Aquatic Ecosystem Restoration Foundation

Tour of Florida Aquatic Plant and Mosquito Management Operations

June 4-8, 2018

On June 4-8, 2018 the Aquatic Ecosystem Restoration Foundation (AERF) sponsored a tour of aquatic and wetland systems in South and Central Florida. The purpose was to provide insight for pesticide regulatory personnel at the U.S. Environmental Protection Agency (EPA) and Florida Department of Agriculture and Consumer Services (DACS) into conditions faced by aquatic plant and mosquito managers when applying EPA-registered pesticides. EPA representatives toured natural and highly managed areas, observed pesticide applications, and spoke directly with managers and field personnel. (See Appendix 2 for the Tour Agenda and Appendix 3 for Tour participants.) Especially important was conveying unintended consequences of pesticide label language that may be pertinent to large-scale crop management, but may unnecessarily limit small-scale, preemptive, or preventive measures in aquatic plant and mosquito control.

Day 1 included travel to South Florida and meeting with aquatic plant researchers and managers. Information was presented regarding the importance of aquatic plant management to conserve the multiple uses and functions of Florida's 1.25 million acres of public lakes and rivers under the direction of the Florida Fish and Wildlife Conservation Commission (FWC). FWC oversees the annual control of approximately 70,000 acres of aquatic plants. Most of which is for the control of invasive species and most is achieved using EPA- and DACS-registered herbicides.

In addition to natural areas, there is substantial aquatic plant control conducted in the tens of thousands of miles of water conveyance canals managed by the South Florida Water Management District (SFWMD) and numerous aquatic plant and mosquito control districts. SFWMD personnel explained their aquatic plant maintenance programs that sustain water transport and flood protection in the extensive canal system in South Florida while maintaining prescribed levels of vegetation in Everglades restoration and storm water treatment areas (STAs), and conserving

Map of SFWMD Flood Control canals, structures, and Water Conservation Areas

uses and functions within natural areas. The SFWMD alone manages more than 2.0 million acres of STAs, natural lakes and rivers, and more than 2,600 miles of flood control canals. Each of these systems is managed with differing objectives as outlined in Table 1.

Table 1: Water Uses and Management Objectives in SFWMD-Managed Aquatic and Wetland Sites

Water Type	Approx. Area	Management Objective
Flood control canals	2,600 mi	Free of floating and submersed plants that may impede water flow
STA's	~100,000 ac	Water storage/supply, sequester nutrients, reduce turbidity, maintain diverse plant communities
Lakes and rivers	430,000 ac	Manage invasives to conserve native plants and water uses/functions
Conservation lands	1.62m ac	Manage invasives to conserve native plants and wetland/upland uses/functions

Canals are kept relatively free of floating and submersed plants that can impede water transport. The STAs are vegetation-based water treatment facilities. STA's require selective vegetation planting and maintenance to conserve prescribed aquatic plant diversity and abundance. Plant management in lakes, rivers, and conservation wetlands ranges from spot herbicide applications to large-scale control of hundreds to thousands of acres to conserve native plants and activities in these systems.

Key points were discussed on Day 1 in advance of field trips for first-hand observation of control operations and interaction with program managers and pesticide applicators during the remainder of the week. Managers stressed the need for EPA to register multiple herbicide mechanisms of action (MOA) and active ingredients (ai) with different formulations. This is needed to rotate or combine different MOA for resistance management. Multiple MOA also provide options to accommodate control of different target plants, or use in differing water chemistries, water movement patterns, sediment types, and scales of aquatic plant management (e.g. spot vs. large-scale applications). EPA pesticide regulatory personnel are generally more familiar with crop management logistics and requirements. In crop management, broad spectrum herbicides are often applied to control multiple weed species growing among 1-2 crop species. When managing aquatic plants growing in natural areas, most often 1-2 invasive plant species must be controlled while conserving dozens of non-target plant and animal species. Attendees were directed to the UF/FWC aquatic plant management website (http://plants.ifas.ufl.edu/manage/). The site addresses 56 different water use, biological, physicochemical, and climatological considerations made by managers when

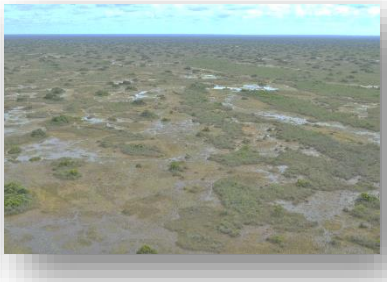
selecting herbicides for each management operation to provide cost-effective control of target plant species while selectively conserving or enhancing non-target plants and animals. See Appendix 1 for a list of key subjects discussed in relation to EPA herbicide registrations.

Day 2 began with onsite discussions about vegetation management strategies in the STAs and evaluating herbicides in small-scale research ponds. The STAs are used for water storage and supply and as a filtering system located between the Everglades Agriculture Area to the north and Everglades National Park to the south. Phosphorus entering the STAs can approach as high as 200 ppm but must be at or below 10 ppm before release to the downstream Water Conservation Areas and National Park. Strategic vegetation planting and management also lessens water flow and wind-driven mixing in the shallow STAs to reduce turbidity in discharge water. The types, amounts, and locations of aquatic vegetation in the STAs play critical roles in meeting water quality objectives. Herbicides play a significant role in managing aquatic vegetation, especially invasive species, at appropriate levels. Different compounds are needed to control different target plants growing among different assemblages of desired species.

Left to right: UF researcher Bill Haller discusses ponds in secure areas where herbicides are evaluated in small-scale natural environments; Jonathan Glueckert demonstrates drone utility for rapid assessment of test plots and vegetation distribution in remote STAs; planting vegetation in the STAs.

After lunch, attendees visited a pump station located among the STAs to regulate water flow for flood control and water supply. Participants divided into small groups, alternating flying over the STAs and Water Conservation Areas (WCAs) while others observed pump station and vegetation trash rake operations. The aerial tour encompassed wetlands and tree islands in natural states as well as heavily invaded by invasive Australian melaleuca trees and old world climbing fern. The SFWMD guide discussed different herbicides and application strategies applied in conjunction with biocontrols released to manage these invasive plants. He stressed the need for evaluating new herbicide compounds for increased efficacy as well as resistance management and selectivity.





Left to right: Boarding the helicopter to tour the STAs and WCAs; (Aerial view (file photos) of WCA showing a tree island highly invaded and intensively managed for melaleuca trees and Old World climbing fern (yellow/green); to conserve habitat and sheet flow among uninvaded tree islands.

Integral to the proper functioning of this system is consistent optimum water flow, requiring frequent maintenance of floating invasive plants (water hyacinth and water lettuce) that can block water movement and clog intake pipes at strategic pumping stations.

During the pump station tour, water and plant managers emphasized the importance of numerous small-scale herbicide applications to control floating plants that accumulate on cable barriers in the canals. There is discussion regarding implementing label language that limits the numbers of herbicide applications or amount of active ingredient that can be applied to an area during a year's time. Floating plants that collect on canal cable barriers, on the edges of canals, or in strategic areas in the STAs may be controlled 3-5 times per year in spot or small-scale applications. This


Aquatic plant management contractor controlling invasive water lettuce in a canal (left) upstream of the water pumping station (right) that regulates water flow from agricultural areas before entering the STA and water conservation areas. Water lettuce is frequently managed throughout the year along the canal banks to prevent plant jams in the downstream water control structure.

aquatic scenario differs from crop management in that only a minute portion of the canal system is managed with herbicides, and water flow and dissipation disperse herbicides from the precise control area.

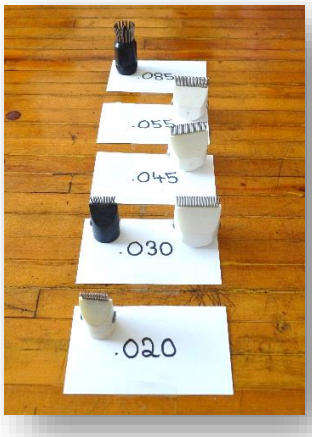
Day 2 ended with a tour of the University of Florida (UF), Institute of Food and Agricultural Sciences (IFAS) research station in the Everglades Agricultural Area in Belle Glade. Researchers discussed efforts to manage agricultural pests, especially in sugar cane, in South Florida's humid climate and organic soils. The group gathered at the subsidence pole that gauges the settling of soils since the removal of native sawgrass and construction of drainage ditches and canals that have dried and compressed the formerly saturated soils. Soils have subsided about six feet since the pole was driven into the bedrock in 1921.

Tour group at the subsidence pole at Belle Glade.

On Day 3, the group began with an airboat tour of the rim canal and marshes on the south end of Lake Okeechobee near Clewiston, with U.S. Army Corps of Engineers (USACE) and FWC aquatic plant management staff. About 12,000-15,000 acres of floating water hyacinth and water lettuce are controlled with herbicides on the lake each year by for-hire contractors under supervision and monitoring by FWC and USACE. Similar to the cables and structures in water management canals seen the previous day, floating plants accumulate along edges of marshes and in the lake's 25 water control and navigation lock structures and must be managed several times in the same general locations each year. Plants must be selectively managed in and around endangered Everglades snail kite nesting (January-August) as well as waterfowl hunting locations (October-January). Managers again stressed the importance of multiple herbicide active ingredients with activity in controlling water hyacinth and water lettuce that are almost always growing among native plants that must be conserved for fish and wildlife habitat. Several herbicides registered for hydrilla control since 2005 have also demonstrated in-water activity on water hyacinth (penoxsulam, bispyribac) and water lettuce (flumioxazin) via root uptake from submersed vs. traditional foliar applications. This gives managers more resistance, selectivity, and application options.


Boarding boats to see floating plant management on Lake Okeechobee.

The group observed a helicopter loading and application demonstration (Helicopter Applicators, Inc.) before leaving Clewiston. Different nozzle apertures and boom arrays were displayed to aerially apply herbicides ranging from large-scale applications to torpedograss fields covering a thousand or more acres (40ft boom), to spot treating (8ft boom) individual melaleuca trees in remote Everglades locations out of reach by ground or airboat crews. Pilots emphasized the use of specialized booms (microfoil, thruvalve boom) to minimize herbicide particle drift and allow for precise applications.



Left to right: Explanation of the various nozzle apertures designed to control droplet size and placement. Support vehicle with self-contained herbicide concentrate and diluent tanks and landing/loading platform.

The helicopter ground crew demonstrated a rapid herbicide loading system that punctures, drains, and applies a water volume equivalent to triple rinsing 2.5-gallon containers in just a few seconds. This not only reduces loading and rinsing time, but also minimizes mixer/applicator exposure.

Demonstrating rapid loading and rinsing 2.5-gallon herbicide containers for helicopter applications.

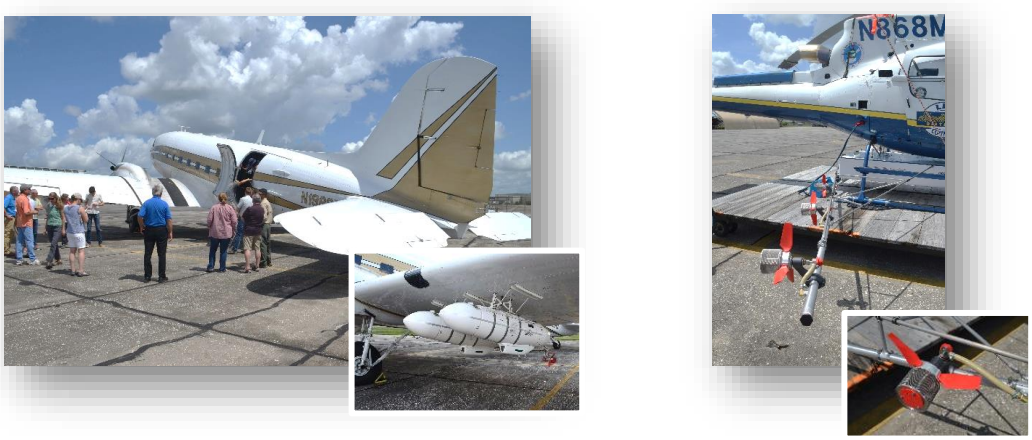
Day 4 began at the Lee County Mosquito and Hyacinth Control Districts. Lee County controls a variety of mosquito species in freshwater ponds and lakes as well as in nearly 60 thousand acres of salt marshes. Mosquito control operators recommended that pesticide labels need to consider the lifecycles of mosquitoes to allow for applications and reapplications (that may be just a few days apart) at times that are best suited to suppress populations at the lowest levels or to kill juveniles before they become egg-laying adults.

There are nearly 50 different mosquito species in Lee County. The District targets four species; three of which are disease carriers of primary concern (see Table 2). Five active ingredients are

Table 2: Types of Disease Carrying Mosquitoes Targeted by Lee County Mosquito Control District

Type of Mosquito	Virus Spread	Biting Habits
Aedes aegypti *Aedes albopictus*	Chikungunya, Dengue, Zika	Primarily daytime, but can also bite at night
Culex species	West Nile	Evening to morning

available in liquid or granular formulations. Larvicides are applied any time of day; adulticides are applied only at night. The District uses a variety of detection methods including traps, visual inspections, and sentinel chickens. Pesticides are applied selectively only to areas where mosquito populations reach threshold levels. Aerial applications are delivered by airplane and helicopters. Flight paths are controlled by computer over preestablished control polygons determined from the ground inspections. The onboard computer activates application when the aircraft enters the polygon and adjusts for forward speed to apply pesticide evenly and only to the target zone. This allows pilots to concentrate on flying, especially important since adulticides are applied at night.



Aerial application platforms and delivery apparatus operated by Lee County Mosquito Control District.

The District also monitors and controls freshwater aquatic vegetation. Floating water hyacinth and water lettuce harbor certain mosquito species (*Mansonia* spp.) and thrive in the District's hundreds of miles of canals. The District applies biological and chemical controls where appropriate and implements cultural management activities. Grass carp are used to assist in controlling the submersed invasive plant, hydrilla, and several herbicides are available to control floating, emergent and submersed plants. Nutrient monitoring and fertilizer abatement regulations are enacted at key times of year to slow invasive plant and algae growth that can harbor mosquitoes. The District is also developing means to sterilize and release male mosquitoes to lessen the frequency and amounts of pesticide applications to control mosquitoes.

Day 4 ended with a walking tour of Corkscrew Sanctuary near Immokalee. This gave participants a first-hand view of aquatic and wetland plants and animals in an undisturbed state. The route from

Left: Corkscrew Swamp Sanctuary

Right: Tour group at the public pier on Lake Okeechobee

Immokalee to Orlando passed the public pier on the north end of Lake Okeechobee, providing insight to the size of the lake and a photo opportunity for the group.

On Day 5, the group observed an infestation of submersed hydrilla in 19,000-acre Lake Toho south of Kissimmee. Lake Toho is at the headwaters of the Kissimmee Chain of Lakes and is a USACE Designated Federal Flood Control and Navigation Project. Lake Toho is also a world-class bass fishery, ecotourism destination and supports a significant population of endangered Everglades snail kites. FWC and UF staff described the planning process for controlling hydrilla, emphasizing the need for multiple herbicides to use alone or in combination. During peak summer growth, hydrilla stems can elongate by as much as 8-10 inches per day, quickly reaching and matting at the surface in shallow Florida lakes. Large-scale hydrilla control (1,000-5,000 acres) is generally

applied in cooler months from February-April, with spot control (10-100 acres) applied as necessary and as conditions allow, throughout the lake during the rest of the year.

As in other systems, target plants, whether floating, emergent or submersed, must be cost-effectively managed under a variety of conditions; in Toho's case, while conserving snail kite nesting and foraging sites, fish and waterfowl habitat, and flood control and navigation attributes. No single herbicide active ingredient or management strategy fits all current conditions. Therefore, effective management requires a number of herbicide active ingredients to apply under different water conditions, plant assemblages, and growth stages.

FWC biologist Ed Harris explaining aquatic plant management complexities in a multi-use lake.

Harvester removing dense masses of primrose willow from Lake Toho.

The tour also included observing a mechanical harvesting operation removing dense masses of invasive primrose willow. While harvesting has proven too slow and costly for large-scale invasive plant management, it is effective in removing dense submersed and floating masses of emergent plant roots, stems, and rhizomes. The Lake Toho tour ended with observation and discussion with

Applying a tank mix of flumioxazin and imazamox to primrose willow

One week after flumioxazin + imazamox application (looking from opposite direction)

an FWC for-hire contractor applying herbicides to early growth stages of invasive primrose willow overgrowing native plant habitat. The applicator advised he was applying a mixture of 4oz of flumioxazin and 32oz of imazamox per acre. This mixture is effective in controlling primrose willow but does not control comingled native grasses important for fisheries. Scattered cattail mixed in with the primrose willow will likely be controlled; however, damage to larger stands of adjacent cattail, important for endangered Everglades snail kite nesting, is avoided by applying up to the bases of cattail and preemptively controlling the primrose willow before it becomes dense and overgrows the cattail.

Appendix 1: Key Subjects Presented by Aquatic Plant Control Managers

- EPA-registered herbicides are essential, especially for invasive aquatic plant management
  - Provide cost-effective, selective, environmentally compatible management options
  - Some biocontrols are available to provide some control of some invasive plants
  - Mechanical control is too slow, expensive, and non-selective for large-scale control

- Need multiple herbicides with differing mechanisms of action
  - Rotation or combinations for resistance management
  - Different herbicides have different efficacy on different target plants
  - Different herbicides have different selectivity on different non-target plants

- Label language for crop or turf management may not apply for aquatic plant management
  - Multiple plants are controlled in crops to conserve 1-2 beneficial/non-target species
  - 1-2 invasive plants are controlled among dozens of non-target species in aquatic plant
  - Aquatic plant control usually involves multiple small-scale maintenance applications

- Need ability for multiple applications in one area with same compound within one year
  - Language is under consideration to limit the number of applications to a site in 1 year
    - Floating plants may be controlled, especially spot applications several times
      - Near flood control structures or pumps
      - Near access points, bridges, flood control structures, critical habitat in lakes and rivers

- Newer herbicide registrations are active in ppb vs. ppm
    - Represents a large reduction in amounts of herbicides applied to the environment

- Newer herbicide registrations are active on one plant gene vs. broad spectrum chemicals

- Applicator training/annual certification requirements improve label language adherence

Appendix 2: EPA Field Trip - June 4-8, 2018

Monday June 4

12:30pm	All participants arrive Hilton Palm Beach Airport (150 Australian Ave, West Palm Beach FL 33406-1473)
12:30pm	Lunch buffet at Hilton Palm Beach Airport
2:00pm	Introductions and informal presentations on how, why, where the State of Florida controls aquatic and wetland weeds; the Florida Fish and Wildlife Conservation Commission and South Florida Water Management District Programs
5:00pm	Dinner at Don Ramon Cuban Cuisine (502 S Military Trail, West Palm Beach, FL 33415 – 561-687-0161)

Tuesday June 5

7:00am	Breakfast onsite Hilton Palm Beach Airport - checkout
8:00am	Board charter bus: travel to Stormwater Treatment Area (STA) 1W (~1 mile from intersection of SR 80 and CR 880/near 21500 FL 80, Loxahatchee FL) **19.5 miles/26 minutes**
8:45am	Arrive STA test cells: research and herbicide screening discussion; drone demonstration by Jonathan Glueckert
10:00am	Board bus; travel to pump station G319 (20700 SR 80, Loxahatchee, FL 33470) **5 miles/10 minutes**
10:30am	Arrive at pump station G319: discuss the need and limitations of pumping water, weeds, flood control
11:15am	Board bus: travel to Park Avenue BBQ (13897 Wellington Trace, Wellington, FL 33414 – 561-795-7427) **9.8 miles/13 minutes**
11:30am	Lunch at Park Avenue BBQ in Wellington
12:45pm	Board bus: return to pump station G319 for helicopter pick up point (exact location TBA) **9.8 miles/13 minutes**

1:15pm	Helicopter tour of Loxahatchee Wildlife Management Area and STAs
3:00pm	Board bus: travel to Belle Glade Everglades Research and Education Center (3200 E. Palm Beach Rd, Belle Glade, FL 33430) **16.9 miles/20 minutes**
3:30pm	Meet Dr. Calvin Odero; discussion about agriculture and water quality and weeds in the EAA (Everglades Agricultural Area)
4:30pm	Board bus: travel to Roland Martin Marina and Resort (920 E Del Monte Ave, Clewiston, FL 33440 – 863-983-3151) **22.3 miles/30 minutes**
5:00pm	Arrive at Roland Martin Marina and Resort: dinner onsite

Wednesday June 6

7:30am	Breakfast on-site Roland Martin Marina and Resort - checkout
8:30am	Board bus: travel to Belle Glade boat ramp (Torrey Island Campground, 5000 W Canal St N, Belle Glade FL 33430) **21.7 miles/31 minutes**
9:00am	Airboat tour of aquatic weeds on the Federal Navigation and Flood Control Project water, Lake Okeechobee - see herbicide application, talk to applicators
12:00am	Board bus: travel to Sunrise Mexican Restaurant (842 Sugarland Highway, Clewiston, FL 33440) **21.5 miles/27 minutes**
12:30am	Lunch at Sunrise Mexican Restaurant
2:15pm	Board bus: travel to Airglades Airport (1090 Airglades Blvd, Clewiston, FL 33440) **9.2 miles/11 minutes**
2:30 pm	Meet with Mike Page: discuss helicopter applications, micro foil booms and handling of empty pesticide containers; observe helicopter loading, application, and drift control procedures
3:45pm	Board bus: travel to Hotel Indigo Ft. Myers Downtown River District (1520 Broadway, Suite 104, Fort Myers FL 33901) **54.9 miles/1 hour 8 minutes**
5:45pm	Arrive Hotel Indigo Ft. Myers: dinner walk to local restaurant

Thursday June 7

7:00am	Breakfast onsite Hotel Indigo Ft. Myers - checkout
8:00am	Board bus: travel to Lee County Mosquito and Hyacinth Control District (15191 Homestead Road, Lehigh Acres, FL 33971) **10.8 miles/20 minutes**
8:30am	Tour: lectures on mosquito and weed control; lunch onsite Host: Wayne Gale, Executive Director
1:00pm	Board bus: travel to Corkscrew Swamp Sanctuary (375 Sanctuary Rd W, Naples, FL 34120) **49.4 miles/57 minutes**
2:00pm	Arrive Corkscrew Sanctuary
4:00pm	Board bus: travel to Lake Okeechobee waterfront park in Okeechobee; travel to Hampton Inn Orlando-International Airport (5767 T.G. Lee Blvd, Orlando, FL 32822) **209.6 miles/3 hours 34 minutes**
7:30pm	Arrive Hampton Inn Orlando-International Airport: dinner local/walking

Friday June 8

7:30am	Breakfast onsite Hampton Inn - checkout
8:30am	Board bus: travel to Lake Toho/Scotty's Cove – Richardson's Fish Camp (1570 Parsons Rd, Kissimmee, FL 34744) **23.2 miles/30 minutes**
9:00am	Arrive Lake Toho: meet with Dean Jones (UF) and Ed Harris (FWC); airboat tour of Lake Toho; discuss monitoring submersed weed treatments, endangered species, multi-use urban lakes and a new invasive aquatic weed; observe harvesting operation and herbicide handgun application
11:00am	Board bus: travel to MCO airport (1 Jeff Fuqua Blvd, Orlando, FL 32827) **21.8 miles/31 minutes**
12:00pm	Arrive MCO: drop off guests and hosts; return to Gainesville, UF and drop off UF/AERF participants **2.8 miles/6 minutes**

Appendix 3: Participants Attending the Entire Week Tour (June 4-8)

EPA (Environmental Protection Agency)

BEAD (Biological and Economic Analysis Division)

1. Caleb Hawkins
2. T.J. Wyatt

BPPD (Biopesticides and Pollution Prevention Division)

3. Elyse Bilardo

EFED (Environmental Fate and Effects Division)

4. Cassandra Kirk

HED (Health Effects Division)

5. Josh Godshall

PRD (Pesticide Re-Evaluation Division)

6. Jordan Page

RD (Registration Division)

7. Driss Benmhend
8. Grant Rowland

UF (University of Florida)

9. Bill Haller
10. Lyn Gettys
11. Jason Ferrell

AERF (Aquatic Ecosystem Restoration Foundation)

12. Carlton Layne
13. Jeff Schardt
14. Dan Thayer

CSI (Compliance Services International)

15. Ashlea Frank

FDACS (Florida Department of Agriculture and Consumer Services)

16. Adriane Rogers