Final

TAHOE KEYS LAGOONS ANNUAL MACROPHYTE CONTROL EFFICACY MONITORING REPORT

Year 1

Prepared for
Tahoe Regional Planning Agency (TRPA)

March 2023





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TAHOE KEYS LAGOONS ANNUAL MACROPHYTE CONTROL EFFICACY MONITORING REPORT

Year 1

Background

The Tahoe Keys is a residential development in the south shore area of Lake Tahoe, consisting of approximately 1,500 homes (almost all of which have private docks or slips) and approximately 170 acres of waterways within three distinct areas. The West Lagoon is the largest portion and where most of the homes and docks/slips are located. The East Lagoon includes a commercial marina and a smaller number of residences that have docks/slips. The East and West Lagoons are not connected to each other but are both directly connected to Lake Tahoe via two separate channels. These areas are major access points for recreational watercraft to Lake Tahoe. The third waterway is Lake Tallac, which is separated from the East Lagoon by a dam and does not allow any type of passage by recreational vessels. Lake Tallac does not support motorized watercraft and there is no direct connection to Lake Tahoe.

These waterways are almost entirely infested with two aquatic non-native invasive weeds, Eurasian watermilfoil (*Myriophyllum spicatum*) and curlyleaf pondweed (*Potamogeton crispus*), and one excessively abundant native plant, coontail (*Ceratophyllum demersum*). Management of these aquatic weeds by the Tahoe Keys Property Owners Association (TKPOA) over the last forty years has been almost exclusively by mechanical harvesting. In spite of this effort, the infestation continues to grow and spread and is a significant threat to Lake Tahoe's ecosystem and famed clarity. The infestation within the Tahoe Keys waterways is the Lake Tahoe Aquatic Invasive Species (AIS) Program's highest priority for control (Wittmann and Chandra 2015).

The Tahoe Regional Planning Agency (TRPA) EIP Project No. 510-101-00 and the Lahontan Regional Water Quality Control Board Order No. R6T-2022-0004 authorize a program to test a range of aquatic weed control methods, both as stand-alone treatments and in combinations. The Tahoe Keys Lagoons Aquatic Weed Control Methods Tests (CMT) (the "Project") are categorized as Group A and Group B methods. Group A methods are initial treatments, applied in the first year (2022) that include both herbicide and non-herbicide methods and are intended to achieve reduction in target aquatic weeds by 75 percent within CMT sites. Group B methods are non-herbicide maintenance treatments applied to control regrowth of residual target aquatic weeds in the test sites where Group A treatments have been applied. Group B methods include spot treatments with UV light, bottom barriers, diver-assisted suction harvesting, and diver handpulling techniques.

The Project tests stand-alone treatments using aquatic herbicides, ultraviolet (UV) light, and laminar flow aeration (LFA), as well as combined herbicide + UV treatments. Two aquatic herbicides were used as a standalone treatment and in combination with UV light: Endothall (USEPA Reg. No. 70506-176) and Triclopyr (USEPA Reg. No. 67690-42), although UV was not applied to the Triclopyr + UV sites during 2022 as intended. Per the labels, Endothall is known to target Eurasian watermilfoil, curlyleaf pondweed, and coontail while Triclopyr targets only Eurasian watermilfoil. UV light in the germicidal range (UV-C) is a patented control method for treating aquatic weeds. Light rays in the 254 nanometers (nm) to 275 nm range can provide a lethal dose of radiation that damages the DNA of plant. LFA is a technology originally used for improving water quality in wastewater treatment plants by assisting in the organic breakdown of sludge. LFA has recently been adapted for water body restoration by accelerating the capability to process nutrients, purge harmful gases such as ammonia and hydrogen sulfide, precipitate iron and manganese, and reduce algae growth.

The purpose of this Annual Efficacy Monitoring Report is to summarize and evaluate macrophyte control efficacy resulting from Project activities in Year 1, as required by TRPA Permit File #EIPC2018-001, Special Condition 22. It includes the effects of CMT treatments on plant biovolume, vessel hull clearance, plant health, and plant species composition within CMT test sites compared to untreated reference sites (controls). In particular, this report describes whether the following CMT goals and objectives related to macrophyte efficacy were achieved in Year 1:

- Reduction of 75 percent in total invasive and nuisance plant biomass (“biovolume”[1]) within treated CMT sites
- Maintenance of three (3-) foot vessel hull clearance
- Increase in occurrence and percent composition of native plants relative to non-native plants

Sites with successful reductions of the target macrophyte species, Eurasian watermilfoil, curlyleaf pondweed, and coontail, will be evaluated for Group B methods in CMT Years 2 and 3.

Methods

Aquatic herbicides were applied by a licensed applicator, UV treatments were performed by Inventive Resources, Inc. (IRI), and one LFA system was installed in 2019 by Clean-Flo International. The herbicide treatment map is provided in **Figure 1** and the herbicide and UV treatment schedules are provided in **Tables 1** and **2**, respectively. Details on the specific treatments can be found in TKPOA (2023), including information on the modified treatment schedule due to access issues and double turbidity curtains. Additional information on the UV treatments may be found in Appendix AA in TKPOA (2023).

Monitoring for the Project involved a suite of protocols aimed at assessing the efficacy of treatments on macrophyte composition and biovolume as well as a comprehensive water quality monitoring program that included grab sampling for nutrient analysis and in situ measurements of

[1] Biovolume, as defined in the Tahoe Keys Lagoons Environmental Impact Report – Environmental Impact Statement (EIR-EIS), is the percentage of the water column occupied by aquatic vegetation

ambient conditions (Anderson 2022). The focus of this report is on macrophyte control efficacy and results of other monitoring activities are described by TKPOA (2023).

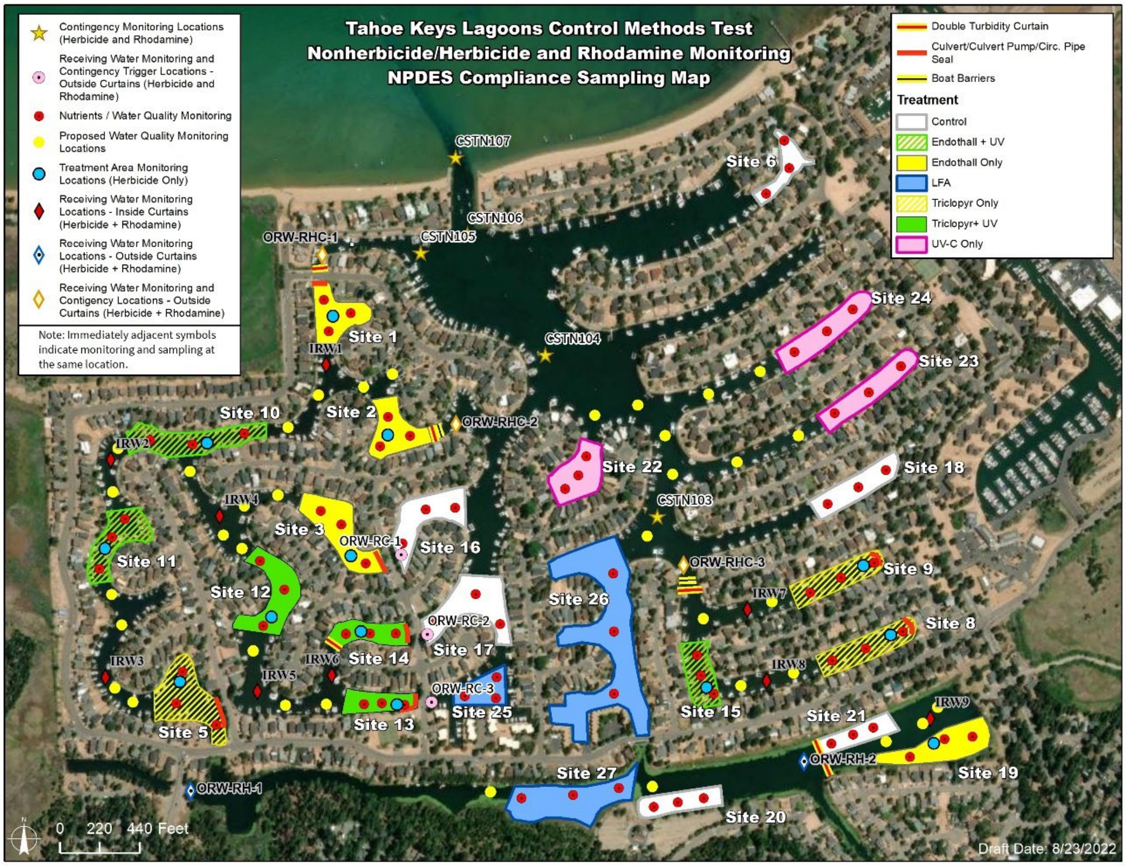


Figure 1 Tahoe Keys Aquatic Weed CMT Treatment Sites

TABLE 1
TAHOE KEYS AQUATIC WEED CMT HERBICIDE TREATMENT SCHEDULE

Site Number	Treatment	Proposed Herbicide	Herbicide Rate (final concentration)[a]	Application Date	Application Day
8	Herbicide only	Triclopyr	1.0 ppm	5/25/22	1
9	Herbicide only	Triclopyr	1.0 ppm	5/25/22	1
15	Combination	Endothall	2.0 ppm	5/25/22	1
All Sites	**No Applications**			**5/26/22**	
1	Herbicide only	Endothall	2.0 ppm	5/27/22	2
2	Herbicide only	Endothall	2.0 ppm	5/27/22	2
3	Herbicide only	Endothall	2.0 ppm	5/27/22	2
All Sites	**No Applications**			**5/28/22**	
5	Herbicide only	Triclopyr	1.0 ppm	5/29/22	3
10	Combination	Endothall	2.0 ppm	5/29/22	3
11	Combination	Endothall	2.0 ppm	5/29/22	3
All Sites	**No Applications**			**5/30/22**	
12	Combination	Triclopyr	1.0 ppm	5/31/22	4
13	Combination	Triclopyr	1.0 ppm	5/31/22	4
14	Combination	Triclopyr	1.0 ppm	5/31/22	4
19 (Lake Tallac)	Herbicide only	Endothall	2.0 ppm	5/31/22	4

NOTES:
[a] ppm = parts per million
SOURCE: TKPOA APAP Amendment 2 dated May 24, 2022

TABLE 2
UV LIGHT MODIFIED TREATMENT SCHEDULE

Site Number	1st Treatment	2nd Treatment	Spot Treatment
10	9/26 - 9/29/22		
11	10/5 – 10/8/22		
15	9/12 – 9/16/22		
22	6/21 – 6/24/22 6/27 – 6/29/22	8/18 – 8/19/22 8/22 – 8/26/22	10/19 – 10/21/22
23	6/7 – 6/10/22 6/13 – 6/15/22	8/31 – 8/22 9/1 – 9/2/22 9/6 – 9/9/22	10/24 – 10/26/22
24	5/31/22 6/1 – 6/3/22 6/6 – 6/7/22	7/27 – 7/29/22 8/1 – 8/2/22 8/5/22 8/8/22	10/10 – 10/12/22 10/27 – 10/28/22

SOURCE: Inventive Resources, Inc. (IRI); See Appendix AA in TKPOA (2023)

Field Collected Data

Macrophyte control efficacy was evaluated using the following field collected metrics: macrophyte biovolume from hydroacoustic scans, and plant health condition and relative abundance from point sampling. The assessment schedule was based on set days after treatment (DAT) dependent upon treatment type (**Table 3**).

TABLE 3
MACROPHYTE ASSESSMENT SCHEDULE BASED ON CMT TREATMENT TYPE

CMT Treatment Type	Assessment Frequency [a, b]
All	Bi-weekly biovolume using hydroacoustic scans[c]
Controls	Pre-treatment, then every 14 days until mid-November
Herbicide-Only	Pre-treatment, 14DAT, then every 14 days through 120DAT
UV-Only	Pre-treatment, 14 days after first treatment began and continue every 14 days until mid-November
Combination Herbicide and UV-C	Pre-treatment, 14DAT, then every 14 days until mid-November
LFA	Spring and fall

NOTES:
a References: MMRP and Anderson (2022)
b DAT = days after treatment
c Conducted by TKPOA

Hydroacoustic Scans

Biovolume

The comprehensive assessment method for overall macrophyte abundance, and assessment of percent reduction, was derived from hydroacoustic scans using an echosounder (Lowrance HDS) and proprietary data processing tool (BioBase EcoSound) that have been used for over 10 years by the TKPOA and has become a standard method for assessing aquatic plant management effectiveness in the Tahoe Keys Lagoons (Madsen and Wersal 2017; Howell and Richardson 2019). These data represent the percent of all submersed aquatic vegetation (SAV) in a given volume of water beneath the transducer scan path or "biovolume". The method does *not* distinguish between species and therefore provides data on abundance and extent of both CMT- target and non-target macrophytes. Determination of biovolume uses a geostatistical interpolated grid data, that is "interpolated and evenly spaced values representing kriged (smoothed) output of aggregated data points", meaning the BioBase EcoSound's kriging interpolation model makes predictions for the unsampled locations. The TKPOA collected biovolume data bi-weekly.

Though the scans detect total only SAV, these results can be used in conjunction with rake point sampling to evaluate target species control efficacy, as described below. In fact, with the large number of physical point samples taken, it is possible to correlate rake-derived data (i.e., rake fullness comprised of all macrophytes) with hydroacoustic scans (Valley et al. 2015, Helminen et al. 2019).

Vessel Hull Clearance

Data from the hydroacoustic scans was also used to determine "vessel hull clearance", an average of the depth from the top of the plant canopy to the water surface. Plant height/vessel hull clearance data is calculated from point data that contains the actual GPS points recorded on the water with "each point's associated depth, biovolume or composition value for that location". These values were used to determine if the total water column depth and the depth from the water surface to the plant canopy is deep enough for boat navigation with a 3-foot hull clearance. Assessments were made at the same time as biovolume measurements, beginning in April and continued through October. Hydroacoustic scan data sets were used to determine the plant canopy height over time in feet and compared against the 3-foot hull clearance goal.

Point Sampling

The Monitoring and Reporting Program (MRP) and Quality Assurance Project Plan (QAPP) specify that physical "point sampling" will be used to 1) determine the extent and composition of aquatic plants in the Tahoe Keys lagoons and 2) assess the effectiveness of the CMT treatments on the targeted plant species. For each sampling date, 30 sampling points were taken in each CMT site. Points were collected mid-site and along the shoreline (dock-to-shoreline) to represent conditions across the sites. The point sampling regime was conducted pre-treatment and continued bi-weekly beginning two weeks after treatment. The protocol resulted in 60 rake sampling points per month per site. The sampling intensity was approximately 45 to 60 rake sample per acre per month depending upon the size of the site, but always the same intensity for a given site.

For each rake sample, the following data were collected in the field and are more fully described below: 1) all species observed on the rake, 2) an assessment of plant health, and 3) the percent composition of each species (relative abundance of each species present). During the entire 2022 Year 1 CMT "season" (May-November) this protocol resulted in over 7,800 individual sample points (rake samples). These data were recorded on personal tablets with Fulcrum software along with a photo of each rake. Digital data collection forms were developed specifically for the CMT Project.

Plant Health Condition

The plant condition rating scheme was designed to provide a semi-quantitative metric to distinguish healthy plants (with no apparent treatment symptoms) from those with physically discernable symptoms or conditions. The rating has five levels: from 1-5 with 1 being decomposed/decomposing and 5 is a robust, healthy plant (**Table 4**). For each species on each rake, a plant health rating was applied in the field. This metric was used to better inform subsequent analyses such that unviable plant fragments were not further considered, for example, in frequency of occurrence and percent composition assessments. Including unviable fragments would bias the outcome by including plant species that are essentially not present in any meaningful way.

TABLE 4
PLANT HEALTH CONDITION RATINGS

Rating	Description
1	Plants are barely recognizable due to decomposed or disintegrating tissues including leaves, stems, roots and rhizomes, and any attached reproductive parts (flowers, fruit/seed/ turions)
2	Plants are defoliated, roots and stems are recognizable, intact but disintegrating. Plants easily come apart with minor physical force.
3	Plants are defoliated but stems are mostly intact; roots and rhizomes are mostly intact and firm; reproductive parts are intact (if present). Some plants may appear almost normal.
4	Some plants are partially defoliated or have "bleached" or pale leaves; most plant parts are otherwise intact and appear normal: stems, rhizomes, roots, reproductive parts if present.
5	Plants are consistently intact and appear normal with green tissues (leave/stems); rhizomes and roots are firm and intact and reproductive parts if present are normal.

SOURCES: TKPOA (2022) and Anderson (2022)

Percent Composition

The percent composition of each species is critical to understanding the differential effects of CMT treatments on each target species as well as non-target desirable native plants. Since the herbicides used have different selectivity and UV selectivity is relatively unknown, this metric was included to better understand species-specific responses to different treatment types. Additionally, describing the increase in percent occurrence of native plants to non-native plants is a fundamental goal of the Project. The percent composition of each species was determined in the field by assigning the percentage of each plant species represented on each rake, determined for target as well as non-target native species. Where a rake was void of any plants, 0 percent was assigned to all species. Where plants were observed, the total abundance of each rake would equal 100 percent. For example: rake sample 1 had three species (A, B, and C). Species A was dominant and comprised 50% of the composition on the rake. Species B and C each comprised 25% of the composition for a total of 100%. As another example, rake sample 2 was void of any macrophytes or macroalgae thus its percent composition for all species was 0%. For a final example, rake sample 3 was completely covered by Species C thus the composition was 100% Species C. The example rake sample 3 was very common for coontail.

Efficacy Assessment Metrics

Frequency of Occurrence

Calculating frequency of occurrence is routinely used to assess the efficacy of control efforts (Madsen 1999, Madsen and Wersal 2017, Polk County Wisconsin 2020). Additionally, describing the increase in frequency of occurrence of native plants to non-native plants is a fundamental goal of the Project. As assessed here, it was simply a count of the number of observations of a species on a rake, divided by the total number of rakes per sites (in this case, 30) and multiplied by 100. While this approach does not demonstrate reductions in overall biovolume it does illustrate species-specific treatment effects and provides a method to calculate percent reduction in frequency of occurrence, by species.

Calculated Target Species - Biovolume (CTSB)

In an effort to further understand the species-specific effects of the various CMT treatments, the metric “Calculated Target Species - Biovolume” (CTSB) was calculated for each treatment site as:

CTSB = (% composition of each species * biovolume of each site) * 100

Using this approach, it was possible to calculate a percent difference in each species compared to the mean of control sites on any given date. For example, if the percent composition of Eurasian watermilfoil in a treatment site was 65% at pre-treatment and the biovolume of the site was 50%, the CTSB for Eurasian watermilfoil at the site would be 32.5% (the product of 0.65*0.50*100). On the same date at a control site, Eurasian watermilfoil percent composition was 60% with 55% biovolume resulting in a Eurasian watermilfoil CTSB of 33%. At a month after treatment, the percent composition of Eurasian watermilfoil in the treatment site was 10% and the biovolume was 35%, resulting in a CTSB for Eurasian watermilfoil of 3.5%. One month later at the control site, the percent composition of Eurasian watermilfoil was- 65% and biovolume was 70% biovolume resulting in a Eurasian watermilfoil CTSB of 45.5%. The difference between the post-treatment Eurasian watermilfoil CTSB between the herbicide-only site and the mean control sites would be a 42% reduction in Eurasian watermilfoil CTSB.

In calculating CTSB, only species with a plant health condition of 3 or better was used.

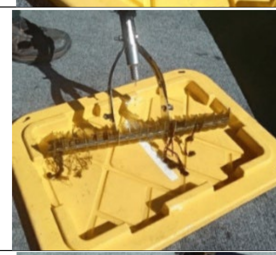
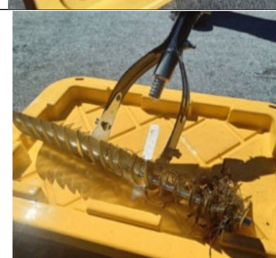
Rake Fullness

The BioBase system has been employed in the Tahoe Keys lagoons for over 10 years to document changes in the submersed aquatic vegetation (SAV) community. This easy-to-use system provides basic maps without the need for expensive tools or complex data processing. The utility of this approach is illustrated a study that evaluated the accuracy and precision of BioBase EcoSound compared to physical measurements and found an 85-100% accuracy (Helminen et al. 2019).

Others have observed a significant correlation between percent biovolume and rake fullness scores, at least within regions in the 4.7-meter zone (summarized in Valley et al. 2015). A rake fullness schema, similar to those used by others (Kenow et al. 2007, Hauxwell et al. 2010, IDNR 2018, Madsen and Wersal 2012, Helminen et al. 2019, Howell and Richardson 2019), was used to corroborate biovolume. We found that while others had used very course scales, a more granular scale provided a better correlation with hydroacoustic scans. Further, it is expected that the correlation would be stronger under more extreme situations of plant density. This was similarly found by Helminen et al. (2019) who reported that hydroacoustic scans were most accurate when vegetation canopy was ≤25% or ≥75%.

Individual digital images captured in the field were used to visually estimate and assign rake fullness ranks (**Table 5**). Three individuals ("raters") with experience collecting submersed aquatic plants independently reviewed rake photos from CMT sites. For each photo, raters applied the schema described in Table 5. Upon completion, a subset of the photos was cross-checked by others. The intent was to ensure consistency between raters, but also to calibrate this approach for Years 2 and 3 monitoring. By assigning a rake fullness rank, the average fullness per site per sampling event was compared by treatments.

Table 5
Plant Rake Fullness Schema and Examples

Rake Fullness Score	Description	Example
0	0%; no plants (but filamentous/macro algae (e.g., Chara) may be present	
1	1-5%; handful of sprigs	
6	6-25%; less than one-fourth of the rake full	
26	26-50%; a fourth to half of the rake full; tines visible	
51	51-75%; more than half of the rake full; some tines still visible	
76	76%+; completely full rake; no tines visible	

Calculated Target Species – Fullness (CTSF)

Average rake fullness data was similarly used to determine “Calculated Target Species – Fullness” (CTSF) as mentioned above, but using fullness ranks rather than biovolume. Note that neither hydroacoustic scans nor rake fullness ranks distinguish species but both provide independent assessments of the total amount of SAV in the CMT site. The CTSF was further used to not only describe the species-specific effects but has the added benefit of accounting for the relative location within a treatment site. That is, since rake data were sorted by mid-site and shoreline, treatment effects can be differentially evaluated by relative location with a CMT site, for example in mid-site where UV was used or combination sites where only the shoreline was treated.

Results and Discussion

Between May 16 and November 16, 2022, over 7,800 rake samples were collected from 25 sites across the West Lagoon and Lake Tallac as part of the Tahoe Keys Aquatic Weed CMT Monitoring Project. Pre-treatment monitoring occurred at all sites the week of May 16, 2022. All sites were sampled according to schedule, with the following exceptions/omissions: sampling was not conducted during mid-August in Site 9, at the end of September in Site 23, during early June in Site 18, and at the end of October in Sites 10 and 11. On at least two occasions, this occurred due to changes made to the sampling schedule after hardcopies had been printed for staff. Conversely, a number of sites were monitored during additional visits, including monitoring in early August in Site 8; end of September in Site 24; two additional sample events in Site 19 in June; and two additional sampling events in LFA Sites 26 and 27 during the summer. Additional pre-treatment sampling was conducted in UV treatment Sites 22, 23, and 24 to correspond with UV treatments that were applied more frequently than herbicide or LFA treatments.

Because the LFA system was not functioning at Sites 25 and 27 until November, those macrophyte data are not considered in this report.

For each treatment type, at least one example figure describing the various macrophyte control efficacy metrics is provided for illustrative purposes while efficacy metrics for the full dataset are discussed in the text and provided in **Attachments A** through **F**. This approach was also used for rake collected data as well as hydroacoustic scans collected by TKPOA. Dates provided in figures are dates for the beginning of each respective two-week period (intervals) because assessment dates varied between sites. The assessment dates differed because each was determined by the start date of the UV treatment, which varied throughout Year 1 depending on the site (see Appendix AA for further details).

Biovolume

Group A methods, including both herbicide and non-herbicide treatments, were intended to achieve a 75 percent reduction in biovolume as assessed using the BioBase system. Data were collected bi-weekly by TKPOA staff and provided to ESA for subsequent analysis.

For each treatment type, examples of biovolume from a limited number of sites are provided. The full suite of results may be found in **Attachment A**. Results are grouped by treatment type and data for each site compared to the average of biovolume assessed from the three control sites in the West Lagoon (Sites 16, 17, 18) and Lake Tallac (Site 20). Also, for each treatment type, the percent difference between biovolume data from the average of controls is compared to the nearest biovolume date for each site. Where the difference is >75%, those data are indicated in bold and grey cells.

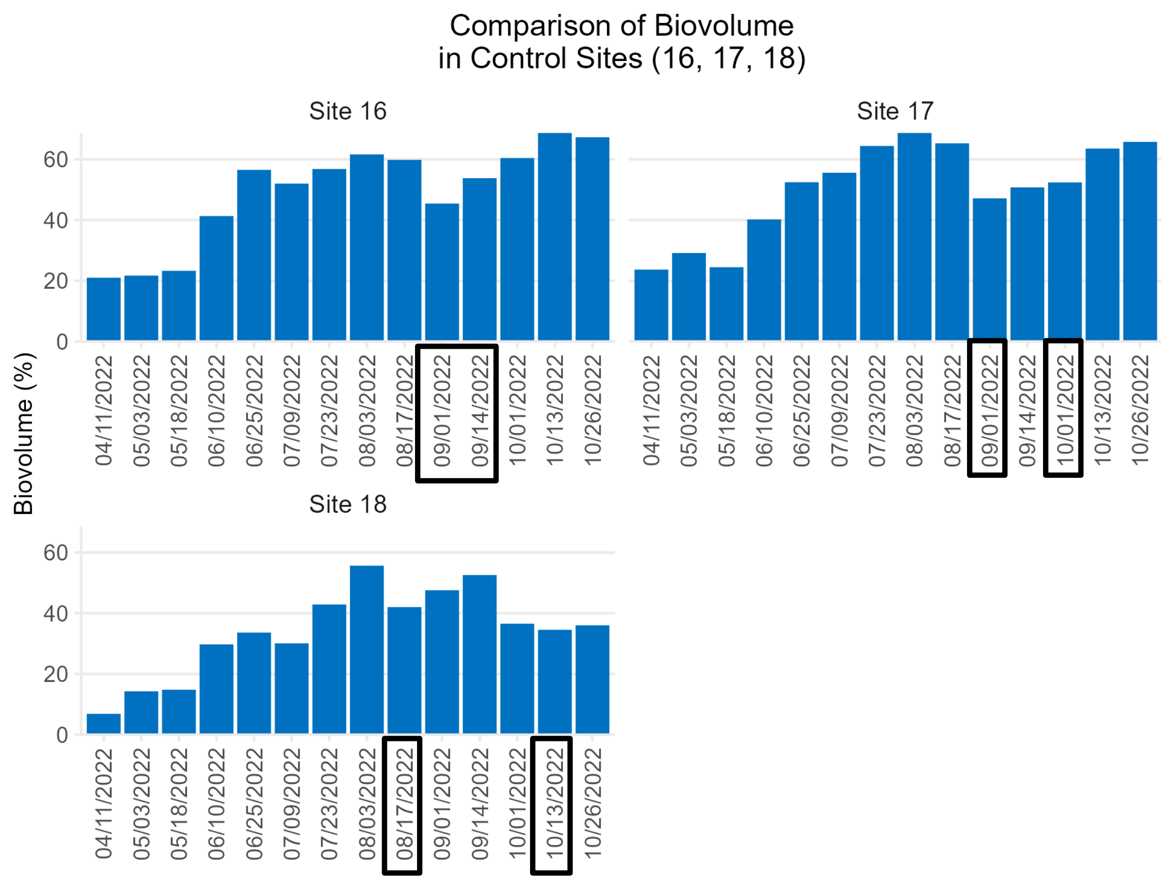
Control sites

An important caveat when assessing the efficacy metrics is that the three control sites in the West Lagoon were harvested on up to four dates after August 9 as part of routine operations throughout the Project (**Table 6**). In addition, two control sites were intended for Lake Tallac: Site 20 (located west of a turbidity curtain) and Site 21 (adjacent to treated Site 19). Although herbicide residue samples were not collected from Site 21, samples collected between Sites 19 and 21 suggest that Endothall likely migrated into Site 21.

Total biovolume of harvested control sites is shown in **Figure 2** illustrating the effect of harvesting.

TABLE 6
HARVESTING SCHEDULE IN CONTROL SITES

Site	Dates [a]
16	8/9/2022, 8/26/2022, 9/3/2022
17	8/11/2022, 8/31/2022, 9/15/2022, 9/21/2022
18	8/17/2022, 10/7/2022
20	9/28/2022



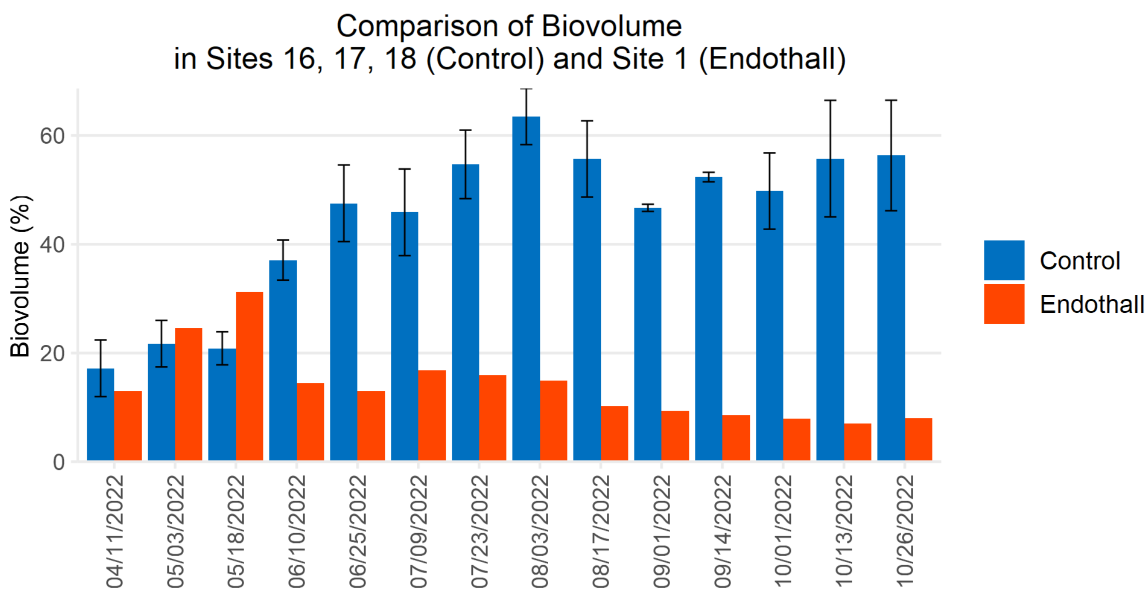
Black boxes indicate nearest date of macrophyte assessment following completion of harvesting. Sources: TKPOA

Figure 2. Biovolume from the Three Control Sites in the West Lagoon

Endothall Sites

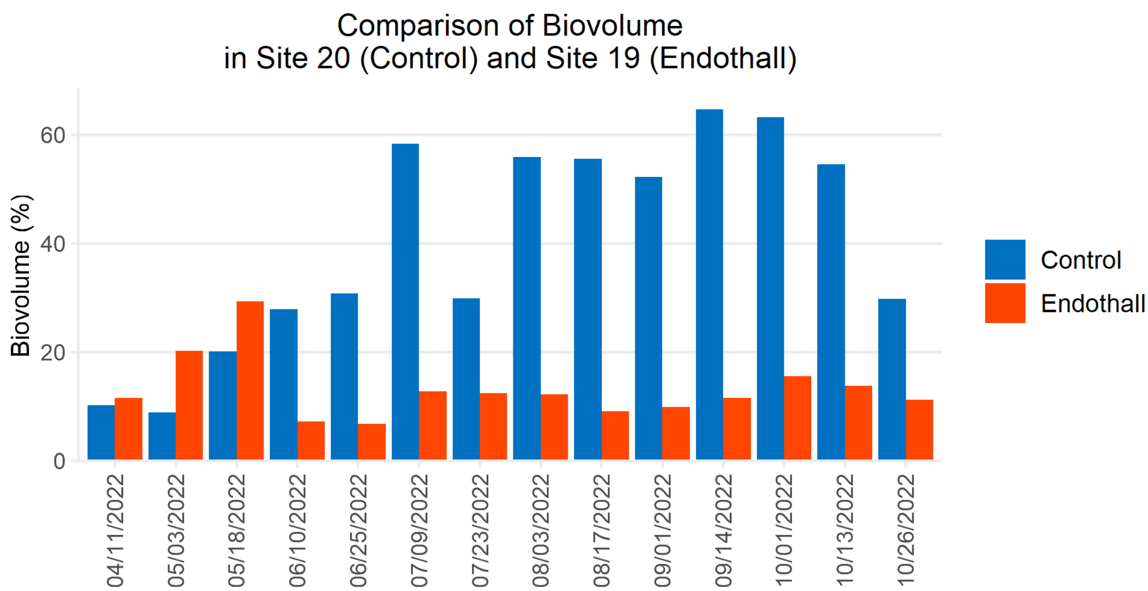
Biovolume in the Endothall sites in the West Lagoon (Sites 1, 2, and 3) was similar to the average of controls (Sites 16, 17, and 18) at pre-treatment (results for Endothall treatment Site 1 is shown as an example in **Figure 3**). Very large reductions in biovolume were observed in all three Endothall sites in the West Lagoon during the first hydroacoustic scan in early June. Biovolume remained near or below 20% in all Endothall sites throughout the summer and into fall.

The biovolume in Endothall Site 19 in Lake Tallac was very similar to Lake Tallac control Site 20 at pre-treatment (**Figure 4**). Similar to Endothall sites in the West Lagoon, substantial reductions in biovolume were observed during the first scan in early July and remained low throughout the season.



Source: TKPOA

Figure 3. Average Biovolume in Sites 16, 17, 18 (Control) and Site 1 (Endothall) in the West Lagoon



SOURCE: TKPOA

Figure 4. Average Biovolume in Sites 20 (Control) and Site 19 (Endothall) in Lake Tallac

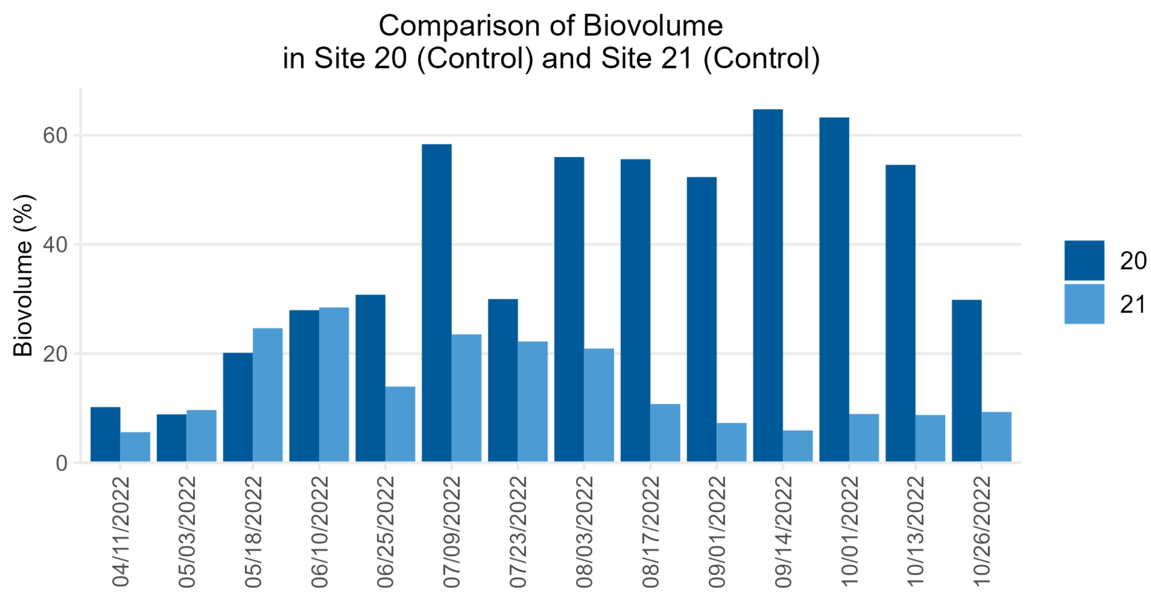
Compared to the average control sites in the West Lagoon, biovolume in Endothall treatment sites achieved a 75% reduction by early August in Sites 1 and 3, and by mid-August for Site 2 (**Table 7**). This trend continued through the end of October in Sites 1 and 2 and through early September in Site 3. These reductions were anticipated as Endothall is known to be highly efficacious against all three target species.

TABLE 7
ENDOTHALL-ONLY (WEST LAGOON): BIOVOLUME BY SITE AND DATE. IF PRESENT, RESULTS IN BOLD AND GRAY INDICATE PERCENT DIFFERENCES > 75% COMPARED TO THE AVERAGE CONTROL SITES ON NEAREST SCAN DATES

Date	Biovolume (%)	Biovolume (%)	% Difference[b]	Biovolume (%)	% Difference[b]	Biovolume (%)	% Difference[b]
	Controls[a]	Site 1		Site 2		Site 3	
5/16/2022	20.86	31.31	↑	41.72	↑	24.61	↑
6/10/2022	37.09	14.47	60.98	21.04	43.27	9.63	74.03
6/25/2022	47.53	13.00	72.65	24.40	48.67	9.71	**79.57**
7/9/2022	45.88	16.81	63.36	30.48	33.57	10.28	**77.60**
7/23/2022	54.69	15.89	70.94	23.58	56.88	29.09	46.81
8/3/2022	63.49	14.97	**76.42**	16.68	73.73	13.01	**79.51**
8/17/2022	55.69	10.22	**81.65**	11.11	**80.05**	11.83	**78.77**
9/1/2022	46.71	9.32	**80.05**	9.58	**79.49**	10.64	**77.22**
9/14/2022	52.37	8.63	**83.52**	9.02	**82.78**	16.50	68.49
10/1/2022	49.78	7.92	**84.09**	8.45	**83.02**	18.73	62.37
10/13/2022	55.75	7.05	**87.36**	8.77	**84.27**	15.63	71.97
10/26/2022	56.33	8.01	**85.78**	9.23	**83.61**	17.34	69.22

NOTES:
a Sites 16, 17, and 18 which were harvested according to dates in Table 6
b Percent difference between CMT treatment site and average control sites
↑ = increased difference above average controls
SOURCE: TKPOA

As previously mentioned, two control sites were intended for Lake Tallac: Site 20 (located west of a turbidity curtain) and Site 21 (adjacent to treated Site 19). Herbicide residue samples collected between Sites 19 and 21 suggest that herbicide incursion to Site 21 likely occurred. This is further supported by plant responses (**Figure 5** and **Table 8**). Compared to control Site 20 in Lake Tallac, biovolume in Site 19 achieved nearly 75% reduction in early June (at 74%), and reduction goals were met through the end of summer and into fall (Table 8).



SOURCE: TKPOA

Figure 5. Average Biovolume in Sites 20 (Control) and Site 21 (Intended Control) in Lake Tallac

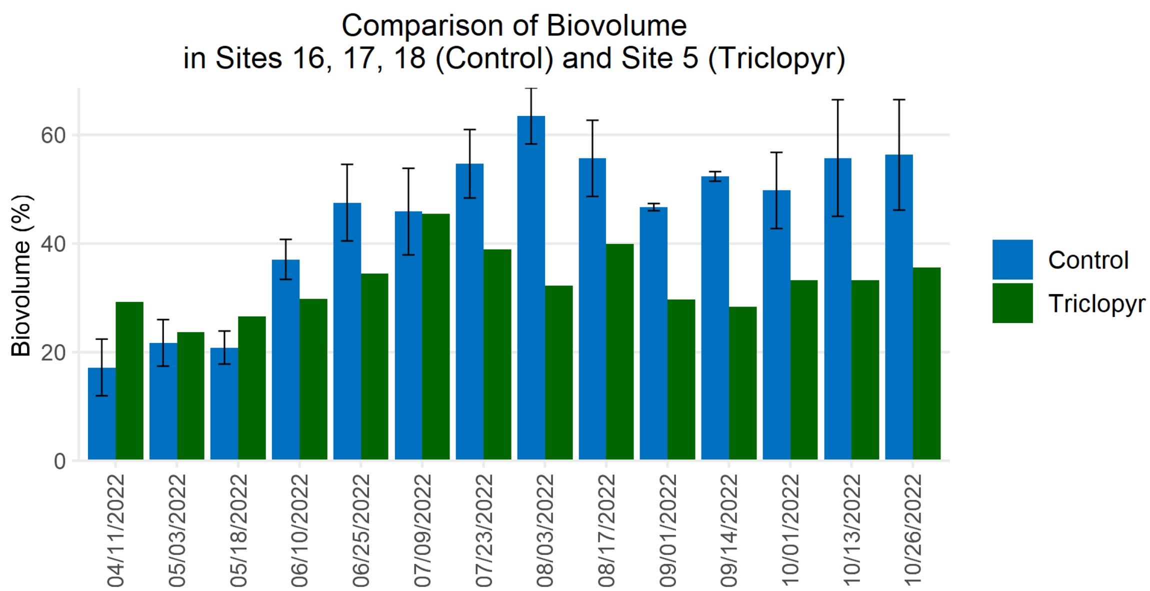
TABLE 8
ENDOTHALL-ONLY (LAKE TALLAC): BIOVOLUME BY SITE AND DATE. IF PRESENT, RESULTS IN BOLD AND GRAY INDICATE PERCENT DIFFERENCES > 75% COMPARED TO THE AVERAGE CONTROL SITES ON NEAREST SCAN DATES

Date	Biovolume (%)	Biovolume (%)	% Difference [b]	Biovolume (%)	% Difference [b]
	Control	Site 19		Site 21	
5/16/2022	20.14	29.41	↑	24.64	↑
6/10/2022	27.95	7.23	74.13	28.45	↑
6/25/2022	30.78	6.77	**78.01**	13.95	54.68
7/9/2022	58.35	12.82	**78.03**	23.52	59.69
7/23/2022	29.98	12.52	58.22	22.22	25.88
8/3/2022	55.99	12.23	**78.16**	20.92	62.64
8/17/2022	55.6	9.17	**83.51**	10.76	**80.65**
9/1/2022	52.32	9.91	**81.06**	7.3	**86.05**
9/14/2022	64.74	11.53	**82.19**	5.93	**90.84**
10/1/2022	63.25	15.56	**75.40**	8.94	**85.87**
10/13/2022	54.56	13.82	**74.67**	8.75	**83.96**
10/26/2022	29.85	11.26	62.28	9.31	68.81

NOTES:
[a] Site 20
b ↑ = increased difference above average controls
SOURCE: TKPOA

Triclopyr Sites

Pre-treatment biovolume in the Triclopyr sites were similar to the average control sites (16, 17, 18) at Sites 5 and 9 (about 20% biovolume), but lower at 10% in Site 8 (example Site 9 in **Figure 6**). Compared to the average control sites in the West Lagoon, biovolume in Sites 5, 8, and 9, treated with Triclopyr alone, did not achieve a 75% reduction (**Table 9**). Site 5 achieved the highest percent reduction in early August at 49%, followed by 39% in Site 9 and 26% in Site 8. The lack of reduced biovolume in Triclopyr sites is because Triclopyr does not target coontail and curlyleaf pondweed, which together contributed to the large biovolume as discussed later.



SOURCE: TKPOA

Figure 6. Average Biovolume in Sites 16, 17, 18 (Control) and Site 5 (Triclopyr)

TABLE 9
TRICLOPYR-ONLY: BIOVOLUME BY SITE AND DATE. IF PRESENT, RESULTS IN BOLD AND GRAY INDICATE PERCENT DIFFERENCES >75% COMPARED TO THE AVERAGE CONTROL SITES ON NEAREST SCAN DATES

Date	Biovolume (%)	Biovolume (%)	% Difference[b]	Biovolume (%)	% Difference [b]	Biovolume (%)	% Difference [b]
	Controls[a]	Site 5		Site 8		Site 9	
5/16/2022	20.86	26.59	↑	16.71	19.88	28.26	↑
6/10/2022	37.09	29.86	19.49	27.39	26.15	31.20	15.87
6/25/2022	47.53	34.47	27.48	34.98	26.41	38.88	18.20
7/9/2022	45.88	45.47	0.90	42.50	7.37	37.15	19.03
7/23/2022	54.69	38.88	28.92	51.76	5.35	33.50	38.74
8/3/2022	63.49	32.28	49.16	66.26	↑	57.05	10.15
8/17/2022	55.69	39.92	28.32	75.06	↑	57.32	↑
9/1/2022	46.71	29.68	36.45	59.29	↑	57.59	↑
9/14/2022	52.37	28.38	45.81	46.75	10.73	43.53	16.87
10/1/2022	49.78	33.23	33.24	44.97	9.66	42.33	14.96
10/13/2022	55.75	33.24	40.38	56.31	↑	48.28	13.40
10/26/2022	56.33	35.60	36.80	55.66	1.19	46.00	18.34

NOTES:
a Sites 16, 17, and 18 which were harvested according to dates in Table 6
b Percent difference between CMT treatment site and average control sites
↑ = increased difference above average controls
SOURCE: TKPOA

UV Sites

The intent of the UV treatments in Sites 24,23,22 was to expose the entire site. However, due to a combination of shallow water and shoreline structures, only the middle part of each site was treated. **Figure 7** illustrates a typical treatment path. Biovolume, however, was assessed across the entire site in all CMT treatment types and not simply the mid-site areas where UV treatments largely occurred. As previously mentioned, biovolume is based on geostatistical interpolated grid data that uses a kriging interpolation model to predict the biovolume of unsampled locations.

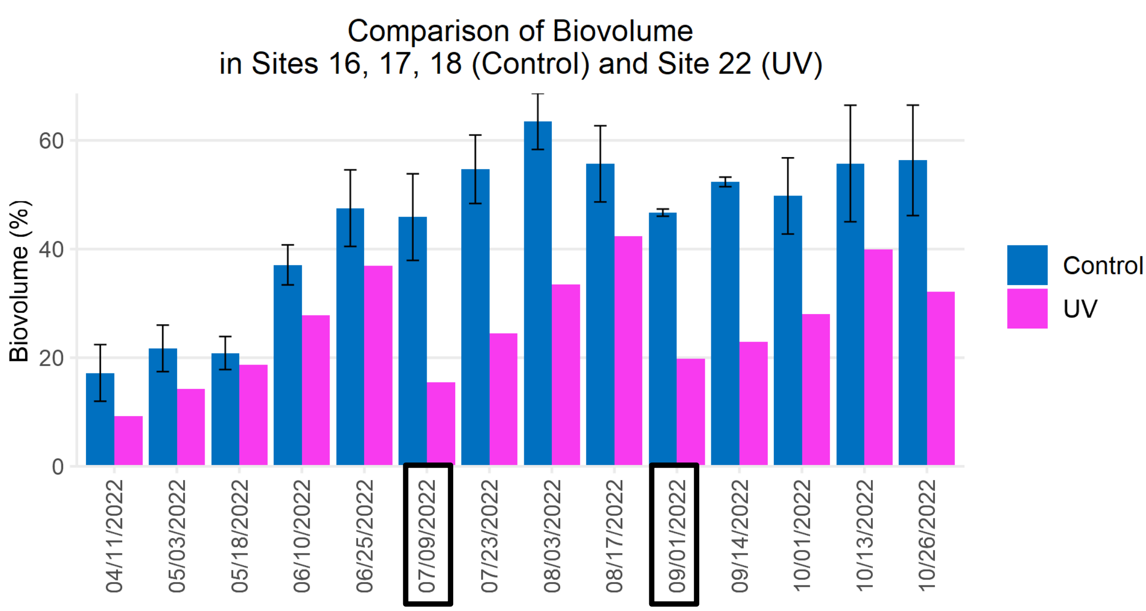
SOURCE: IRI Resources, Inc.

Figure 7
Typical UV Treatment Path at a Combination Site

Additional information on UV treatments may be found in Appendix AA in TKPOA (2023).

Biovolume in the UV sites was similar to the average control sites at Site 23 prior to treatment (~15%), but much lower (at 10%) in Sites 22 and 24 after the first treatment (example Site 22 in **Figure 7**). Site 22 was treated three times in Year 1 with the nearest biovolume estimate dates following approximately 14 days after each of the first two treatments as illustrated by black boxes in Figure 7. The third treatment began on 10/19/2022 and the final biovolume estimate occurred inside the window when declines in plant material is typically observed (14 days). While declines in biovolume were observed following each successive treatment, re-treatments were needed to keep pace with actively growing macrophytes.

Compared to the average control sites in the West Lagoon, biovolume in Sites 22, 23, and 24, treated with UV, did not achieve a 75% reduction (**Table 10**). Across the sites, however, Site 24 (treated first) achieved a 61% reduction by the end of June following six days of treatment (Table 2) and 49% reduction mid-August. Site 23 had a 63% reduction by the end of June and 55% mid-September. Site 22 did not receive a first treatment until late June; however, there was a 66% reduction by early July and 58% reduction early September.



Box around dates indicate nearest time of macrophyte assessment following ~14 days post-UV treatment. SOURCES: TKPOA and IRI Resources, Inc.

Figure 8. Average Biovolume in Sites 16, 17, 18 (Control) and Site 22 (UV)

TABLE 10
UV-ONLY: BIOVOLUME BY SITE AND DATE. IF PRESENT, RESULTS IN BOLD AND GRAY INDICATE PERCENT DIFFERENCES > 75% COMPARED TO THE AVERAGE CONTROL SITES ON NEAREST SCAN DATES

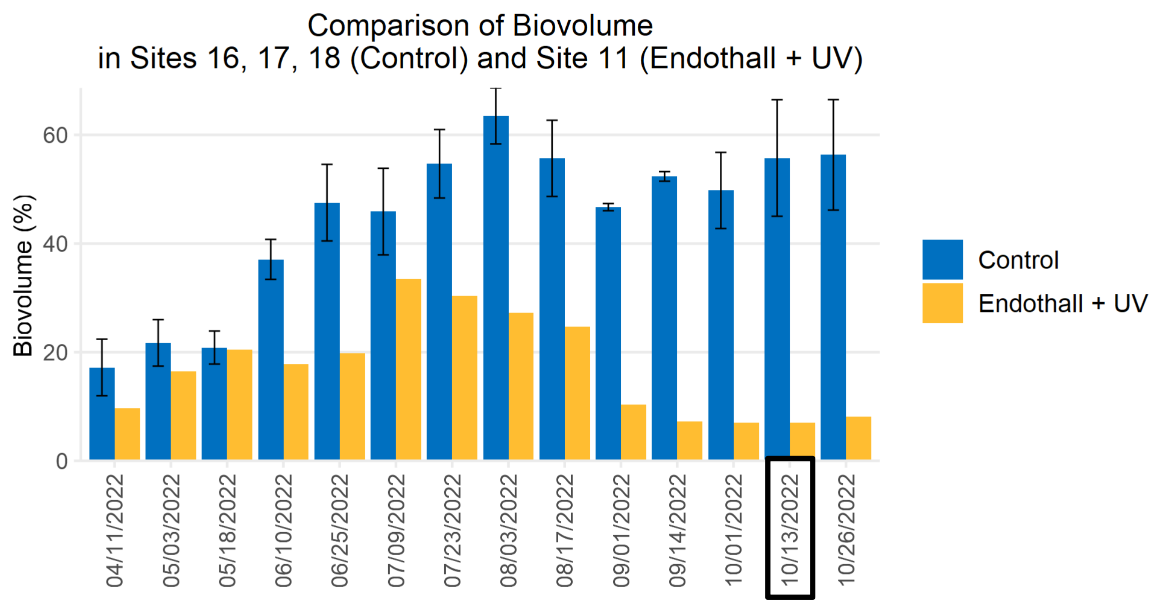
Date	Biovolume (%)	Biovolume (%)	% Difference [b]	Biovolume (%)	% Difference [b]	Biovolume (%)	% Difference [b]
	Controls[a]	Site 22		Site 23		Site 24	
5/16/2022	20.86	18.74	10.15	18.72	10.24	17.92	14.08
6/10/2022	37.09	27.81	25.01	34.93	5.82	20.46	44.83**
6/25/2022	47.53	36.97	22.22	17.55	63.08**	18.63	60.81**
7/9/2022	45.88	15.46	66.31**	29.75	35.16	35.31	23.04
7/23/2022	54.69	24.49	55.22	33.35	39.03	37.61	31.24
8/3/2022	63.49	33.52	47.21	36.94	41.82	39.90	37.16
8/17/2022	55.69	42.41	23.85	26.62	52.20	28.60	48.64**
9/1/2022	46.71	19.79	57.63**	34.74	25.62	28.36	39.28
9/14/2022	52.37	22.97	56.14	23.42	55.28**	34.68	33.77
10/1/2022	49.78	28.06	43.63	28.61	42.52	40.94	17.75
10/13/2022	55.75	39.91	28.42	42.08	24.52	39.35	29.42
10/26/2022	56.33	32.11	43.00	32.24	42.77	42.13	25.21

NOTES:
a Sites 16, 17, and 18 which were harvested according to dates in Table 6
b Percent difference between CMT treatment site and average control sites
Asterisks (**) indicate hydroacoustic scans that nearest followed a UV treatment (see Table 2 for UV treatment schedule)
SOURCES: TKPOA and IRI Resources, Inc.

Endothall + UV

Prior to treatment, biovolume in the Endothall + UV sites (10, 11, 15) were similar to or somewhat less than the average control sites (16, 17, 18) (example Site 11 in **Figure 9**). Following the application of Endothall, biovolume declines in Sites 10 and 11 were very similar to the Endothall-only sites (Sites 1, 2, and 3). Site 15, however, maintained biovolume near or above 40% of the control sites throughout the remainder of the season. UV treatments in combination sites 10, 11, and 15 were delayed (see Table 2) by access limitations to the treatment sites (see TKPOA 2023 for details).

Compared to the average control sites in the West Lagoon, biovolume in Sites 10 and 11 treated with Endothall in May and UV at varying dates (Table 2) achieved a >75% reduction in early September (**Table 11**). Reductions as high as 82% were achieved prior to initiation of UV treatments, suggesting that Endothall applied to the shoreline areas was responsible for the dramatic declines across Sites 10 and 11. The highest percent reduction in Site 15 was only 34%. This followed the first and only UV treatment in that site. Herbicide residue monitoring indicated that Endothall dissipated rapidly from Site 15 (see TKPOA 2023), suggesting an insufficient contact exposure time between the active ingredient and the target species.



Black boxes indicate nearest date of macrophyte assessment following 14 days post-UV treatment Sources: TKPOA and IRI Resources, Inc.

Figure 9. Average Biovolume in Sites 16, 17, 18 (Control) and Site 11 (Endothall + UV)

TABLE 11
COMBINATION ENDOTHALL + UV: BIOVOLUME BY SITE AND DATE. IF PRESENT, RESULTS IN BOLD AND GRAY INDICATE PERCENT DIFFERENCES > 75% COMPARED TO THE AVERAGE CONTROL SITES ON NEAREST SCAN DATES

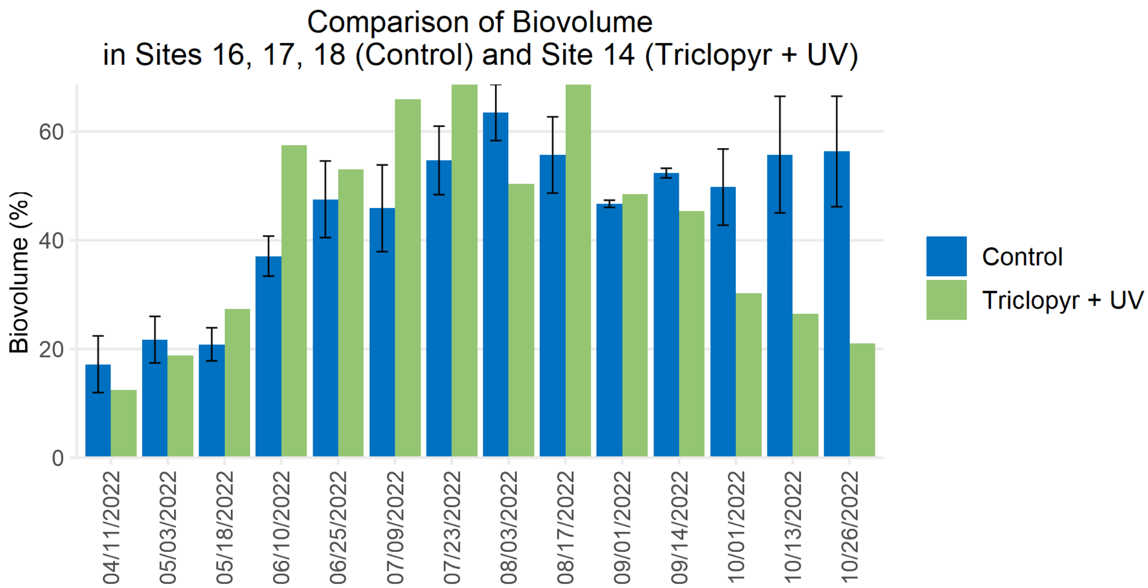
Date	Biovolume (%)	Biovolume (%)	% Difference[b]	Biovolume (%)	% Difference[b]	Biovolume (%)	% Difference[b]
	Controls[a]	Site 10		Site 11		Site 15	
5/16/2022	20.86	39.41	↑	20.46	1.90	29.95	↑
6/10/2022	37.09	13.78	62.84	17.78	52.06	25.59	31.00
6/25/2022	47.53	20.82	56.20	19.77	58.41	40.03	15.79
7/9/2022	45.88	31.73	30.85	33.45	27.10	38.82	15.39
7/23/2022	54.69	24.22	55.71	30.37	44.46	36.43	33.39
8/3/2022	63.49	16.71	73.68	27.30	57.00	49.39	22.21
8/17/2022	55.69	17.02	69.44	24.67	55.70	97.96	↑
9/1/2022	46.71	8.34	**82.14**	10.31	**77.93**	57.66	↑
9/14/2022	52.37	7.34	**85.98**	7.29	**86.08**	41.38	20.98
10/1/2022	49.78	9.07	**81.78**	7.05	**85.84**	32.65	34.41**
10/13/2022	55.75	7.99	**85.67****	6.99	**87.46****	60.41	↑
10/26/2022	56.33	7.65	**86.42**	8.16	**85.51**	82.91	↑

NOTES:
a Sites 16, 17, and 18 which were harvested according to dates in Table 6
b Percent difference between CMT treatment site and average control sites
↑ = increased difference above average controls
Asterisks (**) indicate hydroacoustic scans that nearest followed a UV treatment (see Table 2 for UV treatment schedule)
SOURCES: TKPOA and IRI Resources, Inc.

Triclopyr+ UV

Three sites, 12, 13, and 14, were intended for a combination treatment of Triclopyr + UV; however, due to access issues, the Triclopyr sites were not treated with UV (Table 2). Thus, only Triclopyr was applied in these intended combination sites. Prior to treatment, biovolume was similar to the average of controls in Sites 13 and 14 (example Site 14 in **Figure 10**) and lower in Site 12. Following treatment with Triclopyr, Site 12 biovolume remained low with little variation compared to pre-treatment. Biovolume in Sites 13 and 14; however, continued to increase throughout the season and surpassed the average of the controls in many cases during the summer.

Biovolume in Site 12, which was treated with Triclopyr along the shoreline, achieved a 75% reduction in early August that was intermittently maintained over the summer (**Table 12**). The highest reductions in Sites 13 and 14 were 67% and 63%, respectively. These relatively high reductions are somewhat surprising given (1) Triclopyr's lack of specificity in controlling coontail and curlyleaf pondweed, (2) the presumed lack of dissipation of Triclopyr from the shoreline areas to mid-site (due to the use of granular formulation), and (3) the fact that biovolume is assessed across the entire site and not simply the shoreline where Triclopyr in combination sites was applied. However, as discussed later, coontail and curlyleaf pondweed had a very low frequencies of occurrence during pre-treatment in Site 12 (where initial biovolume was also less than controls) while occurrences were higher for both species in Sites 13 and 14.



Note: No UV light treatments occurred at the intended Triclopyr + UV sites. Source: TKPOA

Figure 10. Average Biovolume in Sites 16, 17, 18 (Control) and Site 14 (Triclopyr + UV)

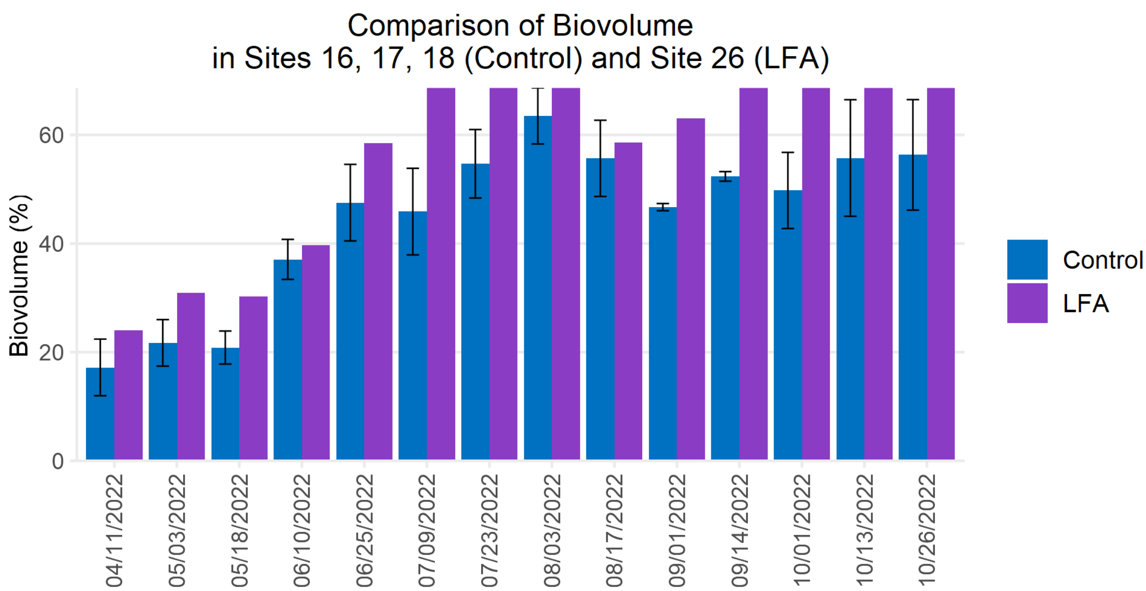
TABLE 12
COMBINATION TRICLOPYR + UV: BIOVOLUME BY SITE AND DATE. IF PRESENT, RESULTS IN BOLD AND GRAY INDICATE PERCENT DIFFERENCES > 75% COMPARED TO THE AVERAGE CONTROL SITES ON NEAREST SCAN DATES

Date	Biovolume (%)	Biovolume (%)	% Difference[b]	Biovolume (%)	% Difference[b]	Biovolume (%)	% Difference[b]
	Controls[a]	Site 12		Site 13		Site 14	
5/16/2022	20.86	17.28	17.16	33.4	↑	27.40	↑
6/10/2022	37.09	18.72	49.53	68.09	↑	57.54	↑
6/25/2022	47.53	10.88	77.11	36.44	23.34	53.02	↑
7/9/2022	45.88	14.16	69.14	77.28	↑	65.92	↑
7/23/2022	54.69	14.19	74.05	87.71	↑	82.16	↑
8/3/2022	63.49	14.22	**77.60**	59.94	5.60	50.39	20.64
8/17/2022	55.69	24.46	56.08	94.57	↑	76.81	↑
9/1/2022	46.71	6.37	**86.36**	38.59	17.38	48.50	↑
9/14/2022	52.37	9.17	**82.49**	45.57	12.98	45.42	13.27
10/1/2022	49.78	5.31	**89.33**	31.76	36.20	30.24	39.25
10/13/2022	55.75	16.67	70.10	23.87	57.19	26.43	52.59
10/26/2022	56.33	9.33	**83.44**	18.50	67.16	21.00	62.72

NOTES:
a Sites 16, 17, and 18 which were harvested according to dates in Table 6
b Percent difference between CMT treatment site and average control sites
↑ = increased difference above average controls
Asterisks (**) indicate hydroacoustic scans that nearest followed a UV treatment (see Table 2 for UV treatment schedule)
SOURCES: TKPOA and IRI Resources, Inc.

LFA Site 26

Operation of LFA Site 26 began in 2019 thus no pre-treatment macrophyte assessment is applicable. Throughout Year 1 monitoring, biovolume in Site 26 was higher than the average control sites in the West Lagoon **(Figure 11**), thus biovolume in Site 26 did not achieve a 75% reduction at any time during the 2022 monitoring season (**Table 13**). In fact, biovolume ranged from 5 to 37% higher in LFA Site 26 compared to the average control sites in the West Lagoon. Discussed later, coontail frequency of occurrence in LFA Site 26 was between 25 and 50%; however, its relative contribution (based on CTSF) to the biovolume was nearly half that of Eurasian watermilfoil. Perhaps the LFA system physically limits coontail from populating the site due to increased circulation from the diffusers.



Source: TKPOA

Figure 11. Average Biovolume in Sites 16, 17, 18 (Control) and Site 26 (LFA)

TABLE 13
LFA: BIOVOLUME BY SITE AND DATE. IF PRESENT, RESULTS IN BOLD AND GRAY INDICATE PERCENT DIFFERENCES ≥ 75% COMPARED TO THE AVERAGE CONTROL SITES ON NEAREST SCAN DATES

Date	Biovolume (%)	Biovolume (%)	% Difference[b]
	Controls[a]	Site 26 (LFA)	
5/16/2022	20.86	30.22	↑
6/10/2022	37.09	39.66	↑
6/25/2022	47.53	58.51	↑
7/9/2022	45.88	72.98	↑
7/23/2022	54.69	83.94	↑
8/3/2022	63.49	80.91	↑
8/17/2022	55.69	58.55	↑
9/1/2022	46.71	63.04	↑
9/14/2022	52.37	69.85	↑
10/1/2022	49.78	70.06	↑
10/13/2022	55.75	76.57	↑
10/26/2022	56.33	75.76	↑

NOTES:
a Sites 16, 17, and 18 which were harvested according to dates in Table 6
b Percent difference between CMT treatment site and average control sites
↑ = increased difference above average controls
SOURCE: TKPOA

Rake Fullness

The metric of rake fullness provides additional information over the biovolume metric, which is particularly important for interpreting the efficacy of UV sites and combination sites. Since rake fullness is evaluated at each sampling point within a treatment site rather than across each treatment site, the differences in rake fullness between mid-site and shoreline sampling points within a site can be separated. This is especially important for evaluations of UV treatment effectiveness as UV was only applied to mid-site areas. In addition, rake fullness can be used as a proxy for biovolume of each sampling point because a strong, significant, positive correlation between mean rake fullness and mean biovolume was observed across all treatment types except for LFA (Pearson's correlation (r = 0.78; p<0.001; n = 203; Figure 12). Presented are examples of rake fullness by CMT treatment type. The full suite of figures are included in Attachment B.

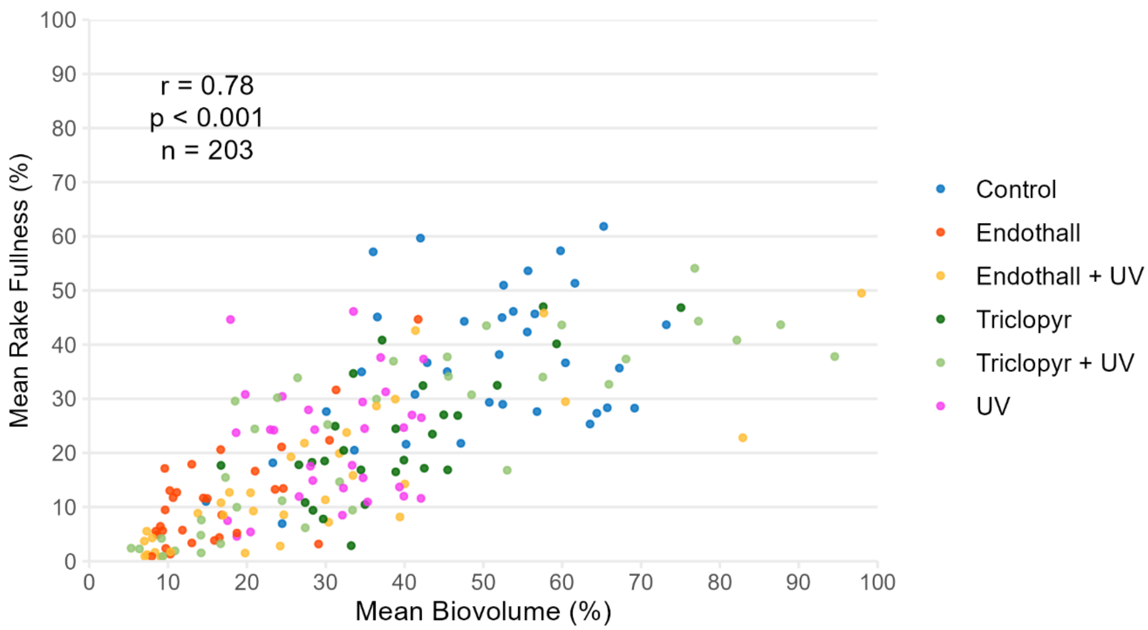


Figure 12 Pearson's Correlation of Biovolume from All Sites and Rake Fullness Assessments

Endothall Sites

In general, biovolume and rake fullness trends were similar in Endothall sites (example Site 1 in **Figure 13**); however, it should be noted that rake sampling ended in late September, but hydroacoustic based biovolume estimates continued into October. Rake fullness data further support a reduction in standing plant material in the Endothall sites per the Project goals.

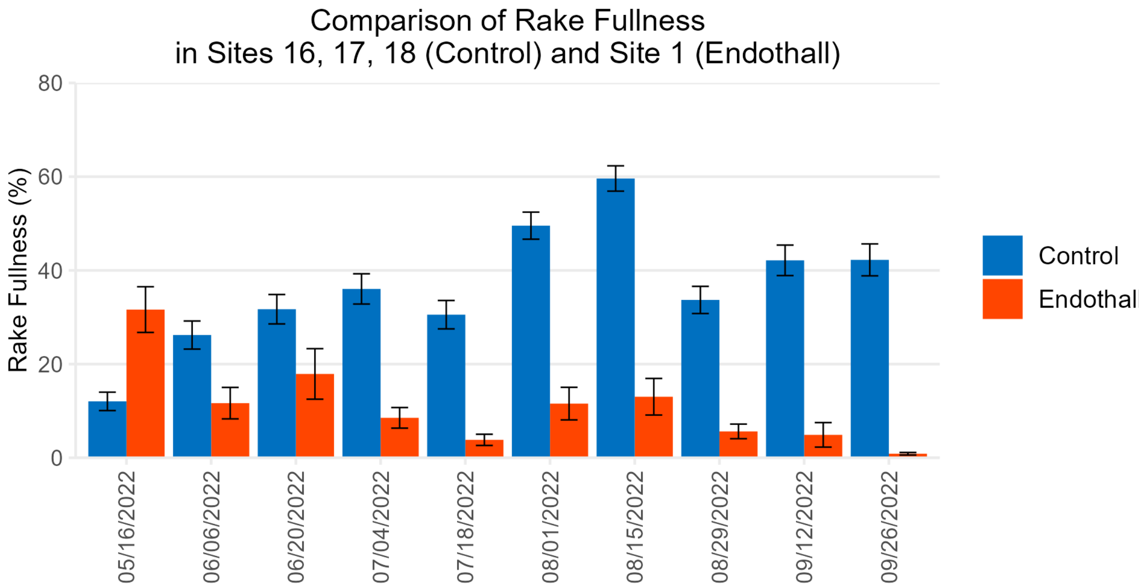


Figure 13. Average Rake Fullness in Sites 16, 17, 18 (Control) and Site 1 (Endothall) in the West Lagoon

Triclopyr Sites

In general, biovolume and rake fullness trends were similar in Triclopyr sites (example Site 5 in **Figure 14**); however, it should be noted that rake sampling ended in late September but hydroacoustic based biovolume estimates continued into October. Rake fullness data further support a reduction in standing plant material in the Triclopyr sites per the Project goals. For these sites, reductions are presumably due to the reduction in Eurasian watermilfoil which is targeted by Triclopyr.

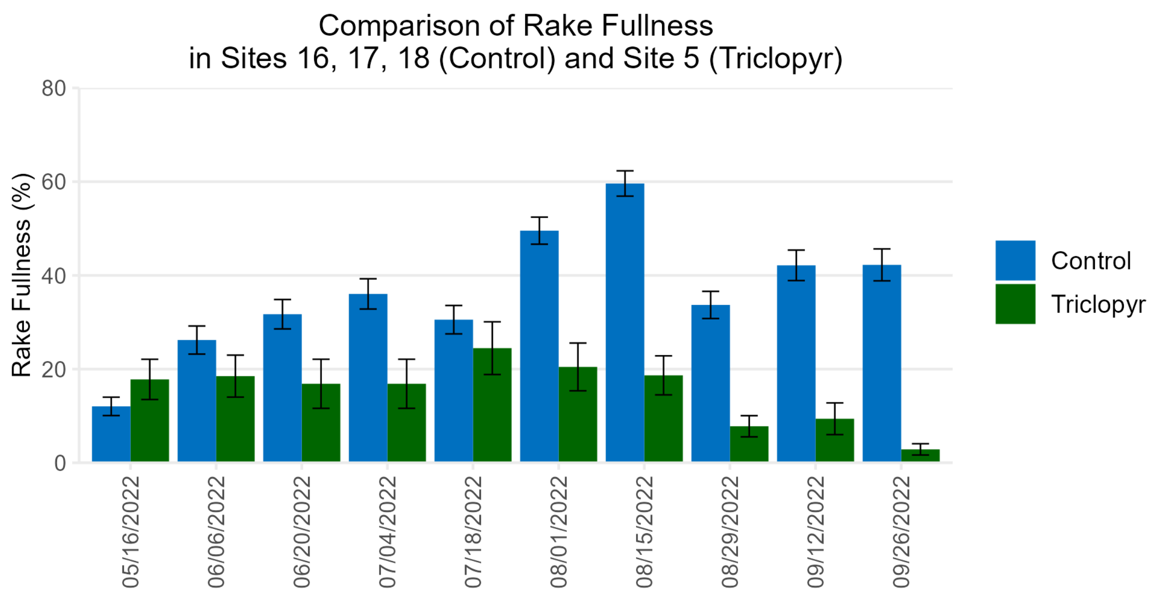


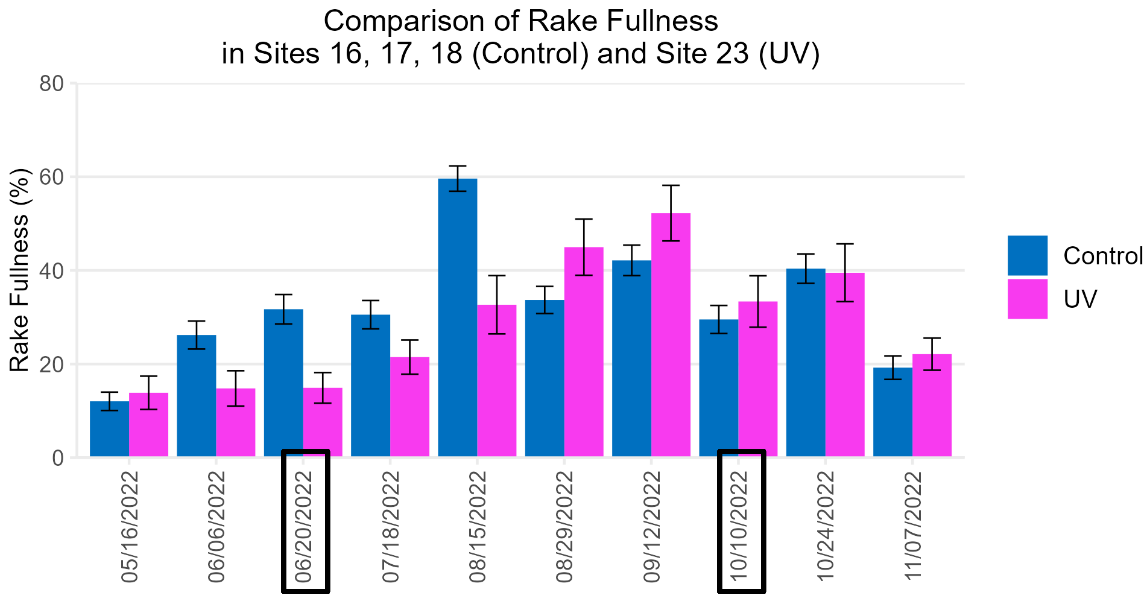
Figure 14. Average Rake Fullness in Sites 16, 17, 18 (Control) and Site 1 (Endothall) in the West Lagoon

UV Sites

Rake fullness data allows for the separation of results between the shoreline and mid-site sample areas. Where the use of the rake fullness data is most informative are with the UV and combination sites as these treatments targeted the mid-site and shoreline at various times during the season. For UV, treatments were limited to the mid-sites due to docks, boats, other structures, and shallow water near the shoreline. For this reason, differences in rake fullness are dramatically different between areas within sites - a nuisance not gleaned from the hydroacoustic scans that are focused on site-wide evaluations.

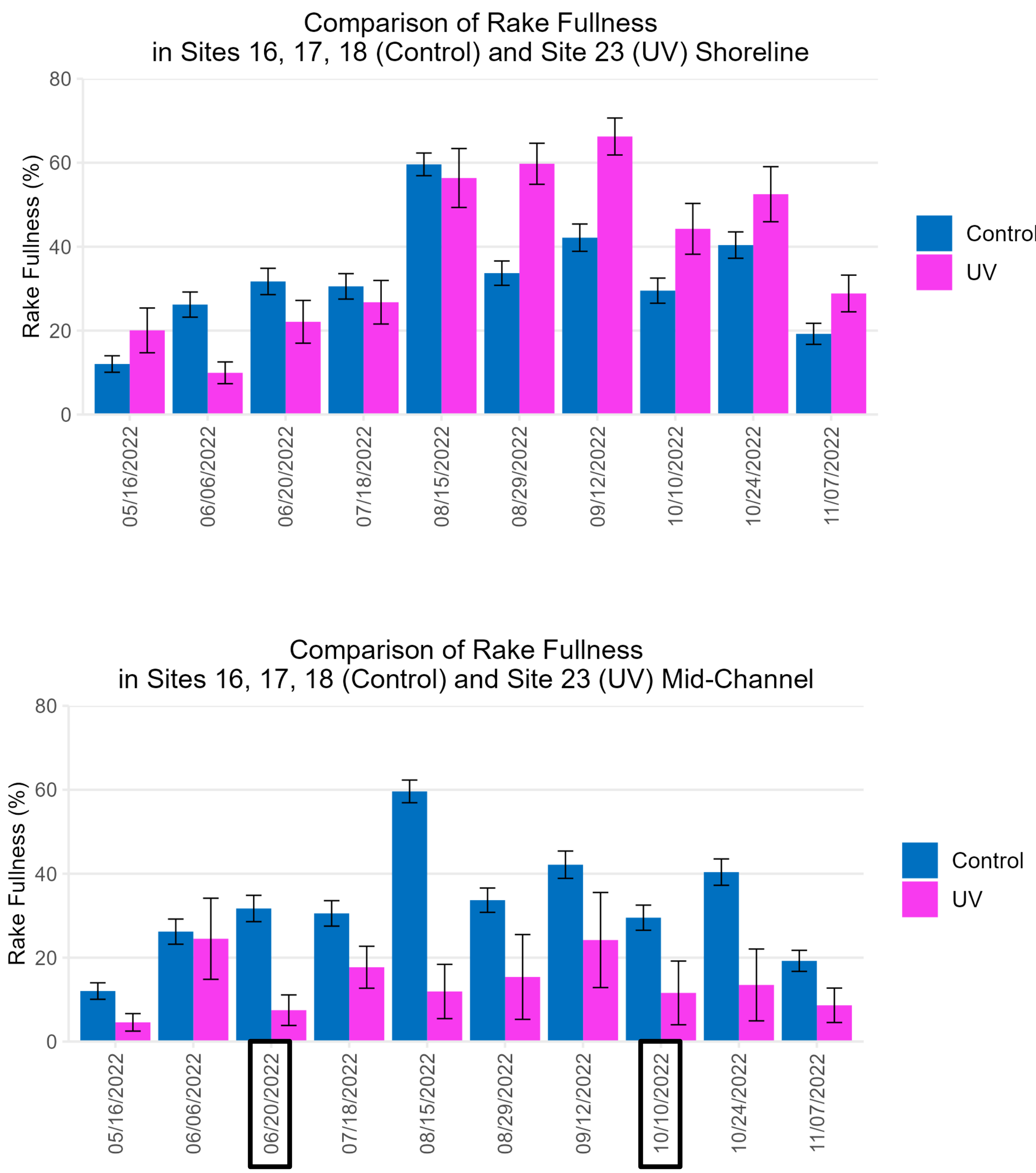
Across entire UV sites, rake fullness was lower than controls following treatment, but were highly variable with no consistent patterns (example Site 23 in **Figure 15**). Shoreline percent rake fullness varied greatly between UV sites with maximum values on the order of 30% to over 60% whereas mid-site fullness was at or below 20% (example Site 23 in **Figure 16**).

Using rake fullness as a proxy for biovolume, comparing UV sites against control sites results in a substantially greater number of instances of >75% reduction in biovolume in mid-site areas across all UV sites. Using this metric, UV treatments were successful in meeting the Project goal of >75% reduction in mid-site areas in all UV sites for several weeks in the summer, however, results were variable by site. The 75% reduction goal was not met in the near-shore areas.



Black boxes indicate nearest date of macrophyte assessment following 14 days post-UV treatment.

Figure 15. Average Rake Fullness in Sites 16, 17, 18 (Control) and Site 23 (UV) in the West Lagoon

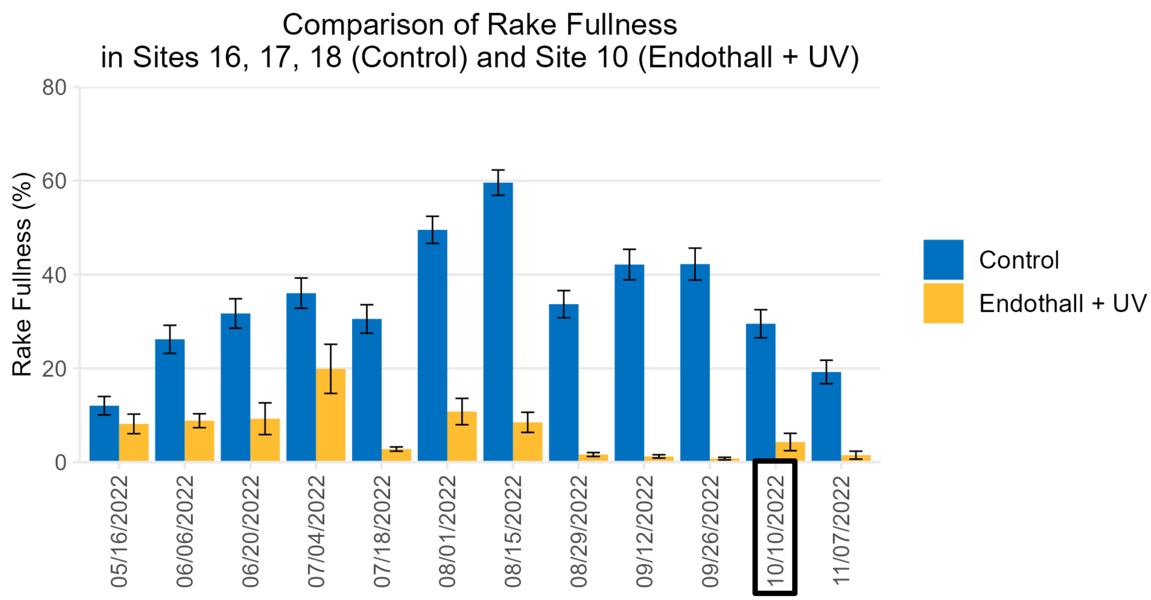


Black boxes indicate nearest date of macrophyte assessment following 14 days post-UV treatment.

Figure 16. Average Rake Fullness in Sites 16, 17, 18 (Control) and Site 23 (UV) Collected from the Shoreline (top) and Mid-Site (bottom) in the West Lagoon

Endothall + UV Sites

In general, biovolume and rake fullness trends were similar in Endothall + UV sites as the Endothall-only sites. Rake fullness was similarly low in Sites 10 and 11, at less than 20% or less through the season (example Site 10 in **Figure 17**). Similarly, Site 15 was very high in rake fullness as was biovolume, suggesting minimal treatment effects. It should be noted that rake sampling ended in late September but hydroacoustic based biovolume estimates continued into October. Rake fullness data further support a reduction in standing plant material in the Endothall sites per the Project goals.

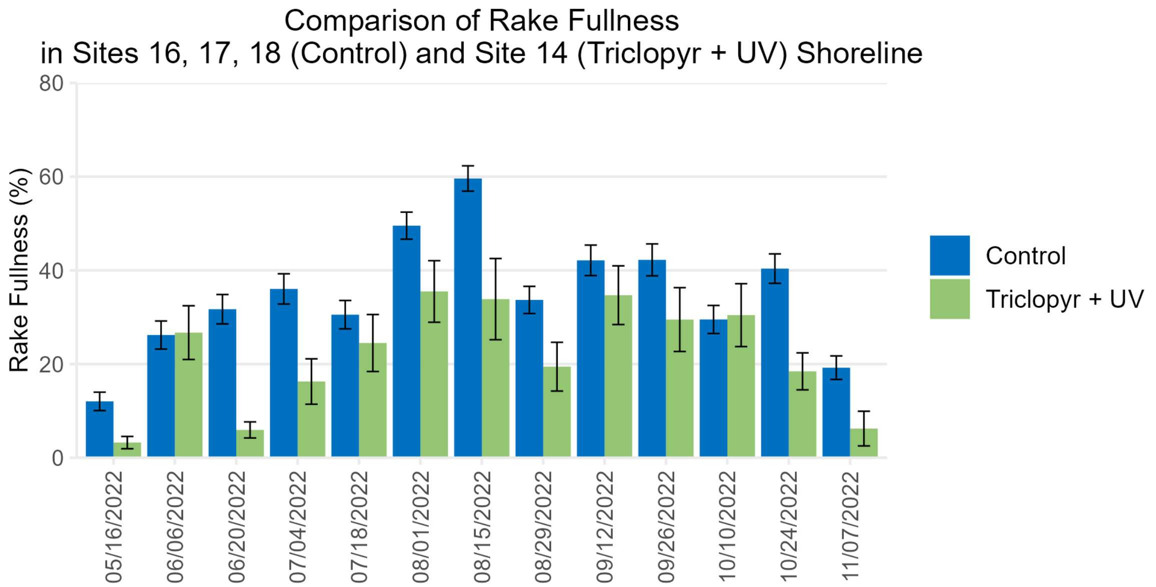


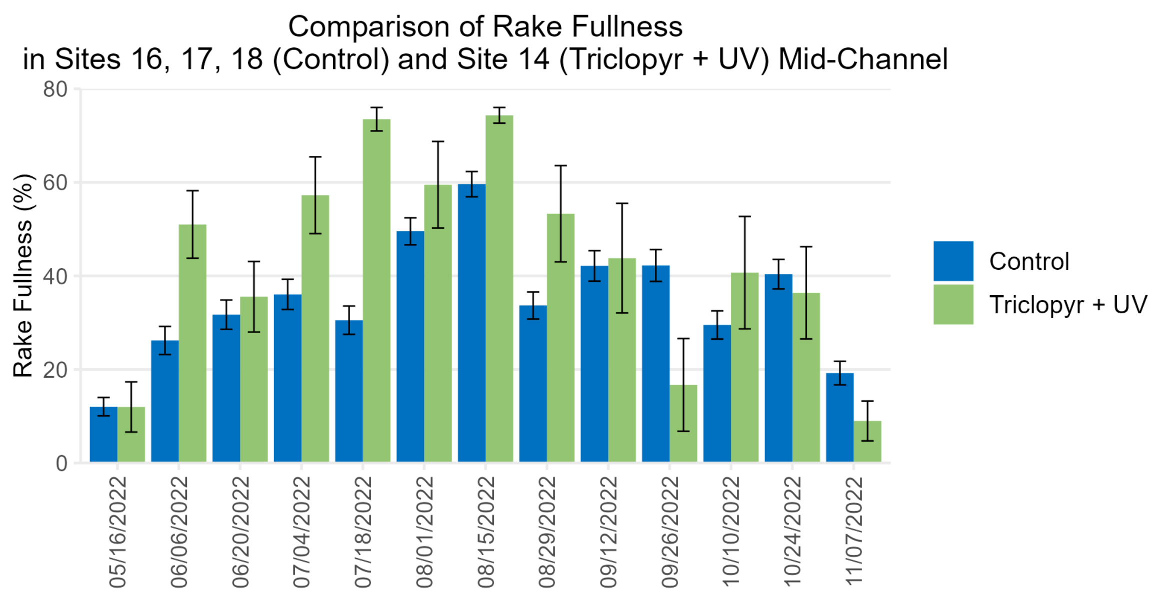
Black boxes indicate nearest date of macrophyte assessment following 14 days post-UV treatment

Figure 17. Average Rake Fullness in Sites 16, 17, 18 (Control) and Site 10 (Endothall + UV) Collected from the West Lagoon

Triclopyr + UV Sites

In general, biovolume and rake fullness trends were similar in Triclopyr + UV sites and the Triclopyr-only sites (example Site 14 in **Figure 18**). Note: intended UV treatments did not occur in these sites and Triclopyr applications (granular formulation rather than liquid formulation was used at the Triclopyr only treatment sites) occurred only along the shorelines. Unlike biovolume determined from hydroacoustic scans, rake fullness data support a reduction in standing plant material along the shorelines in in Triclopyr + UV sites per the Project goals.





Note: No UV light treatments occurred at the intended Triclopyr + UV sites.

Figure 18. Average Rake Fullness in Sites 16, 17, 18 (Control) and Site 14 (Triclopyr + UV) Collected from the Shoreline (top) and Mid-Site (bottom) in the West Lagoon

LFA Site 26

Unlike other CMT sites, rake fullness in LFA Site 26 had an opposite trend from biovolume collected from hydroacoustic scans (**Figure 19**). In fact, rake fullness in LFA Site 26 was up to 45% lower that control sites in October, perhaps due to the effects of harvesting.

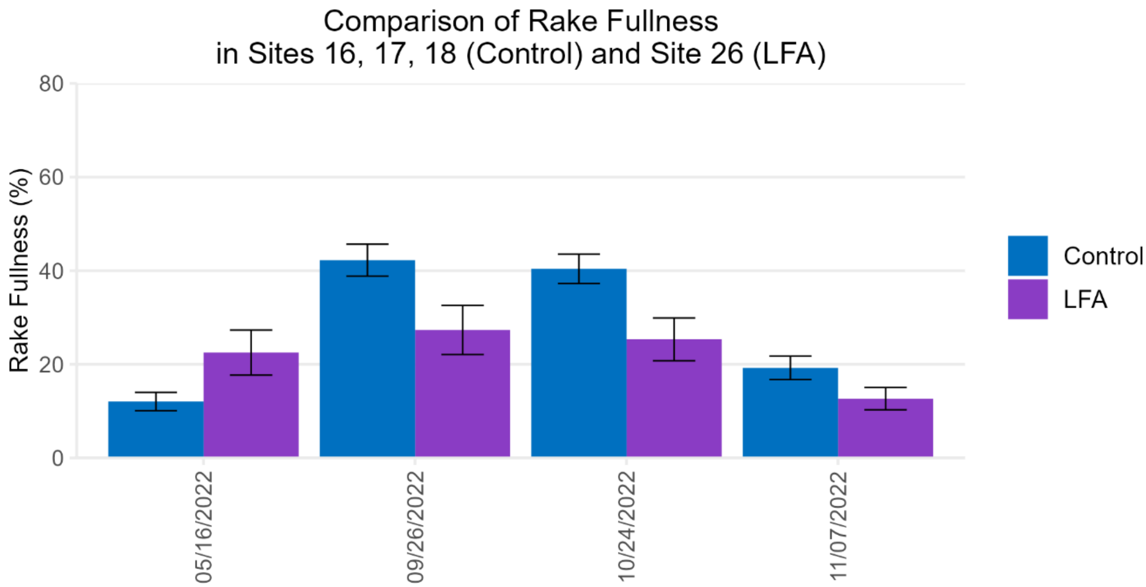


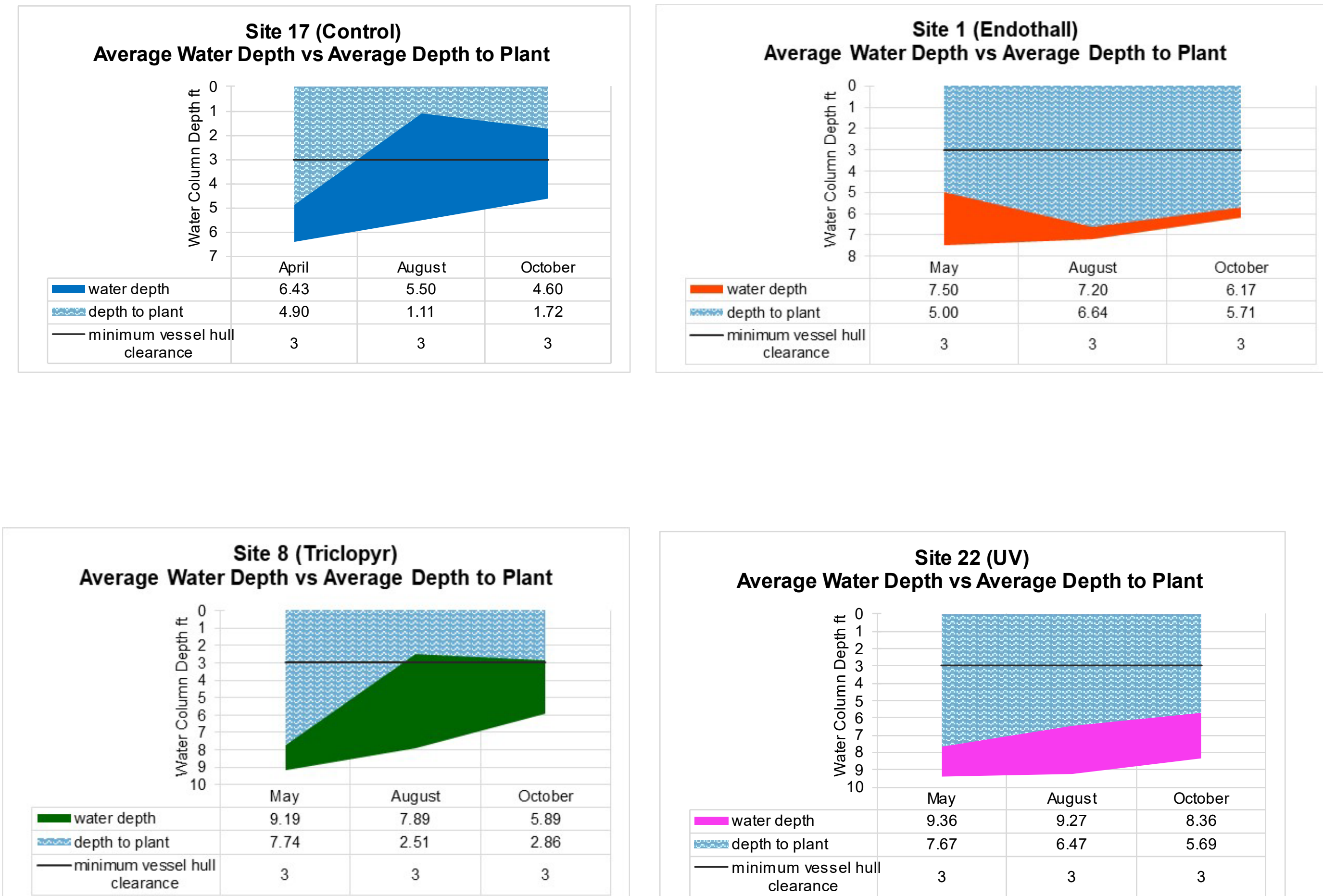
Figure 19. Average Rake Fullness in Sites 16, 17, 18 (Control) and Site 26 (LFA) in the West Lagoon

Vessel Hull Clearance

Results from vessel hull clearance assessments from mid-May (pre-treatment), August, and October 2022 were assessed using hydroacoustic data and provided by TKPOA. **Figure 20** provides examples of the average water depths across control, Endothall, Triclopyr, and UV sites along with the depth from the water surface to the top of the plant canopy (vessel hull clearance). The required 3-foot hull clearance depth is displayed for comparison. Pre-treatment, most all CMT sites had acceptable vessel hull clearance, likely due to the early date in the growing season. Following treatments, sufficient vessel hull clearance was achieved in Sites 1, 2, 3, 19 (Endothall), 5 and 9 (October only) (Triclopyr), 22, 23, 24 (UV), 10, 11 (Endothall + UV), and 12, 13, 14 (October only) (Triclopyr + UV) (**Table 14**).

In general, there was a correlation between reductions in biovolume and increased vessel hull clearance (Table 14); however, more sites reached the goal of 3-foot clearance compared to sites that reached the 75% reduction in biovolume. The very high reductions in vessel hull clearance in the Endothall sites was not surprising given the very high biovolume reductions in those sites (Table 7). Similarly, while Site 5 did not have sufficient biovolume reduction, it was the greatest reduction of all the Triclopyr sites (49% in early August). All UV sites had more than sufficient vessel hull clearance despite not reaching the 75% biovolume reduction (Table 10). Sites treated with Endothall + UV followed a similar pattern as biovolume, with Sites 10 and 11 achieving both Project goal metrics. Although sites intended for Triclopyr + UV were only treated with herbicide in May, efficacy was surprisingly high. In Site 12 there was good efficacy in terms of both vessel hull clearance and biovolume. Site 14 provided sufficient clearance despite biovolume being higher than controls in each two of the three months assessed here.

During peak boating season (August), adequate vessel hull clearance was not achieved in any of the control sites in the West Lagoon or Site 20 in Lake Tallac.



Source: TKPOA

Figure 20 Vessel Hull Clearance for Sites 17,1, 9, and 22. Source: TKPOA

TABLE 14
VESSEL HULL CLEARANCE. RESULTS IN GRAY AND BOLD INDICATE VESSEL HULL CLEARANCE GREATER THAN 3-FOOT

Site No.	Treatment	Average Depth to Plant Canopy (Ft.)		
		May 2022 (pre-treatment)	August 2022	October 2022
	West Lagoon			
1	Endothall	2.50	**6.64**	**5.71**
2	Endothall	**2.99**	**6.09**	**5.55**
3	Endothall	2.14	**8.21**	**6.74**
5	Triclopyr	2.14	**8.06**	**7.61**
8	Triclopyr	1.42	2.51	2.86
9	Triclopyr	2.52	2.10	**3.83**
10	Endothall + UV	**3.03**	**6.60**	**6.27**
11	Endothall + UV	1.64	**6.36**	**6.38**
12	Triclopyr + UV[a]	1.66	**9.43**	**8.56**
13	Triclopyr + UV[a]	1.84	2.10	**3.58**
14	Triclopyr + UV[a]	2.06	**3.15**	**4.85**
15	Endothall + UV	1.31	2.00	0.44
22	UV	1.72	**6.47**	**5.69**
23	UV	1.71	**6.65**	**6.37**
24	UV	1.50	**4.89**	**4.14**
26	LFA	1.65	1.05	1.17
16, 17, 18	Controls[b]	1.50	1.57	**3.15**
	Lake Tallac			
19	Endothall	1.93	**5.65**	**5.66**
20	Control	1.87	1.13	**4.87**

NOTES:
a Sites 12, 13, 14 were intended for UV treatment; however, they did not occur due to access issues
b Average of Sites 16, 17, and 18
SOURCE: TKPOA

Plant Health Condition

The presence of a plant species alone may not adequately assess a treatment effect. Whether the treatment is UV, herbicide, LFA, or no treatment (control), there is expected to be a lag-time (delay) from the time of treatments to the physical collapse and decomposition of a target plant. Additionally, natural plant senescence that occurs during late summer and early fall/winter is captured through the Plant Health Condition metric. The plant condition rating scheme was designed to provide a semi-quantitative metric to distinguish healthy plants (with no apparent treatment symptoms) from those with physically discernable symptoms or conditions. Plant health condition is not intended to describe the quantity or biomass of plant material, but simply the quality of the observed plants. Ratings of ≤3 are considered viable for future spread, while fragments rated at ≤2 are not considered viable.

Average plant health conditions of the West Lagoon control sites (16, 17, and 18) compared to the average of the CMT treatment sites are presented below. Since UV sites were not treated at the same time and were re-treated over time, those sites are summarized individually rather than presented as the average across all UV sites. Examples of plant health conditions from a limited number of sites are provided. The full suite of results may be found in **Attachment C**.

Endothall Sites

Compared to the average control sits in the West Lagoon, plant health condition of all the target species, as well as native plant species, at pre-treatment in the Endothall sites were very similar to or above a rating of 4 (example Site 2 in **Figure 21**). The greatest declines in plant health condition were observed in the first assessments after treatment and were most pronounced in Eurasian watermilfoil, followed by curlyleaf pondweed, and coontail. A dramatic increase in curlyleaf pondweed health condition late season is likely attributed to resprouting turions that were observed at that time. Plant health condition trends were similar across all Endothall treatment plots in the West Lagoon, including steady, but generally stable, declines in native plant condition. Discussed in more detail later, of all CMT sites, the Endothall sites had some of the highest native plant frequency of occurrence prior to treatment. Perhaps the indiscriminate targeting of curlyleaf pondweed with Endothall reduced the formation of turions for future growth in Years 2 and 3.

Trends of plant heath condition were similar in Lake Tallac; however, curlyleaf pondweed was not observed pre-treatment. In addition to previously described biovolume data, plant health conditions further support that Endothall applied to Site 19 dissipated into Site 21 (an intended control site for Lake Tallac). In general, the condition of most species was less in Site 21 compared to Control Site 20 (**Figure 22**).

Watershield (*Brasenia schreberi*), which was present in Lake Tallac, is ranked “2B.3” by the California Native Plant Society (CNPS). This designation indicates that a plant species is rare, endangered, or threatened in California, but common else where (2B), but about which more information is needed (3). Watershield health in Site 19 was similar to, and even slightly better than the nearest control Site 20, located on the other side of the barrier curtain (**Figure 23**).

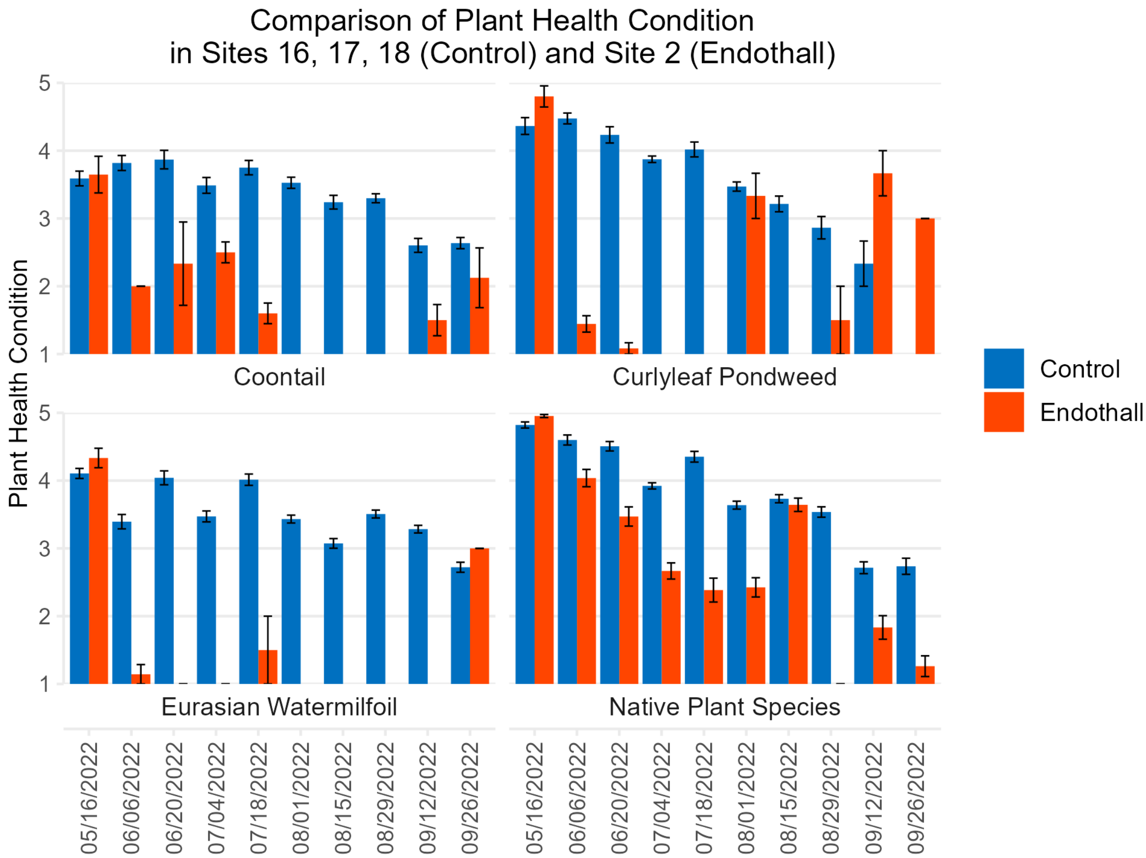


Figure 21 Example of Plant Health Condition of the Three Target Species and Native Plant Species in Site 2 Compared to the Average of the Control Sites (16, 17, 18) in the West Lagoon

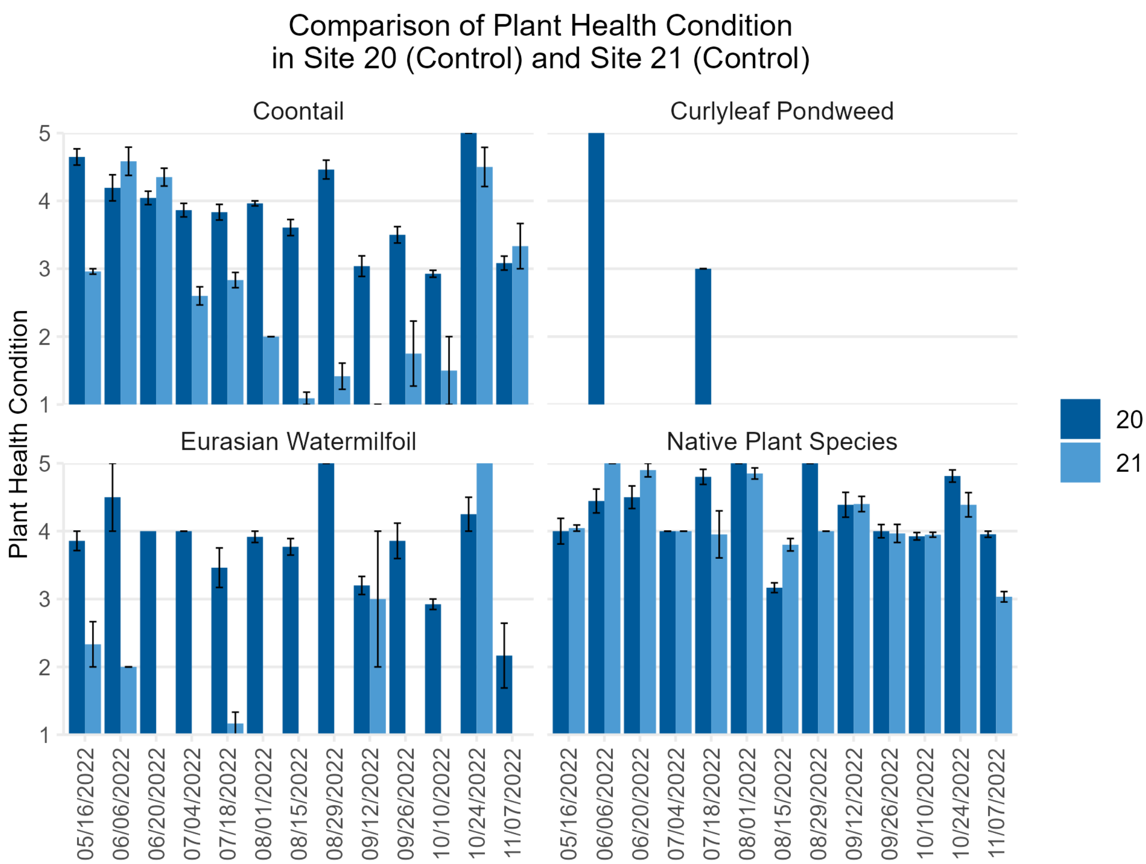


Figure 22 Average Plant Health Condition of the Three Target Species and Native Plant Species in Site 20 Compared to Site 21

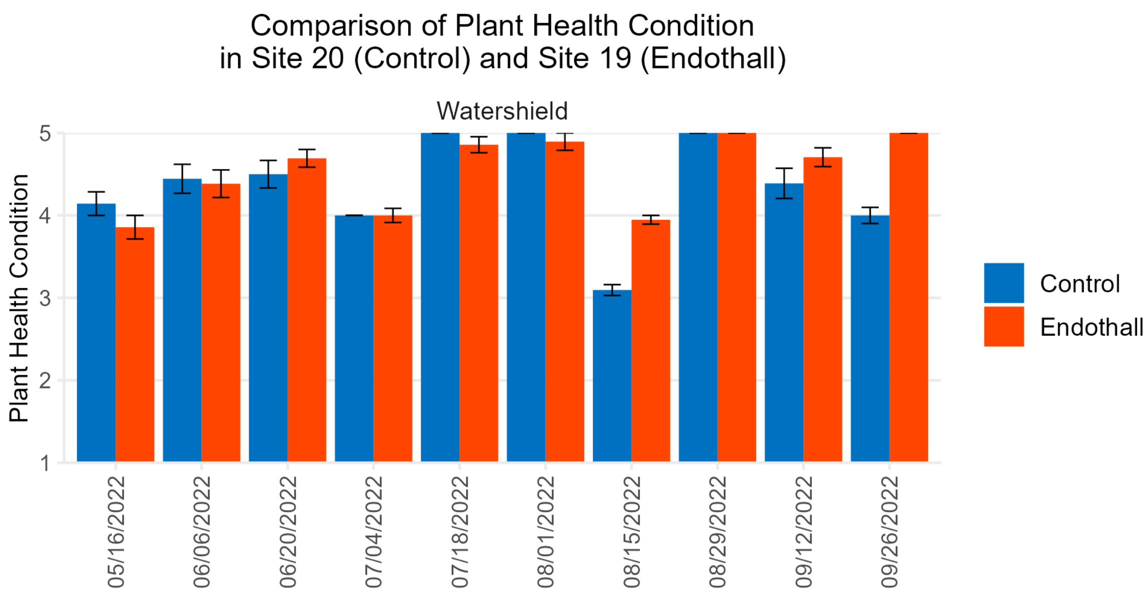


Figure 23 Example Watershield Plant Health Condition in Site 19 Compared to the Control Site (20) in Lake Tallac

Triclopyr Sites

Compared to the average control sites in the West Lagoon, plant health condition of all the target species, as well as native plant species, at pre-treatment were very similar to or above a rating of 4 in Site 5, but lower in Sites 8 and 9 (example Site 9 in **Figure 24**). The greatest declines in plant health condition were observed in the first assessments after treatment and were most pronounced in Eurasian watermilfoil. No impacts to the health condition of the other two target species or the native plant community were observed. Mid-summer, the health condition of Eurasian watermilfoil was on the order of 2 or 1, indicating that the plants were observed but that their viability was significantly compromised (Table 3). This was expected as Triclopyr is highly selective to Eurasian watermilfoil.

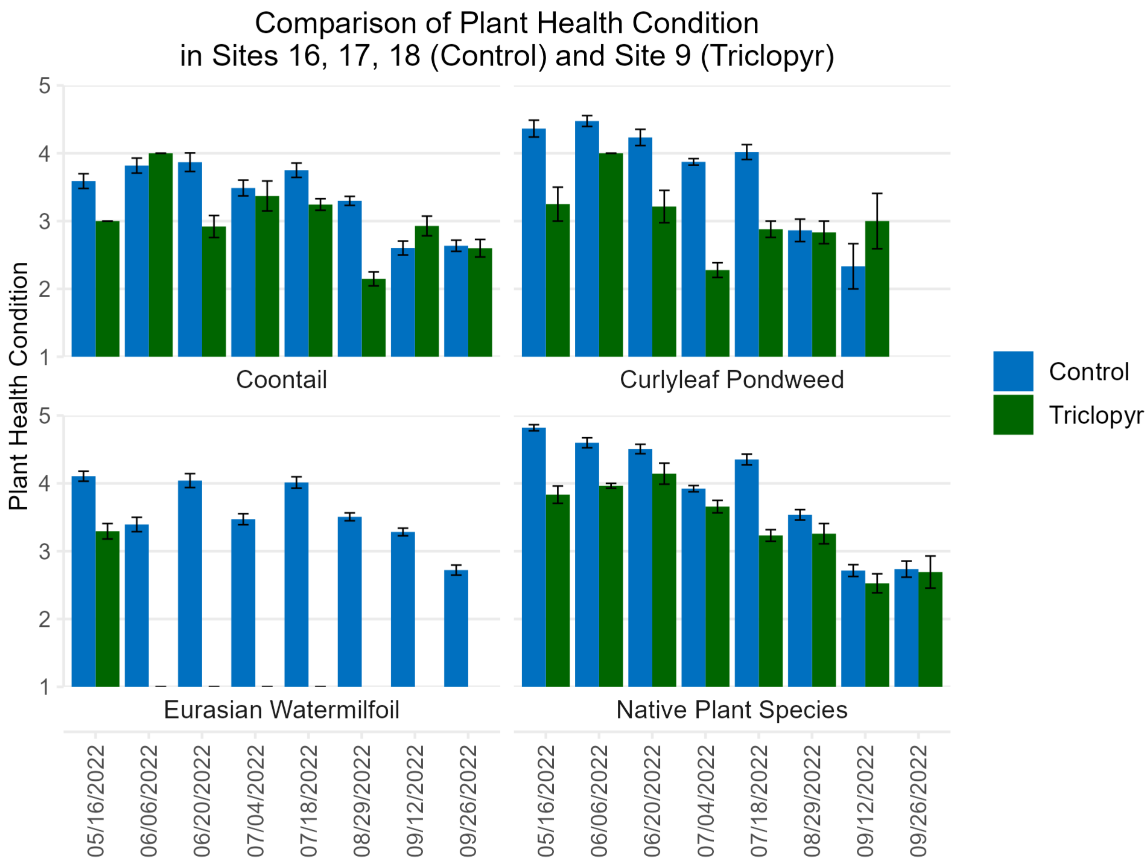
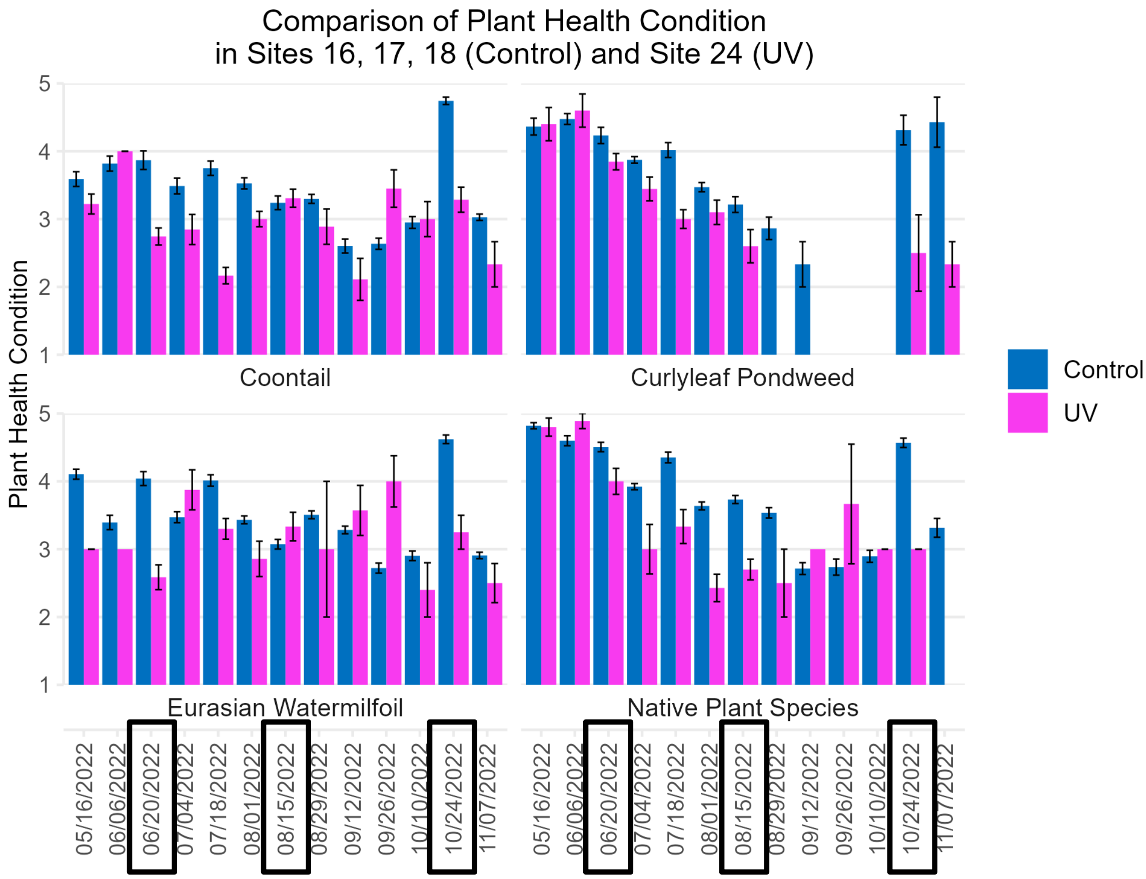


Figure 24 Example of Plant Health Condition of the Three Target Species and Native Plant Species in Site 9 Compared to the Average of the Control Sites (16, 17, 18) in the West Lagoon

UV Sites

Macrophyte assessments were conducted across entire CMT sites, including shorelines and mid-sites. However, for UV sites, only the mid-site data were included in the analysis of rake data. The UV system is unable to fully treat shallow shorelines and tight spaces between docks. Appendix AA in TKPOA (2023) more fully describes these limitations and provides maps of the specific treatment areas. Unlike the CMT sites treated with herbicides on one discrete date within a treatment type (Table 1), the schedules for UV treatments varied by site and were re-treated throughout the summer (Table 2), thus, plant health conditions are summarized by site rather than the average of all UV sites.

Compared to the average control sites in the West Lagoon, the plant health conditions of coontail and Eurasian watermilfoil were generally lower (or not detected mid-site) prior to UV treatments and curlyleaf pondweed health was similar to or lower than controls (example Site 24 in **Figure 25**). Following treatments, there were declines in target species health to levels below the average of controls and near ratings of 2, indicating the plant fragments observed were not likely to be viable. Similar patterns were observed for all target species and native plant species following each successive primary or spot treatment. Coontail in Sites 22 and 23, however, remained similar to the average control sites. Similar to Endothall treatments, which are also indiscriminate in effects across species, it may be that UV treatments prevented the formation of curlyleaf pondweed turions for future growth in Years 2 and 3. However, plant health ratings for native plants also declined (Figure 25), which probably reflects their susceptibility to the UV exposure and is also consistent with the reduction in frequency of occurrence of native plants (See Figure 32).

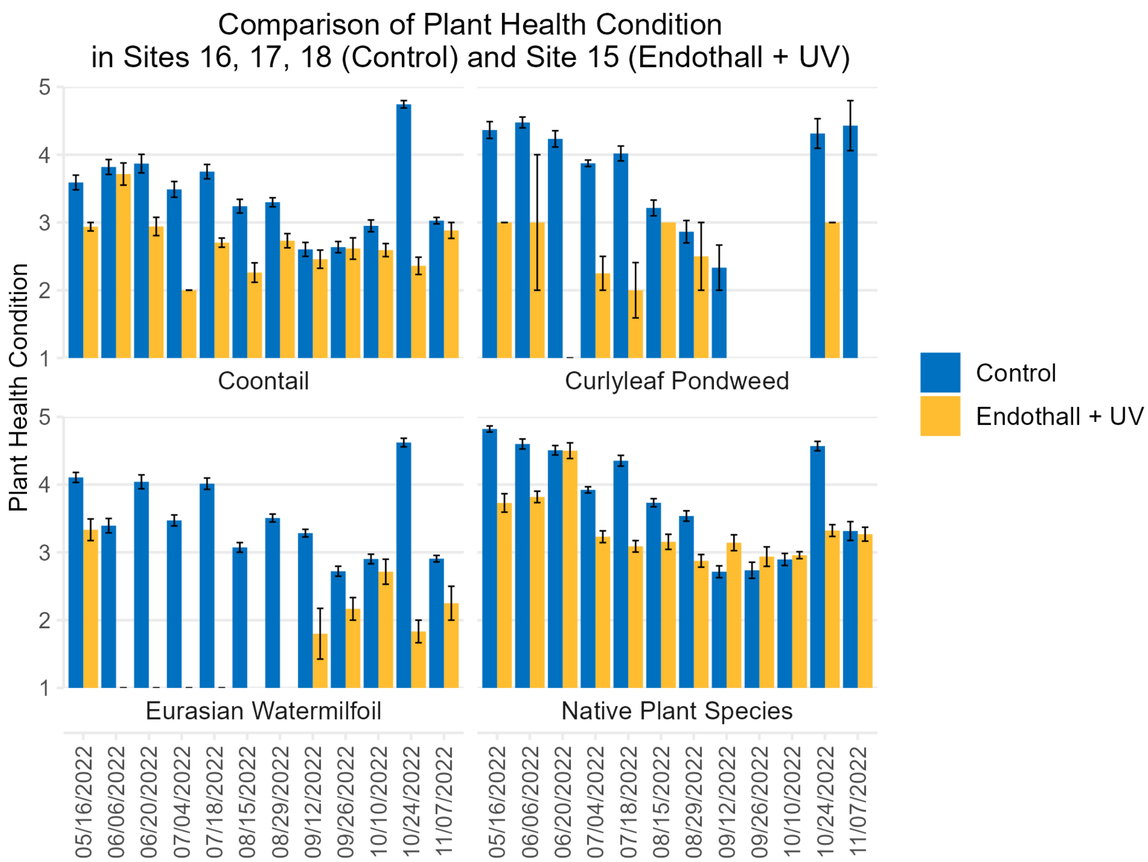


Black boxes indicate nearest date of macrophyte assessment following 14 days post-UV treatment. Sources: TKPOA and IRI Resources, Inc.

Figure 25 Example of Plant Health Condition of the Three Target Species and Native Plant Species in Site 24 Compared to the Average of the Control Sites (16, 17, 18) in the West Lagoon

Endothall + UV Sites

Compared to the average control sites in the West Lagoon, plant health condition of all the target species, as well as native plant species, at pre-treatment were very similar to or above a rating of 3 (example Site 15 in **Figure 26**) in the Endothall sites that were intended to also be treated with UV (Sites 10, 11, and 15). The greatest declines in plant health condition were observed in the first assessments after treatment and were most pronounced in Eurasian watermilfoil, followed by curlyleaf pondweed. A substantial decline in the plant health condition of coontail was not observed until approximately three weeks after treatment in Site 15; however, plant health conditions were nearer to a rating of 2 in Sites 10 and 11 during the first plant assessments following treatments. A dramatic increase in curlyleaf pondweed late in the season is likely attributed to resprouting of turions that were observed throughout the season. Plant health condition trends were similar across all Endothall + UV treatment plots in the West Lagoon, including steady, but generally stable, declines in native plants in Sites 10 and 11, but little differences in Site 15, particularly compared to the average control sites.

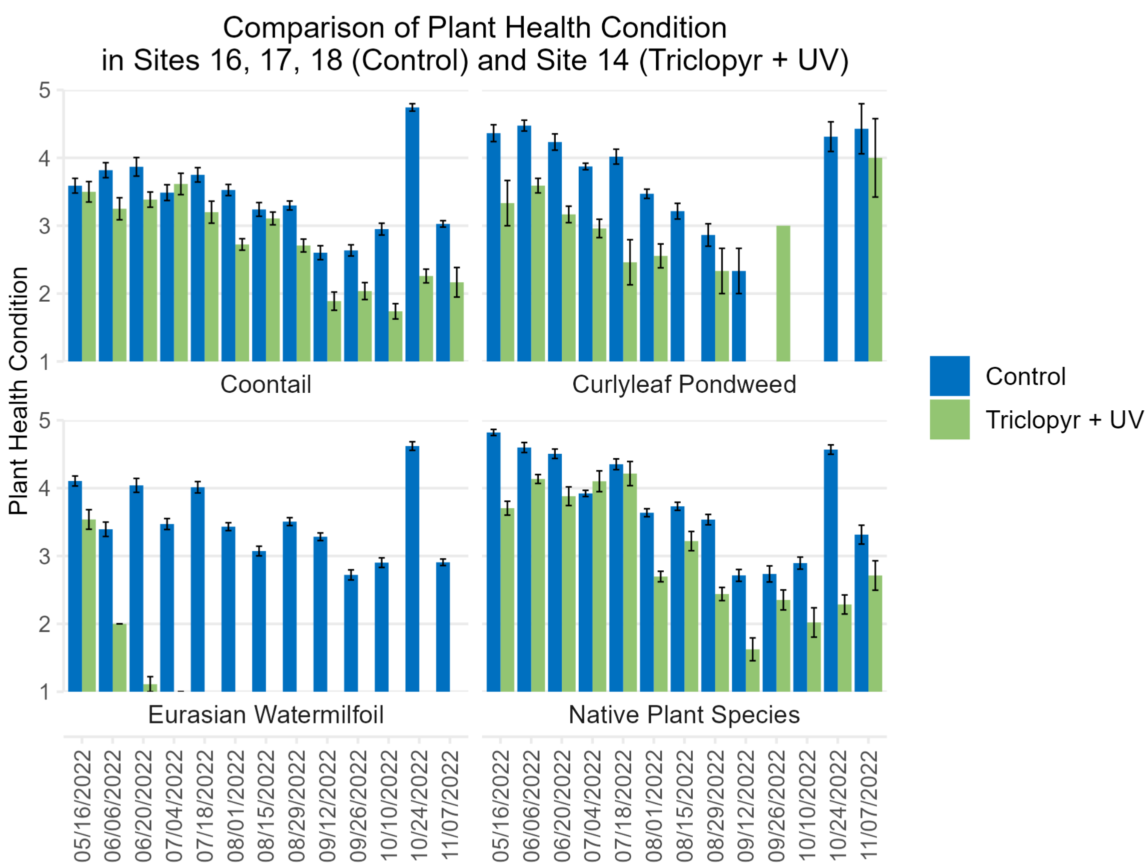


Black boxes indicate nearest date of macrophyte assessment following 14 days post-UV treatment

Figure 26 Example of Plant Health Condition of the Three Target Species and Native Plant Species in Site 15 Compared to the Average of the Control Sites (16, 17, 18) in the West Lagoon

Triclopyr + UV Sites

Compared to the average control sites in the West Lagoon, plant health condition of all the target species, as well as native plant species, at pre-treatment in the Triclopyr sites that were intended to also be treated with UV (Sites 12, 13, and 14) were very similar to or below a rating of 4 (example Site 14 in **Figure 27**). All Triclopyr + UV were slightly lower than the controls. The greatest decline in plant health condition was observed in Eurasian watermilfoil in the first assessments after treatment. In Site 12, the health of coontail was rated near 2 throughout much of the summer; however, more robust coontail was observed through September in other sites. This was expected as Triclopyr is highly selective to Eurasian watermilfoil.



Note: No UV light treatments occurred at the intended Triclopyr + UV sites.

Figure 27 Example of Plant Health Condition of the Three Target Species and Native Plant Species in Site 14 Compared to the Average of the Control Sites (16, 17, 18) in the West Lagoon

LFA Site 26

Compared to the average control sites in the West Lagoon, plant health condition of curlyleaf and native plant species were very similar to or above a rating of 4 in Site 26 during the first plant assessment conducted in May 2022 (**Figure 28**). The average plant health condition was near 2 for coontail and approximately 3 for Eurasian watermilfoil. With some exceptions, plant health condition was generally higher in the control sites compared to LFA Site 26. It should be noted that the LFA system has been in operation since 2019 thus no pre-treatment assessment occurred as part of the CMT monitoring.

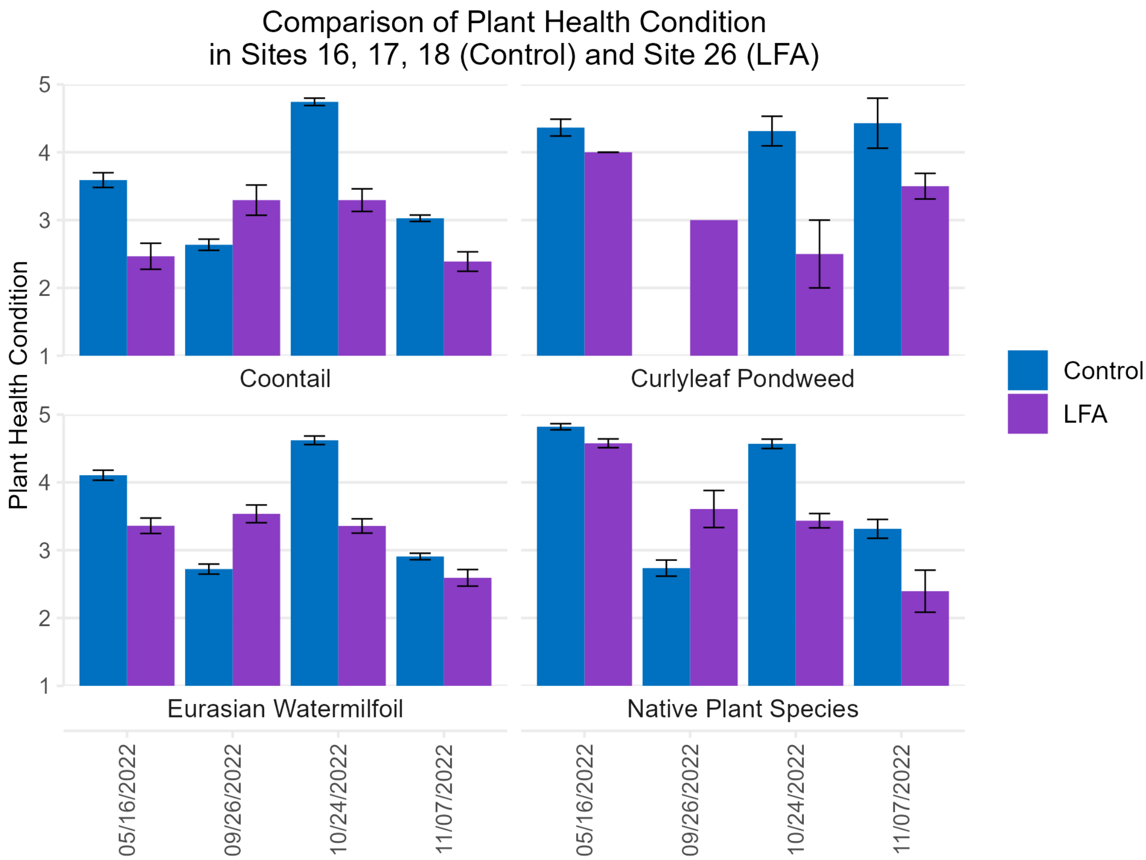


Figure 28 Example of Plant Health Condition of the Three Target Species and Native Plant Species in Site 26 Compared to the Average of the Control Sites (16, 17, 18) in the West Lagoon

Frequency of Occurrence

For areas with a high number of points (e.g., rakes), frequency of occurrence can be used as a rough approximation of percent cover (Madsen 1999) and, more importantly, describe species-specific treatment effects. Results are described by treatment type with examples that compare the average frequency of occurrence species at control sites to treatment sites in the West Lagoon. Lake Tallac treatment and control sites are considered separately. Similar to plant health condition, frequency of occurrence is not intended to describe the quantity or biomass of plant material, but simply the frequency of a particular species observed per site per site visit (e.g., curlyleaf observed on 10 rakes out of 30 rakes per site per visit). Plants with health condition ratings of ≤2 were not considered viable for future spread and were not included in the calculations of frequency of occurrence.

The average frequency of occurrence of the West Lagoon control sites (16, 17, and 18) compared to the average of a particular CMT treatment site is presented below. Since UV sites were not treated at the same time and were re-treated over time, however, those sites are summarized individually rather than presented as the average across all UV sites. Example frequency of occurrence results from a limited number of sites are provided below. The full suite of results may be found in **Attachment D**.

Endothall Sites

Compared to the average control sites in the West Lagoon, the frequency of occurrence of coontail in Endothall treatment sites (Sites 1, 2 and 3) was very similar prior to treatment in approximately 45% of samples (example of Site 1 in **Figure 29**). Following treatment, the occurrence of coontail declined dramatically in all three sites treated with Endothall. With the exception of mid-summer in Site 1, the frequency of occurrence of coontail remained low throughout the summer and into fall.

Pre-treatment, the frequency of occurrence of curlyleaf was approximately 50% or greater in all the Endothall sites, while the average of the control sites was around 25%. Following treatment, frequency of occurrence of curlyleaf declined dramatically in all treatment sites yet increased to at or above 75% in the control sites. The frequency of occurrence of native plants was lower in Sites 1 and 3 compared to the average of control sites; however, frequency of native plants was similar to control through the end of June in Site 2, generally declining thereafter. Canadian waterweed (*Elodea canadensis*) contributed the greatest to the native plant community in all Endothall sites. Beginning in August, frequency of occurrence in the control sites began to decline, presumably due to natural senescence. For sites that were monitored later into the year (e.g., combination and UV), the frequency of occurrence of curlyleaf increased again in October, presumably due to sprouting turions that were shed earlier in the season.

Prior to treatment, the frequency of occurrence of Eurasian watermilfoil was very similar between the average in control sites in the West Lagoon to Sites 2 and 3 at approximately 60%; however, occurrence was only 25% in Site 1. Following treatment, no Eurasian watermilfoil was observed in any Endothall treatment sites until September when occurrence was approximately 15% in Site 2.

Prior to treatment, the frequency of occurrence of native plant species was very similar between the average of the control sites compared to Site 1 at just under 75%; however, occurrence was near 100% in Site 2 and 30% in Site 3. Following treatment, frequency of occurrence declined to approximately 30% in Site 1, but only slightly declined in Site 2 and remained the same in Site 3. Sites 1 and 2 maintained near 50% frequency of occurrence of native plant species through September.

Frequency of occurrence in sites treated with Endothall demonstrate expected outcomes based on the lack of selectively of the active ingredient of the particular formulation of Endothall used (dipotassium salt). Having said that, Endothall has been shown to not significantly impact the native species Canadian waterweed *(Elodea canadensis*) (Skogerboe and Getsinger 2002; Sprecher et al. 2002). Canadian waterweed represented the highest frequency of occurrence of any native species in the West Lagoon.

Trends in frequency of occurrence were similar in Lake Tallac; however, curlyleaf pondweed was not observed at pre-treatment and the frequency of coontail was greater in Endothall treatment Site 19 compared to control Site 20. Following treatment, coontail and Eurasian watermilfoil declined dramatically while native plant species were observed with more frequency compared to the control site.

Similar to plant health condition, the frequency of occurrence of watershield in Lake Tallac Endothall treatment Site 19 was similar to or greater than the nearest control Site 20, located on the other side of barrier curtain (**Figure 30**).

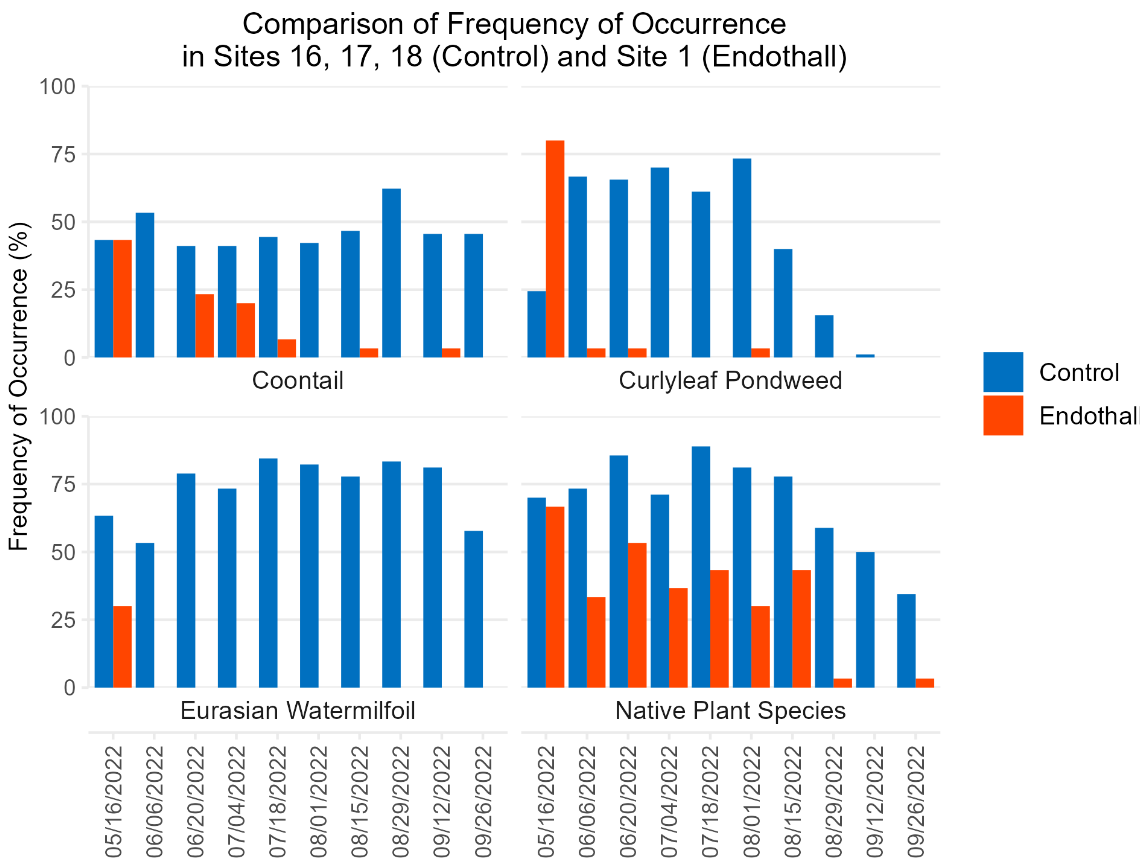


Figure 29 Example Frequency of Occurrence of the Three Target Species and Native Plant Species in Site 1 Compared to the Average of the Control Sites (16, 17, 18) in the West Lagoon

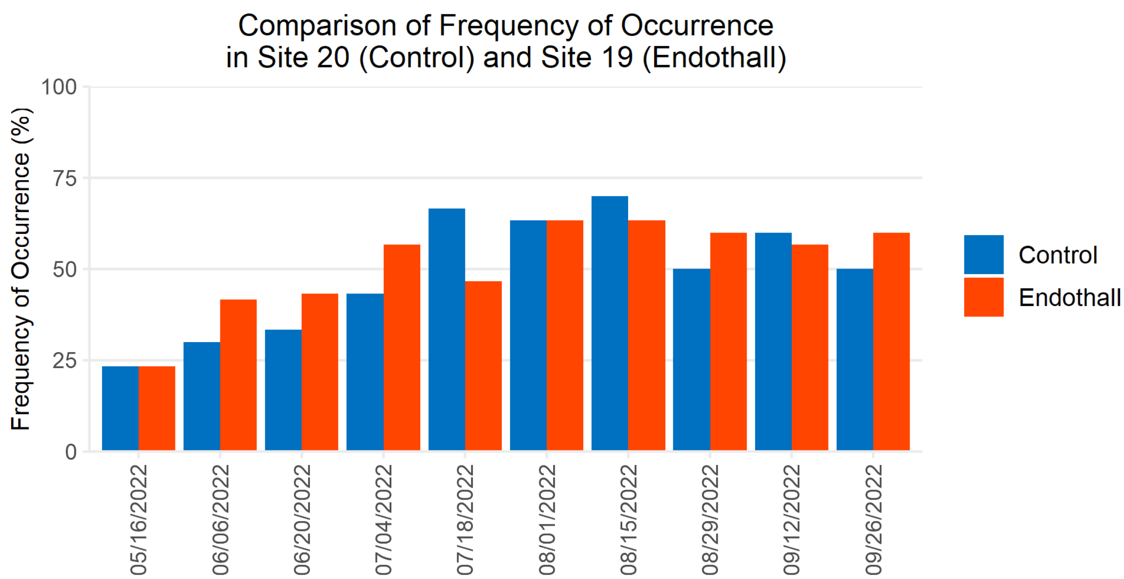


Figure 30 Example Frequency of Occurrence of Watershield in Site 19 Compared to the Control Site (20) in Lake Tallac

Triclopyr Sites

The frequency of occurrence of coontail in Triclopyr treatment Sites 8 and 9 were very similar to West Lagoon control sites prior to treatment at approximately 45% frequency of occurrence (example of Site 9 in **Figure 31**) while occurrence was nearly 75% in treatment Site 5. Following treatment, coontail frequency continued to increase to around 75% through September in Sites 8 and 9. In Site 5, there was a dramatic decline to less than approximately 10% in August. It is unknown what may have prompted such a sharp decline; however, coontail is not a rooted plant and the vegetation could have been moved out of the site by wind and currents.

Pre-treatment, the frequency of occurrence of curlyleaf pondweed was highest in Sites 5 and 9 at approximately 15% and not observed in Site 8. Following treatment, occurrence was consistently lower in the treatment sites compared to the mean controls in the West Lagoon, suggesting curlyleaf pondweed was not well-represented in the Triclopyr sites, even at pre-treatment.

Prior to treatment, the frequency of occurrence of Eurasian watermilfoil was similar between the West Lagoon control sites and the control sites, on the order of 45 to 55% occurrence. Following treatment, there no Eurasian watermilfoil was observed in Sites 5 and 9 and less than 10% occurrence in Site 8. Similar to the Endothall sites, occurrence remained very low throughout the summer.

Prior to treatment, frequency of native plant species was lower in all Triclopyr sites compared to the average controls. Following treatment, occurrence increased and remained above 50% in Sites 8 and 9 for much of the summer and was comparable to the average of control sites. Occurrence of native plants in Site 5 was generally at or below 50% throughout the season. Frequency of occurrence in sites treated with Triclopyr demonstrate expected outcomes based on the selectively of the active ingredient that targets Eurasian watermilfoil (Poovey et al. 2004).

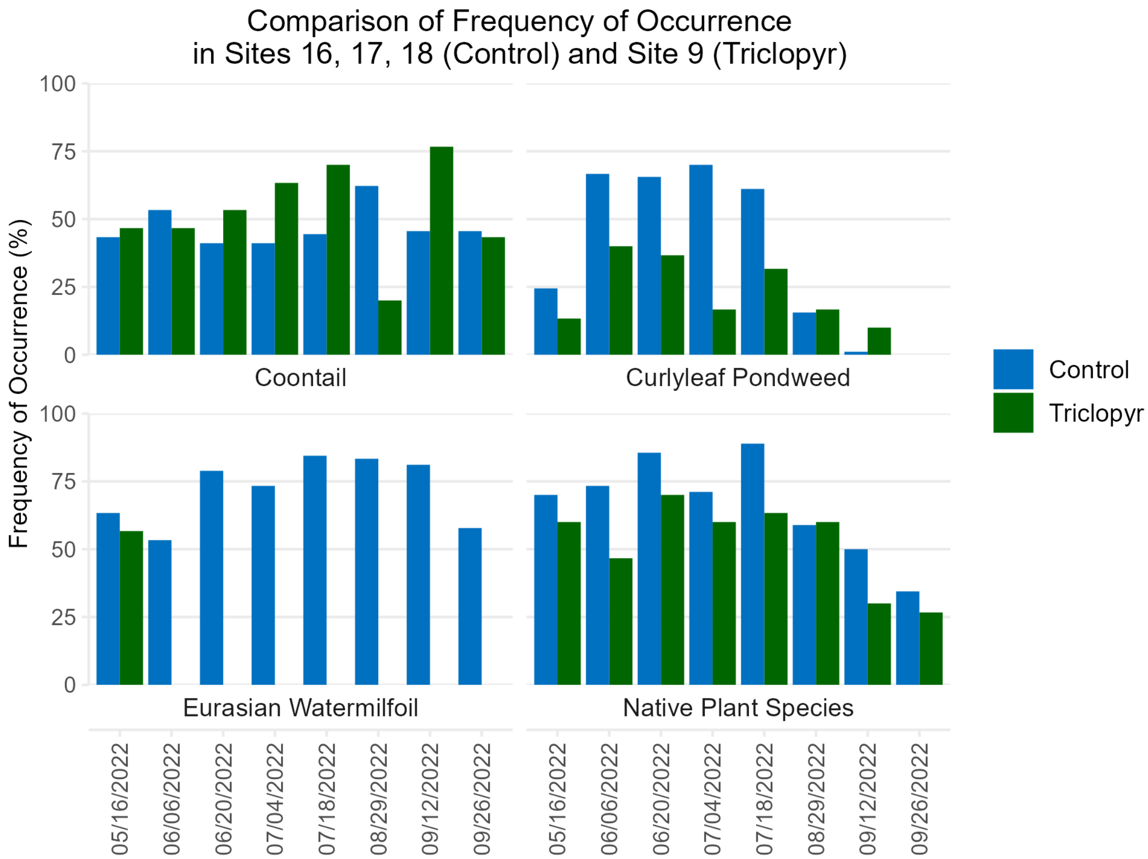


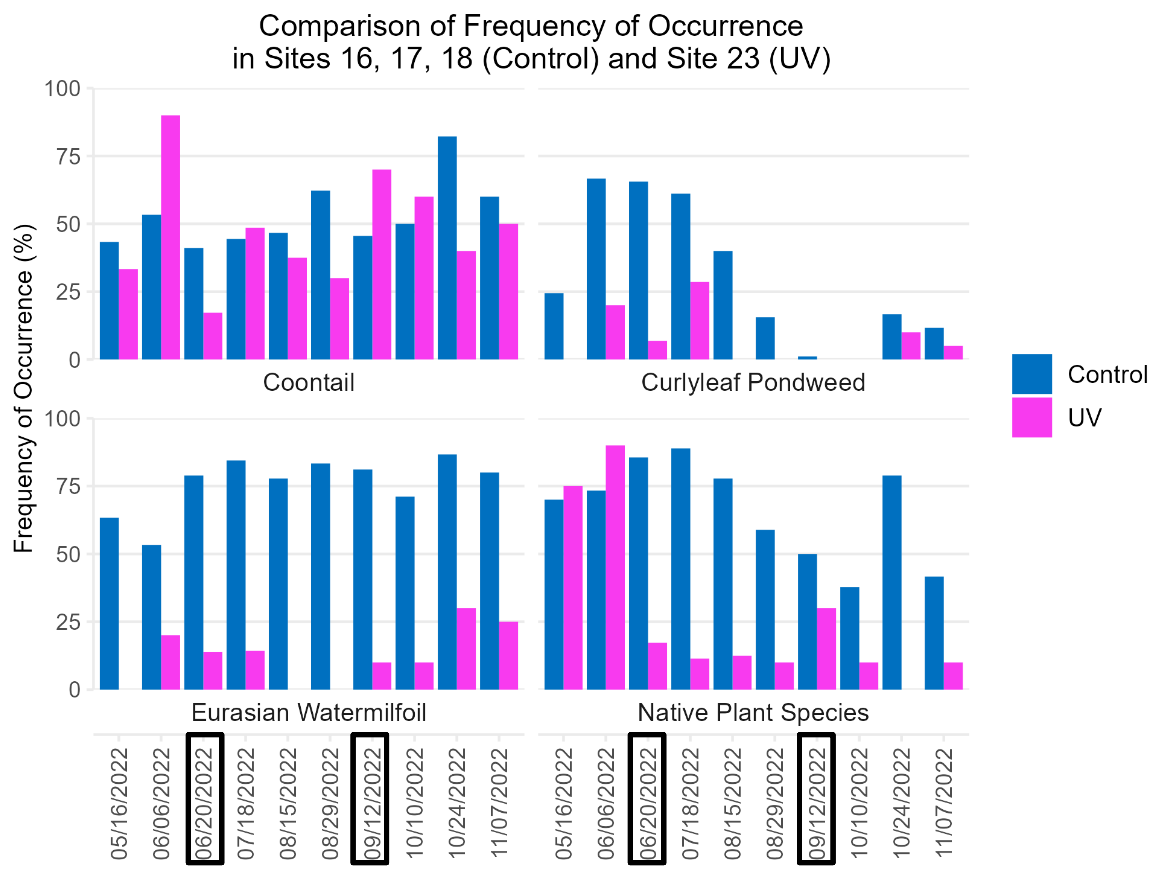
Figure 31 Example Frequency of Occurrence of the Three Target Species and Native Plant Species in Site 9 Compared to the Average of the Control Sites (16, 17, 18) in the West Lagoon

UV Sites

Similar to plant health condition, only the mid-site data were included in the analysis from UV sites. Species occurrence was assumed to be unaffected in areas of the UV treatment sites where the UV treatments were not applied. UV treatments occurred at varying times between sites (Table 2).

Compared to the average control sites in the West Lagoon, frequency of occurrence of coontail in UV Sites 22 and 24 was higher prior to treatments and slightly lower in UV Site 23 (example Site 23 in **Figure 32**). The occurrence of curlyleaf pondweed and Eurasian watermilfoil was highly variable between sites at pre-treatment compared to average controls. It should be noted that for all CMT sites, coontail tended to dominate the mid-site sample points while Eurasian watermilfoil was more common in shoreline sample points, which were not included in evaluations of UV sites. The frequency of native plants was near or above 75% in all UV sites prior to treatment. Native plant composition was largely comprised of Richard's pondweed (*Potamogeton richardsonii*), leafy pondweed (*Potamogeton foliosus*), and Canadian waterweed (*Elodea canadensis*).

There was a decline in coontail frequency of occurrence in Site 23 to levels below the average of controls following UV treatments. Plants rebounded slightly thereafter, however, indicating that repeated treatments were needed to maintain control. Frequency of occurrence of coontail remained around 30% for much of the season. As previously mentioned, coontail is not well-rooted and it is unknown whether plants could have moved in from the adjacent untreated areas. The response of curlyleaf pondweed was highly variable between UV sites and may be related to pre-treatment occurrence. For example, Site 23 had less than 25% frequency of occurrence pre-treatment and remained low throughout the season, while Sites 22 and 24 had initial frequencies near or greater than 50% and remained high until senescence in late summer (which overlapped with senescence is control sites). Similar to coontail, the frequency of Eurasian watermilfoil declined in all sites following treatments and rebounded after approximately one month in Sites 22 and 24 but remained low in Site 23. The occurrence of native plants declined in all UV sites to levels below the average controls. This is attributed to the relatively high number of instances of leafy pondweed (*Potamogeton foliosus)* on the rakes prior to treatment which was greatly reduced following treatment. After that, Canadian waterweed was the most frequently observed native plant species.



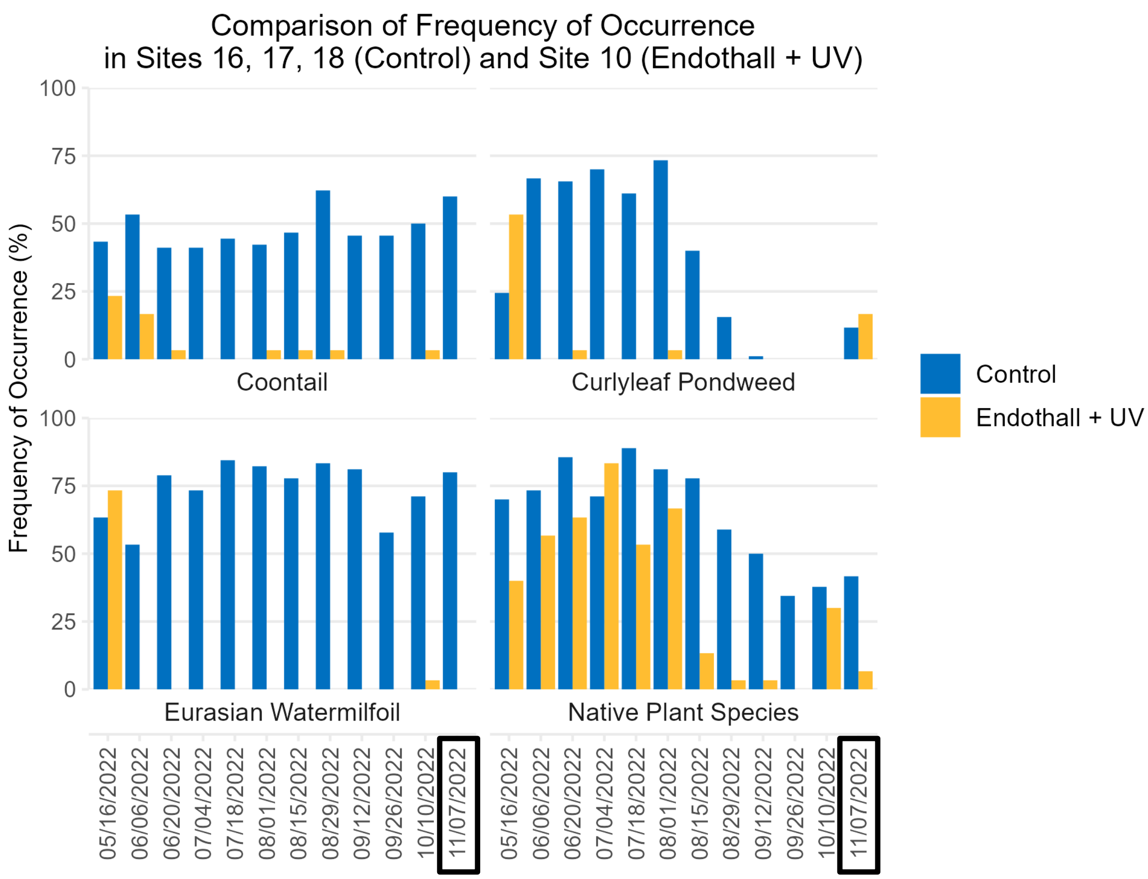
Black boxes indicate nearest date of macrophyte assessment following 14 days post-UV treatment.

Figure 32 Example Frequency of Occurrence of the Three Target Species and Native Plant Species in Site 23 Compared to the Average of the Control Sites (16, 17, 18) in the West Lagoon

Endothall + UV Sites

The frequency of occurrence of coontail in Endothall + UV treatment Sites 11 and 15 was very similar to the average of West Lagoon control sites prior to treatment and was approximately half in Site 10 (example of Site 10 in **Figure 33**). Following treatment, coontail declined dramatically in Site 10 but did not decline in Site 11 until late June. Occurrence remained similar to controls in Site 15 through most of the season.

Both curlyleaf pondweed and Eurasian watermilfoil conspicuously dropped from the water column soon after treatment as evidenced by the first assessments following treatment. The response of native plants was highly variable between the three sites, but their occurrence remained higher than controls in Site 15 but generally lower in Sites 10 and 11.

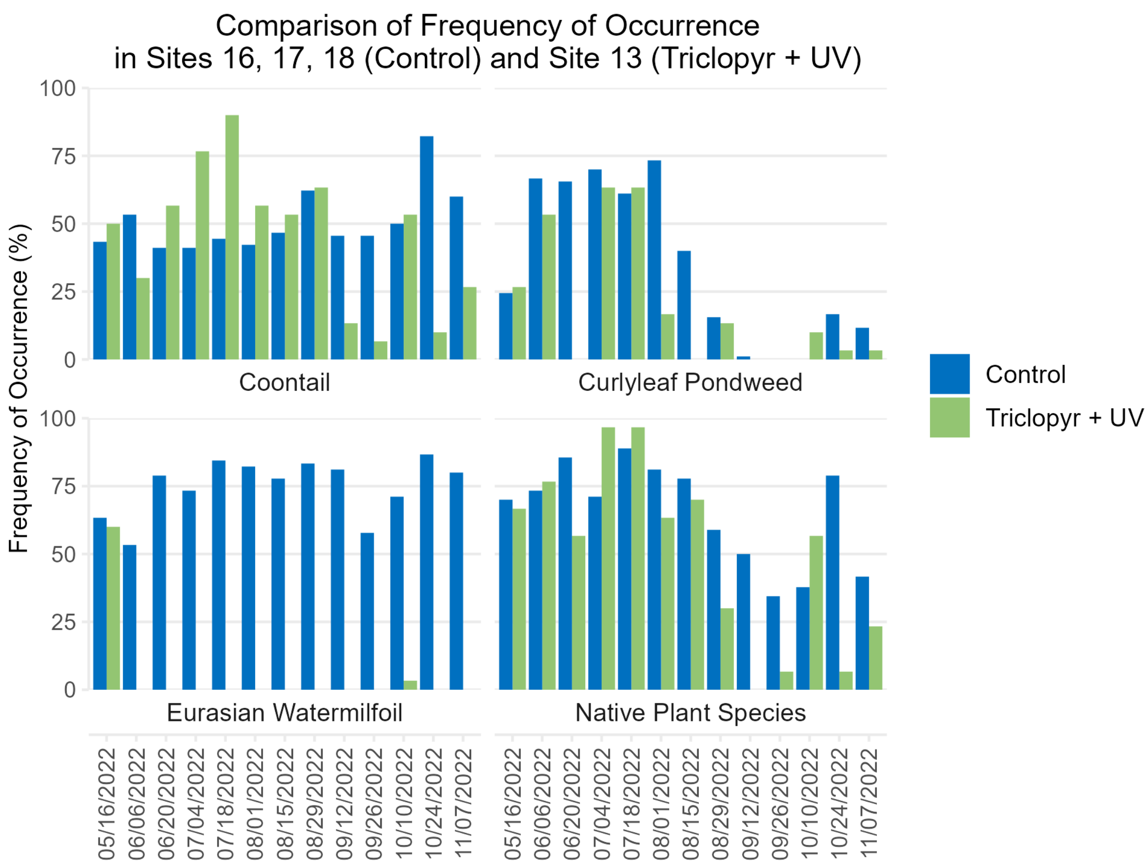


Black boxes indicate nearest date of macrophyte assessment following 14 days post-UV treatment.

Figure 33 Example Frequency of Occurrence of the Three Target Species and Native Plant Species in Site 15 Compared to the Average of the Control Sites (16, 17, 18) in the West Lagoon

Triclopyr + UV Sites

Due to access issues, no UV treatments occurred in Sites 12, 13, 14 which were intended for combination treatments. Prior to treatment, the frequency of occurrence for coontail, curlyleaf, Eurasian watermilfoil, and native species in Triclopyr + UV treatment sites was similar to frequencies in the West Lagoon control sites. Like the Triclopyr-only sites, the frequency of occurrence of Eurasian watermilfoil was completely absent from all sites after treatment and was not observed again until late summer (example Site 13 in **Figure 34**). Occurrence of coontail was very low throughout the season in Site 12 but at or over 50% in Sites 13 and 14 for much of the season. Occurrence of curlyleaf pondweed was low or absent for most of the season in Site 12 but at or over 50% in Sites 13 and 14. The native plant community had a low frequency of occurrence in Site 12 for much of the season, but occurrence was generally equal to or greater than control, particularly during peak summer months.



Note: No UV light treatments occurred at the intended Triclopyr + UV sites.

Figure 34 Example Frequency of Occurrence of the Three Target Species and Native Plant Species in Site 13 Compared to the Average of the Control Sites (16, 17, 18) in the West Lagoon

LFA Site 26

As previously mentioned, LFA Site 26 has been operating since 2019 thus no functional pre-treatment assessment was conducted. In general, frequency of occurrence of coontail was lower in LFA Site 26 compared to controls and was the only clear pattern compared to variable trends in target macrophytes and native macrophytes (**Figure 35**). Curlyleaf pondweed occurrence was higher early and late in the season while Eurasian watermilfoil occurred most often early in the season and declined in November. Occurrence of native macrophytes was very similar to controls throughout the season.

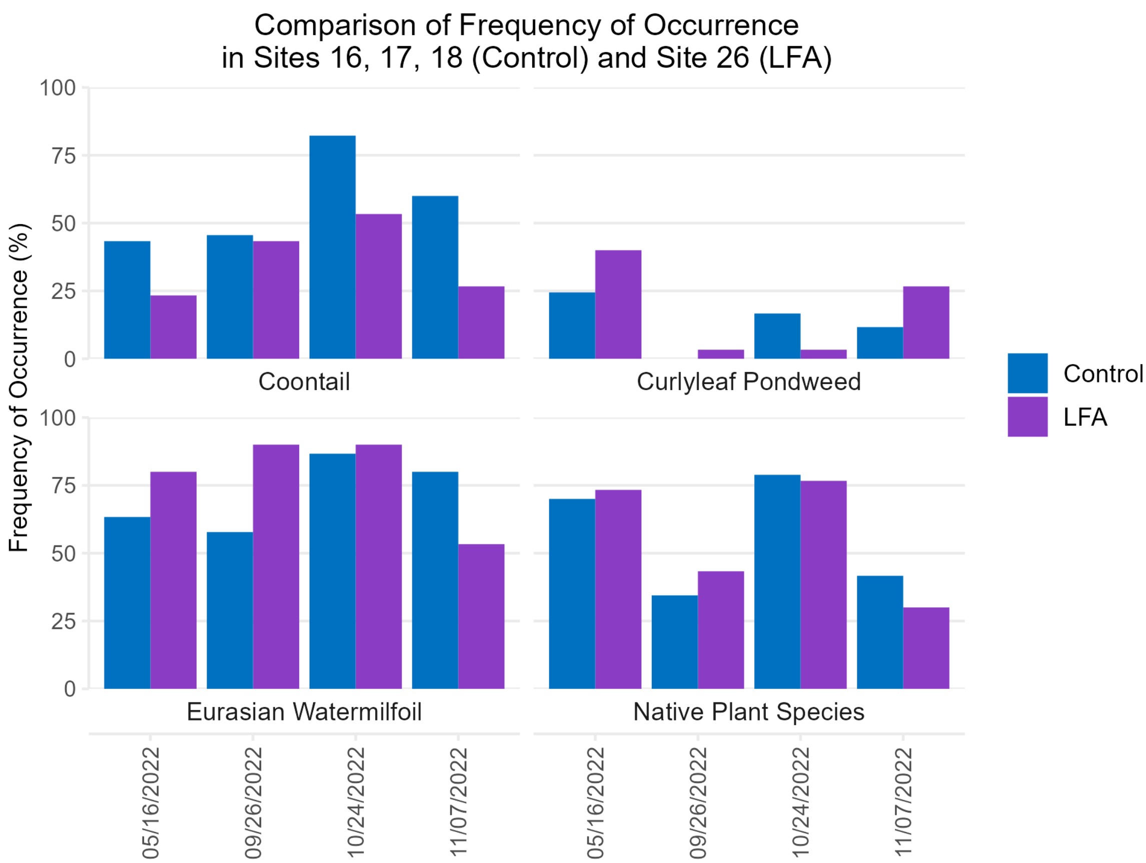


Figure 35 Example Frequency of Occurrence of the Three Target Species and Native Plant Species in Site 26 Compared to the Average of the Control Sites (16, 17, 18) in the West Lagoon

Percent Composition

Percent composition is the relative abundance of individual species in relation to all species observed, in this case, on each rake. Percent composition describes how common or rare a species is relative to other species and generally tracks frequency of occurrence; however, percent composition accounts for its relative contribution to all species on a rake, hence a site. Prior to treatment, percent composition of Eurasian watermilfoil in the West Lagoon control sites, for example, averaged 41% and ranged from 0 to 51% across all treatment sites.

Endothall Sites

Prior to treatments, percent composition of Eurasian watermilfoil in the Endothall sites ranged from 11 to 50%. Following treatments, composition was 0% for all sites except one instance of 3% observed in Site 2 late September (example Site 2 in **Figure 36**).

Prior to treatments, percent composition of curlyleaf pondweed in the Endothall sites ranged from 20.8 to 44.3%. Following treatments, composition was generally near zero with the exception of 3.7% in Site 2 in early August and up to 4.5% in September. It is assumed that these increases were due to resprouting turions as a similar trend was observed in the control sites later in the season. Sites 1 and 3 consistently had curlyleaf pondweed composition less than the controls.

Prior to treatments, percent composition of coontail in the Endothall sites ranged from 8 to 12.8%. Immediately following treatments, composition was near 0%, rebounded to 21.3% in early July, but declined to 4% or less thereafter. With the exception of early July, percent composition of coontail was less than controls.

The percent composition of native macrophytes were near or greater than controls for most of the season in all Endothall sites.

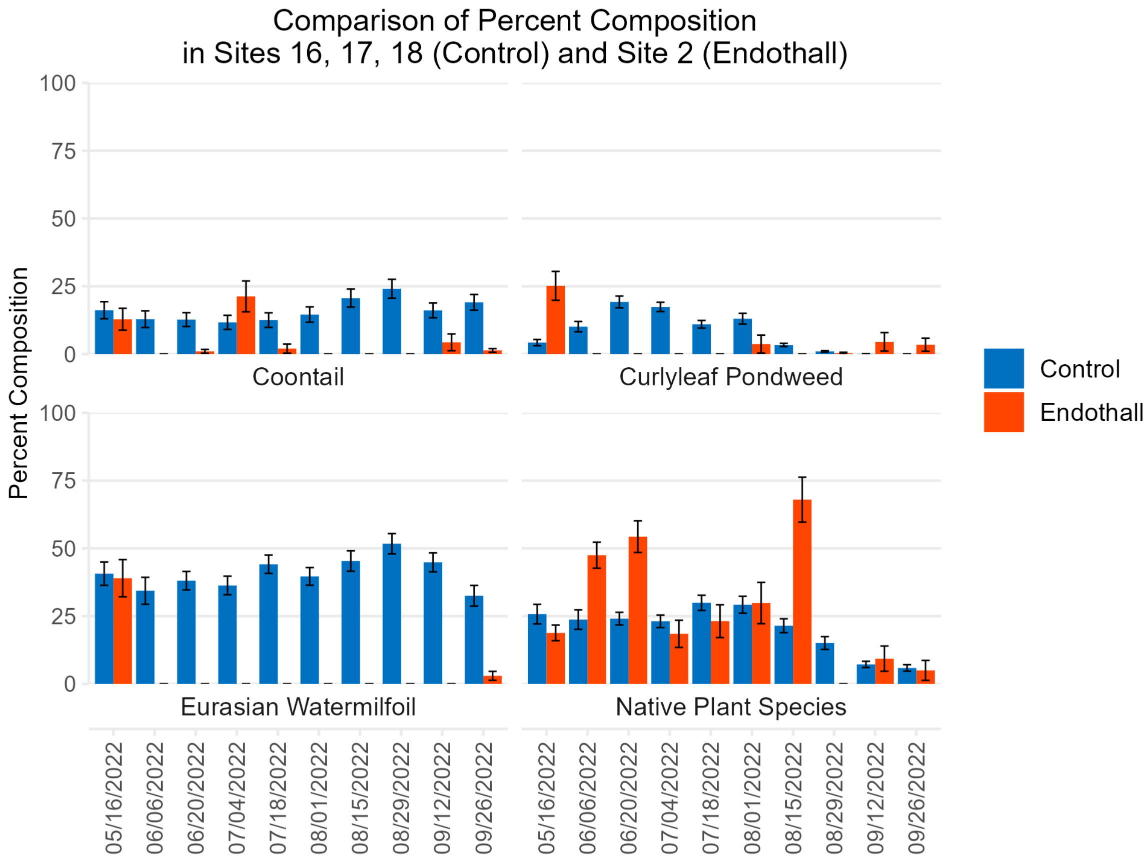


Figure 36 Example Percent Composition of the Three Target Species and Native Plant Species in Site 2 Compared to the Average of the Control Sites (16, 17, 18) in the West Lagoon

Triclopyr Sites

Prior to treatments, percent composition of Eurasian watermilfoil in the Triclopyr sites ranged from 14.4 to 34.7% (example Site 9 in **Figure 37**). Following treatments, composition was at or near 0% until late September when 3.4% was observed in Site 8.

Prior to treatments, percent composition of curlyleaf pondweed in the Triclopyr sites ranged from 0.0 to 5.9%. Following treatments, composition in Site 5 was at or near zero for the remainder of the season, which was unexpected as this site had the highest percent composition of curlyleaf prior to treatments and Triclopyr does not target curlyleaf. Herbicide residue data collected between Site 11 and Site 5 suggest incursion of Endothall from Site 11 could have resulted in concentrations to effect curlyleaf pondweed. Percent composition of curlyleaf in Sites 8 and 9 varied greatly and ranged from 0.0 to 12.5% and was generally similar to or less than controls.

Prior to treatments, percent composition of coontail in the Triclopyr sites ranged from 28.0 to 46.4%. Following treatments, composition continued to increase and far exceeded the average controls. This outcome is expected given that Triclopyr does not target coontail.

The percent composition of native macrophytes were near or greater than controls for most of the season in Sites 8 and 9 but was consistently lower in Site 5 even prior to treatment.

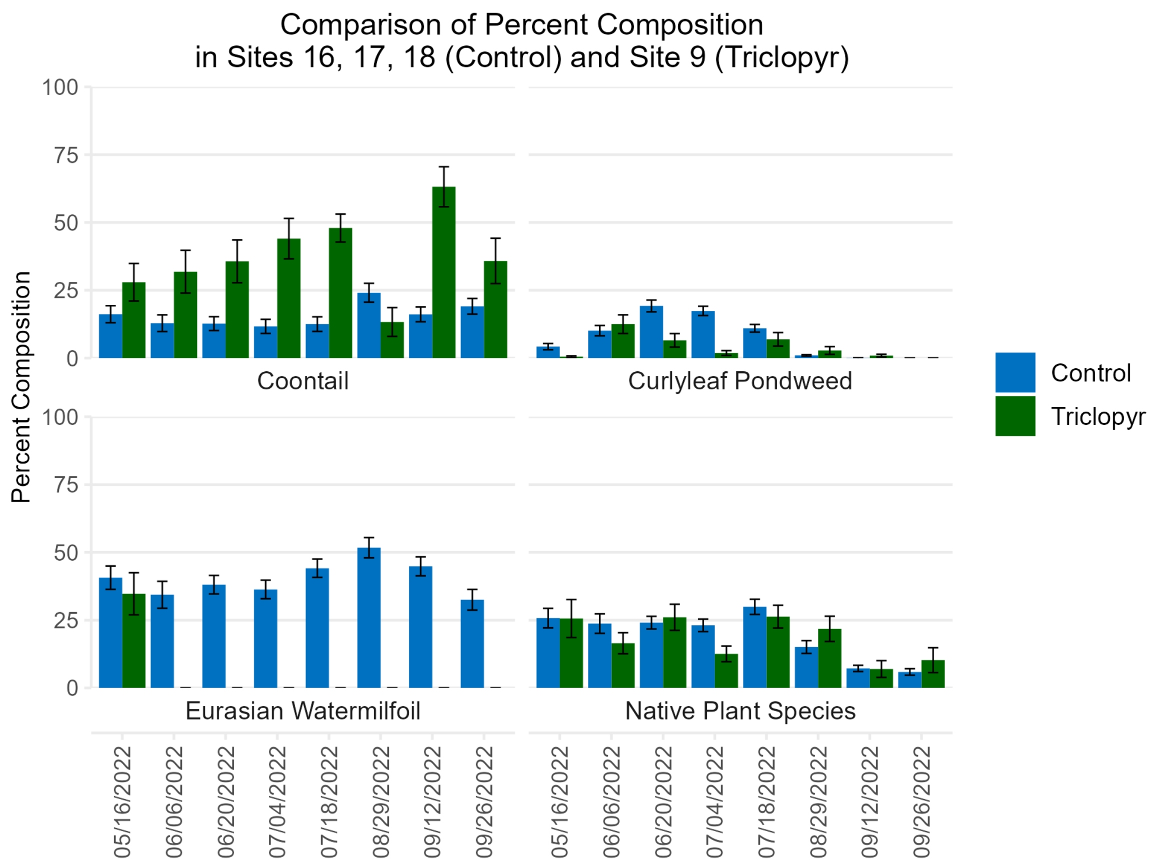


Figure 37 Example Percent Composition of the Three Target Species and Native Plant Species in Site 9 Compared to the Average of the Control Sites (16, 17, 18) in the West Lagoon

UV Sites

Prior to treatments, which were variable between UV sites, percent composition of Eurasian watermilfoil in the mid-site area ranged from 0 to 2% (example Site 24 in **Figure 38**). Following the variable treatments, percent composition of Eurasian watermilfoil ranged from 0 to 26.4%; however, it should be noted that, similar to frequency of occurrence, changes in percent composition were highly dependent upon proximity to the treatment dates. Percent composition of Eurasian watermilfoil in any UV sites never exceeded the average of control sites.

Prior to treatments, percent composition of curlyleaf pondweed in the UV sites ranged from 0.0 to 10.5%. Following treatments, composition declined over time in Site 22, remained low (as it started out) in Site 23, and the composition of curlyleaf pondweed in Site 24 was similar to control sites.

Prior to treatments, percent composition of coontail in the UV sites ranged from 0 to 45.0 %. Following treatments, composition of coontail declined the greatest in Sites 23 and 24, down to 10.9% and 4.8%, respectively. Despite this, the percent composition of coontail remained quite high in all UV sites. These high levels suggest that UV may have greater impacts on the more diminutive species (smaller stature) such as some of the native species, but also that the double-sided thatch rake preferentially captures the more robust coontail. Lastly, it is likely (or possible) that masses of coontail floated in from adjacent untreated areas.

The percent composition of native macrophyte species declined compared to controls in all UV sites.

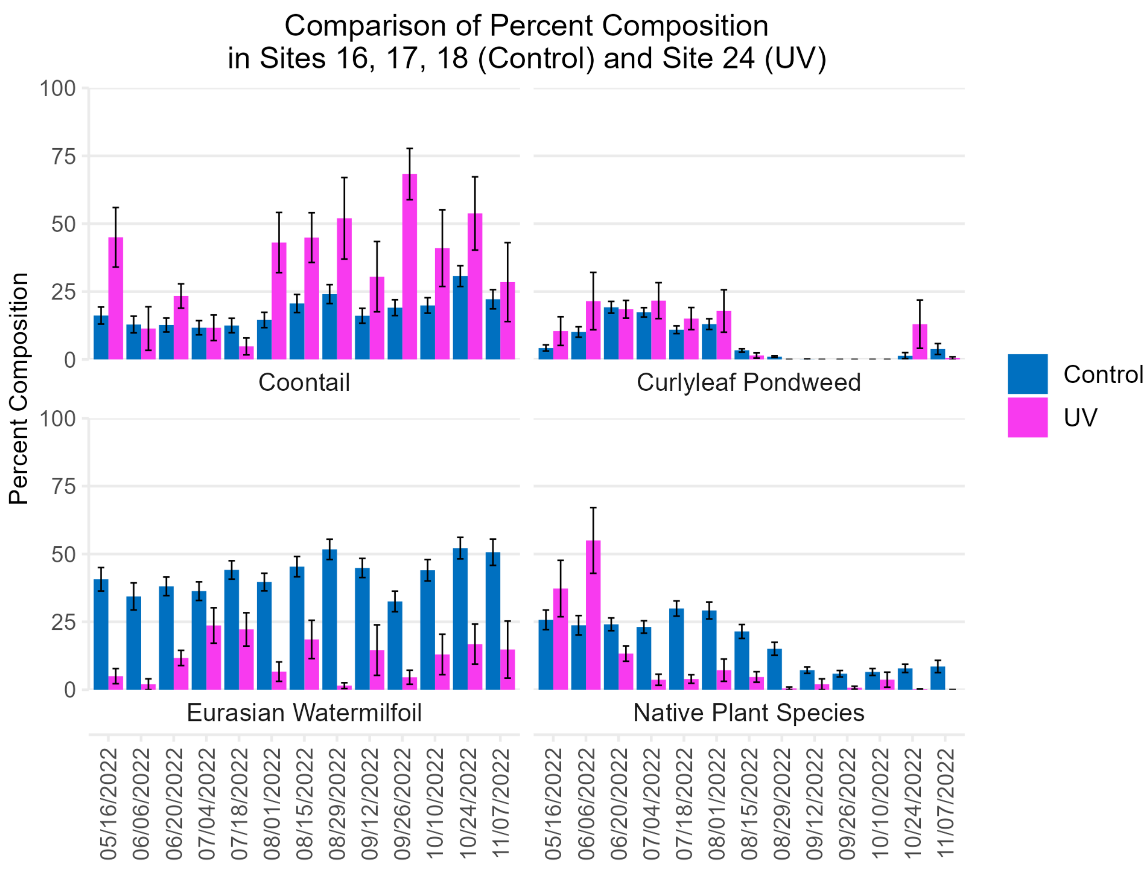


Figure 38 Example Percent Composition of the Three Target Species and Native Plant Species in Site 24 Compared to the Average of the Control Sites (16, 17, 18) in the West Lagoon

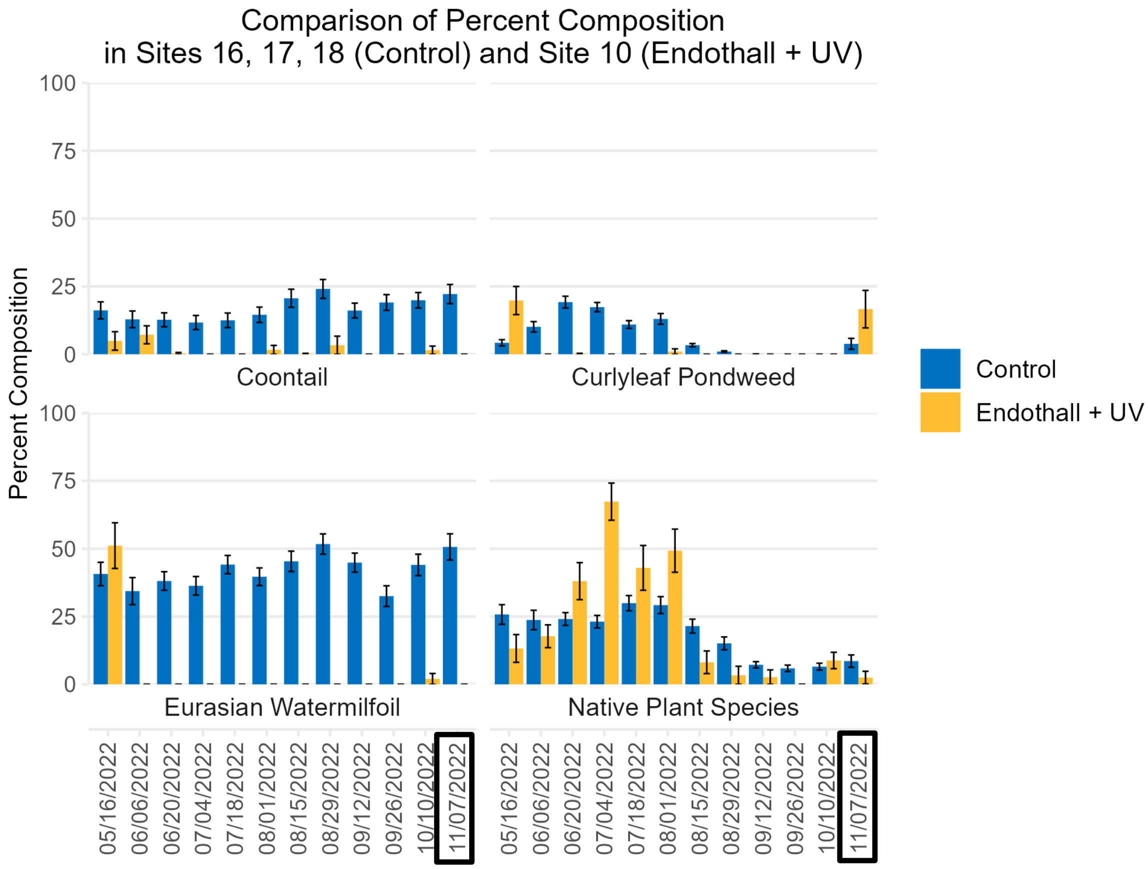
Endothall + UV Sites

Prior to treatments, percent composition of Eurasian watermilfoil in the Endothall + UV sites ranged from 30.9 to 51.1% (example Site 10 in **Figure 39**). Following treatments, percent composition of Eurasian watermilfoil was at or near 0% with the highest exception being 5.5% in Site 15 mid-October. Percent composition of Eurasian watermilfoil in any Endothall +UV sites never exceeded the average of control sites.

Prior to treatments, percent composition of curlyleaf pondweed in the Endothall + UV sites ranged from 1.2 to 19.8%. Following treatments, composition was at or near zero for much of the season until early November when the percent composition of curlyleaf pond weed was 16.6% in Site 10, presumably due to regrowth or plants floating in and establishing from non-treated areas. In general, composition was lower in the Endothall + UV sites compared to controls.

Prior to treatments, percent composition of coontail in the Endothall + UV sites ranged from 4.9 to 25.6%. Following treatments, composition in Sites 10 and 11, ranging from 0 to approximately 1.5% (one instance of 19.8% in late June), but ranged from 0 to 30% in Site 15. Given the efficacy of Endothall on coontail (as evidenced from Sites 1, 2, 3), it is assumed that the inconsistent responses between the Endothall sites may be due to mixing that occurred in Sites 10 and 11 that perhaps did not occur in Site 15 (Endothall was only applied to the shorelines in the combination site). More importantly perhaps is UV light treatments in the mid-site did not occur until late September/early October in Sites 10 and 11, but did not occur in Site 15, suggesting that a combination of Endothall + UV is a promising Group A method. Percent composition in Sites 10 and 11 were lower than the average controls; however, they were near or higher in Site 15 compared to controls.

Similar to Endothall-only sites, the percent composition of native macrophyte species was relatively high compared to controls, particularly during peak summer months.



Black boxes indicate nearest date of macrophyte assessment following 14 days post-UV treatment.

Figure 39 Example Percent Composition of the Three Target Species and Native Plant Species in Site 10 Compared to the Average of the Control Sites (16, 17, 18) in the West Lagoon

Triclopyr + UV Sites

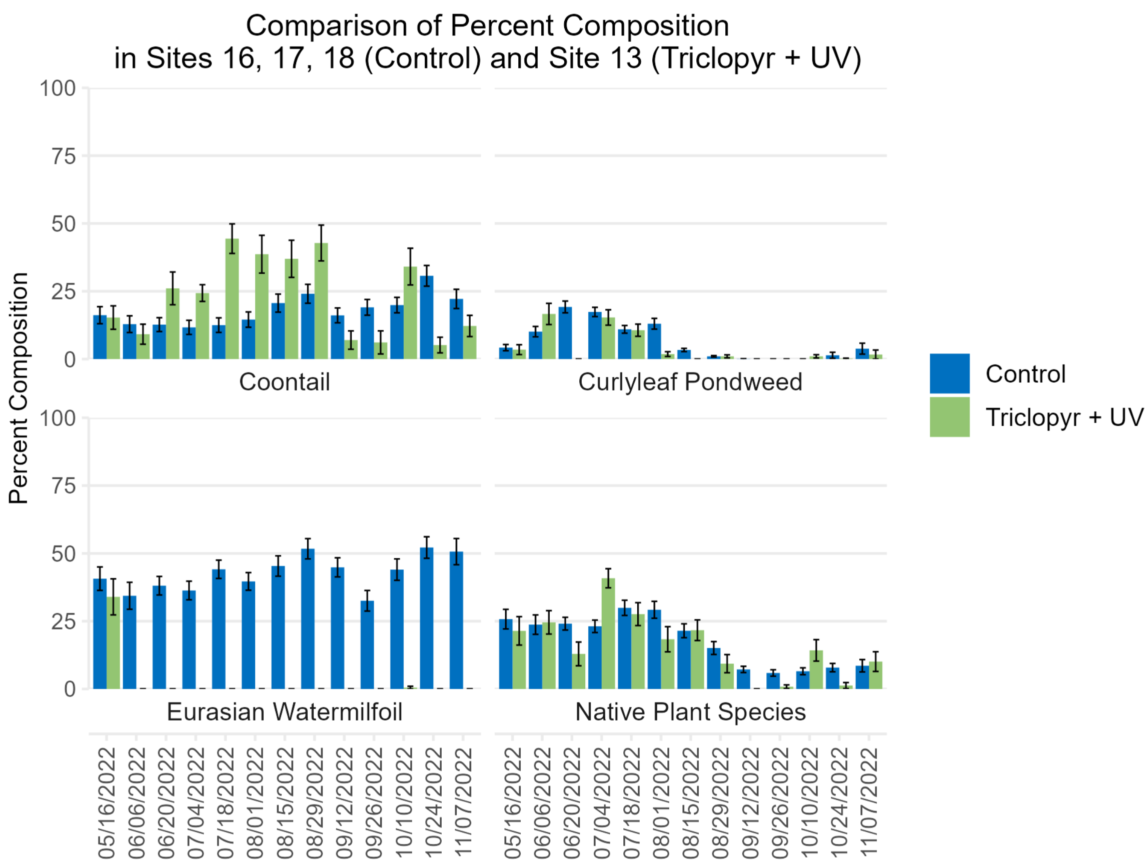
Prior to treatments, which did not include UV treatment with UV due to access issues, percent composition of Eurasian watermilfoil in the Triclopyr + UV sites ranged from 8.9 to 34.0% (sample Site 13 in **Figure 40**). Following treatments, percent composition of Eurasian watermilfoil was at or near 0% with the highest exception being 0.5% in Site 13 mid-October. Percent composition of Eurasian watermilfoil in any Triclopyr +UV sites never exceeded the average of control sites.

Prior to treatments, percent composition of curlyleaf pondweed in the Triclopyr + UV sites ranged from 3.2 to 9.1%. Following treatments, composition in Site 12 was at or near zero for the remainder of the season, which was unexpected as this site had the highest percent composition of curlyleaf prior to treatments and Triclopyr does not target curlyleaf. However, herbicide residue data collected between Site 10 and Site 12 suggest incursion of Endothall from Site 10 could have resulted in concentrations to effect curlyleaf pondweed.

Composition in Sites 13 and 14 were similar and ranged from 0.0 to 16.6%, similar to controls.

Prior to treatments, percent composition of coontail in the Triclopyr + UV sites ranged from 15.3 to 49.0%. Following treatments, composition varied greatly between sites and dates. Oddly, the site with the highest initial percent composition of coontail, Site 12 (49%) had the lowest composition throughout the season. Similar to the response of curlyleaf pondweed, Endothall incursion from Site 10 is the likely cause. Sites 13 and 14 were comparable, ranging from 2.2 to 55.8% with no discernible pattern. These sites routinely exceeded the composition of coontail compared to control sites.

In general, the percent composition of native plant species was very similar between the Triclopyr + UV sites and the control sites and followed similar seasonal trends. Pre-treatment, percent composition was on the order of 25%, increasing to near 50% mid-summer and declining to less that approximately 15% by end of season.



Note: No UV light treatments occurred at the intended Triclopyr + UV sites.

Figure 40 Example Percent Composition of the Three Target Species and Native Plant Species in Site 13 Compared to the Average of the Control Sites (16, 17, 18) in the West Lagoon

LFA Site 26

In May 2022, the percent composition of Eurasian watermilfoil in LFA Site 26 was 33.5% (**Figure 41**). This site was monitored again mid-September, late October, and early November. During that time, percent composition of Eurasian watermilfoil ranged from 33.6 to 58.3%, exceeding composition in control sites. In May, percent composition of curlyleaf pondweed in LFA Site 26 was 9.7 %. Later in the year, composition ranged from 0 to 3.4%, near or less than the average of control sites. In May, percent composition of coontail in LFA Site 26 was around 12 %. Later in the year, composition ranged from 13.3 to 21%, near or less than the average of control sites.

The percent composition of native plant species in LFA Site 26 was similar to the control sites in May, exceeded the composition of controls in September and October, but was lower in November.

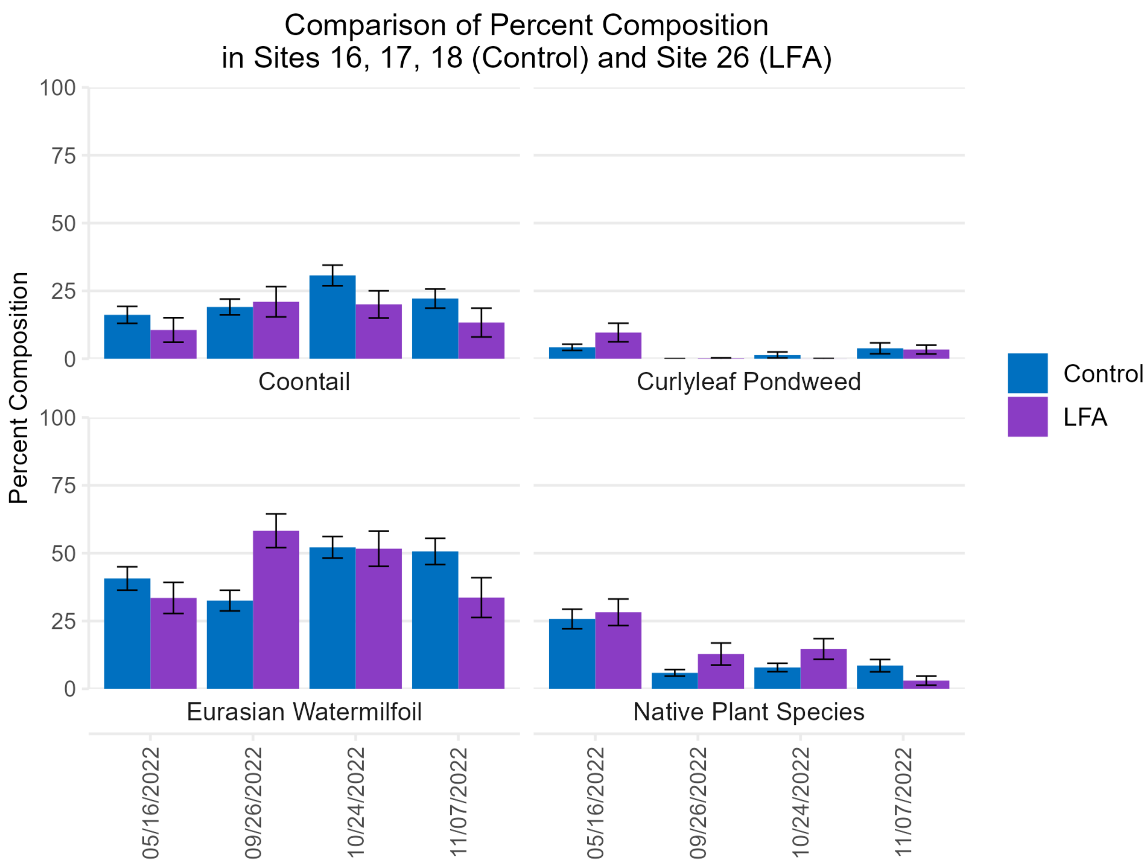


Figure 41 Example Percent Composition of the Three Target Species and Native Plant Species in Site 2 Compared to the Average of the Control Sites (16, 17, 18) in the West Lagoon

Calculated Target Species – Biovolume and Fullness

As previously mentioned, biovolume using the BioBase system was measured bi-weekly by TKPOA throughout the CMT project. This approach has been used by TKPOA for well over 10 years, and is the primary metric used to assess whether a 75% reduction in biovolume and 3-foot vessel hull clearance has been achieved. This approach does not, however, account for species-specific treatment responses nor does it differentiate mid-site from shoreline conditions. Using the product of each species' relative abundance (assessed in the field) x biovolume, the metric we are calling the Calculated Target Species by Biovolume (CTSB) is calculated. Given the strong relationship between rake fullness and biovolume (Figure 12), the Calculated Target Species by Fullness (CTSF) can also be calculated and used to separate shoreline from mid-site collection sites.

Provided are examples of CTSB and CTSF from a limited number of sites. The full suite of results may be found in **Attachment E** and **Attachment F**, respectively.

Endothall Sites

On a site-basis, CTSB and CTSF were generally very similar at Endothall treatment sites (example Site 2 in **Figure 42 and Figure 43**, respectively) with a substantial negative effect on Eurasian watermilfoil, coontail, and curlyleaf. A notable exception was in Lake Tallac where CTSB for the native plant species was on the order of 5 to 15% in Site 19 and well over 20% using CTSF, similar though less dramatic increases in the CTSF approach were observed in control Site 20. Given the very high density of watershield in both sites, and the fact that the floating leaf portion of watershield is not detected by the BioBase unit, rake fullness evaluations should be estimated higher than the BioBase output. This trend is opposite what was observed in other comparisons of the two metrics, where the CTSF typically estimated slightly lower than CTSB. These differences may be attributed to the more rigid rake fullness categories compared to the more fluid biovolume ranges. That is, where biovolume may be reported as 60% for a site, rake fullness evaluations might assign 51%, thus reducing the relative contribution of a particular species.

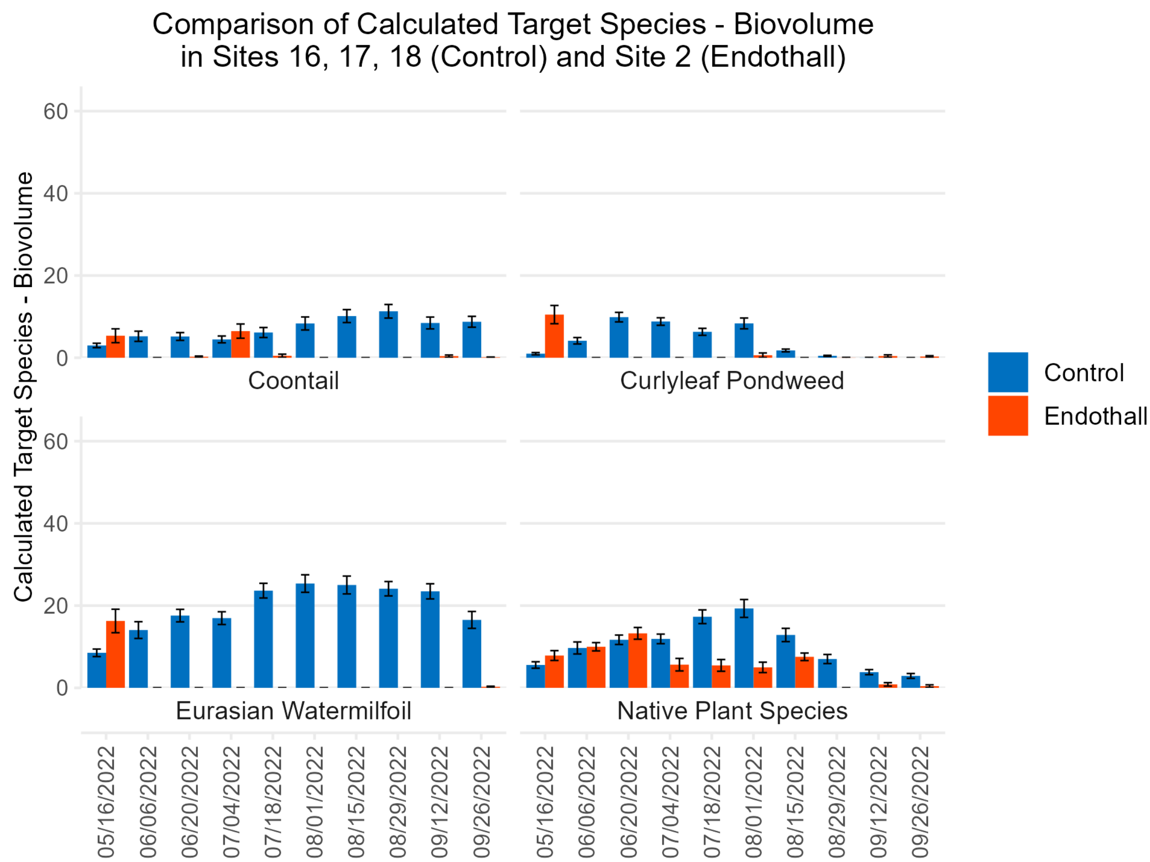


Figure 42 Example Calculated Target Species by Biovolume of the Three Target Species and Native Plant Species in Site 2 Compared to the Average of the Control Sites (16, 17, 18) in the West Lagoon

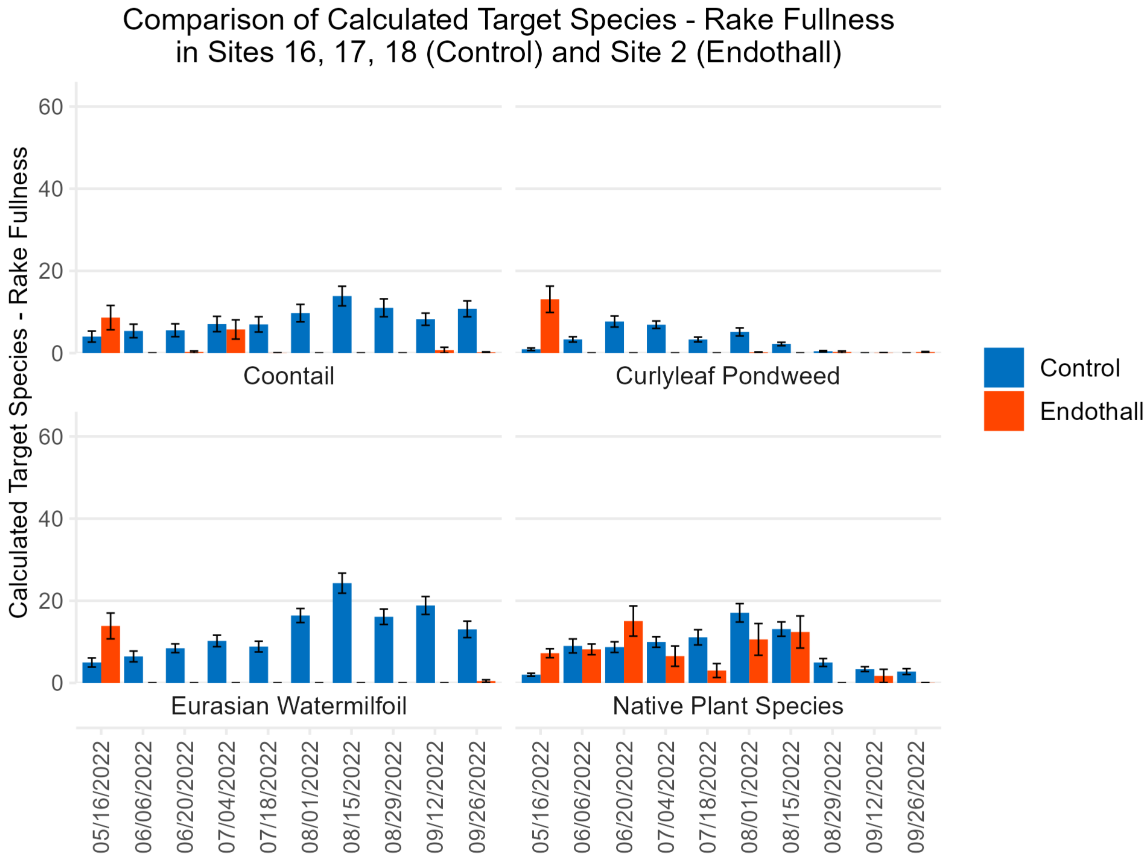


Figure 43 Example Calculated Target Species by Rake Fullness of the Three Target Species and Native Plant Species in Site 2 Compared to the Average of the Control Sites (16, 17, 18) in the West Lagoon

Triclopyr Sites

As expected, the CTSF (as assessed by rake fullness) of Eurasian watermilfoil was substantially lower in the Triclopyr sites compared to the average of control sites (example Site 9 in **Figure 44**). This was expected given that Triclopyr targets Eurasian watermilfoil at the exclusion of other target and non-target species. Compared to the control sites, the CTSF of coontail was higher at pre-treatment in Sites 5 and 9, increasing as the season progressed. The CTSF of curlyleaf pondweed and native plants was quite low in all Triclopyr sites, similar to the control sites. As with Endothall treatment sites, patterns were very similar when assessed using biovolume (CTSB), but overall percentages were uniformly slightly lower.

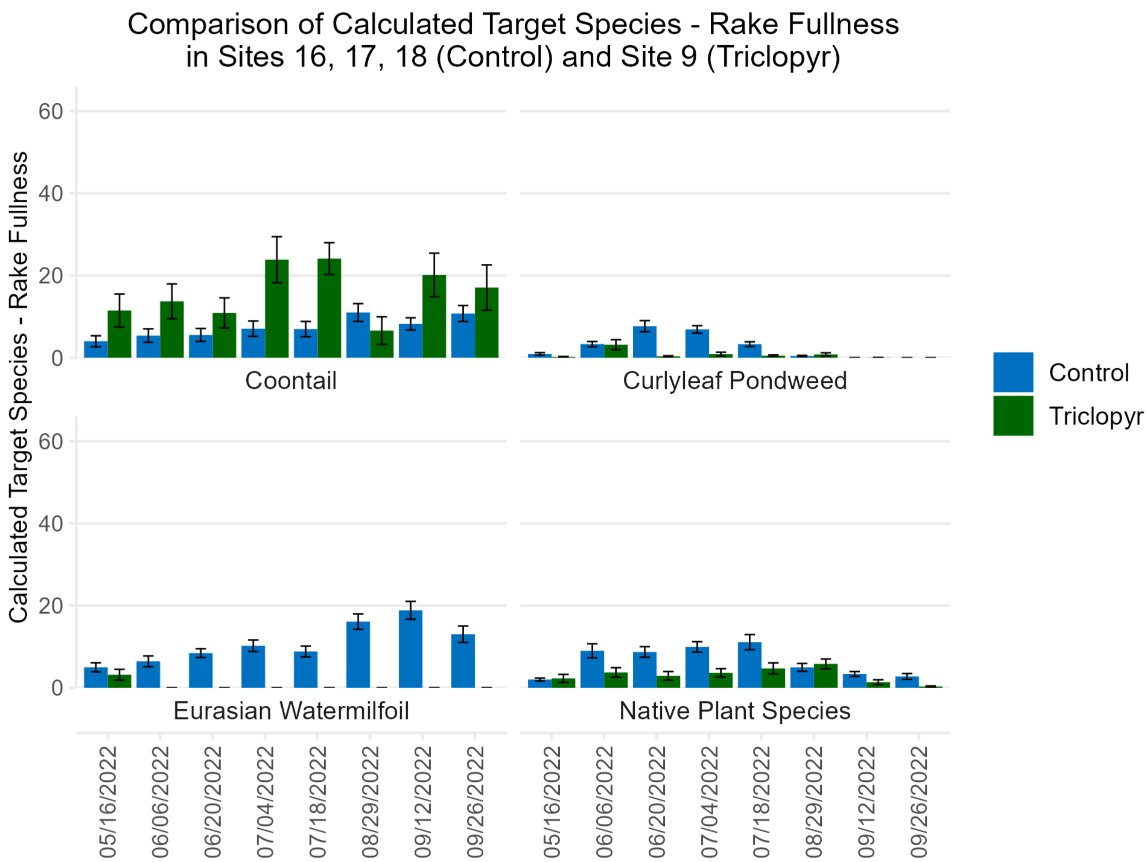
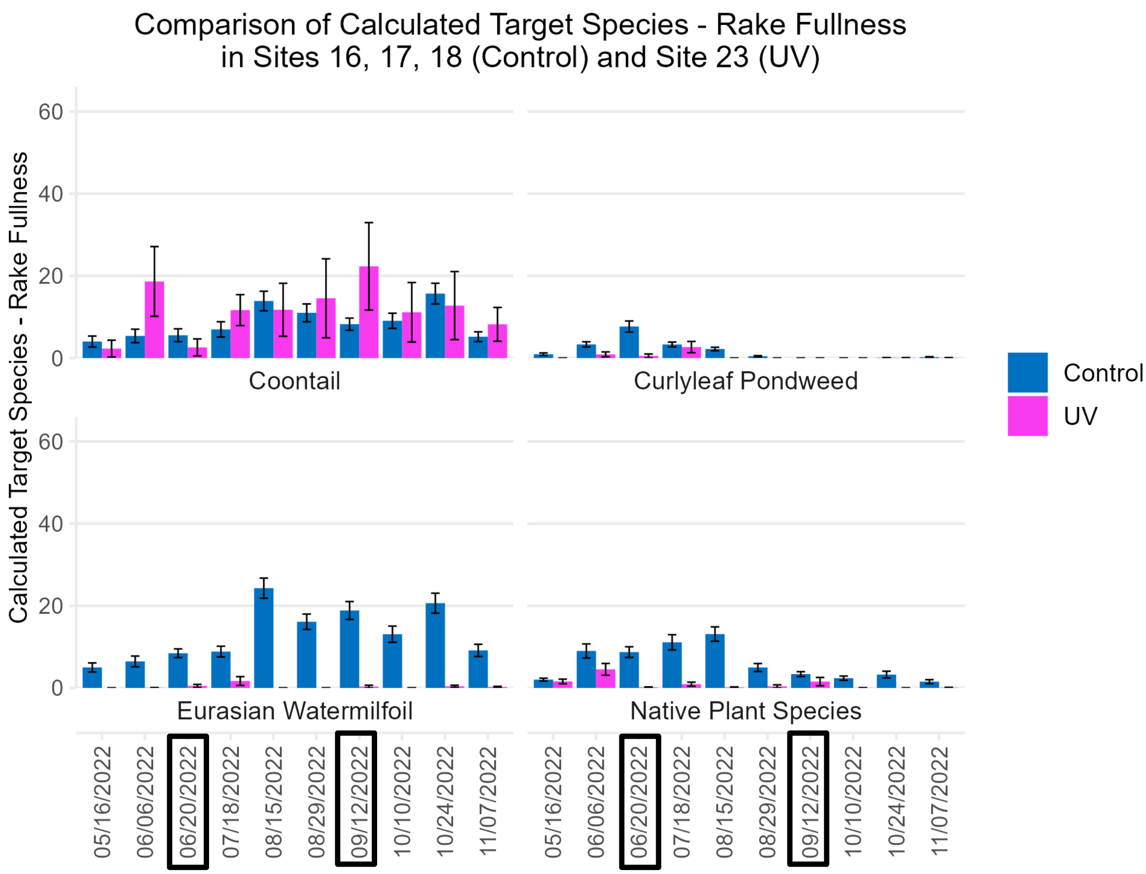


Figure 44 Example Calculated Target Species by Rake Fullness of the Three Target Species and Native Plant Species in Site 9 Compared to the Average of the Control Sites (16, 17, 18) in the West Lagoon

UV Sites

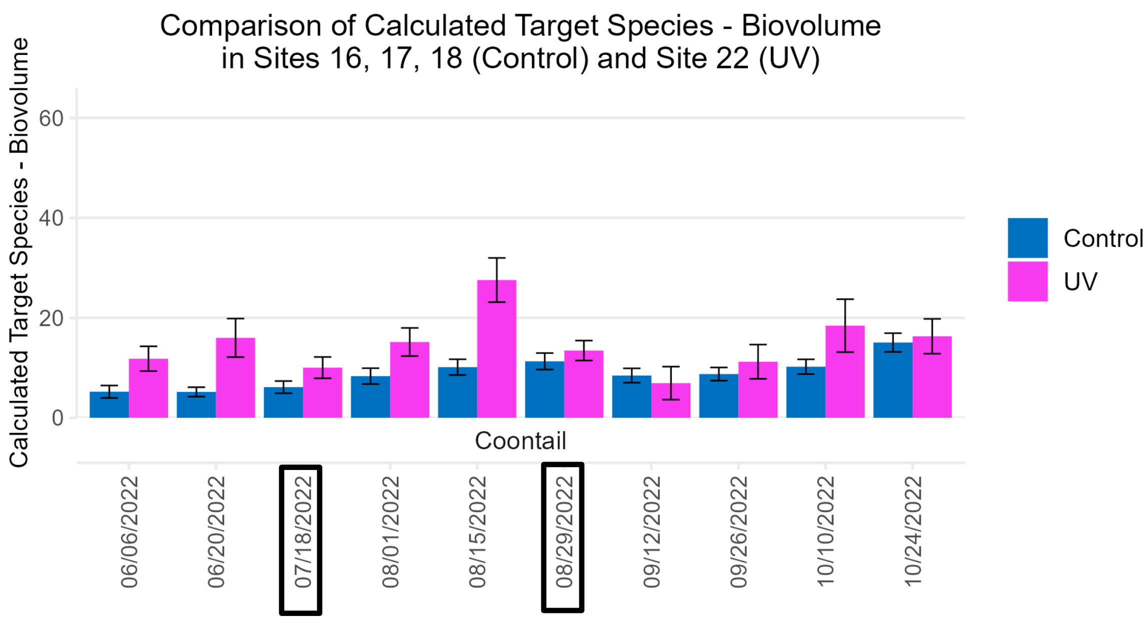
Like plant health condition and frequency of abundance, only the mid-site data were included in the calculation of CTSF and CTSB in the UV sites. Plant health and frequencies were expected to be unchanged in areas of UV sites that were not treated. UV treatments occurred at varying times between sites (Table 2).

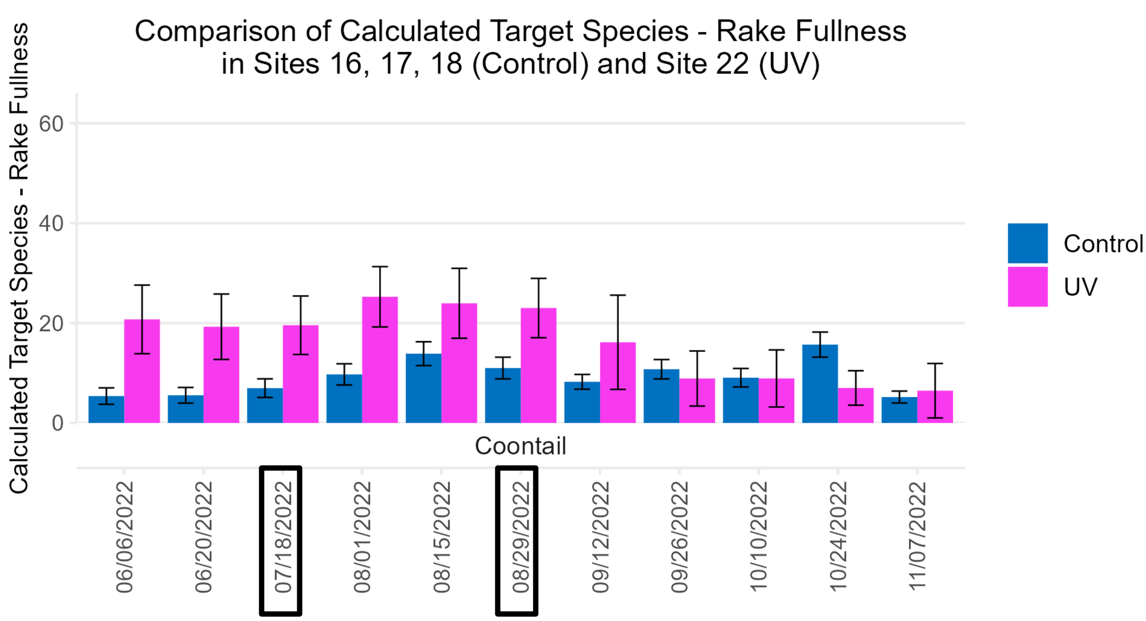
CTSF was variable between sites; however, given the varying treatment dates and differences in initial plant composition, direct comparisons should be evaluated within each site rather than between sites (example Site 23 in **Figure 45**). In general, however, UV treatments were effective in reducing the CTSF in Eurasian watermilfoil and curlyleaf, but less so against coontail. Unlike most other CMT treatment sites, coontail CTSB was lower in UV sites compared to CTSF (example Site 22 in **Figure 46**), suggesting that for this species, rake fullness values may be overestimating the amount of coontail on rakes. Coontail was more common mid-site, which is the focus of the CTSF samples versus CTSB which includes the shoreline as well, where coontail is generally poorly represented.



Black boxes indicate nearest date of macrophyte assessment following 14 days post-UV treatment.

Figure 45 Example Calculated Target Species by Rake Fullness of the Three Target Species and Native Plant Species in Site 23 Compared to the Average of the Control Sites (16, 17, 18) in the West Lagoon



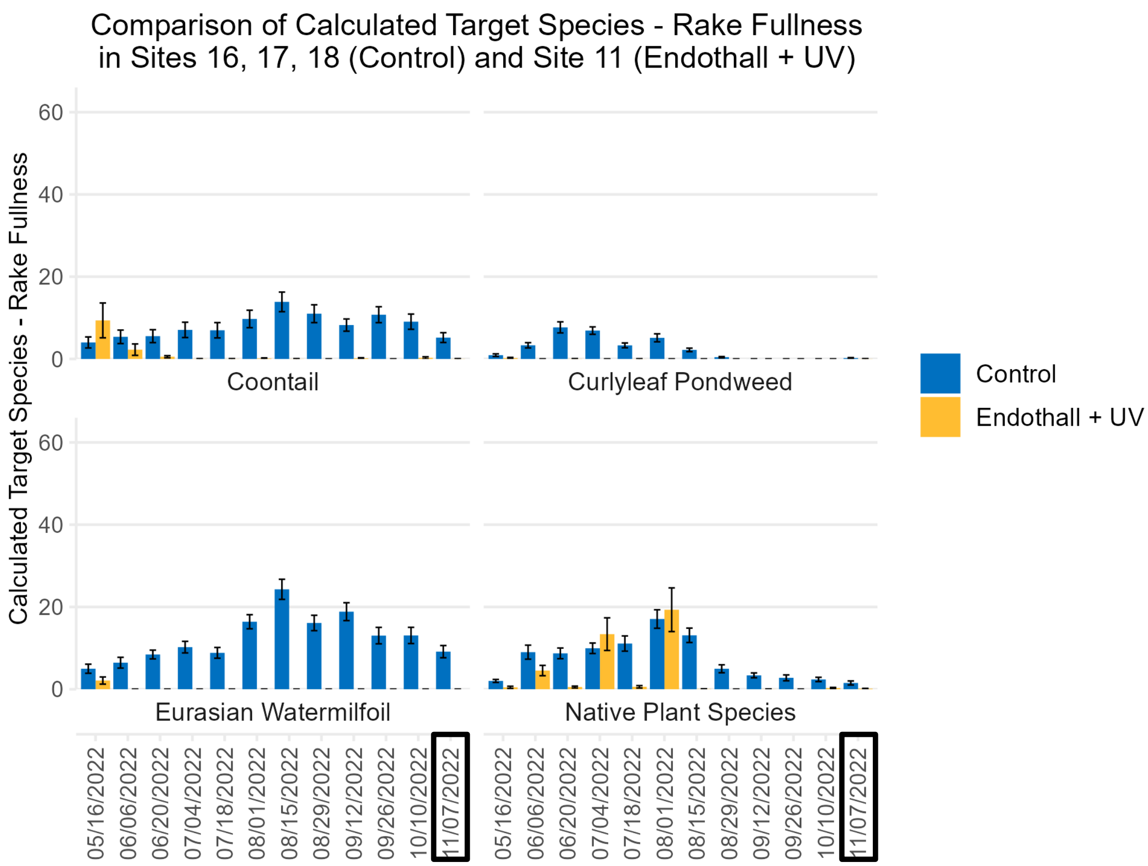


Black boxes indicate nearest date of macrophyte assessment following 14 days post-UV treatment.

Figure 46 Examples of Calculated Target Species by Biovolume (top) Calculated Target Species by Rake Fullness (bottom) of Coontail in Site 22 Compared to the Average of the Control Sites (16, 17, 18) in the West Lagoon

Endothall + UV Sites

Sites 10 and 11 had a very similar response to the Endothall treatment with all target species controlled (example Site 11 in **Figure 47**) The Site 15 treatment, however, was effective on Eurasian watermilfoil and curlyleaf, but had mixed effects on coontail. TKPOA (2023) reported very low Endothall concentrations in Site 15 (~87 ug/L) which likely explains the very low efficacy in that site. Further, Endothall was only applied to the shoreline and coontail is routinely more common in the mid-site regions, suggesting the herbicide was in sufficient concentration to impact Eurasian watermilfoil (relatively more common along the shorelines) but did not migrate to mid-site.

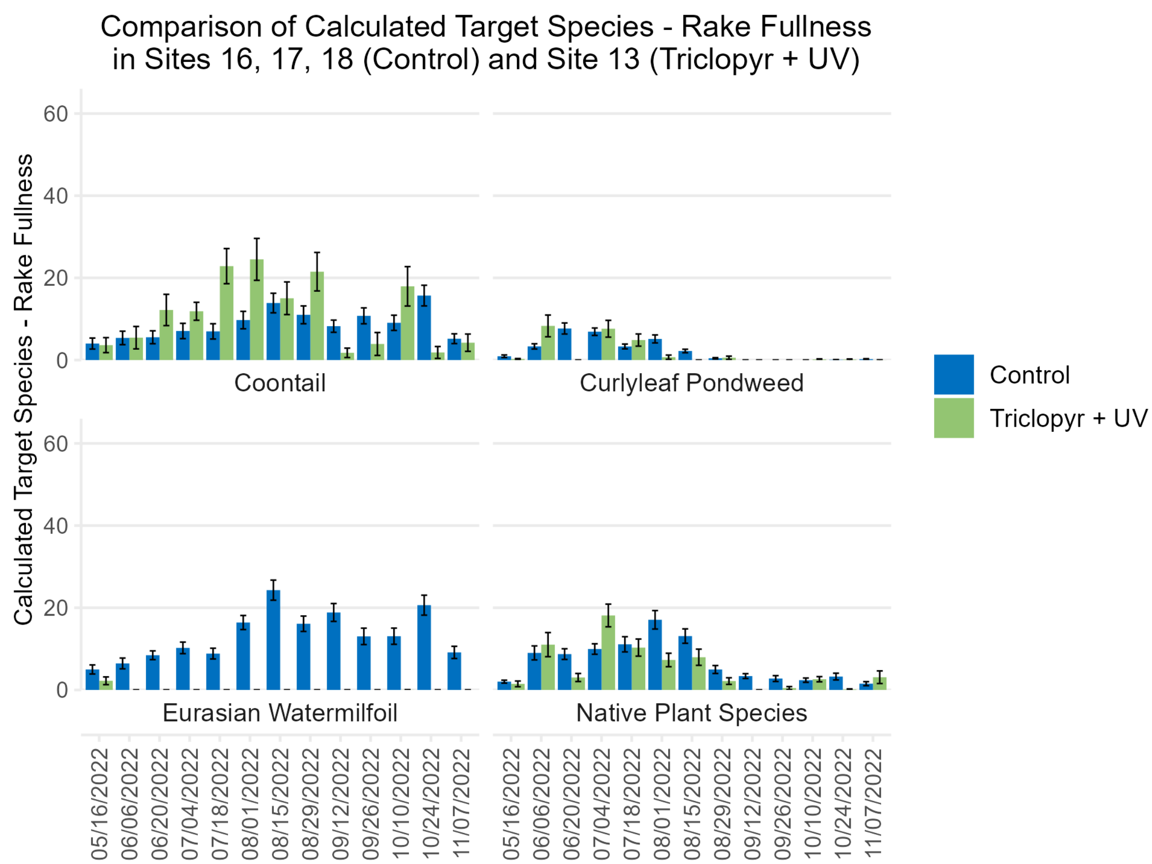


Black boxes indicate nearest date of macrophyte assessment following 14 days post-UV treatment.

Figure 47 Example Calculated Target Species by Rake Fullness of the Three Target Species and Native Plant Species in Site 11 Compared to the Average of the Control Sites (16, 17, 18) in the West Lagoon

Triclopyr + UV Sites

Sites 12, 13, and 14 were intended to be treated with a granular formulation of Triclopyr along the shorelines followed by treatment with UV in the mid-site areas. The sites, however, were not treated with UV due to access issues. Regardless, the response to treatment with the granular Triclopyr formulation as measured with the CTSF and CTSB (example Site 13 in **Figure 48**) metrics was similar to the liquid Triclopyr formulation treatment at sites (Sites 5 and 9 described above). That is, CTSF indicate that Triclopyr effectively targeted Eurasian watermilfoil at the exclusion of the other target species and native plants.



Note: No UV light treatments occurred at the intended Triclopyr + UV sites.

Figure 48 Example Calculated Target Species by Biovolume of the Three Target Species and Native Plant Species in Site 13 Compared to the Average of the Control Sites (16, 17, 18) in the West Lagoon

LFA Site 26

LFA Site 26 has been in operation since 2019 thus no pre-treatment comparisons are available. (**Figure 49**). While there were not appreciable differences in CTSF for curlyleaf pondweed (which was consistently very low) or Eurasian watermilfoil compared to the average of controls, coontail was generally lower than the controls and native plants were somewhat higher. Perhaps the physical movement of water prevented coontail, which is not well-rooted, from establishing.

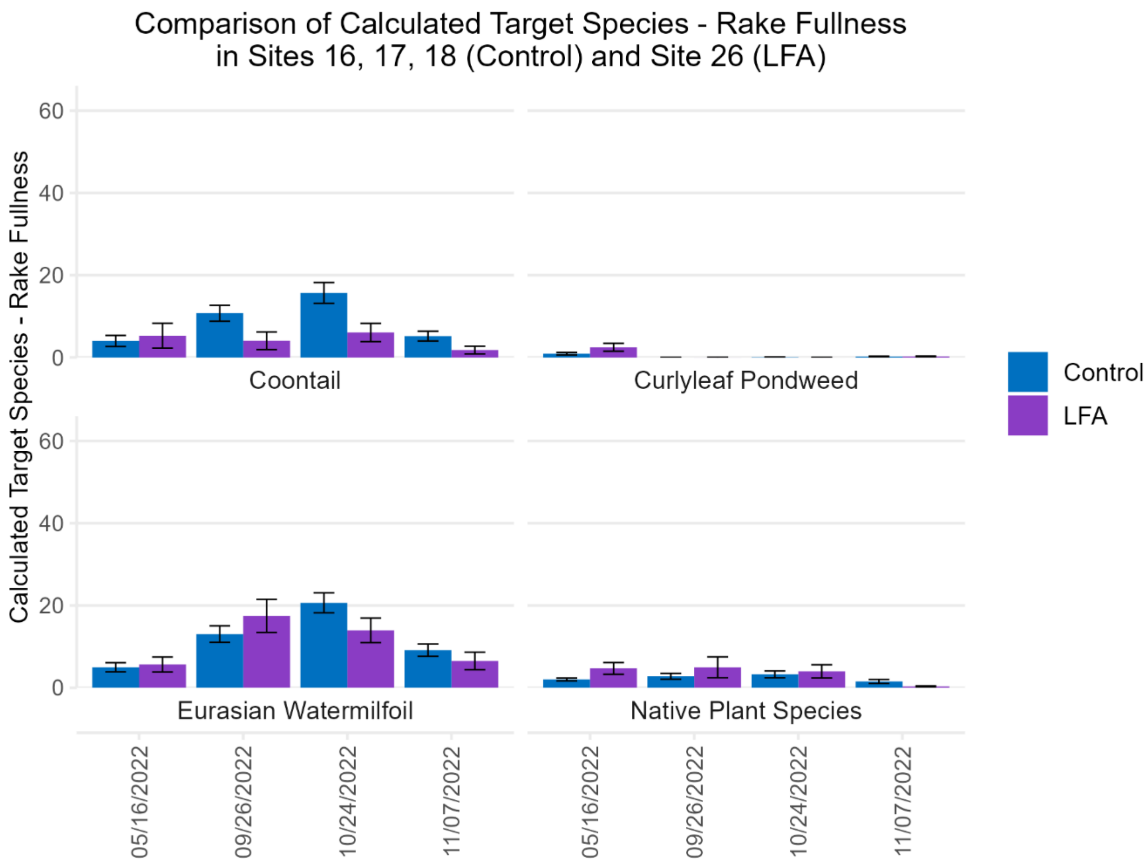


Figure 49 Calculated Target Species by Rake Fullness of the Three Target Species and Native Plant Species in Site 26 Compared to the Average of the Control Sites (16, 17, 18) in the West Lagoon

Summary

A summary of the outcomes of the various CMT treatments in relation to the primary goals and objectives of the Project as they relate to macrophyte control efficacy is presented below. In particular, the goals of a 75% reduction in biovolume, 3-foot vessel hull clearance, and increases in occurrence and percent composition of native plants relative to non-native plants.

For biovolume, occurrence and composition comparisons of treatment sites are made between the average controls in the West Lagoon (16, 17, 18) or in Lake Tallac, between treatment Site 19 and control site 20. As previously mentioned, Site 21 was intended as a control site, but was not included in comparisons as it was likely affected by the Endothall treatment from Site 19. Because control sites were harvested after August 9 (Table 2), comparisons made before August 9 more accurately reflect true control sites.

Frequency of occurrence and percent composition, while often correlated, provide different information on the efficacy of the treatments. Frequency of occurrence describes *how often* a particular species is present in a site, or the probability of a species present in a site. Percent composition better describes *how common or rare a species* is in a site. Neither metric describes how much or the density of each species which is better described with the metrics Calculated Target Species Biovolume and Calculated Target Species Fullness.

Endothall Sites

Biovolume

In the West Lagoon, a >75% reduction in biovolume was achieved in Site 1 from early August to the end of monitoring for that site (end of October), in Site 2 from mid-August through the end of monitoring, and from late June to early September in Site 3, except for just a 47% reduction in late July. Due to technical difficulties, July data was the average of the previous scan and the one following. It should be noted as well that biovolume reductions that did not reach the 75% reduction target often came very near (e.g., 74% in early August in Site 2).

In Lake Tallac at Endothall treatment Site 19, a >75% reduction in biovolume was achieved by late July (74% in mid-June) until the end of monitoring for that site (mid-October) with the exception of a 58% reduction in mid-July. Site 21, which was intended as a control site had biovolume reductions as high as 91% beginning in mid-August.

Rake Fullness

Using rake fullness as a proxy for biovolume resulted in very similar patterns as biovolume from hydroacoustic scans. Using this metric, the Project goal of >75% biovolume reduction was achieved and was achieved earlier in the season compared to similar comparisons of Endothall sites with control sites using hydroacoustic data. Moving forward, the rake fullness score will be assessed in the field and may include subsequent desktop cross-checks.

Vessel Hull Clearance

Following treatments, a > 3-foot vessel hull clearance was achieved in Endothall treatment Sites 1, 2, and 3 in August and October.

Frequency of Occurrence and Percent Composition

Not surprising, the general trends in frequency of occurrence and percent composition were similar. By mid-summer, the percent composition of native species in Site 2, however, was 2 to 3 times higher than controls, suggesting that native plants are more common in Site 2 compared to other species in the site. Conversely, the frequency of occurrence of native plants was less than controls in all Endothall sites, meaning fewer native plants were found on the rakes. Taken together, native plant species may not have been frequently observed, but when they were, they were often the dominate taxa.

Triclopyr Sites

Biovolume

The highest biovolume reduction in a Triclopyr site was 49% (Site 5). In addition, there were many instances where biovolume in Triclopyr treatment sites was greater than in control sites, particularly in Triclopyr treatment Sites 8 and 9. These sites also had very high frequency of occurrence of coontail, which likely comprised most of the biovolume.

Rake Fullness

Using rake fullness as a proxy for biovolume resulted in very similar patterns as biovolume from hydroacoustic scans. Using this metric, however, the Project goal of >75% biovolume reduction was achieved soon after treatment in Site 8.

Vessel Hull Clearance

Following treatments, a > 3-foot vessel hull clearance was achieved in Site 5 in August and October and October in Site 9. Hull clearance of 2.8 feet was achieved in Site 8 in October.

Frequency of Occurrence and Percent Composition

In Site 5, both metrics, frequency of occurrence and percent composition, were higher for coontail compared to the controls, but lower for other target species and natives. Sites 8 and 9 were more similar in that both metrics in both sites generally exceeded controls for coontail, but also equal to or higher than controls for native plants.

UV Sites

Biovolume

The highest site-wide biovolume reduction in a UV site was 66% (Site 22) and all substantial biovolume reductions followed treatments with a steady increase until a follow-up treatment.

Rake Fullness

Using rake site-wide fullness data as a proxy for biovolume resulted in very similar patterns as biovolume from hydroacoustic scans. Using the rake fullness metric applied only to mid-site areas, the Project goal of >75% biovolume reduction was intermittently achieved Intermittent success is attributed to different treatment times between sites over the course of the season.

Vessel Hull Clearance

Following treatments, a > 3-foot vessel hull clearance was achieved in Sites 22, 23, and 24 in August and October.

Frequency of Occurrence and Percent Composition

Patterns in percent composition were highly variable between each of the UV sites. For example, coontail contributed the greatest to composition in all sites while Eurasian watermilfoil the least and was much lower than controls. It should be noted; however, that Eurasian watermilfoil composition was less than 5% prior to treatment in all UV sites while coontail was between 25 and 50% in all sites. Very similar patterns were observed in frequency of occurrence. Based on both metrics, there was not an increase in native plant taxa in UV sites compared to the controls.

Endothall + UV Sites

Biovolume

A >75% reduction in biovolume was achieved in Sites 10 and 11 from early September to the end of monitoring for that site (end of October). It should be noted; however, that many hydroacoustic scans indicated biovolume reductions very near 75% earlier in the season (e.g., 74% and 69% in early to mid-August in Site 10). The highest reduction in Site 15 was 34% in early October which was likely more due to seasonal senescence rather than as a result of treatment.

Comparing the biovolume scans of the Endothall + UV sites with LFA Site 26, Sites 10 and 11 had >75% reductions, similar to when compared to the control sites. Like Endothall-only sites, the reductions occurred earlier in the season and were greater. Following treatments a 73 to 77% reduction in biovolume was measured across all Endothall + UV Sites 10 and 11 across the entire season when compared to LFA Site 26. The highest percent reduction measured from Site 15 was lower (56%) than Sites 10 and 11 when compared to LFA Site 26.

Rake Fullness

Using rake fullness as a proxy for biovolume resulted in very similar patterns as biovolume from hydroacoustic scans. Using this metric, the Project goal of >75% biovolume reduction was achieved and was achieved earlier in the season compared to similar comparisons of Endothall + UV sites with control sites using hydroacoustic based estimates.

Vessel Hull Clearance

Following treatments, a > 3-foot vessel hull clearance was achieved in Sites 10 and 11 in August and October respectively. The vessel clearance goal was not met at Site 15 where only 2.0 and 0.4 foot clearance was achieved in August and October, respectively.

Frequency of Occurrence and Percent Composition

Frequency of occurrence of all target species in Sites 10 and 11 was very low following treatments and remained low through the season. In Site 15, however, coontail appeared unharmed by the endothall treatment, presumably because the herbicide was applied along the shoreline and coontail tends to dominate the mid-site areas. Occurrence of native plants declined in Sites 10 and 11 while increasing substantially in Site 15. Again, this is presumably due to the lack of macrophyte control in the mid-site. It is unclear why treatments were so much more effective in Sites 10 and 11. Percent composition, on the other hand, was much higher for native species in all the Endothall + UV sites, suggesting a release of competition from the target species.

Triclopyr + UV Sites

Biovolume

A >75% reduction in biovolume was intermittently achieved in Site 12 beginning early August through the end of monitoring. The highest reductions in Sites 13 and 14 were 67% and 62%, respectively, in late October, so reductions were likely due to seasonal senescence as well as treatment effects.

Following treatment, Site 12 had an average of 79% reduction across the entire season when compared to LFA Site 26.

Rake Fullness

Using rake fullness as a proxy for biovolume resulted in very similar patterns as biovolume from hydroacoustic scans. Using this metric, the Project goal of >75% biovolume reduction was achieved along the shorelines during most of the season in all Triclopyr + UV sites compared to controls. Mid-site efficacy based on rake fullness; however, was limited to Site 12.

Vessel Hull Clearance

Following Triclopyr + UV treatments, a > 3-foot vessel hull clearance was achieved in Sites 12 and 14 in August and all sites achieved > 3-foot clearance in October.

Frequency of Occurrence and Percent Composition

Not surprisingly, the frequency of occurrence and percent composition of Eurasian watermilfoil was essentially zero following Triclopyr + UV treatment, with only one observation in October at Site 13. Increases in frequency of coontail, curlyleaf pondweed, and native plants were also not surprising, although though this was not the case in Site 12). Percent composition followed similar patterns, but it is worth noting that native plants were similar to or exceeded control site frequency of occurrence and followed similar patterns over the season.

LFA Site 26

Biovolume

Across all sample dates, biovolume in LFA Site 26 was higher than the average control sites. It should be noted; however, that the control sites were harvested over the course of the season (Table 6).

Rake Fullness

Unlike other CMT sites, rake fullness in LFA Site 26 had an opposite trend from biovolume estimated using hydroacoustic scans and was generally lower through the summer and into fall. Using this metric, the Project goal of >75% biovolume reduction was not achieved.

Vessel Hull Clearance

For the three months considered in this report (May, August, and October), LFA Site 26 did not achieve the vessel hull clearance goal of > 3-foot and the maximum clearance only reached 1.2 feet.

Frequency of Occurrence and Percent Composition

Eurasian watermilfoil had the highest frequency of occurrence and percent composition compared to other target species. This suggests that Eurasian watermilfoil is both more widespread (high frequency) and is the dominant plant in terms of biovolume contribution (percent occurrence).

Considerations and Data Limitations

The previously described approaches draw on those applied by others using hydroacoustic scans coupled with point sampling using rakes (Valley et al. 2015, Helminen et al. 2019). Several concerns about the uncertainty of the field collected data (hydroacoustic scans, point-intercept sampling, plant health rating, relative abundance) and post-field desktop assessments based on the field collected data (rake fullness evaluations, and Calculated Target Species by Biovolume and Rake Fullness) are discussed below.

Hydroacoustic Scans/Biovolume

It is recognized that several factors contribute to the uncertainty around the use of hydroacoustic approaches. For example, environmental conditions, including aquatic plant growth form (e.g., fully submerged or floating leaf), plant density, water current, wind, waves, and gas bubbles can affect the hydroacoustic scans and well as potentially differential reliability based on plant species/canopy. In some systems, the complexity of the underlying sediment surface can be a contributing factor in separating the interface between dense plant beds and the underlying sediment which could bias the outcome of hydroacoustic biovolume estimates. The Tahoe Keys Lagoons, however, are completely manmade features with very low bathymetric relief within or between sites. Water depths averaged between 5.9 and 6.3 ft. from May to July and fell to 4.7 to 4.1 ft. between August and November, with little variation across all sites (**Figure 50**).

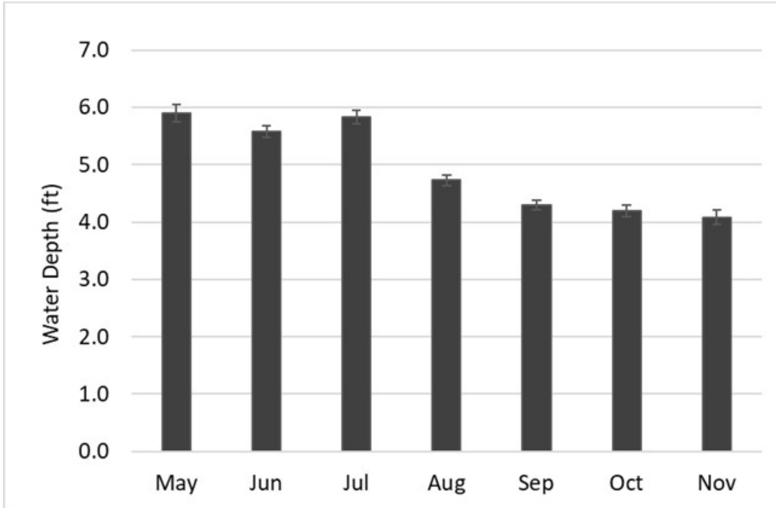


Figure 50 Average Water Depth (±SE) Across all Sites for Each Month of the CMT

The Project required that the macrophyte control efficacy of all treatments be assessed using "shore to shore" polygons within treatment sites. Thus, the percent reduction of biovolume using hydroacoustic scans is calculated by averaging the entire selected area. Due to shallow depths near shore and obstacles (e.g., boats, docks, buoys), UV treatments were mainly limited to areas between docks and open areas alongside docks (e.g., mid-site). Hydroacoustic scans, however, incorporated areas inaccessible by the UV vessels, and therefore include biovolume from shoreline vegetation area that were not treated by UV in the final biovolume estimates. Conversely, since the rake fullness data was strongly correlated to biovolume, we were able to employ a more granular assessment of shoreline versus mid-site macrophyte control efficacy for UV as well as UV + herbicide combination sites where the mid-sites s were not treated.

Measures to best capture only the treated areas will be implemented in Years 2 and 3. It should also be mentioned, however, that a primary Project goal is to assess efficacy across entire treatment sites, not just areas away from shorelines. While unfortunate that the combination treatments did not occur as planned, there were still lessons learned from the treatments that did occur at those sites. In the Endothall + UV sites, there was very good control of all the target species. Sites intended for the Triclopyr + UV treatment were treated with a granular formulation of Triclopyr at shoreline areas only, as opposed to the Triclopyr-only treatment sites where liquid Triclopyr was applied across the entirety of each site. Good control of Eurasian watermilfoil was achieved regardless of Triclopyr formulation. Coontail and curlyleaf pondweed were not controlled mid-site at the Triclopyr + UV intended sites but may have been controlled by a mid-site UV treatment.

Point Sampling

Rake samples were collected using a double-sided thatch rake attached to a tele-scoping pole that was lowered and raised from the water while twisting. While this method was uniformly applied by all field staff, the plant growth form sampled at each site likely biased the species that could consistently be pulled from the sites. For example, since coontail is not rooted, or is loosely-rooted, and therefore is easily removed using a rake, it was routinely the dominant species on a rake. Lower statured or thin leaved species such as the native elodea or many of the pondweed species, in contrast, are not as easily removed using a rake and their density and occurrence may be underestimated. Additionally, point sampling did not necessarily occur on the same day as the hydroacoustic scans, thus comparing specific treatment days (or dates for UV and LFA) with point sample days could vary by as much as a week.

Plant Health Condition

Plant health ratings were conducted by multiple field staff which inherently presents potential for bias based on field staff's understanding of SAV robustness. The ratings and descriptions were provided as an "information" tab on tablets. When there was doubt about how to rate species on a rake, staff were encouraged to consult the rating descriptions. The plant condition rating scheme was designed to provide a semi-quantitative metric to distinguish healthy plants from those with physically discernable symptoms or conditions. In the field, scores from 1-5 were applied; however, it is proposed that only plants with a score of 3-5, plants considered viable, will be used in subsequent analyses. This eliminates potential for bias in the higher plant health rated categories due to inexperience in comparing natural morphological differences between species. For example, healthy coontail and elodea tends to remain stiff and robust when removed from the water while healthy pondweeds tend to appear less rigid (limp) when, in fact, all may be very viable.

Percent Composition

Percent composition by species was also applied in the field by multiple field staff, thus likely suffers the potential for personnel bias. Most of the rake samples typically have none or one, but rarely more than four species. This paucity of diversity inherently minimizes some bias. As an example, it was very common to only find Eurasian watermilfoil or elodea in samples collected along the shoreline and applying an appropriate relative abundance was generally straightforward and the field crews could come to quick agreement. Additionally, coontail was routinely the dominant species in midchannel sites, to the exclusion of most other species. Another point of uncertainty is whether the rake captures different plant species with the same efficiency. In an attempt to overcome this potential bias, the rake was always lowered and raised in the same fashion by all field crews. While this still could bias the capture of certain species over others, providing uniformity is intended to keep this bias constant. Because the same procedures were followed for both treatment and control sites, any biases would likely be applied equally to all sites across time and would not be consequential after comparing treatments to controls.

Frequency of Occurrence and Percent Composition

In addition to being widely used in the literature, frequency of occurrence is far less biased than the percent composition assessments collected in the field. Simply put, frequency of occurrence indicates whether the species was present or not. Other than improper identification, or perhaps missing underrepresented taxa, there is little room for error. Percent composition, on the other hand, can overlook underrepresented or diminutive taxa not easily captured on a rake.

Calculated Target Species – Biovolume and Rake Fullness

Targeted species percent composition multiplied by the BioBase biovolume estimate per site (the Calculated Target Species by Biovolume: CTSB) or the percent targeted species percent composition multiplied by rake fullness for individual rake sites (Calculated Target Species by Fullness: CTSF) can provides a mechanism to better understand how the various treatment methods affect target species across CMT sites. However, these approaches inherently increase uncertainty as percent composition is multiplied by biovolume or rake fullness. Valley et al. (2015) used a "dominance-index point value" to incorporate relative contribution of all submersed and all floating leaf species at each sample point. This assessment, however, did not go to the species level as we are attempting to document. The CMT criteria for *successful control* is set at a large (75%) reduction in target plant biovolume. Since we are comparing relatively high biovolumes conditions (controls) with low biovolumes (effective treatments), the CTSB and CTSF are valid composite metrics that takes the biovolume estimates and abundance data derived from higher spatial resolution rake samples into account.

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