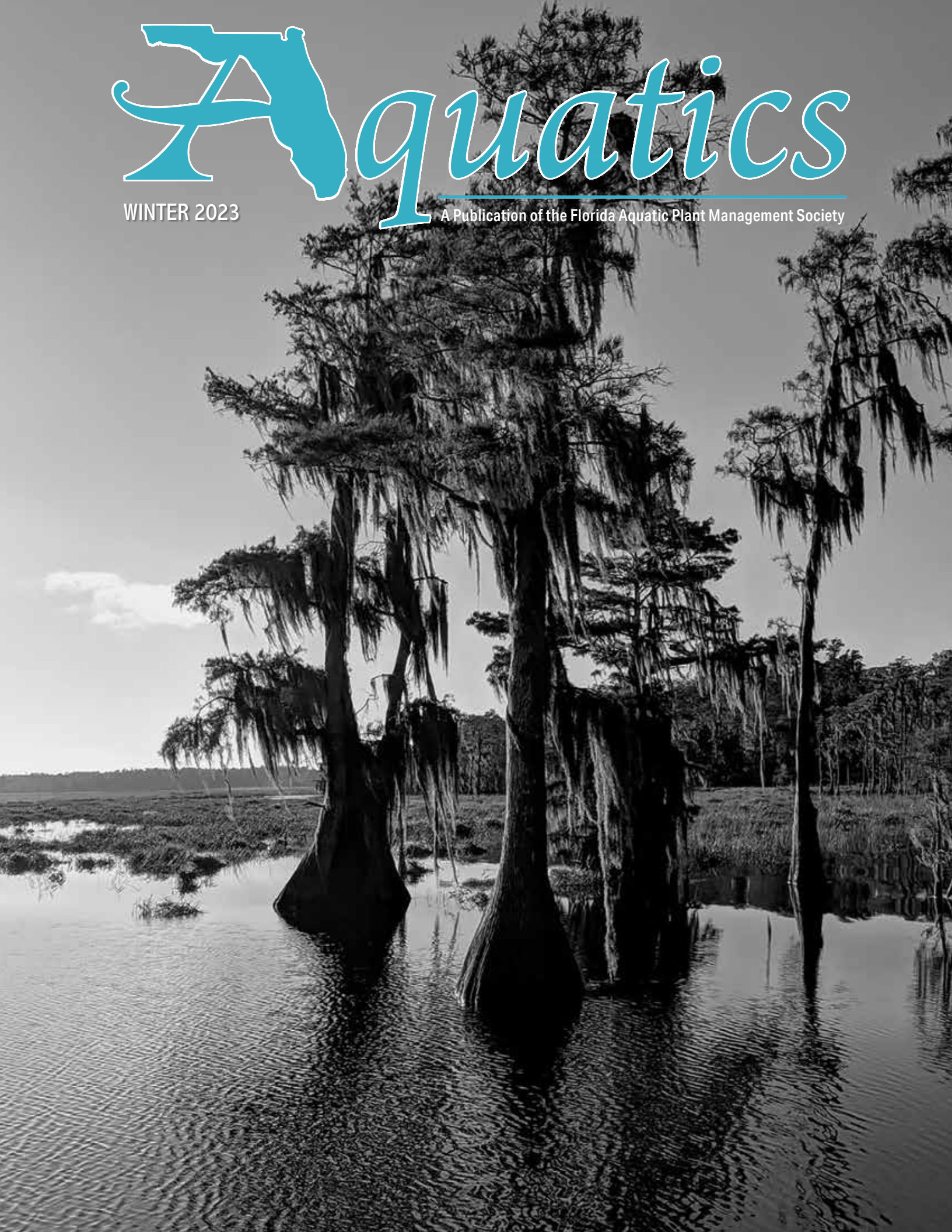

Aquatics

WINTER 2023

A Publication of the Florida Aquatic Plant Management Society

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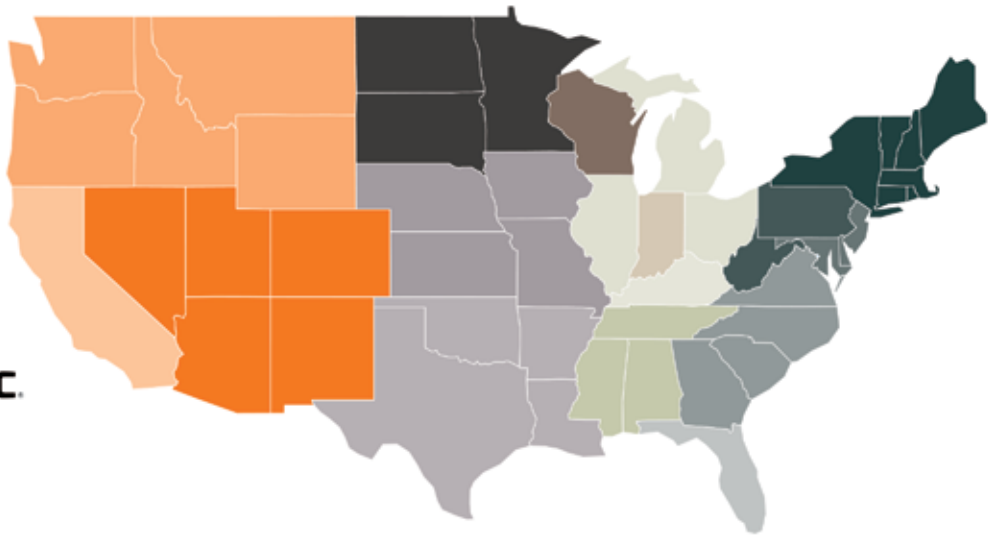

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Aquatics
WINTER 2023
Volume 45, Number 1

Beautiful black and white image of cypress trees draped in Spanish moss at Lake Louisa State Park near Clermont, FL. Photo submitted by Nathalie Visscher, Biological Administrator – Invasive Plant Management Section, Florida Fish and Wildlife Conservation Commission.

Contents

Letter from the Editor

As I complete another year as Editor of *Aquatics,* it is nice to reflect on the content shared by our authors over these last 5 years. The magazine is a wonderful resource for waterfront residents, lake enthusiasts, applicators, managers, educators, and scientists, and I hope that the range of articles provides helpful information on the physiology, growth, impacts, and management of aquatic vegetation in Florida and beyond. I want to thank our sponsors and supporters for their efforts, including the layout, graphic design, and printing. It really does take a village!

In addition to articles related to aquatic plants, I have tried to weave in informative content on safety related to the work that we as aquatic plant managers do. Issues have addressed heat illness, hearing loss prevention, boating safety, fueling precautions, how to mitigate skin cancer risks, and more. Thank you to the professionals who have contributed to these articles, and I'd like to encourage submissions from our audience for future features on job safety education. If you have content ideas or suggestions, I would love to hear from you!

Another goal over these last few years has been to showcase some of the academic and extension programs at various universities around the United States and abroad that specialize in aquatic plants. Raising awareness about aquatic plant research and management in other locations helps expand our collective knowledge here in Florida. Previous issues have featured programs like those at the University of Florida Center for Aquatic and Invasive Plants, Michigan State University, Missouri State University, Louisiana State University, etc. This issue takes us across the Pacific to the laboratory of Dr. Deborah Hofstra and colleagues at the Centre for Freshwater and Estuaries (at the National Institute of Water and Atmospheric Research – NIWA) in New Zealand who are working tirelessly to protect New Zealand from invasive species. New Zealand has one of the most advanced biosecurity programs on earth, and this article from the *Journal of Aquatic Plant Management* highlights their ongoing research into the management of invasive fanwort (*Cabomba caroliniana*).

I hope that you find this issue of *Aquatics* informative, educational, and interesting! As always, FAPMS is accepting articles related to aquatic plant management for consideration in the magazine, and I am happy to assist with formatting and revising as needed. Articles can be submitted to aquaticsmagazine@gmail.com.

See you on the water!

Amy L. Giannotti, MS, CLM
Editor

Figure 1. Drawn down 15 ac waterfowl pond infested with knotgrass (*Paspalum distichum*).

Knotgrass (*Paspalum distichum*) control to Improve Waterfowl Habitat in Mississippi

Gray Turnage

Assistant Research/Extension Professor, Mississippi State University, GeoSystems Research Institute

BACKGROUND

Many aquatic and wetland grasses can survive a broad range of environmental conditions and disturbance events making them particularly difficult to control in areas managed for waterfowl habitat by seasonal drawdown. Knotgrass (*Paspalum distichum* L.) is a native grass in the United States that is capable of excluding other aquatic plants that may be preferred waterfowl forage. Knotgrass is also a weed in citrus orchards and agronomic crops, particularly rice fields. Knotgrass populations have been linked to livestock and human disease vectors by providing habitat for livestock pathogens and disease carrying organisms like mosquitoes.

Knotgrass spread has been documented via human activities and by mammals and waterfowl feeding on the inflorescences and excreting viable seeds at new locations. In addition to sexual reproduction and spread, vegetative spread occurs as knotgrass stem nodes will readily sprout in a variety of light, temperature, and moisture regimes. Knotgrass can rapidly outcompete many plant species in aquatic habitats around the globe which can negatively affect biodiversity of aquatic fauna relying on other aquatic flora for resources. A diverse floral community is preferred by waterfowl resource managers in order to sustain greater waterfowl diversity and larger waterfowl populations. Muscadine Farms Wildlife Management Area (MFWMA) near Greenville, MS in the Mississippi flyway is a series of man-made ponds that are each 15-20 acres in size covering approximately 2,000 ac of land. Most ponds are drawn down annually so resource managers can utilize machinery to manage non-native vegetation and establish supplemental waterfowl forage like millet and corn. In recent years, knotgrass has become a dominant species in the system (Figure 1) and displaced a diverse native plant community in many of the ponds with dense knotgrass monocultures (Figure 2).

Knotgrass is consumed by some species of waterfowl, but it is not a preferred forage species at MFWMA as there are other plant species with greater rates of productivity that can support larger waterfowl numbers, therefore, knotgrass reduction was needed to open habitat for other plant species. A number of chemical control techniques for knotgrass have been documented with ALS inhibiting herbicides being among the most studied. Unfortunately, most of the previously studied ALS herbicides are not labeled for general aquatic use in the U.S. but there are other ALS inhibiting herbicides (bispyribac-sodium, imazapyr, imazamox, and penoxsulam) that are legal for use. The purpose of this project was to assess short term control of knotgrass reduction by aquatic use labeled ALS inhibiting herbicides as stand-alone control methods.

METHODOLOGY

This project was conducted at MFWMA and repeated 2 weeks later. A total of 5 treatments were administered: a non-treated reference and four herbicide applications. Prior to applying herbicide treatments, pre-treatment samples were collected from each plot by recording knotgrass plant height and percent cover then placing a 0.1 m^2 PVC frame on the ground in the plot and removing all aboveground knotgrass biomass within the frame. Knotgrass biomass was dried in a forced air oven at 70C for 5 days, then biomass weights were measured and recorded.

Treatments were randomly assigned to treatment plots 30 ft X 30 ft in size; each

Figure 2. Image showing density of knotgrass stems and leaves.

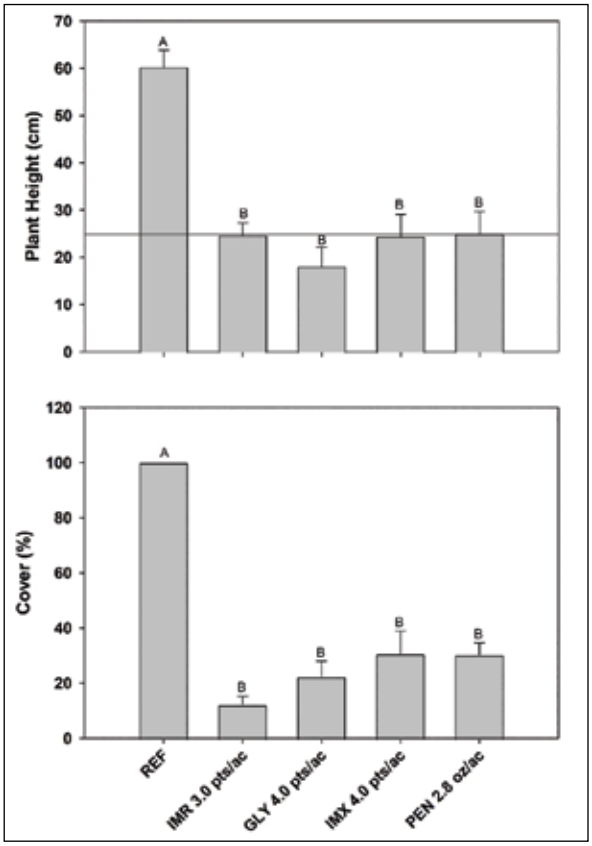

Figure 3. Knotgrass (*Paspalum distichum* L.) height and percent cover 12 weeks after treatment with systemic herbicides; bars sharing the same letter are not different at the alpha = 0.05 significance level (n=8); in the upper panel, the solid line is pre-treatment height; along the x-axis, IMR is imazapyr, GLY is glyphosate, IMX is imazamox, and PEN is penoxsulam.

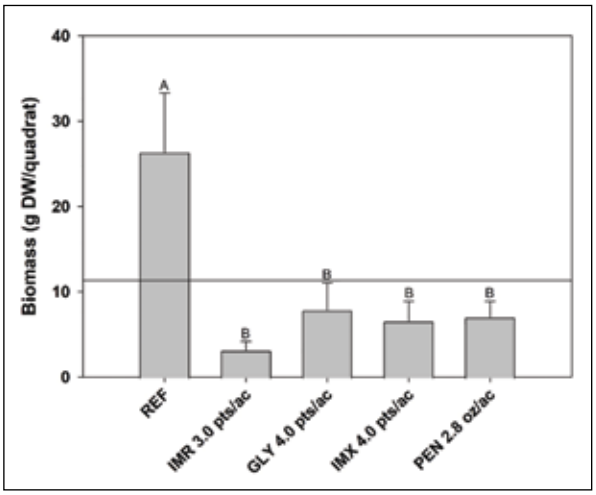

Figure 4. Knotgrass (*Paspalum distichum* L.) biomass 12 weeks after treatment with systemic herbicides; bars sharing the same letter are not different at the alpha = 0.05 significance level (n=8); the solid line is pre-treatment biomass; along the x-axis, IMR is imazapyr, GLY is glyphosate, IMX is imazamox, and PEN is penoxsulam.

treatment was replicated four times per trial. Herbicide treatments were applied as a foliar spray using an ATV sprayer outfitted with a boomless nozzle (spray swath of 30 ft) and applied at a target carrier volume of 50 gal/ac. Herbicide treatments were imazapyr (Habitat; 3 pts/ac), glyphosate (Roundup Custom; 4 pts/ac), imazamox (Top Deck; 4 pts/ac), and penoxsulam (Galleon SC; 2.8 oz/ac); each herbicide treatment included 0.5% v:v methylated seed oil to enhance herbicide uptake by plants. At 12 weeks after treatment (WAT), plant height and percent cover were recorded in each plot, and biomass was collected at three points in each plot in the same manner as pre-treatment specimens. Plant community data was also assessed to determine which species were recolonizing treated sites (data not presented). A final data collection and harvest event will occur in the summer of 2023 to collect 52 WAT data.

An ANOVA procedure was used to detect differences in treatment means and if differences were detected, a Fishers Least Significant Difference test was used to separate treatment means at the alpha = 0.05 significance level.

CONCLUSIONS

Knotgrass height was reduced 58 to 70% (Figure 3), percent cover was reduced 69 to 88% (Figure 3), and biomass was reduced 70 to 88% (Figure 4) by all herbicide treatments 12 WAT when compared to non-treated reference plants. There was no difference in height, percent cover, or biomass reduction among herbicide only treatments 12 WAT (Figures 3 and 4) and most herbicide treatments suppressed knotgrass near

or below pre-treatment levels. Many sites (except imazapyr treated sites) were being re-colonized by members of the polygonum (smartweeds) and cyperus (flat sedges; Figure 5) species; both of which contain species that produce prolific amounts of seed consumed by waterfowl.

This work provides evidence that ALS inhibiting herbicides labeled for general aquatic use in the United States can be used for short term knotgrass reduction; however, long term results will give a better understanding of the role of these herbicides for future knotgrass management. Long term data is a critical need before these herbicides can be recommended for operational knotgrass management and will be collected in the summer of 2023 (52 WAT). Future work is planned to assess these herbicides on knotgrass in flooded conditions, the efficacy of other herbicide modes of action on knotgrass, as well as integration of herbicides with other control techniques like mowing, disking, or prescribed fire for knotgrass reduction.

Figure 5. Herbicide treated plot re-colonized by flat sedges (*Cyperus* spp.) and smartweed (*Polygonum* spp.).

JAPM article introduction

New Zealand (NZ) has a multitude of freshwater bodies and lakes, which are highly valued for their scenic beauty, recreational, cultural and commercial uses and are home to unique flora and fauna due to the country's isolation in the South Pacific. However, a succession of new aquatic plants and animals have been introduced to NZ, primarily for ornamental and aesthetic reasons through the aquarium trade, and subsequently spread either deliberately or accidentally by people[1,2]. Some of these introduced species are invasive, readily displacing native plants and animals and impeding the use of lakes and waterways, and therefore pose a continued threat to the associated anthropogenic values of freshwater[3].

There is a strong focus on biosecurity in NZ, both through border protection to keep unwanted species out of the country, and regionally to respond to new incursions of invasive species when they occur. However, effective management of invasive aquatic plants is only possible where appropriate methods have been developed for their detection and control or eradication, alongside an understanding of species risks, particularly as the climate changes and species impacts and ranges shift. There is increasing evidence that species risk assessments must diligently include the risks associated with different biotypes, hybrids, variants and phenotypes within single species that have been recognised in recent years[4 5 6 7]. Some of these new or newly recognised variants are able to grow and thrive under an extended environmental range, compared with the originally described species, and may respond differently to established control methods[8 9]. While variation within a species occurs by natural means (e.g., hybridisation, mutations), there are also human mediated changes such as the introduction of new plant phenotypes to a region, including those that may have been cultivated for desirable appearance or growth characteristics. Regardless of their origins, means to detect meaningful variation and efficacious control tools are needed where invasive species (and their biotypes) threaten aquatic ecosystems.

The below paper is an example of evaluating control tools for the cabomba variant present in NZ.

1 Champion PD, Clayton J, Rowe D. (2002). Alien Invaders – Lake managers handbook. Ministry for the Environment, No 444. Pp 51. https://environment.govt.nz/assets/Publications/Files/lm-alien-invaders-jun02.pdf

2 Champion PD, de Winton MD, Clayton JS. (2014). A risk assessment based proactive management strategy for aquatic weeds in New Zealand. Management of Biological Invasions 5: 233–240, http://dx.doi.org/10.3391/mbi.2014.5.3.06

3 Parliamentary Commissioner for the Environment (2022). New Zealand under siege. A review of the management of biosecurity risks to the environment. Pp 116. https://pce.parliament.nz/media/pwvjsrz0/under_seige_full.pdf

4 Netherland M. (1997). Turion ecology of hydrilla. J. Aquat. Plant manage. 35: 1–10.

5 Moody M, Les D, Ditomaso J. (2008). The role of plan systematics in invasive plant management. J. Aquat. Plant Manage. 46: 7–15.

6 Thum R, Zuelllig M, Johnston, R, Moody M, Vossbrinck C. (2011). Molecular markers reconstruct the invasion history of variable leaf watermilfoil (*Myriophyllum heterophyllum*) and distinguish it from closely related species. Biol. Invasions 13: 1687–1709.

7 Bultemeier B. (2008). The response of three cabomba populations to herbicides and environmental parameters: implications for taxonomy and management. M.Sc. thesis. University of Florida, Gainesville, FL.

8 Bultemeier B, Netherland M, Ferrell J, Haller W. (2009). Differential herbicide response among three phenotypes of *Cabomba caroliniana*. Invasive Plant Sci. Manag. 2: 352–359.

9 APMS (2014). Herbicide resistance stewardship in aquatic plant management. APMS white paper. Pp 18.

Response of fanwort (*Cabomba caroliniana*) to selected aquatic herbicides in New Zealand

Deborah E Hofstra, Daniel Clements, Denise M Rendle, and Paul D. Champion*

ABSTRACT

Fanwort (*Cabomba caroliniana* A. Gray, also known as cabomba) is an obligate submersed macrophyte native to the southern United States and Central and South America that has naturalized in the eastern United States, Canada, and various countries in Europe, Asia, and Oceania. It has been cultivated in New Zealand as an aquarium plant for at least 30 yr, but until recently (2009) had not naturalized. Fanwort is now declared an Unwanted Organism in New Zealand and as part of

Surface reaching cabomba, with developing flowers and surface-floating leaves.

incursion response planning, effective management responses are required to achieve eradication. In this study we conducted herbicide trials on fanwort in containment using the herbicides carfentrazone, endothall, flumioxazin, and triclopyr. All four herbicides reduced fanwort biomass; however, with all herbicides viable plant material remained, indicating the potential for rapid regrowth after treatment, and a high degree of uncertainty of outcome where the herbicides are to be used for the management of field populations. None of the herbicides are recommended for use in eradication programs on fanwort without a clear understanding that multiple applications will likely be required, and there is a degree of uncertainty regarding the level of efficacy that can be achieved.

Key words: aquatic weed control, cabomba, carfentrazone, endothall, flumioxazin, triclopyr.

INTRODUCTION

Cabomba caroliniana A. Gray (fanwort, also known as cabomba) is an obligate submersed macrophyte native to Central America, South America, and the southern United States (Bultemeier et al. 2009). It has naturalized in the eastern United States (Bultemeier 2014), Canada, Malaysia, New Guinea, China, Japan, southern Europe, India, and Australia (Wilson et al. 2007). In the Northeast and Midwest of the United States fanwort behaves more like an invasive species (Bultemeier 2008) and less like a native that has found an expanded range. In New Zealand, it has been cultivated as an aquarium plant for at least 30 yr (Champion and Clayton 2001), but until more recently (2009) had not naturalized.

Fanwort is a perennial and primarily reproduces via vegetative fragmentation. Fanwort is not known to reproduce sexually in New Zealand, although reproduction by seed has been recorded in northern Australia (Schooler et al. 2006). Shoot fragments have a high regeneration potential (Dugdale et al. 2013a), a single-node fragment had 50% establishment success when planted in substrate and this increased to 100% for fragments with two or more nodes. Establishment success was lower for free-floating propagules, which had a 1 to 30% chance of colonization, depending on fragment size (Bickel 2017). As with other similar submersed invasive weeds, dispersal between water bodies is largely human mediated (Bickel 2015). Potentially, human-mediated spread by contaminated machinery, boats, and trailers or nets could disperse plants from the naturalized site in New Zealand.

Importantly, variation has been recognized amongst fanwort from different locations that is reportedly influenced by temperature and light (Bultemeier et al. 2009). In the United States, plants differ in color (green to red and intermediate) and respond differently to pH and temperature, both of which are parameters that influence photosynthesis and plant growth. ''Green'' fanwort had peak photosynthesis at pH 6.2, and was tolerant of a wide temperature range, including cool conditions expected for overwintering in the northeastern United States (Bultemeier 2008). By comparison the ''red'' and the ''intermediate'' (''aquarium'') fanwort had peak photosynthesis at pH values of 5.9 and 6.5 respectively. Red fanwort had higher photosynthetic rates than both the intermediate and green fanwort phenotypes as temperature increased to 32 C (Bultemeier 2008).

Climate modelling suggests that fanwort could potentially grow in most lowland New Zealand water bodies (Champion and

Table 1. Summary of effective herbicide treatments on fanwort. For each herbicide, target concentration rate, comments on efficacy and the cited literature is listed. Information is summarized and expanded on from Hackett et al. (2014) and DiTomaso et al. (2013).

Herbicide	Concentration	Efficacy Comments	References
Carfentrazone	100 lg ai L^{-1} to 2 mg ai L^{-1}	Not registered for use in water in New Zealand 60 to 90% biomass reduction in mesocosms Likely eradication of a field site	Bultemeier et al. 2009, Day et al. 2014, Hunt et al. 2015, Gettys et al. 2018
Diquat	0.3 to 2 mg ai L^{-1}	Approved for aquatic use in New Zealand Ca. 50% reduction of photosynthesis, limited efficacy on whole plants	Bultemeier 2008, Bultemeier et al. 2009, Dugdale et al. 2012
Endothall amine salt	1 to 5 mg ai L^{-1}	Not registered for use in water in New Zealand Ca. 86% biomass reduction Biomass reduction of 83, 100, and 100% at 0.5, 1.5, and 3 mg ai L^{-1}; 50% biomass reduction at 6.9, 2.8, and 0.3 h exposure period were obtained at 0.5, 1.5, and 3 mg ai L^{-1}	Bultemeier et al. 2009, Dugdale et al. 2012, Hunt et al. 2015
Endothall dipotassium	1 to 3 mg ai L^{-1}	Approved for aquatic use in New Zealand Symptoms within 3 to 7 d Less effective than endothall amine	Bultemeier et al. 2009, Dugdale et al. 2012
Florpyrauxifen-benzyl	10 to 20 lg ai L^{-1}	Not registered for use in water in New Zealand Ca. 90% reduction of biomass in mesocosms Not effective with static 4-wk exposure at 81 lg ai L^{-1} in mesocosm experiment	Gettys et al. 2018, Richardson et al. 2016
Flumioxazin	0.1 to 0.4 mg ai L^{-1}	Not registered for use in water in New Zealand Reduced photosynthesis in laboratory study, ca. 96% reduction of biomass of whole plant and field success	Bultemeier 2008, Bultemeier et al. 2009, Valent 2009
Fluridone	5 to 20 lg ai L^{-1}	Not registered for use in water in New Zealand Reduces biomass by . 80% after 84 d at 0.02 mg ai L^{-1} Exposure period – weeks	Mackey 1996, Nelson et al. 2001, 2002
Penoxsulam	0.1 to 0.2 mg ai L^{-1}	Not registered for use in water in New Zealand Exposure period – weeks Penoxsulam with diquat, ca. 90% reduction of biomass in mesocosms	DiTomaso et al. 2013, Gettys et al. 2018
Triclopyr	0.5 to 2.5 mg ai L^{-1}	Permitted for use in water in New Zealand, under Environmental Protection Agency controls and permissions Ca. 90% biomass reduction in mesocosms	DiTomaso et al. 2013, Gettys et al. 2018

A pond with surface reaching cabomba.

Clayton 2001). Fanwort can grow rooted in sediment, or free-floating in stagnant to slow flowing water, including streams, small rivers, lakes, ponds, and ditches, although it does prefer slightly acidic waters (DiTomaso et al. 2013). Fanwort was assigned an Aquatic Weed Risk Assessment score of 58 in New Zealand in 2001, but at that time it was considered premature to ban the species from sale and distribution based on its long cultivation history and lack of naturalization (Champion and Clayton 2001, Champion et al. 2007). However, it was recognized that locally, native species will be displaced where fanwort occurs and that uncontrolled populations of fanwort pose a threat if the continued spread of the plant occurs.

Until recently, fanwort was not managed in New Zealand (Champion et al. 2013). However, following the discovery of an infestation (ca. 2.5 ha) in the Paremuka stormwater retention ponds, West Auckland, an incursion response has been enacted and fanwort declared an Unwanted Organism in 2016. Under this designation, it is an offense to propagate, sell, or distribute the species as the plant poses a major weed risk to New Zealand (New Zealand Government 2019).

Neither of the two herbicides currently registered for control of submersed aquatic weeds in New Zealand (diquat dibromide, endothall dipotassium salt) are particularly efficacious on fanwort. The effective chemical control options reported for fanwort internationally are limited to the amine salt of endothall (. 2.3 mg ai L^{-1} to 5 mg ai L^{-1}) and flumioxazin (200 to 400 lg ai L^{-1}), with lower (or variable) efficacy reported for carfentrazone, dipotassium endothall, diquat, florpyrauxifen-benzyl, fluridone, penoxsulam, and triclopyr (Table 1) (Moore 1991, Mackey 1996, Madsen 2000, Nelson et al. 2001, 2002, Bultemeier et al. 2009, van Oosterhout et al. 2009, Dugdale et al. 2012, DiTomaso et al. 2013, Bultemeier 2014, Hackett et al. 2014, Richardson et al. 2016). However, there are some contradictory efficacy results in the literature which could be due to differences in the scale of experimental trials (Hackett et al. 2014), or due to differences in the susceptibility of different fanwort phenotypes (Bultemeier 2008, Bultemeier et al. 2009). This highlights the importance of using plants sourced from the field site in New Zealand to assess efficacy.

The aim of this study was to understand the efficacy of several herbicides which have potential to effectively eradicate occurrences of this weed in New Zealand and mitigate further biosecurity concerns. We conducted an experiment in mesocosms to determine efficacy of herbicides against fanwort to guide subsequent eradication efforts in New Zealand.

MATERIALS AND METHODS

The effectiveness of four herbicides was tested on fanwort in a mesocosm study during summer (January to April 2017), at the National Institute of Water and Atmospheric Research experimental research facility, Hamilton, New Zealand (37846030.600S; 175818045.1200E). Fanwort plant material collected from West Auckland (3685209.96600S; 174818045.11900E) was cultured in a greenhouse with 30% shade, in plastic tanks filled with municipal dechlorinated water and continuously aerated. One shoot (250 mm long) of fanwort was planted into each pot (375 ml) containing topsoil (1.3 g phosphorus: 3.6 g nitrogen per kilogram dry weight of soil), augmented with fertilizer1 (N– P–K, 15.3–1.96–12.6; at label rate of 5 g L^{-1} soil) and topped with a layer of washed sand (10 mm). A total of 15 pots containing fanwort were placed in each of 25 experimental tanks (180 L). An additional 20 shoots of fanwort were prepared and oven dried to determine initial plant weight (0.218 6 0.08 g SD). Water temperature and light was recorded (15-min intervals) over the experimental period with the use of pendant loggers2 that were placed near the surface of the water in three randomly selected tanks. The pH3 of the water was recorded in the morning and afternoon occasionally over the cultivation period, to provide an indication of the pH shift occurring in the tanks as pH is related to carbon availability to plants for photosynthesis.

After approximately 14 d in cultivation, ambient temperatures were 21 C (daily average) but there was still little new growth. Subsequently, CO2 was delivered into the water through the aeration system. The CO2 was gently bubbled through the tanks for a short period (ca. 1 h) every 2 to 3 d to provide plants with additional dissolved carbon (Nelson et al. 2002). One month after planting, fanwort had new shoots and shoot length had visibly increased with some shoots at the surface of the water. In response to increased algal growth in the tanks, the shade level was increased (80%).

Once fanwort was reaching toward the surface of the water in each tank (8-wk culture period), the selected herbicides were applied directly to the water column to maximize dispersal and contact with plant surfaces. The treatments were flu-

mioxazin4 (400 lg ai L^{-1}), carfentrazone5 (2 mg ai L^{-1}), endothall dipotassium salt6 (5 mg ai L^{-1}), and triclopyr7 (2.5 mg ai L^{-1}). The treatments reflect maximum label rates of the active ingredients. It is noted that the maximum label rate for carfentrazone, as sourced,5 exceeds the maximum on the label rate in the United States (0.2 mg ai L^{-1}). Treatments were replicated five times including untreated (no-herbicide) control tanks. Herbicides were applied at dawn, when the water pH was lowest. The water pH was recorded prior to treatment, 1 h after treatment and at midday, to provide an estimate of likely contact time for those herbicides (e.g., flumioxazin) that degrade more rapidly as pH increases (Netherland 2014).

Plant condition was visually assessed at weekly intervals posttreatment. Four weeks after treatment a destructive harvest of viable plant biomass was undertaken. At that time, damaged plant material had largely decayed, and new growth was initiating on some plants. Plant material was harvested from each tank, washed, and dried at 80 C until constant dry weight was achieved. Data are reported as fanwort dry weight biomass per tank for each treatment. Data were analyzed using ANOVA with Student's t post hoc tests. All mention of statistical significance refers to $P < 0.05$.

RESULTS AND DISCUSSION

Over the trial period water temperature in tanks ranged from 14 to 27 C with a daily average of 20.5 C. Light levels varied greatly over the growth and experimental period with seasonal change and the increased shade cloth used to reduce light and minimize algal growth. The average daytime light in midsummer was 1,182 lmol photons m 2 s^{-1} (under 30% shade cloth) and ranged from 426 to 176 lmol photons m 2 s^{-1} (under 80% shade) toward the end of summer. However, light was sufficient to support fanwort growth, as indicated by the surface-reaching growth of plants after approximately 6 wk. The largest range in pH values was recorded in January with a minimum of 5 (at 9 a.m.) and a maximum of 8 (at midday), with values more typically recorded between 6 and 7 and within the range suitable for fanwort growth (Mudge 2018). Prior to herbicide applications water pH averaged 6.6 6 0.2 SD.


Surface reaching cabomba, and koi carp (also an invasive species in NZ).

During the posttreatment period, plants in the untreated control tanks remained healthy and continued to grow with new shoots and buds observed. Fanwort did not show herbicide symptoms within the first week following any treatment. In tanks treated with endothall dipotassium salt and flumioxazin, a distinct discoloration of some plants was observed, whilst others were relatively unaffected 1 wk after treatment (WAT) within those treatments. By harvest, at 4 WAT, individual plants within tanks ranged from discolored to collapsed and fragmented. Similarly, some, but not all, plants treated with carfentrazone and triclopyr were fragmented whilst others remained intact. In contrast, the triclopyr-treated plants appeared to be intact, yet when they were touched most plants collapsed, presenting little structural integrity.

The highest biomass was recorded from untreated control tanks. All herbicides had a significant effect on fanwort biomass, reducing the amount of fanwort in the treated tanks compared with the untreated control tanks (Figure 1). However, biomass between herbicide treatments was similar, ranging from 47 to 67% reduction in biomass compared to the untreated control tanks.

Fanwort is sensitive to factors such as pH, water movement, and light levels in cultured conditions, as such the slow initial growth of fanwort in the experiment was not unusual. High pH levels (> pH 7) can strongly limit growth of fanwort (Mackey 1996, Nelson et al. 2002, Bickel 2015), with the optimum pH range being 5 to 6.5 (Bultemeier 2008, Schooler et al. 2009). In the experiment the addition of bubbling CO2 and alternately bubbling air into the culture tanks with fanwort provided gentle water movement, dissolved carbon, and aided in keeping the water slightly acidic for optimum plant growth.

There are relatively few studies that have treated rooted fanwort plants with herbicides against which the present study can be compared. Additionally, varied susceptibility to herbicides was noted between different fanwort phenotypes, with green fanwort being the most tolerant (Bultemeier et al. 2009). Furthermore, the green fanwort phenotype differs from the fanwort population that has established in Auckland, which is also green (as opposed to red) but often tinged with purple and the undersides of the leaves were paler (P. D. Champion, unpub. data), potentially similar to the intermediate phenotype known from the aquarium trade in the United States (Bultemeier 2008). In addition to phenotype, plant age (length of time in cultivation) and length of time between treatments and harvest all vary in the literature. All these factors complicate comparisons from which to draw a greater understanding of herbicide efficacy. For example, although the herbicides in the present study all reduced the biomass of fanwort, only the use of carfentrazone resulted in an apparently similar response to that reported in the literature, with ca. 60% reduction (Bultemeier 2008, Hunt et al. 2015). However, the similar level of

biomass reduction was achieved with different rates, i.e., 0.2 mg ai L^{-1} (Bultemeier 2008) compared with 2 mg ai L^{-1} in the present study. Gettys et al. (2018) noted an even lower rate of carfentrazone (0.1 mg ai L^{-1}) also resulted in a higher level of biomass reduction (ca. 90%) when left for 16 WAT. Of note, carfentrazone was applied at 2 mg ai L^{-1} to half of a small (ca. 8 ha), shallow (maximum depth, 2.7 m) lagoon in Australia, resulting in the putative eradication of fanwort (Day et al. 2014). Further, Dugdale et al. (2013b) suggest that carfentrazone, registered in Australia, can be useful for the control of fanwort.

In contrast, triclopyr was more effective (ca. 50% reduction in biomass, using 2.5 mg ai L^{-1}) than was reported by Bultemeier (2008) against green fanwort using a higher treatment rate. Green fanwort treated with triclopyr (4 mg ai L^{-1}) did not differ from the untreated control plants at 2 WAT (Bultemeier 2008). However, Gettys et al. (2018) used the same treatment rate as the present study (2.5 mg ai L^{-1}) and reports still greater efficacy of ca. 90% reduction. Amongst the other herbicides, flumioxazin was not as efficacious in the present study as has been described in previous studies. For example, Valent (2009) reported 100% control with 200 lg ai L^{-1} flumioxazin at a field site (Hackett et al. 2014), and Bultemeier (2008) suggested that 400 lg ai L^{-1} flumioxazin provided the best control of green fanwort (the least susceptible phenotype). In the present study, there was only a 40% biomass reduction of fanwort with 400 lg ai L^{-1} flumioxazin. The efficacy of flumioxazin has reportedly been linked to the pH of the water (rapid breakdown occurs at high pH levels, ca. 15-min half-life at pH 9) and light penetration, although no evidence of an effect was reported by Bickel et al. (2018). Trials in Australia showed that fanwort was effectively controlled even if exposed to the herbicide for only 15 min (Bickel et al. 2018).

Endothall at 5 mg ai L^{-1} (dipotassium salt) provided ca. 67% biomass reduction. This contrasts with the findings of Bultemeier (2008), which did not consider endothall (dipotassium salt) at 3 mg ai L^{-1} to be efficacious, with similar conclusions reached by Dugdale et al. (2012) when using up to 5 mg ai L^{-1} endothall (dipotassium salt).

Genetic studies to elucidate which phenotype/s exist in New Zealand and internationally would enable greater comparisons to be made with previous studies. It is important to realize that if multiple phenotypes exist in New Zealand, employing a particular suboptimal control measure may select for more difficult to control fanwort in the future. Previous results have demonstrated clear phenotypic differences in response to herbicide treatments and lack of susceptibility of fanwort to most herbicides (Bultemeier et al. 2009).

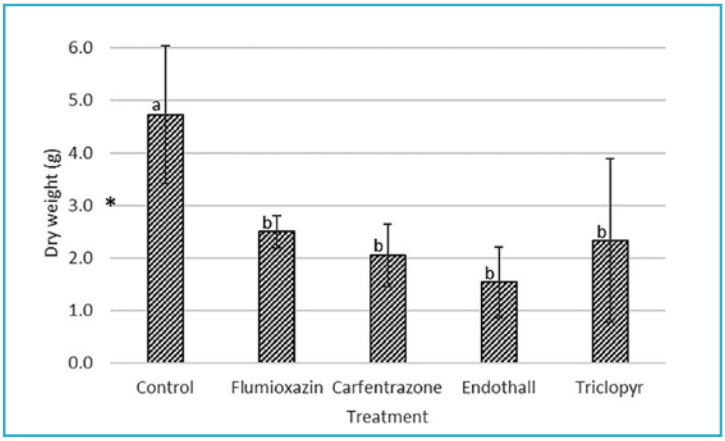

Figure 1. Fanwort biomass 4 wk after herbicide treatment. Solid bars represent average dry weight (g) from five replicate tanks, error bars represent 1 SD. Herbicide treatments include flumioxazin (400 lg ai L-1), carfentrazone (2 mg ai L-1), endothall dipotassium salt (5 mg ai L-1), and triclopyr (2.5 mg ai L-1). Letters represent significant differences between treatments (ANOVA; Student's t tests; P , 0.05). The asterisk (*) represents initial plant biomass per tank.

In summary, challenges in comparing studies, including the recognized variability in the tolerance of different fanwort phenotypes to herbicides, highlights the importance of using plants from the local New Zealand infestation to assess herbicide efficacy relevant to a proposed eradication program. All four herbicides reduced fanwort biomass; however, in all treatments, the amount of viable plant material that remained indicates the potential for rapid fanwort regrowth after treatment. For a successful eradication program, multiple applications of the selected herbicides would likely be required, also noting a degree of uncertainty regarding the level of efficacy that could be achieved with the herbicides evaluated. Small-scale field trials are likely required to fully explore herbicide efficacy and the levels of fanwort biomass reduction that can be achieved.

SOURCES OF MATERIALS

1 Osmocote fertilizer, Scotts Miracle-Gro Company, 14111 Scottslawn Road, Marysville, OH 43041.

2 Hobo pendant temp/light logger (UA-002-64), Onset, 470 MacArthur Blvd, Bourne, MA 02532.

3 EXO1 Multiparameter Sonde (SKU: 599501), 1700/1725 Brannum Lane, Yellow Springs, OH 45387.

4 Flumioxazin (Valort 500 WG Herbicide), Sumitomo Chemical Co., Ltd., 27-1, Shinkawa 2-chome, Chuo-ku, Tokyo 104-8260, Japan.

5 Carfentrazone (Sharke) FMC Corporation, 2929 Walnut St, Philadelphia, PA 19104.

6 Endothall (Aquatholt K), United Phosphorus Inc., 630 Freedom Business Center Dr, King of Prussia, PA 19406.

7 Triclopyr (Garlone 360), Dow Corporate, 2211 H. H. Dow Way, Midland, MI 48674.

ACKNOWLEDGEMENTS

This research was funded by the Strategic Science Investment Fund and Ministry for Primary Industries, New Zealand Government. The authors would like to thank Giorgia Kershaw (B.Sc.Tech student, University of Waikato) for her time spent setting up and maintaining the experiment. Doug Paton (Sumitomo) is acknowledged for supply of flumioxazin for the experiments. The anonymous reviewers are thanked for their time and contribution to the manuscript.

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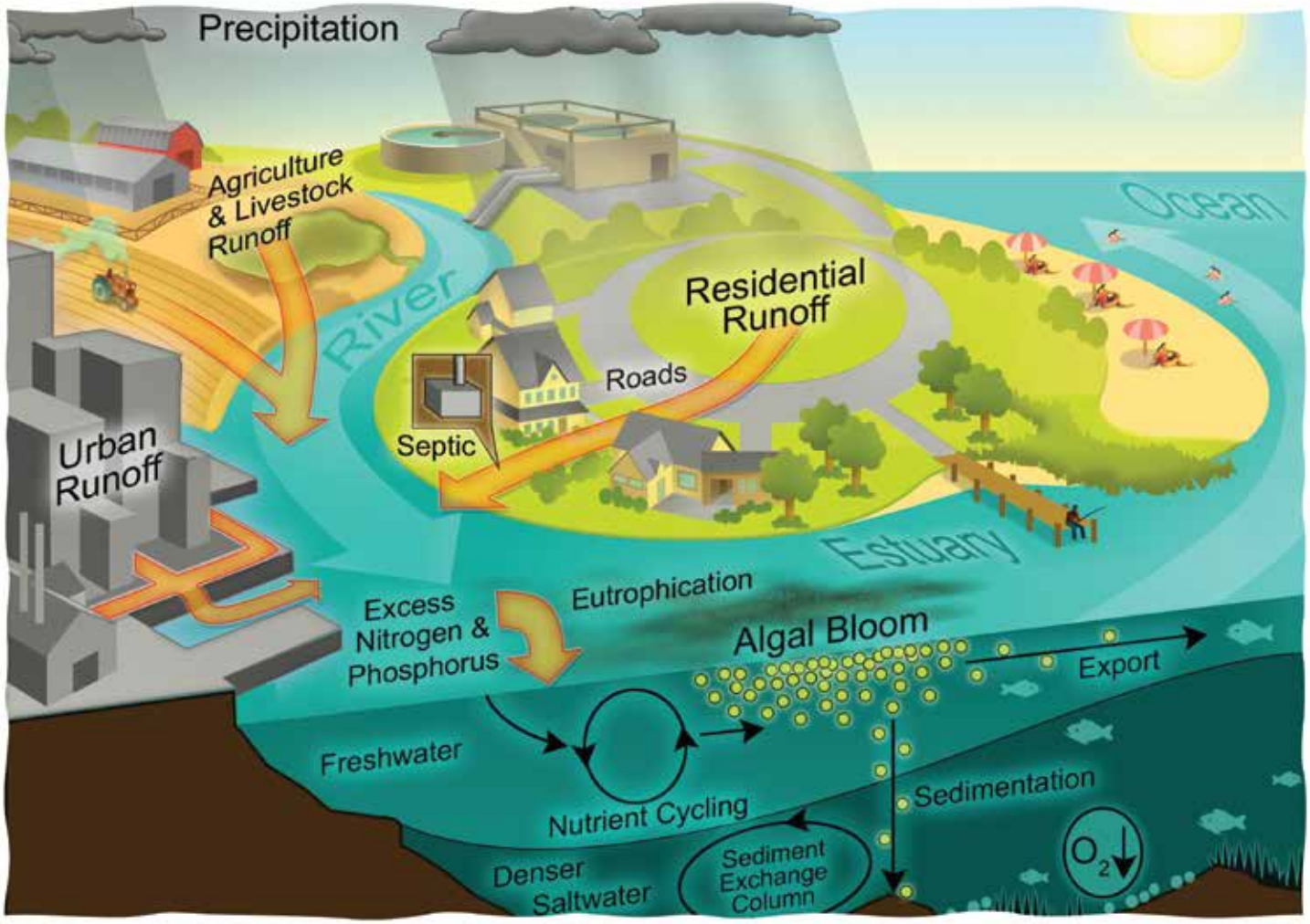
Water Quality & Eutrophication



By Ashley Smyth & Laura Reynolds

Water Quality

On June 22, 1969, the Cuyahoga River in Ohio caught fire. This fire was one of many for this river. But this time, the fire mobilized public concerns about oil and chemical pollution in the river, ultimately leading to the creation of the Environmental Protection Agency and the Clean Water Act. The Clean Water Act established a national commitment to restore and maintain the nation's waters' chemical, physical, and biological integrity. The Act gave the Environmental Protection Agency (EPA) the authority to set water quality standards for various pollutants and the ability to enforce those standards through permits and other regulatory mechanisms. The Clean Water Act has been instrumental in improving the health of rivers, lakes, and coastal waters. It has stopped billions of pounds of pollution from fouling the water and dramatically increased the number of safe waterways for swimming and fishing.

Water quality refers to water's physical, chemical, and biological characteristics that can affect its suitability for a particular use. Oil and chemicals were the big water quality issue for the Cuyahoga River. Still, many things can impact water quality, so we need various ways to measure and quantify water quality. Water quality can be measured using any number of physical, chemical, and biological parameters. Some common measurements include pH, temperature, turbidity, dissolved oxygen, total dissolved solids, and various contaminants such as bacteria, heavy metals, and pesticides. Water samples are typically collected and analyzed in a laboratory, but we can also use field test kits and sensors for on-site testing. Water quality managers can also use biological indicators such as certain aquatic organisms' presence can also be used to assess water quality. It is difficult to have one set of rules for what makes good water quality because of the uses and properties of the water (i.e., saltwater vs. freshwater). As a result, water quality standards vary between the type of water body.

Water quality changes whenever there are pollutants added. These pollutants can range from litter and debris to heavy metals from industrial sources. There are many factors related to water pollution, and the type of pollutant will have different impacts on water quality. Some examples include:

- Heat: Thermal pollution results because paved surfaces tend to hold heat and transfer that heat to rainwater, which runoff into waterbodies.

Power plants and other industries heat water as part of their operations. Warmer water contains less oxygen than cooler water, meaning less oxygen is available for aquatic organisms.

- Sediment: Erosion due to development or increased precipitation becomes suspended in the water. These particles can impact light availability for plants and clog the gills of organisms or transport harmful substances.
- Nutrients (nitrogen and phosphorous): Excess nutrients from fertilizer and animal and human waste and the atmosphere can lead to the excessive growth of algae in water bodies, which, when the algae die, and bacteria decompose them, can deplete the water of oxygen.
- Chemicals: Industrial and household cleaners, heavy metals, gasoline, oil, detergents, and other chemicals can threaten human and aquatic life.
- Genetic pollution: The presence of non-native plants and animals can disrupt the balance of the ecosystem with consequences for biodiversity.

The US government established the Clean Water Act to regulate water pollution and set water quality standards for waterbodies. The Clean Water Act aims to ensure that drinking water is safe and recreational waters are fishable and swimmable. All waterbodies and all pollutants, from nutrients to oil/grease and bacteria, are considered in the Clean Water Act. The Clean Water act allows the EPA to monitor waterways to ensure water quality standards and to regulate pollution discharge. To meet the standards set by the Clean Water Act, facilities that discharge pollutants to water bodies much obtain permits and implement best management practices (BMPs) to reduce their impact on water quality.

BMPs are guidelines and techniques designed to prevent or reduce pollution. Pollution can come from point sources or non-point sources. Point source pollution is pollution from a specific, identifiable location, such as a pipe or ditch—something one can point to. Non-point source pollution comes from diffuse sources, such as runoff from streets and agricultural fields.

BMPs are used throughout the watershed to manage and prevent pollution from both point and non-point sources. BMPs for point sources include treatment systems for industrial and sewage discharges and stormwater management systems for construction sites. Non-point source BMPs usually involve land management practices such as conservation tillage in agriculture and low-impact development for urban areas. BMPs aim to protect and improve water quality by reducing the number of pollutants entering waterways. However, not all pollution can be regulated or controlled with BMPs.

Nitrogen Pollution and The Nitrogen Cascade

Nutrient pollution is one of the most widespread water quality problems. Nutrient pollution can impact freshwater (lakes, rivers, and streams) and saltwater (estuaries, coastal bays) areas. **The EPA reports that** 58% percent of rivers and streams and 45% of lakes have too many nutrients, while 66% of the coastal waters and more than 33% of estuaries do not meet water quality standards for nutrients. While nutrients like nitrogen and phosphorous are all essential for life, these nutrients can have negative consequences when in excess.

Nitrogen pollution can negatively impact air and water quality and plants and animals that depend on these resources. There are two forms of nitrogen: reactive and nonreactive. Reactive nitrogen is useable for life, while nonreactive is biologically inert nitrogen gas (N_2). Human activities have converted the nonreactive nitrogen (N_2 gas) to reactive forms. This increase in reactive nitrogen has the potential to cascade through ecosystems with negative consequences (Galloway et al. 2003) By creating synthetic fertilizers, burning fossil fuels, and cultivating crops, humans have at least doubled the amount of reactive nitrogen cycling since 1960 (Galloway et al. 2008, Erisman et al. 2011). The increase in nitrogen helps to support the growing human population, of which about half is alive today because of synthetic fertilizers and nitrogen-fixing crops. Excess nitrogen causes biodiversity loss in lakes and streams(Vitousek et al. 1997), dead zones, loss of biodiversity, and habitat degradation in coastal systems (Lotze et al. 2006). Because too much nitrogen is harmful, nitrogen is considered a pollutant and regulated under the Clean Water Act.

Too much nitrogen can affect ecological and human health. The nitrogen cascade refers to the series of changes that occur in an ecosystem due to changes in nitrogen availability. The cascade begins with an increase in nitrogen availability, leading to increased primary productivity or the growth of plants and phytoplankton. With more plants, there

can be a larger population of herbivores, sustaining a larger population of carnivores. The increase in nitrogen affects the animal population and can trickle through the plant community. As the availability of nitrogen increases, so does the competition for it among plants and other organisms. This competition can lead to changes in the composition of plant species, with some species better competing for nitrogen out-competing others. It may also change how plants allocate their resources, creating plants with more aboveground biomass (Deegan et al. 2012). The cascade can also lead to negative impacts such as eutrophication of water bodies, where excess nitrogen leads to algal blooms, decreased dissolved oxygen, and can cause fish kills.

Eutrophication

Too much nitrogen in the water can lead to an issue we call eutrophication. Eutrophication is the process by which a body of water becomes enriched with nutrients, leading to an overgrowth of aquatic plants and algae. According to Nixon (1995), eutrophication is the increase in the rate of supply of organic matter to an ecosystem. **Eutrophication results from too many nutrients, usually phosphorus in freshwater and nitrogen in coastal waters.** Eutrophication can occur naturally, but human activities from agriculture and urbanization can accelerate it. These activities can release large amounts of nutrients into water bodies. These nutrients can stimulate the growth of aquatic plants and algae, leading to several problems.

One of the most visible effects of eutrophication is the formation of algal blooms. These are large concentrations of algae that can discolor the water and reduce its transparency. Algal blooms can also produce toxins that can harm wildlife and humans. As the algae die and decompose, oxygen is depleted from the water, leading to dead zones where fish and other aquatic organisms cannot survive.

Another problem caused by eutrophication is the overgrowth of aquatic plants. Overgrowth can lead to dense mats of vegetation that can interfere with recreational activities and make it difficult for fish and other marine animals to move through the water. As plants grow, they utilize the resources available to them. Still, once growth exceeds resources, the carrying capacity, or population size that an ecosystem can maintain, all the resources are used up, and these communities may crash, loading organic material into the system. The decomposition of this plant material can also use up large amounts of oxygen, leading to dead zones.

Eutrophication is a primary concern because it can significantly impact the health of aquatic ecosystems and the human communities that rely on them for drinking water, recreation, and other uses. One of the critical challenges in addressing eutrophication is finding ways to reduce the amount of nutrients entering water bodies while still allowing for the continued use of the land for agriculture and development. Strategies, such as reducing fertilizer use, improving drainage systems, and promoting cover crops and other conservation practices, can help reduce nutrient runoff.

In addition to these strategies, various technical approaches can be used to remove nutrients from water bodies. These include chemical treatments, such as adding aluminum sulfate to the water to precipitate out phosphorus, and biological treatments, such as using bacteria to convert reactive nitrogen to nitrogen gas through denitrification.

Denitrification is a biological process in which microorganisms convert nitrate and nitrite (nitrogen compounds) into nitrogen gas. This process is essential for water quality

because high levels of nitrate and nitrite in water can harm aquatic life and contribute to eutrophication. Denitrification is nature's way of removing nitrogen. This process occurs in anaerobic environments such as sediments and soils. Denitrification can occur naturally in the environment or artificially induced in wastewater treatment plants to remove excess nitrogen before the water is released into waterways. Unfortunately, no similar natural process exists for removing phosphorus, and chemical removal is necessary.

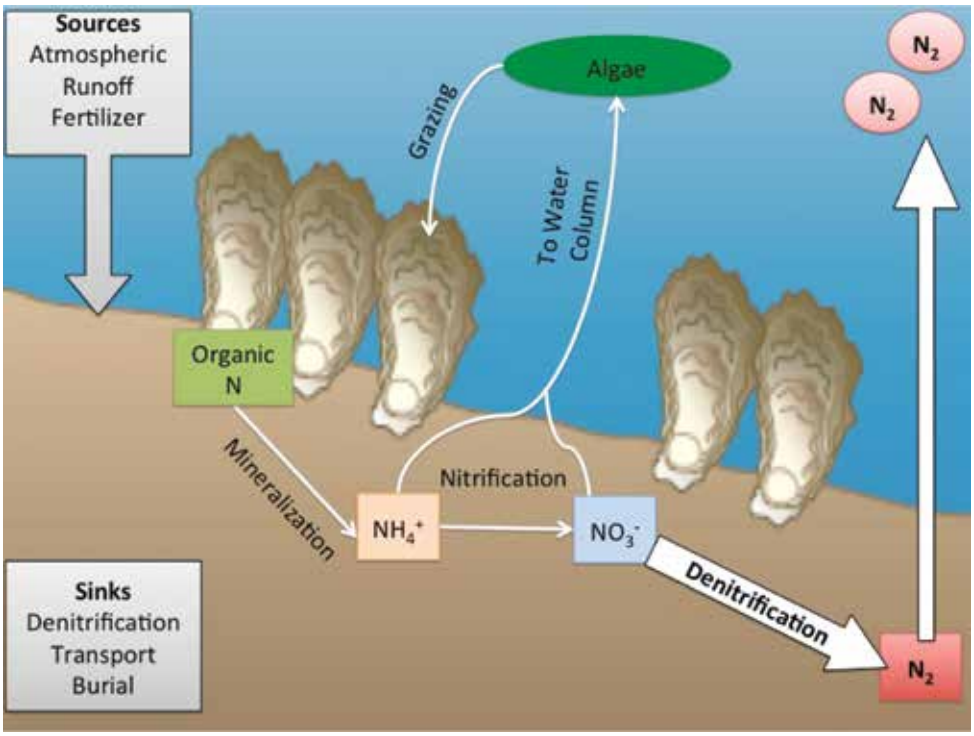
Another way to remove nutrients is to increase the assimilatory capacity of a water body. Assimilatory capacity is the ability of a water body to take on nutrients without negative consequences. For example, planting wetlands or aquatic vegetation, which can use the excess nutrients for their growth, is a way to manage nutrients. Increasing areas that are sinks for nutrients removes the nutrients from the environment. However, it is crucial to find the right balance to ensure no more plants are planted than the environment can handle because if management fails and plants die, the nutrients go back into the water.

Despite the progress that we have made in addressing eutrophication, it remains a significant problem in many water bodies. To see improvements in water quality, we need to continue to reduce the amount of nutrients entering water bodies and develop and implement new technologies for removing nutrients already present are required.

Shellfish as part of the solution to nutrient pollution

There are incentives for farmers to adopt conservation practices and for urban developers to use stormwater control structures to prevent the movement of nutrients from the land to the water. Despite these incentives, nitrogen from land still reaches our waterways, where it causes algal blooms, eutrophication, and habitat degradation and leads to an overall reduction in biodiversity.

Shellfish, such as oysters and clams, can play a role in reducing nutrient pollution in coastal waters. These organisms filter large amounts of water and remove algae, which can absorb excess nitrogen and phosphorus from the water. The shellfish take up these nutrients and store it in their shell and tissue. Filtration can also remove other pollutants, such as sediment. Shellfish clean the water, yet they also are considered hot spots for denitrification. Shellfish increase sediment denitrification relative to sites without shellfish (Smyth et al. 2018). Denitrification increases with shellfish because their filtration moves material from the water column to the anoxic sediments. Because shellfish filter water, which improves water clarity and increases denitrification, there is growing interest from many organizations



in using shellfish to help meet water quality goals and remove nutrients. It is important to note that shellfish alone is not a complete solution to nutrient pollution (Rose et al. 2021) While they can help reduce the nitrogen levels in the water, other measures, such as reducing the amount of agricultural and urban runoff, may also be necessary to address the problem. Additionally, though shellfish can reduce nutrients, nutrients at the highest levels can also be lethal to shellfish, diminishing the effectiveness of shellfish in helping to meet nutrient goals.

What can I do?

Many sources of nutrients cause eutrophication, including agricultural runoff, sewage discharge, and stormwater runoff. A good understanding of the water quality parameters and their relationship to eutrophication is needed to manage water quality. These parameters include nutrient levels, algae concentrations, and dissolved oxygen levels. Using best management practices that can reduce eutrophication, such as reducing nutrient inputs, increasing water circulation (**fountains**), promoting the growth of natural water-filtering organisms like shellfish, and increasing the assimilatory capacity by planting aquatic vegetation may also be a solution.

Knowledge of various tools and strategies to manage and reduce nutrient loads can help protect water quality. There are several steps we can take to reduce nutrient pollution. For example, farmers can use best management practices to reduce the nutrients applied to their fields. Using precision agriculture techniques to apply fertilizer only where and when needed or using cover crops to fix nitrogen in the soil can help manage fertilizer use. Another way to reduce nitrogen pollution is to reduce the amount of nitrogen emitted into the air by burning fossil fuels. Increasing renewable energy sources and converting to hybrid or electric cars are possible solutions. Improving wastewater treatment facilities is another way counties and local municipalities can reduce nutrient pollution and limit the amount released into the environment. You can also make changes at home to prevent nutrient pollution. It is important to inspect your septic system annually to ensure there are no leaks and it is functioning correctly. Following product and county recommendations about fertilizer use will ensure nutrients remain on your lawn. Collecting rainwater and planting rain gardens **or buffers** prevent stormwater from running off your yard and into streams and nearby waters. Reducing nitrogen pollution, preventing eutrophication, and improving water quality requires technological solutions and human behavior changes.

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Dr. Laura Reynolds is a coastal ecologist and assistant professor at the University of Florida in the Soil, Water, and Ecosystem Sciences Department. Dr. Reynolds integrates approaches from population and community ecology, biogeochemistry, and plant physiology to understand better how environmental factors influence the functions and stability of freshwater and nearshore marine ecosystems.
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Regional Chapter Updates

Midwest Aquatic Plant Management Society: Regional Society Update

The Midwest Aquatic Plant Management Society (MAPMS) will be holding our annual conference March 13 through March 16th at the Amway Grand Plaza Hotel in Grand Rapids, Michigan. With the theme being, "Equipped", our goal is that each attendee walks away from the meeting with at least one new tool to equip themselves with this year. We have a few new additions to the conference agenda; highlights include the technical program kicking off with Mark Ostach as our keynote speaker: "Fostering Connection and Wellness in 2023". We will also have a RISE special session following the conference on Thursday morning: "How do I Advocate for the Aquatics Industry?". We encourage everyone to visit our website (www.mapms.org) for more information and look forward to seeing you there.

MAPMS received approval for 501(c)(3) status in December, 2022. There are many great advantages to operating as a 501(c)(3), this grants the society income tax exemption as well as allowing supporters to make tax deductible donations to the society. This is something the board has been working on for quite some time and it is great to finally get approved. We see this as a great opportunity to advance the society.

Also, at the October Board Meeting, the MAPMS Board conducted a strategic planning session facilitated by Dr. Ed Osborne, Professor Emeritus, University of Florida. The session was productive and resulted in updates to the mission, vision, core values, and strategic goals of the society. The new strategic plan will be presented to membership at the 2023 Annual Conference. These strategic goals will help advance and drive the society to new levels.

As always, we appreciate everyone's support of APMS and the regional societies. We hope to put on another great conference in March that provides value to our membership and we are excited to see what we can accomplish in 2023 and beyond.

Texas Aquatic Plant Management Society – Regional Chapter Update:

- Our conference will likely be held **Nov 6-8 at the Mesquite Convention Center**, it was the top pick in our recent BOD poll and we are working on finalizing the details.
- In 2023, we welcomed **3 new BOD members**: Anthony Walker, Ryan O'Hanlon, and Olivia Ybarra.
- We are currently looking into updating the TAPMS Bylaws for Membership which will be presented to membership at least 60 days before the Annual Meeting
- For any inquiries, you can contact the TAPMS BOD through txapms@gmail.com

Submitted by Brittany Chesser
Aquatic Vegetation Management Program Specialist
Texas A&M AgriLife Extension Service
Lead Diagnostic Scientist, TAMU Aquatic Diagnostics Laboratory

Aquatics Magazine - Women of Aquatics

Shannon Junior
Women of Aquatics Editor and Aquatic Ecologist

Women of Aquatics (WOA) was created in 2014 to formalize the supportive network of professional women in the Aquatics industry. Women are historically underrepresented in our field, and our goals are not only to support the professional aspirations of our female colleagues, but also to encourage students and younger women to begin careers in the industry. Our areas of focus include career advancement, continuing education, mentorship, work-life balance, and health and wellness.

Women of Aquatics recently held our Annual Retreat in Orlando, Florida. The gathering included a diverse group of women from throughout the United States, representing the public, private and academic sectors of our industry. We also provide financial support for our Student Director to attend the event each year to ensure succession to the next generation of women. This year's retreat included personal presentations from each attendee,

professional development workshops, and a fun and educational excursion to Rock Springs at Kelly Park.

WOA provides extensive opportunities for networking with other female industry professionals, and the mentorship program connects aspiring students with more experienced members to guide them towards their desired career path. We will be hosting networking events during the WAPMS/WSWS conference in Boise, Idaho, at the end of February, and during the MAPMS conference in March in Grand Rapids, Michigan. Our male colleagues are also welcomed to attend the events, and we are so thankful for their ongoing support of our organization and our professional goals. We also hold monthly virtual roundtable discussions on the first Thursday evening of each month, which are open to current members and interested parties.

We are actively accepting new members and annual sponsors, with 2023 committee assignments currently under consideration. You can find more information on our website at womenofaquatics.org. Please join us!

Shannon Junior (sjunior@solitudelake.com) is an Aquatic Ecologist and Senior Business Development Consultant for SOLitude Lake Management. She has worked in the aquatics industry for over 20 years and currently serves as the Editor for Women of Aquatics.

63rd Annual Meeting of the Aquatic Plant Management Society

July 24-27, 2023
Hyatt Regency Indianapolis – Indianapolis, Indiana

Present Your Original Research

You are invited to submit a title and abstract for the 63rd Annual Meeting of the Aquatic Plant Management Society to be held at the Hyatt Regency in beautiful Indianapolis, IN. Oral and poster presentations are solicited for original research on the biology or ecology of aquatic and wetland plants and algae, control methods (biological, chemical, cultural, mechanical) for invasive, exotic or nuisance plant or algal species, and restoration projects involving wetland or aquatic plants and algae. Presentation of original research will be given preference and should be indicated by including results in the abstract. This year's meeting is in the region of the Midwest Aquatic Plant Management Society, so regional presenters are strongly encouraged to submit an abstract.

Oral presentations will be allotted a total of 15 minutes with an additional 5 minutes for questions and discussion. Contributed oral presentations should be scientific or technical in nature, which will be determined from the submitted abstract. All presenters will be required to upload their final PowerPoint presentation to the abstract submission portal prior to the meeting. Note: All presentations that include externally run programs; models or special animation, must be reviewed and approved by the Program Chair prior to the meeting. You will not be allowed to set up a personal computer for your presentation. A poster session will also be scheduled. Free-standing display boards (4' x 4') will be provided for posters.

Special Session – Navigating Conflict with Improved Communication

The society will be holding a special session discussing how to navigate difficult, and often contentious, conversations regarding invasive plant management. Invited speakers and submitted talks will drive discussions around finding common ground while remaining committed to data and the scientific process. Abstracts submitted for the special session should be indicated during the abstract submission process.

Students

The society will provide all student presenters with room accommodations and complimentary registration. First, 2nd, and 3rd place prize money will be awarded in separate contests for both oral and poster presentations. In addition, a student tour of local management sites and scenic places is being put together for student enjoyment. Students may contact the Program Chair (Dr. Jason Ferrell; jferrell@ufl.edu) or the Student Affairs Committee Chair (Dr. Candice Prince, cprince14@ufl.edu) with any questions.

Abstract Submission Information

Abstracts must be submitted on the WSSA abstract system at https://weedscimeetingabstracts.com/. Instructions for abstract submittal are below. The WSSA Title and Abstract Submission System is now active and will remain open until **June 15, 2023**.

Acceptance of contributed papers will not occur until after the abstract deadline and will be confirmed by a separate e-mail.

Logging in to the WSSA System

If you have used this system before, enter your e-mail address and password to sign on to the system. If you cannot remember your password, click "Forgot your password?" to reset the password.

If you do not have an account with the WSSA abstract submission system, click "Register as a new user" and follow the instructions.

Once you are logged in, you will see a list of conferences that are open for Title and Abstract submissions. Click on "My Titles" at the top, and then click on "Create New". You will be prompted to select a conference. Select "2023 APMS" and hit the "Continue" button.

- **Entering a Title:** Type in the title capitalizing key words (e.g., Response of Eurasian and Hybrid Watermilfoil to Five Auxin-mimic Herbicides). Please do not submit your title in bold typeface or all caps. Just capitalize the major words in the title.
- **Students:** Please indicate if you are a student. The society will provide all student presenters with room accommodations and complimentary registration. There will be a contest awarding 1st, 2nd, and 3rd place for both the oral and poster presentations.
- **Section:** Indicate whether you are presenting an oral or poster presentation using the "Type" dropdown menu.
- **Presenter Biography:** Please provide a short biography of the presenting author (200 word maximum).
- **Abstract:** Type or copy the text of your abstract into the abstract box (300 word maximum).
- **Authors:** Be sure to add the full names and contact information of all authors. Please indicate the presenting author with the checkbox. Please enter all authors in the correct order, and the order can be changed by dragging the boxes.

If you have any questions, please contact:

Dr. Jason Ferrell
2023 APMS Program Chair
jferrell@ufl.edu

Calendar of Events

February 27-March 3, 2023
Western Aquatic Plant Management Society Meeting (Joint Meeting with Western Society of Weed Science)
Grove Hotel
Boise, ID
https://wsweedscience.org/annual-meeting-2023/

March 13-16, 2023
43rd Annual Midwest Aquatic Plant Management Society Conference
Amway Grand
Grand Rapids, MI
https://www.mapms.org/conferences/2022-conference/

May 15-18, 2023
UF/IFAS Aquatic Weed Control Short Course
Orlando, FL
https://sfyl.ifas.ufl.edu/aquatic-weed-short-course/

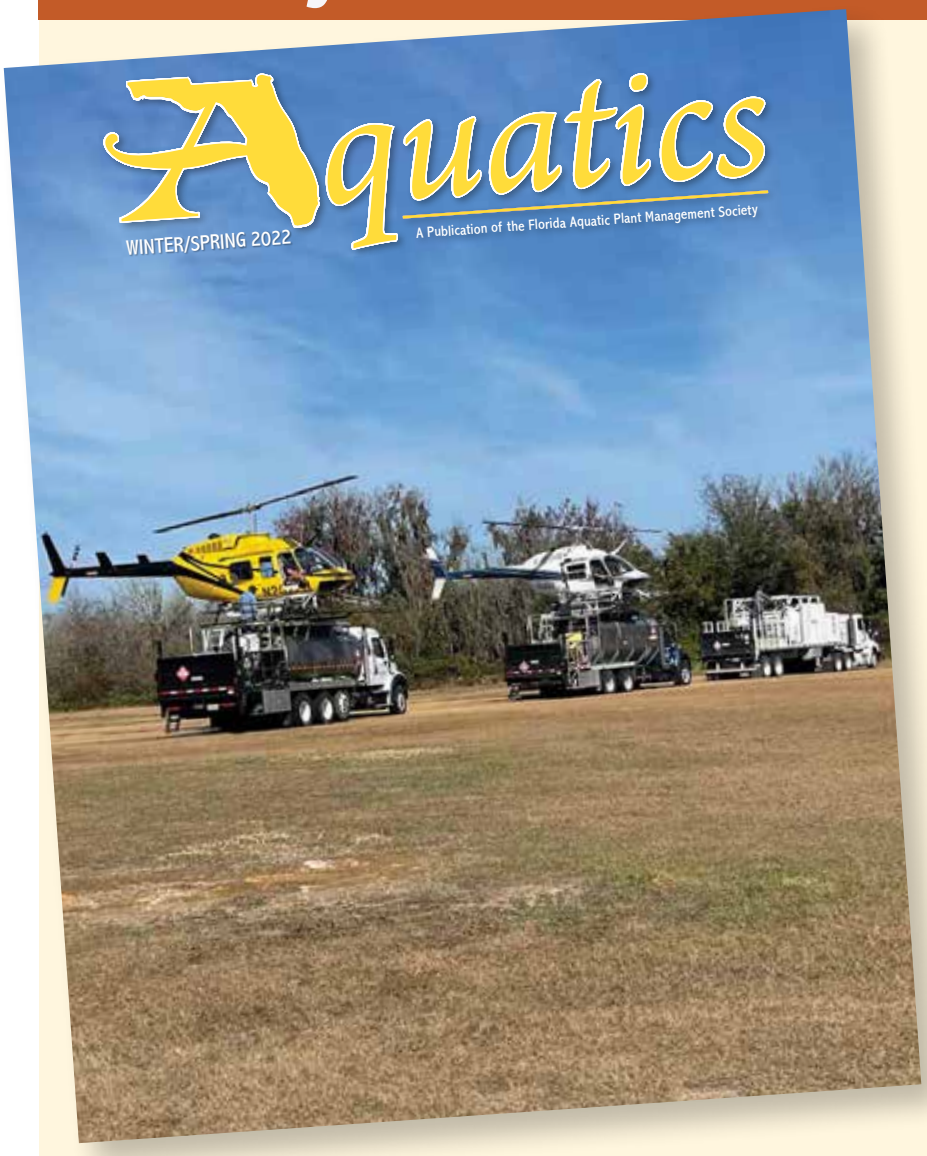
July 24-27, 2023
63rd Annual Meeting of the Aquatic Plant Management Society
Hyatt Regency
Indianapolis, IN
https://apms.org/2023-annual-meeting/

TBD Fall 2023
South Carolina Aquatic Plant Management Society Annual Conference
Ocean Drive Beach and Golf Resort
North Myrtle Beach, SC

October 16-19, 2023
47th Annual Florida Aquatic Plant Management Society Annual Training Conference
Hilton St. Petersburg Bayfront
St. Petersburg, FL
https://fapms.org/conference/2023-conference/

November 13-17, 2023
International Aquatic Plants Group
Antwerp, Belgium
www.internationalaquaticplantsgroup.com

It Pays to Advertise



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