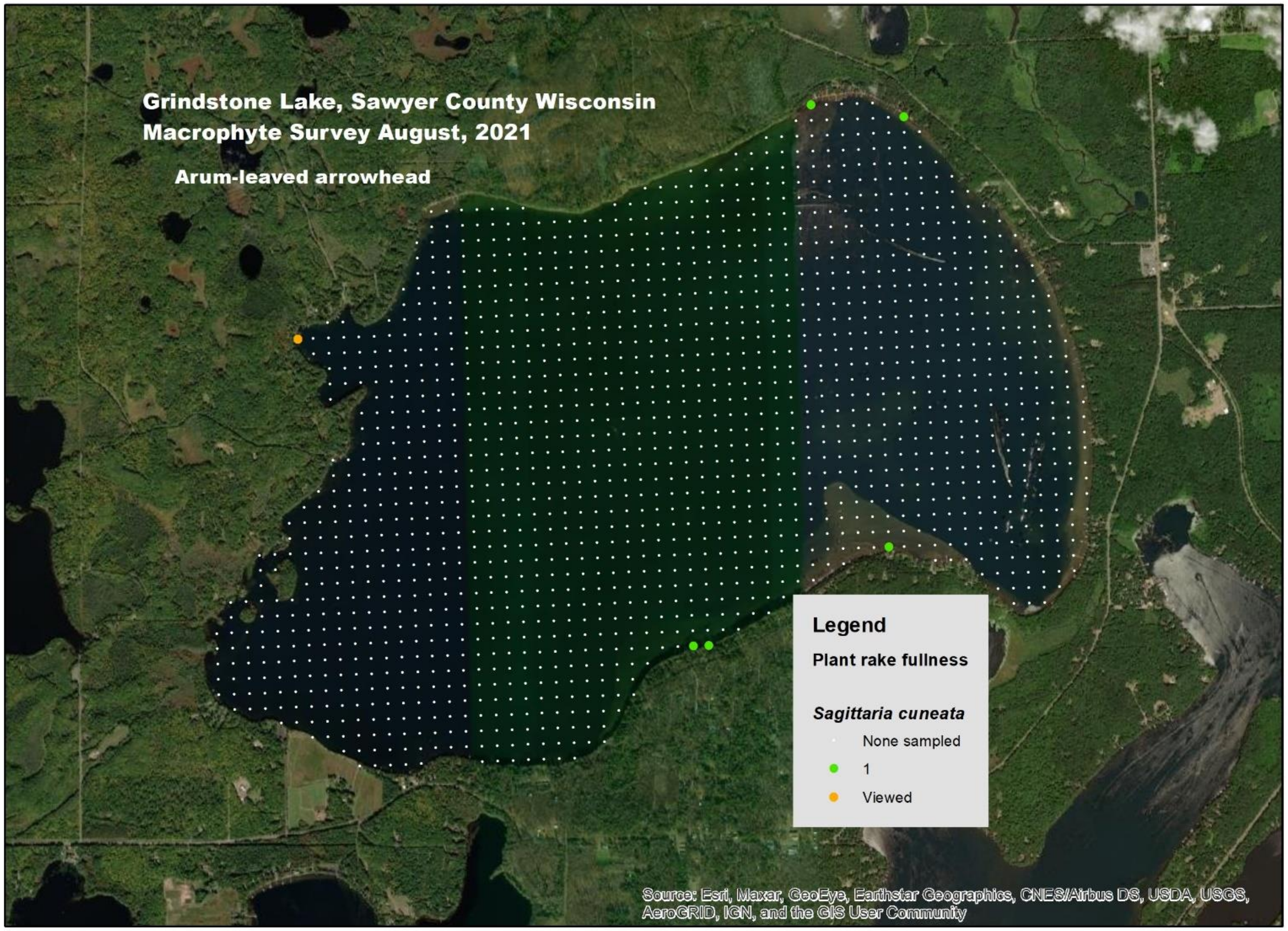
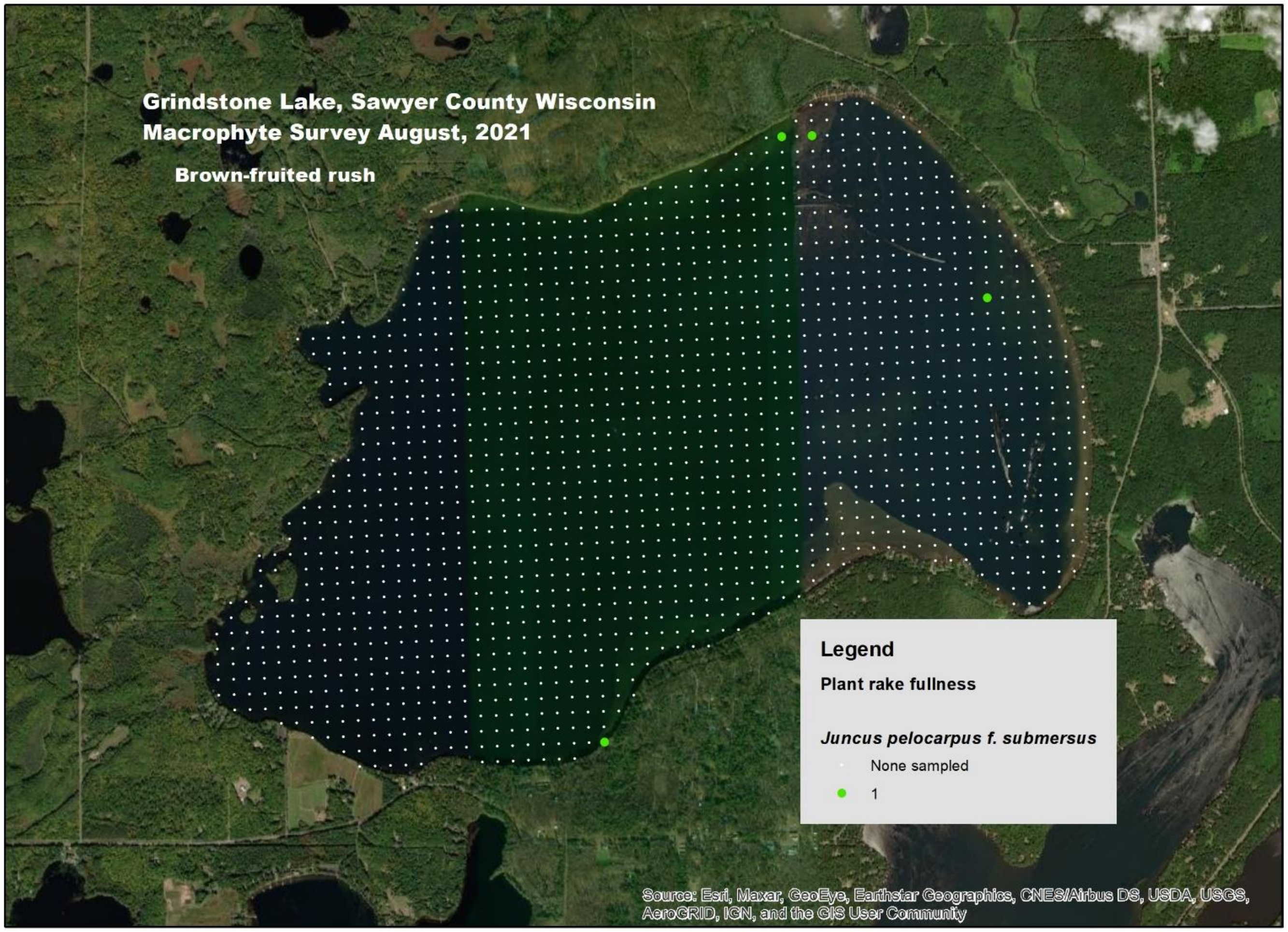
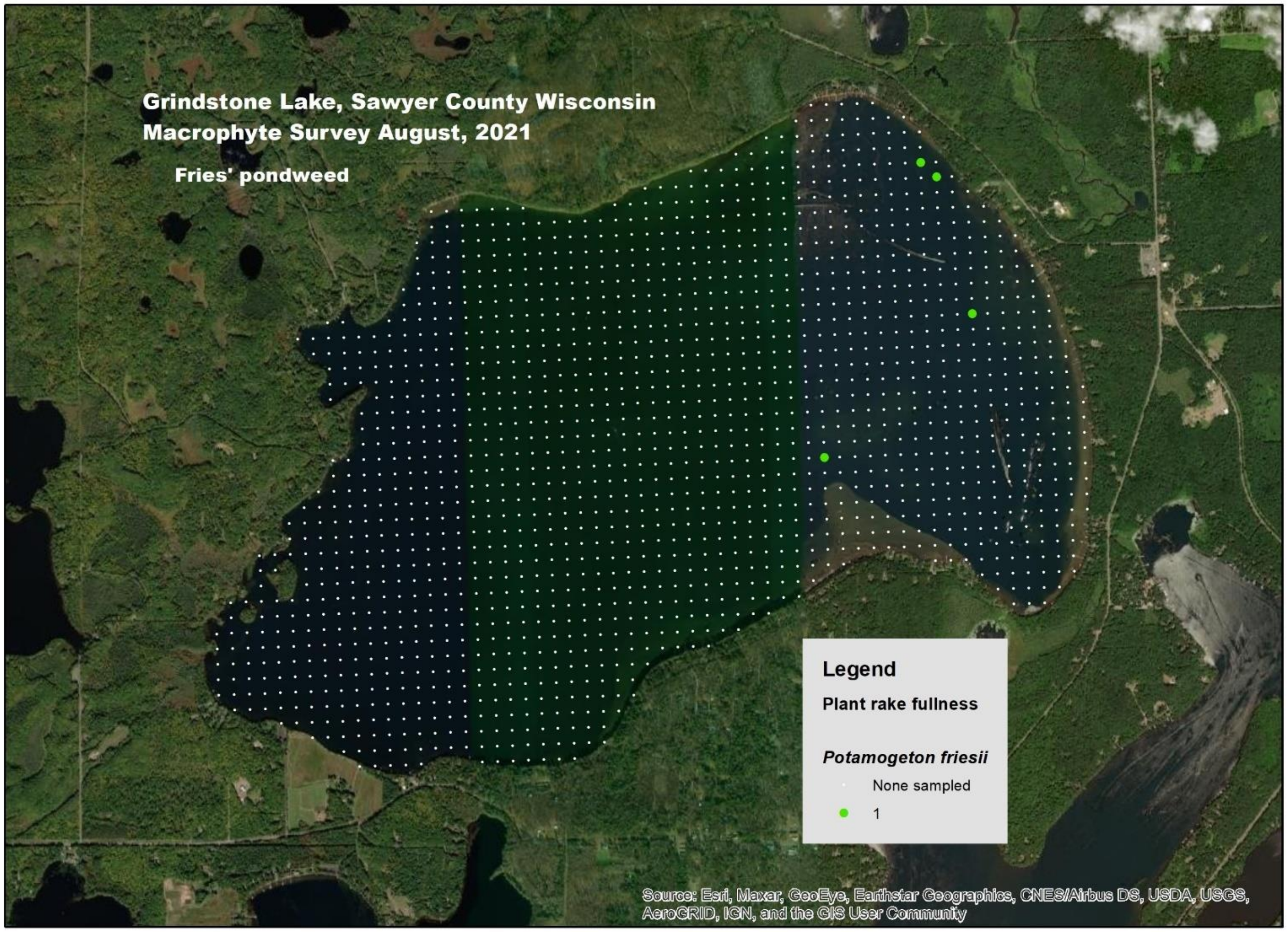
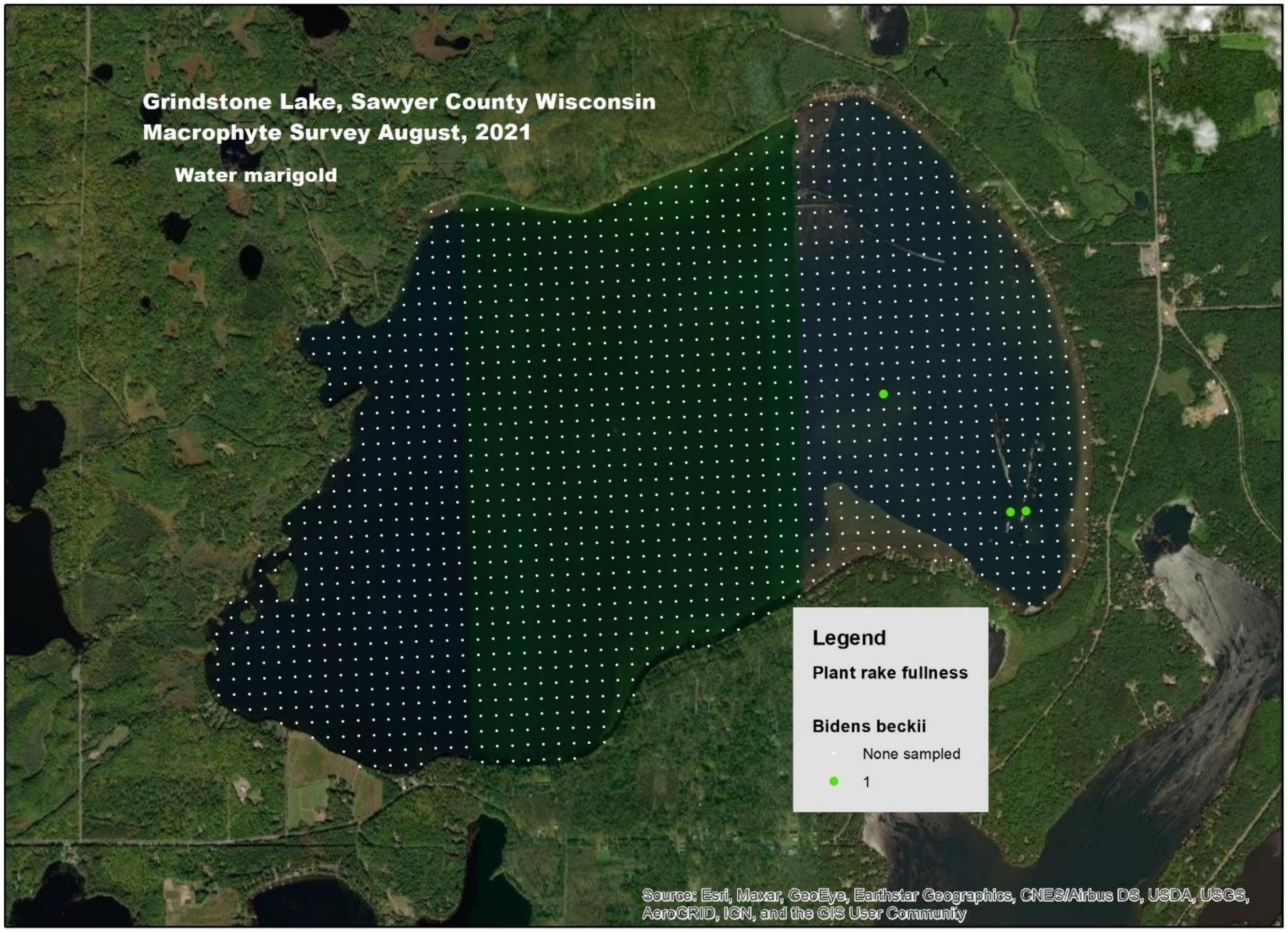
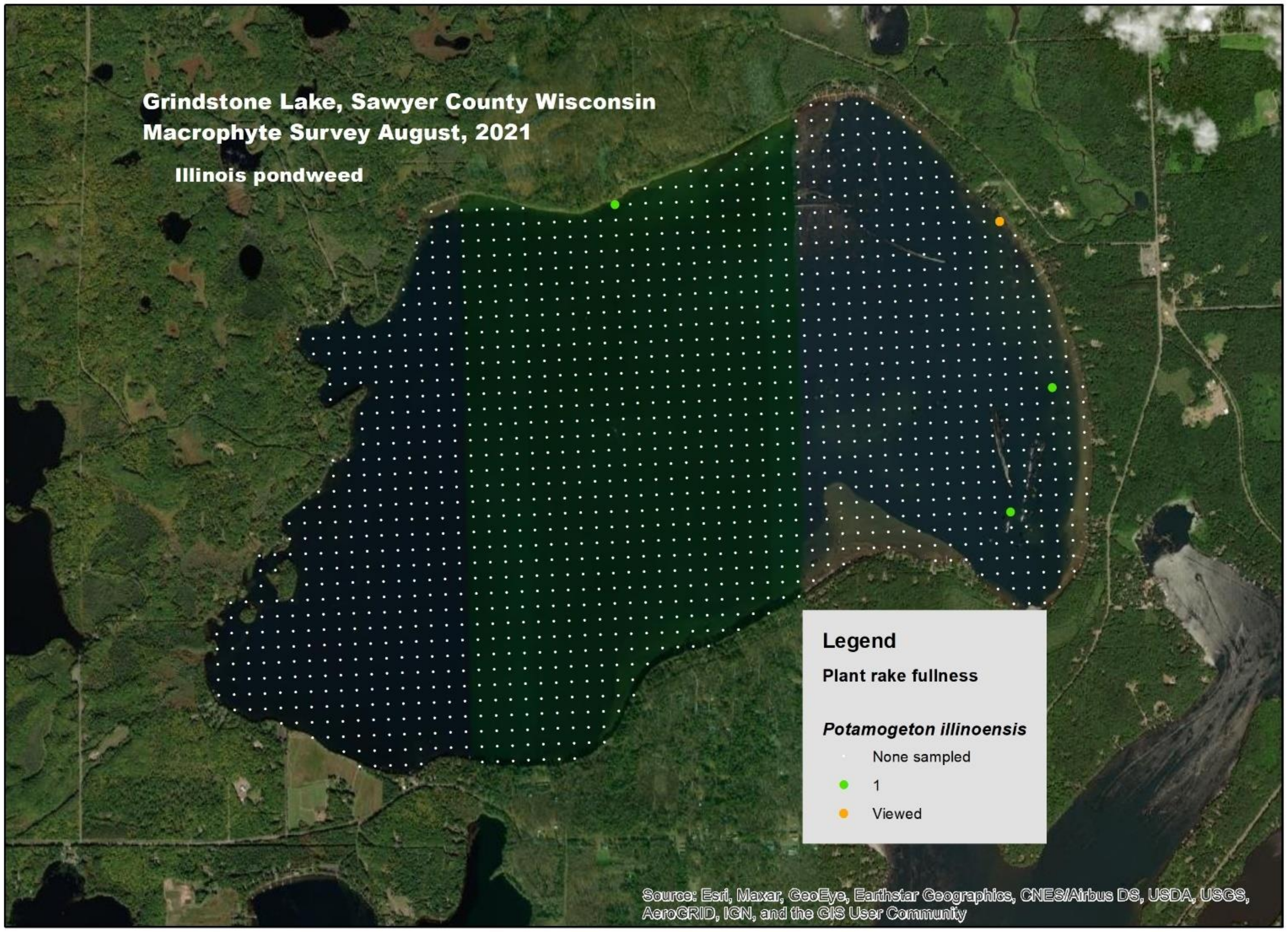

Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Arum-leaved arrowhead
Legend
Plant rake fullness
Sagittaria cuneata
None sampled
1
Viewed
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Brown-fruited rush
Legend
Plant rake fullness
Juncus pelocarpus f. submersus
None sampled
1
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

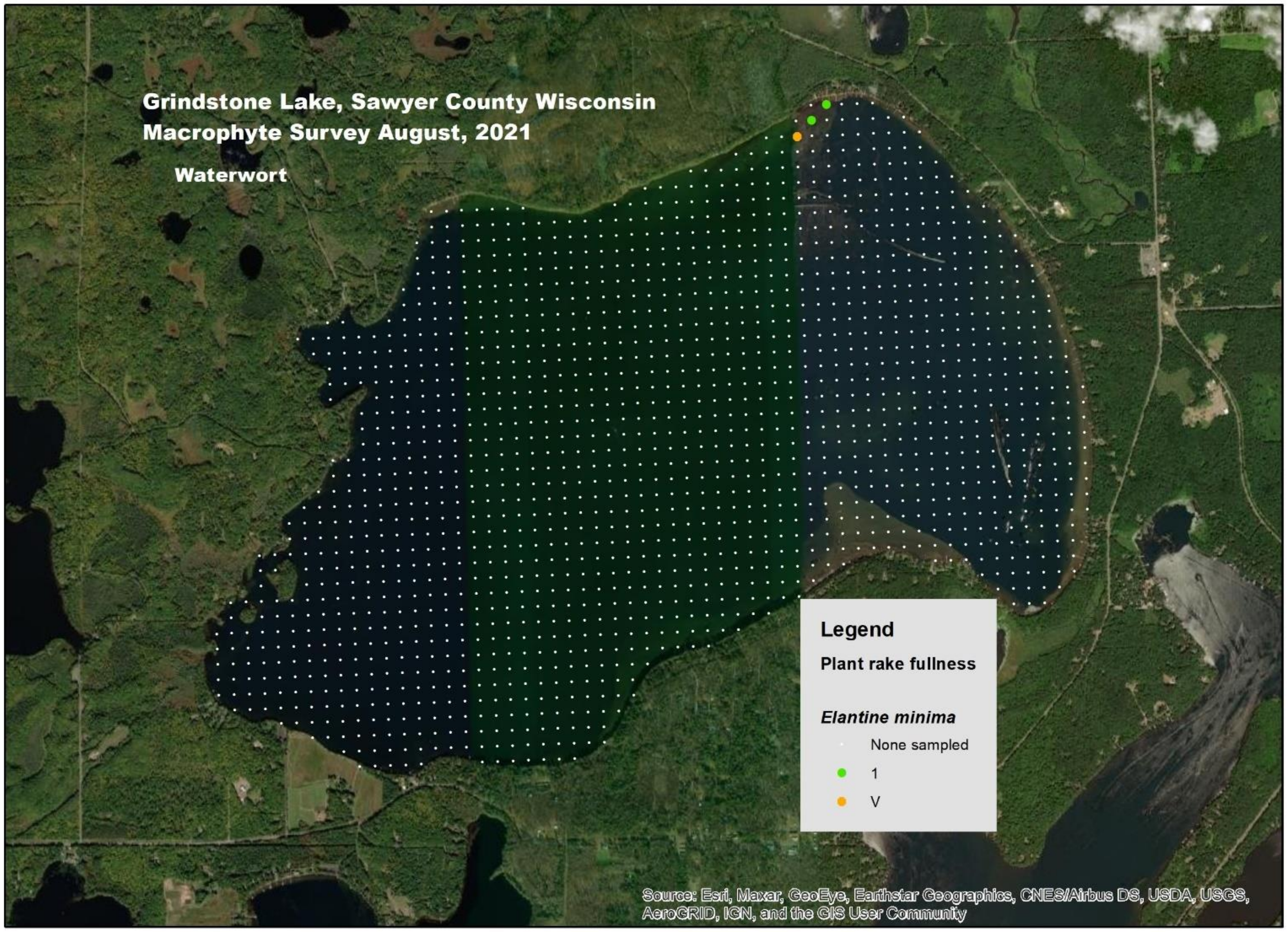

Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Fries' pondweed
Legend
Plant rake fullness
Potamogeton friesii
None sampled
1
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

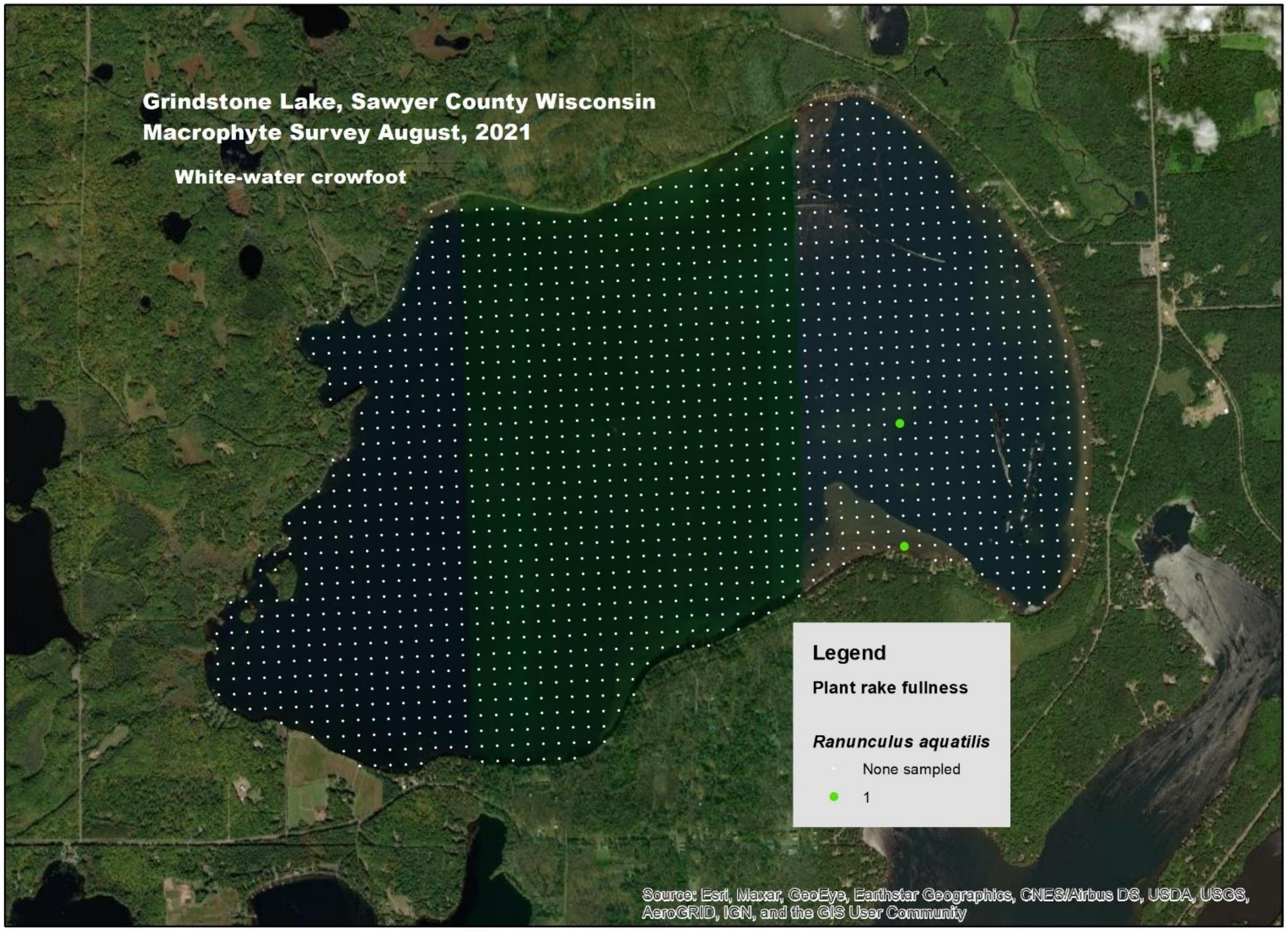


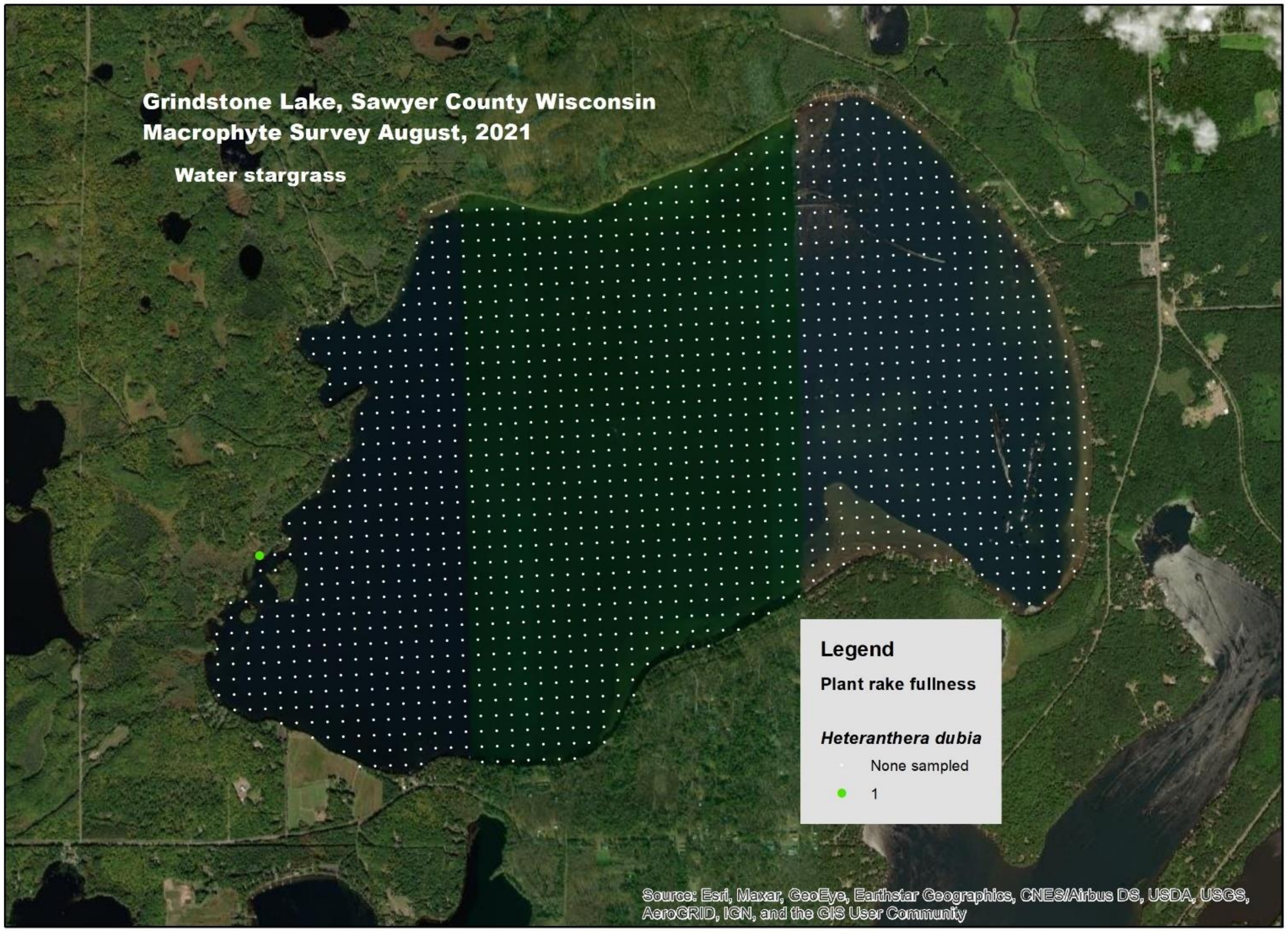
Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Water marigold
Legend
Plant rake fullness
Bidens beckii
None sampled
1
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



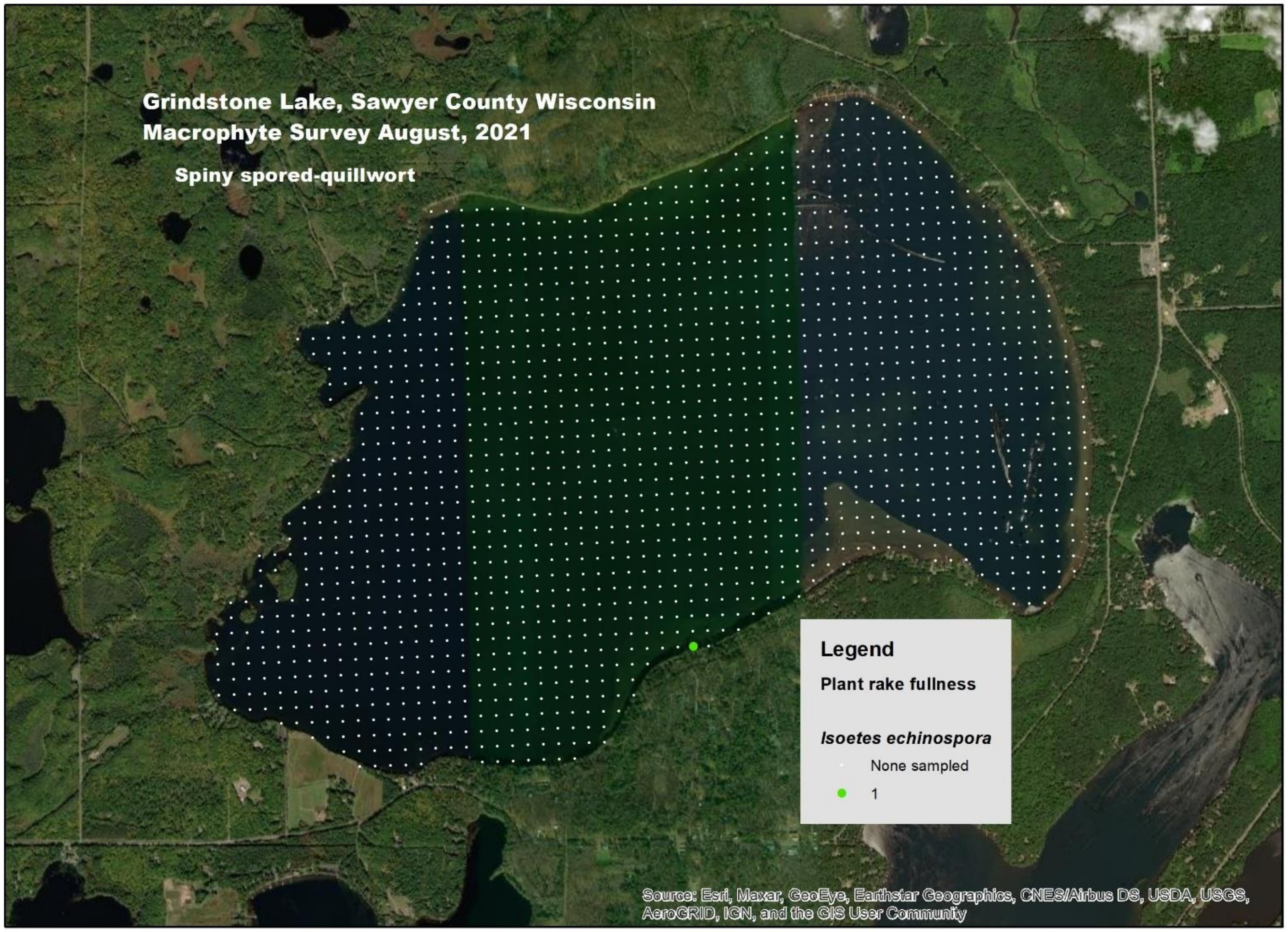
Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Illinois pondweed
Legend
Plant rake fullness
Potamogeton illinoensis
None sampled
1
Viewed
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

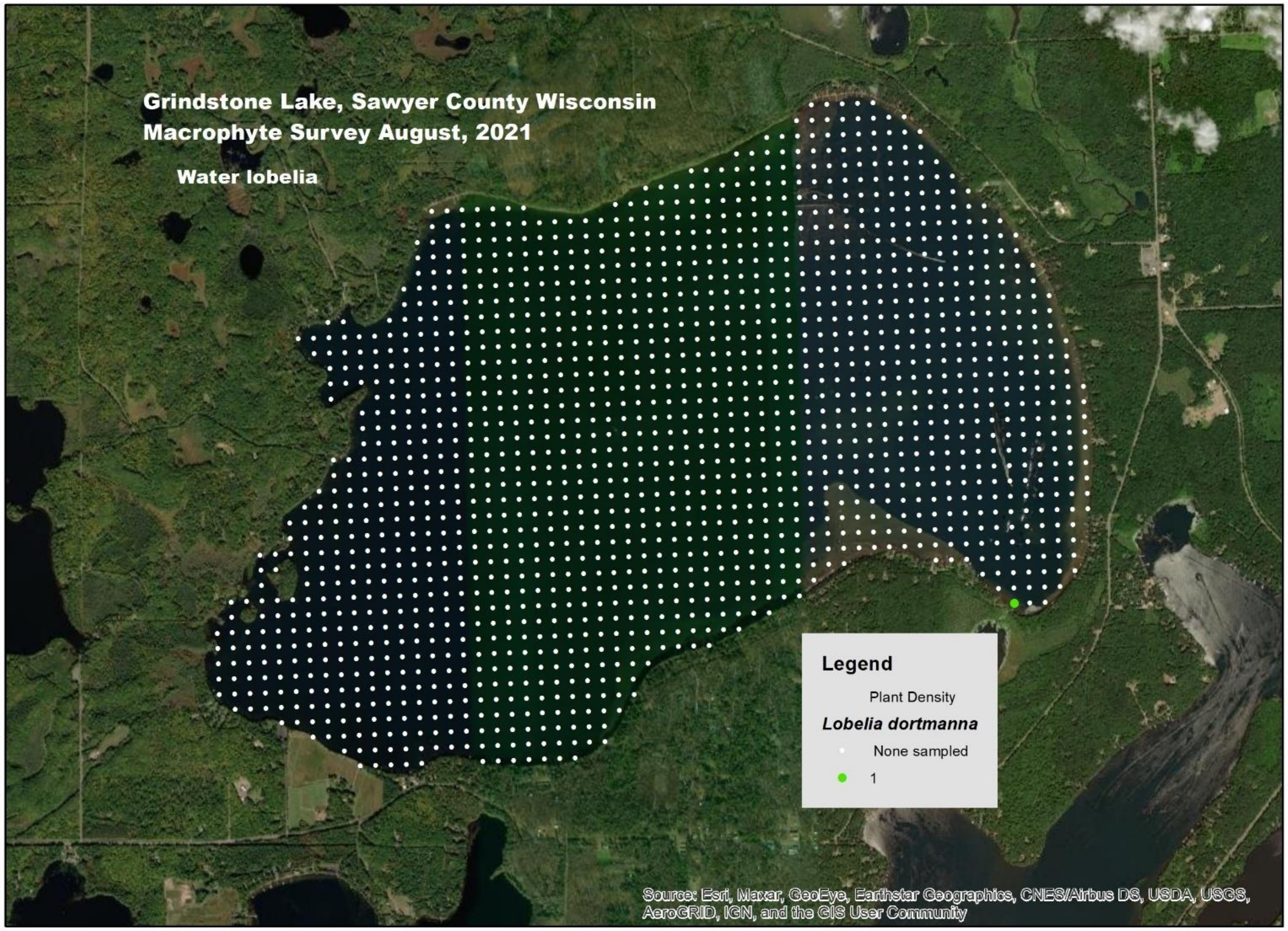

Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Waterwort
Legend
Plant rake fullness
Elantine minima
None sampled
1
V
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

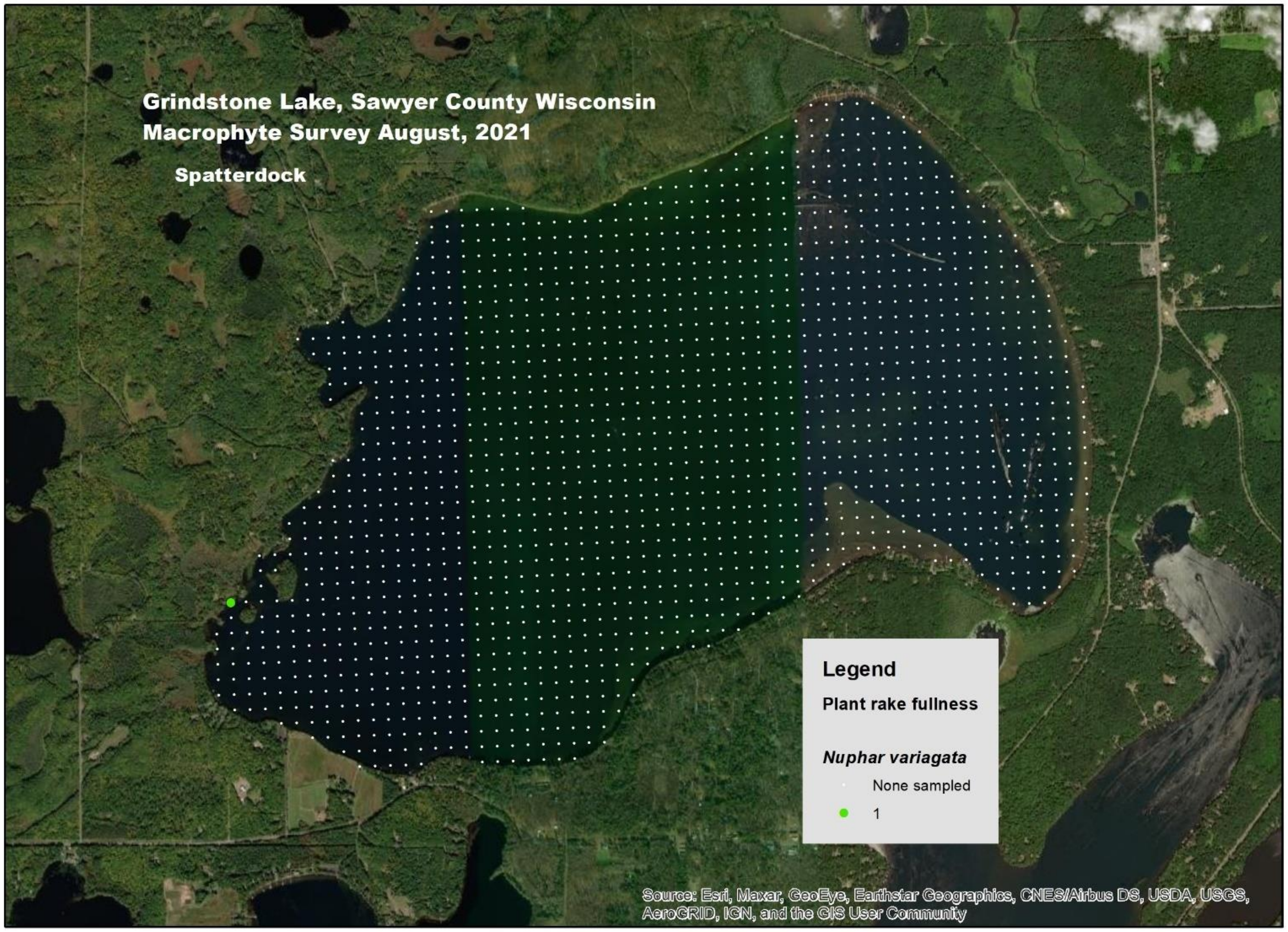

Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
White-water crowfoot
Legend
Plant rake fullness
Ranunculus aquatilis
None sampled
1
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

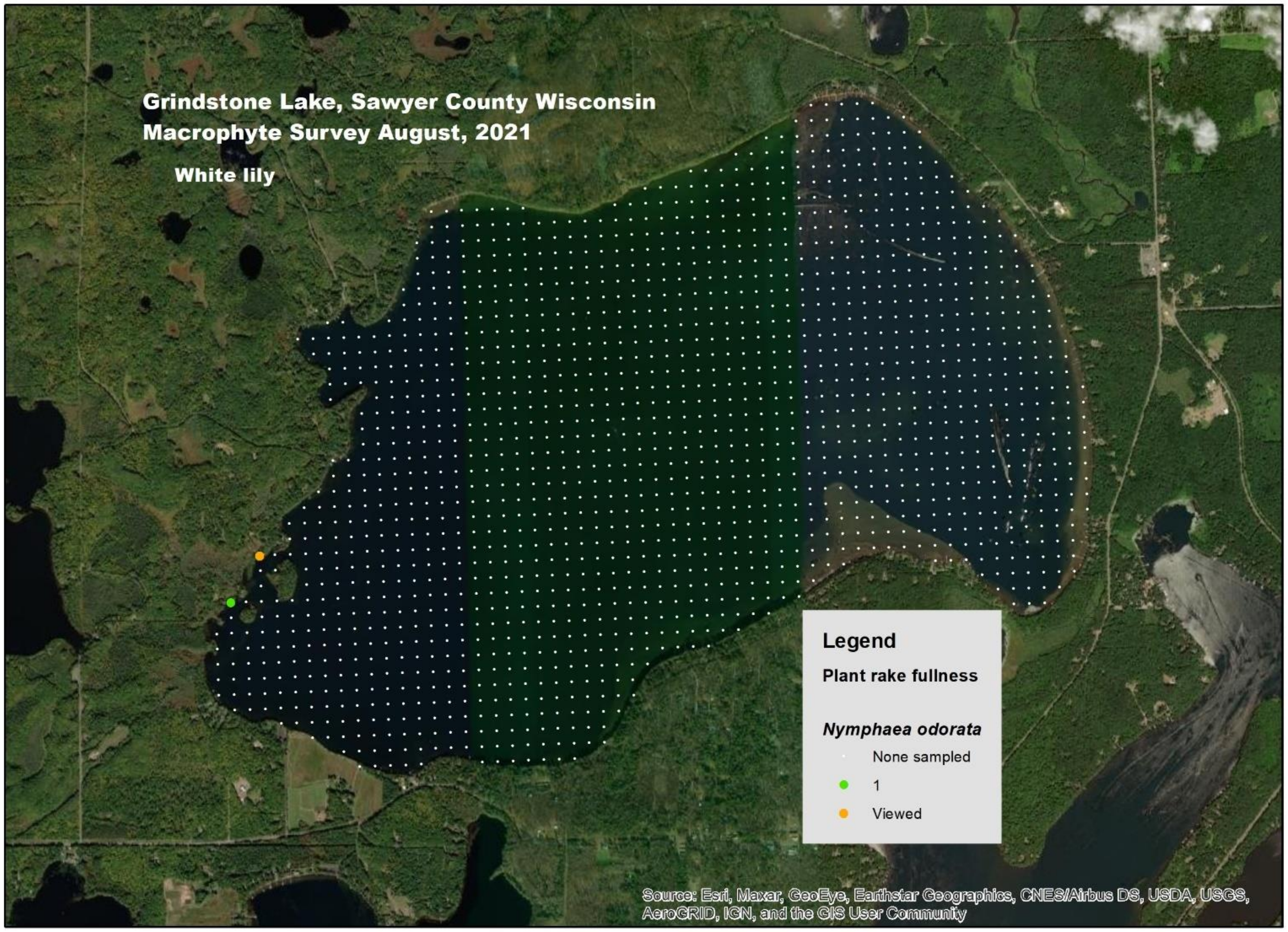


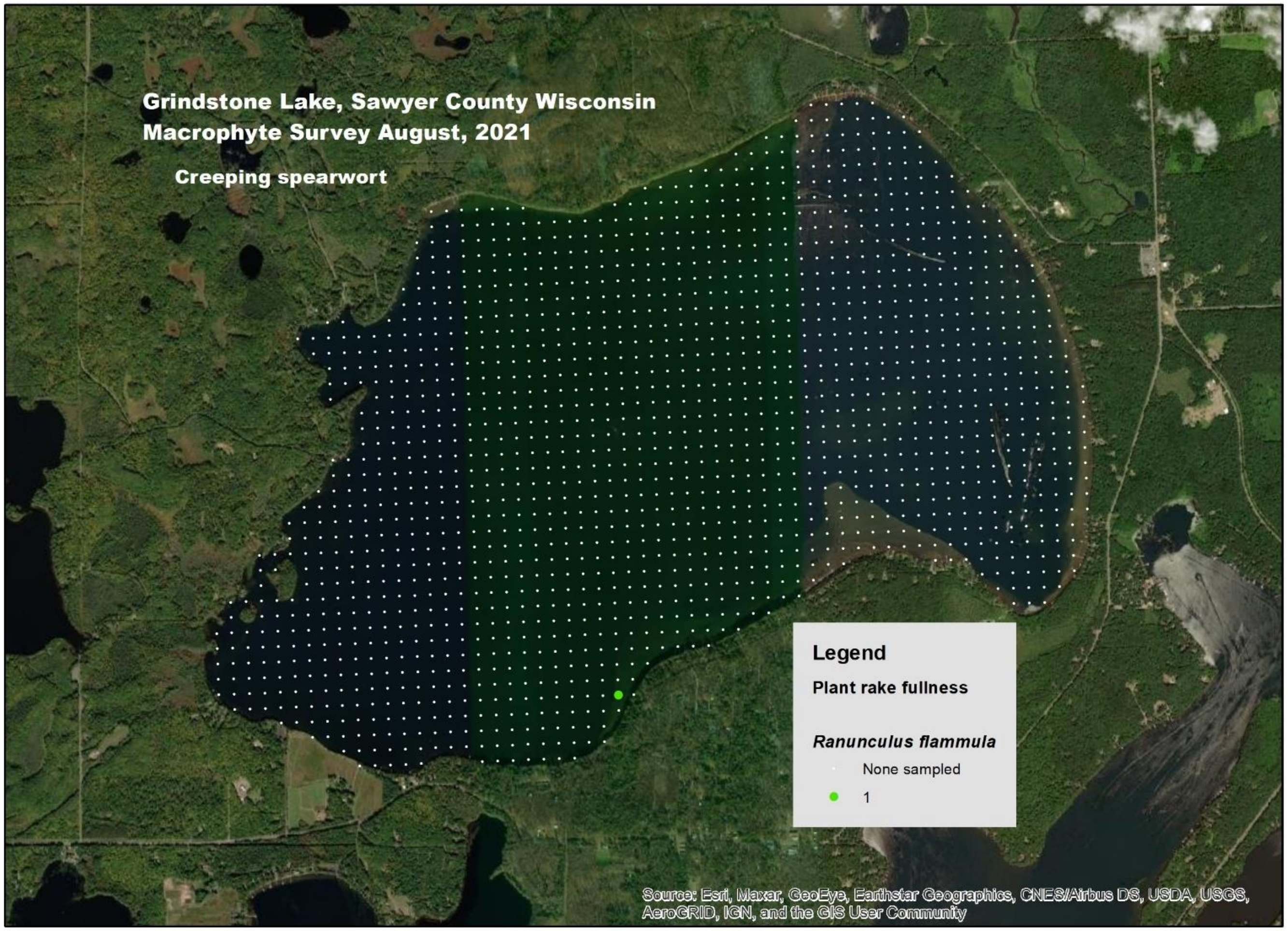
Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Water stargrass
Legend
Plant rake fullness
Heteranthera dubia
None sampled
1
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

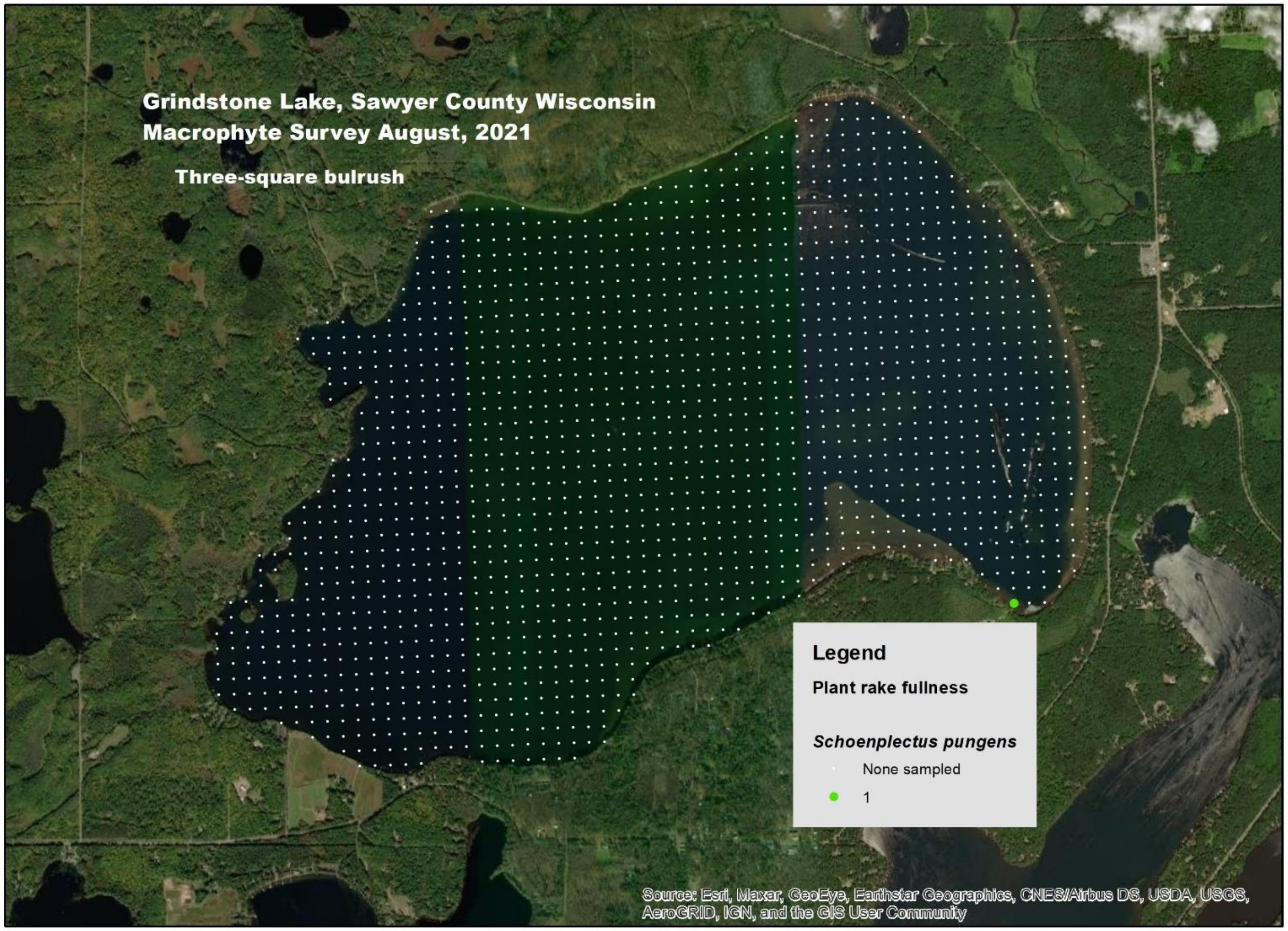

Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Spiny spored-quillwort
Legend
Plant rake fullness
Isoetes echinospora
None sampled
1
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Water lobelia
Legend
Plant Density
Lobelia dortmanna
None sampled
1
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

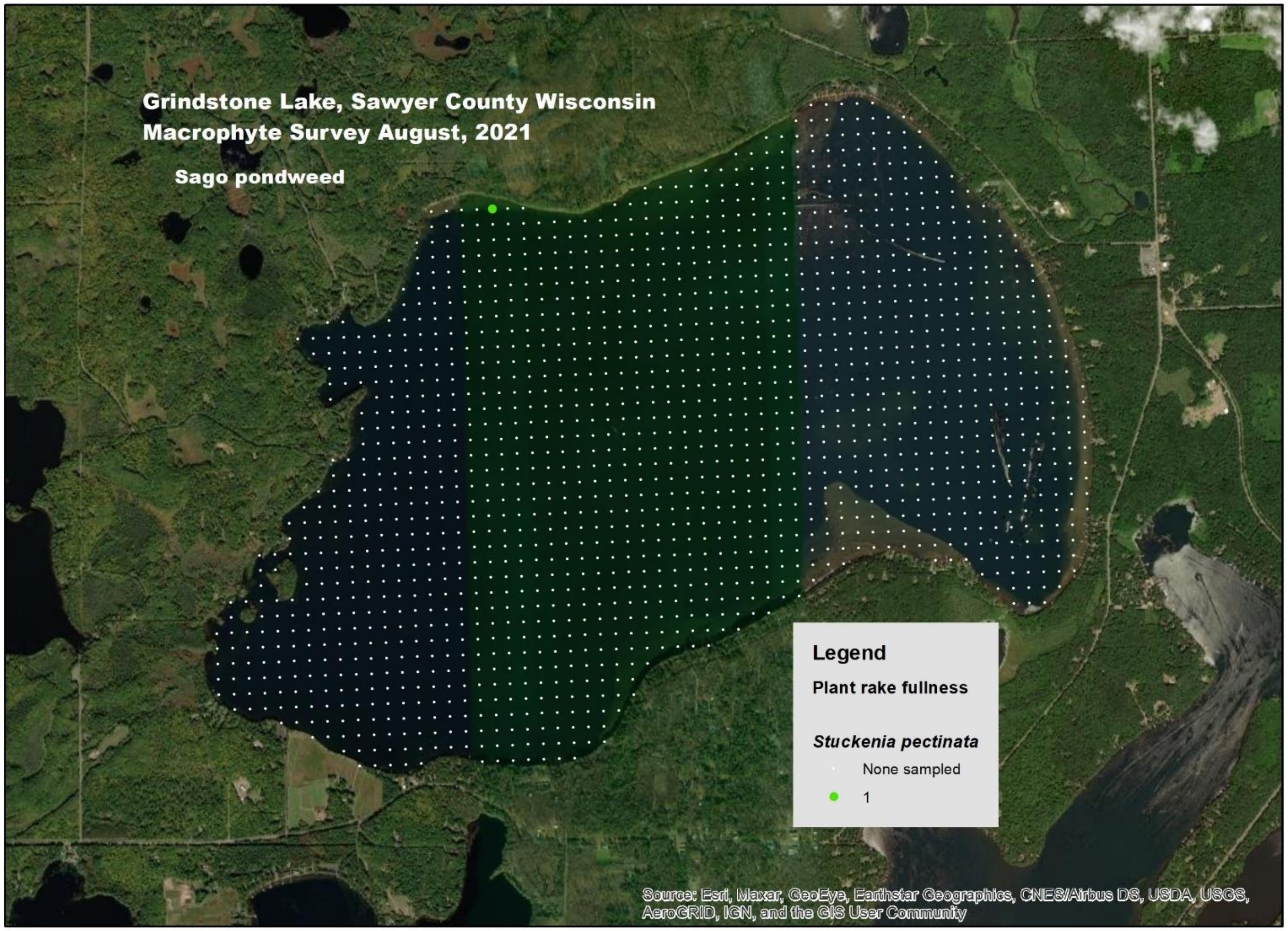

Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Spatterdock
Legend
Plant rake fullness
Nuphar variagata
None sampled
1
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
White lily
Legend
Plant rake fullness
Nymphaea odorata
None sampled
1
Viewed
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

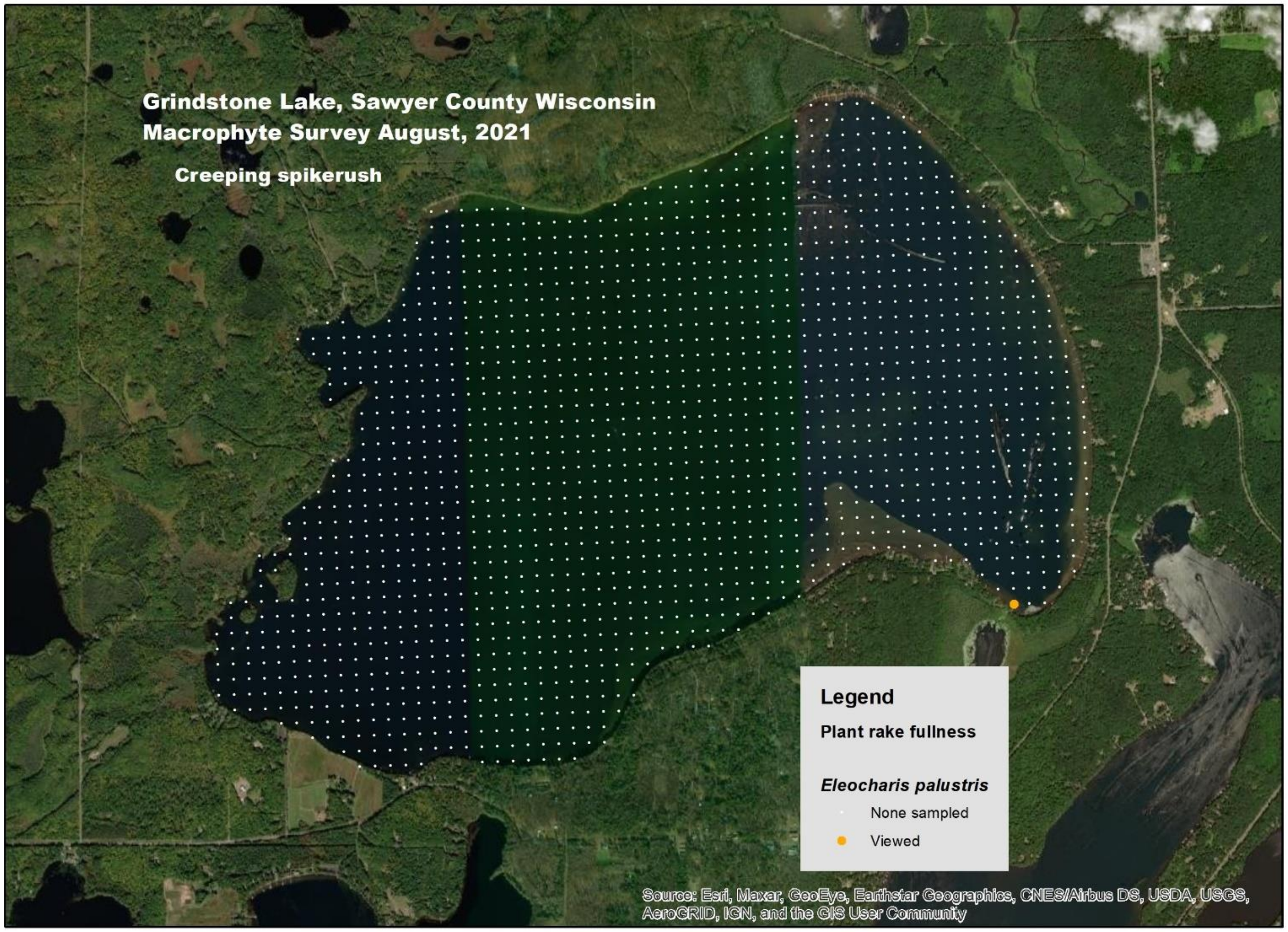

Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Creeping spearwort
Legend
Plant rake fullness
Ranunculus flammula
None sampled
1
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



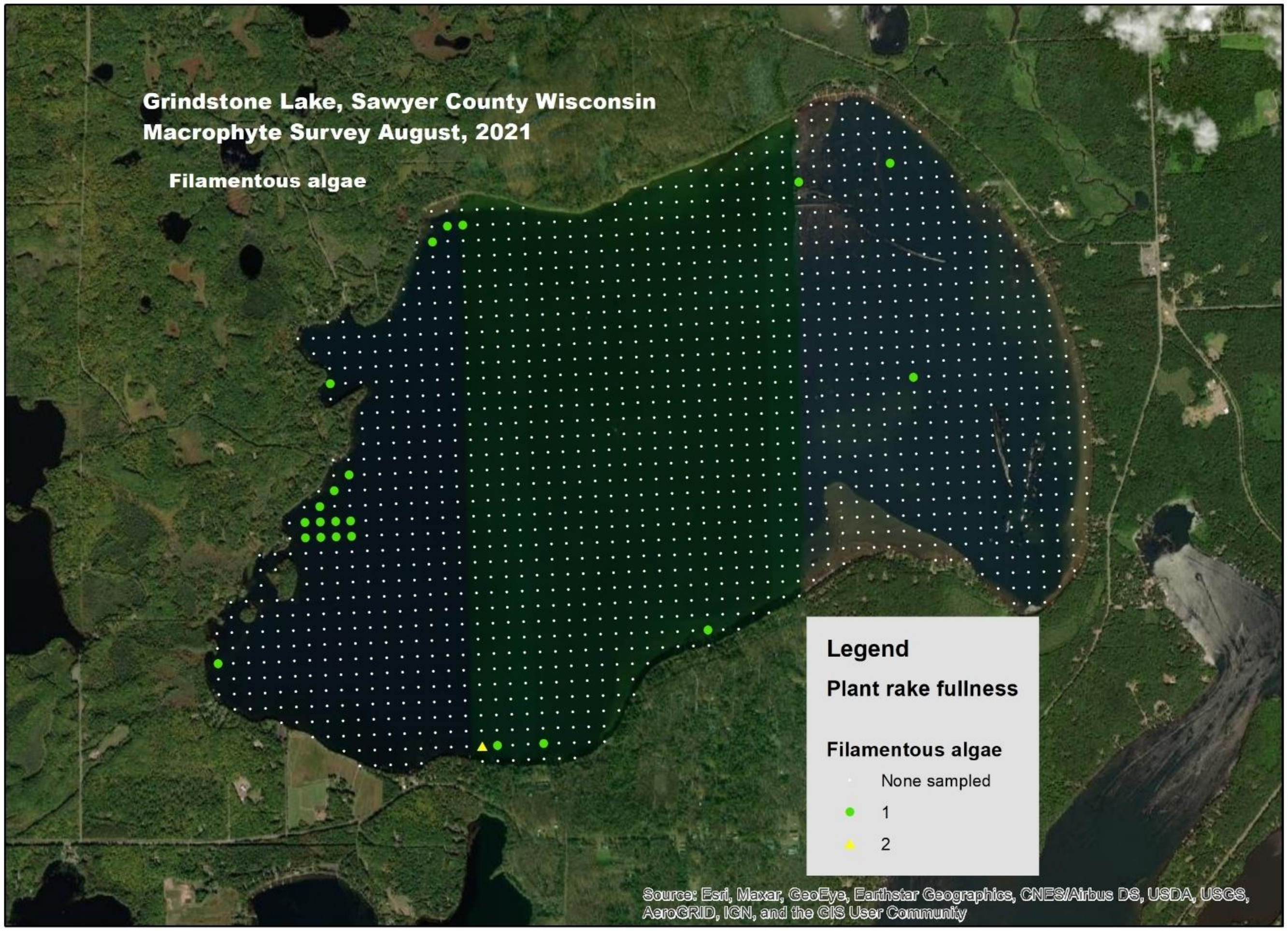
Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Three-square bulrush
Legend
Plant rake fullness
Schoenplectus pungens
None sampled
1
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

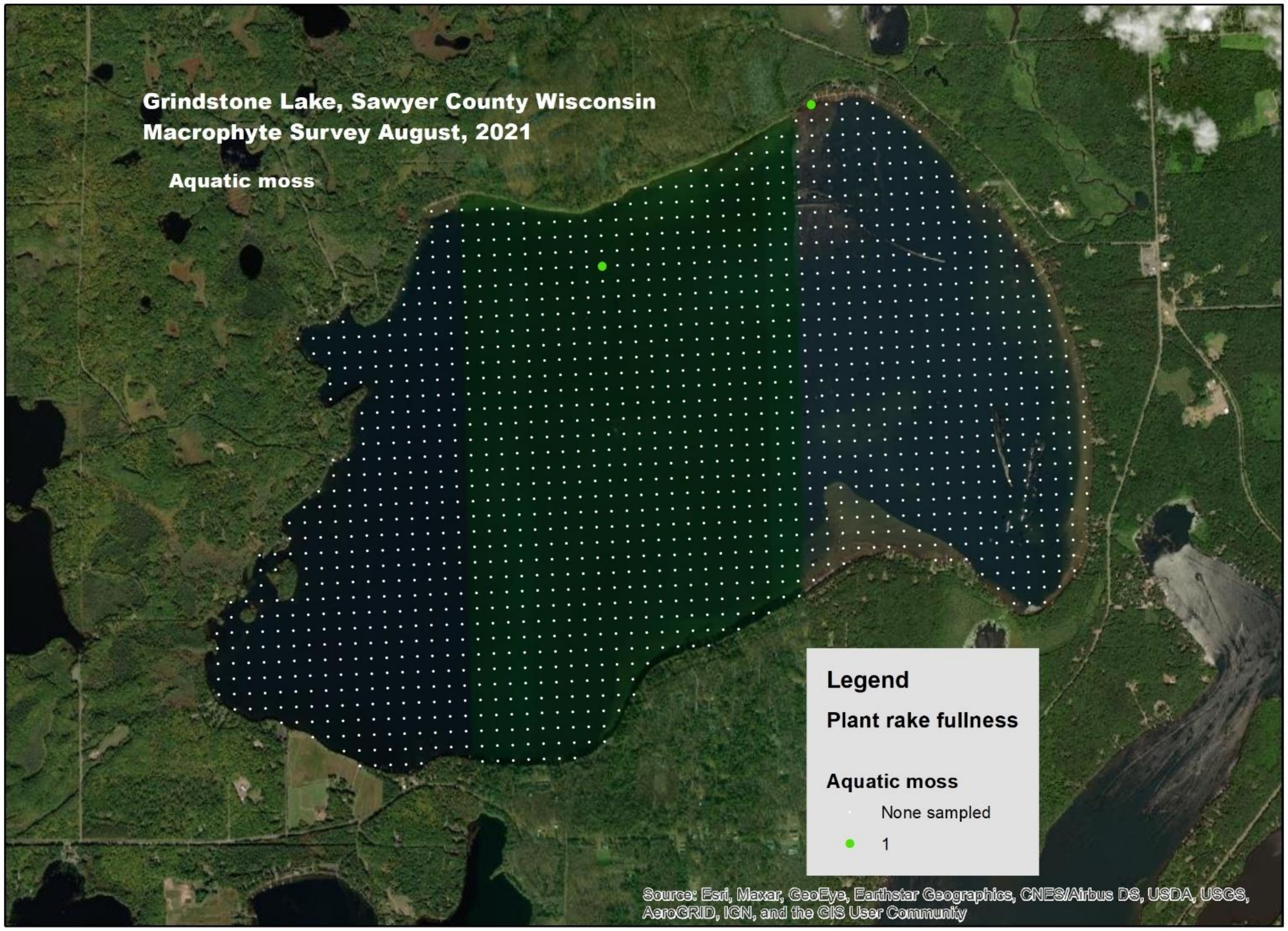


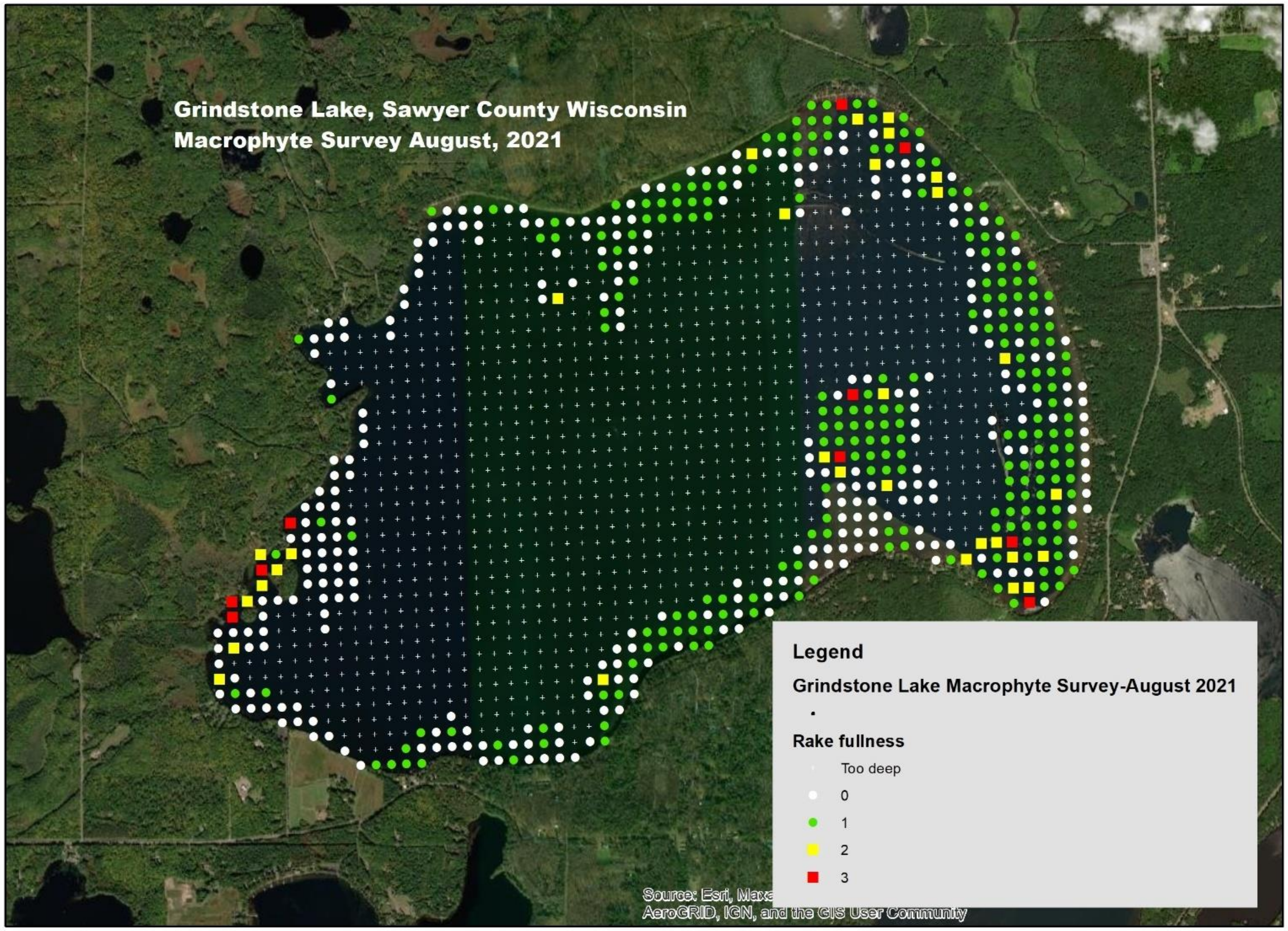
Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Sago pondweed
Legend
Plant rake fullness
Stuckenia pectinata
None sampled
1
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

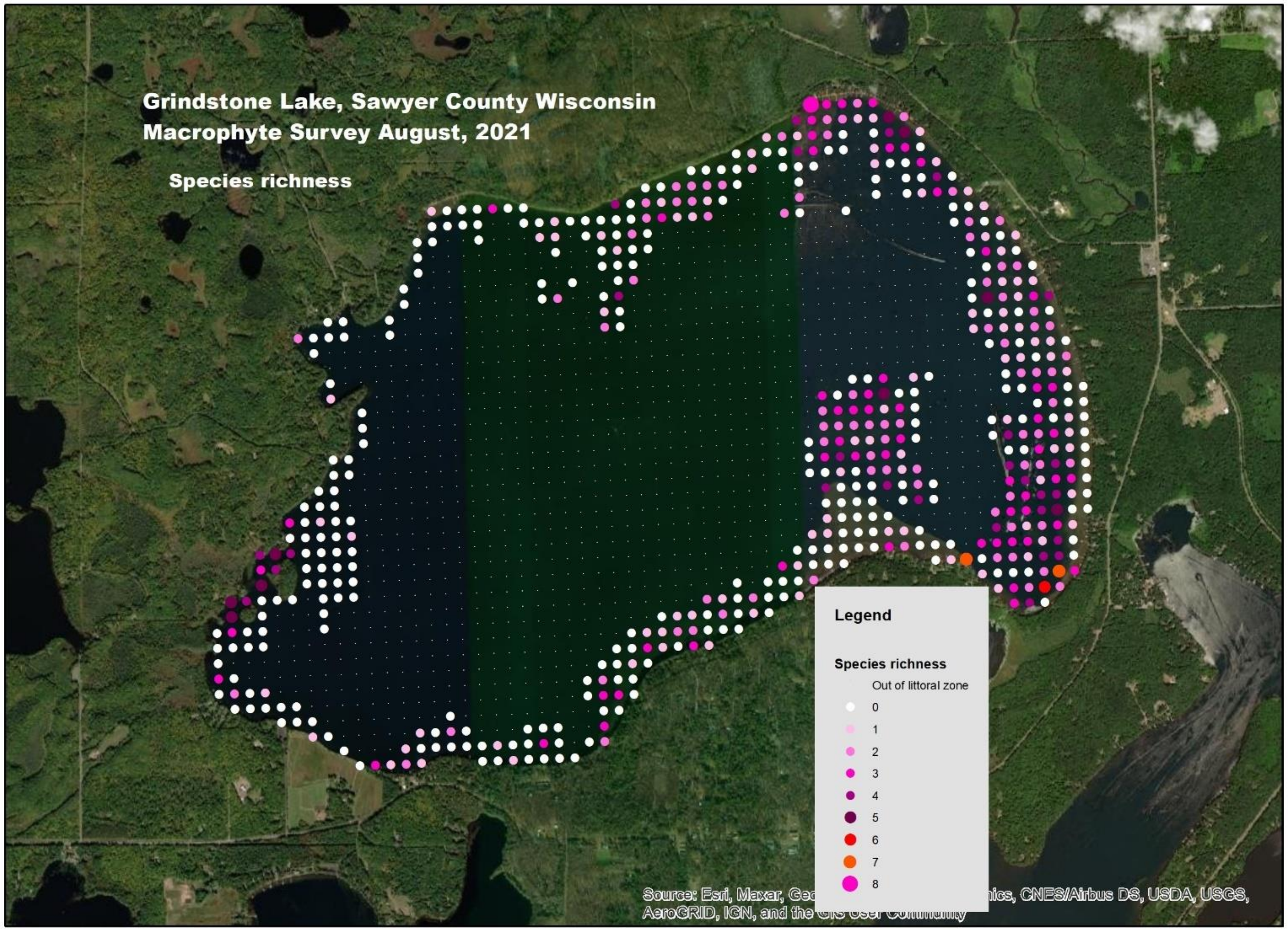


Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Creeping spikerush
Legend
Plant rake fullness
Eleocharis palustris
None sampled
Viewed
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

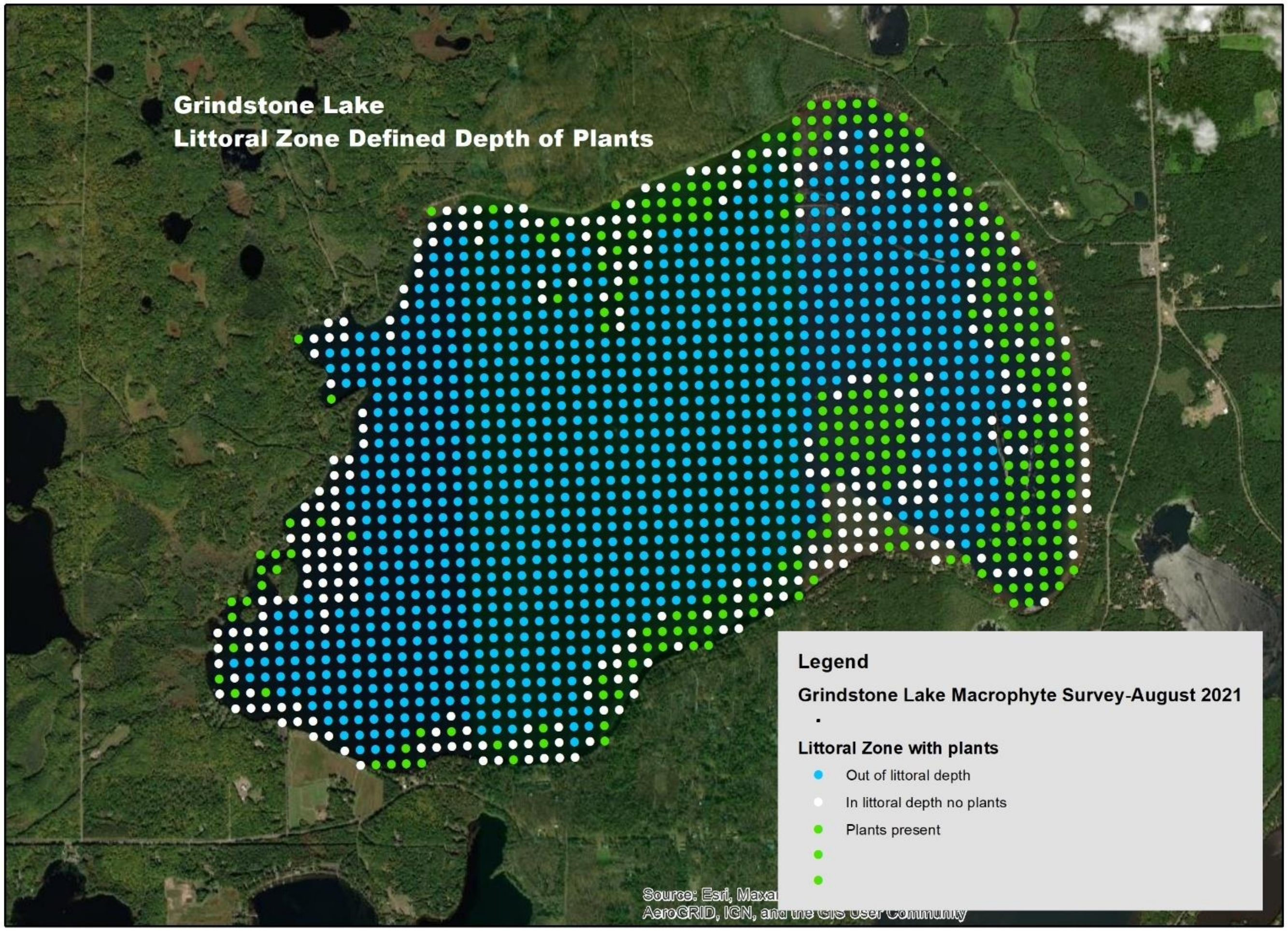

Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Filamentous algae
Legend
Plant rake fullness
Filamentous algae
None sampled
1
2
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Aquatic moss
Legend
Plant rake fullness
Aquatic moss
None sampled
1
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

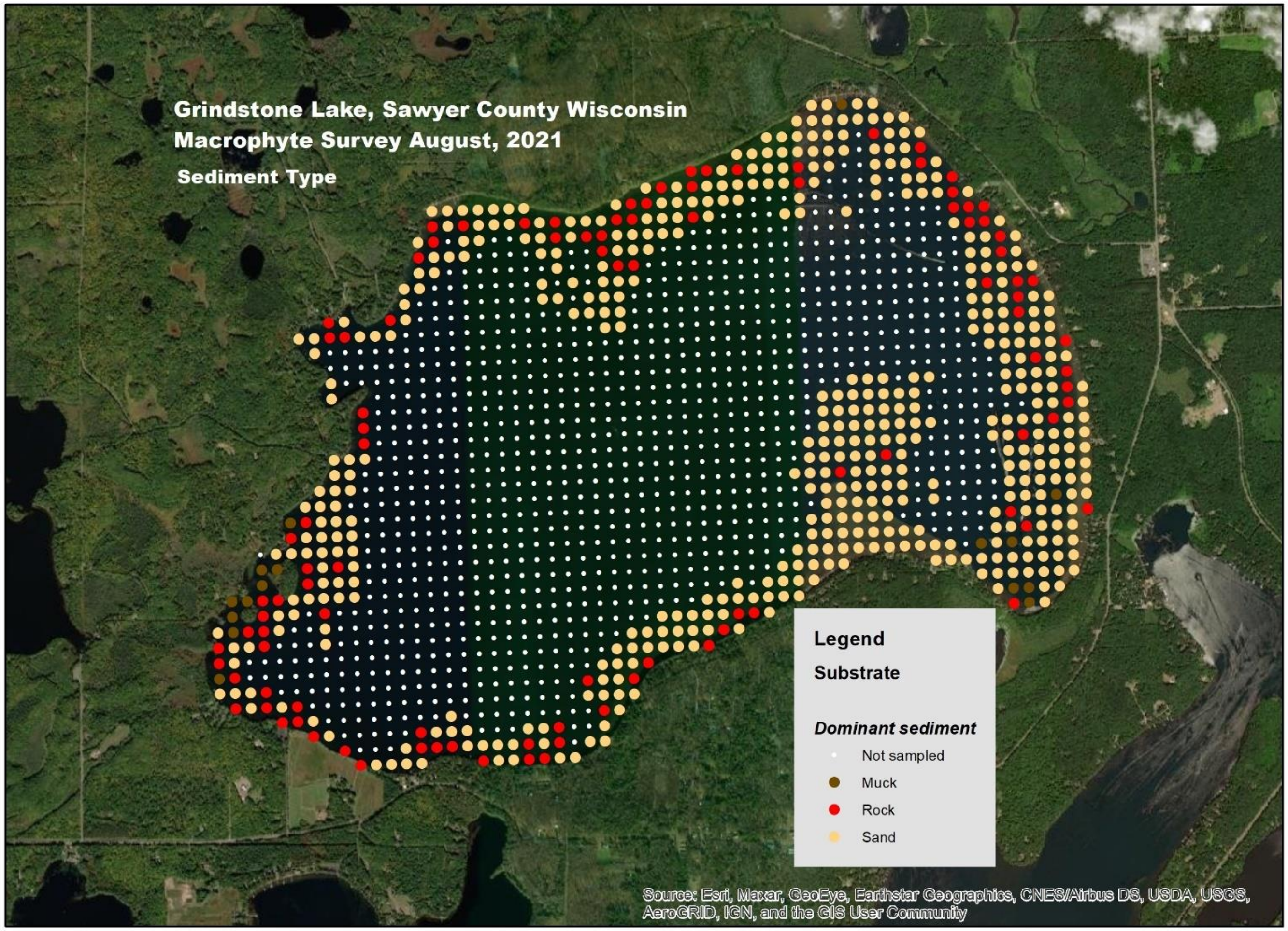

Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Legend
Grindstone Lake Macrophyte Survey-August 2021
Rake fullness
Too deep
0
1
2
3
Source: Esri,
AeroGRID, IGN, and the GIS User Community

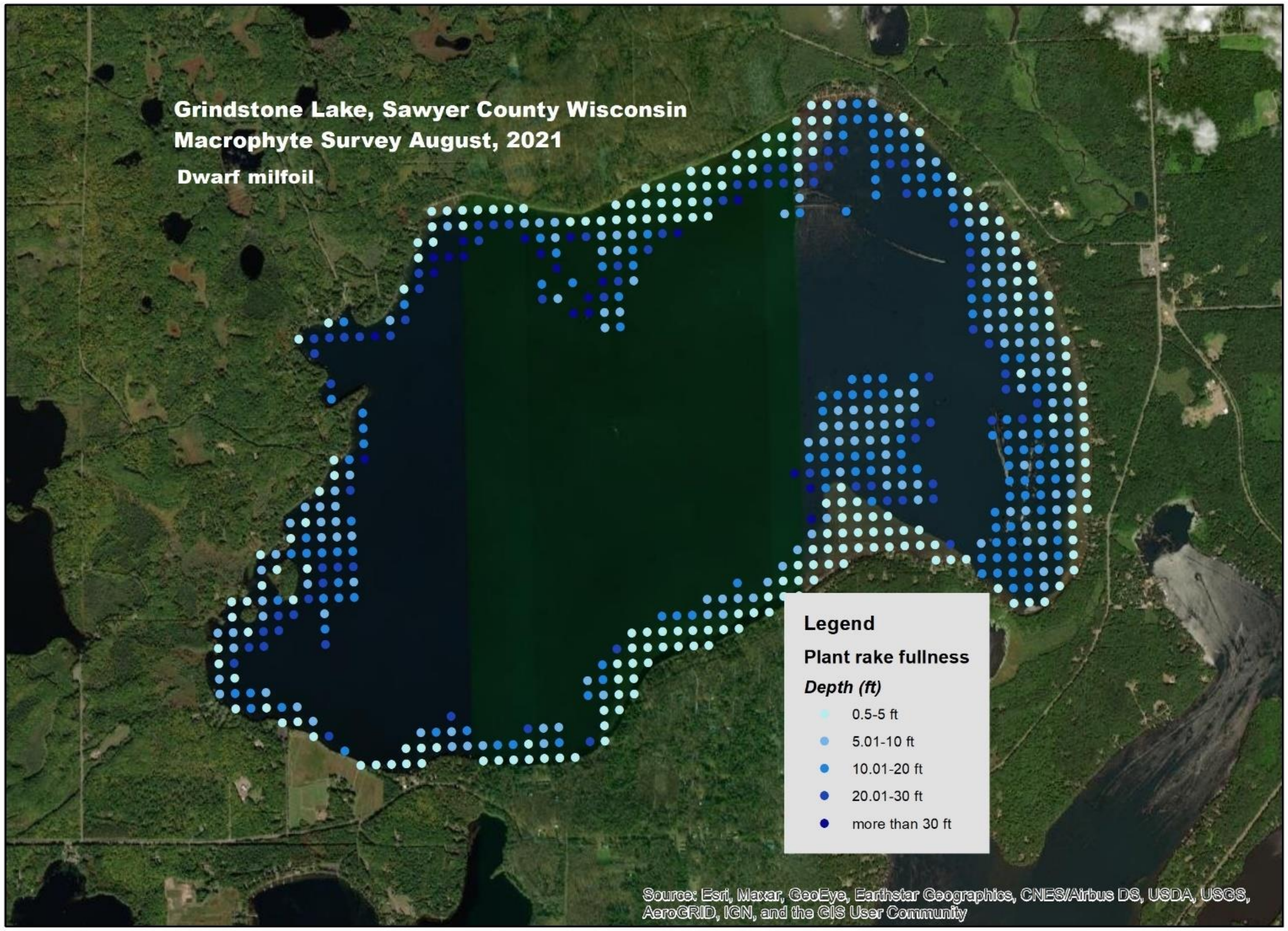


Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Species richness
Legend
Species richness
Out of littoral zone
0
1
2
3
4
5
6
7
8
Source: Esri, Maxar, Ge
nics, CNES/Airbus DS, USDA, USGS,
AeroGRID, IGN, and the GIS User Community



Grindstone Lake
Littoral Zone Defined Depth of Plants
Legend
Grindstone Lake Macrophyte Survey-August 2021
Littoral Zone with plants
Out of littoral depth
In littoral depth no plants
Plants present
Source: Esri, Maxar
AeroGRID, IGN, and the GIS User Community


Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Sediment Type
Legend
Substrate
Dominant sediment
Not sampled
Muck
Rock
Sand
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Grindstone Lake, Sawyer County Wisconsin
Macrophyte Survey August, 2021
Dwarf milfoil
Legend
Plant rake fullness
Depth (ft)
0.5-5 ft
5.01-10 ft
10.01-20 ft
20.01-30 ft
more than 30 ft
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community