New developments with aquatic herbicides, herbicide resistance strategies, and biological controls targeting invasive aquatic plants in Florida

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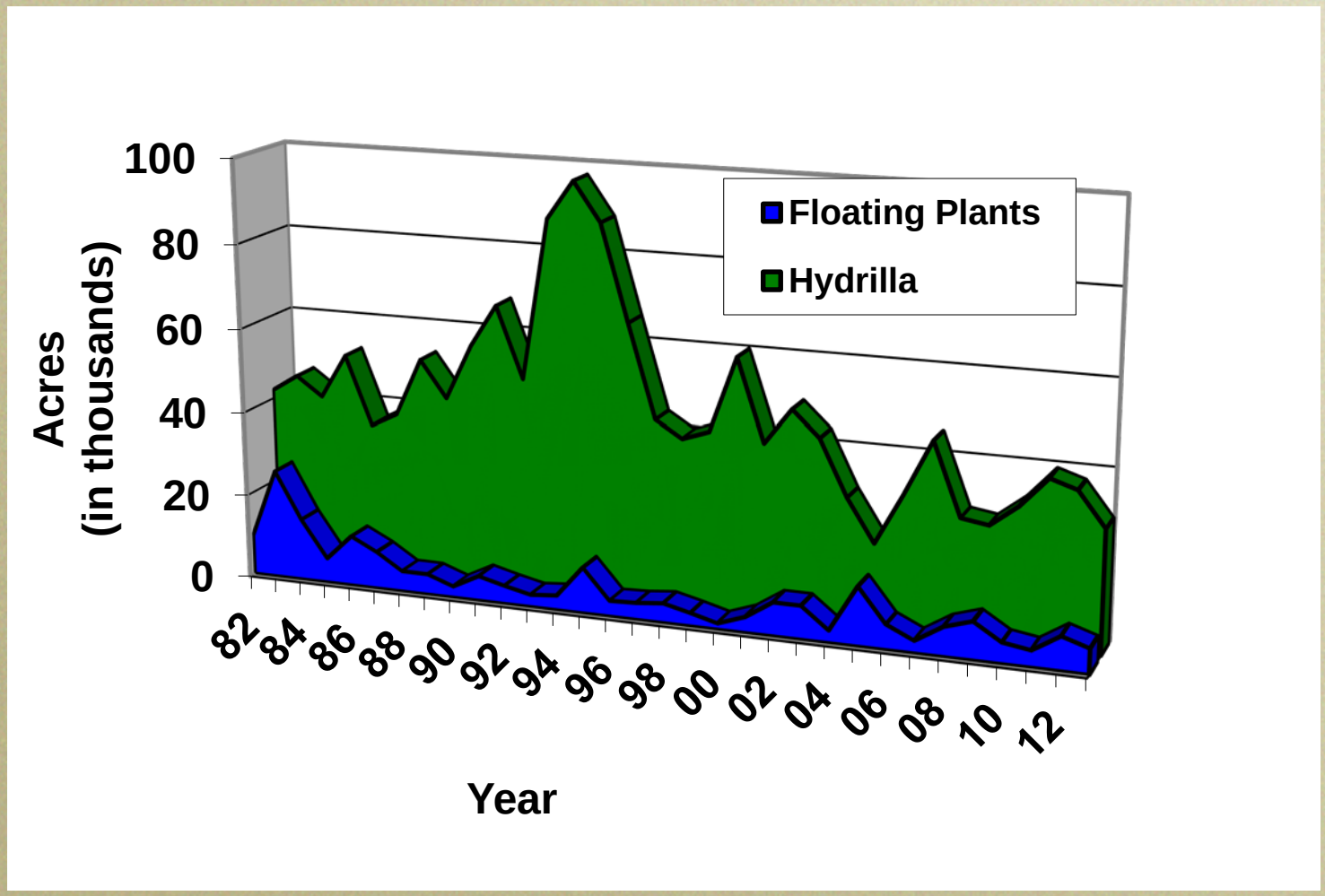
Floating Plants / Hydrilla Acres 1982 - 2013



Acres Controlled & Dollars Spent 1980 - 2013

Plant type	Acres	Dollars
Floating	940,578	$92.65 M
Hydrilla	495,423	$253.71 M
Total	1,436,001	$346.36 M

Aquatic Herbicides

Hydrilla populations resistant to the aquatic herbicide fluridone in 2000 resulted in management failures

Fluridone was the tool we relied on to manage large hydrilla infestations in big Central Florida lakes since the mid 1980s.

In 2009, out of 205 samples of hydrilla collected across Florida, there were at least 127 unique genotypes

Aquatic Use Herbicides Registered Before 2001

Herbicide	Application Site	Year Registered	Mode of Action
Copper	Submersed	1950s	Undefined
2,4-D	Sub., Emergent, Floating	1959	Auxin mimic
Endothall	Submersed	1960	Serine/threonine phosphatase inhibitor
Diquat	Sub., Emergent, Floating	1962	Photosystem I inhibitor
Glyphosate	Emergent	1977	Enzyme inhibitor - EPSP
Fluridone	Submersed	1986	Enzyme inhibitor - PDS

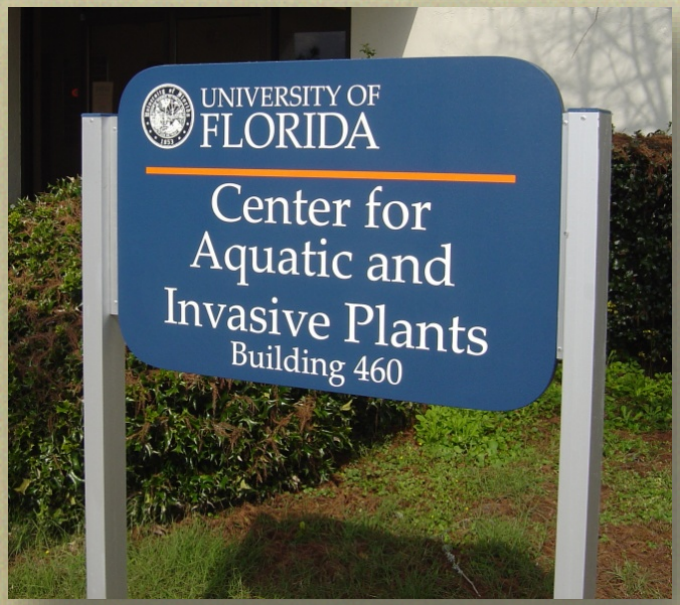
In 2001, there were only six herbicide compounds registered for use in natural area aquatic systems.

Plan A. Registering Brand New Herbicides

Seeking U.S. EPA Registration for use in <u>Water</u>

Chemical compounds must pass a lengthy and rigorous process to be registered by U.S. EPA for use in natural area aquatic sites.

- **More than 140 health and environmental tests**
- **Average 8-10 years for full EPA registration**
- **$40-60 million to register for aquatic site use**



Plan B. Contracted research into finding registered herbicides for use in natural aquatic areas:

- ***>250 existing registered herbicides screened and/or in combinations to find environmentally compatible and effective herbicides (100 too toxic, 130 not effective, <u>15-20</u> candidates, mostly the rice herbicides)***

- **2004-2014: Cost $729,767**

Aquatic Use Herbicides Registered Since 2002

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Glyphosate	Emergent	1977	Enzyme inhibitor
Fluridone	Submersed	1986	Enzyme inhibitor
Triclopyr	Submersed, Emergent	2002	Auxin mimic
Imazapyr	Emergent	2003	Enzyme inhibitor - ALS
Carfentrazone	Sub., Emergent, Floating	2004	Enzyme inhibitor - PPO
Penoxsulam	Submersed, Floating	2007	Enzyme inhibitor - ALS
Imazamox	Sub., Emergent, Floating	2008	Enzyme inhibitor - ALS
Flumioxazin	Sub., Emergent, Floating	2011	Enzyme inhibitor - PPO
Bispyribac	Submersed, Floating	2012	Enzyme inhibitor - ALS
Topramezone	Submersed	2013	Enzyme inhibitor - HPPD

Herbicides Available - 2014

Herbicide	#
bispyribac	1
carfentrazone	1
copper	3
diquat	1
endothall	4
flumioxazin	1
fluridone	6

Herbicide	#
glyphosate	1
imazamox	1
imazapyr	1
penoxsulam	2
topramezone	1
triclopyr	2
2,4-D	2

14 herbicides, 27 formulations available

Aquatic Herbicide Truisms

1. **Important to be cost-effective on the target plant!**

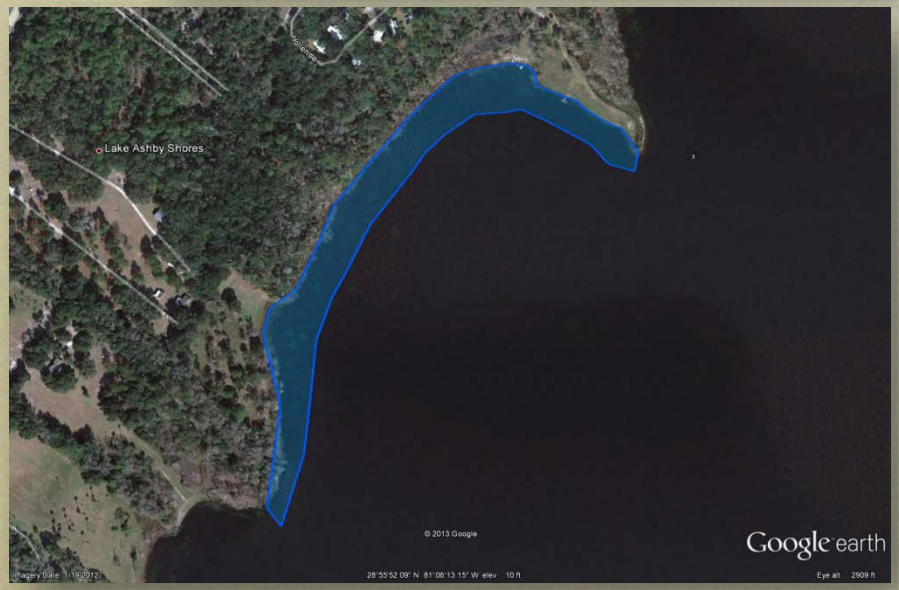
2. **Even more important to be selective!**

3. **Not all aquatic herbicides are created equal (see 1 and 2).**

Field testing for using newly labeled aquatic herbicides

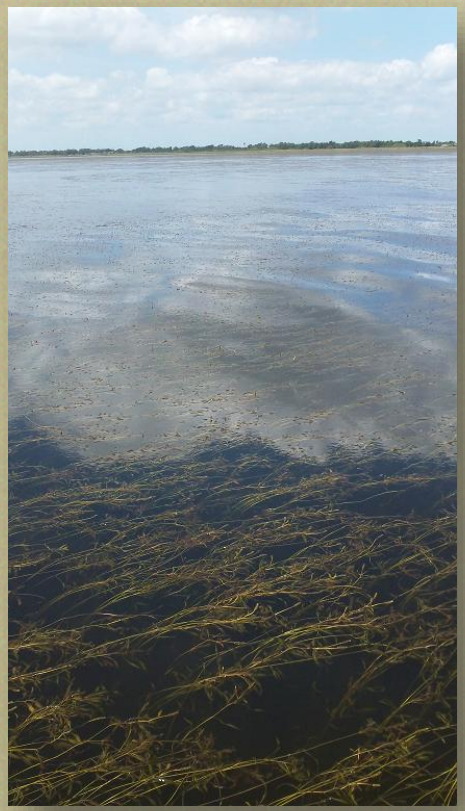
1. Start out in small ponds
2. Small lakes (250-500 acres)
3. Small areas of large systems, shoreline strips
4. Fully operational, large scale treatments

(3-5 year process)



From Schardt, J. 2014. Aquatic Plant Management Society Annual Meeting

Key Findings for Hydrilla Management:



- **Endothall – almost complete control, highly selective (*resistant hydrilla in 2 lakes, 2014*)**
- **Penoxsulam + Endothall - good control**
- **Bispyribac – secondary treatments are needed, grass carp**
- **Diquat + Endothall – good control**
- **Flumioxazin + Diquat – use in high water clarity and low pH, good for spot treatments**

From: Netherland, M. 2014. Technical Support for Evaluating Large-scale and Experimental Hydrilla Management Projects. USAERDC, Center for Aquatic and Invasive Plants, University of Florida, Gainesville, FL.

Water hyacinth Control – the problem:

- 2,4-D and diquat use – strong visual injury symptoms or control of non-target natives

- Treating mixed communities of invasive and non-target species results in short-term injury or death to bulrush, spikerush, sagittaria, pickerelweed, etc.

Penoxsulam Combos vs Water Hyacinth 8 WAT

Control

Penoxsulam

Penoxsulam + Flumioxazin

Penoxsulam + Carfentrazone

From: Mudge, C. 2013. Developing Novel Selective Use Patterns for Newly Registered Herbicides on Water Hyacinth and Water Lettuce. USAERDC Vicksburg, MS.

All seven herbicides registered for aquatic use since 2003 are single site enzyme inhibitors, classes of compounds in which resistance has been documented in terrestrial applications.

Herbicide Resistance Management Strategies Employed in FLA Aquatic Sites

- Eliminate pioneer invasive plant populations
- Manage at low levels to avoid large scale herbicide applications
- Apply only when success is most likely
- Rotate active ingredients where feasible
- Combine active ingredients if cost-effective
- Follow-up applications with different methods
- Integrate chemical, physical and biocontrols
- Control plants before they produce seeds, tubers

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Limitations to Herbicide Resistance Management Strategies in Aquatic Sites

- Cannot use maximum rates because of cost and/or selectivity reasons
- Reduced non-target selectivity by certain herbicides
- Water flow and exchange impacting optimum rates
- Regulatory constraints - drinking water, irrigation
- Stakeholder objection (examples- copper, 2,4-D)
- Long-term field testing required to justify use in sensitive areas (multi-use areas)

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Biological Control

Insect biocontrols released for hydrilla:

- **Search began 1981**
- ***85 spp. evaluated***
- ***4 spp. Released (2 weevils, 2 flies)***

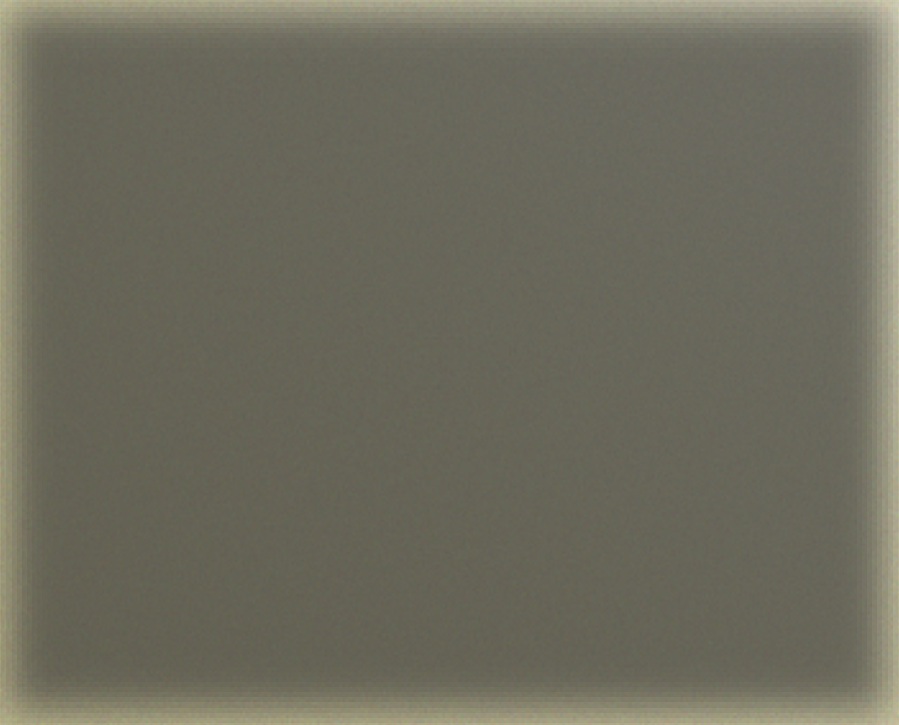
Bagous affinis

Biocontrol research on hydrilla

Biocontrol researchers in China looking for hydrilla bugs.

- **Biological control research 1972-2010**
- **$1.65 million spent**
- **Exploration in Africa, China, Southeast Asia**
- **Looked at grass carp, insects, and fungal agents**
- **Hydrilla evolved in a wet-dry season area complicated the search for host-specific organisms (likely only few exist)**
- **FWC Research funding ended in 2010.**

Newly released Megamelus scutellaris targeting water hyacinth (released in 2010)



- From South America,
- Specific to waterhyacinth,
- Short development time,
- External feeder

Control – no weevils, no *Megamelus*

Megamelus + Weevils

Outreach

How do we communicate information?

- **2000 - Fluridone resistance confirmed**
- **2001 - Industry summit - UF / Orlando**
- **2004 - Management workshop - UF / Gainesville**
- **2005 - Research summit - DEP / Orlando**
- **2007 - Industry update - DEP - Crawfordville**
- **2009 - Operation review - FWC - Crystal River**
- **2011 - Operation review - FWC - Orlando**
- **2014 - Operation review - FWC - Orlando**

Tech Exchange

- **UF-IFAS Short Course / FAPMS**
- **FWC Workshops**
- **FWC / UF Research Reviews**
- **Industry Tech Exchange Workshops**
  - **SePRO - 2012 - 2013**
  - **UPI - 2012**
  - **Valent - 2012**

FWC Outreach - Plant Management in Florida Waters Website (UF CAIP)

- Encyclopedic guide to plant management in Florida water-ways
- Info about developing management plans
- Covers more than 400 topics
- Written for scientists, public

http://plants.ifas.ufl.edu/manage/

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