Aquatics

FALL 2023

A Publication of the Florida Aquatic Plant Management Society

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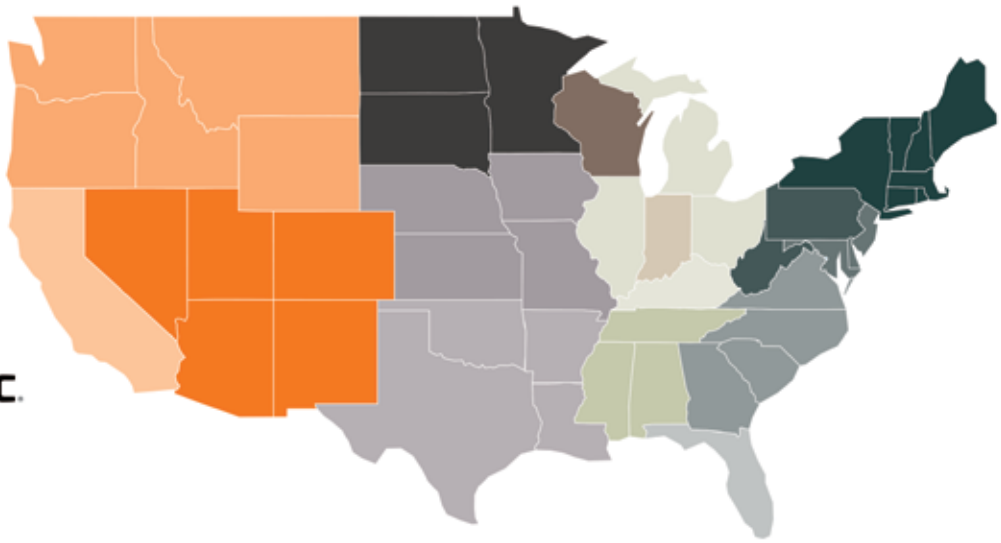

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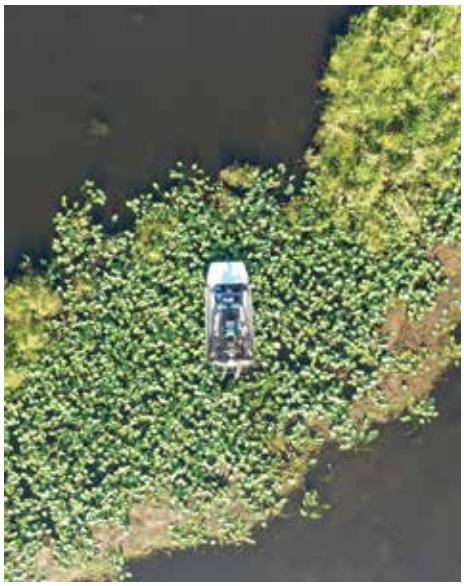


Cover photo is of UF biological scientist, Kelli Gladding, while monitoring hydrilla and native submersed aquatic plants on South Lake in Brevard County, FL using a Skydio UAV (Unmanned Aerial Vehicle- Drone).
Photo Credit: Kelli Gladding

Contents

Letter from the Editor

Shelby Thomas

Dear Aquatics Readers,

This is my first issue as Editor of Aquatics, and I am happy to bring you the Fall 2023 issue of Aquatics Magazine.

This issue brings you a variety of updates. The water levels on Lake Toho have been influenced by changes people have made to the natural environment or anthropogenic control. These consequences include a boon in aquatic vegetation and created large expanses of floating island tussocks. Read more about this project on page 5.

This issue also features a report on the Central Arizona project on page 12. Lake Havasu has experienced an increase in vegetation growth since quagga mussels invaded the Colorado River in 2008. This report explores the issues created by vegetation at the Central Arizona Project's Mark Wilmer Pumping Plant. To read the full update flip to page 12.

On page 18 Applicator's Corner features a piece by Dr. Jason Ferrell of the UF/IFAS Center for Aquatic and Invasive Plants discussing how plants become herbicide resistant. This month Aquatics also features a short point of view from Jeff Holland. On page 23 you will find an interesting take on one of the most prolific invasive plants in Florida.

A new regular addition to Aquatics Magazine is Naturally Native, a column by Kelli Gladding of the UF/IFAS Center for Aquatic and Invasive plants. In this short feature, Kelli explores the bladderwort plant species. She invites others to submit reviews of Florida native plants and the ways they are being influenced by invasive vegetation. Flip to page 26 to read the glimpse into the life of the Florida native.

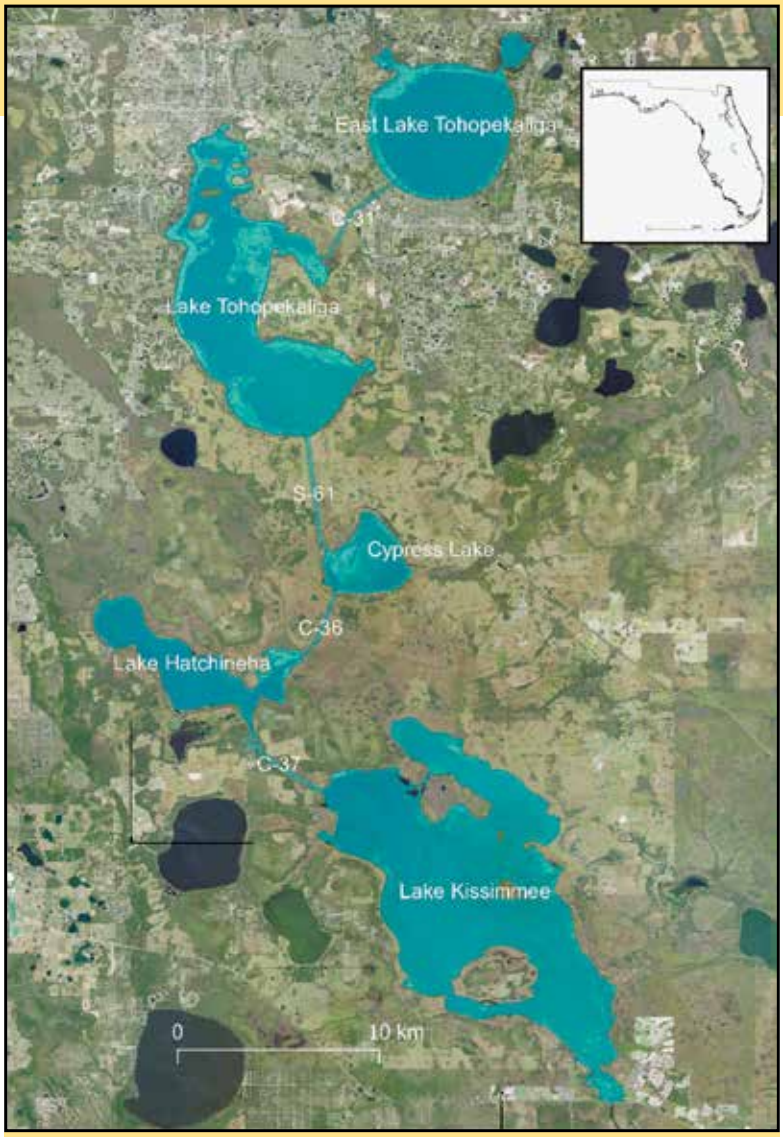
Thank you again for the opportunity to serve as your Editor. I look forward to bringing you the latest information and features from our industry. Interested in being featured or writing for Aquatics, email Shelby Thomas at aquaticsmagazine@gmail.com.

A Change Detection Analysis of Lake Tohopekaliga Using Historical High-Resolution Aerial Imagery

Jacob Ferris[1], Ed Harris[2], James Leary[3]

Introduction

Freshwater systems account for over 18% of Florida's surface area, with an estimated 7,800 lakes of at least one acre (Schiffer, 1998). Many of these lakes are formed by natural processes forming sinkholes and depressions in the karst (limestone) topography of the Florida peninsula (Beck 1986, Lakewatch 2001). Florida lakes tend to be shallow (< 10 ft deep) with proportionally large littoral zones. A sub-tropical climate makes most Florida lakes perennially warm, polymictic or continuously circulating systems and are also highly productive and diverse trophic webs supported by naturally occurring phosphatic nutrient deposits (Bachmann, 2012).



Kissimmee Chain of Lakes with man-made canals

Florida was granted statehood in 1845. Soon after, the federal government passed the Swamp and Overflowed Lands Act of 1850 allowing for ownership transfer of over 20M acres of submersed (swamp) land to the state of Florida, with a stipulation that proceeds of any land sales thereafter be reinvested into drainage projects. In 1855, the Internal Improvement Trust Fund of Florida (IITF) was established to "reclaim" swamp lands for expanding transportation networks (i.e., rail) in support of enterprises in agriculture and tourism (dos.myflorida.com). In 1881, Hamilton Disston, an industrialist from Philadelphia, PA entered into a drainage contract with the IITF. By 1884, the St. Cloud and South Port Canals were both completed, connecting Lake Tohopekaliga to East Lake Tohopekaliga and Cypress Lake, respectively.

Lake Tohopekaliga (Toho) is the seventh largest lake in Florida (18,800-22,000 acres) and one of five lakes of the "Kissimmee Chain" depositing into Lake Okeechobee (Welch, 2004). In 1949, after several destructive hurricanes swept through the Upper Kissimmee River Basin, the U.S. Army Corps of Engineers (USACE) implemented the Central and Southern Florida (C&SF) Project with a mission to construct levees and control structures on the southern shores of the Kissimmee Chain for improving downstream conveyance and control water levels in order to prevent future catastrophic flooding. In 1964, the lock and spillway structure S-61 was completed on the southern canal of Lake Toho.

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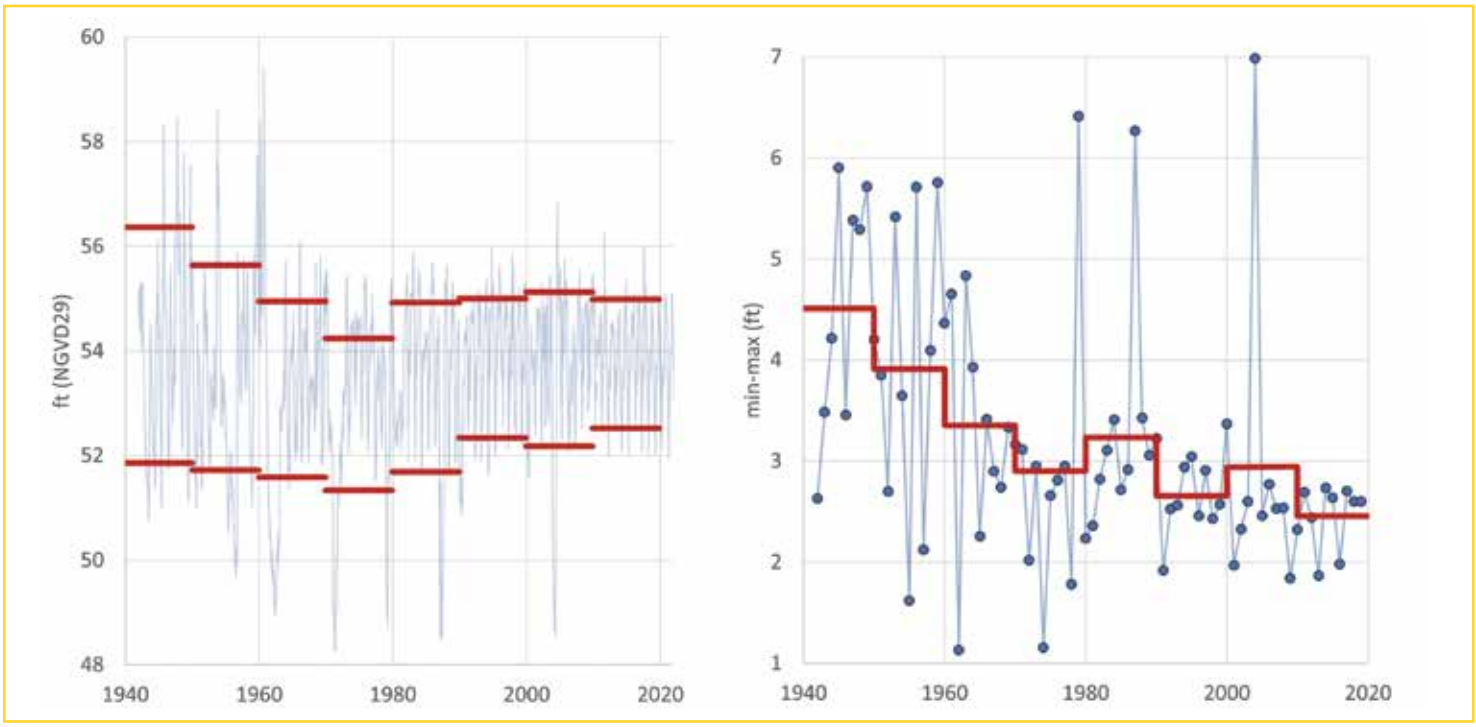
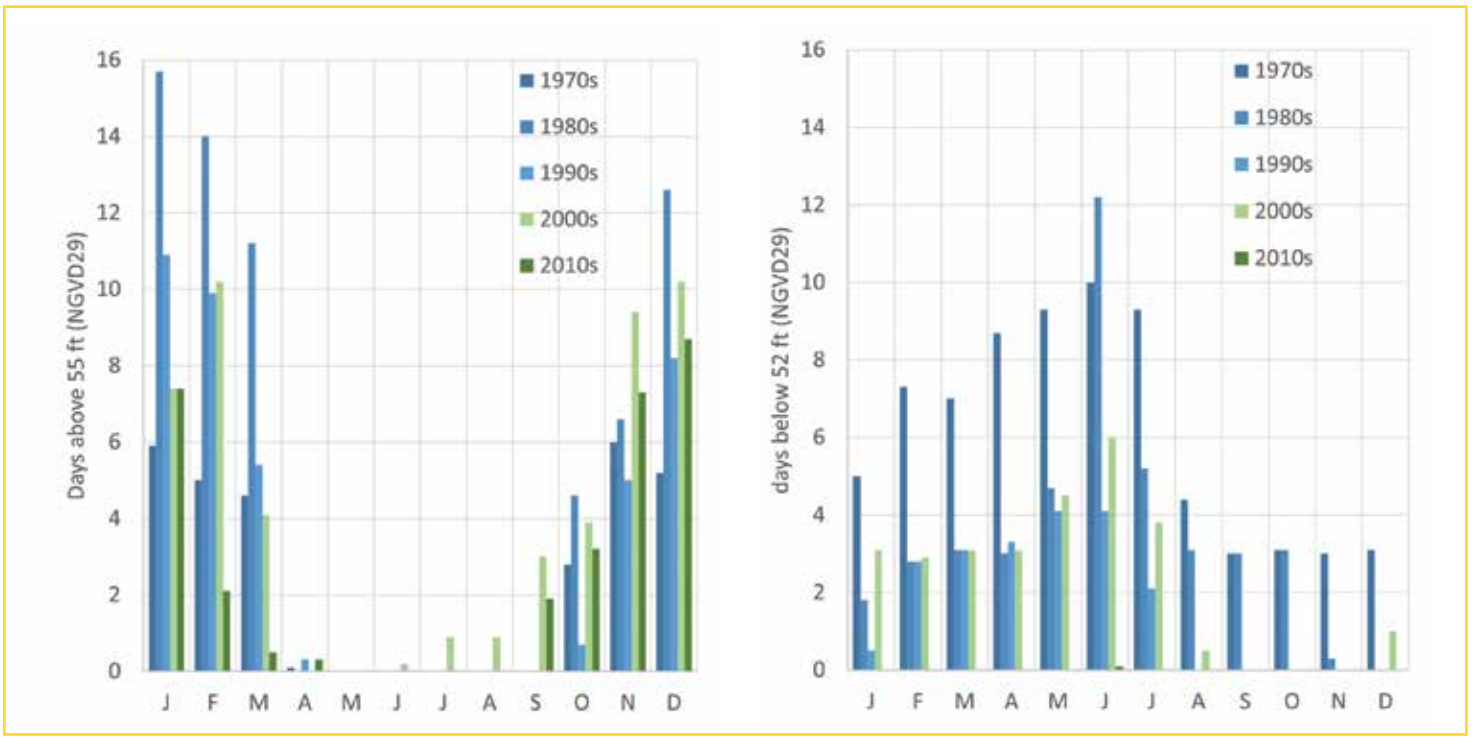


Daily elevation (ft. NGVD29; blue) and decadal mnimum and maximum averages (red lines) or Lake Tohopekaliga (left panel) and the average annual (blue dots) and decadal (red lines) minmax fluctuations.

In the 1940s and 1950s, before completion of the S-61 spillway, average seasonal lake levels on Toho ranged between 51.8 ft and 56.0 ft NGVD29 (National Geodetic Vertical Datum of 1929) above sea level. Since the completion of S-61, lake levels on Toho have been maintained on a seasonal schedule, confining the average seasonal range between 52.0 and 54.9 ft NGVD29. Average seasonal fluctuations were maintained at less than 4 ft starting in the 1960s and through to the 1980s. Since 1990, fluctuations have been confined to less than 3 ft. This last decade (2010-2020) had the lowest average seasonal fluctuation on record at 2.5 ft. Moreover, lake level regulations have reduced the number of days lake levels were above 55 ft during



Average number of days above 55 ft (left panel) and below 52 ft (right panel) on Lake Tohopekaliga for each month in the decades before and after completion of spillway S-61.

the wet season (July-December) and the number of days below 52 ft during the dry season (January-May). According to records, lake levels dropped below 52 ft only once since 2010.

Lake level stabilization can influence hydrodynamic forces and other environmental conditions conducive to the expansion of littoral areas colonized by submersed and emergent vegetation communities (Hoyer and Canfield 1997, Scheffer 1994). In Florida, there are strong coincidences of these anthropogenic changes with eutrophication and increasing aquatic plant management activities (e.g., water hyacinth in the 1950s and hydrilla in the 1980s). In this study, we seek to understand how vegetation communities have changed over time through remote sensing of high-resolution imagery captured from historical aerial surveys commissioned by the US Department of Agriculture. These images dating back to the 1940s were made available through the University of Florida Digital Collections. Using basic workflows in geographical information systems (GIS), this study shows a visual depiction of changes to Lake Toho coinciding with some of the historical events described above.

Methods

UF Digital Collections (UFDC) maintain over 160,000 archived aerial images from surveys conducted from 1937–1990 (https://www.uflib.ufl.edu/aerials/). Image sets overlapping Lake Tohopekaliga (n=21) were downloaded from aerial surveys conducted in January 1944 and April 1968. Original images were recorded in black and white format and subsequently digitized into 8-bit, 29.16 Mp files compressed into jpeg2000 formats (.jp2). Images were converted back to .jpg using GNU Image Manipulation Program software (GIMP 2.10.32). These images were further transformed into georeferenced tag image file format (.tiff) and co-registered with the other georeferenced layers for lake feature comparisons (e.g., open water, vegetated tussock, etc.).

Georeferencing is a process in GIS for assigning geographical coordinate information such as reference location, scale and orientation that co-registers (i.e., matches up) with a base layer map with known coordinates. We used the latest image ortho-mosaic for Osceola County (FIPS code 097) procured by the National Agriculture Imagery Program from aerial surveys conducted in November 2021. Image tiles are compressed into a multi-resolution Seamless Image Database (.sid) files with a 60-cm ground sampling distance and projected to the UTM coordinate system using the North American Datum of 1983.

The Freehand raster georeferencer plugin for QGIS (v. 3.22; Open Source Geospatial Foundation) was used for importing, moving, scaling and orienting images. Multiple tie points of semi-permanent features, i.e., buildings, roads and canals were used for lining up overlapping images and the base image. TIFF images were exported with separate "sidecar" world files (.tfw) describing the location, scale and rotation adjustments made to the raster for importing into GIS.

Spatial accuracies of the georeferenced images were measured by the root mean square error (RMSE) of 20 calibration points around the lake corresponding with other semi-permanent features (e.g., buildings, roads and property lines) present from 1944 to 2021 (Figure 6). Euclidian distances were calculated from corresponding calibration points between layers using the built-in distance matrix tool in QGIS and exported as .csv files to be accessed in Excel (Microsoft Inc., Redmond WA) for calculating RMSE with the following equation:

$$RMSE = \sqrt{\frac{\sum_1^n (Distance)^2}{n}}$$

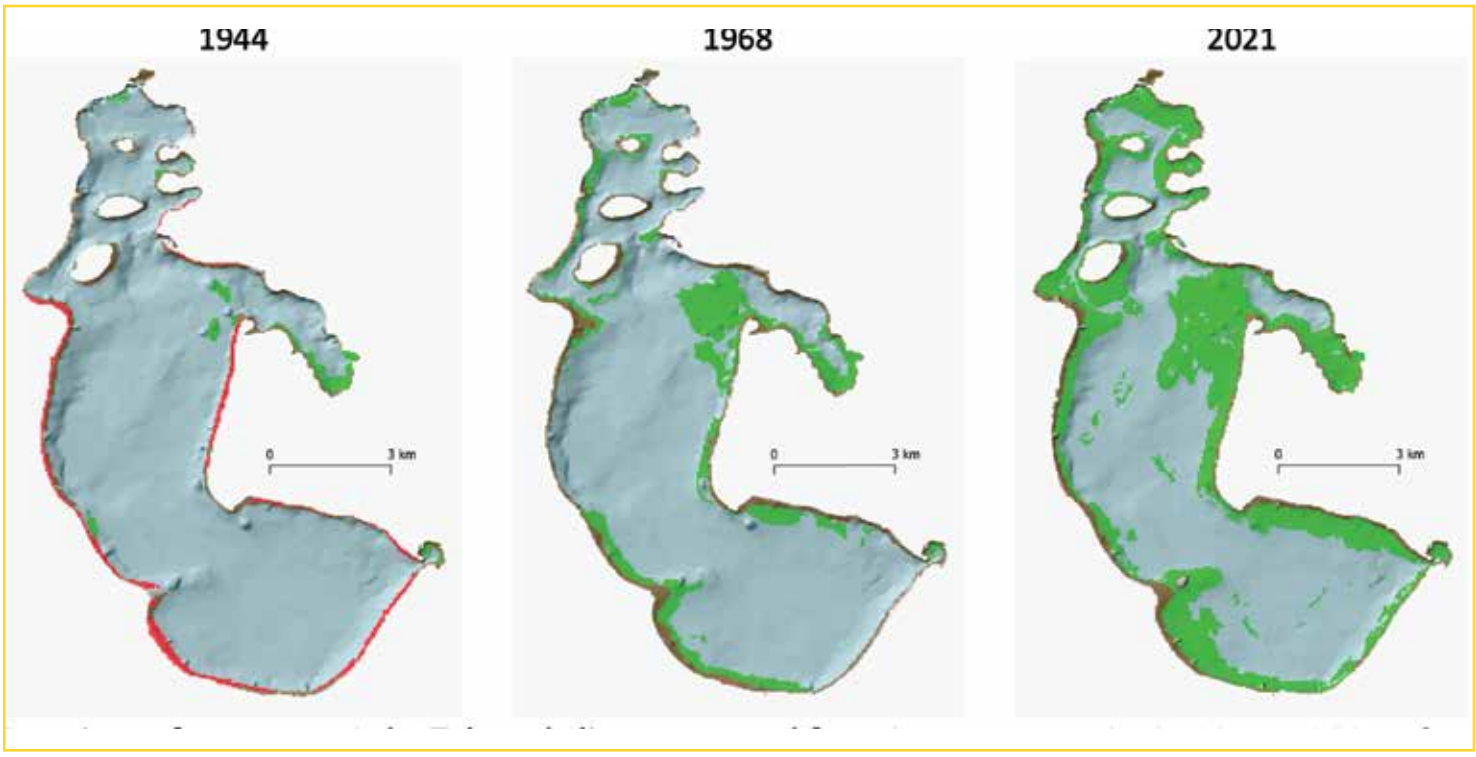
where n = 20 observations.

A semi-transparent 50 m grid (0.62 acre) mask layer was embossed over a shoreline polygon of Lake Toho including the shoreline (n = 29,756 grids). Each grid cell was manually labeled with one of seven different feature classes: (i) Open Water; (ii) Sandy Shoreline; (iii) Organic

Estimated feature areas from grid maps comparing images from 1944, 1968 and 2021.

	Area (acres)			rm ANOVA	
Feature	1944	1968	2021	1944 v 1968	1968 v 2021
Open Water	15,846	13,678	10,315	**	**
Sandy Shore	602	4	1	**	NS
Organic Shore	786	1,362	1,245	**	*
Littoral Tussock	264	2,260	5,670	**	**
Agriculture Land	767	928	807	NS	NS
Forest	87	107	191	*	*
Urban/Residential	28	43	152	*	*

** significant at p < 0.05; ** significant at p < 0.01; NS not significant*



Prominent features on Lake Tohopekaliga annotated from imagery mosaics in 1944, 1968 and 2021: Sand shoreline (red); organic vegetated shoreline (brown); vegetated floating island (green); open water (blue)

Shoreline; (iv) Littoral Tussock; (v) Agriculture Land; (vi) Forested Land; and (vii) Urban/Residential Land. Grid mask layers for each date were merged together, creating a single table including all feature class attributes and exported as .csv files to be accessed in Excel.

A repeated measures analysis of variance (rmANOVA) was administered with a Greenhouse-Geisser correction adjusting the degrees of freedom when the assumption of sphericity was violated, i.e., variances of the differences within groups were unequal. The p-values were adjusted with Bonferroni corrections according to the number of comparisons (n = 3). Post-hoc paired t-tests were administered between years (i.e., 1944, 1968, 2021) within features. The statistics were performed using the Real Statistics Resource Pack plugin software for Excel (Release 7.6; real-statistics.com).

A point-grid survey was conducted in 2021 by the Florida Fish and Wildlife Research Institute, Long Term Monitoring team (LTM). The grid covers the entire lake (n=951) with each point representing approximately 20 acres. At each point, all submersed, emergent and floating macrophytes are classified to species and ranked for abundance on a 1-3 ordinal scale. Feature attributes of the nearest cells from the 2021 grid layer were joined and exported as tabular .csv files in QGIS. Tables were accessed in Excel for reclassifying each cell into functional groups: (i) submersed aquatic vegetation (SAV); (ii) floating leaf pads (PAD); (iii) emergent grasses (GRS); (iv) Floating plants (FLT); and (v) emergent broadleaf (EMG). Each cell was also reclassified as native or exotic origination.

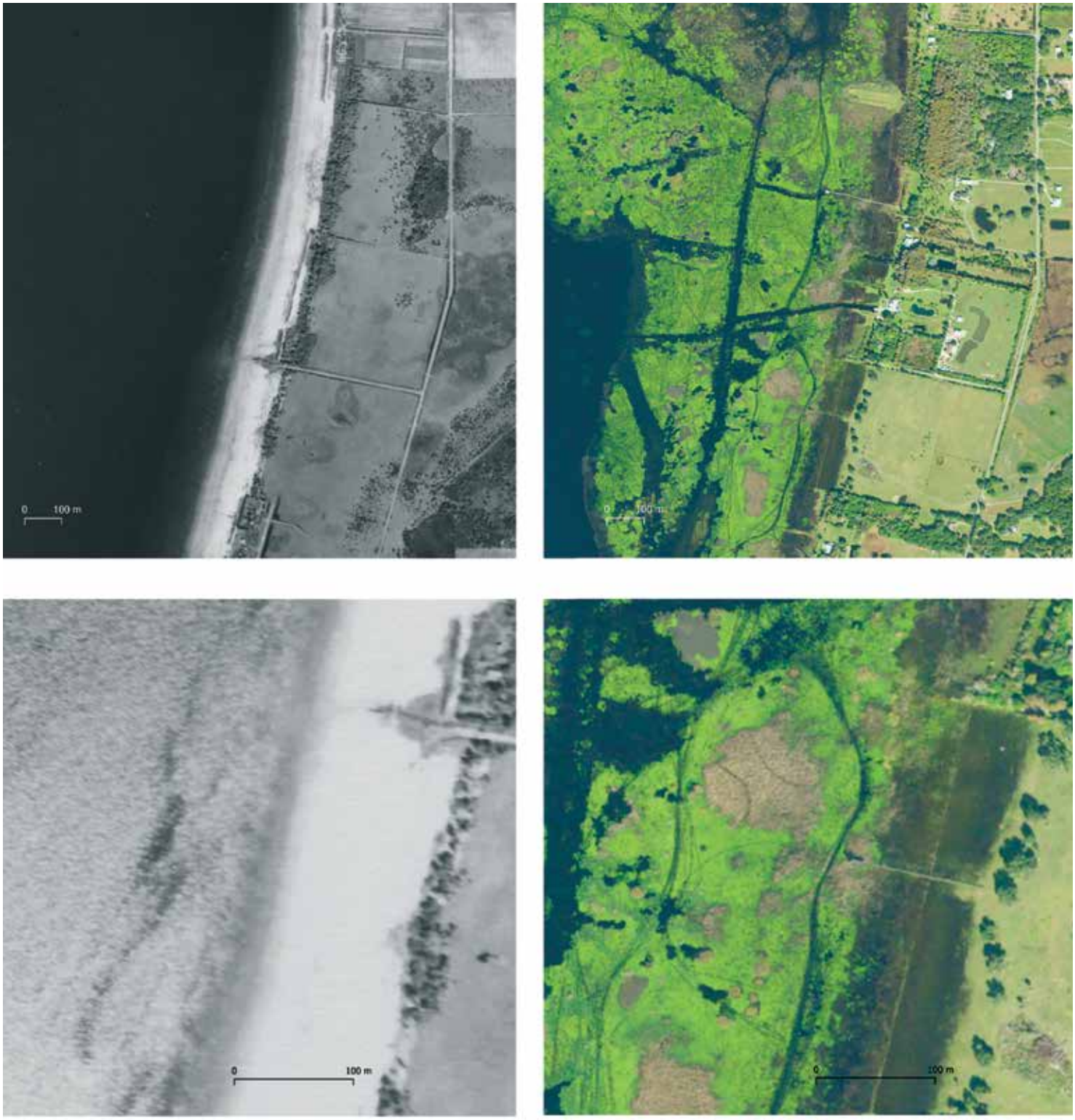
Results

The RMSE for the offset distances compiled from the twenty calibration points were 31.6 ft, 24.0 ft and 44.2 ft for 1944 v. 2021, 1968 v. 2021 and 1944 v. 1968, respectively. In general, this is low spatial accuracy and unqualified for any type of certified engineering or archeological survey. However, this was satisfactory for our purpose of a broad assessment of ecological change over time and compensated by grid cells that were >10 times the size of the error.

The 1944 aerial survey was conducted five years prior to when the C&SF project started and 20 years prior to the completion of the S-61 spillway. Over 86% of Lake Toho was open water (i.e., 15,846 acres) with 602 acres of sandy shore and 786 acres of "organic"vegetated shore. The 1968 survey was conducted 4 years after the completion of the S-61 spillway, when new lake level regulations were established. Significant reductions in open water (13%) and almost a complete loss of sandy shore (99%) was measured. These features were displaced with significant increases in vegetated shorelines (73%) and littoral tussock (856%).

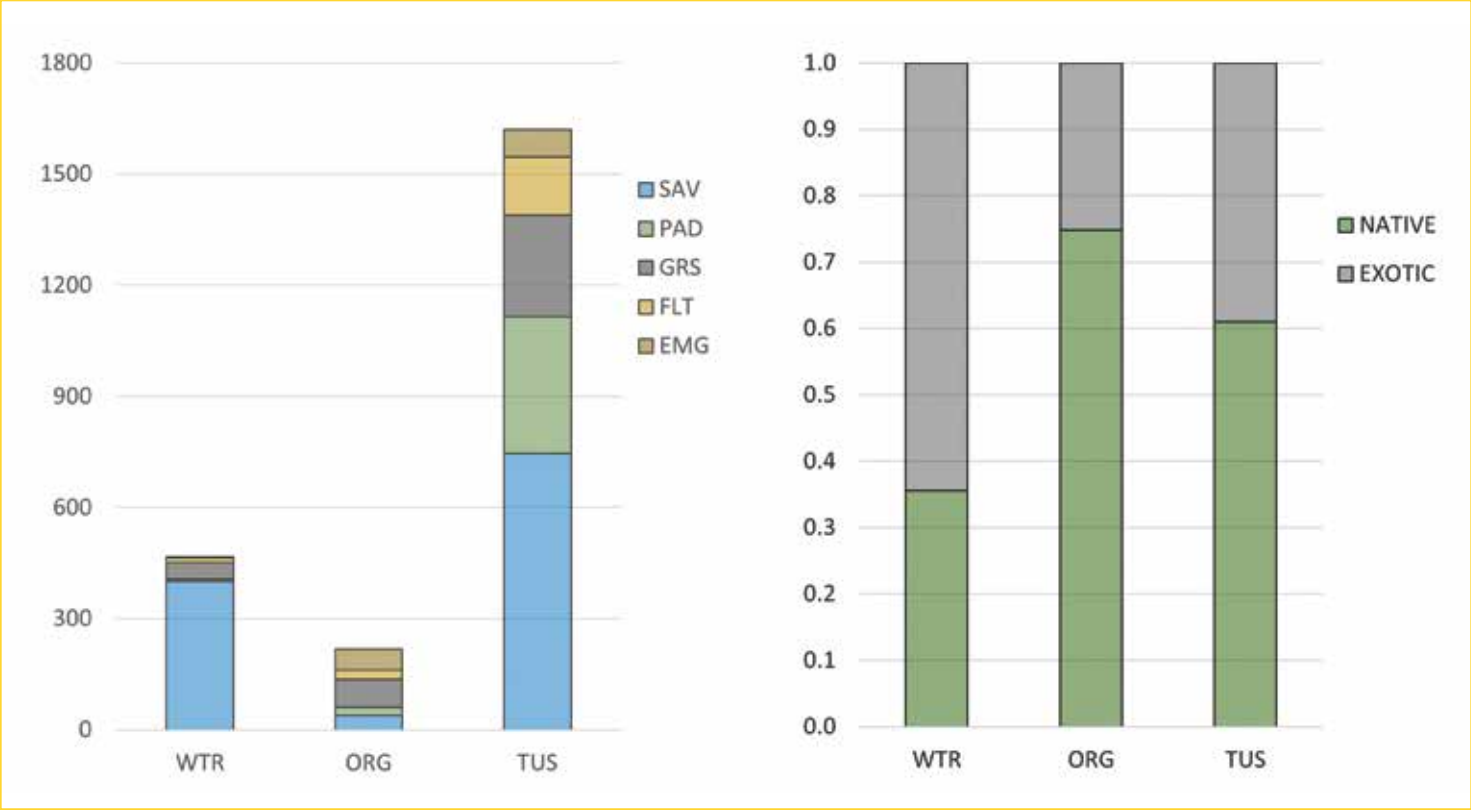
Open water area continued to reduce from 1968 to 2021 (24%) while littoral tussock continued to expand (251%). There was no significant reduction in sandy shore on the account there was little remaining in 1968. Organic vegetated shore also significantly reduced from 1362 acres to 1245 acres. This may have been due to visual confusion during analysis trying to distinguish shoreline obscured by littoral tussock and other terrestrial features.

Total feature changes between 1944-1968 and 1968-2021 were 5338 acres and 6893 acres, respectively. The transition



Perspectives of North Steer Beach on the eastern shore of Lake Toho comparing shorelines from 1944 (left panels) and 2021 (right). Zoomed in (bottom panels) note the open water with over 300 ft of white sand beach in 1944 transitioned to organic shoreline and displacement of open water with large vegetated tussocks dominated by a Nuphar/Typha community.

from open water to littoral tussock was the most prominent transition over the last 80 years, accounting for roughly 91% of the change detected. While it pales in comparison, there were also significant transitions from open water to organic shoreline occurring for both time periods (277 acres and 142 acres, respectively). The majority of the immediate surrounding watershed was agricultural in 1944 and continued to be in 1968 and 2021. Successive increases were observed for both forested and urban/residential features with a noticeable 353% increase of the latter from 1968 to 2021. An assessment of the surrounding watershed was not a comprehensive part of the study and likely doesn't follow the broader trends with



Frequencies of vegetation classes (left panel) and status of origination (right panel) determined by the FWRI the annual long-term monitoring point-grid survey in 2021 assigned to one of three annotated features from 2021 image mosaic organic vegetated shore (ORG); vegetated floating islands (TUS); open water (WTR)

Florida's increase in resident and visitor populations.

Open water, organic shoreline and littoral tussock were the most prominent features in the 2021 grid layer. In the LTM survey, macrophyte occurrences were 3- and 5-times higher in littoral tussocks than open water and shoreline, respectively. Species richness was lowest in open water with 23 species of macrophytes, while organic shoreline and littoral tussock showed increasing richness with 40 and 46 species, respectively. Over 84% of open water was dominated by SAV and mostly represented by *Hydrilla verticillata* (69%). The littoral tussocks were also most represented by SAV (44%) with hydrilla being the most representative (26%) but was also more balanced with pad (22%), grass (16%) and floating (9%) plant groups. The organic shoreline was also a balanced community of grass (31%), emergent broadleaf (24%), SAV (16%), floating (10%) and pad (9%). Finally, while open water was dominated by exotic hydrilla, organic shoreline and littoral tussock communities were over-represented by native members.

Conclusion

Florida law has established policy that state water resources be managed under the administration of the Department of Environmental Protection which oversees five regional water management districts (WMD). The WMDs have a broad mandate with core missions in: (i) water supply, (ii) water quality, (iii) flood protection and floodplain management, and (iv) natural systems (https://floridadep.gov/water-policy). In the age of climate change, the protection of our precious water resources cannot be overstated. It is the abundance of freshwater that allows Florida to be the third most populous state along with being the second most visited. Any failure in these core missions could result in catastrophic impacts to our society, economy and environment.

As with any alteration of a natural system, the anthropogenic control of water levels on Lake Toho had unexpected consequences. Decreasing the maximum level and stabilizing depth fluctuations has led to a dramatic increase of the littoral zone, conducive for establishing functionally diverse macrophyte communities (Hoyer, 1997; Hoyer, 2008). This boon in aquatic vegetation has resulted in a positive feedback loop with accumulations of organic matter building up over time permanently altering the shoreline and creating large expanses of floating island tussocks colonizing the open water (Hoyer, 2008), while incidentally also supporting a highly productive fishery (Bonvechio and Bonvechio 2006).

Aquatic plant management (APM) in Florida dates back to the late nineteenth century around the same time when large-scale wetland reclamation and conveyance projects were taking shape. However, APM really started to ramp up with water hyacinth (*Eichhornia crassipes*) in the 1960s and hydrilla in the 1980s. Is it possible that changes to regulating our freshwater systems contributed to the invasive plant problems we're dealing

with today? Outlook is probable, but there are several other culprits likely contributing to this phenomenon (i.e., non-point source nutrient pollution). Would reverting to a "natural" hydrology with extreme seasonal fluctuations reduce vegetation communities including invasive macrophytes? Again, this is probable, but really more of an academic question when considering the abandonment of the other core stewardship activities vital to sustaining the other social, economic and environmental functions. Thus, APM today is institutional to the stewardship of Florida lakes contributing to all of the core missions and will continue to show importance as we advance as a society with a heritage of protecting our unique water resources.

Acknowledgements

Jacob Ferris graduated Summa Cum Laude with a degree in Civil Engineering in the class of Spring 2023 at the University of Florida. This article is a rendition of his honor's thesis of the same name. Much appreciation to thesis committee members Dr. Christine Angelini and Dr. Mark Newman for their mentoring and support.

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2022 Central Arizona Project Report

Lake Havasu has experienced an increase in vegetation growth since quagga mussels invaded the Colorado River in 2008. The growth, and eventual senescence, of the vegetation creates issues at Central Arizona Project's (CAP) Mark Wilmer Pumping Plant (MWP), as mats of floating vegetation threaten the reliability of the system to transport water. The MWP supplies 3 counties in SW Arizonia, including Phoenix and Tucson with drinking water.

The CAP intake channel has been mapped using sonar since 2012 to determine the distribution and density of the vegetation growth. The distribution is quantified using a calculation known as percent area coverage (PAC). PAC is a measurement of the total mapped area that has at least 5% vegetation growth. Due to environmental factors (e.g. temperature, sunlight, and turbidity) and occasional herbicide treatments, some years result in less growth than others. However, the overall trend has been an increase in vegetation growth within the intake channel (Figure 1).

The primary management method for controlling nuisance plant growth in the intake channel has historically been mechanical removal. While effective, this method was very labor intensive and required personnel to be on call to deal with excess floating vegetation after cutting. Despite the effectiveness of the mechanical removal, overall PAC was on an increasing trend that required exploration of new management techniques. In 2014, 2015 & 2017 a copper based herbicide was used in the intake area with mixed results. A switch to dipotassium salt of Endothall in 2019-2021 showed improvement from the copper but some inconsistent results lead to a consultation with Endothall manufacturer UPL on how best to utilize their product on this challenging site. UPL recommended utilizing the granular formulation of Endothall in a large deep water site that had previously been difficult to achieve control in. This was in addition to the liquid formulation which was used in shallow areas (<18 ft). To better track the herbicide movement a liquid water tracing dye (Rhodamine) was applied in conjunction with the herbicide.

Figure 1. Maximum percent area coverage (PAC) in the CAP intake channel during each year beginning in 2012. The red dotted line shows the overall trend in vegetation growth with the intake channel.

Methods

Mapping

Bathymetry and growth of vegetation within CAP's 62-acre intake channel was mapped using a Lowrance HDS-9 Live® chartplotter. Point data is uploaded to BioBase®, where complex algorithms are applied to create representative vegetation maps. Along with comprehensive bathymetric and vegetation coverage maps, BioBase also provides several metrics that describe the extent of vegetation growth. Two of the more valuable metrics are Percent Area Coverage (PAC) and Average Biovolume (BV). PAC, as described above, is the percentage of the mapped area that exhibits weed growth that is taller than 5% of the water column (calculated by BioBase). BV is the average percentage of the water column that has vegetation; effectively how tall the vegetation is growing. Because BV can be affected by plant density (sonar may not reach the actual bottom in dense growth areas), PAC is generally a more useful metric to determine the extent of plant growth.

Application Plan

Within the intake channel, pondweed species (sago, horned, and curlyleaf) have historically grown in the early season (April-June), with the heaviest growth in shallow waters near the jetty. Naiad species (southern and spiny) have tended to have higher growth rates later in the year (June-August), with most of the growth occurring in deep waters (>18 feet).

Based on results of the 2021 herbicide application, a one-time treatment was again recommended by UPL. However, since the deeper water naiad growth did not appear to be affected by the liquid Endothall treatment, UPL recommended using the granular formulation so that the product would not be affected by wind or water flow; essentially sinking to the bottom and instantly being in contact with the plant. Liquid Endothall would still be utilized in the shallow areas to target the pondweed species.

Liquid Endothall use was planned in a 9.5A treatment area with a concentration goal of 5 ppm (3.2 gallons per acre-foot). The concentration goal for the granular Endothall was 3 ppm (13.2 pounds per acre-foot) and was planned for an area of approximately 5 surface acres (Table 1). The concentration goal was lowered from the max label rate because the treatment was applied at a time when vegetation

Table 1. Size of each treatment polygon, including the amount of herbicide applied and the concentration achieved.

Polygon	Acres	Avg Depth (ft)	Acre-Feet	Herbicide	PPM	Gallons per acre-foot	Total Gallons
C1	4.595	16.83	77.32	Cascade	5	3.2	250
C2	4.867	16.63	80.94	Cascade	4.8	3.1	250
Polygon	**Acres**	**Avg Depth (ft)**	**Acre-Feet**	**Herbicide**	**PPM**	**Pounds per acre-foot**	**Total Pounds**
A1	4.986	21.42	106.82	Aquathol Super K	3.06	13.48	1440

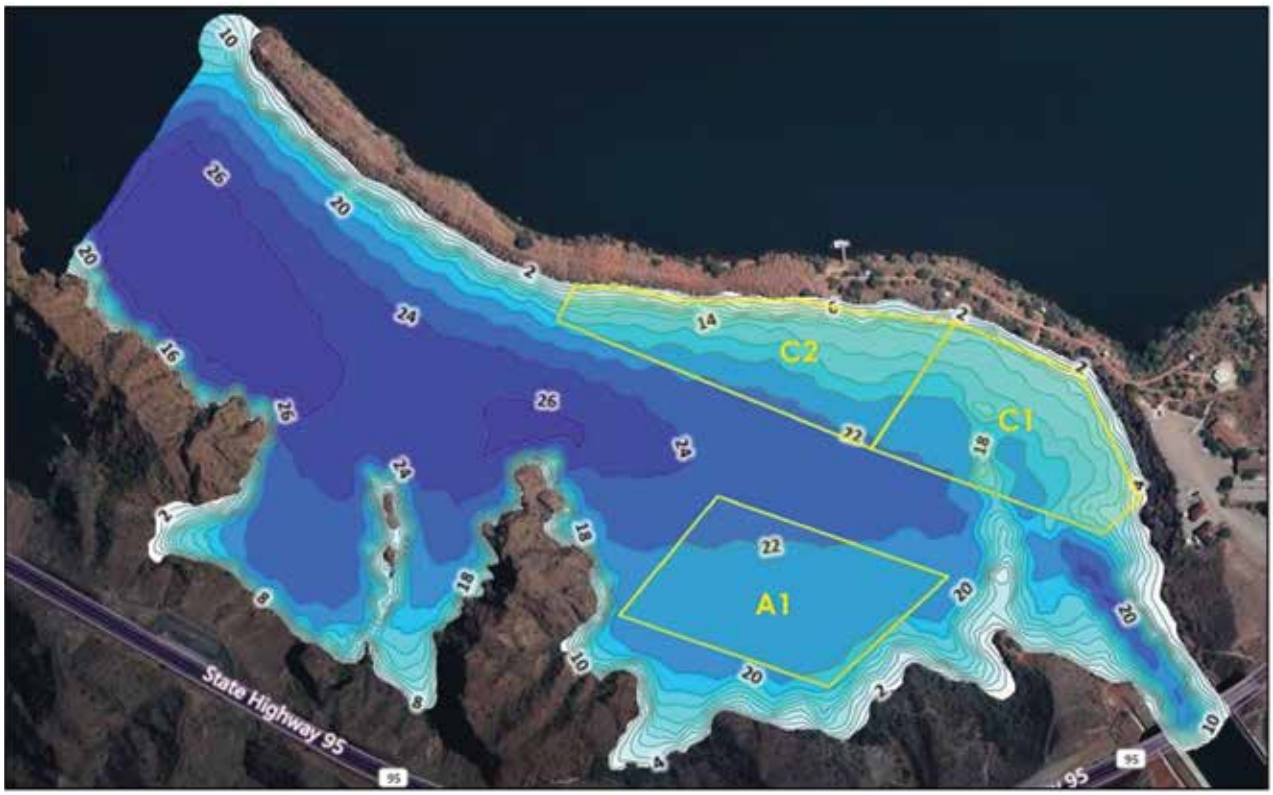


Figure 2. Planned areas for treatment in 2022. Areas C1 and C2 were targeted for liquid Endothall treatment, while A1 was targeted for granular Endothalll treatment.

growth was less than 50% of the water column. Due to the product sinking to the bottom, the full water column treatment of 3 ppm is essentially closer to a 5 ppm concentration directly on the targeted weeds. It was felt that applying the herbicide at these concentrations during late June would effectively control/eliminate both pondweed and naiad species. Treatment areas were determined by creating BioBase polygons on existing contour maps (Figure 2).

Endothall is a systemic herbicide that requires moderate contact time to maximize effectiveness. Typically, MWP pumps create flows within the intake channel that range from 1,800–3,500 cfs. This would severely reduce contact time if the herbicide were applied when pumps were running. To increase contact time of the herbicide, a 48-hour pump outage was scheduled for MWP, which would reduce flows to nearly zero within the intake channel. The application was scheduled for 6:00 am on June 28th; therefore, pumps were shut down at 12:00 am on June 28th and remained off until 11:59 pm on June 29th.

Treatment

For application of the liquid Endothall, CAP's machine shop fabricated a "trailing weighted hose" application system so that the liquid herbicide could be dispensed at various depths (3, 6, and 12 feet). The granular product was applied first to avoid projected winds later in the day that could blow chemical dust and create safety concerns for the applicators. A Vortex blower was used to disperse the product as the boat navigated overlapping transects within the treatment area. The liquid Endothall was applied in tandem with 10 ppb of rhodamine dye. To ensure adequate coverage of the treatment area, overlapping transects were run perpendicular to the shoreline.

Monitoring

To better understand the persistence of the active ingredient of the herbicide (endothall), UPL representatives collected water samples at various locations and depths within the treatment areas. In addition, UPL representatives utilized a handheld fluorometer to measure the

Figure 3. Map of vegetation sampling points in each polygon.

concentration and distribution of dye as a surrogate representing the chemical distribution.

Pre-treatment mapping was conducted on June 27th to determine existing vegetation coverage and density. To determine the effectiveness of the herbicide, post-treatment vegetation mapping was conducted 1, 2, 3, 4, 6, and 8 weeks after treatment. In addition, vegetation at random points was sampled following each mapping survey (Figure 3). At each point, a weighted thatch rake was used to sample overall health and density of the vegetation.

Results

Mapping that was completed just prior to the treatment in late-June showed heavy vegetation growth throughout the treatment area, as well as other areas of the intake channel (Figure 4). Pre-treatment PAC within the granular Endothall treatment area (A1) was 78.8%, while growth in the liquid Endothall treatment areas was 86.9% and 99.4% in C1 and C2, respectively. Relative vegetation height (BioVolume) was obscured with the heavy vegetation growth in C1 and C2, i.e. the sonar could not penetrate the dense weed beds to find the bottom. However, in treatment area A1 the vegetation was sparse enough that the BV of 10.1% was likely accurate. That meant plant growth was ~10% of the water column. In treatment areas C1 and C2, the mapping showed BV's of 16.7-17.3%; thatch rake samples and visual observation showed that the average BV was likely closer to 50% or more.

The granular Endothall was applied with effective coverage across the treatment area. Application of the liquid Endothall was efficient and the addition of the dye

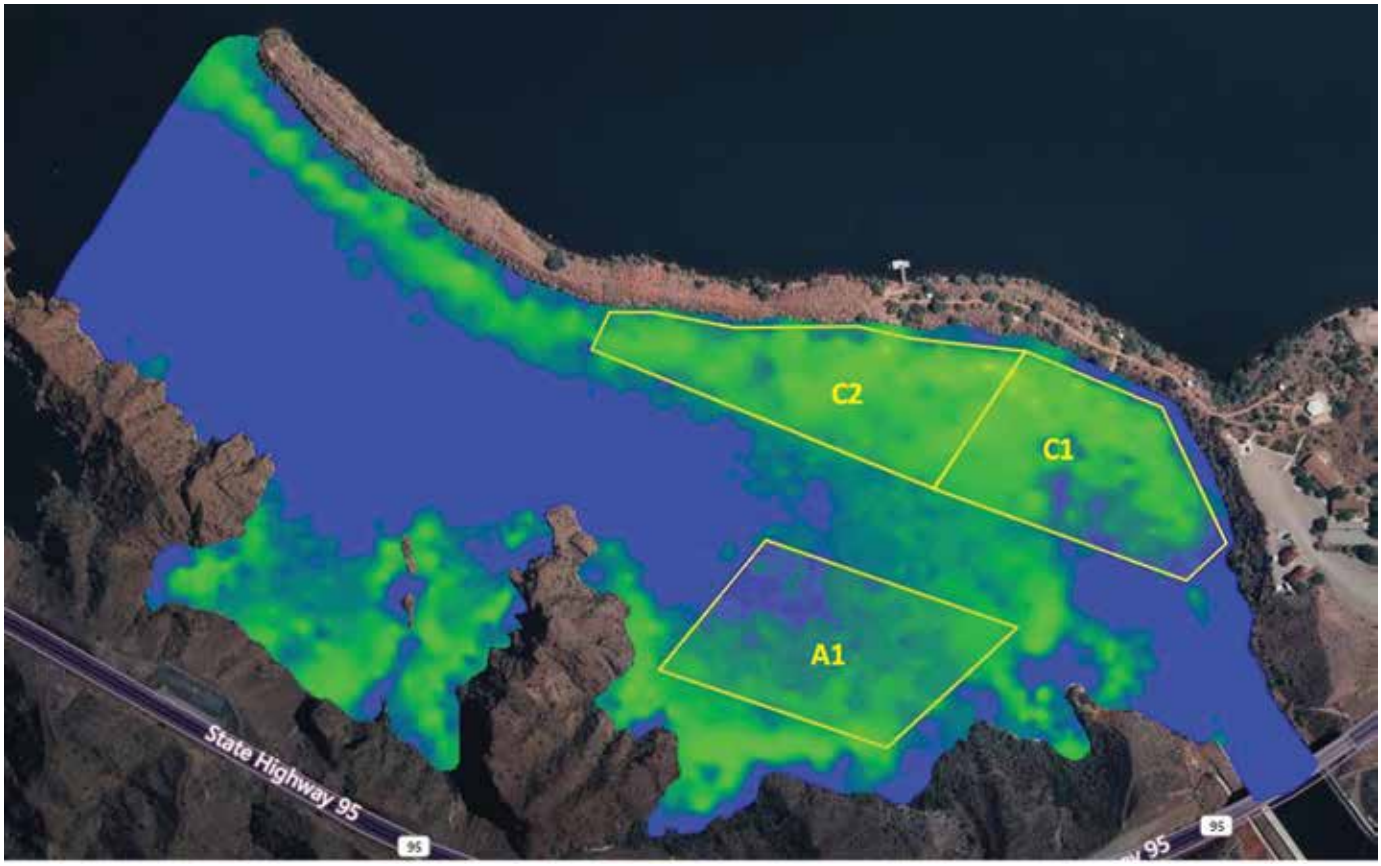


Figure 4. Pre-treatment vegetation survey from June 27, 2022. The yellow polygons represent the treatment areas.

helped to ensure good coverage. However, it was noted during treatment that the dye remained relatively close to the surface, indicating that the weighted lines were not reaching intended depths (3, 6, and 12 feet) and product was not reaching the lake bottom. This was likely for two reasons. First, the lines were probably not weighted enough, even at extremely slow speeds, and they drifted towards the surface. Second, the aquatic vegetation in C1 and C2 was very dense, which may have prevented the herbicide from reaching greater depths.

Within plots C1 and C2, water samples to test endothall concentrations were taken at arms-length because the application appeared to be concentrated in the upper portion of the water column (Table 2). In plot A1, concentration samples were collected near the top of the weed growth; equipment would not reach to the sediment (Table 2). Rhodamine dye concentrations were also collected near-surface dye concentration data in C1 and C2.

Table 2. Concentration data for the treatment areas.

Polygon	Herbicide	Hours after Treatment	Endothall Concentration (ppm)	Dye Concentration (ppb)
C1	Cascade	2	1.5975	7.95
		4	2.3275	24.6375
		21.5	1.455	11.1
C2	Cascade	2	2.9	25.906
		19	0.812	6.28
A1	Aquathol	2	0.166	
		4	0.016	
		6	0.02	
		23.5	0.186	

Analysis

From the herbicide and dye concentration data a linear regression trendline was fitted to each plot and a theoretical half-life was calculated. The half-life calculation in this instance is not the measure of the breakdown of the active ingredient but rather the time for the concentration in each plot to dissipate out of the treatment area to half the initial concentration. There are two ideal herbicide concentration exposure time (CET) scenarios that are effective at controlling macrophytes. The first being a high concentration that is held in the treatment area for a minimal amount of time (>12 hr). The second is being able to maintain a lower herbicide concentration for an extended period in the treatment area (<24 hr).

The half-lives in treatment area C2 were calculated to be 12 hours for both the endothall and rhodamine dye. Much longer values were noted for treatment area C1, with 42 and <45 hr half-lives calculated for the endothall and dye, respectively. Winds were blowing west to east during the afternoon of application, pushing the herbicide towards the pumping plant. This likely explains why an endothall and dye concentration increase was seen at 4 hours after treatment in C1, as the herbicide applied to C2 was moving eastward into C1.

The half-life in A1 was not able to be calculated, as there was a substantial increase in endothall concentration from 6 to 23.5 hours after treatment. The low and somewhat erratic endothall concentration measurements are likely due, in part, to the inability to sample deeper in the weed growth area (near the sediment). Established submersed weed beds have been shown to drastically reduce water flow thus reducing dissipation of herbicides, which should in turn increase the control of the macrophytes.

Early season mapping showed that the vegetation growth in the CAP intake channel in 2022 was trending towards being the most severe in the past 10 years (Figure 5). In June 2022, the average PAC was nearly 20% higher than the 10-year average and 3% higher than in 2021. However, the treatment applied in late June appeared to have an impact on overall vegetation growth within treatment areas and return overall PAC levels to near the 10-year average.

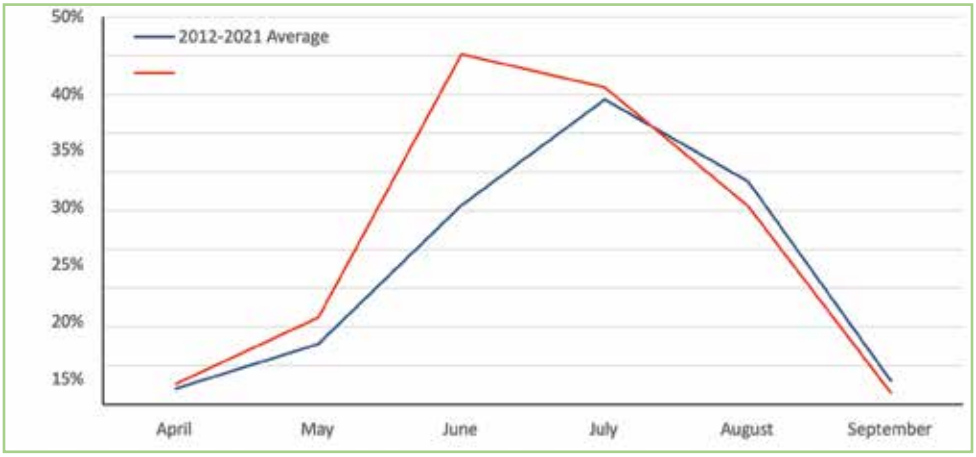


Figure 5. Average monthly vegetation coverage (PAC) in the CAP intake channel from 2012-2021 (blue) compared with the average month PAC in 2022 (red).

Rake Samples

Pre-treatment rake samples collected two weeks prior to the herbicide application showed healthy green vegetation at all sites, although weed density (spiny naiad) throughout A1 was relatively sparse. There was significantly more growth in A1 at the time of treatment. In treatment areas C1 and C2, sago and horned pondweed, curly-leaf pondweed, southern naiad, and spiny naiad were all found. However, in contrast to previous years, the naiad species were dominant in both shallow (southern naiad) and deeper waters (spiny naiad).

One week after treatment, vegetation in A1 (SP01 - SP03) was very sparse, although there was more vegetation at the eastern edge of the treatment area. In C1 (SP05 – SP06) and C2 (SP07 – SP08), there was some "browning" of vegetation, but it remained dense at all sampling points (Figure 6). Two-weeks after treatment, vegetation

was nearly non- existent at points SP01 and SP02, while vegetation at SP03 and SP04 (untreated) was thinning. Spiny naiad at SP05 and SP08 appeared to be unaffected by the treatment, but there was continued browning of vegetation in SP06 and SP07 (shallower areas). Subsequent rake samples showed the same pattern: almost complete elimination of vegetation at SP01-SP03 (Aquathol), elimination of vegetation at SP04 (untreated), no effect at SP05 and SP08 (Cascade), and degradation and thinning of vegetation at SP06 and SP07 (Cascade) (Figure 6).

Mapping

Vegetation heat maps showed a similar pattern to rake samples (Figure 7). The pre- treatment map shows the dense vegetation growth in treatment areas and other areas of the intake channel. One-week after treatment, vegetation is thinning in A1 as well as the area between treatment plots (untreated), and the shallow areas of C1 and C2. By four-weeks after treatment, the vegetation had been nearly eliminated from A1 and a large untreated area between plots. There was continued degradation (thinning) of vegetation in the shallow areas of C1, but coverage in C2 remained relatively high. By six- and eight-weeks after treatment, there were signs of natural senescence, so effects of the treatment were not discernable.

Percent Area Coverage (PAC) was calculated for the treated and untreated areas prior to the application and for each mapping survey after the treatment (Figure 8). In untreated areas, vegetation coverage slowly declined throughout the monitoring period, until natural senescence in late-August. In treatment polygons, there was an initial decrease in vegetation coverage of 16-25% immediately following the herbicide application, with the largest decrease occurring in the treatment area (A1). In C1, vegetation coverage continued to decrease slightly throughout the monitoring period. In C2, coverage remained relatively stable after the initial decline. The treatment area A1, showed a continuous significant decline in vegetation coverage, with the largest occurring one to two weeks after treatment (54.6%) and quickly dropping to less than 1% just three weeks after

Discussion

The Mark Wilmer Pumping Plant has struggled for years trying to control nuisance aquatic plants that jeopardize supplying the most populous regions of Arizona with drinking water. Mechanical harvesting as well as limited liquid herbicide applications have shown limited success. The challenge in obtaining adequate control of the target plants is due in part to the location, bathymetry and water clarity of the inlet cove. The inlet cove is oriented that the prevailing West to East winds will push into the cove creating a large amount of mixing especially near the surface. The usual excellent water clarity results in plant growth down to the 20ft mark greatly increasing the PAC in the cove. Traditional application drop hoses have difficulty in reaching such depths, which when coupled with the potential for excessive winds mixing the water it can be challenging to reach the appropriate exposure time of the herbicide on the target plants.

This treatment demonstration highlights the benefit of granular formulations and some of the particular circumstances where utilizing such products greatly increases the achieved control. Sinking granular products can instantly be in contact with the target plants bathing them in released herbicide. Wind and wave action effects are greatly reduced with the use of granular products, they can also negate the presence of a thermocline which may hold liquid herbicide above the target plants if misapplied above the inversion. While there was no temperature profile collected in the treatment site A1, the control noted just North of the plot could likely have been

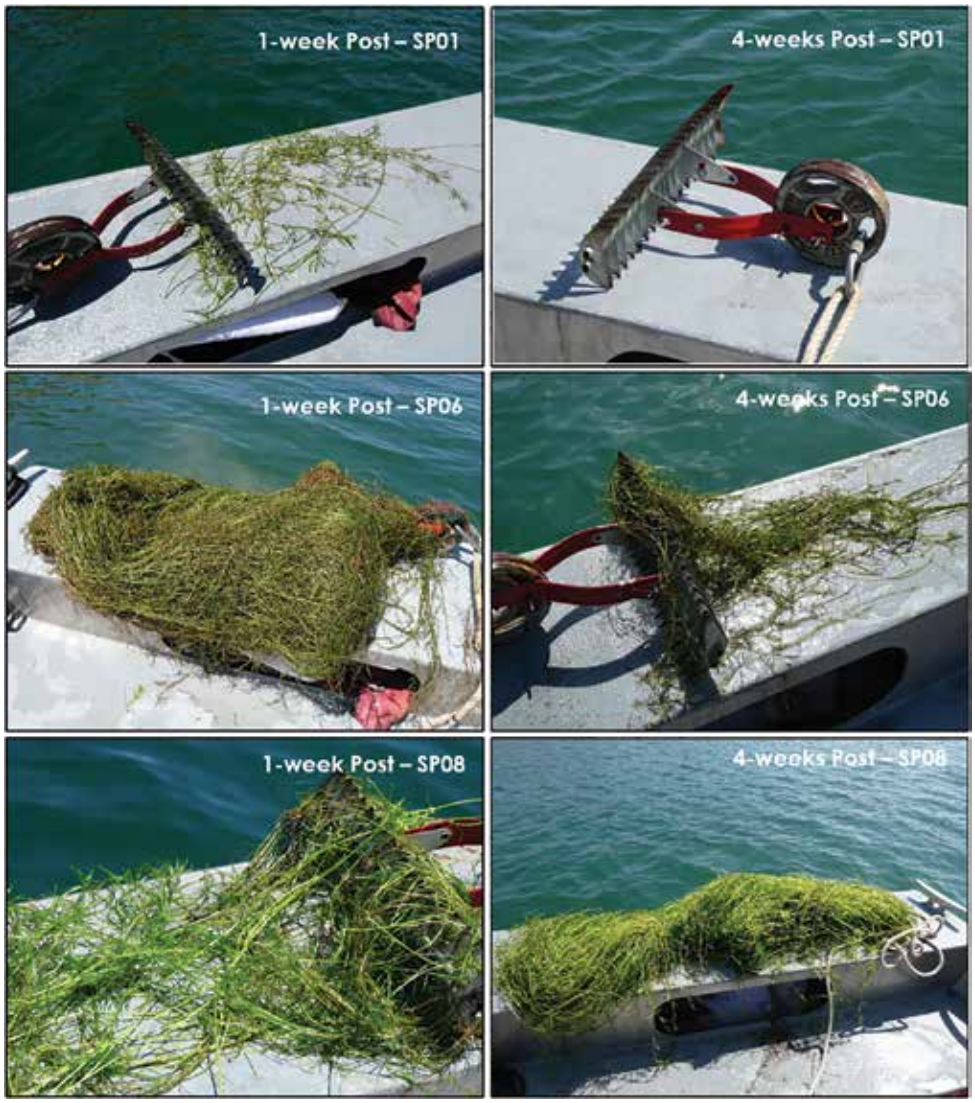


Figure 6. Examples of vegetation sampled one-week (July 5) and four-weeks (July 26) following vegetation treatment

lateral movement of the herbicide magnified perhaps due to a thermocline holding the concentration low in the water column. In contrast the liquid herbicide applications did show some level of control but not as pronounced as the granular treatment. The drop hoses (3, 6 & 12 ft) were likely to short and not weighted enough to effectively get the herbicide down to the weed beds. Instead the herbicide likely stayed just above the beds having some effect on the plants but largely falling victim to wind and wave action that diluted and moved it off target. Selecting the correct application equipment and herbicide formulation as demonstrated here can have a substantial effect on achieved control.

Scott Bryan, Water Quality and Biology Administrator, Central Arizona Project

Scott is the Biology and Water Quality Administrator for Central Arizona Project (CAP), the water conveyance system that delivers Colorado River water to over 5 million residents in Central and Southern Arizona. He holds a B.S. degree in Environmental Biology from Eastern Illinois University and an M.S. degree in Fisheries Management from South Dakota State University. He started his career as a research biologist for the Arizona Game and Fish Department, primarily focusing on fisheries and aquatic systems. In his current position with CAP, Scott develops and executes targeted research for a variety of aquatic and terrestrial issues that impact the CAP system, and he administers the water quality program for the organization.

Justin Nawrocki Ph.D., New Product Development and Technical Service Manager, UPL Environmental Solutions

Justin received my B.S from University of Idaho in Environmental Science with an emphasis on groundwater and aquatic ecology. He then spent several years working in MI and NC as a commercial aquatic herbicide applicator. Justin was then afforded the opportunity to attend graduate school at NC State where he received his M.S. and Ph.D. studying the impacts of invasive species, particularly hydrilla, on sport fish, macroinvertebrates, and the ecosystem as a hole. Upon graduation Just accepted a job at UPL as a territory sales manager where he worked for 6 years until accepting his current role in 2021.

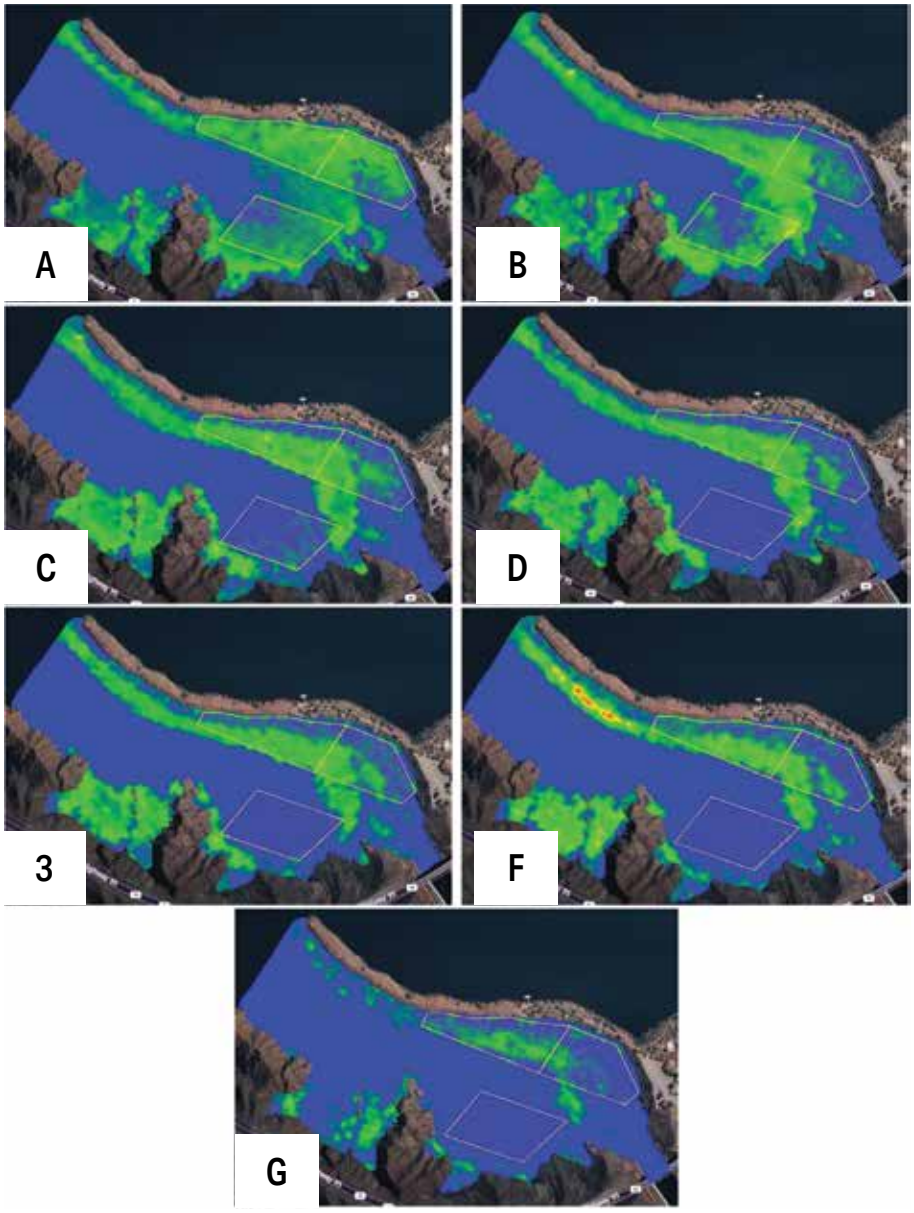


Figure 7. Maps of vegetation growth within the intake channel during July-August 2022. (a) Pre-treatment (June 27); (b) 1-week post-treatment (July 5); (c) 2-weeks post-treatment (July 12); (d) 3-weeks post-treatment (July 19); (e) 4-weeks post-treatment (July 26); (f) 6-weeks post-treatment (August 12); and (g) 8-weeks post-treatment (August 23).

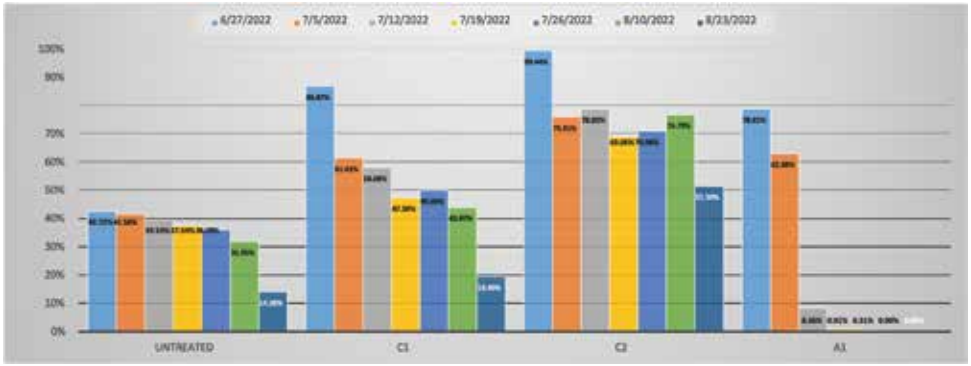


Figure 8. Percent area coverage (PAC) measured in treated and untreated areas during June through August 2022.

Applicator's Corner

How do plants become herbicide resistant?

Dr. Jason Ferrell
UF/IFAS Center for Aquatic and Invasive Plants

Modern herbicides have been a powerful, and irreplicable, tool for plant management since the development of 2,4-D in the late 1940s. With time, herbicides have become more consistent, more selective, and more effective. But what happens when they stop working? Or to ask the question in a different way, why have some plants become resistant to specific herbicides?

To answer this question, we should start with a brief discussion on how herbicides work — then we can tackle why they stop working.

Most herbicides work by attaching themselves to a specific plant enzyme, causing it to stop functioning. Since that enzyme is doing work that is essential to the plant, deactivating the enzyme will eventually cause the plant to die. But there is a catch; herbicides are extremely picky. Each herbicide will only bind to a highly specific place on a specific enzyme. Any changes in how that enzyme is shaped can mean the herbicide doesn't bind as well – or maybe doesn't bind at all. How well the herbicides stick to the enzyme is the difference between plant death, plant injury and recovery, or complete immunity to the herbicide.

The DNA inside a plant determines how the enzyme is shaped. If you were to sample the DNA in a million hydrilla plants, chances are 99.999% of the plants have the exact same DNA code and identical enzymes. But it is likely that there are a few plants out there that have a slightly different DNA code — maybe 1 in a million have a slightly different enzyme shape due to a random mutation. Think of an albino deer that is completely white. All members of its family are brown, but this one individual — due to a random mutation — is white. While very rare, similar mutations will occur in plants and cause herbicide resistance.

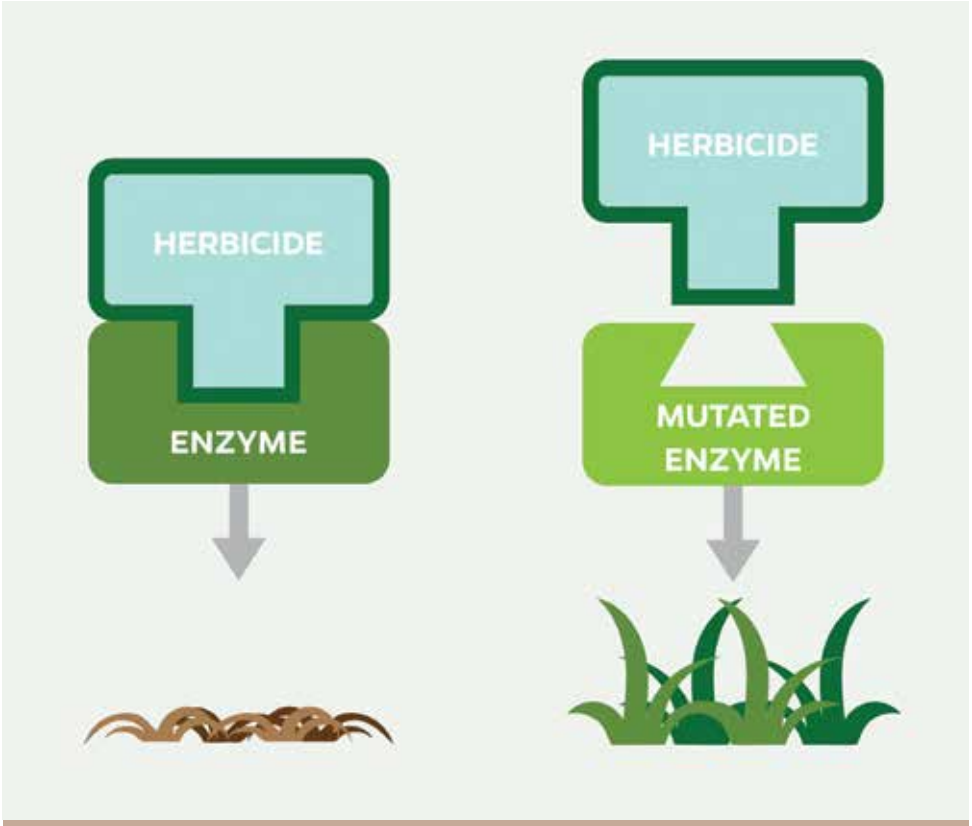


Figure 1. Plant enzyme mutation and herbicide resistance.

So, what happens when you have one plant in a million that has an enzyme with a slightly different shape? Well, nothing happens, at first. It lives there in harmony with the others – until you add a herbicide. When that highly effective herbicide is applied, it may kill all the susceptible plants and leave that 1 in a million to survive and make tubers. Next year, there will be more than 1 in a million resistant plants since it survived the application and made tubers. This process will continue every year that herbicide is applied until the population is essentially 100% resistant.

At this point, there are two things that are essential to understand. 1. Herbicides do not cause plants to become resistant. The DNA mutations that cause resistance are rare, but completely random. Herbicides don't cause resistance; they simply find that 1 in a million plant and ensure it reproduces by removing all the plants around it. 2. After a population becomes resistant, it rarely reverts to susceptible. That random mutation that caused resistance is now locked in the DNA and is not likely to disappear.

Does this mean it is possible for herbicide resistant plants to be present before the herbicide is ever applied? This simple answer to this is yes, it is possible. Since the mutations that cause herbicide resistance are totally random, it is possible that resistance traits are always lurking in the background. However, herbicide resistance traits provide no advantage to a plant until a herbicide is applied. Since there is no advantage, it is unlikely that this trait will persist since that plant is competing with all its neighbors for light, nutrients, space, and will be outcompeted by plants that

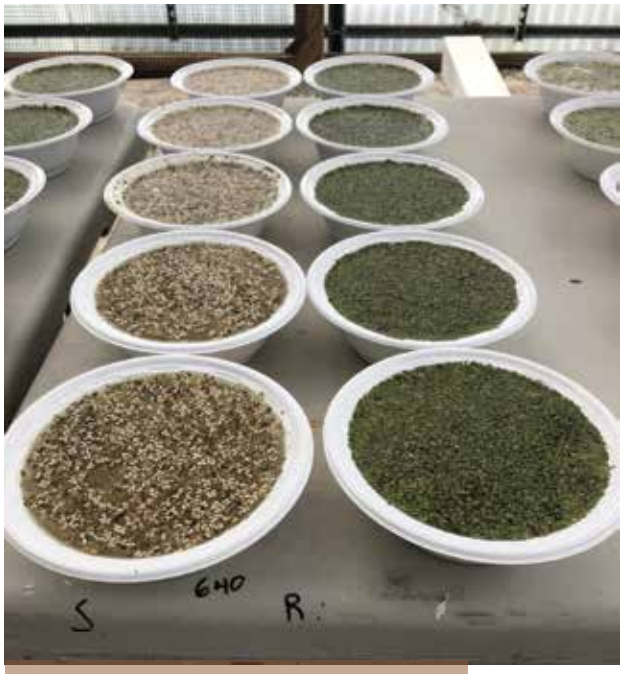


Figure 2. Two populations of duckweed, treated with the same herbicide.

have mutations for faster growth, better tuber germination, or faster reproduction. But when you line up that mutation with a highly effective herbicide, you have just ensured that the resistance trait will be locked in place due to the huge advantage it provides. It doesn't matter how fast you grow or how easy you reproduce when a herbicide is present. The only trait that ultimately matters at that point is resistance.

All this said, why do should we care if resistance occurs? Herbicide resistance mutations are rare and even if they occur, there are several other products that can fill the gap — right? That is correct, but the mutations don't stop at one. There are situations in Midwest crop fields where resistance occurred, and the farmers switched to a different herbicide. After time, the plant was resistant to two herbicides. Ultimately, that same weed ended up being resistant to five distinctly different herbicide classes. This is why we should care. While rare, herbicide resistance can progress faster than the discovery of new herbicide molecules and we need to do the best we can do prevent the development of resistance.

So, how do we prevent resistance? Repeated use of a herbicide that targets the same enzyme every time, will eventually find that randomly mutated plant and ensure it survives. So, 1. Avoid using the same herbicide year after year. If a mutant plant survives a herbicide in year one, but you effectively manage it in year two, you might prevent that plant from becoming fully established in the lake. 2. Always monitor your herbicide treatments the best you can to see if any plants have mysteriously survived. If you see dead and dying plants all over, with a nice green plant right in the middle – you may have just found that one in a million mutant. If that is the case, remove that plant before it can reproduce. 3. If you suspect resistance, notify your state or federal biologists and researchers so they can investigate in a lab setting whether the plant is actually resistant, or if it simply survived for an unexplained reason.

Herbicide resistance started as a very interesting and academic way to understand plant genetics and population ecology. But it proved to be a very challenging reality for plant managers in all professions. Knowing the basics of why it occurs and how to prevent it can mean the difference hard to manage plants becoming almost impossible to manage plants.

This article was written by Dr. Jason Ferrell professor and director of the UF/IFAS CAIP. Questions or comments can be sent to at caip@ifas.ufl.edu.

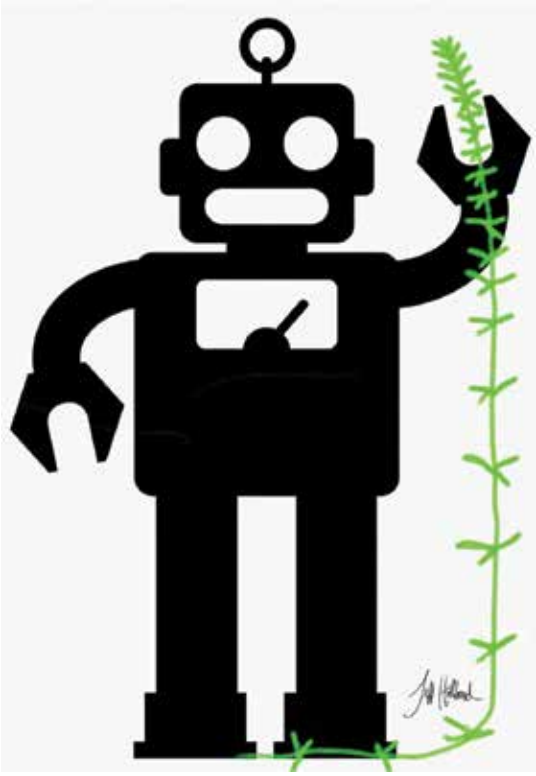
Aquatics Short:
What if Future Robots Learn from Aquatic Plants?

Hydrilla, Photo credit: Kelli Gladding

After the 47th annual Florida Aquatic Plant Management Society (FAPMS) Training conference, I was thinking about how advanced technologies and robotics have begun to help the aquatics industry. Cloud based ordering systems, automatic advertising and website sales, machine-based chemical mixing algorithms, GPS delivery routing, robotic loading machines, and even spray-rig application software have benefited the industry as a whole. But what if science, in an effort to improve robotics, tried to make a robot that mimics "the perfect aquatic weed", as termed by Dr. Ken Langeland in 1996*.

Such a robot would be able to work in any aquatic environment, power itself from the light of the moon, and grow continuously, even grow exponentially

An invasion of Hydrilla, Photo credit: Cayla Romano



Robot Hydrilla, by Jeff Holland

during the months of June & July each year. Such a robot could be pummeled into little pieces, only to have each piece grow back into fully functioning new robots. And to top it off, such a robot could drop pea-size pieces of itself in the soil throughout the world that could last for decades, and then grow into new robots months or years later.

Luckily, I am only describing the attributes of hydrilla, its turion/tuber production, and characteristics of its growth and fragmentation abilities, not any malicious robots. However, it sounds really scary when you think about any machines adopting hydrilla's abilities, doesn't it? As you battle to control this perfect plant, hydrilla, on your job sites, just image you're in 'terminator training", secretly learning how to battle any future robots that try to mimic this plant.

Hope you enjoyed this humorous perspective. I encourage you to re-read Dr Langeland's publication to review this exotic invader: hydrilla; not robots, yet.

Jeff Holland

Footnotes:

* Langeland,K. A.1996.Hydrilla verticillata (L.f.) Royle (*Hydrocharataceae*), "The perfect aquatic weed." Castanea 61:293–304

Jeff Holland is a recently retired Limnologist who worked 35yrs with the Reedy Creek Improvement District (RCID/CFTOD), helping manage the natural water & aquatic plant resources, and was a part of "the magic behind the magic" at Walt Disney World.

Hydrilla, Photo credit: Cayla Romano

Florida Invasive Species Partnership Update

I am pleased to introduce myself, Deb Stone, as the University of Florida's new Invasive Species Extension Coordinator. I have a long and dedicated history of invasive species and vegetation management work here in Florida, working with many different organizations across the state- the Florida Park Service, St. Johns River Water Management District, the Nature Conservancy, Hillsborough County and Bok Tower Gardens. I am also currently a Doctoral Candidate in Forest Resources and Conservation at the University of Florida. I bring a strong analytical skill set to the job and am already well established within the Florida Invasive Species Partnership (FISP) and Cooperative Invasive Species Management Area (CISMA) network. I am particularly passionate about prioritization, decision support tools, addressing the implementation gap, and fire-invasive plant interactions. My Master's project of the Spatial Invasive Infestation and Priority Analysis tool (https://www.eddmaps.org/project/florida/SIIPA/#home) highlights the innovative and strategic approach I strive to bring to all of my work.

One of my core duties is to coordinate FISP, and several of the main activities, like the monthly webinars and the monthly digests, are already back in full swing. Recordings of past webinars can be viewed on FISP's YouTube channel at: https://www.youtube.com/@floridainvasivespeciespart4750/videos. I have started collaborating more closely with a few of the CISMAs and I'm thrilled to be a part of these hard-working and experienced teams. The breadth in topics and sheer number of projects accomplished by these volunteer-driven groups- spanning from workshops to outreach to workdays- are truly inspiring.

Deb Stone

I will also be focusing on finishing the merger with the Florida Invasive Species Council (FISC), facilitating the alignment of FISC's statewide efforts with the regional activities of the various CISMAs and FISP. The merger has been approved by both groups' members, and the final step is to establish the structure of the new committee within FISC. Strengthened collaboration at multiple scales will enhance our ability to address the urgent challenges in invasive management across the state and beyond.

Please don't hesitate to contact me at debitharp@ufl.edu regarding any partnership, CISMA or invasive education issues. I am always looking for better ways to help the boots on the ground reach their management goals.

The Many Faces of Waterhyacinth

Hannah Brown[1], Candice Prince[2], Benjamin Sperry[3]

Accurate identification is critical to invasive aquatic plant prevention and management. Many aquatic plant managers are already experts on the identification of regional invasive plants. However, managers should also keep up to date on how to identify potential new invasive species that could be found in surrounding areas. Aquatic plant identification can be extremely nuanced. For example, the invasive waterhyacinth (*Eichhornia crassipes*) can be hard to distinguish from the native plants American frog's bit (*Limnobium spongia*) and pickerel weed (*Pontederia cordata*). Identification can become even more confusing when including non-native species that are not in Florida yet but have a high risk of invasion such as European frog's bit (*Hydrocharis morsus-ranae)* and South American spongeplant *(Limnobium laevigatum)*. Without proper knowledge on the morphological and anatomical differences between these plants, there is potential for waterhyacinth and other invaders on Florida's doorstep to be mistaken for native plants and their spread to be overlooked. Accurate identification can also prevent accidental management of native plants. Therefore, invasive plant identification should be a skill biologists keep honed and not restricted to known invaders. Additionally, managers and researchers who have experience with expanding aquatic invasives should continue to give advice, recommendations, and share observations for identification of these plants. With plant identification in mind, let's discuss differences in waterhyacinth floral color.

Figure 1. Comparison of "bull" waterhyacinth (left) to smaller waterhyacinth (right) at the Center for Aquatic and Invasive Plants in Gainesville, FL. Photo by Hannah Brown.

Many invasive plants have high levels of what is called phenotypic plasticity—or the ability of plant traits (for example, leaf size) to change in response to environmental conditions. Waterhyacinth is a great example of this. It has two common appearances: plants with long, spindly stems, or petioles, that approach 3' in height and plants with small stems that have a bulbous spongy deposit. Although these are two distinct appearances, they come from the same clonal plant species. These differences arise from the environmental conditions waterhyacinth matures under. Congested mats lead to the large "bull" hyacinth while spare populations contribute to smaller hyacinth individuals (Figure 1).

Waterhyacinth can also show variation in flower color. Many have given the classic description of "showy purple flowers" to describe waterhyacinth blooms. However, this description isn't always the case, as waterhyacinth occasionally produce white flowers (Figure 2). When populations of the same plant species produce two or more distinct flower colors, it is called flower color polymorphism (Figure 3). Variations among flower colors within a species can be attributed to several factors such as genetic variation and environmental conditions. Some may think waterhyacinth populations do not have genetic variation because they primarily spread through clonal reproduction, but that is not the case. Clonal plants are still subjected to somatic mutations, or genetic changes that happen after reproduction. These changes are caused by environmental factors, such as ultraviolet radiation, that damage DNA. In Florida, waterhyacinth mainly reproduce asexually (clonal reproduction), although they can also reproduce sexually (seeds). These mutations allow waterhyacinth populations to

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[2]Assistant Professor, University of Florida Center for Aquatic and Invasive Plants, Gainesville, FL

[3]Research Biologist, US Army Corps Engineer Research and Development Center, Gainesville, FL

Figure 2. White flowers before and after blooming on waterhyacinth from Lake Tohopekaliga in Osceola County, FL grown in mesocosms at the Center for Aquatic and Invasive Plants in Gainesville, FL. Photos by Raychel Rabon.

develop genetic diversity, even with clonal reproduction. Genetic differences between water hyacinth populations may influence the chances individuals have to produce white flowers.

Environmental conditions such as nutrient availability, light, temperature, pH, etc. can have a massive effect on waterhyacinth growth and could also play a role in bloom color. Although the cause for white blooms amongst waterhyacinth has not been scientifically evaluated, anecdotal evidence suggests that the appearance of white flowers might be a stress response. Waterhyacinth is very prevalent in Florida and is commonly managed using herbicides. White blooms have been observed following herbicide treatment, which disrupts metabolic and growth processes and commonly elicits stress responses from plants. Conversely, the presence of white blooms also exists in seemingly healthy, untreated populations,

Figure 3. Waterhyacinth white and purple bloom comparison on Lake Sommerset in Seminole County, FL. Photos by Damien Rockwood.

which suggests that genetic variation could also play a role in their development.

Regardless of whether waterhyacinth flower color polymorphism is caused by genetic or environmental factors, its occurrence should be included when discussing waterhyacinth identification.

Authors Bio:

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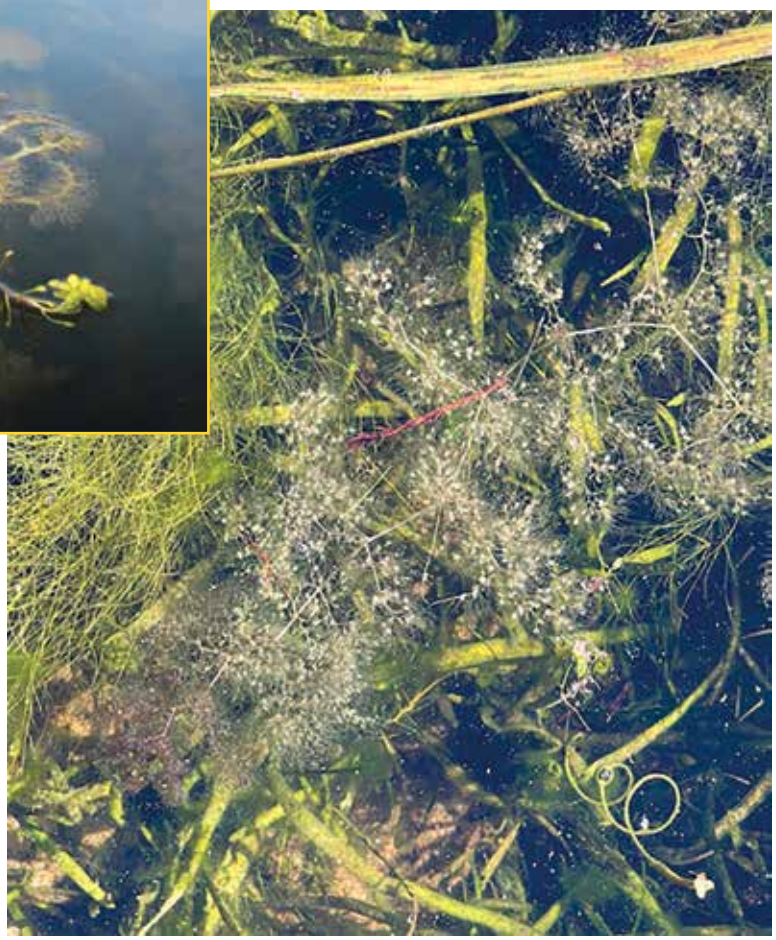
NATURALLY NATIVE

Submitted by Kelli Gladding,
Biological Scientist with the University of Florida, IFAS, Center for Aquatic and Invasive Plants.

Utricularia gibba, South Lake, Brevard County



Bladderwort plant species:

Bladderwort plants (*Utricularia spp.*) are a fascinating group of >220 different species of carnivorous plants found in lakes, streams and waterlogged soils around the world. This genus is often overlooked in many aquatic habitats until it blooms with a showy colorful flower that varies significantly in appearance based on the species. Bladderworts are characterized by small, hollow, bladder-like structures that are used to capture and digest small aquatic invertebrates and microorganisms, like water fleas, mosquito larvae and other tiny organisms such as protozoa and rotifers swimming in the water. These bladders are highly specialized vacuum-like traps that capture tiny prey within a fraction of a second and then use a digestive enzyme to decompose the prey. According to the USF Plant Atlas, all 14 bladderwort species are native to Florida. These macrophytes are rootless, free floating and easiest to locate in shoreline areas where native emergent pad communities {Spatterdock (*Nuphar advena*) and Fragrant Water Lily (*Nymphaea odorata*)} are present. Because they utilize nutrients from captured prey to supplement nutrition from photosynthesis, bladderworts can survive in oligotrophic (nutrient poor) waters. When invasive floating plants like waterhyacinth (*Eichhornia crassipes*) and water lettuce (*Pistia straiotes*) are not managed, bladderworts cannot compete for space, light and habitat. These invasive floating plants create a canopy over the water's surface preventing light penetration and continuously drop leaves creating detrital mats which makes it difficult for our natives, such as bladderworts, to

thrive. It is hard to choose one of these as a favorite, but I personally enjoy the Purple Bladderwort (Untricularia purpurea) for its delicate lavender blooms.

For more information on Bladderworts and other aquatic plants, please visit the Center for Aquatic and Invasive Pants website: https://plants.ifas.ufl.edu/

Kelli has been a biological scientist with UF/ IFAS CAIP for four years and has been involved with aquatic plant management efforts in Florida for twenty years. She is a past president of FAPMS and is currently the Secretary/ Treasurer for FAPMS Scholarship & Research Foundation.

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**We want to hear from YOU! Please submit your favorite native plant column to Kelli and to spotlight your regional chapter.*

Calendar of Events

Regional Chapter Conference Dates – 2024

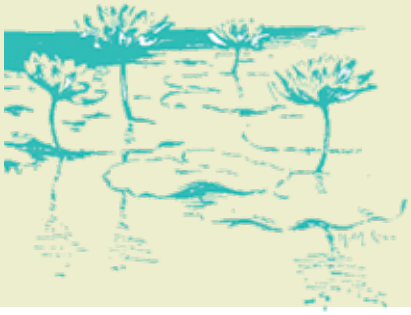
January 9-11, 2024
25th Annual Northeast Aquatic Plant Management Society
Wentworth by the Sea
New Castle, NH
https://www.neapms.org

February 26-29, 2024
44th Annual Midwest Aquatic Plant Management Society Conference
Hyatt Regency Downtown
Columbus, OH
https://www.mapms.org/conferences/2024-conference/

March 18-22, 2024
Western Aquatic Plant Management Society Annual Conference
Tropicana Las Vegas
Las Vegas, NV
https://wapms.org

Fall 2024
MidSouth Aquatic Plant Management Society
Chattanooga, TN
https://msapms.org

Fall 2025
MidSouth and Texas chapters plan to hold a joint conference
Location is TBD
https://msapms.org
https://www.tapms.org



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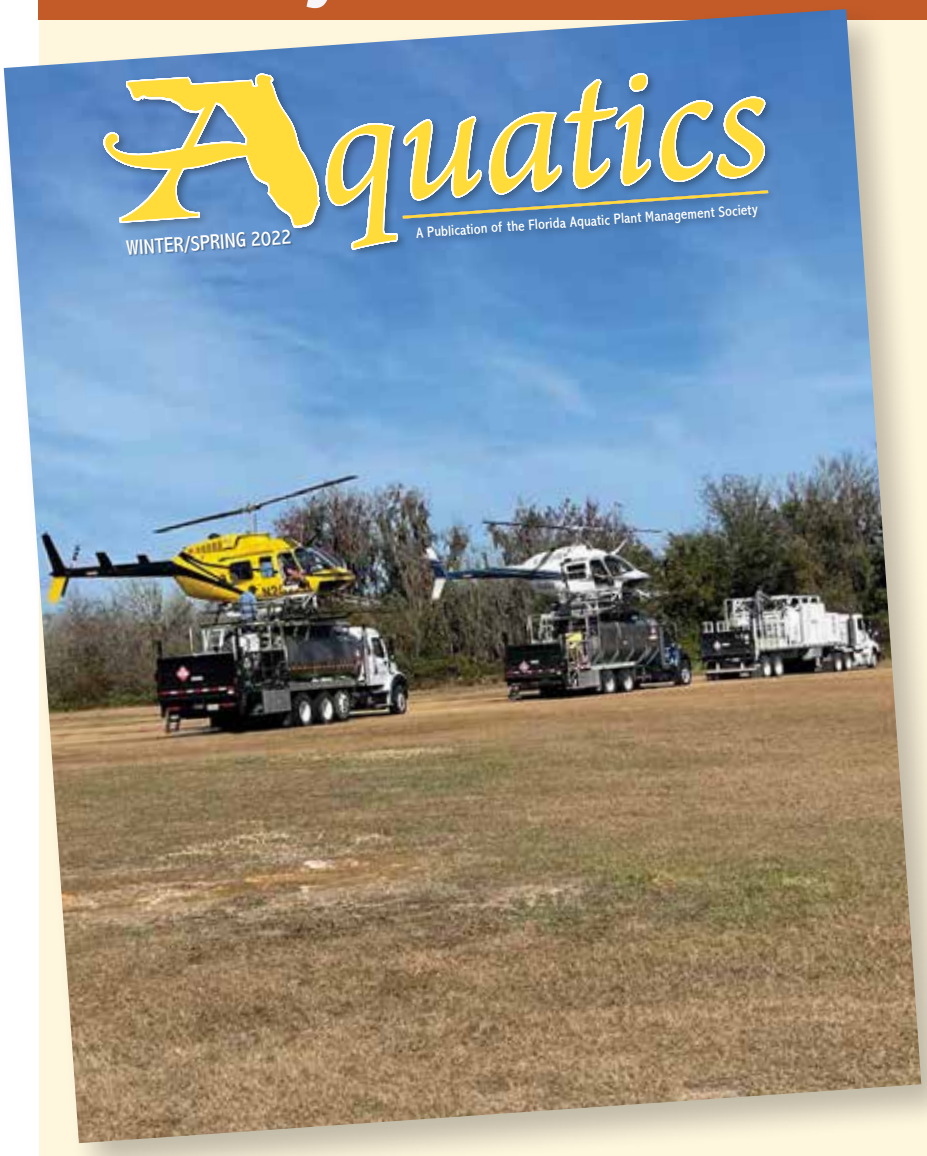

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