Aquatics

SUMMER 2020

A Publication of the Florida Aquatic Plant Management Society

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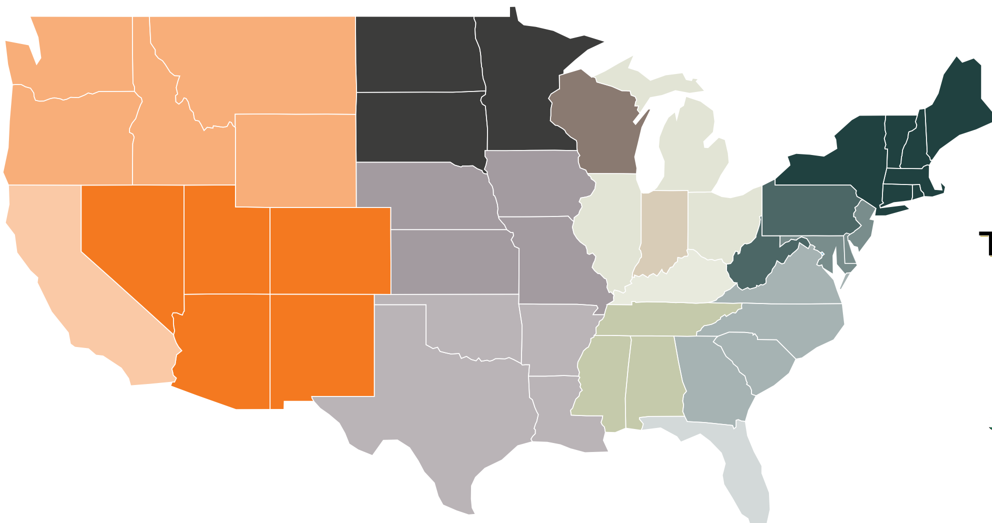

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Native thin-leafed pondweed offers refuge for largemouth bass fry (*Micropterus salmoides*), a painted turtle (*Chrysemys picta*), and a freshwater bryozoan colony in Sunset Lake, Greenfield, NH. Photo by Jake Stout. Species identification provided by Amy Smagula and Andy Chapman of New Hampshire Department of Environmental Services.

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

LETTER FROM THE PRESIDENT

Dear FAPMS members,

Hope this Aquatics edition finds you and your family healthy and well. As we all navigate through the COVID-19 global pandemic, it has certainly affected all of us on different levels. Although it is difficult to foresee what the coming weeks and months will bring, the Florida Aquatic Plant Management Society is actively planning and preparing to hold our 44th Annual Conference in Daytona Beach on October 5-8, 2020.

Along with our mission, "to provide the education and resources necessary to support responsible stewardship of Florida's aquatic ecosystems comprehensive plant management", FAPMS takes the issue of its members' health and safety as a top priority. We will continue to closely monitor state and federal guidelines related to COVID-19 restrictions and follow accordingly as we prepare for the conference.

Thank you for all you do for our society and be well!

Scott Jackson, President
FAPMS

Do Pesticides Cause Boat Corrosion?

Brett Bultemeier,
Extension Professor Pesticide Information Office, University of Florida

Corrosion/fouling of boat surfaces has been a problem for as long as boats have been used for either travel or leisure. From wood decay and barnacle growth on ancient vessels to corrosion of metal on modern boats, there are a host of issues that can damage the integrity of a boat hull. It is not just seafaring vessels that have to contend with corrosion and fouling, many freshwater boats are also subjected to these forces. Particularly with the advent of newer materials and disparate metals used in modern boat manufacturing, the process of corrosion continues to be a major problem. Of late, there have been some questions related to whether the use of aquatic herbicides for invasive weed control would contribute to accelerated corrosion.

Management of invasive aquatic species (particularly plant and algal species) is both necessary and common for many of our waterbodies throughout the United States. This is commonly accomplished with the intervention of chemical control (herbicides and algaecides) to remediate these problematic invaders. However, this has led to the common misconception that these chemicals are directly causing corrosion or pitting. Though it is possible for these chemicals to be involved in that process, this article will discuss why that is unlikely in most circumstances.

Many Floridians are aware of corrosion on boats, particularly those who use/store their boats in saltwater. It is true that the brine solution that is marine systems can cause corrosion if it isn't mitigated properly, but fewer pay attention to the same potential in freshwater systems. Since many Floridians will move equipment in and out of fresh and marine water systems, it is useful to discuss corrosion for both.

Modern boat hull and propeller construction involves the use of different types of metals that can act as either an anode or cathode, being negatively and positively charged, respectively. The basic formula for a working battery is when electrons from an electrolyte solution (acid for batteries) flow from the anode (-) to the cathode (+). For those who have seen the corrosion old batteries can cause, this is similar to the galvanization that can occur in boats. The hull of a boat is commonly aluminum - which carries a negative charge, and propellers and other boat parts are made of materials that carry a positive charge. Both marine and freshwater carries enough electrolytes to create conditions for galvanic corrosion. Though saltwater is more commonly associated with this process, freshwater has enough dissolved minerals and particles with a charge to cause corrosion as well. Furthermore, stray current in the water from powered boat docks or incorrect boat wiring can further add to the corrosive nature of boats in freshwater.

“Dark Rudder” by Kevin Grocki is licensed under CC BY-NC-ND 2.0

A common way to minimize the corrosive effects on boats is to utilize sacrificial anodes made of zinc, aluminum or magnesium. These anodes will serve to preferentially absorb the charges and corrode first, protecting the more valuable metals such as the boat hull or propeller. This can either be passive or induced (with electricity), but the key piece is that these anodes MUST be in the water in order to work. A boat that is partially submerged in the water will not be effectively protected if the sacrificial anodes are out of the water. If an induced system is at work, then power must be provided, so anodes need a power source. Alternatively storing a boat completely out of the water will halt the corrosive process. The sacrificial anodes will wear out with time and need to be replaced. As with any system, proper maintenance and routine checks of the system will keep them functioning at their best. If caught early, damaging corrosion can likely be stopped.

Sometimes aquatic plant and algae management is blamed for causing corrosion of boats in the area of treatments. Although it is true that in their undiluted form these chemicals can be corrosive, these chemicals are greatly diluted into a spray tank before being even further diluted into the lake water. Once in the treated water, these chemicals are found at very low concentrations—as low as a few parts per billion and even at their highest only a few parts per million. Furthermore, these low concentrations are short-lived in the environment due to rapid dilution away from the treatment site and environmental breakdown/sequestration. This short-lived, low concentration introduction of charged particles to the water is very small compared to the conditions that exist naturally in the lake. If all lakes were pure deionized water, then perhaps these chemicals would be a significant contributor to long term corrosive possibility; but, in lakes as they


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This boat hull is in the early stages of corrosion and corrective action should be taken to prevent any further damage. Photo by Jim Donahoe, used with permission.

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exist now, their contribution to enhanced corrosion is essentially a non-factor.

Many people have become convinced of the negative effects of chemicals on their boat surfaces through the following sequence of events. An individual will observe a chemical treatment and become concerned about their boats. Upon checking the hull, they notice corrosion. They then link the spray event with the newly observed corrosion, but correlation in this case is unlikely to be causation. More than likely, the corrosion was already present and was only noticed because of the attention the spraying caused. If corrosion from in-water treatments were common, the spray boats themselves would constantly corrode during the treatments, which is not what happens.

Galvanic corrosion is a common problem for modern boats, even in freshwater systems, and requires constant diligence and maintenance. The protection of boats with the use of sacrificial anodes is critical to help protect the metal parts of a boat (boat hull, propeller, etc.). Therefore, these anodes must be kept in the water, checked routinely, and constantly energized (if relevant), in order to be effective. Storing the boat slightly out of water such that the anode is not submersed is a common error that can lead to lack of corrosion protection.

Chemical control of aquatic plants and algae is a common and necessary activity but is highly unlikely to contribute to corrosion of boats due to the rapid dilution and short-lived nature of these treatments. Diligent maintenance and routine inspections of the boat and the protective processes (i.e. sacrificial anodes) are the best tools to prevent corrosion of boats. For more in-depth reading on this topic see the following websites: http://www.boatus.com/boattech/articles/marine-corrosion.asp; http://www.boatus.com/boattech/casey/sacrificial-zincs.asp

Modified from “Rust Wars: The Galvanic Force Awakens, Rise of the Anodes”, a brochure published by the Aquatic Ecosystem Restoration Foundation; reprinted with permission.

Applicators' Corner

Figure 1: Waterhyacinths dumped in a farm field next to Astor Florida by Corps of Engineers working on a harvesting project in 1976. The farmer leveled the waterhyacinths to dry and then harrowed them into the soil and planted pasture grass. Photo credit, Bill Haller, UF

How many times have you been asked at a public meeting or by someone at a boat ramp the question: "Why don't you just find a use for these aquatic weeds such as cattle feed or paper making or some other way to utilize the biomass and nutrients contained in these weeds?". The answer to this is that for many decades, engineers and biologists have evaluated and tried to develop some valuable uses of these plants, primarily waterhyacinths since they do produce a lot of biomass. Much of the biomass is water, but it also contains significant amounts of nitrogen (N) and phosphorus (P) that might be used as a fertilizer. The Food and Agricultural Organization (FAO), under the jurisdiction of the United Nations, has provided significant funding and designed many projects to evaluate the use of waterhyacinths in developing nations in areas where wood supplies, commercial fertilizers, and forages for animal production are limited. Citations for further information will be added at the end for those who would like additional information.

In the last APPLICATORS CORNER, we indicated that the standing crop biomass of waterhyacinths is about 15,000 lbs. dry weight per acre and this acre of plants contains about 241 pounds of N and 46 pounds of P. An acre of dry biomass of hydrilla weighs much less – about 1,200 pounds of dry weight per acre, with 40 pounds of N and 2.3 pounds of P. These numbers alone show why there has been little interest in the use of hydrilla (and other submersed plants) as fertilizers, with most emphasis on utilization of the much greater biomass produced by waterhyacinths and other floating and emergent plants.

Waterhyacinths were a huge problem in Florida's waters in the 1940s and 1950s. There were no coordinated efforts nor dedicated funding to manage these plants, which was accomplished by mosquito control districts, counties, cities, towns, and the Florida Game and Freshwater Fish Commission (GFC). Following WW II, fishing, fish camps, and recreational uses of Florida's waters were increasing as the population became mobile and many people moved to the state. In 1952, the GFC received Federal funding for fish management purposes, and much of this was devoted to waterhyacinth control. Shortly thereafter (in the late 1950s), hydrilla was introduced into Florida as an aquarium plant and soon infested canals in south Florida and the highly used urban lakes around Orlando and other metropolitan areas. The public, as well as elected officials, were well aware of the aquatic weed problems around the state by the 1960s, and in 1967 Governor Claude Kirk appointed the Governors Aquatic Research and Development Committee to evaluate beneficial uses and most effective means of aquatic weed control. In addition, the Governors Committee was asked to make suggestions as to how a funding program for aquatic weed management might be developed in the state (which marked the beginning of the Florida Invasive Plant Management Program). The Governors Committee provided funding in the late 1960s for major efforts at the University of Florida to evaluate mechanical harvesting (Agricultural Engineering), processing and use of aquatic plants for animal feed (Animal Science), use of waterhyacinths as an organic/nutrient amendment to sandy soils (Soil Science), and evaluation of waterhyacinths for use in paper pulp production (Chemical Engineering). Much of this work was published in the 1974 issue of the Journal of Aquatic Plant Management (JAPM), which you can access at www.apms.org. Details about these and other potential uses for aquatic plants that have been explored include the following.

Cattle/Animal Feed. Historically, there have been issues with providing forage to cattle in Florida during the winter when native grasses become dormant, and this problem remains today. Nutrient, lipid, ash, fiber, carbohydrate, and protein contents have been evaluated and aquatic plants were found to have nutrient characteristics that were similar to most terrestrial plants. Animal feeding trials with aquatic plants included limited work on hydrilla, but most studies focused on waterhyacinths. In mid-1960s, the Lykes Brothers and GFC cooperated to conduct a feeding trial using chopped waterhyacinths covered with molasses and found that this mix (5 to 10% waterhyacinths with other grain and forage) was readily accepted by beef cattle. Waterhyacinths were fed to cattle as fresh chopped plants, made into silage, dried, and also dried and made into pellets. In general, these trials showed that waterhyacinths could be used for 10 to 30% of the diet, replacing the roughage component of the rations. Meanwhile, many other studies conducted in many other nations have been reported by the FAO. Other interesting concerns that need to be further addressed are the high calcium contents of aquatic plants (which could cause pH problems in the stomachs of ruminants) and the high sand or diatom contents of the plants (which could cause increased tooth wear in cud-chewing animals). Waterhyacinths and other aquatic plants have been evaluated as feeds for other farm animals, aquaculture, ducks, geese, crayfish, manatees, water buffalo, and numerous other animals.

Paper/Wallboard. Waterhyacinths and emergent aquatic plants can and have been made into paper in small, localized areas of developing countries, but there apparently have been no large-scale commercial operations using waterhyacinths for paper pulp production. Nolan and Kirmse (Chemical Engineering, UF) reported on their extensive studies in the 1974 issue of JAPM and concluded that the characteristics of waterhyacinth pulp "make it impossible to consider these pulps to have any salable value to the paper industry". I interpret this to mean that waterhyacinth pulp cannot efficiently be made by the existing pulp mills that process pulp from pine trees. It may be possible that pulp processing and paper making machinery could be developed to use waterhyacinth pulp, but the question remains as to whether waterhyacinth processing would be economically competitive with current pine paper making. This may be feasible in a country with extensive de-forestation and no other source of fiber for papermaking.

Mulch/Fertilizer. This is likely the highest use of waterhyacinths and other aquatic plants in the world. Recall that aquatic plants contain similar amounts of the major and minor nutrients as terrestrial plants. One ton of waterhyacinths contain 241 pound of N and 46 pounds of P, but to get this amount of nutrients you have to harvest about 150 tons fresh weight of waterhyacinths (or around 1 acre). Commercial mineral fertilizer is expensive or simply not available in many parts of the world, so this source of nutrients (along with animal dung) is used to fertilize crops on probably thousands of small family farms. Waterhyacinths can be composted, but this requires extra handling and regular turning, so plants are often chopped or applied to the field green; after a few days of drying, they are worked into the soil and the crops are planted soon thereafter. The FAO book cited at the end of this column has many different suggestions on the proper use of aquatic weeds for mulch or fertilizer use. Parra and Hortenstine (also published in JAPM in 1974) conducted a study by adding ground waterhyacinths to soil mixes at NPK nutrient concentrations that were similar to that of commercial fertilizer. They grew pearl millet in nursery containers and harvested 6 weeks after planting, re-seeded, and harvested this second crop after 6 weeks of growth. Pearl millet grew equally well in the waterhyacinth-amended soils and in soils amended with commercial fertilizer; also, in one sandy soil with very low organic matter, pearl millet actually produced significantly more growth in the waterhyacinth-amended soil. The major nutrients in waterhyacinth produced growth equal to that of commercial fertilizer, and the organic matter added to the very sandy soil improved growth compared to plants grown with inorganic fertilizer only. There is no reason to doubt or not expect these results since plants do not distinguish between organic NPK and inorganic NPK, and adding peat moss or other organic matter to sandy soils is a common horticultural practice to improve soil tilth and water holding capacity.

Furniture/Mat/Rope. Rope, mats, and even boats (Kon-Tiki) have been made with papyrus, reeds, cattails, and other aquatic plants. It is likely that the first reference to a reed, bulrush, or papyrus basket occurred in biblical times, when Moses' mother placed the young baby in a papyrus basket on the Nile River to save him from the Egyptian Pharaoh. A surprising niche market has developed around making furniture from waterhyacinth petioles (leaf stalks). Tall bull waterhyacinths are harvested, the roots and leaf blades are removed, and the petioles are dried in the sun or under solar driers. These are then woven (and sometimes knitted around pieces of wood to add strength) and the neatest decorative items and furniture are produced in this manner. A UF student from Thailand published an article in the Fall 2009 Aquatics magazine about this industry in his home country (see http://fapms.org/aquatics/

Figure 2: Vases, baskets and urns made from waterhyacinth in a Target advertising inset. Photo credit, Lyn Gettys, UF

Figure 3: A basket made from waterhyacinth. Photo credit, Lyn Gettys, UF

issues/2009fall.pdf) and many additional items crafted from waterhyacinth are available on the internet.

Fuel/Charcoal/Biogas. The FAO is has developed small family-size biogas generators so people can generate methane gas (primarily for cooking purposes) in countries that lack wood for cooking fuel. Waterhyacinths are chopped into fine pieces, mixed with animal dung and straw to charge the digester, and left for several days to generate biogas. In the early 1980s there was a concerted effort to make charcoal from dried waterhyacinths, but they were found to be undesirable since the briquets produced a copious amount of smoke. To solve this problem, wood chips were mixed with the waterhyacinths to reduce the smoke problem, which sort of defeated the original purpose. Rice hulls and coconut husks have been used successfully to produce acceptable briquets, but production remains on a relatively small scale.

Mushroom/Horticultural Compost. Compost can be made with most any vegetable material, but it is a long and difficult process that requires regular additions of water and mixing or turning the compost piles. Button mushrooms for human consumption have been grown in composted waterhyacinths and production was compared to that of the fungi grown in composted rice straw. Mushroom production in the two substrates was equal, but rice straw was easier to collect.

Summary. This short article should give you confidence that the next time you are asked why we don't simply find a use for waterhyacinths or other aquatic weeds, you can state simply that literally hundreds of people have sought to find ways to economically and effectively use aquatic plants for an infinite number of uses. This column did not discuss sewage renovation with plants, medicinal uses, leaf protein extracts from waterhyacinth leaves, and other miscellaneous uses as books have been written on this subject. I viewed a video once on the waterhyacinth problem in a canal in Egypt which sort of sums it up: Here we are in the Sahara Desert and a herd of about 40 goats are feeding vigorously on the grasses and sedges along the canal bank but ignoring the lush waterhyacinth growing two feet away…

Further reading:

www.FAO.org home page: click on publications and find Handbook of Utilization of Aquatic Plants contains updated information on nutrient and feed components of aquatic plants and discusses their use with citations. Very detailed.

Making Aquatic Weeds Useful: some perspectives for developing countries. National Academy of Sciences Washington, DC 1976, 175 pages

Use Water Hyacinth! A practical handbook of uses for the water hyacinth from across the world. Keith Lindsey and Hans-Martin Hirt, 1999. ANAMED, Action for Natural Medicines, Germany, 114 pages

APMS by the Decade – A 60-Year Review

As we celebrate the 60th Anniversary of the Aquatic plant Management Society, it is insightful to look back at the events that have led us to today. The following trends and events are summarized from the Society's Journal articles, Newsletters and Board and Annual Business Meeting Minutes over the previous six decades as well as issues in the headlines related to aquatic plant management.

1961 – 1970

The Hyacinth Control Society incorporated on July 17, 1961 primarily for managers to share information on their efforts to control water hyacinth in Florida's lakes, rivers and canal systems. Accordingly, the Society is one of the first organizations formed exclusively to manage invasive species in natural areas. The first years of the Society are dedicated to defining the extent of the problem and establishing infrastructure for planning and sustaining funding to control water hyacinth. The scope of the Society quickly expands to include hydrilla (first mistakenly identified as elodea) and by the end of the decade, research begins to focus on specific tools to manage these two plants.

Key Events and Issues of the 1960s

- APMS organizational years
  - Articles of Incorporation are developed, a Board is elected, and Bylaws are adopted
  - Annual meetings are scheduled to share ideas and research results
- A Journal is published to provide information to aquatic plant managers throughout the year
- *Hyacinth Control Journal* articles:
  - Majority of articles are on assessing environmental problems, planning, funding, etc.
  - Most management articles focus on herbicide registration and general environmental impacts
  - Plant management articles concentrate equally on water hyacinth and hydrilla
  - Emphasis is on Florida waters and issues
- **Hydrilla is reported in FL – misidentified and called elodea through the mid 1960s**

The following tables and the tables at bottom of the next five pages summarize the focus of APMS Journal articles through the decades. The first table condenses subjects of Journal articles into three categories: invasive plants, plants not considered to be invasive (i.e. native or non-problem causing exotic plants) and general articles. General articles do not concentrate on a particular plant or group of plants; rather, their focus is on establishing management programs, control priorities, funding sources, mapping protocols, etc. The second table lists plants that were the primary subject of Journal articles at least five times during the decade. Both tables list the source of the article as from the USA or outside the USA (International). These summaries can reveal interesting trends. For example, from the two tables below, of the 47 invasive plant articles (top table), 37 focused on water hyacinth and hydrilla (bottom table). Nearly 2/3 of all articles during the 1960s addressed general issues related to aquatic plant management rather than control methods for specific plants.

1971 – 1980

Pesticide issues like DDT and Agent Orange compel the U.S. federal government to revise pesticide regulations. The U.S. Environmental Protection Agency (EPA) is created, and the Federal Water Protection and Clean Water Acts are passed by Congress. The Society further broadens its scope in the 1970s addressing plant management issues across the U.S. After five years of debate, Society Membership votes to rename from the Hyacinth Control Society and reincorporates as The Aquatic Plant Management Society. Most of the research reported in the newly re-named *Journal of Aquatic Plant Management* centers on specific control methods for invasive aquatic plants. The species of primary concern are water hyacinth, hydrilla, and Eurasian watermilfoil; a plant that is more problematic in waters outside of Florida. Several regional chapters form to address specific operational needs of field managers. Student participation is emphasized to bring fresh ideas and leadership into the Society.

Key Events and Issues of the 1970s

- The U.S. Environmental Protection Agency is formed
  - Pesticides are hereafter registered under EPA vs. the U.S. Department of Agriculture
- The Federal Water Protection Act (1972) and Clean Water Act (1977) are enacted
  - President Ford signs Noxious Weed Bill to prevent introduction/spread of noxious weeds in U.S.
- First NPDES (National Pollution Discharge Elimination System) permits are issued
- The Hyacinth Control Society broadens its reach to a national scope
  - In 1976, the Hyacinth Control Society becomes the Aquatic Plant Management Society, Inc.
- Annual Meetings are increasingly held outside Florida – First in Huntsville, AL in 1970
- APMS expands to cover regional issues
  - Regional Chapters form:
    - Florida (1976), South Carolina (1979), Mid-south (1979), Midwest (1980)
  - *Aquatics* magazine is first published by FAPMS in 1979
- The 1st APMS student paper contest is held at the 1974 Annual Meeting
- *Journal of Aquatic Plant Management* articles:
  - Emphasis increases on specific control methods for targeted plants
  - Most management articles address chemical and biological control methods
  - Plant management articles focus on specific invasive aquatic plants
    - water hyacinth[1], hydrilla[2], and Eurasian watermilfoil[3]
- **Hydrilla is first reported in AL, CA, DE, GA, LA**

1981 - 1990

APMS grows both internally and internationally during the 1980s. Steps are taken to improve internal organization and financial sustainability of the Society as well as to reach out to the international community. APMS sponsors an International Symposium on Watermilfoil in conjunction with the Silver Anniversary Annual Meeting in Vancouver, Canada in 1985. Research increases on understanding plant physiology to better exploit weaknesses in plants targeted for control and to conserve non-target, comingled plants. Debate increases regarding utilizing hydrilla as a fishery and water clarity improvement tool in several southeastern states where hydrilla has colonized.

Key Events and Issues of the 1980s

- Internal growth of APMS:
  - Initiatives: develop financial plan, operating manual, membership drives, fund student initiatives,
  - Projects: purchase computer, develop membership database, video tapes and other educational materials are developed
- APMS joins the Weed Science Society of America with representation on the WSSA Board (1987)
- APMS first collaborates with the North American Lake Management Society (1989)
- Increase international contacts and relevance
- Watermilfoil symposium at 25th APMS Anniversary Meeting in Vancouver, Canada
- Hydrilla expansion - especially monoecious hydrilla in the Potomac River and surrounding states
- Hydrilla debates:
  - Clears water in VA and MD
- Supports fisheries in NC and FL
- Two additional APMS Regional Chapters form:
- Western APMS forms in 1981, Texas APMS forms in 1989
- *Journal of Aquatic Plant Management* articles:
  - Emphasis on additional plants: algae, water lettuce, duckweed, spikerush, sago pondweed
- Increasing emphasis on plant physiology, morphology, and genetics
- Plant management focused primarily on hydrilla[1], water hyacinth[2], and Eurasian watermilfoil[3]
- **Hydrilla is first reported in AZ, CT, MD, MS, NC, SC, TX, VA**

1991 – 2000

Eurasian watermilfoil continues to gain importance as an invasive weed of national significance in the U.S. as water hyacinth continues to fade as an APMS research priority. Nearly three decades after the formation of the Hyacinth Control Society, a national awareness of problem-causing, non-native or alien plants and animals begins to take shape and the term "invasive plant" enters the lexicon to describe non-native species that have profound negative impacts on the environment and the economy. Federal funding through the U.S. Army Corps of Engineers (USACE), the long-time leader in invasive aquatic plant research and control, is substantially reduced during the mid-1990s prompting an increased role in state and non-government entity involvement in aquatic plant management. This transition is facilitated via the years of networking through APMS.

Key Events and Issues of the 1990s

- Increasing use of terms like holistic management, biological pollution, and invasive species
- Reduction in federal funding leads to increased APMS management role
  - USACE research and operational cost-share funds are significantly reduced nationwide
  - Aquatic Ecosystem Restoration Foundation (AERF) is founded
  - More state and APMS regional chapter activity
    - APMS members assist MN and WA in developing aquatic plant management strategies
- Education and Outreach efforts
  - Scholastic Endowment Committee established in 1991 to raise funds for APMS projects
  - First Graduate Student Research Grant awarded in 1998 – co-funded by AERF and APMS
  - Considerable outreach efforts with BASS including Memorandum of Understanding (1995)
  - Establish APMS website and online Member Directory
  - APMS creates the Education and Outreach Committee in the Bylaws
- APMS holds international Annual Meetings – Daytona (1992) and San Diego (2000)
- Northeast APMS forms in 1999
- *Journal of Aquatic Plant Management* articles:
  - Management articles have increasing focus on impacts to non-target plants
- Hydrilla[1] & Eurasian watermilfoil[2] peak in numbers of research articles; hyacinth[3] is a distant third
- Numbers of plant physiology articles draw close to chemical control research projects
- **Hydrilla is first reported in AR, PA, TN, WA**

2001 – 2010

Seeking to re-energize, APMS increases efforts to support student involvement at all grade levels through instructional materials, scholarships, and financial assistance to attend and present information at APMS Annual Meetings. Hydrilla and Eurasian watermilfoil still top the list in terms of numbers of research articles; however, nearly a dozen invasive and native plants share the limelight with increasing awareness of giant salvinia and harmful algae blooms leading the newcomers. Standardization of regulations and federal oversight of pesticide applications to waters of the U.S. for the control of aquatic plants takes shape during the decade culminating in a 2010 EPA draft Pesticide General Permit under the National Pollution Discharge Elimination System (NPDES) permitting program. This effort shapes the direction of the APMS for the next decade.

Key Events and Issues of the 2000s

- APMS Education and Outreach
  - Graduate Student Research Grant increase in funding
  - Student Poster and Presentation competitions established; complimentary rooms / registration
  - APMS and sponsors produce 16-page *Understanding Invasive Aquatic Weeds* booklet
    - 800,000 copies distributed nationwide 2001-2010: online interactive version activated in 2009
- NPDES permitting for aquatic plant control evolves from northwestern states to nationwide

- 9th Circuit Court rules in 2001 that NPDES permits are required for aquatic plant control (APC)
- EPA issues 2006 rule negating NPDES permits for APC conducted according to the EPA label
- 6th Circuit Court vacates EPA 2006 rule, requiring national NPDES permitting for APC
- EPA publishes draft Pesticide General Permit for APC under the NPDES permitting program
- Researchers at several universities and institutions confirm fluridone resistance in Florida hydrilla
  - APMS works with Industry and EPA to register new herbicide compounds for hydrilla control
- Harmful algae blooms become an increasing environmental and management issue
- *Journal of Aquatic Plant Management* articles:
  - Numbers of Eurasian watermilfoil[1] articles surpass hydrilla[2]; giant salvinia articles match hyacinth
  - 25 different invasive species are focus of published research
- **Hydrilla is first reported in ID, IN, KY, MA, ME, NJ, NY, OK, WI, WV**

APMS 2011 - 2020

As of 2011, all states and U.S. territories are covered under the NPDES General Permit for pesticide use to control aquatic plants and algae in waters of the U.S. (WOTUS). Several bills were forwarded by the U.S. House of Representatives to amend duplicative regulations under NPDES, but efforts failed in the Senate. EPA and USACE finalized a WOTUS rule in 2015 expanding federal jurisdiction of the Clean Water Act. The rule was immediately challenged and in January 2020, a new rule was implemented that returned regulatory jurisdictions to pre-2015 levels. During strategic planning sessions (2012 & 2017), APMS reaffirms its commitment to student initiatives including the Michael D. Netherland Graduate Student Research Grant (GSRG). APMS amends its Mission to include algae ecology and management as key Society initiatives.

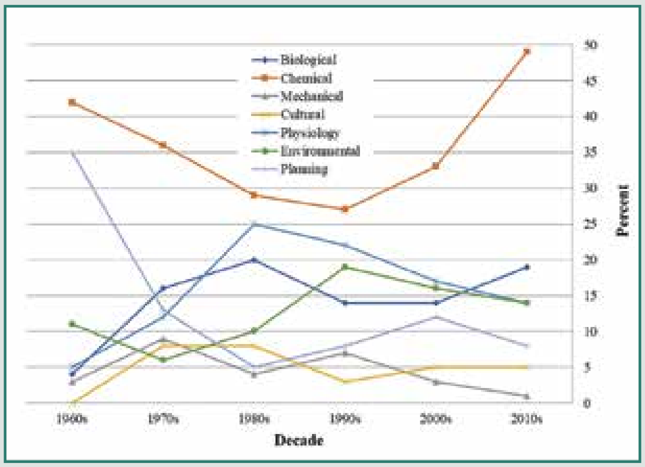
Key Events and Issues of the 2010s

- APMS broadens focus to ecology and management of aquatic plants and algae
  - Revise Mission and Vision statements to include algae
  - Work with Industry and Chapters to fund Starry Stonewort GSRG
- APMS outreach publications and web site upgrades
  - White Papers: *Managers Definition of Aquatic Plant Control - Herbicide Resistance Stewardship*
  - CAST Commentary Paper: *Benefits of Controlling Nuisance Aquatic Plants and Algae in the U.S.*
  - APMS blog evolves into regularly scheduled posts by social media editor
  - Newsletter becomes online only / email service provides job listings and other news to members
  - Formation of LinkedIn Aquatics Group / Online Abstract Submittal System for Annual Meetings
- Five new herbicides representing five mechanisms of action are registered during the 2010s

- Flumioxazin, bispyribac, topramezone, sethoxydim, florpyrauxifen-benzyl
- World Health Organization lists glyphosate as "probably carcinogenic to humans" in 2015
- EPA announces results of regulatory review of glyphosate in 2020: …there are no risks or concern to human health when glyphosate is used according to the label and that it is **not a carcinogen**.
- *Journal of Aquatic Plant Management* – 211 articles are published during the 2010s:
  - 79% focused on invasive plants; 11% native / non-native, 10% mapping / education / planning
  - Numbers of Eurasian watermilfoil articles equal hydrilla; giant salvinia articles surpass hyacinth
  - 46 different invasive species are focus of research—many to evaluate efficacy of new herbicides
  - 35 native or non-invasive spp. are research focus—mostly to evaluate selectivity of new herbicides
- **Hydrilla is first reported in IA, IL, KS, MO, OH and is now present in 33 states.**
- Covid-19 pandemic compels APMS to cancel the 2020 Annual Meeting and increase online presence

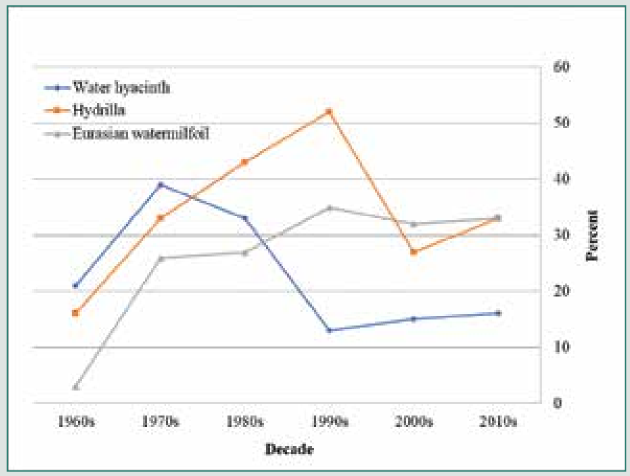
Summary of *Journal of Aquatic Plant Management* Articles

Percent Journal Articles by Topic and Decade



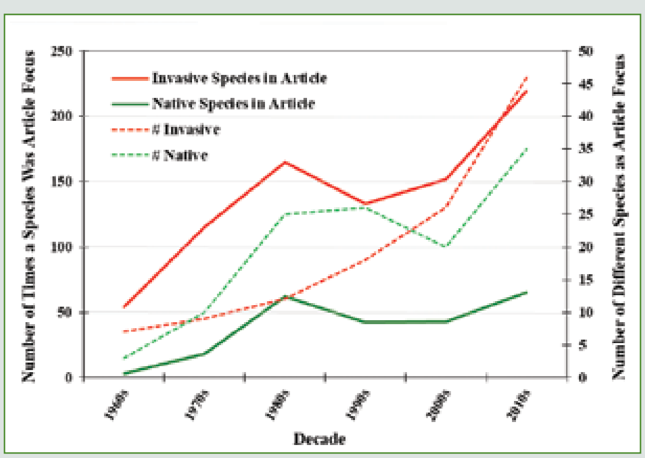
Through the decades, APMS Journal articles focused primarily on chemical control of aquatic plants. Articles range from application strategies, to efficacy and selectivity, to evaluating mechanisms of action. Planning articles were abundant in the 1960s as managers developed regulations and economic strategies to implement them. More recent planning articles evaluate mapping and sampling techniques. Mechanical and cultural control articles remained consistently low through the years. Attention to biological controls tapered off in the 1990s-2000s but increased again in the 2010s. Articles focusing on plant physiology and environmental parameters that impact plants and management increased steadily during APMS's first 30 years and have converged with biological control and planning articles during the past three decades.

Percent Journal Articles of the Most Problematic Invasive Aquatic Plants



Early objectives of the Hyacinth Control Society included organizing management and funding efforts to control water hyacinth. Shortly thereafter, hydrilla was identified in Florida and became the focus of attention for researchers contributing to the Society's Journal. Hydrilla's expansion into more states also came with increasing awareness of other invasive plants like Eurasian watermilfoil, ironically a problem in nearly every state except Florida. Although there has been increasing research on other invasive as well as native plants in recent years, these three species remain high as the primary focus of JAPM articles for 60 years; ranking in the top 3-4 most studied and reported aquatic plants in each of APMS's six decades.

Number of Times an Invasive or Native Species Was the Focus of JAPM Articles (left) & Number of Invasive or Native Species that Were the Focus of a JAPM Article (right)



In the 1960s-1970s most JAPM articles focused on managing three invasive species: water hyacinth, hydrilla and Eurasian watermilfoil, with little mention of native plants. The graph at the left depicts the increasing focus of JAPM articles on additional invasive plants along with native or otherwise non-invasive species. This is especially evident since the mid-2000s. As new chemistries with new mechanisms of action have been registered by EPA, so have the number of research articles that focus on invasive plant efficacy as well as selectivity toward multiple non-target native species. In the graph to the left, the left Y-axis depicts the number of times an invasive or native plant species was the focus in a research article. The right Y-axis shows the number of different invasive or native species that were the focus in a research article during each decade.

Closing the Human-Nature Feedback Loop:
Understanding People's Responses to Changing Lakes

V. Reilly Henson, Kelly M. Cobourn, Cayelan C. Carey, Kevin J. Boyle, Michael G. Sorice, Nicole K. Ward, Kathleen C. Weathers

Introduction

Humans are entwined in reciprocal—and often complex—relationships with lakes. When a community, agency, or individual makes a land management decision, it can impact lake water quality by affecting drinking water supplies, ecosystem health, and recreation opportunities. When negative impacts become great enough that the public begins to observe them, it can inspire individuals and communities to act to protect the lakes they love and rely upon. We think of this relationship as a feedback loop, in which people affect lakes, and lakes in turn affect people (see Figure 1).

The scientific community has made great progress in understanding the relationship between human decisions and lake water quality, but there is still much to learn about this feedback loop. A great deal of research has focused on lakes' chemical, physical, and biological responses to people's actions. Yet significantly less attention has been paid to how people respond to changes in lakes, and how their responses can influence lake water quality in the future. The way that lake ecology affects human decision-making represents a considerable gap in our knowledge (Troy *et al.* 2015).

This knowledge gap, which is captured by the brown and yellow arrows in Figure 1, represents the ways in which people respond to changes in water quality. Our team is currently conducting research to better understand this response by working to model the relationship between people and lakes. We are a team of social scientists, ecologists, and physical scientists, who collaborate by sharing our disciplinary knowledge about components of the human-lake relationship, and work to link those components together to understand the complete feedback loop.

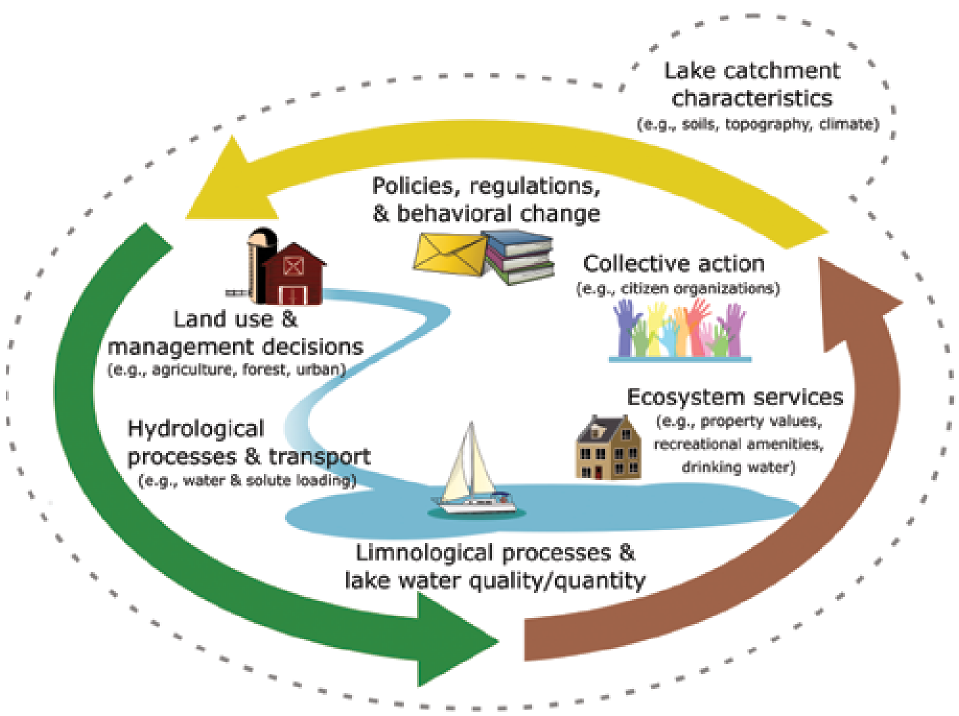


Figure 1. An illustration of how our project conceptualizes the feedback loop between lakes and people.

The Importance of Understanding Behavior

Understanding the feedback loop between people and their environment is critical to achieving environmental, social, and economic goals over the long term (Matson *et al.*, 2016). However, decision-making and policies usually address only one part of the feedback loop (a single arrow in Figure 1), which can result in unintended, often negative consequences (Matson *et al.*, 2016). For example, if a policy requiring erosion control on personal property does not improve water quality the way that people expect, people may reject future policies under the assumption that they are ineffective.

The overarching goal of our project is to understand the full feedback loop between people and lakes, paying particular attention to the human behavioral response to changes in a lake ecosystem. This behavioral response occurs when people make decisions based on knowledge gained from past experiences, as well as predictions they make about the future. For instance, if residents observe cloudy lake water near shoreline areas with sparse vegetation after storms, they may choose to add plants or other features to reduce erosion, either individually or by working together to implement a policy. By understanding what kinds of changes in a lake inspire behavioral response, and how those behavioral responses in turn influence lakes, our research supports lake management decisions that are more likely to achieve short and long-term goals.

Types of Behavioral Responses

Changes in lake water quality can affect people through a variety of mechanisms, and people respond to changes in a variety of ways (see Figure 2). These mechanisms—such as changing property values and effects on an individual's personal connection with a lake—may interact with one another, producing complex social and economic dynamics. Behavioral responses can take place at an individual or group level, or some combination of the two. An example of group behavior might be the formation of a civic organization whose mission is to protect lakes; an example of individual action would be if a resident reduced the amount of fertilizer applied to their yard in the hopes of reducing runoff into the lake.

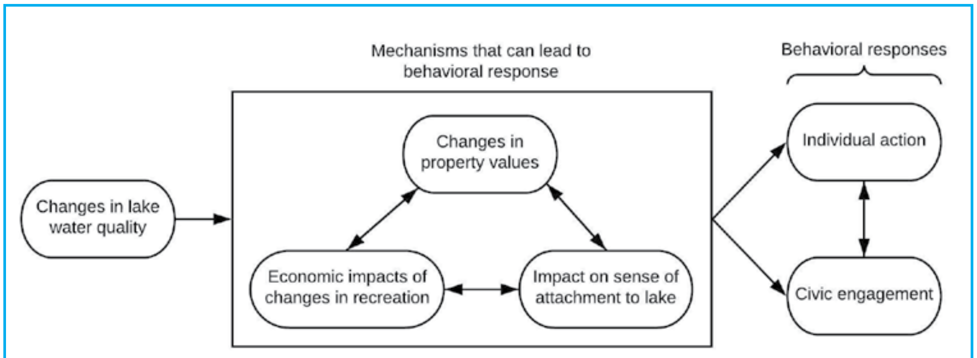


Figure 2. Examples of mechanisms by which changes in water quality can lead to behavioral responses.

The most pronounced behavioral changes occur in response to lake water quality degradation, which is often due to eutrophication. That could mean, for example, that the water becomes cloudier, there are longer periods of hypoxia (low oxygen) that lead to fish kills, or that algal blooms become more frequent. Identifying the mechanisms by which these changes affect people is a key step in studying the relationship between people and lakes. One such mechanism is that decreased water quality can reduce the monetary value of nearby properties. This is a phenomenon that economists study by analyzing trends in property prices. Another way people respond to degradation is to organize efforts to sustain lake water quality, which social scientists study by examining the types of action people take as a group to protect lakes, as well as their motivations for acting. Studying responses from these different disciplinary perspectives leads to a richer, more complete understanding than any one scientific discipline can provide.

Changes in Property Values

When water quality noticeably decreases, it can make lakefront homes less desirable, and nearby businesses may suffer if people do not visit the lake for recreation (Nichols and Crompton 2018). Property values decline due to diminished lake aesthetics, recreation quality, and other negative conditions. By using data on changes in property values alongside water quality data, it is possible to measure how strongly a decrease in water quality negatively influences property prices. Conceptually, this measures how much property owners are willing to pay to avoid a decline in water quality. This "willingness to pay" is often a helpful figure when making policy and management decisions, because it provides an economic justification for protecting lake water quality.

More complicated behavioral dynamics can also occur when a lake exhibits a pronounced shift in water quality. For instance, as water quality declines, people living near the lake who value water quality may decide to move away. The people who move in after them may tend to be more accepting of low water quality, making them less likely to actively protect the lake. This dynamic has been observed in some contexts, such as with amenities like open space, though more research is needed on its occurrence specifically around lakes.

Though scientists most often study how degradation in water quality affects people, improvements in lake water quality also affect human decision-making in potentially unexpected ways. For example, improvements in water quality make the lake and surrounding landscape more attractive to developers, who build housing, businesses, and other structures. As more land in the watershed is developed, the increase in impervious surface and changes in land-use practices (e.g., lawn fertilization) may create a new source of nutrient loading that degrades water quality anew. Through our research, we aim to understand and anticipate more of the unexpected responses to changes in lake water quality, including how those unexpected responses may affect the full feedback loop between people and lakes.

Changes in Recreation

Just as property values tend to decrease with poorer water quality, so do tourism and recreation. When people visit from out of town to fish, boat, or sightsee, they often spend money at local businesses, including restaurants, recreational supply stores, and more. This boosts the economy of the community surrounding the lake. When decreased water quality causes these people to visit less often (perhaps choosing to visit a different lake instead), the community loses this economic benefit, providing yet another economic incentive to protect lakes (Keeler *et al.* 2015).

Additionally, if lower water quality reduces the number of people who visit the lake for recreation, it may contribute to a public perception that the lake is only an amenity for lakefront property owners. This will further reduce the amount of support for lake protection in the broader community, potentially reducing the degree to which land and lake managers adopt best practices for water quality.

Citizen Engagement through Lake Associations

Sometimes people react to the observed change in water quality on an emotional, psychological, and even spiritual level, which occurs when people form an attachment to lakes because of the meaning the lake holds for them. For instance, a person who grew up near a lake may consider that lake to represent who they are as a person, their family heritage, or their livelihood. When people feel strongly connected to a lake in this way, it makes them more likely

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to take action when their lake is threatened (Stedman 2002). These bonds that people form with lakes and their communities, along with reductions in property values and diminished recreation opportunities, can motivate homeowners and people who recreate on a lake to join in civic action. Often, this action is in the form of citizen-formed lake associations.

Our project uses data on water quality, along with observations of lake associations, to examine how changes in a lake coincide with levels of civic engagement over the course of years or even decades. Lake associations can represent a variety of stakeholders, missions, and activities, often serving to educate the public, advocate for policies, and even help to bring science into community land-use planning and lake management. To understand what lake associations do, as well as how and why they do it, our project tracks their efforts over time using their newsletters, websites, and mission statements. By systematically searching for key themes and events, researchers compare changes in lake associations with changes in the lakes themselves over a given time period.

Challenges to Studying Behavioral Responses

An interesting challenge arises when aligning ecological changes with human responses. It can take a long time for people to perceive the effects of a change in water quality, because changes are often gradual. It can take even longer for people to formulate and enact a response to these changes. This requires them to work together at multiple levels (local, state, and even national) to agree upon and implement actions. Sometimes different stakeholders' interests are not aligned with each other, or there may not be enough available scientific information, which can delay response further. To address this, our project focuses on lakes that have extensive, long-term data, meaning that a change in the lake could still be linked to a behavioral response, even many years later. This approach can provide insights for other lakes, where less information may be available, about how proactive actions to protect lakes unfold.

Conclusion

People's behavioral responses to changes in lakes can be complex, to say the least. Yet understanding these responses is critical to revealing the full dynamic relationship between humans and lakes. The better we understand coupled human-lake systems, the greater our ability to predict what management actions will work best, and when. Our project demonstrates a way to incorporate multiple disciplines to better understand human behavior, and this type of work is becoming more widespread in the scientific community. As this work progresses, we will better understand the complex human-lake relationship, which will directly inform improved lake management.

Acknowledgements

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Kelly M. Cobourn studies natural resource economics from a variety of angles, including water quality degradation, land use, and invasive species management. She leads the development of this project's economic model of land use and management, which draws connections between environmental conditions and agricultural decision making.

Cayelan C. Carey studies nutrient pathways and microbial communities in lake ecosystems. Her main focus is on how humans affect freshwater systems. In her role on this project, she uses software to model lake dynamics, including the causes and effects of eutrophication.

Kevin J. Boyle's research evaluates the best methods for economists to measure the value people place on environmental resources. He develops hedonic property value models for this project, which investigate the relationship between water quality and home prices.

Michael G. Sorice investigates how and why people engage in pro-environmental behaviors, and why humans tend to prioritize short-term benefits over long-term sustainability. As part of this project, he studies civic engagement in the form of lake associations.

Nicole K. Ward studies human-freshwater interactions. She is particularly interested in the intersection of decision-making, land use, and water quantity and quality. In this project, she uses a lake ecosystem model to simulate water quality outcomes of land use decisions.

Kathleen C. Weathers, of the Cary Institute of Ecosystem Studies, studies the ways in which living organisms influence biogeochemical cycling, especially across multiple landscapes and systems. She leads this project's efforts to work closely with lake associations, and to communicate its results to related organizations.

This article first appeared in the Fall 2019 issue of *Lakeline*, and it was reprinted with permission.

A LAKEWATCH Series... 1 2 3 4 5 6 7 8 9 10

Countless Ways to Use LAKEWATCH Data

Lake History Revealed in Sediments

Lakes age, just like people do. But instead of accumulating wrinkles, lakes accumulate sediments. Stormwater runoff is one factor that influences sediment accumulation, especially if the runoff is piped directly into a waterbody. (Residents living near Lake Wales, in Polk County are currently dealing with this problem.) However, rapid short-term build-up of lake mud is not as common as one might think. While lakes do accumulate sediments, the rate tends to be slow, generally on the order of one to ten millimeters (mm) per year. Also, some natural processes actually slow the rate of sediment accumulation. For instance, periodic droughts, like those experienced a few years ago in Florida, are one way Mother Nature keeps lakes from filling with sediment too quickly. During that time, as water levels fell, bottom sediments were exposed to air and blew away or dried and hardened before Florida's normal rain patterns returned and water levels rose once again.

Paleolimnologists (scientists who examine the history of a lake by studying lake sediment cores) have begun to explore the aging process in several Florida lakes. One recent study was conducted by UF researchers Mark Brenner and Jason Curtis on Lake Davis, a 150 acre "pool" located within the Tsala Apopka Chain-of-Lakes, in the city of Inverness (Citrus County). The project was initiated by local citizens who were concerned about the development of floating mats of vegetation (tussocks) within the lake. Both lakeside residents and scientists suspected that the sudden appearance of tussocks might also be accompanied by a rapid accumulation of sediments throughout the waterbody. Because the Davis pool is rather shallow, with many areas less than two meters deep (i.e., about six feet), there was concern that the lake might be filling in too quickly.

Funded by Citrus County Aquatic Services and the Southwest Florida Water Management District, Brenner and Curtis set out to answer two basic questions:

1) How thick are sediments at sites throughout the lake? 2) How long have the sediments been accumulating in the basin?

Matthew Beck / Citrus County Chronicle

UF researchers Mark Brenner (right) and Jason Curtis (far left) sample organic sediment cores from Davis Lake in Citrus County.

Results of the project were somewhat surprising: Sediment thickness was measured at 33 stations throughout the open-water portion of the lake, revealing organic deposits (also known as mud) that ranged from 180 to 641 centimeters thick (6 to 21 feet)! Most stations had thick accumulations of mud, with 28 of them showing more than 400 cm (13.1 feet) of sediment.

The next step was to determine how long it took for the mud to accumulate. Long sediment cores were collected at three places within the lake and organic material near the base of each core was dated using radiocarbon techniques. The cores showed that the original onset of sediment accumulation in the lake was nearly identical at each of the three locations. However, it wasn't a recent event; the basal sediments dated back about 5,000 years! Also, the radiocarbon dates throughout the cores show that sediment accumulated at a relatively constant rate of about one meter per millennium (i.e. a little over three feet every 1,000 years). So, while it's true that lakes do eventually fill in as part of the aging process, Lake Davis has been experiencing progressive in-filling for thousands of years and is not suffering from a recent rapid sedimentation.

With this information available, researchers now theorize that the recent tussock development on the lake was caused by low water levels during the drought from 1999-2001. The low water allowed plants to grow on the exposed bottom for the first time in a long time. In addition, plants could grow in shallow-water areas that had previously been too deep (i.e., light was now able to penetrate to the bottom, allowing photosynthesis to occur there). When rains returned and water levels rose to "normal," the plants were uprooted, creating large floating islands of vegetation.

This study underscores the importance of using multiple lines of evidence to address environmental issues. When combined with information on contemporary water chemistry, the sediment data provides us with a much clearer picture of what is happening in Florida lakes over time and it also helps us predict what may happen in the future.

Florida LAKEWATCH

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Yellow floating heart – an invader on the move in Ohio

Fig. 1: Close-up of the yellow floating heart at the Washington Park Golf Course. Photo by Mark Warman.

Heat and humidity hold sway in the suburbs of Cleveland and cool, Lake Erie winds are a big draw during the dog days of summer. The city has opportunities to enjoy the Cuyahoga River and lakefront with a new water trail, additional launch sites, and connections from rivers and marinas to Lake Erie. But some aquatic invasive plants cast shadows on the summer fun. Yellow floating heart (*Nymphoides peltata*) and its dense mat of lily pads, offers only heartbreak to those who love water resources. To help boaters, anglers, and recreational paddlers enjoy the water, natural resources managers in Ohio have used several strategies to remove the invasive yellow floating heart from marinas and inland waterbodies.

Yellow floating heart has been in the United States since the 1890's and was first introduced on the east coast. Native to Asia and the Mediterranean, it was likely brought in as an ornamental water garden plant (Stuckey, 1973). Infestations are now in 32 states and the District of Columbia. A notable observation came just last year as Ohio confirmed yellow floating heart in a marina connected to Lake Erie and a State Nature Preserve. The first record in a Great Lake. It is an emerging species of concern in Ohio with over three quarters of the 22 total observations coming between 2017 and 2019.

Fig 2: A view of the yellow floating heart infestation at the marina connected to Lake Erie. Photo by Mark Warman.

Yellow floating heart may catch your eye with five frilly, canary-yellow petals. The same number of petals as fellow aquatic invasive plant crested floating heart (*Nymphoides cristata*) whose white flowers are found in the southern United States. The lily pads of both species have scalloped edges as if someone used elementary school, patterned scissors along the edges. As nice as the flowers and leaves are to look at, lily pads quickly overlap and leave little sunlight for native plants below. Water oxygen levels have been shown to decrease under a canopy of floating heart which may affect fish spawning and the macroinvertebrate community (DiTomaso and Healy, 2003). Both leaves and flowers start at the same spot, a node, and lateral stems called stolons link one plantlet to another and another. Each underwater stolon may stretch six feet and grow dozens of nodes with more flowers, more leaves, and roots. These messy, tangled networks make paddling difficult, fishing a challenge, and may jam boat propellers. Yellow floating heart is rooted in the sediment of slow-moving rivers, ponds, and lakes in water as deep as nine feet.

Controlling the spread of yellow floating heart is a challenge because its seeds have stiff hairs, like Velcro®, that are specifically designed to hitch a ride on waterfowl from one waterbody to another. For instance, Cleveland Metroparks discovered an infestation at an urban, cattail-dominated wetland in the middle of our Washington Park golf course! (Fig. 1). A second population was a mile from any parking lot, deep in a wooded reservation, on an acre pond. Yellow floating heart can spread rapidly and to unexpected places once seeds are produced. Also, like many other aquatic invasive plants, yellow floating heart can grow new plants by fragmentation. Fishing gear, clothes, boats, and watercraft may also spread yellow floating heart seeds and fragments. Rapid response to this plant is critical to help stop the spread and keep waters flowing freely.

Inside the Park District, Cleveland Metroparks has hand-pulled yellow floating heart for the past three years. Physical removal is tricky business since stems can break and care must be taken to remove all the root. Even one rhizome, or rooted stem, is enough to relaunch the population. Repeated efforts over multiple years are often required to remove yellow floating heart by hand-pulling. Even so, it has been effective in shallow, isolated waterbodies in Ohio and Michigan. The Michigan Department of Environmental Quality and partners have declared eradication—plants not seen for three consecutive years—of yellow floating heart from two waterbodies in 2019. And although Cleveland Metroparks has not completely removed yellow floating heart, each year the number of plants has decreased at two sites. At sites too deep or large for physical removal, herbicides are likely the appropriate management option.

Chemical management of yellow floating heart in the Midwest started in the 2000's and has grown in use as new populations have been discovered. A sister park district in Geauga County, Ohio, eradicated a population of yellow floating heart using imazapyr at label rates. A stubborn population in Michigan was successfully treated with the herbicide ProcellaCOR® and results were shared at the Great Lakes Panel on Aquatic Nuisance Species in the fall of 2018. Cleveland Metroparks and partners plan to manage the marina (Fig. 2) connected to Lake Erie using either imazapyr or ProcellaCOR® this summer, as we wait to hear back on pending grant opportunities.

Future management of yellow floating heart may involve the use of biological control agents such as insects. No current biological control options are approved for use. However, last September, Cleveland Metroparks provided plants to a U.S. Army Corps of Engineers Research Biologist, Nathan Harms, as part of a nationwide collection of yellow floating heart to experiment on the vulnerability of different populations to biological control agents.

Another effective strategy to keep Cleveland's water free from yellow floating heart is education. Last year partner agencies and individuals alerted us to yellow floating heart in Columbus and Cleveland as word spread about this invader. We have received tips for websites still selling yellow floating heart to Ohioans—the plant was listed as invasive in Ohio in 2018. Yellow floating heart was also removed for sale from a brick and mortar store last year with partnership from Ohio Department of Agriculture. Since this plant can pop up in unexpected locations with its Velcro®-like seeds, Cleveland Metroparks needs the help of others to spot it early so we can respond quickly. If we can continue to get the word out about yellow floating heart, we can stop it in its tracks.

In summary, yellow floating heart is a fast-growing, showy invader that can hitch rides by seed and fragments to new waterbodies. Where it grows, it casts profound shade with a thick tangle of leaves, stems, and roots which may restrict boating, fishing, and swimming. Physical removal via hand pulling has limitations but can be effective in shallow and small waterbodies. Chemical methods for management are options with a proven track record that can quickly reduce a population of plants to prevent spread on the path to eradication. In addition to early detection and rapid response, education and outreach are key pieces of the yellow floating heart management plan in Ohio: Prevent new introductions, encourage community reports, and promote native alternatives.

So, as you take to the waters of your state to beat the summer heat, watch out for yellow floating heart, keep your equipment cleaned between waterbodies, and enjoy the beautiful native plants in and around the water.

Cleveland Metroparks supports early detection and rapid response to aquatic invasive plants in Ohio's Lake Erie basin through a Great Lakes Restoration Initiative grant, administered by Ohio Department of Natural Resources and The U.S. Fish and Wildlife Service. There are several species of concern in Ohio and neighboring states: European frogbit, starry stonewort, flowering rush, Hydrilla, water chestnut and yellow floating heart are some aquatic invasive plants in the Great Lakes region.

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Lake Trophic State Indices and Implications for Florida Lake Management

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Florida is famous for its more than 8000 lakes, which are physically, chemically, and biologically diverse. In the words of the late, great Mike Netherland, "*Every lake in Florida has its own personality*." Florida is also the third most populous state in the US and a popular travel destination with > 21.4 million permanent residents in 2019 and 126.1 million visitors in 2018. This level of human activity fuels our economic vitality, but also creates environmental strain. Eutrophication (i.e., nutrient enrichment) of fresh waterbodies, caused by activities such as agriculture, wastewater disposal, urban runoff, and mining has been a problem in Florida for more than a century. In 2010, the Florida Department of Environmental Protection (FDEP) Integrated Water Quality Assessment identified ~380,000 acres of fresh water as nutrient-impaired, according to criteria established by the US Environmental Protection Agency. It has been argued, however, that many of Florida's lakes are naturally high in nutrients and therefore should not be classified as "impaired," but instead should be considered different from other waterbodies elsewhere in the country (Bachmann *et al.* 2012).

The term *trophic* is derived from the Greek *trophia*, which refers to nutrition. The trophic status of a lake, in simple terms, defines the nutrient concentrations and abundance of living biomass in the lake. Traditionally, lake trophic status has been considered to be an indicator of water body health. Whereas one might expect an increase in trophic state to imply a "healthy" condition, a fully nourished state (eutrophy) is typically associated with negative lake characteristics; excessive nutrient loading leads to harmful algal blooms (HABs) and oxygen depletion, resulting in catastrophic fish kills and harm to other wildlife, domesticated animals and humans. Public concern about HABs is at the forefront of assessing lake water quality and is the main reason why algal biomass is used as a primary indicator of trophic state (Canfield *et al.* 1983).

So, what exactly is meant by lake trophic state? As it turns out, it is a rather complex concept that refers to a multitude of lake characteristics. For limnologists (scientists who study lakes), the trophic state of a lake offers insights into its ecology, geology and climate. Here, we briefly review the history and evolution of the trophic state index and its implications for lake management.

Trophic State Index – A Brief History

The concept of lake trophic state has received considerable attention over the past century, leading to the development of several trophic state classification schemes (Lee *et al.* 1978). The terms now used to define lake trophic state were originally applied to bogs and wetlands (Weber 1907 cited by Hutchinson 1969). Swedish limnologist Einar Naumann (1929) and German limnologist August Thienemann (1928) were the first to adapt the trophic state terms to classify lake systems. They classified oligotrophic lakes as those with clear water and low concentrations of phytoplankton (algae), and eutrophic lakes as turbid with high concentrations of phytoplankton (Hutchinson 1969).

Naumann (1929) and Thienemann (1928) proposed that lake productivity (the amount of carbon fixed per unit area of lake surface per unit time) was largely a function of phytoplankton abundance. This can be affected by climate and geological features but is primarily determined by the concentrations of nitrogen and phosphorus in the water. As the two European limnologists continued to build a conceptual framework for addressing lake trophic state, additional lake types were being described, adding complexity to the original classification scheme (Hutchinson 1973). Ultimately, this became so complex that it undermined the original objective of comprehending lake productivity. It became clear that a simpler trophic state classification system was needed (Carlson and Simpson 1996).

It wasn't until 1977 when Robert Carlson, a limnologist at the University of Minnesota, created a trophic state index (TSI) that assigned lakes to three basic categories of productivity: (i) oligotrophic, (ii) mesotrophic, and (iii) eutrophic. Similar to the Naumann and Theinemann classification scheme, Carlson (1977) focused on algal biomass as a descriptor of trophic state, but instead of using more than nine variables, as in Naumann's classification scheme, Carlson's TSI focused on three easy-to-measure variables: 1) Secchi disk depth, 2) chlorophyll *a* concentration, and 3) total limnetic phosphorus concentration. These were mathematically correlated with algal biomass to generate a TSI score between 0 and 100, which covers the full range of possible trophic states, from ultra-oligotrophic to hyper-eutrophic. In the Carlson TSI, an increase of 10 in TSI score is equal to a theoretical doubling of algal biomass, and thus considered a new trophic state. The three TSI values, each calculated from a limnological measure, should not be averaged, but instead should be considered individually, with priority given to the TSI for chlorophyll *a*, as it is the most direct measure of algae abundance (Havens 2000). Carlson believed that having algae abundance at the core of his TSI would help scientists communicate the concept of trophic state to the public (Carlson 1977).

Carlson Trophic State Index (TSI) values and associated lake variables and trophic state categories. CHL *a* is Chlorophyll *a*, SD is Secchi depth, and TP is total phosphorus.				
TSI Value	**CHL *a* (µg/L)**	**SD (m)**	**TP (µg/L)**	**Trophic State**
>30	< 0.95	> 8	< 6	Ultra-oligotrophic
30-40	0.95 – 2.6	8 – 4	6 – 12	Oligotrophic
40-50	2.6 – 7.3	4 – 2	12 – 24	Mesotrophic
50-60	7.3 – 20	2 – 1	24 – 48	Eutrophic
60-70	20 – 56	1 – 0.5	48 – 96	Eutrophic
70-80	56 – 155	0.5 – 0.25	96 – 192	Hyper-eutrophic
>80	> 155	< 0.25	192 – 384	Hyper-eutrophic

Does Carlson's TSI Work for Florida Lakes?

Carlson's TSI has been used widely to characterize lake trophic state, particularly in temperate climates, but its application to Florida's shallow, subtropical lakes has received some criticism. For example, Kratzer and Brezonik (1981) showed that some Florida lakes can be persistently nitrogen-limited, which is not considered in Carlson's TSI measures. To account for this, Kratzer and Brezonik developed a TSI for total nitrogen to be used in nitrogen-limited lakes.

Carlson's TSI comes from measures made in the limnetic (open-water) area of the lake and ignores productivity by submersed macrophytes (Canfield et al. 1983). Most Florida lakes are shallow (zmax < 5 m), with broad littoral zones occupied by abundant submersed and emergent macrophytes. Some lakes have submersed macrophytes that occupy the entire basin. Canfield et al. (1983) estimated that submersed macrophytes in selected Florida lakes accounted for 20-96% of the total phosphorus (excluding the sediments). They concluded that such macrophyte-dominated lakes can have relatively low chlorophyll a concentrations in the open water, leading to underestimates of trophic state using Carlson's TSI. Release of these stored macrophyte nutrients (e.g., following herbicide application) can cause algal blooms and an increase the calculated TSI (Canfield et al. 1983, Hodgson and Linda 1984). Therefore, an accounting of the total phosphorus bound in macrophytes might yield a more accurate estimate of the trophic status in macrophyte-dominated lakes. What is not considered in this approach is the amount of time required to accumulate these nutrient stores in the plant biomass. That is, could Florida lakes with high standing macrophyte crops receive low nutrient inputs, despite their lush plant populations? Further complicating the matter is the question of where such macrophytes derive their nutrients – e.g. they may "mine" TP from sediment that was delivered to the lake decades ago.

Eutrophic lakes can switch between algal-dominated (left) and macrophyte-dominated (right) stable states

TSI Trends in Selected Florida Lakes

Despite the diversity of Florida's lakes, limnological data collection in the state did not really start in earnest until the 1980s. Efforts were strengthened with the creation of Florida's five Water Management Districts in the 1970s, and since the inception of the Florida LAKEWATCH Program in 1986, data extending back several decades have been compiled on hundreds more lakes. These archived datasets include the TSI variables as well as macrophyte coverage among many other limnological and hydrological features. Comprehensive data collections have been coordinated by Florida LAKEWATCH, the Florida Fish and Wildlife Conservation Commission (FWC), the South Florida Water Management District (SFWMD), and the Army Corps of Engineers, among others.

Recently, it was reported that some state residents claimed conditions in the Kissimmee Chain of Lakes (KCOL) are "the worst they've ever seen." To investigate this, we pooled archived data collected by SFWMD in the KCOL from the early 1980s through today. We calculated the limnetic TSI values from these data and plotted the values over time. We also plotted hydrilla (*Hydrilla verticillata*) coverage (acres), recorded by the Invasive Plant Management Section of FWC. As it turns out, KCOL TSIs have apparently been on the decline for nearly 40 years. For example, Lake Tohopekaliga (Toho) was hypereutrophic in the 1980s, with total P and chlorophyll *a* concentrations of >450 and 120 µg/L, respectively. The lake was approaching a mesotrophic state by the mid-1990s and continues on that trajectory today, with limnetic total P and chlorophyll *a* values <30 and 20 µg/L, respectively. Williams (2001), who first reported this dramatic in-lake phosphorus reduction, argued it was strongly connected to the mitigation of municipal wastewater discharge.

The early 1980s was also when exotic hydrilla was first recorded in Lake Toho, which subsequently switched from an algal-dominated to hydrilla-dominated system. It might be suspected that hydrilla sequestered incoming P and outcompeted algae. The data, however, indicate that P reduction reduced algal concentrations, driving them to a threshold concentration that was more suitable for hydrilla growth (<100 µg/L TP and 40 µg/L Chl *a*). Filstrup and Downing (2017) recently showed that TP <100 µg/L can be limiting to algal biomass. Is it possible that actions in the 1980s to improve water quality may have created the largest infestation of hydrilla in Florida?

For the last quarter century, hydrilla has been maintained in Lake Toho at ~50% (+/- 30%) cover (~9000 acres). This represents a substantial amount of standing biomass and stored nutrients (Canfield *et al.* 1983) and may also influence trophic state determinations estimated from water-column measures. Thus, a lake that today is perceived to be approaching a mesotrophic state may in fact still be quite eutrophic.

Nevertheless, the simplicity of the Carlson TSI still provides insights into lake function and can be useful for lake management. For example, differences between TSI values can be used to make inferences about a lake. Havens (2000) used TSI differences to gain insight into the factors that limit phytoplankton and the composition of seston (abiotic and biotic free-floating particles) in the lake. He proposed that when TSI for CHL *a* was ≥ TSI for TP, algal biomass was limited by phosphorus. Additionally, when TSI CHL *a* was > TSI SD, one could conclude that light penetration in the lake was reduced by factors other than algae (e.g. dissolved color, re-suspended sediment particles, etc.). We used Havens (2000) approach to identify differences between TSI CHL *a* and TP, and between TSI CHL *a* and TSI SD in the KCOL over time. For the past ~40 years, in the KCOL, TSI CHL *a* has been declining and appears to correspond with reductions in nutrient TSIs. The higher TSI-SD values, which might suggest eutrophy, imply that algae are not exclusively responsible for light limitation, which may be more influenced by macrophyte-generated seston and dissolved color. This might explain why some local residents claim they have not seen any improvement in their lakes, as they likely equate water clarity with water quality, and Secchi Disk depth has changed very little.

Florida's eutrophic lakes are managed to maintain diverse aquatic systems with multiple functions. Aquatic invasive plants such as hydrilla and water hyacinth can become so dense that a lake becomes practically unusable. Aquatic plant managers are presented with the difficult challenge of balancing macrophyte infestations and maintaining resistance against HABs. As demonstrated with the example of the KCOL, managers have successfully reduced the trophic state index measures in these lakes, making them more resistant to HABs, while maintaining macrophyte populations, albeit an exotic, invasive taxon, at functional densities. Lake trophic state is a complex topic, but objective measures of trophic status and their implications enable better lake management decisions. An appreciation for the positive aspects of eutrophic conditions is critical to making informed decisions about nutrient reduction, HAB mitigation and aquatic plant management.

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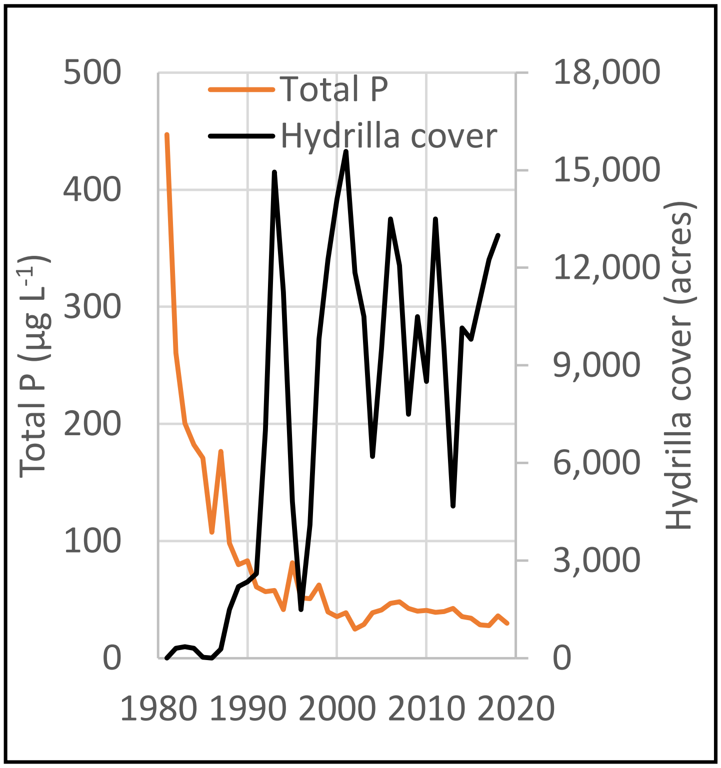
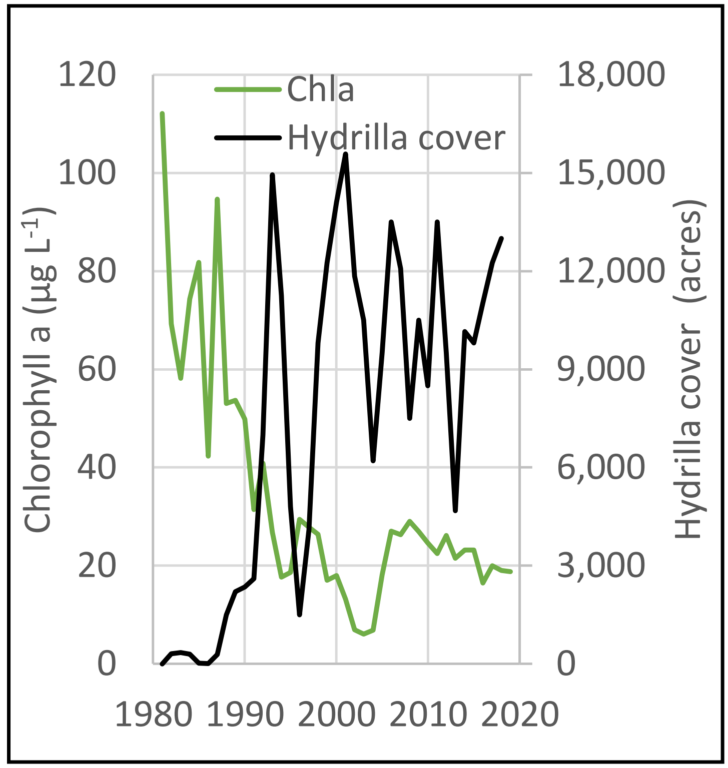
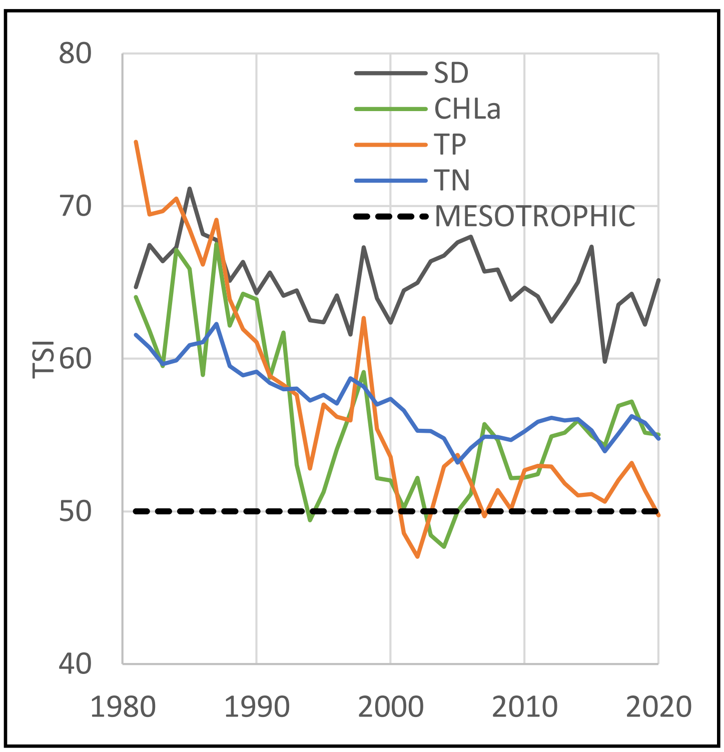
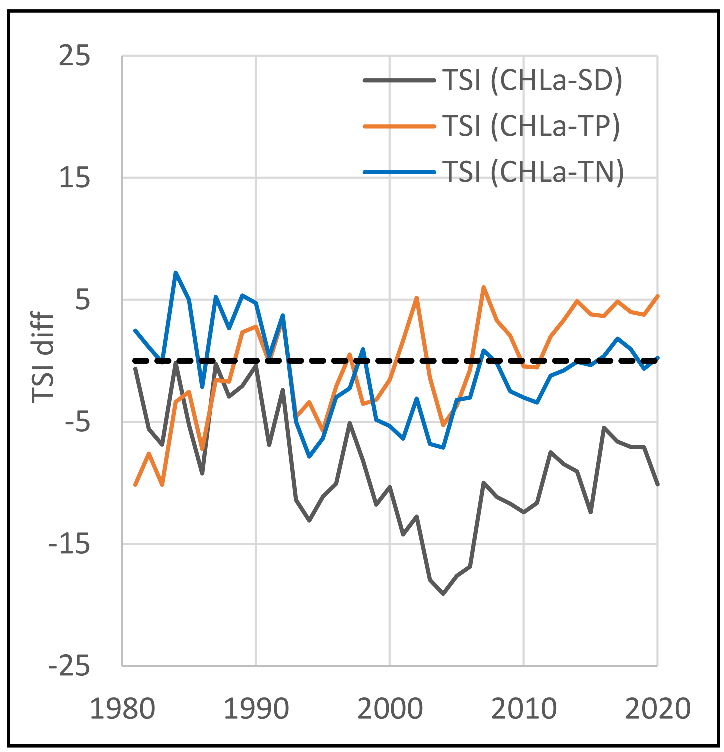




Total limnetic P (left), chlorophyll a (right) and hydrilla coverage measured over time (1981-present) in Lake Tohopekaliga.





Average TSI values in the KCOL calculated from Secchi disk depth, chlorophyll a and total limnetic P and N measured from 1981-2020 (left graph). Differences between TSI-CHLA and other TSI measures, showing the lakes are becoming nutrient-limited and that turbidity is caused in part by non-algal particles or color (TSIN/P<<TSICHLA<<TSISD) (right graph).

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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: Nomination submitted to FAPMS President; All nominations must be received at least 6 weeks before FAPMS annual training meeting. FAPMS Board of Directors (BODs) vote on nominees presented. Votes collected and tallied by the current President of FAPMS. In the event the current President of FAPMS is nominated, the vote tally duties will reside with the President-Elect. Additionally, if a FAPMS Director or Officer is nominated, they will be removed from the process. Votes will then be submitted to Secretary for the record. Nominations and supporting information will remain anonymous. Award presented at FAPMS annual training meeting.

Award Frequency: Discretionary—FAPMS BODs accepts nominations annually. One award given after majority FAPMS BODs vote on submissions.

Criteria: A special recognition given to a current or former APMS affiliate member who personifies Michael Netherland's 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 "Dr. Michael D. Netherland Exemplary Colleague Award presented to for their selfless display of friendship and optimism in the pursuit of knowledge and understanding of aquatic plant management." … meeting location and date.

Who was Mike Netherland?

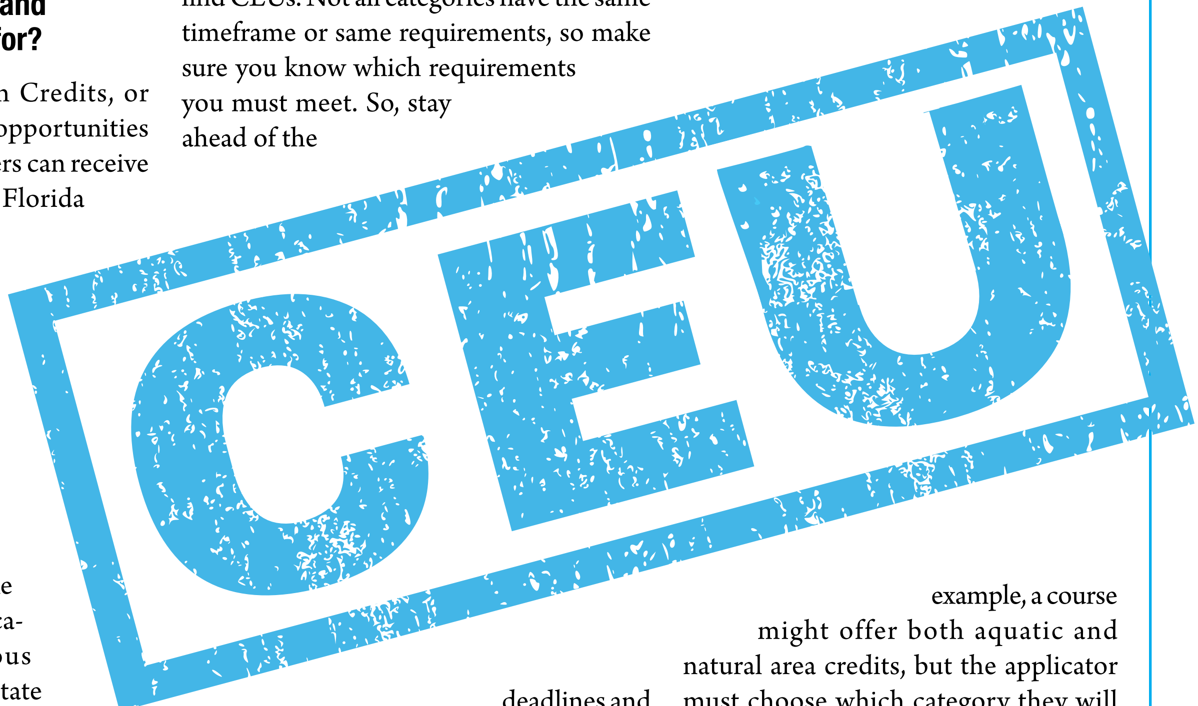
Mike Netherland was a leader in aquatic plant research and technology, and his work was instrumental in the development of various-scale aquatic plant management programs in North America. Mike is credited with being the first to use dye to track herbicide movement in lakes, reservoirs, and flowing systems, and he was also the first to suspect herbicide resistance occurring in aquatic plants. This body of knowledge serves as the foundation for the herbicide use patterns that are in use today. His excellence in research, mentoring, and communicating also led to the development of several aquatic herbicides, a technical approach to vegetation mapping and monitoring, and increased our understanding of plant genetics and response. He had an unparalleled ability to convey the most advanced scientific concepts to any person or audience he encountered. Above all, Mike was an exceptional scientist, cordial colleague, and a valued friend to everyone he met.

The Great CEU Hunt Simplified

Brett Bultemeier,
Extension Professor Pesticide Information Office, University of Florida

What are CEUs and what are they for?

Continuing Education Credits, or CEUs are the educational opportunities that pesticide license holders can receive to renew their license. All Florida pesticide licenses carry a requirement to earn these CEUs in order to maintain a valid applicators license. Failure to gather the appropriate number of CEUs in a 4-year timeframe (some categories have a shorter timeframe) will require you to re-take the exams to regain certification. There are numerous offerings throughout the state to receive in-person training offered by the UF/IFAS Extension services, professional organizations, and numerous other private groups. However, locating these training opportunities can sometimes be difficult. Keep reading below to find an easier way to locate these training events in order to keep your license up to date.



Where to find them

The Florida Department of Agriculture and Consumer Services (FDACS) provide information on their website:

http://ceupublicsearch.freshfromflorida.com/AvailableClassSearch.asp

This website allows you to search available CEUs that fit your needs by category, county, or a defined date range. Most license categories give you 4 years to earn the required number of CEUs for license recertification without having to retake the exam. Some categories can require as many as 20 total CEUs (4 Core and 16 in your category), so finding training each year prevents a last second scramble to find CEUs. Not all categories have the same timeframe or same requirements, so make sure you know which requirements you must meet. So, stay ahead of the deadlines and earn your CEUs. For an in-depth discussion about how many credits are required for each license, https://edis.ifas.ufl.edu/pi077.

What if I can't attend in person

In person training not only offers a variety of categories, but oftentimes allows the applicator to directly ask questions and interact with experts in their field. While this is the preferred method for continuing education, in person training might not always be feasible. For example, if you find yourself short on credits and time, remote training might be a better option. CEUs can be found online through the UF/IFAS Extension Online Learning: https://ifas-pest.catalog.instructure.com/.

There is a registration fee associated with these CEUs, but they are fully accredited and accepted by FDACS. Fifty minutes of training is good for one credit in one category. Another important detail to understand is that an online course for CEUs may be approved for several different categories, but the applicator must choose only 1 category when taking the course. For example, a course might offer both aquatic and natural area credits, but the applicator must choose which category they will claim, as you can't apply BOTH to the license for that single training.

There are many training options to help you stay current and up to date with your pesticide licenses if you remain flexible keep our eyes open for training opportunities.

Additional Resources

FDACS Bureau of Licensing and Enforcement: https://www.fdacs.gov/Divisions-Offices/Agricultural-Environmental-Services

University of Florida Pesticide Information Office: https://pested.ifas.ufl.edu/

Dr. Brett Bultemeier (bwbult@ufl.edu) is the Pesticide Information Officer for UF/IFAS and is responsible for creating and developing materials for educational outreach associated with pesticide applications.

Lightning Safety and Science – How to Avoid Being Struck in the Great Outdoors

Granted, our jobs can be ELECTRIFYING – beautiful scenery, amazing wildlife, and enjoying parts of Florida that most people never get to see! Most of us spend a lot of time on the water in the summer months, surveying, planning treatments, or conducting aquatic plant control activities. Cell phones with weather apps allow us to better predict patterns of storm development and movement, and this is helpful because the engine noise from airboats often prevents our ability to hear approaching storms. Lightning can strike up to 10 miles away from the storm's location, so anyone working or recreating on the water should return to shore and seek shelter inside as soon as the first roll of thunder is heard—or as soon as that Lightning Alert on your weather app indicates your location is within striking distance. It is only safe to resume activity on the water when at least 30 minutes have passed since the last audible thunder roll. Here are some things to consider about lightning safety in the great outdoors:

I'm stuck outside – what do I do?

While there is no safe place to shelter outside, if you are caught in a thunderstorm and cannot get to a fully-enclosed structure (roof, walls, and floor), follow these tips to minimize your risk:

- Avoid tall structures (trees, fences, towers, picnic shelters, pavilions, etc.)
- Avoid open areas
- Avoid seeking refuge under a single tree; instead look for low-lying cluster of trees or shrubs.
- Assume the "lightning position" if you feel your hair stand on end and/or if you are caught out in the open: crouch down low on the balls of your feet and hug your knees. Do NOT lie flat on the ground. Minimizing your contact with the ground helps to minimize your risk of being struck.
- Avoid any water, metal objects, wet items, radios, cell phones, etc. as these can become 'lightning rods' and 'attract' lightning to you.
- If you are stuck on board a boat without a cabin, get as low as you can in the boat but minimize your contact with the hull (assume the "lightning position" as best you can). Remember to keep your lifejacket on…lightning strikes to boats can disrupt electronics, communications, and start a fire.

If you witnessed or suspect that someone has been struck:

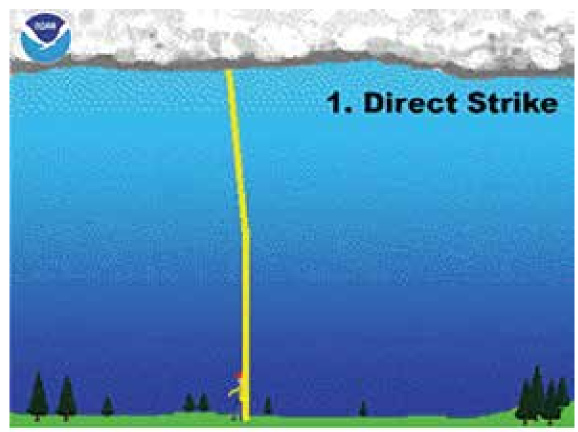
Immediate medical attention, including calling 911, starting CPR, and using an AED, may be critically important to keep the person alive until more advanced medical care arrives. Irregular heart rhythms, cardiac arrest, severe burns, and nerve damage are all common conditions that occur as the result of a lightning strike. It is important to remember that people who have been struck by lightning are safe to touch—their body does NOT carry a charge. **Please keep in mind that lightning can 'strike without warning' and that you may come upon someone who has been struck even when weather conditions 'look safe.'*

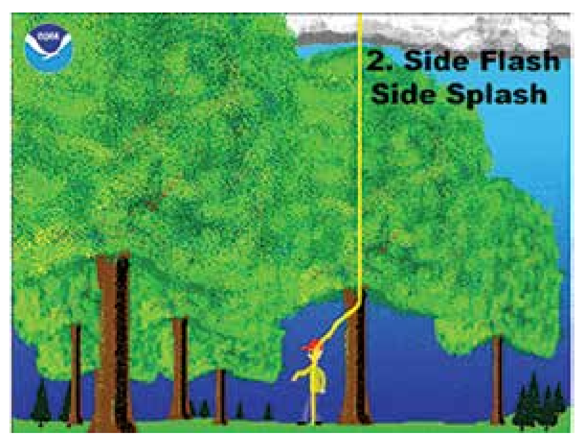
It is not always possible to know exactly how a victim has been struck, but here is a list of ways that lightning strikes its victims. Pay close attention to these and visit the animations on this website (https://www.weather.gov/safety/lightning-struck) so that you can communicate to emergency personnel what may have happened. Any of these types of strikes can be deadly.

Five ways Lightning Strikes People

Direct Strike

A person struck directly by lightning becomes a part of the main lightning discharge channel. Most often, direct strikes occur to victims who are in open areas. *Direct strikes are not as common as the other ways people are struck by lightning, but they are potentially the most deadly*. In most direct strikes, a portion of the current moves along and just over the skin surface (called flashover) and a portion of the current moves through the body—usually through the cardiovascular and/or nervous systems. The heat produced when lightning moves over the skin can produce burns, but the current moving through the body is of greatest concern. While the ability to survive any lightning strike is related to immediate medical attention, the amount of current moving through the body is also a factor. (See Fig. 1, Direct Strike)



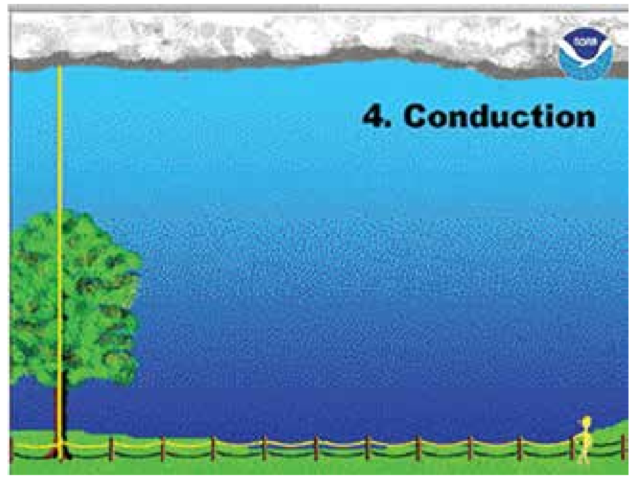


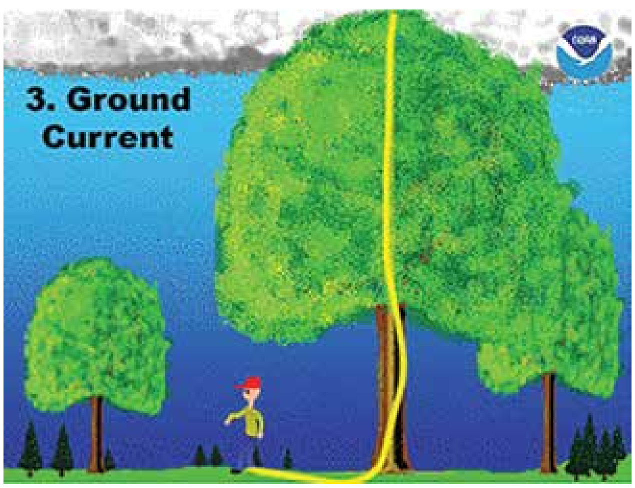
Side Flash or Side Splash

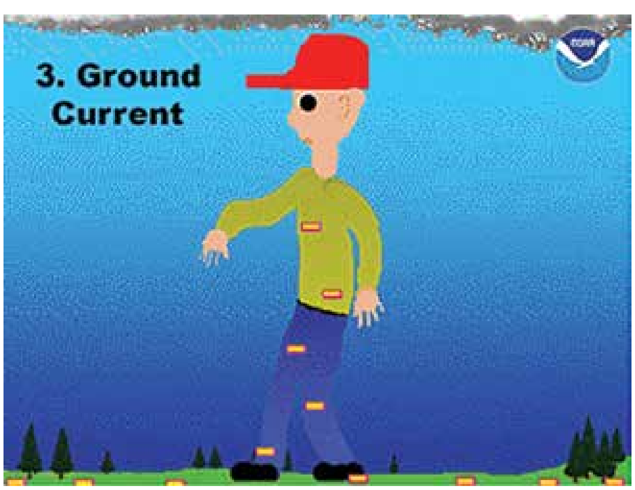
A side flash (also called a side splash) occurs when lightning strikes a taller object near the victim and a portion of the current jumps from taller object to the victim. In essence, the person acts as a "short circuit" for some of energy in the lightning discharge. Side flashes generally occur when the victim is within a foot or two of the object that is struck. *Most often, side flash victims have taken shelter under a tree to avoid rain or hail.* (See Fig. 2, Side Flash – Side Splash)

Ground Current

When lightning strikes a tree or other object, much of the energy travels outward from the strike in and along the ground surface. This is known as the ground current. Anyone outside near a lightning strike is potentially a victim of ground current. In addition, ground current can travel in garage floors with conductive materials. *Because the ground current affects a much larger area than the other causes of lightning casualties, the ground current causes the most lightning deaths and injuries.* Ground current also kills many farm animals. Typically, the lightning enters the body at the contact point closest to the lightning strike, travels through the cardiovascular and/or nervous systems, and exits the body at the contact point farthest from the lightning. The greater the distance between contact points, the greater the potential for death or serious injury. Because large farm animals have a relatively large body-span, ground current from a nearby lightning strike is often fatal to livestock. (See Figs. 3 , Ground Current A & Ground Current B)





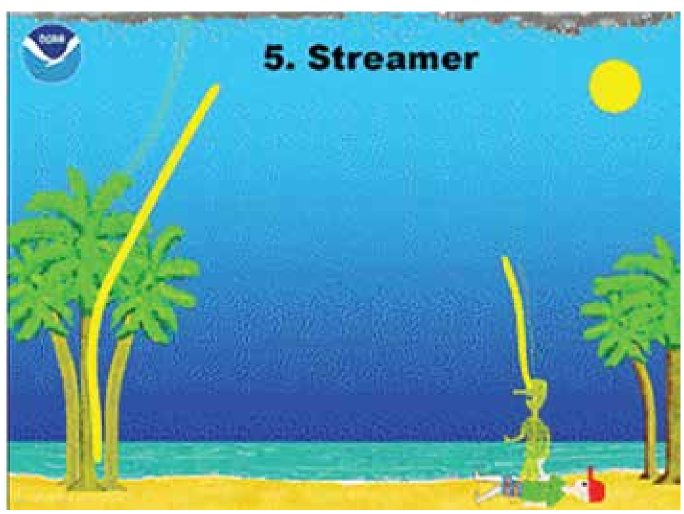


Conduction

Lightning can travel long distances in wires or other metal surfaces. Metal does not attract lightning, but it provides a path for the lightning to follow. Most indoor lightning casualties and some outdoor casualties are due to conduction. *Whether inside or outside, anyone in contact with anything connected to metal wires, plumbing, or metal surfaces that extend outside is at risk.* This includes anything that plugs into an electrical outlet, water faucets and showers, corded phones, and windows and doors. (See Fig. 4, Conduction)

Streamer

While not as common as the other types of lightning injuries, people caught in "streamers" are at risk of being killed or injured by lightning. Streamers develop as the downward-moving leader approaches the ground. *Typically, only one of the streamers makes contact with the leader as it approaches the ground and provides the path for the bright return stroke; however, when the main channel discharges, so do all the other streamers in the area.* If a person is part of one of these streamers, they could be killed or injured during the streamer discharge even though the lightning channel was not completed between the cloud and the upward streamer. (See Fig. 5, Streamer)



Adapted and Excerpted from:

NOAA, National Weather Service (Accessed 5/2020) Lightning Science: Five Ways Lightning Strikes People
https://www.weather.gov/safety/lightning-struck

NOAA, National Weather Service (Accessed 5/2020) Lightning Safety Tips and Resources
https://www.weather.gov/safety/lightning

2020 Calendar of Events

With the sudden disruption of spring and summer meetings due to COVID-19, please see links to upcoming meetings and conferences, some of which may have virtual learning options available.

July 29
FTGA/UF-IFAS Great CEU Roundup (virtual meeting)
https://www.ftga.org/page/CEURoundUp

September 24
South Florida Aquatic Plant Management Society General Meeting (location TBA)
http://sfapms.org/

September 30-October 2
South Carolina Aquatic Plant Management Society (North Myrtle Beach, SC)
http://scapms.org/meetings.html

October 5-8
Florida Aquatic Plant Management Society 44rd Annual Training Conference (Daytona Beach, FL)
http://www.fapms.org/

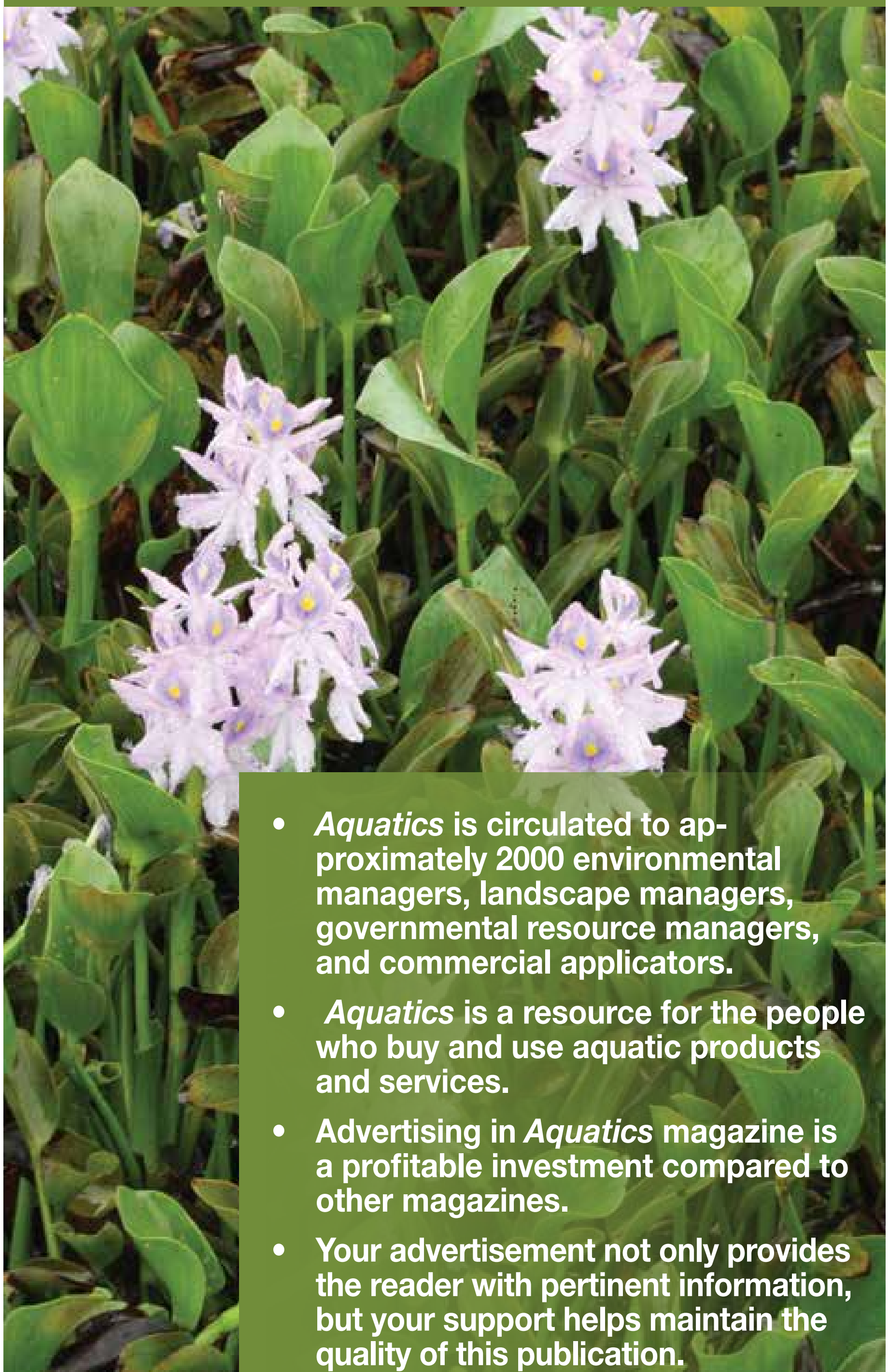
October 13-15
Western Aquatic Plant Management Society Annual Meeting (Tucson, AZ)
https://wapms.org

October 27-30
University of Florida Aquatic Weed Control Short Course (Coral Springs, FL)
https://conference.ifas.ufl.edu/aw/index.html

November (exact dates TBA)
Texas Aquatic Plant Management Society (location TBA)
https://www.tapms.org

Need CEUs but don't see anything that fits your schedule? Visit the FDACS website and search for available CEU classes here: http://aessearch.freshfromflorida.com/AvailableClassSearch.asp. For more information about licensing, certification and finding Florida CEUs, check out "CEUs just for you" in the Summer 2014 issue of Aquatics magazine (http://fapms.org/aquatics/issues/2014summer.pdf)

It Pays to Advertise



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