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Pachaug Pond

Griswold, CT

Aquatic Vegetation Survey
Water Chemistry
Aquatic Plant Management Options
2021

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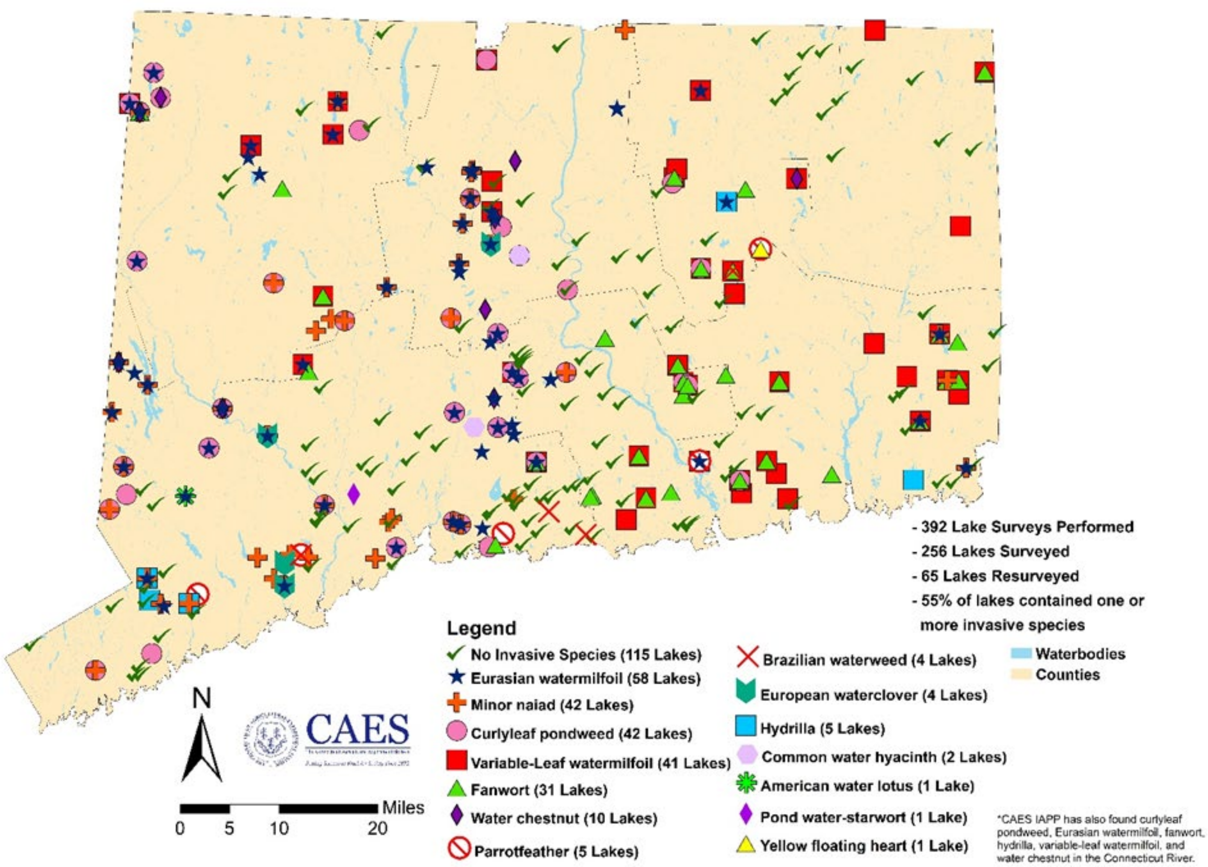


Figure 1. Locations of invasive aquatic plants found by CAES IAPP from 2004 – 2021.

Introduction

Since 2004, The Connecticut Agricultural Experiment Station (CAES) Invasive Aquatic Plant Program (IAPP) has surveyed or resurveyed aquatic vegetation and monitored water chemistry of nearly 400 Connecticut lakes, ponds, and rivers (Figure 1). Approximately 55% of the lakes and ponds contain invasive (non-native) plant species that are capable of causing rapid deterioration of aquatic ecosystems and recreational value. The presence of invasive species is related to water chemistry, public boat launches, random events, and climate change (Rahel and Olden, 2008). A CAES IAPP database is online where stakeholders can view digitized vegetation maps, detailed transect data, temperature and dissolved oxygen profiles, and water test results for clarity, pH, alkalinity, conductivity, total phosphorus, and total nitrogen https://portal.ct.gov/caes-iapp. This information allows citizens, government officials, and scientists to view past conditions, compare them with current conditions, and make educated management decisions. This is the fifth CAES IAPP survey of Pachaug Pond.

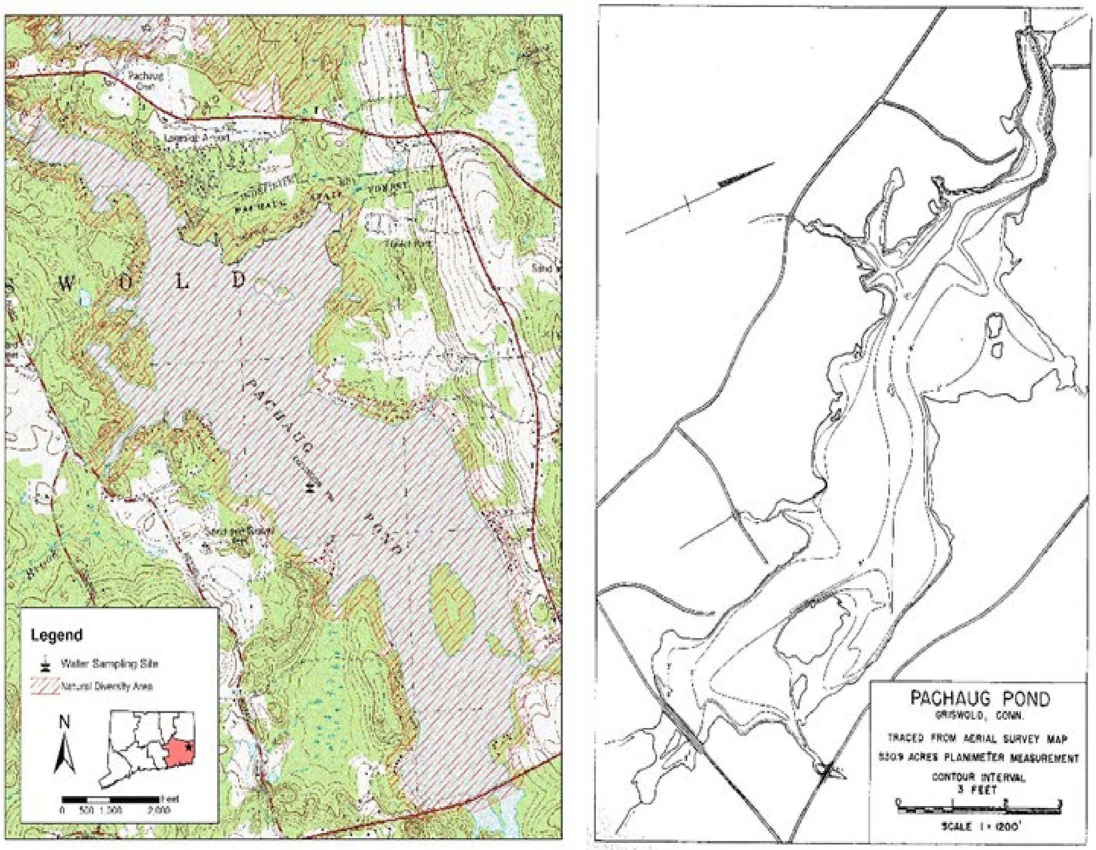


Figure 2. Topographic map of Pachaug Pond including location of state-listed species (Natural Diversity Area) and CAES IAPP water sampling site (left) and bathymetry map circa 1959 (right).

Pachaug Pond is an 817-acre waterbody located in Griswold, CT. It is Connecticut's largest body of freshwater east of the Connecticut River and offers important wildlife habitat as well as recreational opportunities including fishing, swimming, boating, cross-country skiing, and snowmobiling. The pond is home to a marina, a campground, a state boat launch ramp, and a fish and game club. Stocked with northern pike, the pond is the site of many fishing derbies (PWCA, 2022). It has a maximum depth of approximately 16 feet and an average depth of about six feet. The shallow nature of the lake creates a large littoral zone that favors aquatic plant growth. State-listed species are present throughout the entire lake (Figure 2, left; CT DEEP, 2021a). Protection of these species requires withholding details from the public without special request forms. Public access is via a state boat launch on the northern shore. There are no motor restrictions. Previous work on Pachaug Pond dates back to the 1950's when the State Board of Fisheries and Game (1959) described the lake as being shallow and fertile with abundant emergent and submergent vegetation (Figure 2, right; see appendix for full description). The specific plant species were not mentioned, but the bottom was described as being mud, swampy ooze, and sand. A dense algal bloom was observed that reduced the water clarity to two feet. Bass fishing was described as excellent with fish over five pounds common. The 1959 description mentioned frequent severe summer drawdowns that may have been controlling aquatic vegetation. These drawdowns were stated as needed for "industrial" purposes, which was likely power generation (personal communication). Apparently, drawdowns were lessening as of 1959, and aquatic vegetation was increasing. CAES studied Pachaug Pond in 1979 as part of a statewide investigation into changes in lake water chemistry (Frink and Norvell, 1984). In addition to detailed water chemistry, the study mentions Pachaug Pond as having moderately dense aquatic weeds in shallow areas and watermilfoil near the boat launch (species not identified). Interestingly, pioneer infestations of invasive species might first be noticed at the boat launches if the plant arrived on a boat or trailer. The 1979 CAES water tests found a water clarity of 3.5 m (12 feet), an alkalinity of 15 mg/L $CaCO_3$ and a total phosphorus concentration of 16 μg/L at the surface and 13 μg/L at the bottom. These results suggest an oligo-mesotrophic condition where nutrients are not excessive.

Objectives

- Perform a fifth survey of Pachaug Pond for aquatic vegetation and test water to quantify water chemistry.
- Compare with previous surveys and add vegetation maps and water chemistry information to the CAES IAPP website.
- Update aquatic plant management options.

Materials and Methods

Aquatic Plant Surveys and Mapping

We surveyed Pachaug Pond for aquatic vegetation on August 17, 19, 20, and 25, 2021. The survey utilized methods established by CAES IAPP with the exception of fewer transects and less detail due to funding restrictions. Surveys were conducted from 16- and 18-foot motorized boats traveling over areas that supported aquatic plants. Plant species were recorded based on visual observation or collections with a long-handled rake or grapple. Lowrance® Hook 5 and HDS 5 sonar systems as well as ground truthing with occasional grapple tosses were used to identify vegetated areas in deep water. Quantitative information on plant abundance was obtained by resurveying 10 transects that were positioned perpendicular to the shoreline in 2017. Transect locations represented the variety of habitats occurring in the lake. Transects were located using a Trimble® R1 GNSS global positioning system with sub-meter accuracy. Sampling data points were taken along each transect at points 0, 5, 10, 20, 30, 40, 50, 60, 70, and 80 m from the shore. We measured depth with a rake handle, drop line, or digital depth finder, and sediment type was estimated. Abundances of species present at each point were ranked on a scale of 1 – 5 (1 = very sparse, 2 = sparse, 3 = moderately abundant, 4 = abundant, 5 = very abundant). When field identifications of plants were questionable, we brought samples back to the lab for review using the taxonomy of Crow and Hellquist (2000a, 2000b). One specimen of each species collected in the lake was dried and mounted in the CAES IAPP aquatic plant herbarium. Digitized mounts can be viewed online https://portal.ct.gov/caes-iapp. Plant species are referred to by common name in the text of this report, however corresponding scientific names can be found in Table 1. Cattail and phragmites are wetland plants included in our survey at the request of the Pachaug Pond Weed Control Association, Inc. Phragmites is an invasive wetland species and is marked as such in our report. We post-processed the GPS data in Pathfinder® 5.85 (Trimble Navigation Limited, Sunnyvale, CA) and then imported it into ArcGIS® Pro 2.9.0 (ESRI Inc., Redlands, CA). Data were then overlaid onto recent high-resolution (1m or better) aerial imagery for the continental United States made available by the USDA Farm Services Agency.

Water Analysis

Water was analyzed from the deepest part of the lake. Water temperature and dissolved oxygen were measured 0.5 m beneath the surface and at 1 m intervals to the bottom. Water was tested for temperature and dissolved oxygen using an YSI 58® meter. Water clarity was measured by lowering a six-inch diameter black and white Secchi disk into the water and determining to what depth it could be viewed.

Water samples (250 mL) for pH, alkalinity, conductivity, total phosphorus, and total nitrogen testing were obtained from 0.5 m beneath the surface and 0.5 m above the bottom. The samples were stored at 38°C until testing. A Fisher AR20® meter was used to determine pH and conductivity, and alkalinity (expressed as mg/L CaCO3) was quantified by titration with 0.016 N H2SO4 to an end point of pH 4.5. We determined total phosphorus using the ascorbic acid method preceded by digestion with potassium persulfate (APHA, 1995). Phosphorus was quantified using a Milton Roy Spectronic 20D® spectrometer with a light path of 2 cm and a wavelength of 880 nm. Total Nitrogen was determined with a O-I Analytical 1080® Total Organic Carbon Analyzer.

Table 1. Plants present in Pachaug Pond from 2017-2021. Present indicates the species presence in the lake while Frequency of Occurrence (FOQ) indicates presence of a species on transects.

Pachaug Pond											
Species (invasives in bold)		**2017**		**2018**		**2019**		**2020**		**2021**	
Common Name	**Scientific Name**	**Present**	**FOQ (%/point)**	**Present**	**FOQ (%/point)**	**Present**	**FOQ (%/point)**	**Present**	**FOQ (%/point)**	**Present**	**FOQ (%/point)**
Arrowhead	*Sagittaria* species	X	9	X	13	X	6	X	13	X	6
Bur-reed	*Sparganium* species	X	12			X	4	X	4	X	8
Cattail	*Typha* species	X	0	X	0	X	0	X	0	X	0
Clasping-leaf pondweed	*Potamogeton perfoliatus*	X	2			X	1	X	1	X	1
Common bladderwort	*Utricularia macrorhiza*	X	8	X	54	X	1				
Common duckweed	*Lemna minor*					X	0			X	8
Coontail	*Ceratophyllum demersum*	X	17	X	17	X	16	X	10	X	7
Eelgrass	*Vallisneria americana*	X	65	X	59	X	53	X	72	X	53
Eurasian watermilfoil	***Myriophyllum spicatum***	**X**	**31**	**X**	**45**	**X**	**28**	**X**	**26**	**X**	**45**
Fanwort	***Cabomba caroliniana***	**X**	**48**	**X**	**42**	**X**	**42**	**X**	**39**	**X**	**68**
Flat-leaf bladderwort	*Utricularia intermedia*									X	0
Floating bladderwort	*Utricularia radiata*	X	48			X	32	X	1	X	10
Floating-leaf pondweed	*Potamogeton natans*	X	3	X	1	X	0	X	2	X	1
Golden hedge-hyssop	*Gratiola aurea*	X	5	X	1					X	0
Great duckweed	*Spirodela polyrhiza*			X	4	X	9	X	7	X	5
Humped bladderwort	*Utricularia gibba*	X	1	X	8	X	9	X	16	X	21
Large-leaf pondweed	*Potamogeton amplifolius*	X	9	X	19	X	8	X	19	X	31
Leafy pondweed	*Potamogeton foliosus*	X	1	X	3	X	1	X	2		
Lesser bladderwort	*Utricularia minor*			X	1					X	0
Little floating heart	*Nymphoides cordata*			X	9	X	10	X	6	X	10
Low watermilfoil	*Myriophyllum humile*	X	8	X	4			X	2	X	8
Minor naiad	***Najas minor***	**X**	**4**	**X**	**20**	**X**	**3**	**X**	**30**		
Mudmat	*Glossostigma cleistanthum*	X	1	X	7	X	3	X	8	X	2
Phragmites	***Phragmites australis***	**X**	**1**	**X**	**2**	**X**	**0**	**X**	**3**	**X**	**1**
Pickerelweed	*Pontederia cordata*	X	12	X	22	X	13	X	17	X	17
Pondweed	*Potamogeton* species							X	7		
Primrose-willow	*Ludwigia* species	X	2	X	5	X	4	X	1	X	3
Purple bladderwort	*Utricularia purpurea*	X	1	X	3	X	6	X	6	X	15
Quillwort	*Isoetes* species			X	3			X	0	X	0
Ribbon-leaf pondweed	*Potamogeton epihydrus*	X	35	X	13	X	14	X	29	X	21
Robbins' pondweed	*Potamogeton robbinsii*	X	35	X	41	X	40	X	32	X	38
Slender naiad	*Najas flexilis*	X	11	X	19	X	18	X	32	X	10
Small pondweed	*Potamogeton pusillus*							X	12	X	0
Small-leaved pond-lily	*Nuphar microphylla*	X	0								
Snailseed pondweed	*Potamogeton bicupulatus*	X	10	X	13	X	7	X	8	X	4
Spikerush	*Eleocharis* species	X	8	X	11	X	14	X	16	X	19
Swollen bladderwort*	***Utricularia inflata***									**X**	**43**
Variable-leaf watermilfoil	***Myriophyllum heterophyllum***	**X**	**8**	**X**	**9**	**X**	**20**	**X**	**29**	**X**	**47**
Water smartweed	*Polygonum amphibium*	X	4	X	12	X	11	X	9	X	9
Watermeal	*Wolffia* species	X	1							X	3
Watershield	*Brasenia schreberi*	X	31	X	30	X	32	X	35	X	32
Waterwort	*Elatine* species			X	7	X	1	X	3	X	0
Western waterweed	*Elodea nuttallii*			X	1	X	1			X	5
White water lily	*Nymphaea odorata*	X	18	X	22	X	26	X	24	X	27
Yellow water lily	*Nuphar variegata*	X	13	X	14	X	6	X	11	X	11
Total Species Richness	45	34	32	34	34	35	31	36	34	40	33
Total Native Species Richness	39	29	27	29	29	30	26	31	29	35	28
Total Invasive Species Richness	**6**	**5**	**5**	**5**	**5**	**5**	**4**	**5**	**5**	**5**	**5**

*Swollen bladderwort is easily confused with common bladderwort. DNA analysis will determine the identification. It is possible common bladderwort found in the past is also swollen bladderwort.

Figure 2. Water smartweed, fanwort, and water lilies in the northwestern cove of the lake.

Results and Discussion

General Aquatic Plant Surveys and Transects

We found five invasive and 35 native plant species in Pachaug Pond in 2021 (Table 1). Eurasian watermilfoil, fanwort, phragmites, variable-leaf watermilfoil, and swollen bladderwort comprised the invasive species. Descriptions are in the appendix. Swollen bladderwort is a new addition to the invasive species found in Connecticut and is commonly confused with other native bladderworts. Samples of bladderworts from Pachaug Pond in earlier surveys and swollen bladderwort found in 2021 have been sent out for DNA analysis to confirm identification. Minor naiad was not found in 2021 for the first time since surveys began in 2017; however, being an annual the propagates from seed each year, it will likely reappear in future years. The 35 native species found in 2021 represented the most found throughout our survey years. Pachaug Pond contains among the greatest number of plant species found in any waterbody surveyed by CAES IAPP (2021). Although providing details on the specifics of the native plants is beyond the scope of this report, information is available at USDA "About PLANTS" website: https://plants.usda.gov/about_plants.html.
Although monostands of invasive species were found in a few areas of the lake, areas covered by native species or invasive species mixed with native species were more common. Many of the shallow coves contained nuisance vegetation such as fanwort, water smartweed, and various water lilies that reached the surface (Figures 3 and 4). Much of the lake, however, did not have problematic vegetation reaching the surface despite it being shallow enough to support luxuriant growth. In these areas, the bottom either did not support plant growth or was covered with native eelgrass and Robbins' pondweed. Reasons for this may include the brown water coloration that limits light, infertile substrate, and previous drawdowns.

Compared to 2018 – 2020, vegetation appeared to slightly increase but remained less abundant than in 2017 (Figure 5; see appendix for closeup maps and previous years' maps). Vegetation was found further towards the middle of the lake, especially in the northern and southern sections compared to 2018 – 2020. Many coves had nuisance levels of emergent vegetation such as white and yellow water lily, water smartweed, and watershield. The CAES IAPP website contains digitized survey maps where individual plant layers can be viewed separately: https://portal.ct.gov/caes-iapp. Occasionally only charophyte, which is low-lying filamentous algae, was found. Water smartweed, fanwort, and water lilies often occurred in patches dense enough to restrict navigation but likely created desirable habitat for fish, wildfowl, and other aquatic organisms (Figures 3 and 4). Many of these areas also contained dense bladderworts; however, these plants were rarely a nuisance.

Figure 4. Drone image of dense patches of water smartweed, fanwort, and water lilies in the northwestern cove of Pachaug Pond from late July 2021. Photo Credit: Doug Taber

Unlike previous years, the northwestern cove seen in Figure 4 and the southwestern cove near Transect 3 each had a boat path through the vegetation.

Comparisons of our frequency of occurrence (FOQ) data from 2017 – 2021, taken from transect points, found little overall change in total native species, but an increase in invasive species to an all-time high of 79 percent (Figure 6; see appendix for transect data). Statistically significant increases in individual invasive species in 2021 were found with fanwort, Eurasian watermilfoil, and variable-leaf watermilfoil (Figure 7; Table 1). Swollen bladderwort was identified for the first time in 2021, with confirmation by DNA analysis underway. Despite a significant increase in minor naiad in 2020, none was found in 2021. The native plants found on the most transect points in 2021 (Table 1) were eelgrass (53%), Robbins' pondweed (38%), watershield (32%), and large-leaf pondweed (31%). A few native species were found less frequently on transects in 2021 including slender naiad. Overall species richness remained relatively unchanged for native species. Because of discovery of swollen bladderwort, species richness of invasive species increased significantly from previous years (Figure 6).

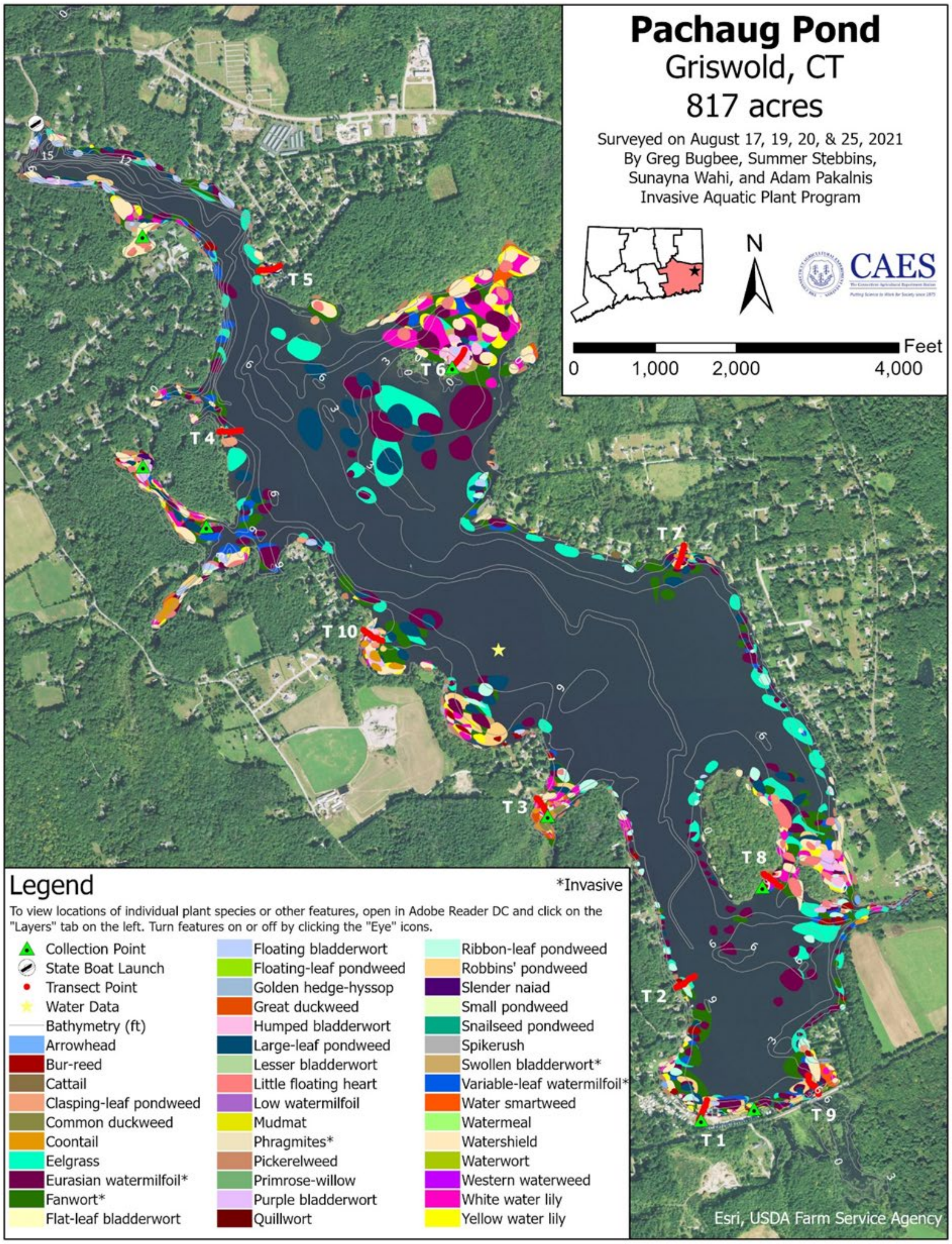


Figure 5. 2021 aquatic plant survey map of Pachaug Pond.

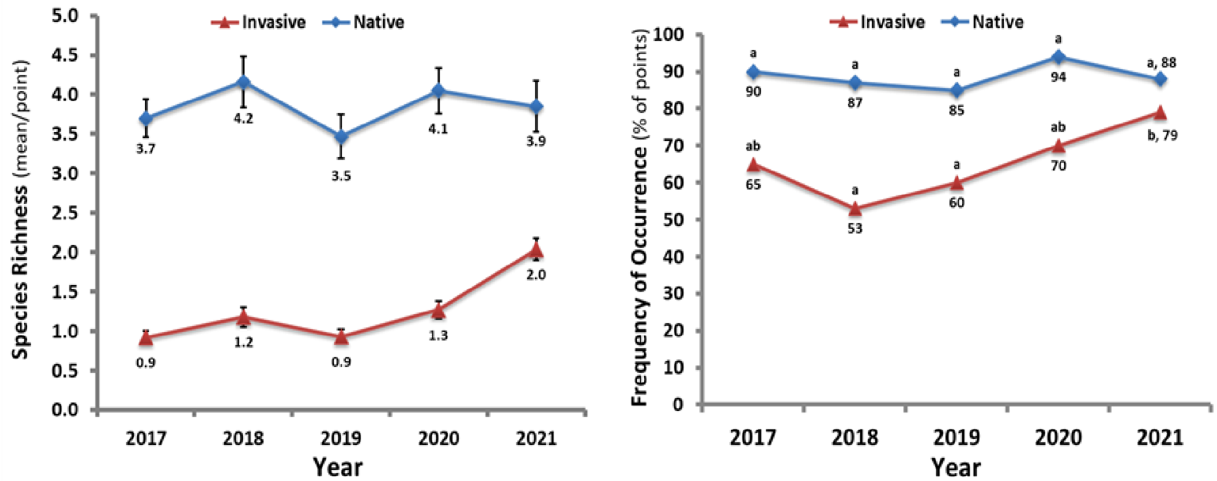


Figure 6. Species richness (left) and frequency of occurrence (FOQ, right) of native and invasive aquatic plants on transects in Pachaug Pond from 2017 – 2021.

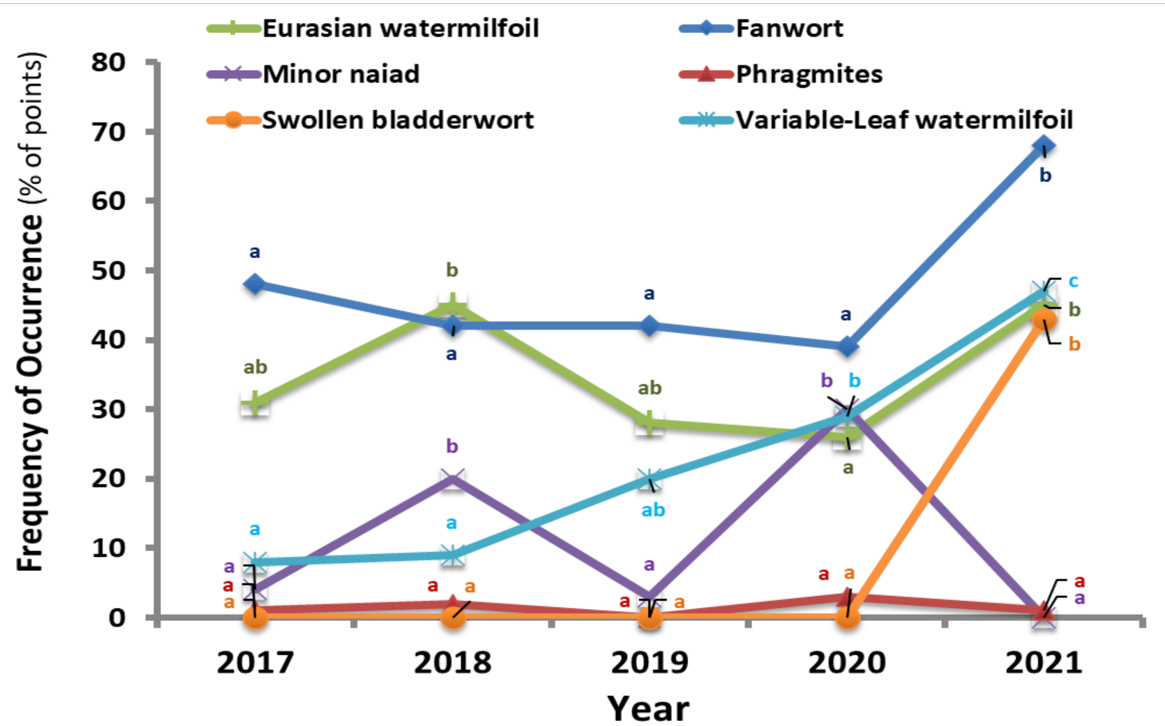


Figure 7. Frequency of occurrence (FOQ) of individual invasive aquatic plant species on transects in Pachaug Pond from 2017 - 2021.

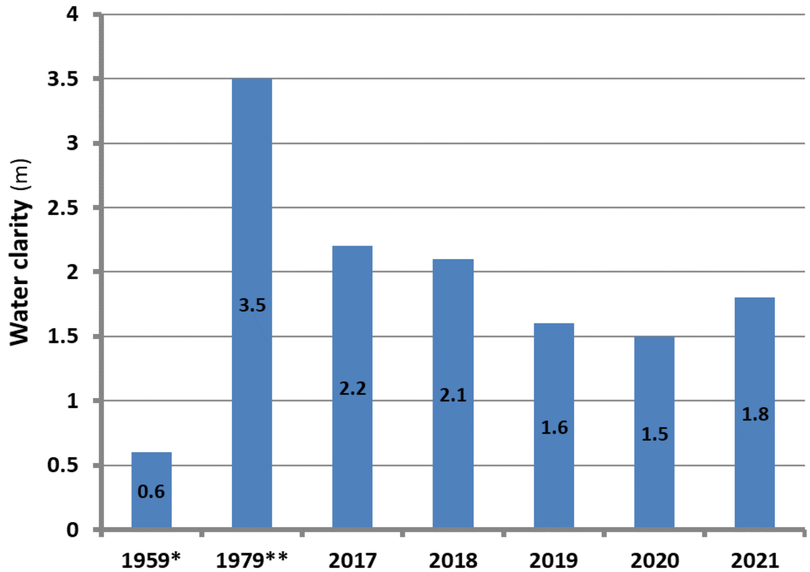


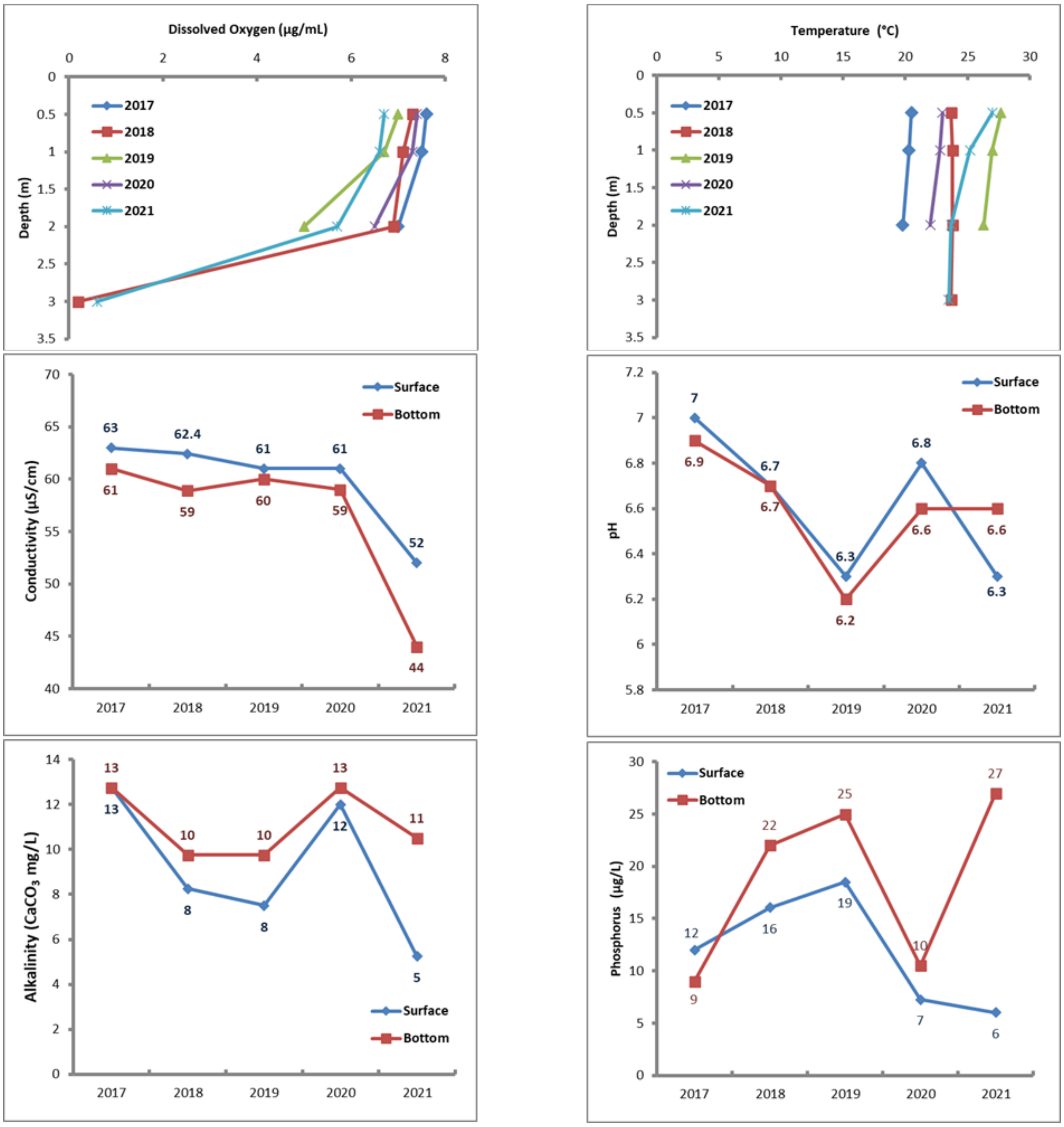
Figure 8. Water clarity in Pachaug Pond in 1959 (*State Board of Fisheries and Game), 1979 (**CAES), 2017 – 2021 (CAES IAPP).

Water Chemistry

Water clarity in Connecticut's lakes ranges from 0.3 - 10 m (1-33 feet) with an average of 2.3 m (7 feet) (CAES IAPP, 2021). Pachaug Pond had a water clarity of 1.8 m (5 feet) in our 2021 survey, which is slightly greater than 2019 and 2020, but still less than 2017 and 2018 (Figure 8). Measurements in 1979 found clarity to be 3.5 m (12 feet) (Frink and Norvell, 1984) while in the 1950's it was only 0.6 m (2 feet) (State Board of Fisheries and Game, 1959). The poor water clarity in the 1950's was attributed to an algal bloom. This could have been due to the reported industrial use of the water. Our 2021 observation was consistent with previous years with water clarity not reduced by algal blooms but rather the brown coloration caused by naturally occurring organic derivatives.

The shallow nature of Pachaug Pond resulted in little stratification of temperature in all years and the presence of anaerobic bottom water at depths below 2 m (Figure 9). Water pH was near neutral (6.2 – 7.0) with an alkalinity of 5 - 13 mg/L $CaCO_3$ which is low for Connecticut lakes which range from near 0 to >170 (CAES IAPP, 2021). Low alkalinity waterbodies are more prone to pH change due to outside influences such as watershed activities and acid rain. Conductivity is an indicator of dissolved ions that come from natural and man-made sources (mineral weathering, organic matter decomposition, fertilizers, septic systems, road salts, etc.). Connecticut waterbodies have conductivities that range from 50 - 250 µS/cm. Pachaug Pond's conductivity of 52 µS/cm at the surface and 44 µS/cm at the bottom in 2021 was lower than in our previous surveys. This may be caused by removal of ions by the increased vegetation, less road salts, or other factors.

A key parameter used to categorize a lake's trophic state is phosphorus (P) in the water column. High levels of P can lead to nuisance or toxic algal blooms (Frink and Norvell, 1984, Wetzel, 2001). Rooted macrophytes are considered to be less dependent on P from the water column as they obtain a majority of their nutrients from the hydrosoil (Bristow and Whitcombe, 1971). Lakes with P levels from 0 - 10 µg/L are considered nutrient-poor or oligotrophic. When P concentrations reach 15 - 25 µg/L, lakes are classified as moderately fertile or mesotrophic and when P reaches 30 - 50 µg/L they are considered fertile or eutrophic (Frink and Norvell, 1984). Lakes with P concentrations >50 µg/L are categorized as extremely fertile or hypereutrophic. Pachaug Pond's P concentration in 2021 was 6 µg/L at surface and 27 µg/L near the bottom, which classifies the lake as oligotrophic/mesotrophic (Figure 8). Analysis of the water in by CAES 1979 (Frink and Norvell, 1984) found similar P concentrations of 16 µg/L at surface and 13 µg/L near the bottom. We tested total nitrogen (TN) for the first time in 2020 and found 267 µg/L the surface and 293 µg/L near the



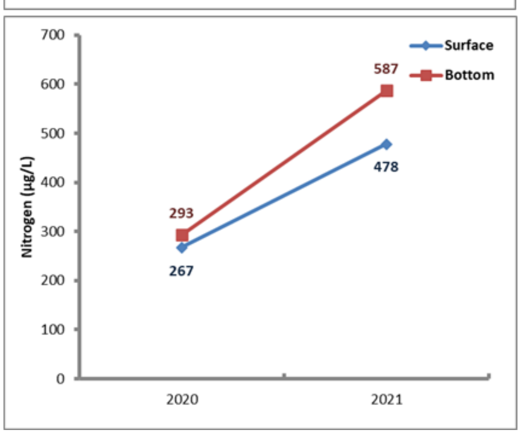


Figure 9. Water chemistry for Pachaug Pond from 2017 - 2021. Nitrogen was measured only in 2020 and 2021.

bottom (Figure 8). TN in 2021 was considerably higher both at the surface (587 µg/L) and at the bottom (478 µg/L). Although nitrogen is likely less limiting to the growth of aquatic plants and algae compared to terrestrial plants, it may play a role in lake productivity. Frink and Norvell (1984) found TN in Connecticut lakes ranged from 193 - 1830 µg/L and averaged 554 µg/L, placing Pachaug Pond's 2021 TN level near the average.

CAES IAPP has found that the occurrence of invasive plants in lakes can be attributed to specific water chemistries (June-Wells et al., 2013). For instance, lakes with higher alkalinities and conductivities are more likely to support Eurasian watermilfoil, minor naiad, and curlyleaf pondweed while lakes with lower values support fanwort and variable-leaf watermilfoil. Pachaug Pond's water chemistry appears to be an outlier to this trend as its low alkalinity and conductivity suggests Eurasian watermilfoil and minor naiad should be less abundant than observed.

Aquatic Vegetation Management Options

Managing nuisance aquatic vegetation in Pachaug Pond will be challenging because the lake has extensive areas of desirable native vegetation, and state-listed species may need protection. In addition, large numbers of residents utilize the lake for recreational activities, particularly fishing, boating, and swimming. Options include water level drawdown, harvesting, herbicides, biological controls, and benthic barriers (Cooke et al., 2005). Dredging may also be employed but is usually impractical for large lakes like Pachaug.

Water level drawdown can be an effective and economical means of controlling nuisance vegetation in large shallow lakes like Pachaug Pond. Fortunately, the lake has a dam with an outlet suitable for the technique, and it has already been employed with some possible success. Due to ongoing dam work, there were intermittent drawdowns between 2018 – 2020; however, there was no drawdown between 2020 and 2021. Survey results in 2021 showed more vegetation than in previous years, especially further into the lake, which may be partially due to the lack of a drawdown. On August 2nd, 2021, work on the dam began to draw the lake down four feet; the contract states that by April 1, 2022, the drawdown will have to be reduced to three feet (Grahn, 2021). The dam work should be completed by July 2022 (CT DEEP, 2021b). This work may cause a long-term drawdown similar to lakes such as Bashan Lake, Moodus Reservoir, and Lake Beseck. Because the lake usually remains low during the growing season, significant changes may occur in the plant community of Pachaug Pond with wetland plants proliferating in the former sediment and aquatic plants inhabiting areas that were formerly too deep. Often these plants are invasive such as phragmites, milfoil, and fanwort or nuisance native species such as cattails and water lilies.

Figure 10. Eco-Harvester removing aquatic plants. Photo Credit: Givens Shorescapes.

Figure 11. Grass carp introduction into Candlewood Lake in 2015 (left). By 2018 the fish had shown considerable growth (right).

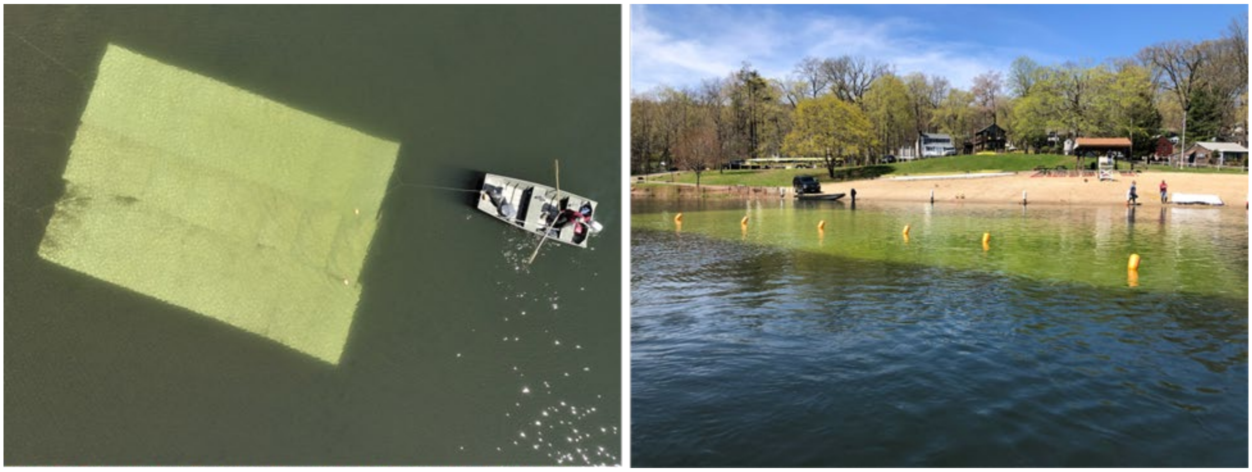


Figure 12. CAES IAPP testing of short-term benthic barriers in Lake Beseck.

Current interest in mechanical harvesting could result in this being a viable option; however, knowledge of the pros and cons is needed prior to making large purchases of the necessary machinery. Major benefits of mechanical harvesting include quick results, the ability to target areas and avoid damage to species needing protection, avoidance of aquatic herbicides, and removal of nutrients contained in the harvested vegetation. Drawbacks include the initial expense of the harvesting machine, maintenance costs, rapid regrowth, the need for follow-up work, and costs for vegetation removal and disposal. New mechanical harvesting machines are now available that offer promise for removal of the root system, but this varies by plant species and sediment type (Figure 10).

Herbicides can be effective in controlling unwanted aquatic vegetation. Aquatic herbicide use requires clearance from the CT DEEP Pesticides Unit and the Natural Diversity Database. Herbicides must be chosen carefully as some have efficacy on certain target species and not others. Also, any desirable plants, including state-listed species, may need to be tolerant. Specifics on the use of aquatic herbicides in Connecticut are found in the CT DEEP publication titled "Nuisance Aquatic Vegetation Management: A Guidebook" (CT DEP, 2005). In 2018, CAES IAPP tested a new herbicide called ProcellaCOR to control variable-leaf watermilfoil in Bashan Lake with excellent results.

Although efforts are underway to find biological controls for nuisance aquatic vegetation, breakthroughs have been limited. To date the only biological control used in Connecticut is grass carp (*Ctenopharyngodon idella*, Figure 11). Grass carp are herbivorous fish that feed on most submersed aquatic plants The introduction of grass carp into Connecticut lakes requires approval by CT DEEP. In Connecticut, only sterile (triploid) grass carp are permitted. Introducing grass carp in Pachaug Pond could cause damage to non-target plants necessary to maintain the current fishery. Grass carp primarily feed on submergent vegetation, so the water lilies and water smartweed impacting many of the coves will be unaffected. Over-stocking in some waterbodies has led to an undesirable reduction in plants needed for fish and other wildlife. CAES has worked with officials from the United States Department of Agriculture to find new plant pathogens and insects that control nuisance aquatic plants with little success.

Benthic barriers or "bottom blankets" are effective at eliminating nuisance vegetation in small areas such as swim zones, around docks, and pioneer infestations. CAES IAPP has tested short-term placement (<30 days) of the barriers in Lake Quonnipaug, Bashan Lake, and Lake Beseck (Figure 12). Season-long control for Eurasian watermilfoil and fanwort was achieved. Although labor intensive, benthic barriers may be able to be moved from place to place during a season for effective control. They can also be used over multiple years, reducing cost of materials.

Conclusions

Our 2021 survey of Pachaug Pond found an increase in aquatic vegetation from previous years. A total of 40 plant species were documented of which five were invasive. Pachaug Pond is among the most plant species rich lakes in Connecticut. The five invasive species found were Eurasian watermilfoil, fanwort, phragmites, swollen bladderwort, and variable-leaf watermilfoil. Most are the same as previous years except for swollen bladderwort which needs DNA analysis to confirm its identification. Most of the coves contained nuisance vegetation such as fanwort, water smartweed, and/or water lilies that reached the surface. Much of the remainder of the pond, in areas less than six feet deep, contained a mixture of invasive and native species not reaching the surface which could become problematic should conditions such as light limitation, infertile substrate, water level, and control from previous drawdowns change. Aquatic plant management and monitoring is critical to assure the potential a rapid decline in the quality of Pachaug Pond is avoided.

Water level drawdowns have been reasonably effective, although harvesting, herbicides, benthic barriers, and grass carp are aquatic plant management tools that deserve consideration. Our water tests found Pachaug Pond to be relatively low in alkalinity with minimal stratification. Water clarity was limited by the water's brown coloration.

Pachaug Pond is Connecticut's largest body of freshwater east of the Connecticut River and offers important wildlife habitat as well as recreational opportunities including fishing, swimming, boating, cross country skiing, and snowmobiling. The pond is home to a marina, a 122-site campground, a state boat launch ramp, and a fish and game club. Stocked with northern pike, the pond is the site of many fishing derbies. The area's economy relies heavily on the visitors to Pachaug Pond and protection of this valuable resource from the deterioration cause by nuisance aquatic vegetation is critical.

Acknowledgments
The technical assistance of Riley Doherty, Matthew Latella, Amanda Massa, Michael Modica, Adam Pakalnis, Deanna Rackie, Maylani Velazquez, Sunayna Wahi, and Abigail Wiegand is gratefully acknowledged.

Funding
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Appendix

Narrative from State Board of Fisheries and Game
Lake and Pond Survey Unit – 1959

Pachaug Pond

Pachaug Pond is a large, artificial impoundment located in New London County in the township of Griswold. This shallow, fertile pond was formed by impounding the Pachaug River. It has a surface area of 830.9 acres, a maximum depth of 18 feet and an average depth of 6.1 feet. Much of the well-wooded shoreline is in the Pachaug State Forest. Submerged and emergent vegetation is abundant, particularly in the shoal areas and shallow areas. The pond bottom is of mud, swampy ooze and sand. A dense algal bloom reduces transparency to two feet. The waters of this pond are not thermally stratified.

Shoreline development is very light and there are only a few cottages present. Boats are available for rental at a livery at the southern end of the pond. There is a state-owned right-of-way present, but this is poorly developed and is unuseable.

Pachaug Pond has been stocked with smallmouth bass and yellow perch.

Largemouth bass are common in abundance and exhibit excellent growth. Yellow perch are common in abundance. This species grows at a rate equal to the state average. Bluegill sunfish are abundant and grow at a rate well above the state average. Chain pickerel are scarce and exhibit an above-average growth rate. Calico bass are common in abundance. The growth rate of this species is equal to the state average. Bullheads are common in abundance and golden shiners are abundant.

This pond has the reputation of producing excellent bass fishing. Bass over five pounds are relatively common. Fishing for panfish such as perch, bluegill sunfish, calico bass and bullheads should be excellent.

In the past, this body of water was subject to severe drawdown during late June, July and August. This drawdown took place after the game species had reproduced and did not destroy their nests or young. As a result of the drawdown, the game fish and panfish were crowded into a smaller area and the panfish were more readily available to the game fish as forage. The resultant increase in predation aided in controlling the numbers of panfish and helped to keep these fish within the limits of the food supply and, at the same time, helped to provide numerous fast-growing game fish. The drawdown process also helped to control aquatic vegetation and this resulted in considerable open water relatively free from water weeds. For the past several years, the water has not been used for industrial purposes and, as a result, the water level has remained fairly stable. Aquatic vegetation is becoming more abundant and the amount of open water more restricted. This increase in the abundance of "water weeds" may provide excessive escape cover for panfish and can well result in stunted populations of yellow perch and bluegill sunfish.

The drawdown and exposure of considerable areas of the pond bottom also allowed smartweed and other semi-terrestrial plants to grow on the exposed shoals. These terrestrial plants furnished excellent food for waterfowl and attracted large numbers of ducks during the fall shooting season.

It is recommended that a control structure be installed in the dam so that the pond can be lowered three to four feet every summer. Such a drawdown should be started in June and the reduced water level should be held until the end of August.

No special regulations are recommended at this time.

Invasive Plant Descriptions

Cabomba caroliniana


Photo by CAES IAPP

Common names:
Fanwort
Carolina fanwort

Origin:
Southeast United States
South America

Key features:
Plants are submersed

Stems: Can be 6 feet (2 m) long

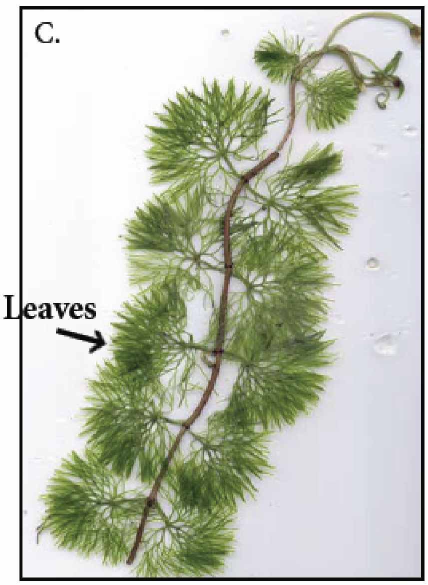
Leaves: Dissected, opposite leaves 0.8-2 inches (2-5 cm) are fan-like and made up of forked leaflets attached to the stem by a petiole. Floating leaves 0.2-0.8 inches (6-20 mm) wide are oblong and produced on flower shoots

Flowers: Small, solitary flowers are usually white to pinkish

Fruits/Seeds: Flask shaped

Reproduction: Seed and fragmentation

Easily confused species:
Watermilfoils: *Myriophyllum* spp.
White water crowfoot: *Ranunculus longirostris*
Water marigold: *Megalodonta beckii*

C.
Opposite Leaves


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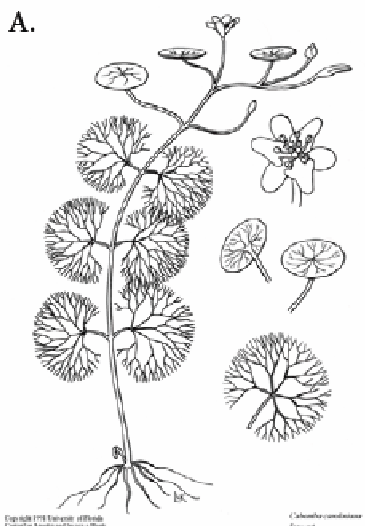
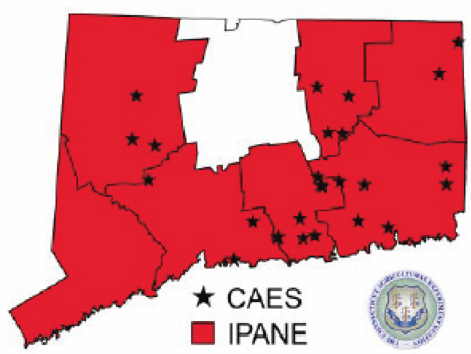


B.


A. Copyright 1991 Univ. of Florida, Center for Aquatic and Invasive Plants
B. Copyright 2002 Univ. of Florida, Photo by A. Murray
C. Photo by A. Smagula



Myriophyllum heterophyllum

Common names:
Variable-leaf watermilfoil
Variable watermilfoil
Two-leaf watermilfoil

Origin:
Southern United States

Key features:
Plants are submersed

Stems: Dark brown stems extend to the water's surface and spread to form large mats

Leaves: Triangular with ≤ 11 pairs of leaflets. Leaves are dissected and whorled (4-6 leaves/whorl) resulting in a feathery appearance with leaf whorls < 1 inch apart giving it a ropy appearance

Flowers: Inflorescence spike 2-14 inches (5-35 cm) long extend beyond the water's surface with flowers in whorls of four with reddish petals

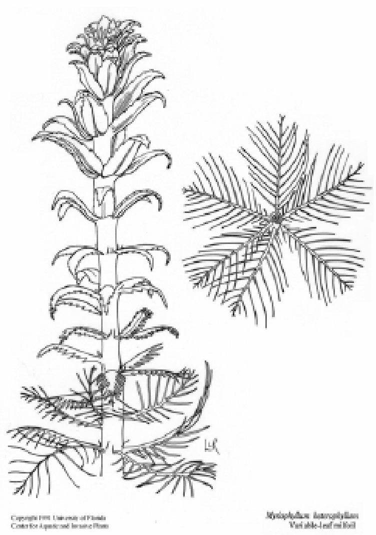
Fruits/Seeds: Fruits are almost round, with a rough surface

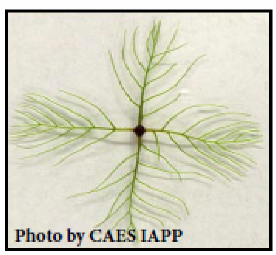
Reproduction: Fragmentation and seeds

Easily confused species:
Eurasian watermilfoil: *Myriophyllum spicatum*
Low watermilfoil: *Myriophyllum humile*


Photo by CAES IAPP


Photo by CAES IAPP

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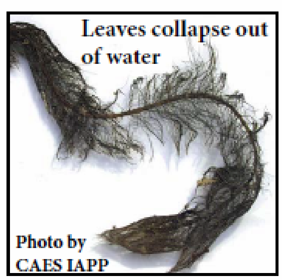
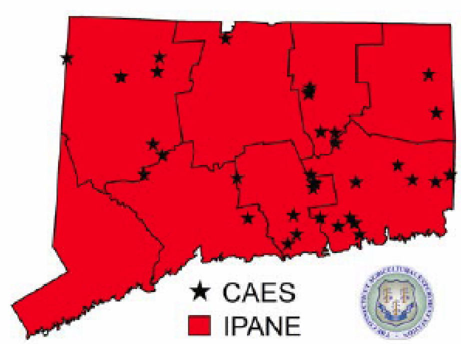


Photo by CAES IAPP



Myriophyllum spicatum

Photo by CAES IAPP

Common name:
Eurasian watermilfoil

Origin:
Europe and Asia

Key features:
Plants are submersed

Stems: Stem diameter below the inflorescence is greater with reddish stem tips

Leaves: Leaves are rectangular with ≥ 12 pairs of leaflets per leaf and are dissected giving a feathery appearance, arranged in a whorl, whorls are 1 inch (2.5 cm) apart

Flowers: Small pinkish male flowers that occur on reddish spikes, female flowers lack petals and sepals and have 4 lobed pistil

Fruits/Seeds: Fruit are round 0.08-0.12 inches (2-3 mm) and contain 4 seeds

Reproduction: Fragmentation and seeds

Easily confused species:
Variable-leaf watermilfoil: *Myriophyllum heterophyllum*
Low watermilfoil: *Myriophyllum humile*
Northern watermilfoil: *Myriophyllum sibiricum*
Whorled watermilfoil: *Myriophyllum verticillatum*

Photo by CAES IAPP

Photo by CAES IAPP

Photo by CAES IAPP

Utricularia inflata

Common names:
Swollen bladderwort

Origin:
Southern and Eastern North America

Key features:
Plants floating in water, sometimes appearing anchored

Stems: Stem is submersed, slender and elongated

Leaves: Submersed leaves (<18 cm) are alternate, bushy, repeatedly forked with bladders along the sides. Uppermost leaves are whorled and inflated, floating on the water's surface (3-8 cm).

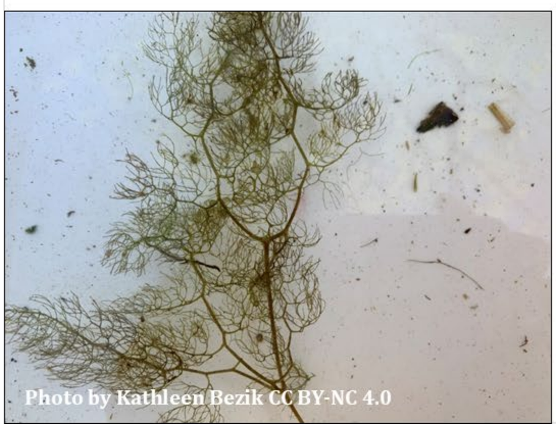
Flowers: Flowers located at the center of inflated leaves and have five bright yellow petals

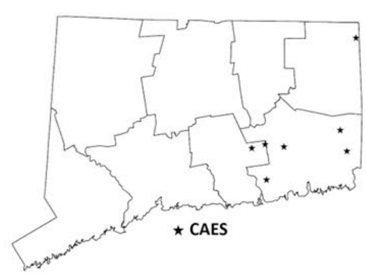
Fruits/Seeds: Fruit is dry and splits open when dry (3-6 mm)

Reproduction: Fragmentation and Tubers

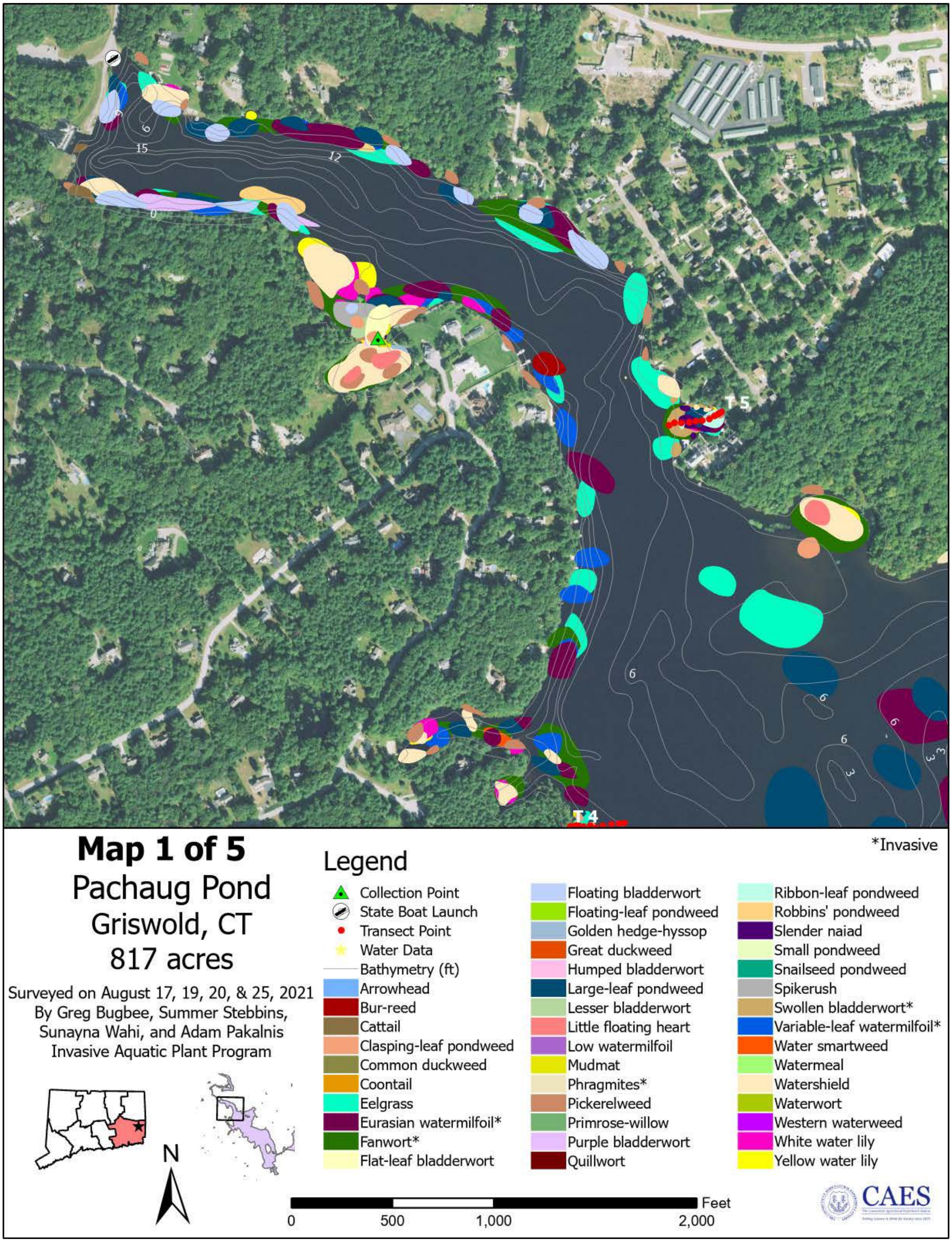
Easily confused species:
Common bladderwort: *Utricularia macrorhiza*

Floating bladderwort: *Utricularia radiata*





Aquatic Plant Survey Maps by Section



Map 1 of 5
Pachaug Pond
Griswold, CT
817 acres
Surveyed on August 17, 19, 20, & 25, 2021
By Greg Bugbee, Summer Stebbins, Sunayna Wahi, and Adam Pakalnis
Invasive Aquatic Plant Program
Legend
*Invasive
Collection Point
State Boat Launch
Transect Point
Water Data
Bathymetry (ft)
Arrowhead
Bur-reed
Cattail
Clasping-leaf pondweed
Common duckweed
Coontail
Eelgrass
Eurasian watermilfoil*
Fanwort*
Flat-leaf bladderwort
Floating bladderwort
Floating-leaf pondweed
Golden hedge-hyssop
Great duckweed
Humped bladderwort
Large-leaf pondweed
Lesser bladderwort
Little floating heart
Low watermilfoil
Mudmat
Phragmites*
Pickerelweed
Primrose-willow
Purple bladderwort
Quillwort
Ribbon-leaf pondweed
Robbins' pondweed
Slender naiad
Small pondweed
Snailseed pondweed
Spikerush
Swollen bladderwort*
Variable-leaf watermilfoil*
Water smartweed
Watermeal
Watershield
Waterwort
Western waterweed
White water lily
Yellow water lily
T 5
T 4
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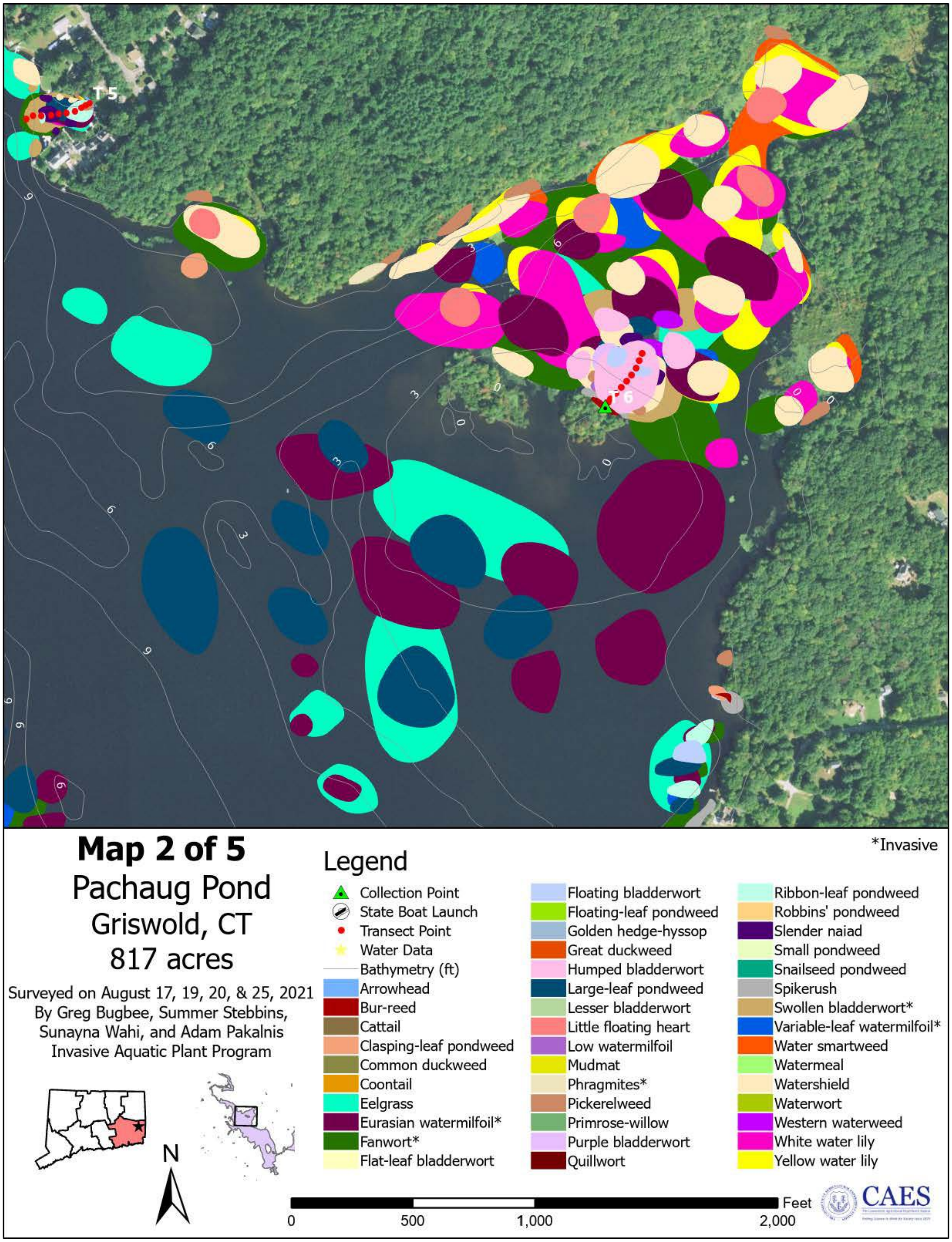
2,000
Feet
CAES


T 5
T 6
Map 2 of 5
Pachaug Pond
Griswold, CT
817 acres
Surveyed on August 17, 19, 20, & 25, 2021
By Greg Bugbee, Summer Stebbins,
Sunayna Wahi, and Adam Pakalnis
Invasive Aquatic Plant Program
N
Legend
*Invasive
Collection Point
State Boat Launch
Transect Point
Water Data
Bathymetry (ft)
Arrowhead
Bur-reed
Cattail
Clasping-leaf pondweed
Common duckweed
Coontail
Eelgrass
Eurasian watermilfoil*
Fanwort*
Flat-leaf bladderwort
Floating bladderwort
Floating-leaf pondweed
Golden hedge-hyssop
Great duckweed
Humped bladderwort
Large-leaf pondweed
Lesser bladderwort
Little floating heart
Low watermilfoil
Mudmat
Phragmites*
Pickerelweed
Primrose-willow
Purple bladderwort
Quillwort
Ribbon-leaf pondweed
Robbins' pondweed
Slender naiad
Small pondweed
Snailseed pondweed
Spikerush
Swollen bladderwort*
Variable-leaf watermilfoil*
Water smartweed
Watermeal
Watershield
Waterwort
Western waterweed
White water lily
Yellow water lily
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Feet
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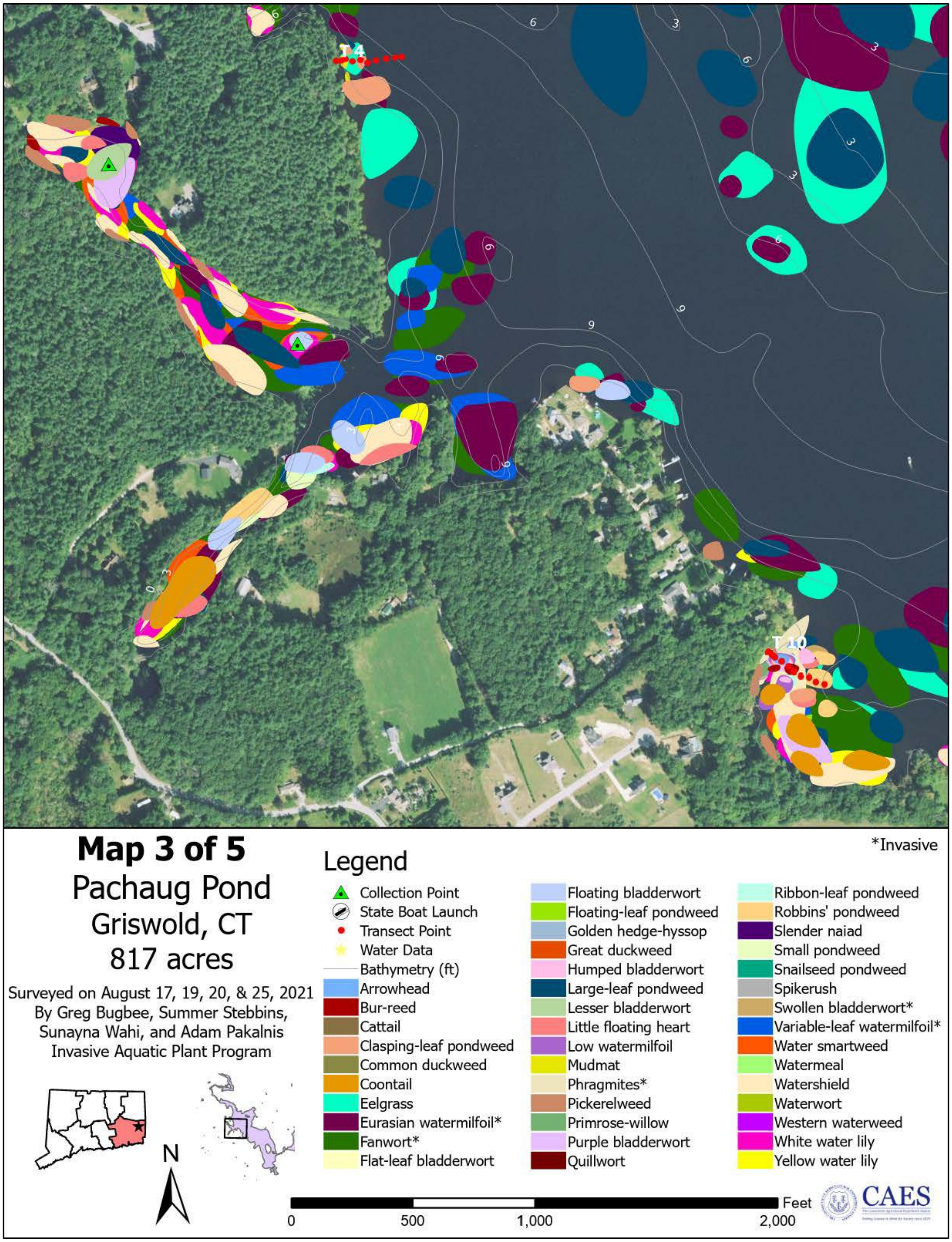
Map 3 of 5
Pachaug Pond
Griswold, CT
817 acres
Surveyed on August 17, 19, 20, & 25, 2021
By Greg Bugbee, Summer Stebbins,
Sunayna Wahi, and Adam Pakalnis
Invasive Aquatic Plant Program
N
Legend
*Invasive
Collection Point
State Boat Launch
Transect Point
Water Data
Bathymetry (ft)
Arrowhead
Bur-reed
Cattail
Clasping-leaf pondweed
Common duckweed
Coontail
Eelgrass
Eurasian watermilfoil*
Fanwort*
Flat-leaf bladderwort
Floating bladderwort
Floating-leaf pondweed
Golden hedge-hyssop
Great duckweed
Humped bladderwort
Large-leaf pondweed
Lesser bladderwort
Little floating heart
Low watermilfoil
Mudmat
Phragmites*
Pickerelweed
Primrose-willow
Purple bladderwort
Quillwort
Ribbon-leaf pondweed
Robbins' pondweed
Slender naiad
Small pondweed
Snailseed pondweed
Spikerush
Swollen bladderwort*
Variable-leaf watermilfoil*
Water smartweed
Watermeal
Watershield
Waterwort
Western waterweed
White water lily
Yellow water lily
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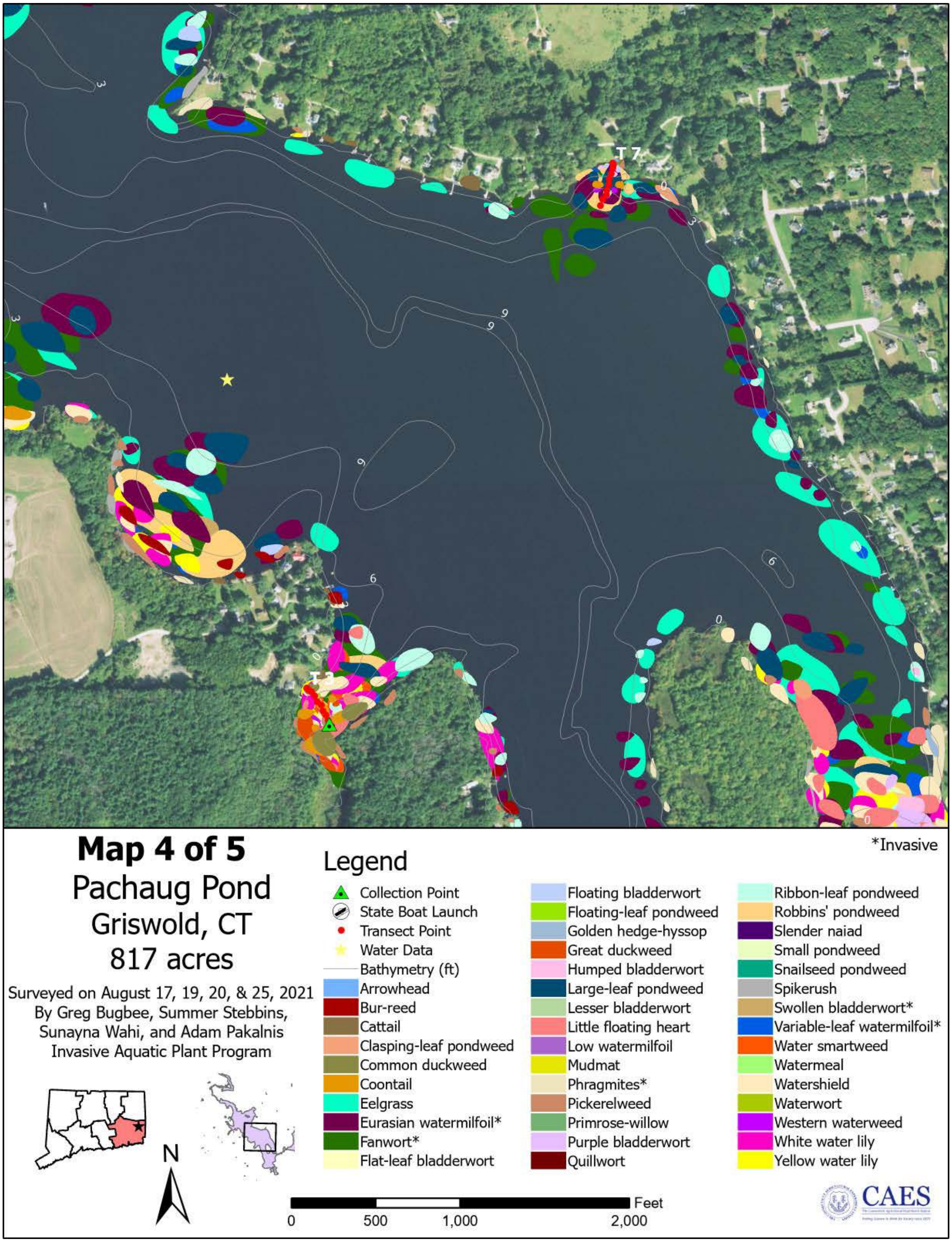
Feet
CAES


Map 4 of 5
Pachaug Pond
Griswold, CT
817 acres
Surveyed on August 17, 19, 20, & 25, 2021
By Greg Bugbee, Summer Stebbins,
Sunayna Wahi, and Adam Pakalnis
Invasive Aquatic Plant Program
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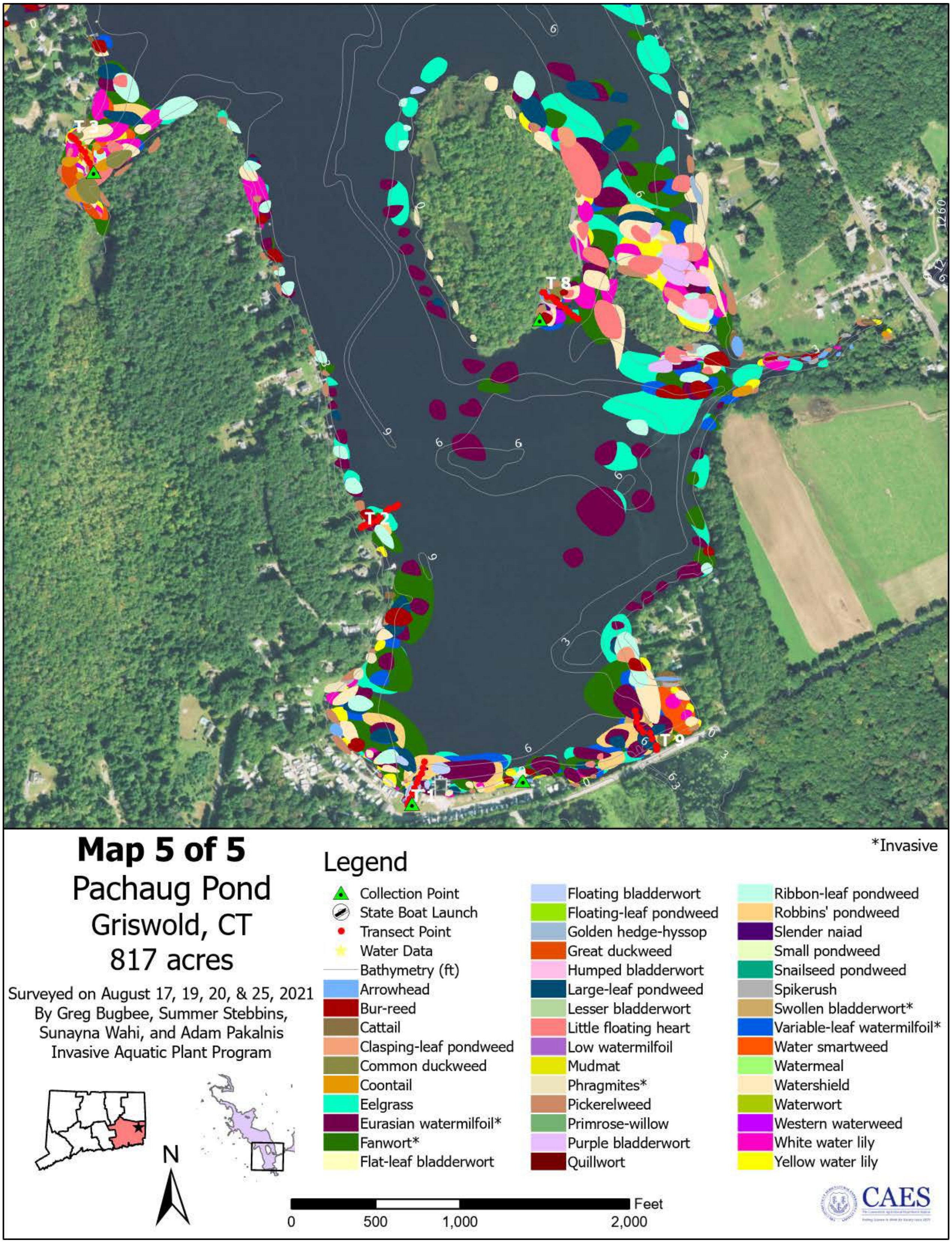
*Invasive
Collection Point
State Boat Launch
Transect Point
Water Data
Bathymetry (ft)
Arrowhead
Bur-reed
Cattail
Clasping-leaf pondweed
Common duckweed
Coontail
Eelgrass
Eurasian watermilfoil*
Fanwort*
Flat-leaf bladderwort
Floating bladderwort
Floating-leaf pondweed
Golden hedge-hyssop
Great duckweed
Humped bladderwort
Large-leaf pondweed
Lesser bladderwort
Little floating heart
Low watermilfoil
Mudmat
Phragmites*
Pickerelweed
Primrose-willow
Purple bladderwort
Quillwort
Ribbon-leaf pondweed
Robbins' pondweed
Slender naiad
Small pondweed
Snailseed pondweed
Spikerush
Swollen bladderwort*
Variable-leaf watermilfoil*
Water smartweed
Watermeal
Watershield
Waterwort
Western waterweed
White water lily
Yellow water lily
0 500 1,000 2,000 Feet
CAES
T 7
T 3


Map 5 of 5
Pachaug Pond
Griswold, CT
817 acres
Surveyed on August 17, 19, 20, & 25, 2021
By Greg Bugbee, Summer Stebbins,
Sunayna Wahi, and Adam Pakalnis
Invasive Aquatic Plant Program
Legend
*Invasive
Collection Point
State Boat Launch
Transect Point
Water Data
Bathymetry (ft)
Arrowhead
Bur-reed
Cattail
Clasping-leaf pondweed
Common duckweed
Coontail
Eelgrass
Eurasian watermilfoil*
Fanwort*
Flat-leaf bladderwort
Floating bladderwort
Floating-leaf pondweed
Golden hedge-hyssop
Great duckweed
Humped bladderwort
Large-leaf pondweed
Lesser bladderwort
Little floating heart
Low watermilfoil
Mudmat
Phragmites*
Pickerelweed
Primrose-willow
Purple bladderwort
Quillwort
Ribbon-leaf pondweed
Robbins' pondweed
Slender naiad
Small pondweed
Snailseed pondweed
Spikerush
Swollen bladderwort*
Variable-leaf watermilfoil*
Water smartweed
Watermeal
Watershield
Waterwort
Western waterweed
White water lily
Yellow water lily
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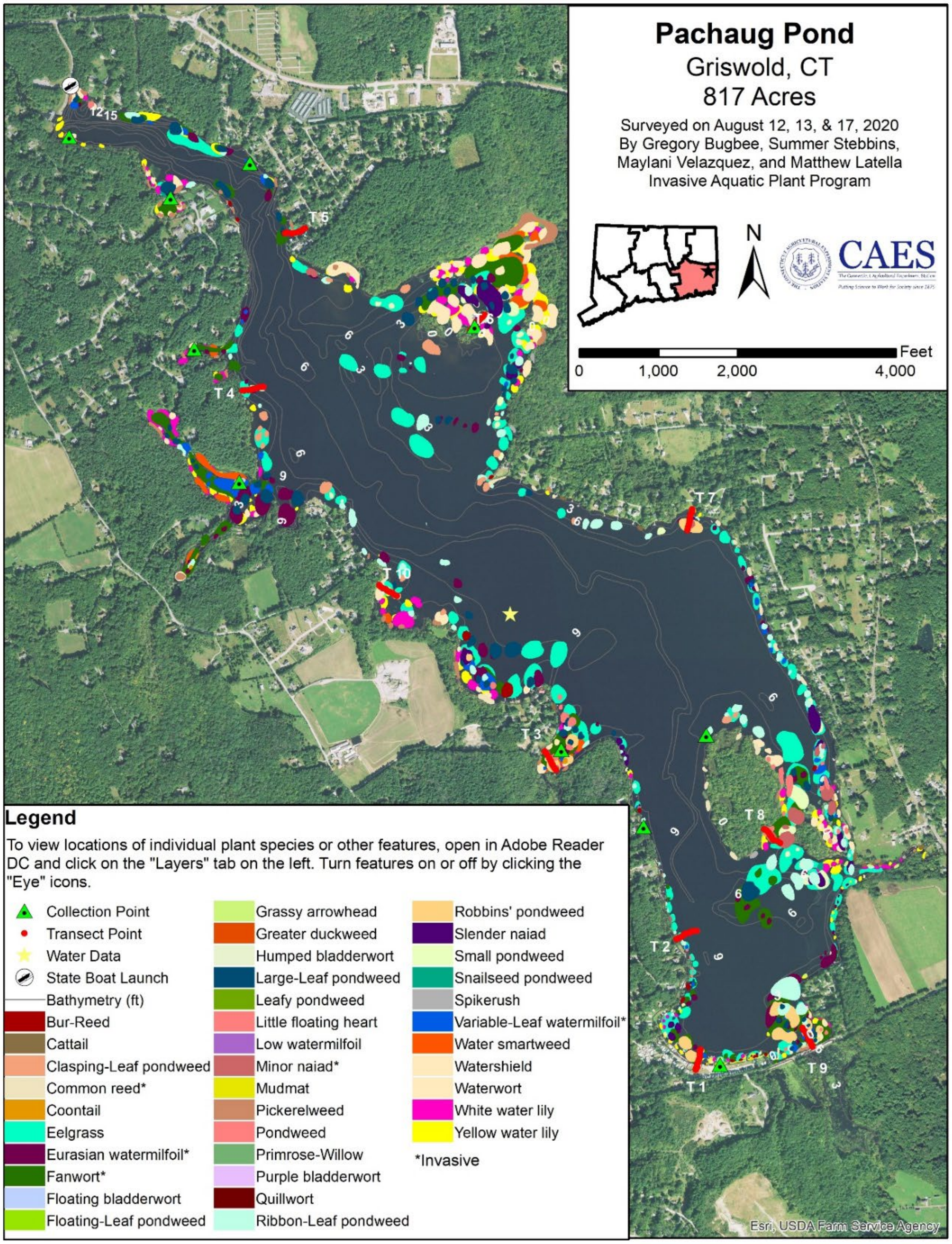
Feet
CAES

Previous Years Aquatic Plant Survey Maps


Pachaug Pond
Griswold, CT
817 Acres
Surveyed on August 12, 13, & 17, 2020
By Gregory Bugbee, Summer Stebbins,
Maylani Velazquez, and Matthew Latella
Invasive Aquatic Plant Program
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CAES
Feet
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Legend
To view locations of individual plant species or other features, open in Adobe Reader DC and click on the "Layers" tab on the left. Turn features on or off by clicking the "Eye" icons.
Collection Point
Transect Point
Water Data
State Boat Launch
Bathymetry (ft)
Bur-Reed
Cattail
Clasping-Leaf pondweed
Common reed*
Coontail
Eelgrass
Eurasian watermilfoil*
Fanwort*
Floating bladderwort
Floating-Leaf pondweed
Grassy arrowhead
Greater duckweed
Humped bladderwort
Large-Leaf pondweed
Leafy pondweed
Little floating heart
Low watermilfoil
Minor naiad*
Mudmat
Pickerelweed
Pondweed
Primrose-Willow
Purple bladderwort
Quillwort
Ribbon-Leaf pondweed
Robbins' pondweed
Slender naiad
Small pondweed
Snailseed pondweed
Spikerush
Variable-Leaf watermilfoil*
Water smartweed
Watershield
Waterwort
White water lily
Yellow water lily
*Invasive
T 1
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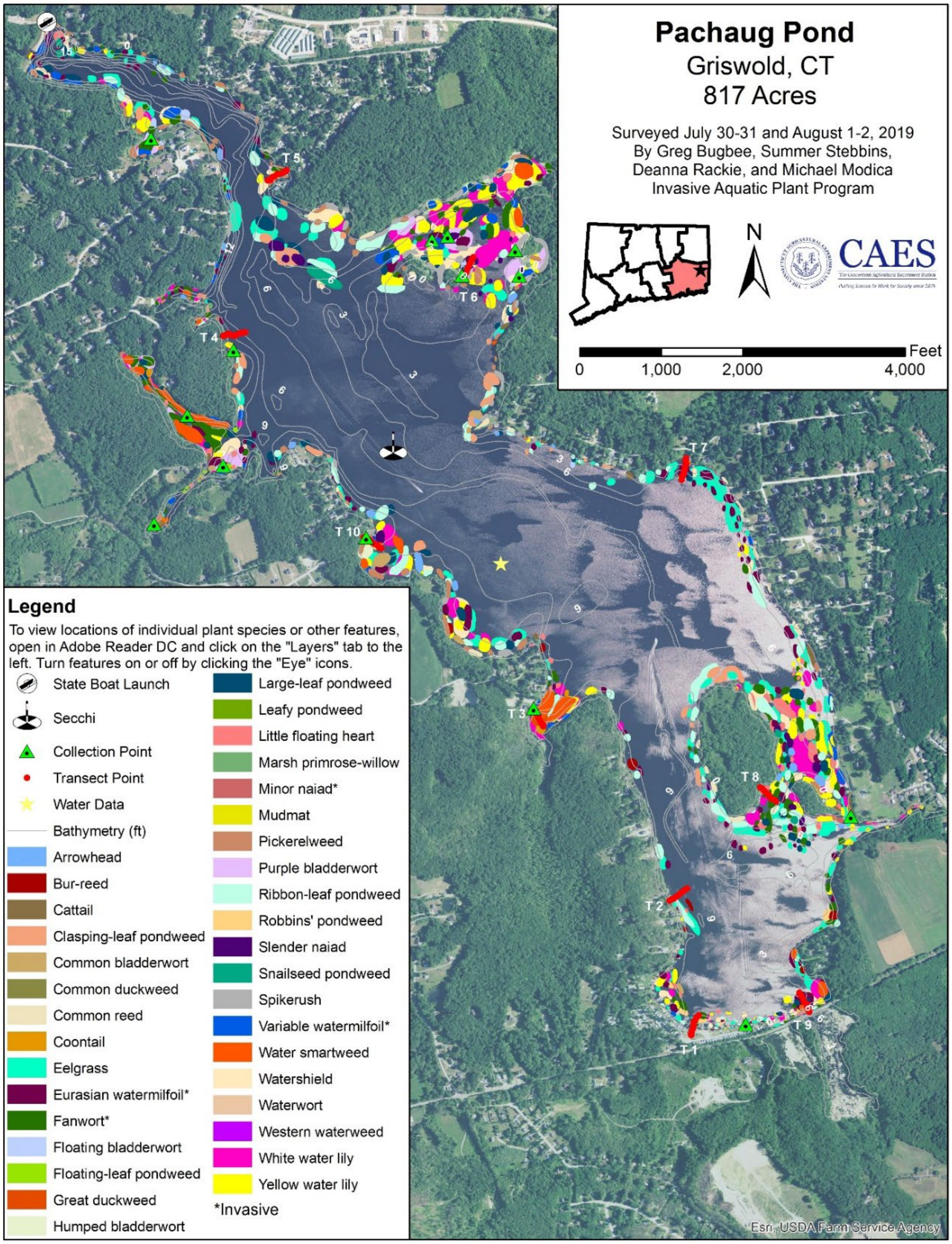
T 7
T 8
T 9
T 10
T 12
T 15
Esri, USDA Farm Service Agency



Pachaug Pond
Griswold, CT
817 Acres
Surveyed July 30-31 and August 1-2, 2019
By Greg Bugbee, Summer Stebbins,
Deanna Rackie, and Michael Modica
Invasive Aquatic Plant Program
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Feet
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Legend
To view locations of individual plant species or other features, open in Adobe Reader DC and click on the "Layers" tab to the left. Turn features on or off by clicking the "Eye" icons.
State Boat Launch
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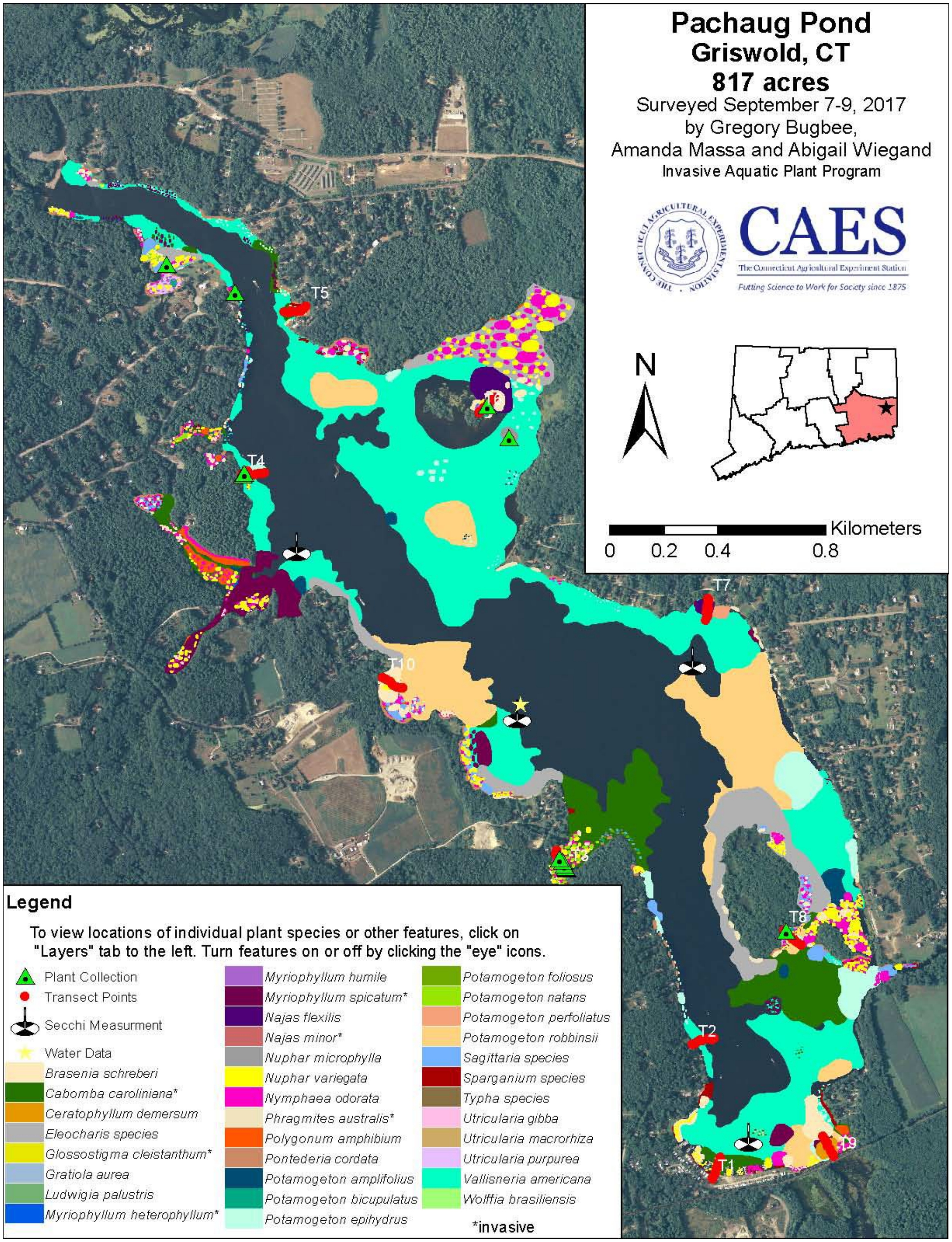
Collection Point
Transect Point
Water Data
Bathymetry (ft)
Arrowhead
Bur-reed
Cattail
Clasping-leaf pondweed
Common bladderwort
Common duckweed
Common reed
Coontail
Eelgrass
Eurasian watermilfoil*
Fanwort*
Floating bladderwort
Floating-leaf pondweed
Great duckweed
Humped bladderwort
Large-leaf pondweed
Leafy pondweed
Little floating heart
Marsh primrose-willow
Minor naiad*
Mudmat
Pickerelweed
Purple bladderwort
Ribbon-leaf pondweed
Robbins' pondweed
Slender naiad
Snailseed pondweed
Spikerush
Variable watermilfoil*
Water smartweed
Watershield
Waterwort
Western waterweed
White water lily
Yellow water lily
*Invasive
T 1
T 2
T 3
T 4
T 5
T 6
T 7
T 8
T 9
T 10
Esri, USDA Farm Service Agency


Pachaug Pond
Griswold, CT
817 acres
Surveyed September 7-9, 2017
by Gregory Bugbee,
Amanda Massa and Abigail Wiegand
Invasive Aquatic Plant Program
CAES
The Connecticut Agricultural Experiment Station
Putting Science to Work for Society since 1875
N
Kilometers
0 0.2 0.4 0.8
T1
T2
T4
T5
T7
T8
T10
Legend
To view locations of individual plant species or other features, click on "Layers" tab to the left. Turn features on or off by clicking the "eye" icons.
Plant Collection
Transect Points
Secchi Measurment
Water Data
Brasenia schreberi
Cabomba caroliniana*
Ceratophyllum demersum
Eleocharis species
Glossostigma cleistanthum*
Gratiola aurea
Ludwigia palustris
Myriophyllum heterophyllum*
Myriophyllum humile
Myriophyllum spicatum*
Najas flexilis
Najas minor*
Nuphar microphylla
Nuphar variegata
Nymphaea odorata
Phragmites australis*
Polygonum amphibium
Pontederia cordata
Potamogeton amplifolius
Potamogeton bicupulatus
Potamogeton epihydrus
Potamogeton foliosus
Potamogeton natans
Potamogeton perfoliatus
Potamogeton robbinsii
Sagittaria species
Sparganium species
Typha species
Utricularia gibba
Utricularia macrorhiza
Utricularia purpurea
Vallisneria americana
Wolffia brasiliensis
*invasive

Transect Data

Appendix Pachaug Pond Transect Data (1 of 2)

Transect	Point	Distance from Shore (m)	Surveyor	Latitude	Longitude	Date	Depth (m)	Substrate	Brasch	CabCar	CerDem	EleSp	EloNut	GloCle	LemMin	LudSp	MyrHet	MyrHum	MyrSpi	NajFle	NupVar	NymOdo	NymCor	PhrAus	PolAmp	PonCor	PotAmp	PotBic	PotEpi	PotNat	PotPer	PotRob	SagSp	SpaSp	SpiPol	UtrGib	UtrInf	UtrPur	UtrRad	ValAme	WolSp
1	1	0.5	Greg Bugbee	41.54863	-71.90053	8/20/2021	0.2	Gravel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	2	5	Greg Bugbee	41.54867	-71.90052	8/20/2021	1.5	Muck	3	2	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2	0	0	0	0	3	0	0	0	0	0	0	2	3	0
1	3	10	Greg Bugbee	41.54872	-71.90049	8/20/2021	1.8	Muck	3	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	1	0	0	0	0	3	0	0	0	0	0	0	2	3	0
1	4	20	Greg Bugbee	41.54882	-71.90043	8/20/2021	1.8	Muck	0	3	0	0	0	0	0	0	2	0	2	0	0	0	2	0	0	0	1	0	0	0	0	3	0	0	0	0	0	0	2	2	0
1	5	30	Greg Bugbee	41.54889	-71.90038	8/20/2021	1.9	Muck	0	3	0	0	0	0	0	0	2	0	3	0	0	0	0	0	0	0	2	0	0	0	0	3	0	0	0	0	0	0	2	2	0
1	6	40	Greg Bugbee	41.54898	-71.90033	8/20/2021	1.9	Muck	2	3	0	0	0	0	0	0	2	0	3	0	2	0	0	0	0	0	2	0	0	0	0	4	0	0	0	0	0	0	2	2	0
1	7	50	Greg Bugbee	41.54908	-71.90033	8/20/2021	1.8	Muck	0	4	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	2	0	1	0	0	3	0	0	0	0	0	0	0	2	0
1	8	60	Greg Bugbee	41.54913	-71.90022	8/20/2021	2.0	Muck	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	2	0
1	9	70	Greg Bugbee	41.54922	-71.90019	8/20/2021	1.9	Muck	0	3	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	3	0
1	10	80	Greg Bugbee	41.54932	-71.90015	8/20/2021	1.9	Organic	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
2	1	0.5	Greg Bugbee	41.55314	-71.90136	8/20/2021	0.1	Sand	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	2	5	Greg Bugbee	41.55318	-71.90131	8/20/2021	0.7	Sand	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	3	10	Greg Bugbee	41.55318	-71.90125	8/20/2021	1.2	Sand	0	2	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
2	4	20	Greg Bugbee	41.55322	-71.90115	8/20/2021	1.4	Sand	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
2	5	30	Greg Bugbee	41.55324	-71.90102	8/20/2021	1.9	Gravel	0	2	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	2	0
2	6	40	Greg Bugbee	41.55331	-71.90094	8/20/2021	2.2	Organic	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
2	7	50	Greg Bugbee	41.55339	-71.90081	8/20/2021	2.5	Organic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
2	8	60	Greg Bugbee	41.55343	-71.90075	8/20/2021	2.5	Organic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	9	70	Greg Bugbee	41.55346	-71.90062	8/20/2021	2.6	Organic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	10	80	Greg Bugbee	41.55349	-71.90054	8/20/2021	2.6	Organic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	1	0.5	Greg Bugbee	41.55966	-71.90739	8/20/2021	0.2	Organic	3	2	0	2	0	0	2	2	2	0	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0	2	2	2	0	0	2	0	2
3	2	5	Greg Bugbee	41.55962	-71.90734	8/20/2021	0.5	Muck	3	2	0	0	0	0	2	0	3	0	0	0	0	4	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	2	0	1
3	3	10	Greg Bugbee	41.55959	-71.90729	8/20/2021	1.0	Muck	2	2	2	0	0	0	1	0	2	0	0	0	0	4	0	0	2	0	0	0	0	0	0	2	0	0	2	0	0	0	2	0	1
3	4	20	Greg Bugbee	41.55953	-71.90722	8/20/2021	1.5	Muck	0	3	0	0	1	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
3	5	30	Greg Bugbee	41.55943	-71.90717	8/20/2021	1.5	Muck	0	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0	2	0	0	0	0	2	0	0	0	0
3	6	40	Greg Bugbee	41.55938	-71.90708	8/20/2021	1.6	Muck	0	3	2	0	2	0	0	0	0	0	0	0	2	2	0	0	2	0	0	0	0	0	0	3	0	0	0	0	2	0	0	0	0
3	7	50	Greg Bugbee	41.55928	-71.90705	8/20/2021	1.5	Muck	2	3	2	0	2	0	0	0	0	0	0	0	0	4	0	0	2	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	0
3	8	60	Greg Bugbee	41.55921	-71.90699	8/20/2021	1.3	Muck	2	2	2	0	0	0	0	0	0	0	2	0	0	4	0	0	1	1	0	0	1	0	0	0	0	0	2	0	2	0	0	2	0
3	9	70	Greg Bugbee	41.55912	-71.90695	8/20/2021	1.0	Gravel	2	3	0	0	0	0	0	0	2	0	0	0	2	2	0	0	0	1	0	0	2	0	0	0	0	0	0	0	3	0	0	0	0
3	10	80	Greg Bugbee	41.55905	-71.90692	8/20/2021	0.5	Gravel	0	3	0	0	0	0	0	0	2	2	0	2	0	2	1	0	0	1	0	2	2	0	0	2	0	1	0	0	3	0	0	0	0
4	1	0.5	Greg Bugbee	41.57235	-71.92116	8/20/2021	0.2	Sand	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	2	5	Greg Bugbee	41.57235	-71.92108	8/20/2021	0.4	Sand	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
4	3	10	Greg Bugbee	41.57237	-71.92102	8/20/2021	1.0	Sand	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
4	4	20	Greg Bugbee	41.57234	-71.92092	8/20/2021	1.3	Sand	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
4	5	30	Greg Bugbee	41.57235	-71.92080	8/20/2021	1.6	Sand	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0
4	6	40	Greg Bugbee	41.57232	-71.92069	8/20/2021	2.4	Silt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	7	50	Greg Bugbee	41.57234	-71.92057	8/20/2021	3.0	Silt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	8	60	Greg Bugbee	41.57235	-71.92041	8/20/2021	3.5	Silt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	9	70	Greg Bugbee	41.57236	-71.92028	8/20/2021	3.7	Silt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	10	80	Greg Bugbee	41.57237	-71.92018	8/20/2021	3.7	Silt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	1	0.5	Greg Bugbee	41.57788	-71.91820	8/20/2021	0.2	Sand	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	2	0	0	0	2	0	0	0	0	0	0	0	0
5	2	5	Greg Bugbee	41.57786	-71.91826	8/20/2021	1.0	Muck	3	4	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	3	0	0	2	0	0	0	0	0	0	0	2	0	0	3	0
5	3	10	Greg Bugbee	41.57783	-71.91832	8/20/2021	1.5	Muck	2	3	0	0	0	0	0	0	2	0	2	0	0	2	0	0	0	2	2	0	2	0	0	0	0	0	0	0	2	0	0	3	0
5	4	20	Greg Bugbee	41.57779	-71.91842	8/20/2021	1.6	Muck	0	4	0	0	0	0	0	0	2	0	2	0	0	2	0	0	0	0	2	0	2	0	0	0	0	0	0	0	2	0	0	3	0
5	5	30	Greg Bugbee	41.57777	-71.91855	8/20/2021	1.3	Muck	0	3	0	0	0	0	0	0	2	0	2	0	0	2	0	0	0	0	2	0	3	0	0	0	0	0	0	0	2	0	0	3	0
5	6	40	Greg Bugbee	41.57777	-71.91866	8/20/2021	1.3	Muck	0	3	0	0	0	0	0	0	2	0	2	2	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	3	0	0	3	0
5	7	50	Greg Bugbee	41.57776	-71.91878	8/20/2021	1.3	Muck	0	3	0	0	0	0	0	0	2	0	2	2	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	3	0	0	3	0
5	8	60	Greg Bugbee	41.57775	-71.91893	8/20/2021	1.6	Muck	0	3	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0	3	0
5	9	70	Greg Bugbee	41.57776	-71.91905	8/20/2021	1.8	Muck	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	3	0
5	10	80	Greg Bugbee	41.57772	-71.91916	8/20/2021	2.0	Organic	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	4	0

Appendix Pachaug Pond Transect Data (2 of 2)

Transect	Point	Distance from Shore (m)	Surveyor	Latitude	Longitude	Date	Depth (m)	Substrate	Brasch	CabCar	CerDem	EleSp	EloNut	GloCle	LemMin	LudSp	MyrHet	MyrHum	MyrSpi	NajFle	NupVar	NymOdo	NymCor	PhrAus	PolAmp	PonCor	PotAmp	PotBic	PotEpi	PotNat	PotPer	PotRob	SagSp	SpaSp	SpiPol	UtrGib	UtrInf	UtrPur	UtrRad	ValAme	WolSp
6	1	1	Greg Bugbee	41.57428	-71.91060	44433	0.2	Muck	2	2	0	2	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0	1	2	2	0	2	0
6	2	5	Greg Bugbee	41.57432	-71.91055	8/25/2021	0.8	Muck	3	2	0	2	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	0	0	0
6	3	10	Greg Bugbee	41.57436	-71.91051	8/25/2021	1.2	Muck	3	2	0	2	0	0	0	0	2	2	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	0	0	0
6	4	20	Greg Bugbee	41.57442	-71.91043	8/25/2021	1.2	Muck	4	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	2	0	0	0
6	5	30	Greg Bugbee	41.57449	-71.91034	8/25/2021	1.2	Muck	4	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	2	3	2	0	0	0
6	6	40	Greg Bugbee	41.57455	-71.91026	8/25/2021	1.0	Muck	4	2	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	1	2	0	0	0	0	0	0	2	3	2	0	2	0
6	7	50	Greg Bugbee	41.57462	-71.91018	8/25/2021	1.0	Muck	4	0	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	2	2	0	0	0
6	8	60	Greg Bugbee	41.57470	-71.91011	8/25/2021	1.0	Muck	4	0	0	2	0	0	0	0	2	0	2	2	0	2	0	0	0	2	2	0	2	0	0	0	0	0	0	2	2	2	2	3	0
6	9	70	Greg Bugbee	41.57478	-71.91006	8/25/2021	1.0	Muck	3	2	0	2	0	0	0	0	2	0	1	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2	0	3	0
6	10	80	Greg Bugbee	41.57486	-71.91002	8/25/2021	1.2	Muck	4	2	0	2	1	0	0	0	2	0	1	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	2	2	2	0	3	0
7	1	0.5	Greg Bugbee	41.56804	-71.90042	8/25/2021	0.2	Sand	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	2	5	Greg Bugbee	41.56800	-71.90042	8/25/2021	0.6	Sand	0	2	0	0	0	0	0	0	2	0	2	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0
7	3	10	Greg Bugbee	41.56794	-71.90043	8/25/2021	0.8	Sand	0	2	0	0	0	0	0	0	2	0	3	2	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0	2	0	0	3	0
7	4	20	Greg Bugbee	41.56787	-71.90047	8/25/2021	1.1	Sand	0	1	0	0	0	0	0	0	0	0	3	2	0	0	0	0	0	0	1	0	0	0	0	3	0	0	0	2	0	0	0	3	0
7	5	30	Greg Bugbee	41.56778	-71.90052	8/25/2021	1.7	Organic	0	1	0	0	0	0	0	0	2	0	3	0	0	0	0	0	0	0	1	0	0	0	0	4	0	0	0	0	0	0	0	2	0
7	6	40	Greg Bugbee	41.56768	-71.90052	8/25/2021	1.8	Organic	0	2	0	0	0	0	0	0	4	0	4	0	0	0	0	0	0	0	1	0	1	0	0	3	0	0	0	0	2	0	0	2	0
7	7	50	Greg Bugbee	41.56759	-71.90057	8/25/2021	1.6	Organic	0	1	1	0	0	0	0	0	2	0	3	0	0	0	0	0	0	0	1	0	1	0	0	2	0	0	0	0	2	0	0	2	0
7	8	60	Greg Bugbee	41.56752	-71.90059	8/25/2021	1.8	Organic	0	1	0	0	1	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	2	0	0	2	0
7	9	70	Greg Bugbee	41.56745	-71.90067	8/25/2021	1.8	Sand	0	2	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
7	10	80	Greg Bugbee	41.56735	-71.90072	8/25/2021	2.0	Silt	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0
8	1	0.5	Greg Bugbee	41.55688	-71.89729	8/25/2021	0.2	Sand	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	1	0	0	1	0	0	0	0	0
8	2	5	Greg Bugbee	41.55687	-71.89726	8/25/2021	0.3	Sand	2	1	0	2	0	0	1	0	2	0	2	0	2	2	2	0	0	0	0	0	2	0	0	0	2	0	0	2	0	1	0	0	0
8	3	10	Greg Bugbee	41.55680	-71.89720	8/25/2021	0.4	Sand	2	1	0	2	0	0	1	0	1	1	1	0	0	0	2	0	0	0	0	0	1	0	0	0	2	0	0	2	2	0	0	2	0
8	4	20	Greg Bugbee	41.55679	-71.89708	8/25/2021	1.0	Muck	2	1	0	2	0	0	1	0	1	0	2	0	0	4	1	0	0	0	0	0	0	0	0	0	0	2	0	2	2	0	0	2	0
8	5	30	Greg Bugbee	41.55671	-71.89701	8/25/2021	1.3	Muck	2	3	0	2	0	0	1	0	2	0	0	0	0	3	2	0	0	0	0	0	0	0	0	2	0	2	0	1	3	0	0	2	0
8	6	40	Greg Bugbee	41.55666	-71.89692	8/25/2021	1.5	Muck	0	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
8	7	50	Greg Bugbee	41.55660	-71.89681	8/25/2021	1.9	Muck	0	3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0
8	8	60	Greg Bugbee	41.55654	-71.89673	8/25/2021	1.9	Muck	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
8	9	70	Greg Bugbee	41.55649	-71.89664	8/25/2021	1.8	Muck	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	4	0
8	10	80	Greg Bugbee	41.55643	-71.89654	8/25/2021	1.8	Muck	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
9	1	0.5	Greg Bugbee	41.54940	-71.89513	8/25/2021	0.2	Gravel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	2	5	Greg Bugbee	41.54945	-71.89513	8/25/2021	0.2	Organic	0	3	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	2	0	0	0	0	3	0	0	0	0	0	0	0	0	0
9	3	10	Greg Bugbee	41.54947	-71.89513	8/25/2021	2.0	Organic	0	2	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	2	0	0	0	0	4	0	0	0	0	0	0	0	0	0
9	4	20	Greg Bugbee	41.54958	-71.89522	8/25/2021	2.2	Organic	0	2	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	2	0	0	0	0	4	0	0	0	0	0	0	0	0	0
9	5	30	Greg Bugbee	41.54967	-71.89526	8/25/2021	2.3	Organic	0	2	0	0	0	0	0	0	1	0	2	0	0	0	0	0	2	0	2	0	0	0	0	4	0	0	0	0	0	0	0	0	0
9	6	40	Greg Bugbee	41.54969	-71.89541	8/25/2021	2.3	Organic	0	2	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	2	0	0	0	0	4	0	0	0	0	2	0	0	0	0
9	7	50	Greg Bugbee	41.54976	-71.89547	8/25/2021	2.3	Organic	0	2	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	2	0	0	0	0
9	8	60	Greg Bugbee	41.54986	-71.89555	8/25/2021	2.5	Organic	0	3	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	2	0	0	0	0
9	9	70	Greg Bugbee	41.54995	-71.89554	8/25/2021	2.5	Organic	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	1	0	0	0	0	4	0	0	0	0	2	0	0	0	0
9	10	80	Greg Bugbee	41.55004	-71.89557	8/25/2021	2.5	Organic	0	2	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	1	0	0	0	0	4	0	0	0	0	2	0	0	0	0
10	1	0.5	Greg Bugbee	41.56552	-71.91494	8/25/2021	0.2	Muck	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0	3	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
10	2	5	Greg Bugbee	41.56548	-71.91489	8/25/2021	0.3	Organic	2	2	0	3	0	0	0	0	0	2	0	0	0	2	0	0	0	2	0	2	0	0	0	0	0	0	0	0	2	2	0	0	0
10	3	10	Greg Bugbee	41.56545	-71.91485	8/25/2021	1.0	Organic	2	2	0	3	0	0	0	1	0	2	2	0	2	2	1	0	0	0	1	0	1	0	0	0	1	0	0	2	2	2	0	2	0
10	4	20	Greg Bugbee	41.56541	-71.91475	8/25/2021	1.1	Organic	2	1	0	2	0	0	0	0	1	1	1	0	2	0	1	0	0	0	1	1	2	0	0	0	1	0	0	1	2	2	0	3	0
10	5	30	Greg Bugbee	41.56535	-71.91465	8/25/2021	1.1	Organic	3	0	0	2	0	0	0	0	1	1	1	0	2	0	1	0	0	0	2	0	2	0	0	0	0	2	0	1	2	2	0	3	0
10	6	40	Greg Bugbee	41.56529	-71.91457	8/25/2021	1.8	Muck	2	2	0	0	0	0	0	0	0	0	2	0	3	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0	3	0	0	2	0
10	7	50	Greg Bugbee	41.56524	-71.91446	8/25/2021	1.7	Muck	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	3	0	0	0	0	2	0	0	3	0
10	8	60	Greg Bugbee	41.56522	-71.91434	8/25/2021	1.9	Muck	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	4	0
10	9	70	Greg Bugbee	41.56517	-71.91424	8/25/2021	1.9	Organic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	3	0	0	0	0
10	10	80	Greg Bugbee	41.56514	-71.91411	8/25/2021	2.0	Organic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0