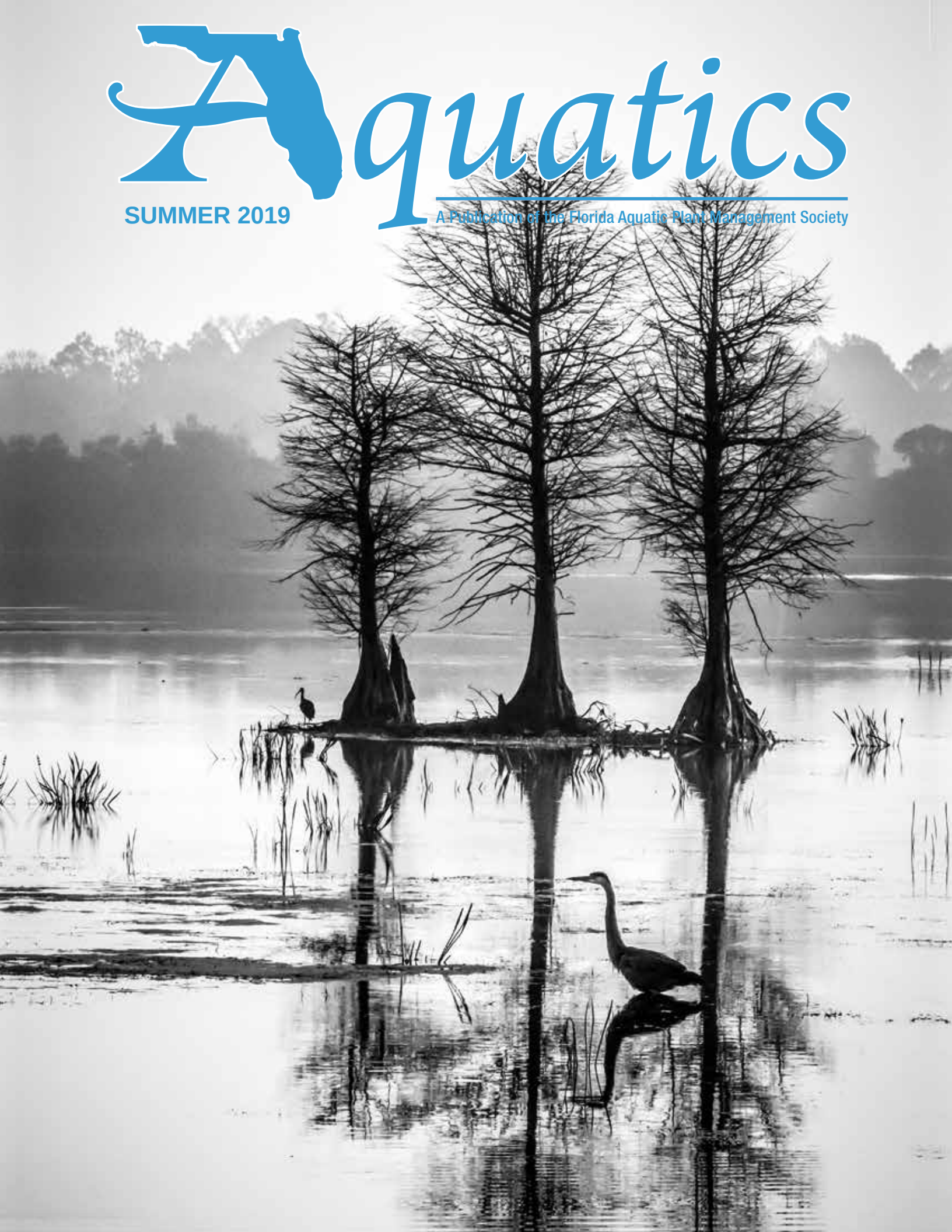
Aquatics

SUMMER 2019

A Publication of the Florida Aquatic Plant Management Society



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Aquatics

SUMMER 2019 Volume 41, Number 2

"Nature Welcomes the Day" — The image was taken on February 20th, 2014, on a foggy morning just after the Orlando Wetlands Park opened. Image was taken using a Nikon V2 camera on a monopod 1/1000 sec f 14, ISO 800 by Bob Willson, a retired optometric physician who is an accomplished documentary and wildlife photographer in Winter Park. His passion is taking documentary images that capture a moment, tell a story, or express a feeling. More of his work is available on his website at rawillson.com.

CONTENTS

Editor's Notes/Corrections:
Correction to cover photo caption from Spring 2019 Issue: The bird on the cover is a tricolor heron (*Egretta tricolor*), not a great blue heron as was incorrectly listed.

To become a member of FAPMS and receive *Aquatics* magazine, please visit the website at: www.fapms.org

The vision of FAPMS is to be a leading resource for promoting excellence in the stewardship of Florida's aquatic ecosystems.

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IN REMEMBRANCE

Dr. Michael D. Netherland Exemplary Colleague Award

In remembrance of our colleague, Dr. Michael D. Netherland, the Florida Aquatic Plant Management Society has established an award to honor his lifelong dedication to research and camaraderie in the field of aquatic plant management. Please see the description below, which includes nomination and recipient criteria.

Award Name: Dr. Michael D. Netherland Exemplary Colleague Award
Nominator: Any FAPMS member
Nominee Membership Status: Any current or former member of any recognized APMS Affiliate
Approval process: Majority FAPMS BOD vote
Award Frequency: Discretionary-can be multiple per year as warranted; Presented at Annual meeting
Criteria:

- A special recognition given to a current or former APMS affiliate member who personifies Michael Netherlands positive attitude, outgoing and inquisitive personality, and genuine selfless giving friendship qualities.
- A person that displays a love and pursuit of gaining and sharing knowledge within the aquatic plant management community.
- A person that exhibits sincerity and friendship towards all FAPMS members, including providing guidance in all forms of aquatic plant management and professional activities.

Award/Honor item: Plaque with inscription to be determined the nominator in conjunction with review of the award committee.
Nominations due by September 1.

APPLICATORS' CORNER

In the spring 2019 issue of *Aquatics* magazine, there were several questions posed to test your knowledge on the biology and other aspects of water hyacinths. These questions were developed from the very classical research conducted by W. T. Penfound and T. T. Earle of the University of Oklahoma and Tulane University, respectively, entitled 'The Biology of the Water Hyacinth' published in 1948, Vol 18, No. 4 issue of the journal *Ecological Monographs*. Published before most of us were born, this is but one example of the value of reading and learning from previous "old" research and observations. This 20-plus page reports on interesting observations and extensive research conducted in Louisiana and should be available on-line. The answers to the quiz questions in the last issue will be numbered and underlined in the following discussion.

Water hyacinth plants produce swollen petioles in **(1.) full sunlight** if they are individual plants or on the fringe of dense hyacinth mats. Within the mat, or in shaded conditions where protected from the sun, plants produce elongated petioles to reach the sunlight at the top of the neighboring plants and do not form float petioles. Despite its introduction all over the world, largely due to its beautiful flowers, the individual flowers are visible for only about **(2.) one day** during summer growing conditions. According to the authors, the flower takes several days to develop and the inflorescence begins to open in the late afternoon of day one, is fully open the next morning of day 2, when by late afternoon the flower stalk bends downward and by 7 am of day three is forced below the water's surface where it continues seed development protected from desiccation and predation. These very small seeds develop over the next 1-2 weeks and fall to the lake bottom or on a **(6.) wet tussock or flotant.** Germination of these **(5.) viable seeds** most often occurs on wet mud on tussocks and along exposed shorelines during drought or drawdown conditions. Seeds apparently do not germinate on lake bottoms and only become a major source

Water hyacinths in Brazil

Water hyacinths in Indonesia

of hyacinth growth on exposed wet soils.

Lake and pond water primarily obtain oxygen from wind and wave action, simple diffusion of oxygen into the water from the atmosphere, and photosynthesis by algae and submersed plants. A dense mat of hyacinths , covering an acre pond may weigh **(4.) 100 - 150 tons per acre fresh weight** and contain **(8.) 95% water** thus having a dry weight of 5-8 tons per acre. This mat of vegetation prevents wind mixing, slows oxygen diffusion into the water and prevents sunlight from reaching into the water column below the surface mat. Oxygen consumption by bacteria and fungi and other critters in the water column, as well as rotting organic matter produced by the hyacinths in this dark water results in **(3.) very low, often < 1 ppm oxygen in the water below the surface hyacinth mats**.

Water hyacinths have been long known by the scientific name *Eichhornia crassipes*, but recently a taxonomic study suggested that the binomial **(10.) *Pontederia crassipes*** is more appropriate. Regardless of its scientific name, the water hyacinth has been reported to be **(9.) among the 10 most serious weeds** of the world due to its need for aggressive continued and expensive control, its effects on human (public health), on the use of water for hydropower, navigation, commerce and transportation, particularly in developing countries were remote villages can be isolated from medical care, food and other life necessities. Its very negative impact on fisheries production and catchability as well as harm to other aspects of aquatic ecology positions it as the only aquatic weed listed as the most serious weeds of the world despite the fact that they have been controlled with 2,4-D since the **(7.) late 1940's**. The expense of maintenance control and continuous effort to manage hyacinths, as well as the intensive use of water for drinking, bathing, cooking, irrigation and other uses make it's control impractical in many geographical areas of the world.

Next issue of APPLICATORS' CORNER will test your knowledge on another major aquatic weed related issue… suggested topics appreciated!!

Water hyacinth on Lake Chapala in Mexico

Water hyacinth on Lake Victoria in Uganda

BRAZILIAN PEPPERTREE IN THE MANGROVES!

Figure 1. Peppertree multistemmed growth habit

Introduction

Brazilian peppertree (*Schinus terebinthifolia)* is native to Brazil, Argentina, and Paraguay and was first introduced into south Florida in the early 1800's as a popular ornamental. It was not long before it was found escaping into natural areas and has since then become one of Florida's worst invasive weeds. Peppertree is listed as a FLEPPC Category 1 plant, which is defined as a "species that alters native plant communities by displacing native species, changing community structures or ecological functions." It is also prohibited from use in Florida according to the Florida Department of Agriculture and Consumer Services (FDACS) Noxious Weed List. Ecosystem impacts caused by peppertree include physically shading out native plants, depleting nutrients needed for growth of native species, altering fire regime, producing chemical compounds that can inhibit other plants from growing, and creating impenetrable thickets that reduce habitat for some species of native fauna.

Peppertree is a shrub-like tree with a growth habit that creates a dense multi-stemmed snarl and can grow as tall as 30 feet (*Figure 1)*. It is in the same family as poison ivy (Anacardiaceae) and can cause skin rashes following contact with the sap. Perhaps its most distinguishing feature is

Figure 2. Red fruits and pinnately compound leaves of peppertree

its bright, showy red fruits that are typically abundant in the fall and winter but can be usually be observed throughout the year. However, it can also be identified by its pinnately compound leaves (*Figure 2*). Peppertree is successful in a multitude of habitats and can be seen across nearly the entire peninsula of Florida from roadside ditches to sensitive habitats like upland scrub, pine forests, coastal dunes, and brackish mangrove communities.

While peppertree can occupy a diverse range of conditions in terms of soil type, light availability, water availability, and salinity, many native Florida plants cannot. Native plants that require specific habitats to thrive are at great risk of being taken over when peppertree invades and creates monocultures. For example, mangroves are specialists that require a certain zone along the coasts with the right amount of water, salinity, and light availability. Their habitat is already at risk since coastlines are some of the most developed and populated areas in Florida. In addition, with a projected rise in sea level, mangrove range could be shrinking even more. The ecosystem services of mangroves include mitigating pollution in the water, buffering the coastlines by reducing erosion, and sequestering a significant amount of carbon from the environment. Mangrove communities are known to be some of the most productive systems in the world.

Managing peppertree in these habitats is difficult because of the difficulty in gaining access to the bases of peppertrees as well as the fact that mangroves can be incredibly sensitive to the herbicide treatments commonly used for peppertree control. This article will discuss what we know about peppertree salinity tolerance and what other creative methods for peppertree control we have attempted at the University of Florida Center for Aquatic and Invasive Plants.

What do we know about peppertree salinity tolerance?

Research by Ewe *et al.* (2009) evaluated salinity tolerance of peppertree relative to some native Florida plants. Researchers found peppertree had salinity tolerance similar to the native plant, red mangrove (*Rhizophora mangle*). How peppertree tolerates salt is not well understood, but it responds to increased salinity by increasing stem mass and leaf area. This is turn provides an advantage of acquiring light in mangrove habitats where vegetation is usually low growing (Ewe *et al.* 2009). It should be noted that this work was done by irrigating plants with differing levels of salinity ranging from 0 parts per thousand (ppt) to 15 ppt; the actual salinity of the ocean is approximately 35 ppt, meaning the approach was a conservative look into a mixed ocean water and fresh water scenario. However, any salt tolerance in peppertree is worrisome since it would be a best-case scenario for Mother Nature to produce its own pest control in these unique habitats.

Figure 3. Salt-spray damage on Brazilian peppertree growing in interdunes along Florida coast, note the bright red fruits in the foreground that are characteristic of peppertree

What about salt-spray on peppertree?

Personal observations of peppertree in coastal dune habitats indicate that salt-spray from the sea breeze appears to significantly defoliate peppertree (*Figure 3*). Noting this, we decided to investigate this further by mixing a seawater solution and adding a surfactant (d'limonene, at rates of 0, 1, 2, 4 qt/A) to spray over the top of peppertree and mangroves. A surfactant is an additive to help the seawater spread and theoretically penetrate into the leaves. It was expected that the seawater solution sprayed as a foliar treatment would defoliate peppertree and leave the mangroves unharmed. We also expected that the d'limonene surfactant would enhance the defoliating effect of the seawater on peppertree. These hypotheses were put to the test over the spring of 2018 in greenhouses at the Center for Aquatic and Invasive Plants in Gainesville. We tested full strength seawater (35ppt) with and without various rates of surfactants on similar sized potted plants of peppertree, red mangrove, white mangrove (*Laguncularia racemosa*), green buttonwood (*Conocarpus erectus)*, and black mangrove (*Avicennia germinans)*. We used d'limonene as a surfactant and deionized (DI) water was applied for the untreated control spray. Treatments were applied to the foliage of the approximately 3ft tall trees with a CO_2 pressurized backpack sprayer. Measurements on leaf area, height, stem diameter, and chlorophyll content were taken at baseline, 7, 14, and 28 days after treatment. There was no difference among surfactant rates, and results indicate that even with a surfactant such as d'limonene applied at low to high label rates, the use of seawater as a potential defoliating agent of peppertree was not effective. To represent this data, chlorophyll was measured to assess functioning and health of leaves; leaves that were not stressed by saltwater show no significant differences in chlorophyll between the DI water treatments and seawater treatments (*Figure 4*). There appeared to be marginal injury post-treatment on peppertree observed with leaf blotching, or yellow spots left on green leaves. However, the healthy chlorophyll responses indicate that there was no lasting injury worth pursuing with field trials.

Conclusion

Alas, there is no salty silver bullet for peppertree control, especially in sensitive mangrove habitats. However, all hope is not lost! We are continuing to focus future

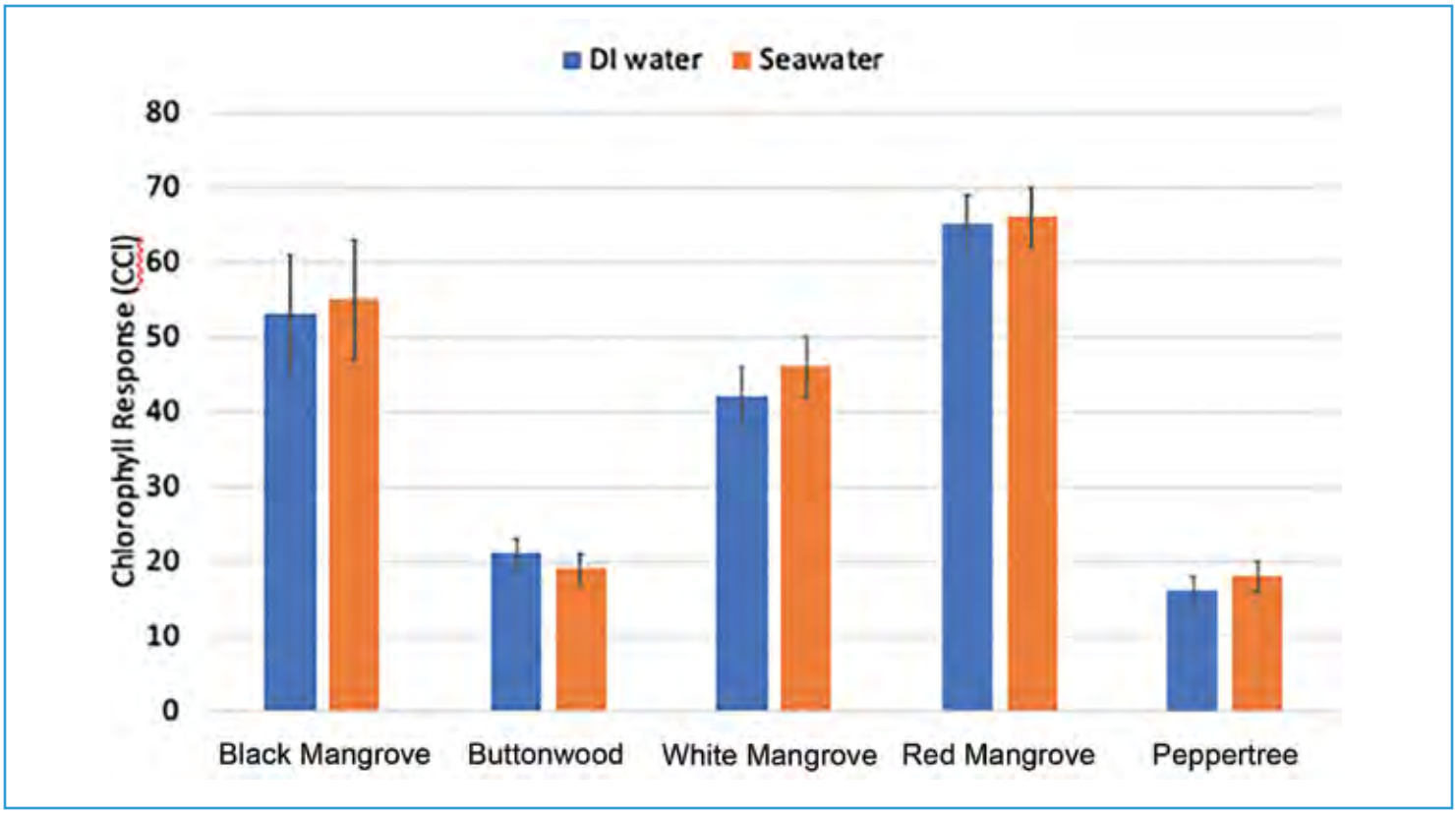

Figure 4. Chlorophyll measured 16 days after treatment (DAT) of all 5 species. X axis: species, Y axis: chlorophyll content. Blue bars represent DI water treatment and orange bars represent seawater treatments. Bars represent standard error (SE).

efforts at the Center for Aquatic and Invasive Plants on new herbicide chemistries and tank mixes in our search for selective treatments for Brazilian peppertree control in mangroves. In addition, the opportunity for integrated pest management is coming to fruition since two biocontrol agents for peppertree are nearing the final stages for release. Lastly, you can do your part to help conserve native Florida habitats by checking the IFAS page for information on how to control peppertree if you happen to have this plant in your yard or simply doing your best to plant Florida friendly landscape gardens!

Mackenzie Bell (me.bell@ufl.edu) is a graduate student at the University of Florida Center for Aquatic and Invasive Plants in Gainesville. She is working under the supervision of Dr. Stephen Enloe and her thesis research focuses on management of Brazilian peppertree. This paper was written as an assignment for the University of Florida class "Aquatic Weed Control" taught by Dr. Bill Haller and Dr. Lyn Gettys in the Spring 2019 semester.

Lake Griffin -

A Restoration and Conservation Success Story

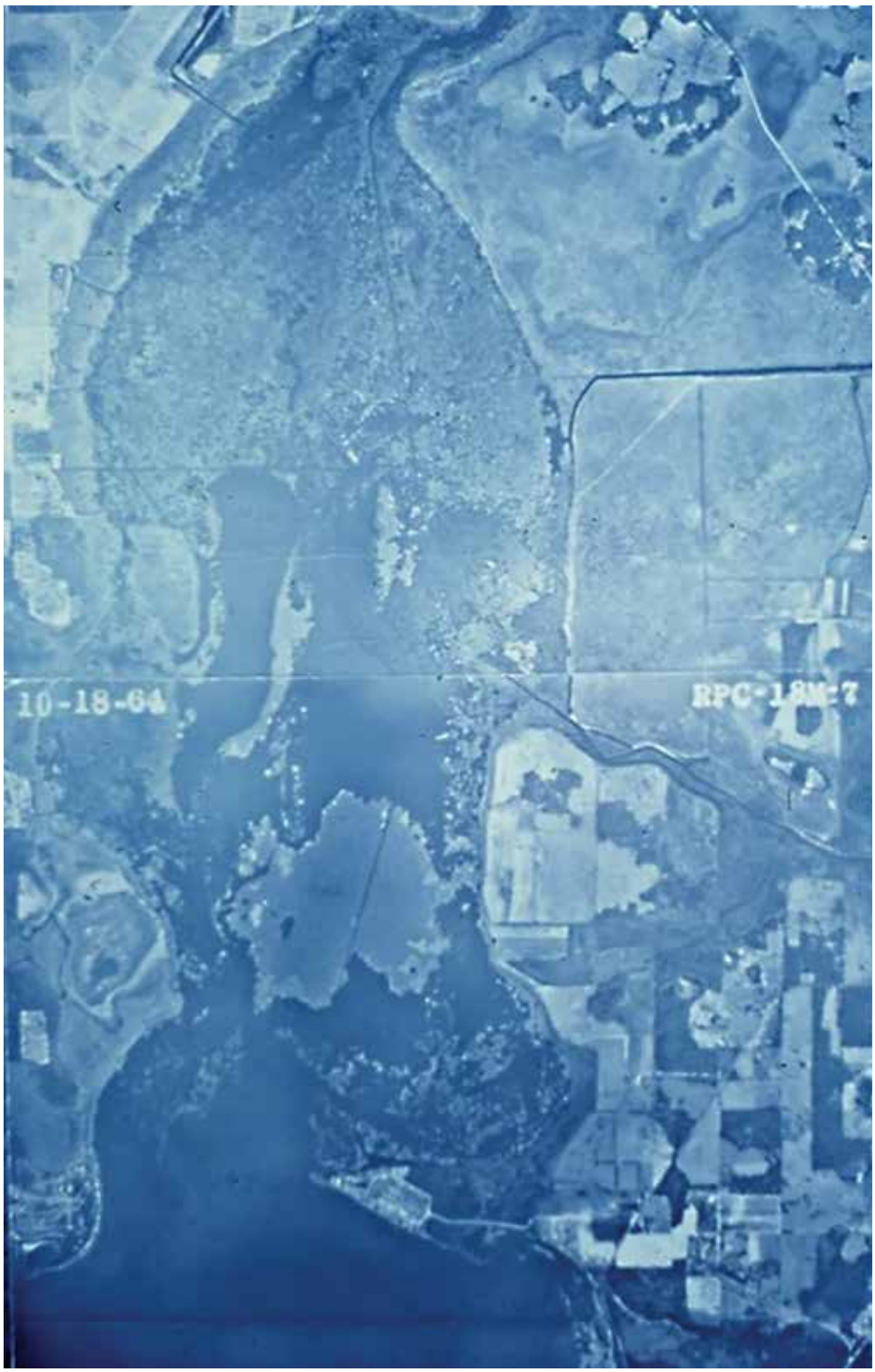

Figure 1. Aerial imagery of Lake Griffin taken in 1964 illustrating the historically widespread coverage of aquatic macrophytes in the lake.

Historically, Lake Griffin was a renowned recreational fishery with high angler effort for Black Crappie and Largemouth Bass. Pre-1960s' Lake Griffin supported a robust aquatic vegetation community with over 50% coverage of aquatic macrophytes. Stabilized hydrology, conversion of marshland into muck farms, and the direct input of sewage and agricultural runoff into Lake Griffin quickly changed the lake from an aquatic macrophyte-dominated lake to a phytoplankton-dominated lake. By the mid-1970s, little aquatic vegetation remained in the lake and both bass and crappie angler effort declined dramatically; bass effort declined from 82,386 angler hours in 1968 to only 9,124 angler hours in 1974.

Efforts to recover Lake Griffin began in the mid-1980s when a partial-lake drawdown was conducted. The drawdown provided initial benefits: aquatic macrophytes quickly expanded in the lake and an increase in bass recruitment was also observed. Unfortunately, Hydrilla became widespread within a couple years and control was needed. A whole lake herbicide treatment was conducted in 1986 and Hydrilla was controlled, but the treatment proved to be too effective and left little to no submersed vegetation in the lake. With little juvenile bass rearing habitat left, recruitment suffered and the population began to crash.

By the late 1990s, Lake Griffin was considered one of Florida's most polluted lakes, and bass fishing was nearly non-existent. A 2001 creel survey estimated there were only around 724 hours of angler effort for bass that year.

Beginning in 1991, the St. Johns Water Management District purchased 7,000 acres of former muck farms adjacent to Lake Griffin. It was estimated that these marshes were responsible for approximately 64% of the total phosphorous entering the

lake. Marsh restoration began in 1994, and by 1997, total phosphorous loading from the marshes began to decrease. Sewage and agricultural discharges to the lake were reduced, and by 2012, total phosphorous loading into the lake from all sources was decreased by approximately 73% (Fulton S.R. et al., 2015).

The reduction of total phosphorous into Lake Griffin resulted in reduced algal blooms and increased water clarity. In the late 1990s and early 2000s, Secchi depths were less than 0.5 meters and vegetation surveys conducted in 2006 estimated < 4% area coverage of submersed aquatic vegetation. However, by 2015-2018, Secchi depth began increasing and average measurements of water clarity during this time period exceeded one meter. This increase in water clarity has resulted in an expansion of submersed aquatic vegetation within the lake. In summer of 2018, the percent area covered by submersed aquatic vegetation was estimated at 32%, and over 75% of Lake Griffin's submersed vegetation community is composed of native species (41.6% southern naiad, 25.7% American eelgrass). A healthy and diverse plant community provided sufficient habitat for fish and wildlife species to thrive and recover as observed in numerous other Florida lakes (Maceina 1996) .

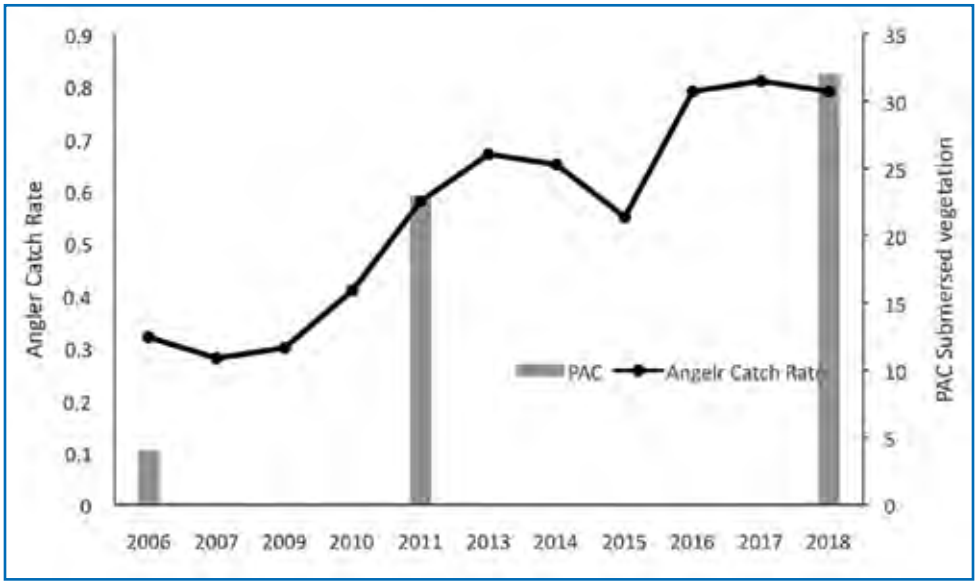

Figure 2. Percent area coverage of submersed aquatic vegetation (2006, 2011, and 2018) and angler bass catch rates estimated from annual creel surveys (no creels were conducted in 2008 or 2012).

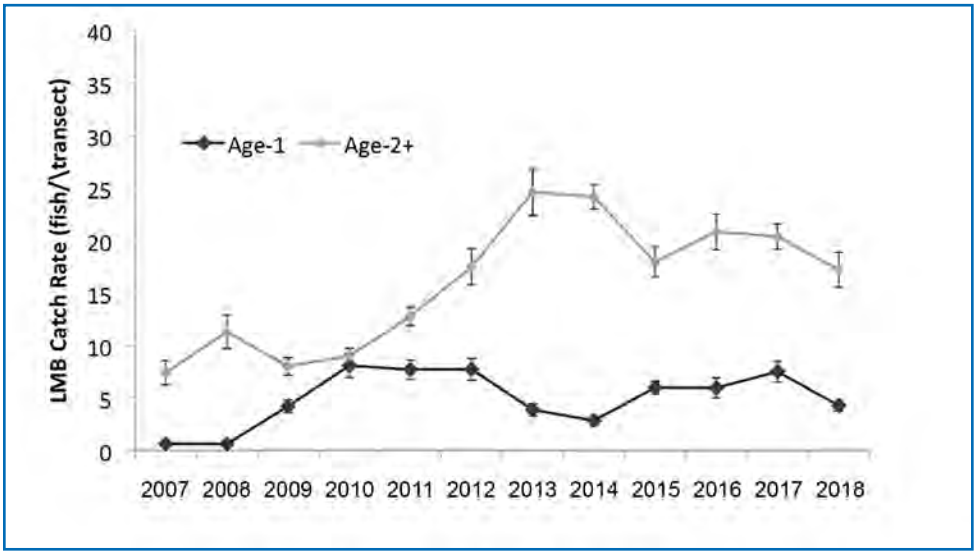

Figure 3. Electrofishing catch per unit of effort of age-1 and age-2+ (adult) bass in Lake Griffin.

With the expansion of submersed aquatic vegetation, juvenile rearing habitat greatly improved survival and recruitment for bass began to climb by 2009. By 2010, the number of age-1 bass collected during spring electrofishing surveys increased by over 10 times compared to the number of fish sampled during the 2007 and 2008 sampling seasons. As vegetation continued to expand after 2010, the vulnerability of age-1 bass to our gear likely declined and thus, we assume our data underestimates the year class strength. It was evident that Lake Griffin was no longer a system with severe recruitment limitations, but instead had been transformed into a thriving nursery for young bass. There was a year or two lag, but by 2011, adult bass abundance began to sharply respond to the strong year classes produced. Lake Griffin's adult bass population went from the lowest electrofishing catch rates for bass on the Harris Chain of Lakes in 2007, to being comparable to some of the other quality bass fishing lakes on the Chain by 2013.

As the adult population continued to improve, more catchable size bass were available to anglers and angler catch rates (number of bass caught per hour) increased dramatically. Angler catch rates for bass improved from 0.28 fish/hour in 2007, to 0.79 fish/hour in 2018; which ranks among the top bass fisheries in Florida. Moreover, angler catch rates for bass over the last eight years are higher than previously observed in the last 50 years. As anglers began to catch more fish, the secret of Lake Griffin's recovery became widespread, and the effort continues to climb each year. The bass fishery has changed from a non-existent bass fishery (only 724 angler hours in 2001) to a popular bass fishing destination in Florida with over 41,000 angler hours from the peak fishing season in 2018. This is the highest bass fishing effort in over 30 years and recently, Lake Griffin has been placed on FWC's top spots for largemouth bass fishing in Florida.

The recovery of the Lake Griffin bass fishery is a prime example of the importance of aquatic vegetation in Florida lakes, the effectiveness of nutrient load reduction,

Figure 4. Two large bass sampled near treasure island point in Lake Griffin during the 2018 – 2019 sampling season.

Figure 5. A 10.5 pound bass that was sampled during the 2018 – 2019 sampling season on the South end of Lake Griffin. The fish was tagged with a high reward trophy tag (yellow tag visible in picture) and released.

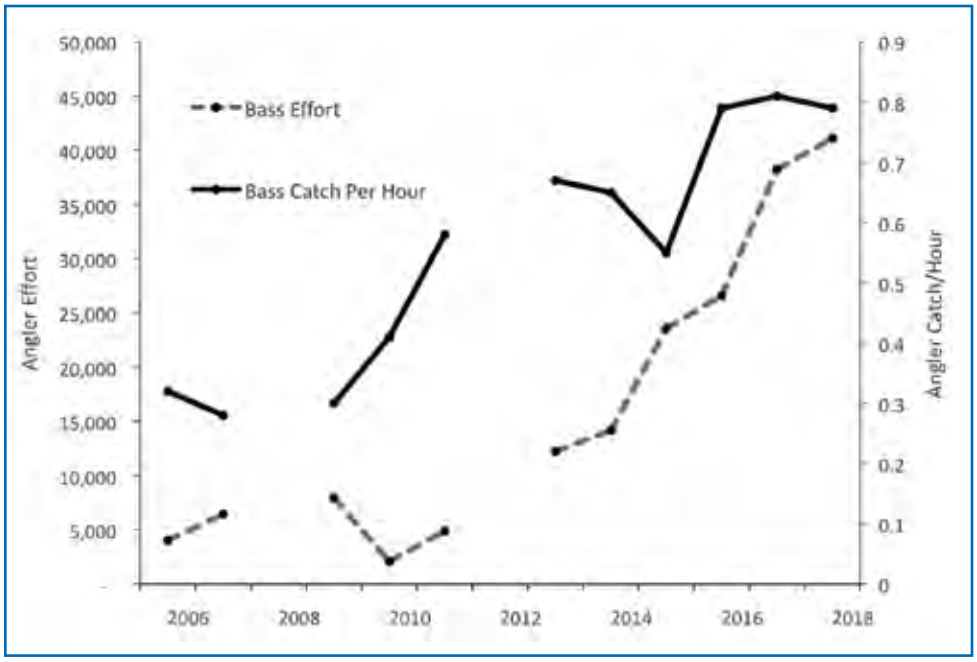

Figure 6. Estimated hours of angler effort for bass and angler catch per hour of bass from annual creel surveys conducted on Lake Griffin.

and large-scale habitat restoration. Healthy submersed aquatic vegetation communities benefit all lake users and ultimately all Floridians by providing crucial habitat for fish and wildlife and improving water quality by taking up excess nutrients. The recovery of Lake Griffin illustrates how restoration activities can impact the health of a waterbody and make significant improvements to the fishery. The reduction of nutrient pollution into Lake Griffin led to improved water quality, and subsequent expansion of native submersed aquatic vegetation. The improved habitat directly resulted in higher juvenile bass survival, which then increased the adult abundance. With a healthy bass population, angler catch and effort once again made Lake Griffin one of the premier bass fisheries in the state. These improvements in water quality and the return of an esteemed recreational fishery benefit not only anglers but the local community as a whole through increased revenue generated by traveling anglers and other recreational user groups. Lake Griffin serves as an excellent example showcasing how large-scale habitat restoration can improve water quality and a reclaim a quality fishery. Although restoration activities such as marsh restoration and reducing anthropogenic nutrient loading can be costly endeavors, Lake Griffin's transition from a degraded system to a healthy ecosystem with recreational, sociological and economic benefits to the state of Florida, illustrates the potential of these positive management initiatives. As urbanization continues to expand in Florida, these types of watershed scale restoration projects will become increasingly important in the effort to protect Florida's prolific aquatic systems.

Literature Cited

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Florida Aquatic Plant Management Society

2019 APPLICATOR Request for Abstracts

Dear Applicator,

We would like to cordially invite you to present at the 43rd Annual Florida Aquatic Plant Management Society Conference in St. Petersburg, FL October 15th – 17th 2019. We are looking for presentations on herbicide application and mechanical techniques (aquatic, natural area and right-of-way), mixtures, innovative control measures, re-vegetation projects, new exotic plant introductions, research projects, boating safety, importance of float plans, tailgate meetings, aerial applications, etc. If you perform an activity during your work day and would like to share that with us, let us know. You don't have to be a professional speaker to present! Remember, FAPMS was formed for the aquatic plant manager and the annual training conference is a chance to share what you have learned with other members. Each year the Society awards all field personnel who present a paper with a plaque. The top three applicator papers will receive a plaque and cash awards. First place will receive $300, second place will receive $200, and third place will receive $100. In addition to these prizes, the first seven applicators to sign up and present a paper will receive a $100 for participating.

All we need, now, is an abstract or outline of what you will be talking about and a short biography of you and your experience in this field. You do not have to have the PowerPoint presentation completed by the deadline below.

If you are interested, please fill out the information below.

NOTE: DEADLINE FOR SUBMISSION IS July 31, 2019

Title: _____

Author(s)*: _____

Organization: _____

Address: _____

Telephone: _____

E-mail: _____

*If more than one author, please circle the name of the person who will present the paper at the meeting. Please list all authors you would like to see listed on the final agenda.

Title of Presentation & Brief Abstract:

Biography of Presenter:

NOTE: Length of talk is 10 minutes or longer. Presentations of 25 minutes will be accepted. Please indicate the length of talk:

_____ **Minutes** (can be condensed if needed)

Check as appropriate: Aquatic Plant Manager paper ☐ Computer (Power Point) ☐

What category or categories best fit your presentation? ☐ Aquatic ☐ Natural Areas ☐ Right-of-Way ☐ Core

The accepted format for presentations is Power Point. If your presentation is in a different format, please contact Kris Campbell to determine if it is compatible with the computers and projector.

Submit this form to: Kris Campbell, FAPMS Program Chair
Florida Fish and Wildlife Conservation Commission
Invasive Plant Management Section
6830 Shadowridge Dr., Suite 201, Orlando, FL 32812
321-246-0682, kristine.campbell@myfwc.com

CALL FOR POSTERS – FAPMS 2019 MEETING

The FAPMS 43rd Annual Training Conference will be held October 15-17, 2019 in St. Petersburg, FL. We are looking for posters on herbicide application and mechanical techniques (aquatic, natural area and right-of-way), mixtures, innovative control measures, re-vegetation projects, new exotic plant introductions, research projects, etc. We welcome posters from researchers, scientists, students, applicators and other field personnel – in short, anyone involved in aquatics! You don't have to be a professional speaker to present a poster! Remember, FAPMS was formed for the aquatic plant manager and the annual training conference is a chance to share what you have learned with other members. There will be a separate Poster Session where poster presenters will have a chance to discuss their work. 1st place will receive $150.00, 2nd place $100.00, and 3rd place $50.00.

NOTE: DEADLINE FOR SUBMISSION IS July 31, 2019

Title: _____

Author(s)*: _____

Organization: _____

Address: _____

Telephone: _____

E-mail: _____

*If more than one author, please circle the name of the person who will present the poster at the meeting. Please list all authors you would like to see listed on the final agenda.

Title of Presentation & Brief Abstract:

Biography of Presenter:

NOTE: Posters are to be set up in the Vendor room at the beginning of the conference and taken down the last day of the conference. Presenter of the poster is expected to be at their poster during the breaks to answer questions and field comments.

There will be an official judging of all posters. Announcement of the winners will be made at the banquet.

What category or categories best fit your presentation? ☐ Aquatic ☐ Natural Areas ☐ Right-of-Way ☐ Core

Please contact Kris Campbell if you need an easel. Please bring clips and back board to secure your poster. Posters are to be set up prior to the start of the conference, which begins on Tuesday at 10:00 AM.

Submit this form to: Kris Campbell,
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Kalanchoe: The "Mother of Millions"

Escaped ornamentals are a common pathway for non-native plants to begin their invasion into new and novel habitats. Usually their unique appearances, ease of care, and fast growth rate are what create the appeal for non-natives to be used as ornamental plants. In Florida, there is a much greater ease for these plants to succeed in the mild climate and seemingly endless amount of sunshine. Two of the newest ornamental plants starting to show very invasive qualities are the Chandelier Plant (*Kalanchoe delagoensis*, Figure 1) and the Mother of Millions (*Kalanchoe xhoughtonii*, Figure 2). It is believed, but not well documented, that *Kalanchoe* species began to arrive to the United States through the ornamental plant trade in the early 1920's. There are over a dozen *Kalanchoe* plant species that are available for purchase at local plant nurseries, grocery stores, and home good stores throughout the U.S. that have not invaded natural areas. It is believed that all *Kalanchoe* species originated in Madagascar and tropical Africa where over 125 different species of *Kalanchoe* have been reported. Their native range indicates preferred conditions of warm to mild temperatures, arid and dry settings, and well-drained, sandy soils; though, these species seem to prosper in a broad range of conditions from full sun to full shade and in very moist, poorly draining soils. The northern extent of these succulent species in North America appears to be due to the plant's inability to tolerate hard freezes.

The genus *Kalanchoe* belongs to the family Crassulaceae, the family that CAM photosynthesis was discovered and named after. The CAM (Crassulacean Acid Metabolism) photosynthesis pathway is differentiated from other forms of photosynthesis by the plants' evolved ability to keep their stomates closed during the daytime to conserve water and open to collect CO_2 at night, during the coolest part of the day. This method of carbon fixation allows the plants to reserve more water in arid conditions by reducing evapotranspiration. The CAM photosynthetic pathway is potentially one of the reasons why these species of *Kalanchoe* have been able to invade the hot and arid conditions of beach dunes.

Another significant means of invasion success for these two species is their plantlet production. In Florida, both *K. xhoughtonii* and *K. delagoensis* exclusively reproduce through plantlets. Plantlets, sometimes referred to as epiphyllous buds, are vegetative clones that grow on the crenate or scalloped edges on the leaf tip, or in the case of *K. xhoughtonii*, along the entire leaf margin (Figure 3). The plantlets are connected to the parent plant's vascular system while developing leaves and roots before dropping to the ground. With adequate sun and water, plantlets can have a 100% survival rate. These plantlets are where the common name "Mother of Millions" is born. Each leaf of *K. xhoughtonii* can produce over a dozen plantlets, and each plant can produce hundreds; not necessarily the "millions" the common name implies, but with many of these plants in an area, the plantlet count can be staggering.

Along the coasts of Florida, many beach communities are bordered by condominiums and homes whose owners often desire to have attractive, colorful but low maintenance landscaping. Invasive exotics fill this role very nicely. In St. Augustine Beach, common landscaping plants include Brazilian Peppertree (*Schinus terebinthifolia*), Asparagus fern (*Asparagus aethiopicus*), as well as the two species of *Kalanchoe*. These species have been observed escaping cultivation and spreading into the beach dunes in many locations. Populations of *K. xhoughtonii* and *K. delagoensis* are noted to be expanding their coverage throughout the interdunes at St. Augustine Beach over the past few years according to the St. Johns County Parks and Recreation Department staff. Beach dunes are considered sensitive habitats due to their unique native species, such as the native sea oat (*Uniola paniculate*) that is slow to spread in the dunes. Disturbances, such as human movements and plant removal, in beach dune communities last for quite some time before recruitment of native dune flora.

There is very little available research and literature on the negative impacts or management of these *Kalanchoe* species, especially in sensitive beach dune communities where there is apparently no available published literature. Hand-pulling is usually considered the most effective and

Figure 1. *Kalanchoe delagoensis*, leaves narrow, tubular, with 3-9 teeth at the apex, coloration varies from tan to light green with dark blotching on upper and lower leaf surfaces.

Figure 2. *Kalanchoe xhoughtonii,* leaves vary in shape, size, and coloration from lanceolate to triangular in shape, marginal unequal toothed crenation, light green to dark green coloration with dark blotching/streaking on just the lower surface, stem color ranges from dark green to purple. *K. xhoughtonii* is a hybrid of *K. daigremontiana* and *K. delagoensis.*

Figure 3. Plantlets developing leaves and roots on the margin of *K. xhoughtonii*.

selective treatment method, especially in habitats with great concern for non-target damage. Unfortunately, hand-pulling has shown to have little effect on *Kalanchoe* populations in beach dune habitats. This can be attributed to a couple of factors: the sensitivity of beach dune communities to disturbance where just a handful of people walking through beach dunes will create significantly long-lasting scars in the landscape, and the multiple age classes and sizes of the *Kalanchoe* plants (Figure 4). Collection of every single plant and tiny plantlet is next to impossible. While the flowering adult plants are very visible, the majority of the plants found on beach dunes are smaller and younger cohorts that are hidden in other vegetation. The Center for Aquatic and Invasive Plants (CAIP) staff is currently conducting herbicide trials on *K. xhoughtonii* evaluating the efficacy of varying herbicides across multiple modes of action. A select few herbicides will then be evaluated in the field to look for efficacy across multiple stages and age classes of both *Kalanchoe* species under operational settings. The current commercial standard for treating *Kalanchoe* is a 5% glyphosate foliar application with a 1% surfactant to cut through the thick, waxy cuticle of the leaves.

The most effective method for *Kalanchoe* management is prevention. The bottom line is, do not let these plants escape cultivation. If you chose to have these in your garden, you need to keep track of the plantlet production, especially if bordering natural areas.

Jessica Solomon (Jess.Solomon@ufl.edu) is a graduate student at the University of Florida's Center for Aquatic and Invasive Plants in Gainesville, FL. She is working under the supervision of Dr. Stephen Enloe and her thesis research focuses on management of Kalanchoe. This paper was written as an assignment for the University of Florida class "Aquatic Weed Control" taught by Dr. Bill Haller and Dr. Lyn Gettys in the Spring 2019 semester.

Figure 4. Multiple age classes and sizes of *K. delagoensis* plants dispersed within other vegetation in the beach dunes of St. Augustine Beach, FL.

Identification and Prevention of Heat Illness

Working in heat and humidity can pose real health threats if proper considerations and precautions are not taken. This is particularly true with the very young and very old, but also in those who lack physical conditioning, or who suffer from conditions that might decrease their ability to cope with increased temperatures. Using alcohol, caffeine, and tobacco products will also make it harder for the body to regulate its temperature.

- ☐ **Nationwide, the Centers for Disease Control reports that 700 people die of severe heat illness annually. A large percentage of those are in Florida.**
- ☐ **There are really 3 keys to protecting yourself from heat illness while working outside:**
- ☐ **Prepare/plan ahead and hydrate properly**
- ☐ **Know/recognize the signs of heat illness**
- ☐ **Choose appropriate strategy for sun protection, breathability of clothing, and rest breaks**

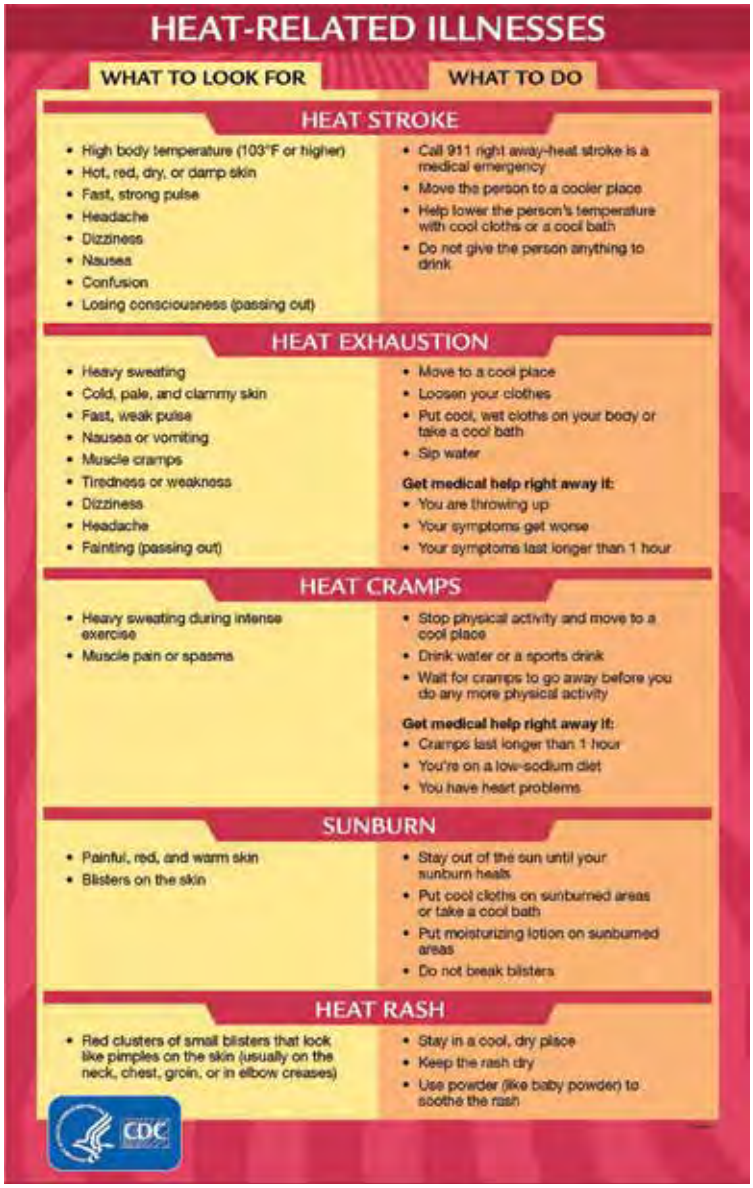
Preparation and hydration

Proper hydration is one of the most important keys to working in the heat. It is most important to note that hydration BEFORE working in the heat is the best preventative measure. It is difficult to trust our thirst to let us know when we are dehydrated. Often, by then, it is too late. It is best to consume 2-3 large beverages (12-24 ounces each) at least 2-8 hours prior to exposure and work in the heat. Thus, hydrating the night before can be important for morning work. Drinking water only can be harmful as well, as it can flush out all the electrolytes in the body over time. It is a good idea to consume some drinks that contain minerals or sugars in addition to water. Sports drinks are not the only way to accomplish this… many juices or sodas or even milk contain some of the nutrients that are helpful. It is important to make sure that caffeine and alcohol consumption are minimized as they will speed the dehydration process. Cold drinks are not essential. Room temperature drinks are actually absorbed more quickly by the body, but most of us are more likely to drink more and more often if the drinks are cold.

- ☐ **Drink 20-30 ounces before starting work**
- ☐ **Maintain at least a twice hourly break to drink water**
- ☐ **Occasionally drink fluids with electrolytes (sports drinks, juice, lemonade, milk)**
- ☐ **Alternate drinking cold and room temperature beverages.**
- ☐ **Avoid drinks with caffeine or alcohol as much as possible.**

Rest and Coverage

The main way the body cools itself is through sweating. The sweat evaporates on the skin, and ultimately cools the skin itself. The blood then becomes slightly cooler as it passes under the cooling skin and returns to the heart. If we keep the skin all covered, then the sweating mechanism - and thus the cooling mechanism - can be disrupted. We need to find a balance between covering up to avoid the sun, or the chemicals we apply, and providing opportunity for the sweat to evaporate. If heavy clothing or protective equipment needs to be worn, work breaks may need to occur more frequently than usual in order to help cool the body. Just



like in competitive athletics, it is advised that protective gear be removed hourly during to reduce the chance of overheating. A cooler full of ice towels or dunking a shirt into the water and putting it around the neck and shoulders can help cool the body down as well.

Rather than covering the body with clothing and preventing the skin from cooling, it may be best to use a Bimini top on the workboat or locate some shade periodically. Shade from overhanging trees or underneath a bridge structure are ideal ways to avoid direct sun and allow the body to cool down. Alternatively, you can speed up the movement of the boat to create evaporation and promote the cooling process.

Scheduling of Work

Plan the heaviest workloads for earlier in the day when we are well-hydrated and the temperatures are the coolest. 10-15 minute breaks/hour during hot times should be planned. It may also possible to alternate the type of activities after each 45 minutes of work. Activity can move to the shade, if available, or decrease the intensity during the hottest parts of the day. Consider doing planning, discussion, or paperwork during the break times to keep up with efficient work but allowing the body to sufficiently rest, cool, and recover. Consideration should be given to increasing breaks or decreasing work times when the heat and humidity or sun exposure are particularly high. Managers should also consider increasing the staff assigned to projects during these times to allow for more rest time for the workers on the project.

Signs and symptoms

Heat illness usually progresses through stages, so with proper recognition of symptoms, it is typically preventable. When the first signs of dehydration are present, rest and increased fluid consumption are necessary. If symptoms persist or worsen into heat exhaustion, stopping activity or altering the plans might be necessary to avoid developing heat stroke, which is deadly.

Care for those with heat illness

Any person suffering from heat illness in any stage should be rested and cooled (move to A/C or apply ice or cold water/towels if possible. If conscious, fluids should be taken, preferably cold. If a person is beginning to lose consciousness, EMS must be activated quickly. Extra moments spent with elevated core temperatures can be deadly.

Paul Giannotti, MEd, ATC, LAT, is the Assistant Athletic Director for Sports Medicine at Rollins College in Winter Park, FL. Paul supervises and provides medical care for 22 varsity sports, and he is active in the care, prevention, and rehabilitation of illness and injury associated with collegiate athletes. Paul, originally from Pahrump, NV, has an undergraduate degree in Sports Medicine from Marietta College (OH), and earned his masters degree in Athletic Training from the University of Virginia.

Summary of FWC Aquatic Plant Management Program Pause

On January 24th, 2019, the Florida Fish and Wildlife Conservation Commission (FWC) announced a temporary pause on all aquatic plant herbicide treatments beginning January 28th, using this time to collect public comments from stakeholder meetings across Florida. This was in response to public outcry over perceived negative effects of herbicides in Florida waterways, and ultimately displayed how many emotions were overriding researched-based science and data.

Throughout the month of February, FWC conducted the "listening sessions" to hear concerns from stakeholders. These sessions were very well attended and, at times, proved to be quite contentious as misinformation spread rapidly and seemed to supersede over 50 years of aquatic plant management research. The major points of contention from the public were:

1. Aquatic applicators are killing the lakes by targeting beneficial vegetation and causing muck buildup
2. The chemical products used are poisonous (glyphosate)
3. FWC needs to rely only on harvesting and not utilize herbicides for management
4. There is little to no oversight of the contractors who are performing the spraying

Sadly, there was very little support from our industry during these sessions. At the Okeechobee meeting, there was only one pro-plant management speaker, Carlton Layne, who was heckled, cursed at, and told to sit down by the enraged audience.

During this time, the Florida Aquatic Plant Management Society prepared a letter and a position statement in the form of a resolution. These were sent to FWC Director Eric Sutton and the FWC Commissioners at Invasiveplants@MyFWC.com. Letters of support for the longstanding successful program were also prepared by SFAPMS, FLMS, APMS, FSA, and many other societies, agencies, municipalities, and individuals.

The FWC Commission meeting was held on February 20th and 21st in Gainesville, with this issue on the schedule for the 21st at 8:30 am. On Wednesday, February 20th, Jeremy Slade, Carlton Layne, Gerald Adrian, Scott Jackson, James Boggs, Clark Boyd, Amy Ferriter and Andy Fuhrman met in person in Gainesville, with FAPMS President Kelli Gladding and *Aquatics* magazine editor Amy Giannotti also participating via phone. The goal was to cover all of our talking points succinctly as each speaker was only permitted three minutes.

Unlike past meetings, the aquatic plant management industry was the majority present for the Commission meeting on the 21st. Applied Aquatic Management (AAM), the primary FWC contractor on Lake Okeechobee and the unfair target of public outrage, had three busloads of AAM employees there by 7:15 a.m. There were 44 speakers, and about a third spoke in support of the current FWC aquatic plant management program. Dr. Jason Ferrell, Director of the University of Florida's Center for Aquatic and Invasive Plants, was the first speaker and gave an excellent overview of the importance of responsible integrated aquatic plant management. Fourteen-year-old Henley Renney, daughter of FAPMS past-president Jerry Renney of AAM, delivered a well-researched and heartfelt conservation talk about the importance of what we do to preserve public waterways and habitat, and Jerry followed with an equally powerful message.

At the end of the day, our message was heard and the FWC and Commissioners leaned on solid science as the basis for their resolution. By the afternoon, FWC Commissioners directed their staff to move forward with resuming the treatment program, and incorporating and implementing suggested improvements gleaned from these listening sessions. This by no means, is the end of this.

Our industry is under a very public microscope. It is imperative that we continue to maintain our professionalism, educate the public on why aquatic plant management is crucial, and emphasize how our licensed professional applicators continue to be good stewards of Florida waterways.

Andy Fuhrman has been Vice President of Allstate Resource Management for the past 12 years. He has also served as President of the Florida Aquatic Plant Management Society in 2017 and is currently the President-Elect of the South Florida Aquatic Plant Management Society and will become the Finance Committee Chair of the Aquatic Plant Management Society this coming year.

"The FWC Aquatic Plant Pause" From a Teen's Perspective

By Hanley Grace Renney

For as long as I can remember, I have called the Kissimmee Chain of Lakes "home". I love hunting, fishing, airboating, and camping. In my lifetime, I've averaged over 100 days per year spent on the KCOL, and I've killed 22 deer, nine turkeys, pigs, coyotes, rabbits, squirrels, fish, and frogs, validating my claim as a stakeholder in issues regarding the KCOL. As an avid user of the water and land of Florida, I've devoted my life to a passion shared by many sportsmen and sportswomen in our state, and as a youth, the lake is my future just as much as it is others' past and present.

On January 28th of this year, FWC enacted a pause on all aquatic herbicide operations under their control due to numerous complaints from users of the lakes. This pause has since ended, but during this time, FWC held a series of meetings around the state to hear all sides of the issue from the public. I had the privilege of attending two of the meetings: one in Kissimmee, as well as the FWC Commissioner meeting in Gainesville. I spoke at both, along with many other concerned users of the lakes.

In my own testimony, I decided to address three main points. I began by establishing my own credentials as a stakeholder. Then, I went on to explain my greatest concern, which had nothing to do with the environment whatsoever. I am 14 years old, and unlike the majority of my peers, I do not own a cell phone, nor do I have any personal social media accounts. I see what it does to our society, and I am well aware of the issues that are escalated in part by social media. I find it silly to believe that all of the information found on these social sites is valid and true, without verifying the information with credible resources.

With this in mind, it didn't take me long to notice that far too many of the speakers at the FWC meetings were repeatedly quoting information regarding certain herbicides or control programs that was false. Upon further research, I discovered that these so-called "facts" had been circulating on social media outlets for months, riling people up and creating all sorts of disruption. Many let their emotions drive them, and when posting online, the truth is often lost within opinions.

It baffles me just how gullible the readers of these posts can be. Even though we are told that we can't believe everything on the internet, many have completely disregarded that advice and blindly followed whatever information has been fed to them through their phones and computers. To say the least, this is incredibly disheartening.

But what sites are trustworthy, then? Well, that question is easy to answer. I encourage anyone looking for facts on the matter to read the information regarding herbicides and invasive plants on the University of Florida IFAS CAIP (Institute of Food and Agricultural Services Center for Aquatic and Invasive Plants) or US Army Corps of Engineers websites, and I'm sure you will find that the information on these sites differs greatly from many comments on social media.

When conducting research for my own presentation, my resources consisted mainly of these two websites. This leads me to my second point. I decided to give a brief history of herbicide operations in Florida, focusing on the water hyacinth (*Eichhornia crassipes*) and the herbicide 2, 4-D. For those against herbicide use who were not around during the prime of water hyacinths, which happens to be the majority of that group, they may not fully understand the necessity of herbicides for maintenance control of these invasives. My goal in addressing this topic was to show them just how important herbicide usage is, not only to the environment, but also to the economy, transportation, and agriculture of Florida.

Hanley with frogs

Water hyacinths were first introduced to the US at the 1884 World's Fair in New Orleans. By means of human transportation or natural dispersion, they spread to Florida, and began establishing a small, seemingly harmless population in the waters of the Saint Johns River. But the hyacinths on the River did what plants generally do: they grew. Hyacinths can double their acreage in as little as six days, according to the University of Florida IFAS branch. In fact, during their first seventy years in Florida, hyacinths covered 126,000 acres of waterways. At this rate, it would take less than 20 years for the entirety of Lake Kissimmee to be completely consumed by water hyacinths.

By 1896, the growth of the

weeds on the River began affecting the populations living nearby. Travel on the River was virtually impossible, and in the summer, the closest towns were flooding. Mechanical removal processes were enacted to control the hyacinths, but the population was just too great, and the harvesting methods were not sufficient to control all of the plants.

In 1947, thousands of acres of hyacinths inhabited not only the Saint Johns River, but also the Withlacoochee, Ocklawaha, and Kissimmee Rivers. Also, mats of hyacinths had made their way into the canals leading to Lake Okeechobee, and a population of about 250 acres was cropping up in the Lake itself.

That was when the herbicide 2, 4-D (2, 4-Dichlorophenoxyacetic acid) was first used on hyacinths. For the first time, the hyacinths were brought down to a manageable population. Over seventy years later, 2, 4-D is still being used, and it has been studied and relabeled many, many times.

In the spring of 1971, the Army Corps of Engineers agreed to restrict all hyacinth spraying operations along the edge of the Saint Johns River, per request by the officials of Putnam County. This Pause was less widespread, but it lasted much longer than our most recent Pause. By early 1973, the number of hyacinths that had grown were impeding traffic on the River, reducing the amount of dissolved oxygen in the water, and blocking public piers and boat ramps. Thus, Operation Clean Sweep was enacted, a 60-day program to remove the masses of hyacinths. In total, 3,026 acres of hyacinths were sprayed. This amount had grown in less than two years.

All of this history was to show just how much of a problem invasive plants can be, but also, to show just how well herbicides work. I'm not aiming to disparage other methods of aquatic weed treatment, though, such as mechanical removal or biocontrols. These are beneficial, and they should be used as much as possible, as they do help greatly. There is a time and place for both, though. No matter how you spin it, when dealing with large quantities of invasives, using herbicides is certainly the most efficient option.

In closing, my third point simply tied everything together, and I made a personal connection to the issue. As a lover of the lakes of Florida, the Pause concerned me greatly, because I was well aware of what would happen if it went on for much longer than it did. True, I wasn't around in the early 1900s to see the effects of drastic water hyacinth growth, but I have researched the history of the plant. We study history in school to ensure that we are aware of it, so that maybe we can prevent it from repeating. During the Pause, we were on the brink of letting exactly that happen.

Following my presentation, I had the opportunity to meet a multitude of individuals, many of whom had given testimony themselves. While I was an audience member, I paid close attention to every speaker. Not only what they said, though, but also how they presented the information. I quickly noticed a trend. Those speakers that I met with after the meeting, most of which shared many of my opinions on the matter, seemed to have a more calm and collected air about them while presenting. On the other hand, the majority of those against herbicides spoke with raw emotion, passion, and sometimes even raised voices and pounding fists. The difference? One group was simply delivering facts, all of which proved that there was no reason to have the Pause in the first place. The other, though they may have believed that their words were facts, shared only their heated opinions, and it was obvious to almost everyone in the room.

This was an incredibly enlightening experience for me, and now I understand that some people will simply believe whatever they hear, if it is what they want to hear. I'd rather trust science, and in the face of conflict, fact will always prevail over opinion.

A successful day turkey hunting

Hanley enjoying a day airboating and fishing

My name is Hanley Grace Renney. I am fourteen years old, and I live in Polk County. I can usually be found hunting, fishing, camping or airboating on the Kissimmee Chain. When I'm not doing one of those four things, I'm probably playing soccer or softball, participating in musicals at my local community theatre, working on projects with my school's Girls Who Code Club, competing in Academic Team meets, or playing viola in All County or All State Orchestra. Also, I enjoy reading and creative writing. I have even had a few works published, including a hunting story in Woods 'N' Water magazine. I love advocating for women and youth in the outdoor world, and it means the world to me that I was given the opportunity to share my thoughts in the Aquatics magazine.

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Florida Aquatic Plant Management Society

CALL FOR PAPERS – FAPMS 2019 MEETING

The FAPMS 43rd Annual Training Conference will be held October 15-17, 2019 in St. Petersburg, FL. We are looking for papers on herbicide application and mechanical techniques (aquatic, natural area and right-of-way), mixtures, innovative control measures, re-vegetation projects, new exotic plant introductions, research projects, etc. We welcome talks from researchers, scientists, applicators and other field personnel – in short, anyone involved in aquatics! You don't have to be a professional speaker in order to present a paper! Remember, FAPMS was formed for the aquatic plant manager and the annual training conference is a chance to share what you have learned with other members. Each year the Society awards all field personnel who present a paper with a plaque. This year the top three applicator papers will receive a plaque and cash awards. First place will receive $300, second place will receive $200, and third place will receive $100. In addition to these prizes, the first seven applicators to sign up and present a paper will receive a $100 for participating. All registration fees will be waived for students who present during the general sessions.

NOTE: DEADLINE FOR SUBMISSION IS July 31, 2019

Title: _____

Author(s)*: _____

Organization: _____

Address: _____

Telephone: _____ E-mail: _____

*If more than one author, please circle the name of the person who will present the poster at the meeting. Please list all authors you would like to see listed on the final agenda.

Title of Presentation & Brief Abstract:

Biography of Presenter:

NOTE: Length of talk is 25 minutes. Presentations of 50 minutes will be accepted. If your presentation is shorter or longer, please indicate the length of talk:

_____ **Minutes** (can be condensed if needed)

Check as appropriate: Aquatic Plant Manager paper ☐ Computer (Power Point) ☐

What category or categories best fit your presentation? ☐ Aquatic ☐ Natural Areas ☐ Right-of-Way ☐ Core

The accepted format for presentations is Power Point. If your presentation is in a different format, please contact Kris Campbell to determine if it is compatible with the computers and projector.

Submit this form to: Kris Campbell, Florida Fish and Wildlife Conservation Commission
Invasive Plant Management Section
6830 Shadowridge Dr. Suite 201, Orlando, FL 32812
321-246-0682 kristine.campbell@myfwc.com

CALL FOR STUDENT PAPERS – FAPMS 2019 MEETING

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321-246-0682 kristine.campbell@myfwc.com

Demonstration of selective hydrilla control through partial-site application of ProcellaCOR® Aquatic Herbicide in a central Florida lake

Mark Heilman, Ph.D.
Senior Aquatic Technology Leader, SePRO

Background: *The Critical Need for New and Improved Methods for the Management of Hydrilla* Since introduction to Florida in the 1950s, hydrilla (*Hydrilla verticillata*) remains the 'perfect weed' (Langeland 1996). It is the most difficult aquatic invasive plant to manage and has spread from Florida to many watersheds of the United States. With its aggressive growth rates (Glomski and Netherland 2012), tuber/turion reproduction (Netherland 1997), and other invasive characteristics, hydrilla continues to negatively impact waterbodies and remains a serious threat to habitat quality and water uses of freshwater ecosystems throughout the U.S. Management strategies for hydrilla range from a myriad of contact and systemic herbicide use patterns, stocking of sterile triploid grass carp, investigation of potential selective, classic biocontrol organisms, and physical removal methods ranging from mechanical harvesting to hand removal of very small populations (Haller 2014). In Florida public lakes, hydrilla management is led by the Florida Fish and Wildlife Conservation Commission's (FWC) Invasive Plant Management Section (IPMS – this section was part of the Florida Department of Environmental Protection until 2008). Sonar® Aquatic Herbicide (a.i., fluridone) was a primary tool for hydrilla management in the IPMS program from the late 1980s into the early 2000's. At the end of this period, hydrilla resistance to fluridone was characterized in a number of Florida public lakes (Michel *et al.* 2004). IPMS, Florida water management districts and other state/local agencies in partnership with public and private scientists were tasked with modifying integrated strategies to address this new challenge in managing hydrilla. Adaptation of hydrilla management ranged from development of new

Figure 1. Location of Fish Lake (Osceola County, Florida) south of Orlando

use patterns of existing aquatic herbicides, herbicide combination strategies, and low-rate stocking of sterile grass carp to more urban lakes to suppress hydrilla. Private and public research scientists worked aggressively to screen new potential herbicide technologies for hydrilla control, which did lead to a period of multiple new aquatic herbicide registrations from 2004 – 2013. However, many of the tools registered during the period did not ultimately fit the greatest need for hydrilla control in Florida public lakes: a short exposure, selective, systemic herbicide for spatially-targeted treatment with preferably an alternate mode of action. This need was reinforced by the 2010 discovery of endothall-resistant hydrilla in isolated sites in central Florida (Berger and MacDonald 2011).

In 2013, after several years of internal research as part of its long-term screening program, SePRO began a collaboration

with the U.S. Army Engineer Research and Development Center's Aquatic Plant Control Research Program (Dr. Mike Netherland) to investigate a promising, unregistered candidate herbicide to fit this need for spot/partial hydrilla treatment. Early evaluations and follow-up testing demonstrated short-exposure, selective activity of this technology on hydrilla and crested floating heart (Netherland and Richardson 2016, Beets and Netherland 2018). Collaboration also began with North Carolina State University (Dr. Rob Richardson) followed by the 2015 public introduction of the new candidate herbicide, ProcellaCOR®. Thereafter, expanding collaboration with many government and university research scientists as well as public and private managers led to further evaluation and small-scale experimental field trials. Following a nearly 2 ½ year review of the new herbicide, ProcellaCOR Aquatic Herbicide (a.i. florpyrauxifen-benzyl) was registered by the U.S. Environmental Protection Agency in February 2018. As many 'PRO-Certified' private and public managers began initial operational use of ProcellaCOR in Florida and around the U.S., FWC IPMS initiated early field demonstration of the herbicide in Florida public lakes for hydrilla control to consider its best fit in their integrated management strategies for the species. Utilizing a science-based approach refined over its years of invasive plant control in Florida, FWC IPMS partnered with the University of Florida (UF) and SePRO to monitor and assess select demonstrations of ProcellaCOR with a focus on hydrilla. In mid-August 2018, a 50-acre demonstration treatment of ProcellaCOR SC was conducted and collaboratively monitored by UF and SePRO on 224-acre Fish Lake in Osceola County, Florida (Fig 1). Results through 5-months following application are reviewed here.

Treatment Protocol and Monitoring/ Assessment Methods

On August 14, 2018, a 5 Prescription Dose Unit (PDU) per acre-foot application of ProcellaCOR SC (2.5 lb a.i. per gallon; 1.35 fl oz per PDU per acre-foot) was applied through sub-surface injection via airboat by Applied Aquatic Management to a 50-acre management area (4-foot average depth) in Fish Lake. Water temperature was 86°F (30°C) and pH was 7.5 at time of application. Water sampling after application was conducted collaboratively by SePRO and UF at 20 sites around the lake (12 in management area, 8 outside – distribution in Fig. 2) at 6, 24, 48, 72 hours, 1 week, and 2 weeks after application. Water samples were analyzed for herbicide concentration via FasTEST® High-Performance Liquid Chromatography (HPLC) at the SePRO Research and Technology Campus (Whitakers, NC). Dissolved oxygen was monitored on a similar schedule and out to 6 weeks post application using a hand-held field meter (datasondes were also deployed with mixed results due to equipment issues – partial data not reported here). Vegetation was monitored by UF on a 58-site, ~410-foot sampling grid (21 sites in the management area, 37 in the remainder of the lake's main basin). Submersed plant presence and density (1 – 3 scale; sparse, moderate, dense) was determined using rotation just off the bottom of a vertical pole sampler with dual perpendicular 12" (30 cm) metal tines. Presence and density of floating and emergent vegetation was assessed visually in proximity to the rake sampling point. Hydroacoustic assessment was also performed by UF on the sampling grid points using a Lowrance HDS system and analyzed using C-MAP BioBase to map bottom coverage and density of submersed vegetation. Full vegetation assessments were conducted 8 days prior to application and subsequently 2, 4, 6, and 8 weeks after treatment. Additional assessments continued monthly through 5 months post treatment (mid-January 2019).

Results and Discussion

Herbicide Dissipation: ProcellaCOR dissipated quickly within the 50-acre management area with <5% of applied ProcellaCOR remaining on average 72 hours after application (Fig. 2). Highest concentrations were measured along the eastern shoreline and southeastern corner of the lake at 6 and 24 hours after application. Data from nearby weather stations and observations after application indicated a light to moderate southwest wind in the afternoon of the morning application with a similar prevailing wind conditions over the first 48-72 hours after treatment. These weather conditions partly explain the early dissipation pattern and lower herbicide levels measured along the southwest windward side of the management area. Overall, the dissipation pattern of the Fish Lake treatment suggested potential for better or at least faster hydrilla control in the eastern/southeastern sections of the management area.

Vegetation Assessment: Prior to

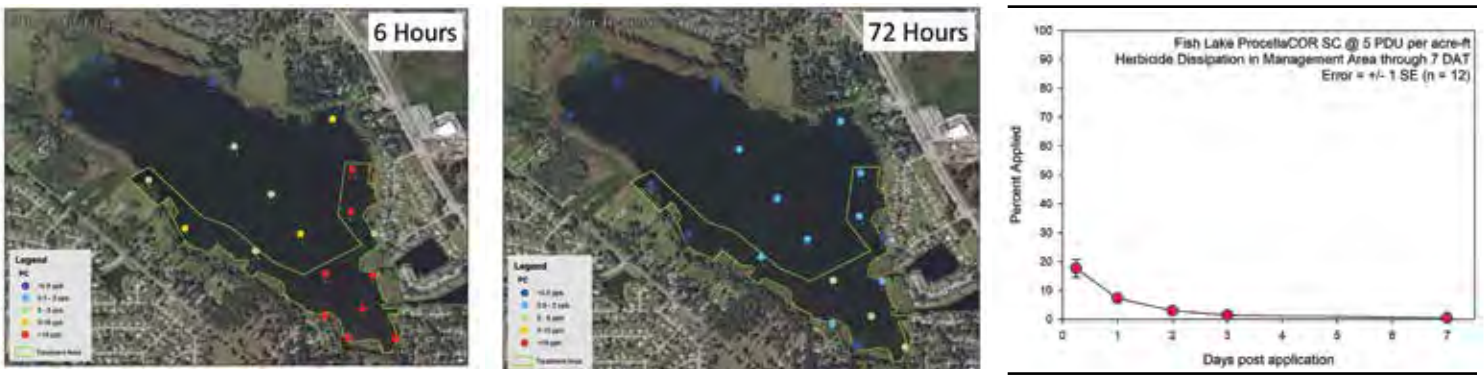

Figure 2. Maps of ProcellaCOR concentrations at 6 and 72 hours post application in Fish Lake. The associated graph (right) depicts average levels of ProcellaCOR as a percentage of initially applied herbicide through 1 week.

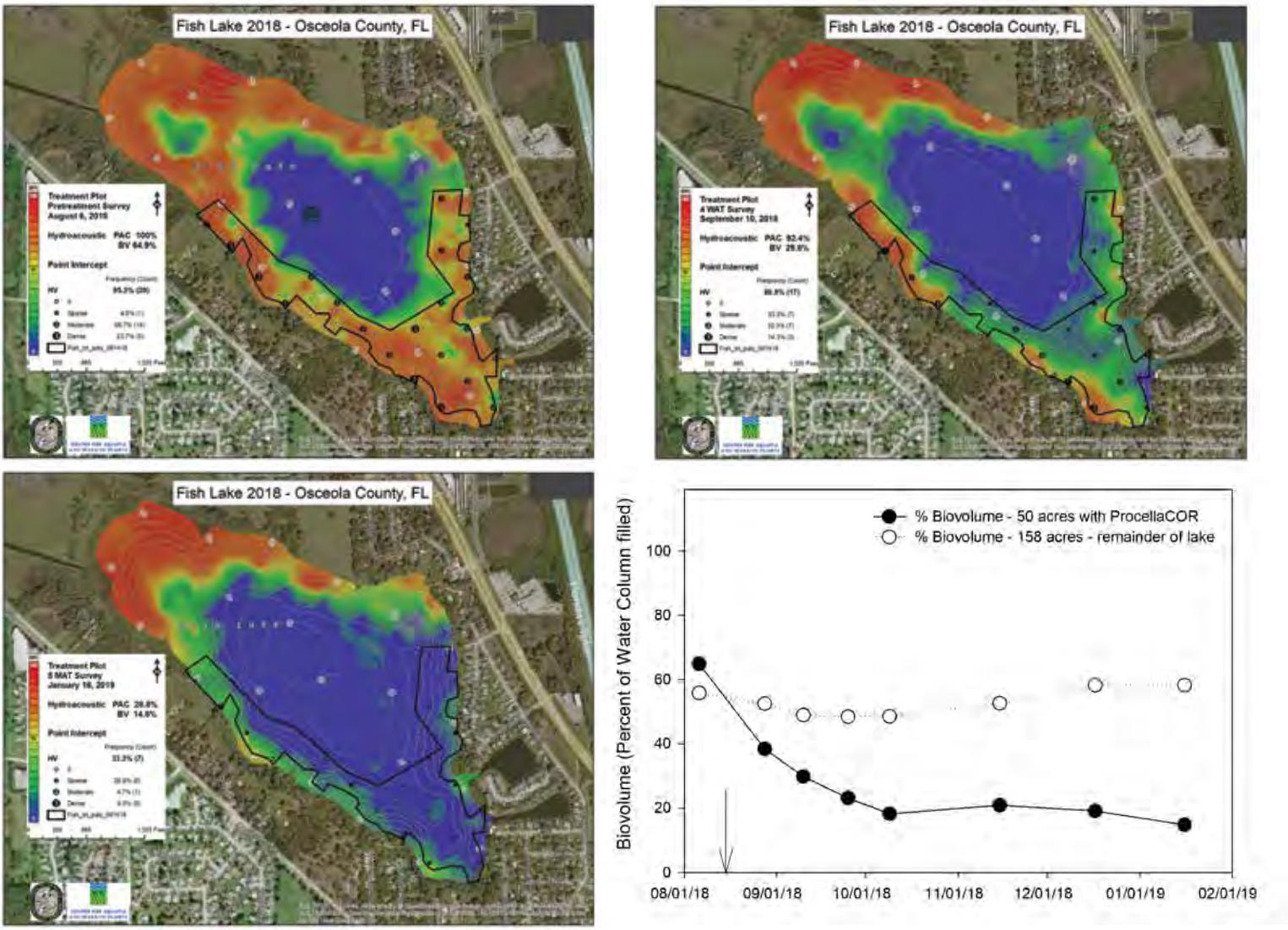

Figure 3. 'Heat' maps of aquatic plant biovolume (% of water column with plants – red = high%, green/blue = low or 0%) in Fish Lake before (upper left) ProcellaCOR application to 50-acre band (black outline on maps) along the southern and eastern shorelines and 4 weeks (upper right) and 5 months (lower left) following treatment. An inserted graph (lower right) illustrates changes in average percent biovolume in the initially hydrilla-dominated, 50-acre management zone versus the remaining 158 acres of the open lake where biovolume remained relatively constant. Arrow represents the August 14 treatment date. Mapping and analysis by Dean Jones, UF.

application, hydroacoustic assessment determined 100% bottom coverage of plants with 65% average biovolume (~2/3 of water column full of plants on average) in the 50-acre management zone (Fig. 3). The plant community in the management area was dominated by moderate to dense levels of hydrilla found at 95% of sites prior to treatment. *Vallisneria* (*Vallisneria americana* or tapegrass) and spatterdock (*Nuphar advena*) were common with 24% frequency (Hydrilla, vallisneria, and spatterdock trends shown in Fig. 4). American lotus (*Nelumbo lutea*) and white waterlily (*Nymphaea odorata*) were also found at lower densities in the management area along with a shoreline band of emergent species including cattail (*Typha* sp.), giant bulrush (*Schoenoplectus californicus*), pickerelweed (*Pontedaria cordata*), jointed spikerush (*Eleocharis interstincta*), duck potato (*Sagittaria lancifolia*), torpedograss (*Pancium repens*), isolated patches of water hyacinth (*Eichhornia crassipes*) and a handful of other species (full review in planned future journal publication). At two weeks after ProcellaCOR application, biovolume of vegetation in the management zone decreased to 38% (40% difference from pre-treatment) as topped-out and near-surface hydrilla was rapidly 'shattered' and knocked off the surface. Biovolume in the management area continued to decrease gradually over the subsequent six weeks as hydrilla presence declined from 100% of sites to 57% mostly sparse, dying plants. A roughly stable ~20% biovolume of submersed plants from 2 through 5 months after ProcellaCOR treatment was dominated by *Vallisneria*, which increased in abundance from 24% up to 40 – 48% of managed sites (Fig. 4). There was a decline in hydrilla noted in some areas adjacent to the management area but hydrilla remained at high densities in the untreated northwest end of the lake. While nuisance levels of biovolume (a correlate for biomass) were reduced in the management area with

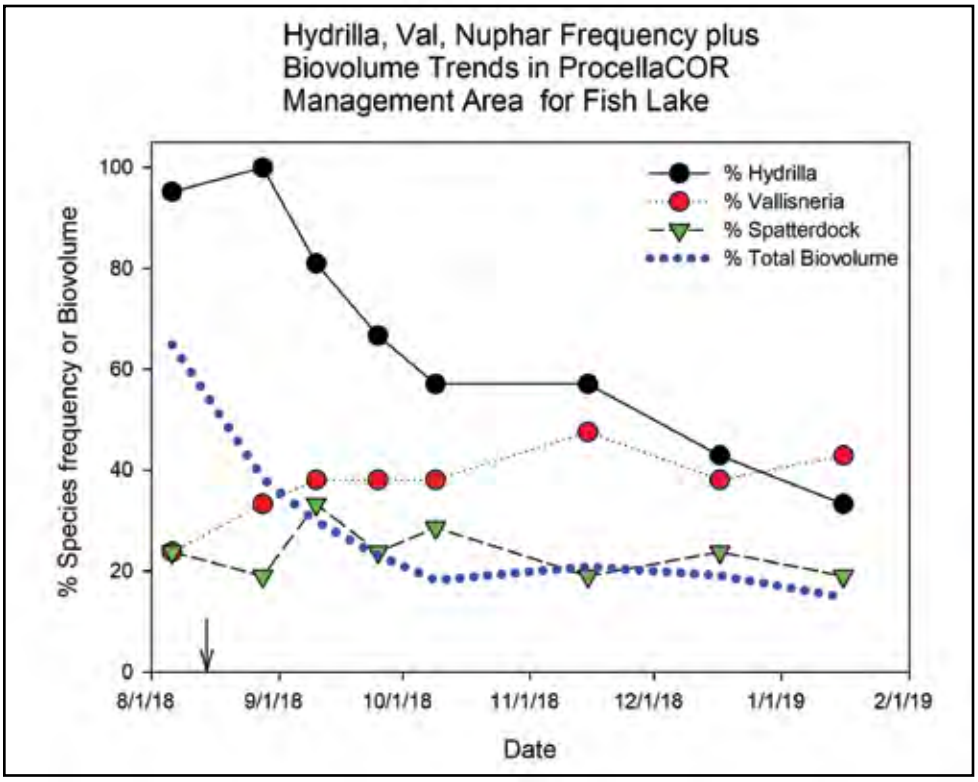

Figure 4. Frequency of occurrence of the most common aquatic plant species (hydrilla, *Vallisneria*, spatterdock) in 21 sampled sites within the Fish Lake ProcellaCOR 50-acre management area and total biovolume measured in the management area before and at 2, 4, 6 weeks and 2, 3, 4, and 5 months after treatment. Data show that the change in total biovolume/density of macrophytes in the management area was directly correlated to reductions in hydrilla frequency through the selective treatment. Arrow represents the August 14 treatment date. Data collection by UF.

Figure 5. Conditions in the management area in the southeastern end of Fish Lake treated with ProcellaCOR on August 17, 2018 (3 days post treatment – hydrilla dominance) and January 16, 2019 (5 months post application – hydrilla controlled with recovering spatterdock under winter-time growth conditions). Photos by Dean Jones, UF.

strong expansion of *Vallisneria*, submersed plant biovolume for the rest of the lake remained similar across the 5-month period as *Vallisneria* expanded and hydrilla was suppressed in some areas where the herbicide moved in during the early stages of treatment.

In terms of other plant responses, 'pad' species are known to have various levels of sensitivity to ProcellaCOR. White water lily and lotus—the more sensitive floating-leaved species—did show injury in the management area within several days after application and were significantly reduced in frequency after treatment. Away from the management area, white water lily showed reduced or no response, and lotus showed a transition of response moving towards the northwest end of the lake. Spatterdock showed significant symptoms and initial reductions in biomass in the management area. There was little or no release of rhizomes from the bottom, and spatterdock frequency was maintained in the management area (Fig. 4) with recovering plants starting at two months after application after selective control of the hydrilla (before/after photos in Fig. 5). Spatterdock biomass and frequency on the untreated side of the lake throughout the evaluation (Fig. 6). Spikerush showed some early chlorosis and thinning but healthy growth in later stages of assessment with ultimately little or no reduction in coverage. Pickerelweed showed some stress within and in areas adjacent to the management area but also showed recovery in later months after treatment. Water hyacinth—a target invasive weed species for the herbicide through foliar or in-water applications—was fully controlled within a few weeks in areas with higher levels of herbicide following treatment (east and southeast). In treated areas with less upfront herbicide exposure, hyacinth was much slower to respond but was fully controlled by 3 months after treatment (Fig. 7). Water hyacinth in the untreated western side of the lake were unaffected (Fig. 6). Cattail, bulrush, duck potato, and torpedograss were unaffected by the treatment.

In conclusion, the August 2018 partial-site treatment of ProcellaCOR cooperatively conducted on Fish Lake by FWC, UF, and SePRO demonstrated favorable properties for selective and systemic control of hydrilla. Treatment effects were predominantly limited to the management area and immediately surrounding areas confirming an ability to localize control with the herbicide when that is a management objective. Hydrilla control was achieved in the management area through 5 months after application with assessment ongoing. *Vallisneria* greatly

Figure 6. Healthy spatterdock with scattered water hyacinth on untreated west side of Fish Lake on December, 17 2018, four months after ProcellaCOR treatment to the south and eastern shorelines of the lake.

expanded following treatment confirming as shown in past development of the herbicide that ProcellaCOR can promote native SAV expansion while controlling hydrilla. Field and controlled studies have also shown good tolerance in pondweed species such as Illinois pondweed or 'pepper grass' (*Potamogeton illinoensis*). A limited number of native plant species including pad species showed stress from treatment, but effects on these plants were focused to areas of direct application for hydrilla control and treatment stress can likely be further reduced through lower, refined use rates under most conditions. Water lily and lotus sensitivity appear higher than spatterdock. The ProcellaCOR treatment also resulted in selective control of water hyacinth with in-water application, a promising additional use pattern to develop for that major floating invasive weed. In this demonstration and other operational programs to date, ProcellaCOR has shown unique properties for spot/partial systemic, selective control of several major invasive aquatic weeds common in Florida and the US. Collaborative field demonstration and research continues to refine use patterns—including combination strategies—and understand best conditions for control across various environmental factors such as weed density, season, and water conditions to optimize the future use of this new technology and new mode of action for hydrilla.

Figure 7. Dense patch of water hyacinth in the 50-acre management area on September 4, 2018, 3 weeks after ProcellaCOR application and then 4 months after application on December 17, 2018. Note that some surrounding vegetation shows natural winter senescence.

Acknowledgements: Many thanks to Fish Lake demonstration partners—the Invasive Plant Management Section of the Florida Fish and Wildlife Conservation Commission (Lead Biologist, Ed Harris), the University of Florida Center for Aquatic and Invasive Plants (Dean Jones and Dr. Jay Ferrell), and SePRO Aquatic Specialist Kelli Gladding. Also, the late Dr. Mike Netherland was active in the design of this demonstration. As with most of what he studied, Mike made invaluable contributions to the development of ProcellaCOR. Thanks Dr. Mike… we all miss you dearly but we know you are with us as we try to live up to your strong commitment to the science of aquatic plant management.

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What are Charales?
A Look at the Ecology of Charales

Maximiliano Barbosa[1], Forrest Lefler1, David E. Berthold[1], H. Dail Laughinghouse IV[1]

Figure 1. *Chara* sp. growing in an artificial setting. Photo credit: D. E. Berthold.

Previously described as the algae most closely related to land plants, Charophyta are a group of green algae that occur in freshwater habitats. Today, however, phylogenetic analyses support that the Zygnematales are the group of green algae most closely related to land plants. The charophytes range from microscopic unicellular organisms occurring individually or in colonies, to the more familiar large branched plant-like organisms. The macroscopic order Charales is of interest to the world of aquatic weeds. This order is the largest and most morphologically, developmentally, and reproductive complex group of charophyte algae. Many taxa in the Charales can accumulate surface layers of calcium carbonate in the form of calcite and because some species have a distinct musty odor, this group is also known as stoneworts, muskgrasses, bassweeds, or brittleworts. The charalean algae morphologically resemble aquatic vascular plants and mostly occur in ponds and lakes; however, they are macroscopic algae. They are well adapted to growing on beds of sand or silt, and in lakes or ponds rich in marlstone sediment; they can form extensive underwater "meadows", which can be a nuisance. These Charales-dominated meadows usually have low phytoplankton production, which often results in very clear water.

Some taxa in the Charales can reach lengths greater than one meter, with a complex morphology consisting of a central stem made of long unicellular internodal cells and short multicellular nodes. Whorls of branchlets (or branches) originate at regular intervals. The group typically has branched filaments, where the main axis (thallus) is differentiated at the apex, nodes, and basal region. The basal region consists of colorless rhizoidal branches, which are used for attachment to muddy or silty substrates (Fig 1). The rhizoids of charalean algae do not take up nutrients; rather, these algae translocate nutrients from the water column via cell-to-cell contact.

Charalean algae can reproduce asexually, through the development of new vegetative shoots from rhizoids, or they can reproduce sexually. Sexually reproductive plants can occur as monoecious (both sexes occurring in one plant) or dioecious (sexes occurring in separate plants) individuals. Like land plants, Charales have conspicuous sexual structures – antheridia (male), where spermatozoids develop, and oogonia (female), each containing a single egg cell (Fig 2).

The antheridia in the Charales are bright orange when mature and are visible with the naked eye. As oogonia develop, they form elongated cells, known as tube cells (or sheath cells) that grow upward along the surface of the egg, keeping pace with the enlargement of the egg. As the egg reaches maturity, openings form between the tube cells, which allow the sperm to fertilize the egg.

Charalean algae occur in all depths within the photic zone and can tolerate salinities from fresh to hypersaline waters (up to 58 g/L; i.e. *Lamprothamnium* spp.), but they are not present in fully marine environments. In addition, Charales are present on all continents, except Antarc-

Figure 2. Male and female reproductive structures in *Chara*. The orange spherical structure is an antheridium and the darker oblong structure is an oogonium. Photo credit: D.E. Berthold.

tica, including some Arctic regions and high mountain regions. Moreover, they can be found in lotic and lentic, natural and artificial habitats. Although most species of Charales inhabit oligotrophic waters, some species can tolerate eutrophic conditions with high conductivity. In fact, most Charales species fare poorly in nutrient-rich waters and are often among the first submerged macroalgae to disappear during eutrophication. These algae are also common in hardwater, calcareous shallow lakes, under oligotrophic conditions. In optimal conditions, it is not uncommon for some charalean beds to have a biomass of more than 400 grams (dry weight) per meter square (Fig 3).

Figure 3. A *Chara* bed in the South Florida Water Treatment Area (STA). Photo credit: D.E. Berthold.

Charalean algae are ecologically important since they are capable of forming massive growths in both deep and shallow lake and ponds, depending on water clarity. These massive growths are important food for herbivorous waterfowl and may provide nursery areas for fish since these beds offer protection from predators and currents. This group of algae is sensitive to environmental changes, which makes them good bioindicators of ecosystem status. Moreover, they play an important role in carbon and nutrient cycles, improving water clarity, and maintaining oligotrophic conditions in ecosystems. Charalean algae can take up nutrients from water into plant biomass, enhance sedimentation, and reduce suspension of sediments, which aids in controlling nutrient cycles. Moreover, due to their ability to precipitate large amounts of calcium carbonate ($CaCo_3$), these algae considerably enhance water clarity in ponds and lakes. In addition, many species are ever-green and their biomass decomposes slowly, which allows for carbon and nutrient to be stored over a long time in the sediment of their beds. Furthermore, for the past few million years, these algae have been major carbonate sediment producers in freshwater lakes, as they can be more heavily encrusted with calcium carbonate than aquatic vascular plants. Although charalean meadows are considered advantageous to an ecosystem, they are sometimes considered a nuisance, and can clog channels and reservoirs if growth is not managed.

Only three of six known charalean genera are found in North America, including *Chara, Nitella,* and *Tolypella*. Of the Charales, the genus of *Chara* or "stoneworts" and *Nitella* are widespread throughout Florida. Over 30 species of *Nitella* have been observed in Florida. Although the genus *Chara* is the most species-rich within the Charales, species discrimination is complicated. This is due to many morphological characteristics overlapping among species. Nevertheless, morphological identification of species is based on morphological traits of the thallus. Species of *Chara* are often associated with healthy water and can serve as bioindicators for water quality and health, usually found in stagnant or slow-flowing oligotrophic waters with high pH. Two species of *Chara* are abundant in South Florida: *Chara haitensis* Turpin and *C. zeylanica* Klein ex Willdenow. These two species are morphologically very similar and their characteristics generally overlap. Because species of *Chara* are so morphologically similar, morphological and simultaneous genetic analyses are required for reliable identification (Fig 4).

Charalean algae provide multitude economic services. Such services include enhancement of water quality, storage of carbon and nutrients, fish culture, food for aquatic animals and farm stock, fertilizers, and much more. Moreover, the development of these macroalgae may be a first successional stage leading to a stable submerged-plant dominated ecosystem. A better understanding of the ecology of this order is therefore important for the conservation and restoration of aquatic ecosystems.

Maximiliano Barbosa is a graduate student at the University of Florida IFAS/FLREC in Davie, Florida. He is working under the supervision of Dr. Dail Laughinghouse and his thesis research focuses on algal ecology. This paper was written as an assignment for the University of Florida class "Aquatic Weed Control" taught by Dr. Bill Haller and Dr. Lyn Gettys in the Spring 2019 semester.

Figure 4. *Chara* plants: Left: *Chara zeylanica*; Right: C. haitensis. Photo credit: D.E. Berthold.

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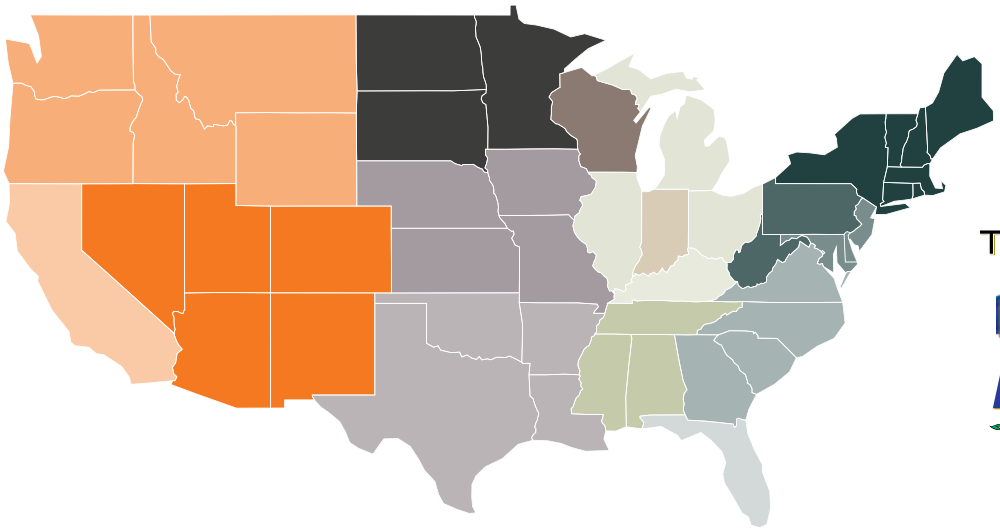

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June 13
South Florida Aquatic Plant Management Society General Meeting (location TBA)
http://sfapms.org/

July 13-17
Aquatic Plant Management Society 59th Annual Meeting and Western Aquatic Plant Management Society Joint Meeting (San Diego, CA)
http://www.apms.org/

September 26
South Florida Aquatic Plant Management Society General Meeting (location TBA)
http://sfapms.org/

October 14-17
Florida Aquatic Plant Management Society 43rd Annual Training Conference (St. Petersburg, FL)
http://www.fapms.org/

October 27-31
21st International Conference on Aquatic Invasive Species (Montreal, Quebec)
https://www.icais.org/

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