Hydrilla

Integrated Pest Management Guide

Verena-Ulrike Lietze
Jennifer L. Gillett-Kaufman
Joan P. Bradshaw
Ken T. Gioeli
James P. Cuda

UF | UNIVERSITY of FLORIDA
IFAS
An Equal Opportunity Institution

HYDRILLA IPM PROJECT

USDA NIFA RAMP Grant 2010-02825

About Hydrilla

Wacissa River Springs, Florida, with surface mats of hydrilla before treatment

Throughout Florida and at least twenty other states, the invasive freshwater plant hydrilla (*Hydrilla verticillata* [L.f.] Royle) causes damaging infestations that choke out native plants, clog flood control structures, and impede waterway navigation and recreational usage.

Every year, the state of Florida spends millions of dollars managing this weed in our waterways.

However, aquatic resource managers are facing a problem: hydrilla is showing resistance to the widely used herbicides fluridone and endothall.

To tackle this problem UF/IFAS County Extension Faculty and Entomology and Nematology Department Faculty are implementing a USDA grant-funded program: the Hydrilla Integrated Pest Management Risk Avoidance and Mitigation Project (Hydrilla IPM RAMP).

Help us spread the word that new strategies for hydrilla IPM are being investigated and developed.

This guide will lead citizens through the basics of hydrilla identification and management.

Goals of Hydrilla Integrated Pest Management

The two most important goals of every successful hydrilla IPM plan must be

- To provide a sustainable, long-term, reduced-risk solution for hydrilla control
- To encourage resource managers to learn about and adopt new IPM tactics

UF/IFAS field research plot in Florida for testing biological control agents against hydrilla

Are You Involved in Public Education?

Contact your local UF/IFAS Extension office.

Each office has brochures and other educational print items available as well as PowerPoint presentations that you can use for events. Our team members will be happy to present our material or provide a display for aquatic weed workshops, field days, and other events to raise public awareness on invasive aquatic plants.

Scan the QR code to find the contact information of your local **UF/IFAS Extension office** (http://solutionsforyourlife.ufl.edu/map/).

Do you have access to kiosks near boat-ramps? We can supply you with a custom-made poster that includes contact information for your organization!

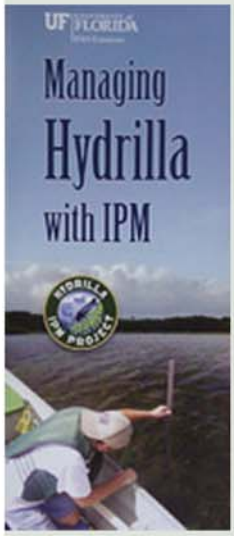
And always remember:

Everyone who visits water bodies should be aware of the threats posed by hydrilla and other invasive aquatic plants and of steps to prevent infestation and spread.

Read on for more information.

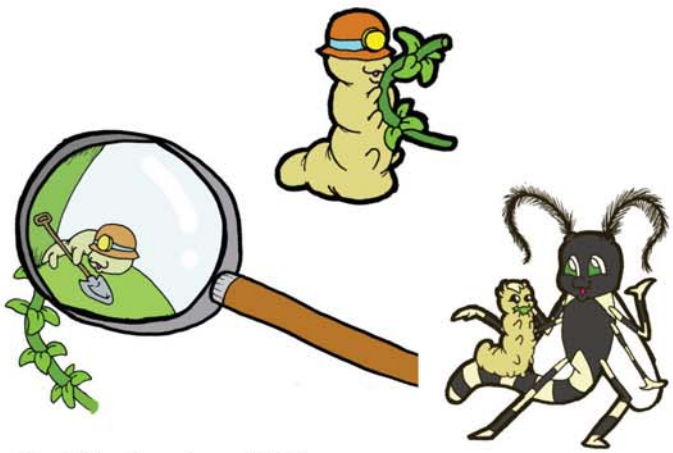
Webcard

Bookmark/ruler



Brochure

If you are involved in children's education, let us collaborate with you to develop educational games for kids. We have some really cute hydrilla miner logos we would happily share with you. Be creative when you include these in your teaching material.



Hydrilla tip miner 4-H logos
(Image credits: Kiante Todd)

Preventing New or Recurring Hydrilla Infestations

Remember: Prevention is cheaper than treatment!

Most freshwater bodies likely are suitable habitats for hydrilla because this invasive aquatic weed can tolerate a wide range of environmental conditions. Previously infested water bodies, of course, are already known to support hydrilla growth.

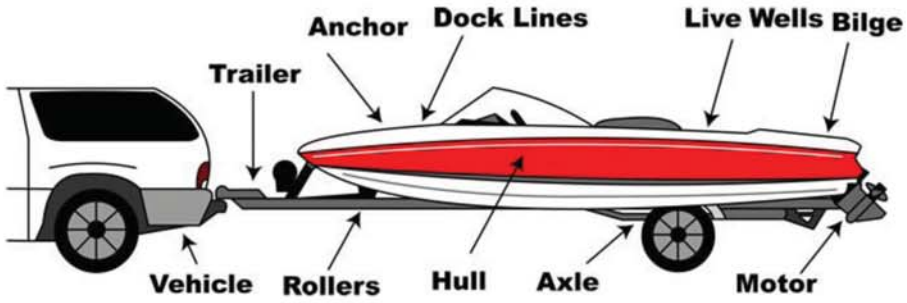
A successful hydrilla education program needs to reach everyone who visits water bodies—in other words, people of all ages and interests. These include families with kids and dogs, boaters, anglers, hunters, water sport enthusiasts, water gardeners, park and lake managers, aquatic plant managers, and pesticide applicators.

No dumping!
(Photo by UF/IFAS/CAIP; used with permission)

Clean up!
(Photo by Don Schmitz, UF; used with permission)

How can YOU help prevent the spread of hydrilla and other invasive aquatic plants?

- **Do not** empty your aquarium contents into waterways.
- Clean your boat, trailer, live wells, fishing equipment, and diving gear before and after you visit a water body. Do this at the boat ramp, so that you won't forget later.
- **Do not** place any plant material back into the water. Dispose of plant material in on-site trash cans or in your household trash. **Do not** compost hydrilla or any other aquatic weeds.
- Did your dog go swimming? **Please** wash and brush the dog thoroughly before allowing your "best friend" to jump into new waters.
- **Be aware** that possession of hydrilla without a special permit is illegal in Florida.
- **Check everywhere** before you leave the ramp:



(Image courtesy of the California Department of Fish and Wildlife; used with permission)

How to Identify Hydrilla

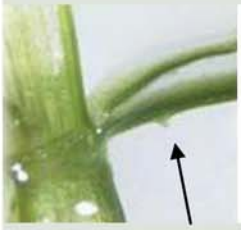
Habitat: Hydrilla grows in literally all freshwater habitats including springs, streams, rivers, lakes, ponds, impoundments, and canals. It tolerates low light intensity, high turbidity, and a range of nutrient conditions.

Plant habit: Hydrilla is a submerged, perennial, rooted plant with slender stems. Stems are sparsely branched until they reach the water surface, where profuse branching leads to a dense canopy.

Stems: Stems can be up to 33 feet (10 m) long, depending on the depth of the water body. Under water, they are erect and generally not branched; at the water surface, they branch heavily. Stolons can creep horizontally under the sediment.

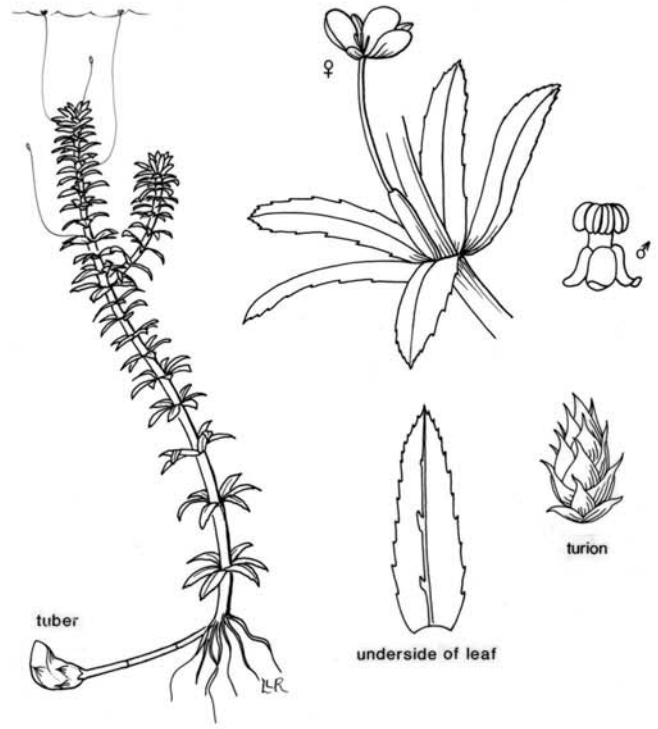
Stems growing on lake bottom
(Photo by Vic Ramey, UF/IFAS/CAIP; used with permission)

Leaves: Leaves are small and narrow, just about 1/10 inch (2.5 mm) wide and 1/4 to 3/4 inch (6 to 18 mm) long. They grow in whorls of 4-8 (often 5) around the stem. The leaf margins are saw-toothed, and the leaf midrib carries one or more small, sharp teeth on the underside.



Leaf spine Leaf whorl
(Photos by Karen Stratman, UF/IFAS; used with permission

Flowers: The female flowers grow on individual long stalks to float on the water surface. Their three sepals and three petals are whitish and about 1/6 inch (4 mm) long. In Florida and the southern U.S. range of hydrilla distribution, no male flowers are found because only the female dioecious form of hydrilla is present. In northern states, the monoecious form of hydrilla (with male and female flowers on the same plant) is present.



Male flowers are tiny and greenish in color, grow close on stem tips close to leaf axils, and eventually break loose and float to the surface.

Turions: Turions are buds in leaf axils. They are cylindrical in shape, about 1/4 inch (6 mm) in diameter, and dark green in color. Turions break off and fall into the sediment, where they overwinter and produce new plants in the spring.

Turions
(Photo by William Haller, UF/IFAS/CAIP; used with permission)

Hydrilla verticillata
Hydrilla

How to Identify Hydrilla (Continued)

Roots: Roots are thin and long, whitish to light brown in color, and anchored in the sediment. Roots also can form at the nodes along the stem or at the end of loose stem fragments.

Tubers: Tubers are turions that form at the root tips in the sediment. They are potato-shaped, about 1/2 inch (12 mm) long, and yellowish brown in color. Tubers can stay dormant for up to four years before they sprout new shoots.

Exposed roots with tubers
(Photo by William Haller, UF/IFAS/CAIP; used with permission)

Tubers
(Photo by Karen Stratman, UF/IFAS; used with permission)

Canopy: The dense surface canopy may remain rooted or may break loose resulting in floating mats of vegetation. At this stage, hydrilla is called "topped out."

Topped-out hydrilla covering a lake
(Photo by William Haller, UF/IFAS/CAIP; used with permission)

Look-alikes

Two aquatic plants commonly found in U.S. freshwater bodies look very similar to hydrilla:

- ***Elodea canadensis*** (Canadian or common waterweed) is native to the United States. It does not produce subterranean tubers and feels softer than hydrilla because leaves do not have teeth on the midrib. Canadian waterweed is densely whorled with two to three leaves per whorl and is considered beneficial at low density.
- ***Egeria densa*** (Brazilian waterweed) is non-native and invasive. Its leaves are about an inch long (25 mm), finely toothed on the margins, and arranged in whorls of four to five. They carry no teeth on the midrib and therefore feel softer than hydrilla. Brazilian waterweed does not produce tubers.

Elodea canadensis
(Photos by William Haller [top] and Vic Ramey [bottom], UF/IFAS/CAIP; used with permission)

Egeria densa
(Photos by William Haller [top] and Ann Murray [bottom], UF/IFAS/CAIP; used with permission)

Contacts for Plant Identification and Management Advice

Before anybody can take any steps towards weed control, they need to verify that the aquatic plant that is causing a problem is an invasive species. Expert help to identify aquatic plant species is available in most counties.

If you are unsure about identification and want to learn more, **contact your local UF/IFAS Extension office!** The extension agents will be happy to assist you and guide you through a tutorial.

Scan the QR code to find the contact information of your local **UF/IFAS Extension office** (http://solutionsforyourlife.ufl.edu/map/).

No time for a tutorial? Here are more options:

You may submit a photo to the **UF/IFAS Distance Diagnostic and Identification System** (DDIS) online at http://ddis.ifas.ufl.edu

You may send questions to the **UF/IFAS Center for Aquatic and Invasive Plants** (CAIP), Gainesville, FL 32653, Phone: 352-273-3667,
E-mail: CAIP-website@ufl.edu

You may call or write to the **Florida Fish and Wildlife Conservation Commission**, Invasive Plant Management Section (Main Office), 3900 Commonwealth Blvd., MS 705 Tallahassee, FL 32399, Phone 850-617-9430, Fax 850-245-2835.

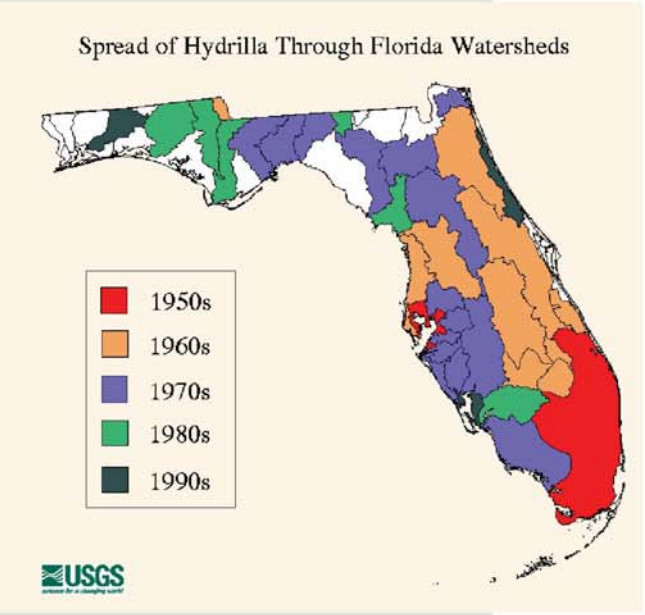
Distribution of Hydrilla in the United States

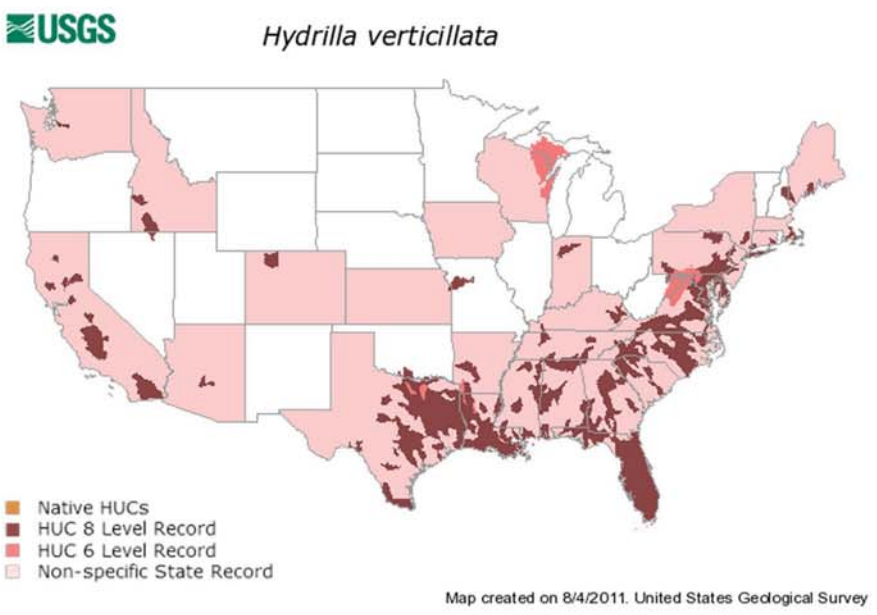
By 2003, hydrilla was present in twenty-one states, infesting over 690 water bodies within 190 watersheds (drainage basins). To date (2013), at least four additional states have recorded infestations, and three states are on the lookout with early eradication programs planned.

The female dioecious biotype (only female flowers are produced) made its way from Asia to Florida in the 1950s as an exotic aquarium plant. It was accidentally released into a freshwater body in the Tampa Bay area.

Within 40 years of this introduction, hydrilla populations have established in over 70% of Florida's watersheds. From Florida, dioecious hydrilla has spread to most of the southeastern coastal states.

The monoecious biotype (male and female flowers produced on the same plant) of hydrilla was first detected in Maryland in the 1970s and is thought to originate from Korea. It now is present along the eastern and western coasts as far north as Maine and Washington State, respectively, and as far south as Georgia and California, respectively. Infestations also occur in inland states.





Hydrilla distribution maps
(Images courtesy of the U.S. Geological Survey, Department of the Interior/ USGS; public domain)

What to Do When You Suspect a New Infestation

Most often, hydrilla enters a new habitat with water flow, boats, or aquatic birds. It is therefore important to survey areas such as inlets, upstream waters, access points, and known habitats of wading or shore birds.

How to Survey for Hydrilla

Early detection under water may allow removal of the plants before they reach the surface and begin to form profusely branched, dense vegetation mats. In shallow areas, surveying the bottom from a boat with a viewing tube or by snorkeling is possible. In deeper waters, scuba diving might be necessary. An underwater video system is useful for scanning larger areas.

No standardized technique has been developed. **Try to be as thorough as possible.** It is best to use a map of the water body; if none is available, draw one. Outline features of the shoreline and add reference points.

For the survey, **space and locate transects by GPS** and make sure to include deep water areas as well as key points such as boat ramps, swimming areas, intakes, and habitats of fish and birds.

Use ID cards or keys to identify the plants you record. If in doubt, take a plant sample and submit it for identification (see page 5: "Contacts for Plant Identification and Management Advice"). If you can, include the roots because hydrilla grows characteristic tubers that facilitate quick identification.

How to Measure the Extent of an Invasion

Mapping the extent of a hydrilla infestation can be tricky. During early invasion, hydrilla mainly disperses by tubers that remain in the sediment and will sprout in the following growth season.

When you discover hydrilla growth, follow up with visual inspection expanding in concentric circles from the center of growth. You may also follow the direction of water current. In large water bodies, focus your attention on likely sources of invasion, such as inlets, boat ramps, docks, and key bird habitats.

Get a rough estimate of coverage, for example the number of stems per area unit or the extent of the area covered by topped-out hydrilla.

How to Report an Invasion

Once the presence of hydrilla is confirmed, **contact the Florida Fish and Wildlife Conservation Commission** to notify the town in which the infested water body is situated.

Also **contact your local UF/IFAS Extension Office.**

You can find contact information on page 5 of this guide.

Laws and Regulations

Since July 2008, Florida's invasive plant management program has been under the direction of the Florida Fish and Wildlife Conservation Commission (FWC).

FWC determines the timing and the level of hydrilla management on each public water body after analyzing risks (addressing human health, economy, ecology, etc.), current water body conditions, primary uses, and available control technologies.

Florida law (F.S. 369.20) requires all persons intending to control or remove aquatic vegetation from waters of the state to obtain a permit from FWC's Invasive Plant Management Section unless an exemption for the activity has been provided in statute or rule (Chapter 68F-20).

Application forms and laws for removing freshwater aquatic plants can be found at FWC's website:
http://myfwc.com/license/aquatic-plants

(Scan the QR code to connect to the website.)

The following additional information is provided by the UF/IFAS Center for Aquatic and Invasive Plants (CAIP):

Hydrilla verticillata

- Is on the State Lists of Noxious Weeds in Arizona, Arkansas, California, Florida, New Hampshire, North Carolina, Oregon, Puerto Rico, South Carolina, Arkansas, California and Washington
- Is on the Florida Prohibited Plants list, Florida Department of Environmental Protection
- Is on the Federal List of Noxious Weeds (USDA/APHIS, 2000)
- Is on the Florida Exotic Pest Plant Council list
- Is a Category I plant, which means it is "invading and disrupting native plant communities in Florida"

Visit CAIP's website, where you can download the above stated lists and access legislative chapters:
http://plants.ifas.ufl.edu/node/634

(Scan the QR code to connect to the website.)

Management Options

A variety of tactics can be used to manage hydrilla infestations.

Nutrient Management

Excessive amounts of nutrients (especially nitrogen and phosphorus) will foster plant growth and may lead to overabundance of aquatic vegetation. Major sources of nutrients include sediment that erodes from adjacent landscapes (source of phosphorus) and runoff from agricultural, turf, and sewage areas (sources of nitrogen).

Physical Control

Physical control involves manipulating the physical environment in hydrilla-infested waters and may include the following:

Hand-pulling: Manual removal of plant material only works when the entire plant, including roots and tubers, is removed.

Suction harvesting: Performed by divers using vacuum hoses; best followed by dredging to remove tubers and prevent regrowth.

Covering: Small patches of hydrilla populations may be controlled by covering the sediment with opaque fabric to exclude sunlight.

Drawdowns: Lowering the water level is a possible control approach in water bodies with water level control structures. Without water, hydrilla plants dry out, die, and decompose. However, the exposure of the sediment to desiccation and extreme temperatures may also harm native aquatic plants and animals (such as frogs, turtles, mollusks, beavers, etc.).

In most states, drawdowns must be authorized. Check with your state and local jurisdictions to find out about permits and other requirements.

Exposed and dried hydrilla during lake drawdown
(Photo by Jeff Schardt, UF/IFAS/CAIP; used with permission)

Mechanical Control

Mechanical harvesting of hydrilla is performed by specialized machines that remove hydrilla from the water, chop the plant material, and transport it to designated sites on shore for disposal and decomposition. Caution: If fragments are left behind in the water, they will produce new plants.

Mechanical harvester at work
(Photo by Jeff Schardt, UF/IFAS/CAIP; used with permission)

Mechanical control may be considered when an infestation covers nearly the entire water body. During early colonization, however, fragmentation and incomplete removal during harvesting could further enhance the spread and growth rate of hydrilla.

Several companies have specialized in mechanical harvesting and should be consulted. To find them on the Internet, conduct a search using search terms like "aquatic mechanical harvesting", "aquatic weed harvesting", and "lake harvesters".

Before you plan a mechanical harvesting project, contact your city or county to find out what permits are required and if mechanical harvesters would be allowed.

Chemical (Herbicidal) Control

Depending on the habitat and vegetation, several active ingredients have the potential to control hydrilla selectively—in other words, to kill hydrilla while not affecting other aquatic plant species.

Copper, diquat, fluridone, endothall, and imazamox are examples of aquatic herbicides that provide temporary control of hydrilla and that are registered with the U.S. Environmental Protection Agency and the Florida Department of Agriculture and Consumer Services.

Before using herbicides, **always read and understand the labels** and adhere to the recommendations!

To become familiar with laws, regulations, and herbicide safety, the UF/IFAS Pesticide Information Office is a fantastic resource: http://pested.ifas.ufl.edu

(Scan the QR code to connect to their website.)

Biological Control

A number of organisms that eat or infect hydrilla have been identified and are currently being evaluated or used to keep hydrilla infestations in check.

Herbivorous fish: The Asian grass carp (*Ctenopharyngodon idella*) is a non-specific yet effective consumer of hydrilla and other aquatic plants. Because this fish is a non-native species, only sterile (triploid) grass carp can be released, and a permit is required.

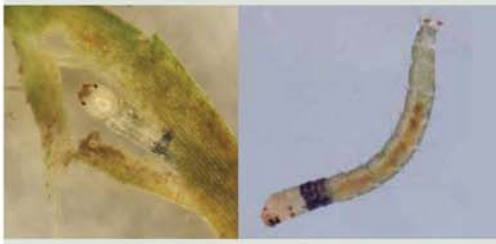
Sterile grass carp have been used successfully to reduce hydrilla biomass in closed water systems. *In Florida, you will need to contact the Florida Fish and Wildlife Conservation Commission and request a permit* for purchase and release of sterile grass carp. Refer to page 8: "Laws and Regulations."

Asian grass carp
(Photo by Eric Engbretson, U.S. Fish and Wildlife Service, Bugwood.org; used with permission)

Herbivorous insects: In the 1980s, several insect species that specifically feed on hydrilla were introduced and released in the United States. Of those, hydrilla tuber and stem weevils (*Bagous* spp.) did not establish in Florida because they require tubers and stems that are not covered by water to complete their development (which rarely is the case in Florida).

Another species, the Asian hydrilla leaf-mining fly (*Hydrellia pakistanae*), now has well-established field populations in all hydrilla-infested water bodies.

Yet another promising control candidate is the hydrilla tip miner (*Cricotopus lebetis*) that was discovered in Florida in the 1990s. Its larvae feed and develop inside growing stem tips and cause the damaged tips to break off and decompose. Our Hydrilla IPM RAMP research team currently is evaluating the control potential of the hydrilla tip miner in an integrated approach when combined with other management tactics.



Hydrilla tip miner
(Photos by Dana Denson, Reedy Creek Improvement District, and Karen Stratman, UF/IFAS; used with permission)

Pathogenic fungus: The fungus *Mycoleptodiscus terrestris* (Mt) is an indigenous pathogen of hydrilla; it was isolated first in 1987 and subsequently formulated and tested as a bio-herbicide. The fungal inoculum operates much like a chemical herbicide in that it contacts, penetrates, and kills hydrilla.

Under various experimental conditions, Mt has significantly reduced hydrilla biomass when applied alone or in combination with chemical herbicides. Hydrilla IPM RAMP researchers are now testing its compatibility with the hydrilla tip miner.

Hydrilla growth following no treatment (left) versus combined treatment with chemical herbicide and Mt fungus (right)
(Photos by Judy Shearer, U.S. Army Corps of Engineers; used with permission)

Wanted: Your Feedback!

Contact us and let us know what you would like to see included in a comprehensive hydrilla IPM guide. Talk to your neighbors, friends, and colleagues. **Anybody who visits Florida's freshwater bodies for any reason is a stakeholder when it comes to hydrilla management.**

Ask people for their opinion and help us assemble stakeholder feedback. Forward responses to vlietze@ufl.edu

You can scan the QR code to send us an email directly from your phone.

Example questions:

1. What do you do or what is being done in your neighborhood or at places you visit to manage hydrilla infestations?
2. Has anybody attempted integrating control tactics, for example combining grass carp releases with herbicide applications? If yes, what tactics have been combined and was the approach successful?
3. What kind of information would you like to see in a hydrilla IPM guide?

If you would like to forward these questions to people who could help, you can download a Word file from our website at: http://entomology.ifas.ufl.edu/hydrilla

You can scan the QR code to connect directly to our website.

Glossary

Biotype: a form of the same plant species that shows special characters (for example, presence/absence of male or female flowers, resistance to a chemical herbicide, tolerance to extreme temperatures)

Dioecious: female and male flowers occur on different plants

Distribution: geographical range in which the plant occurs

Dormancy: a period in which a plant does not grow, generally during times of unfavorable environmental conditions

Herbicide: chemical compound that kills weeds

Herbivorous: plant-eating

Monoecious: female and male flowers occur on the same plant

Pathogenic: disease-causing

Stolon: a stem that grows along the surface of the sediment

Submersed: a plant with most leaves growing underwater; flowers and some of the leaves may float on the water surface

Whorl (leaf whorl): arrangement of three or more leaves, emerging and radiating from a common node along the stem

Acknowledgements

We acknowledge the funding provided by USDA NIFA RAMP Grant 2010-02825.

Our special thanks go to Jane Medley (University of Florida) for designing the front and back covers of this guide.

Photos were taken by the authors unless otherwise indicated. Many photos were provided by the University of Florida's IFAS Center for Aquatic and Invasive Plants (UF/IFAS/CAIP).

Last but not least we appreciate the ongoing support received from our Extension Advisory Committee members (in alphabetic order): Lorrie Bush (St. Lucie West Services District), Stephen Hight (USDA-ARS CMAVE and FAMU Center for Biological Control), Jerry Renney (Applied Aquatic Management), Kelle Sullivan (Florida Fish and Wildlife Conservation Commission), and Bridgett Tolley (Osceola County and South Florida Water Management District).

RESOURCES FOR MORE INFORMATION

Scan these QR codes to connect to the following websites:

UF/IFAS Hydrilla IPM RAMP
http://entomology.ifas.ufl.edu/hydrilla

UF/IFAS Center for Aquatic and Invasive Plants (CAIP)
http://plants.ifas.ufl.edu

Florida Fish and Wildlife Conservation Commission (FWC)
http://myfwc.com

eXtension (America's research-based learning network)
Invasive Species Community of Practice
http://www.extension.org/pages/67208/hydrilla-ipm-ramp-learning-lesson

This guide was printed with funding provided by the U.S. Department of Agriculture, National Institute of Food and Agriculture, Risk Avoidance and Mitigation Program (grant 2010-02825).