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Testing a New IPM Approach for Hydrilla Management in Florida

Presented at FLMS Central Chapter Meeting, Kissimmee, February 12th, 2013

Joan Bradshaw, James Cuda, Jennifer Gillett-Kaufman, Kenneth Gioeli, Raymond Hix, **Verena-Ulrike Lietze**, William Overholt, Judith Shearer

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HYDRILLA IPM PROJECT

Today's Outline

- Introducing Hydrilla
  (distribution, problems, negative impacts)
- Introducing Hydrilla IPM RAMP
  (who, where, why – who cares?)
- Results from a stakeholder needs assessment survey
- Options for hydrilla management
- Introducing the new IPM model
- Current status of research
- Summary and resources

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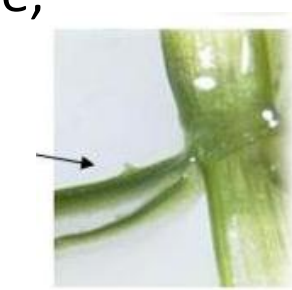
Introducing Hydrilla

- Submersed, rooted aquatic plant, propagates by tubers, turions, fragments
- Monoecious or dioecious forms
- Stems – long and slender with some branching
- Leaves – small (max. 4/5 inch long, 1/6 inch wide), lanceolate, in whorls of 3-8

- Midrib – distinct and can bear small spines



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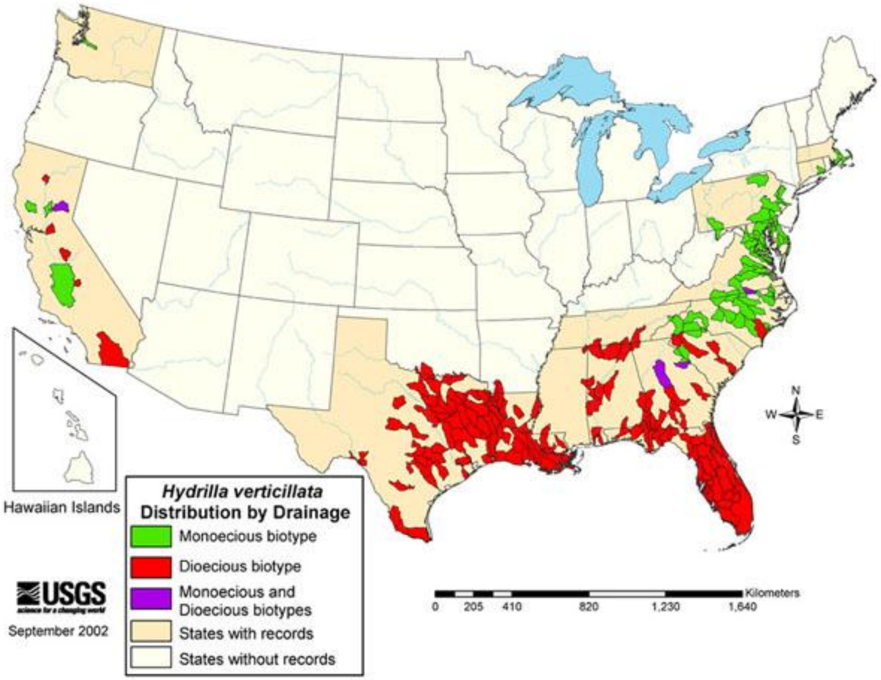
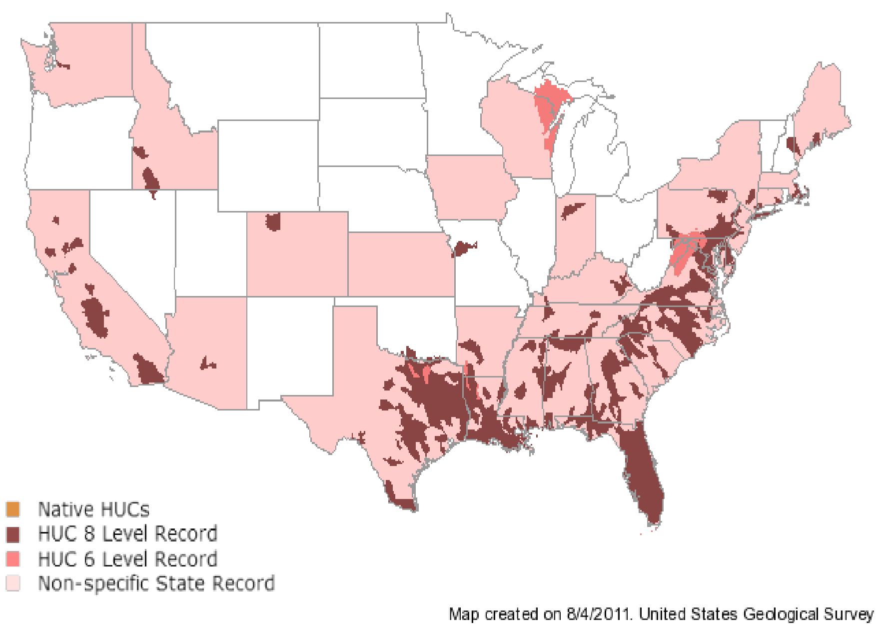


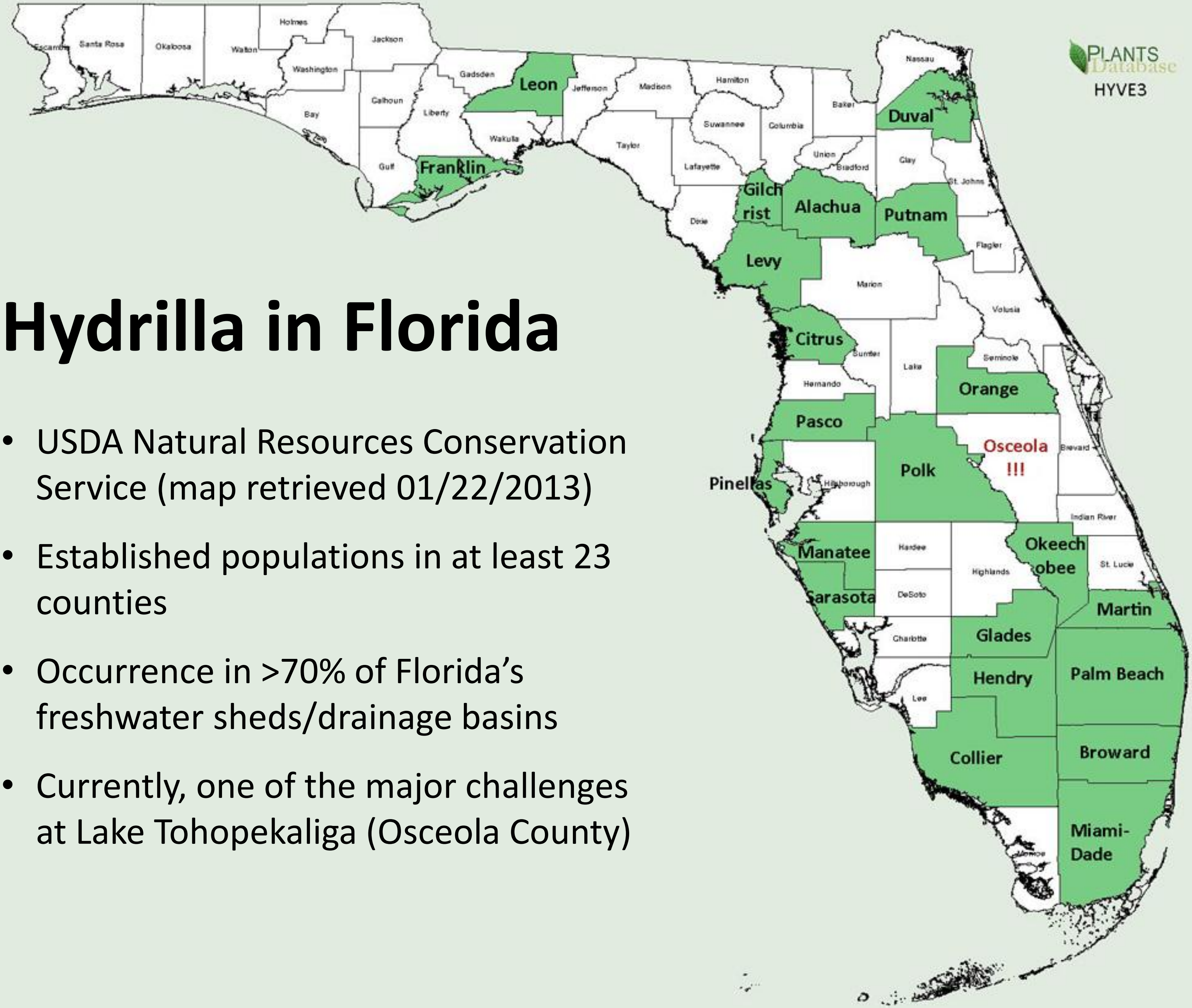


Hydrilla Distribution (U.S.A.)

- Introduced in the 1950s
- Occurs in Florida, along southern and eastern coasts, and in California
- Continues to spread (top map = records 2002, bottom map = records 2011)

Hydrilla in Florida

- USDA Natural Resources Conservation Service (map retrieved 01/22/2013)
- Established populations in at least 23 counties
- Occurrence in >70% of Florida's freshwater sheds/drainage basins
- Currently, one of the major challenges at Lake Tohopekaliga (Osceola County)



Why is hydrilla such a problem?

- Non-native plant, introduced without its natural enemies, outcompetes native vegetation → invasive
- Forms dense vegetation mats
- Resistance development to certain herbicides

Withlacoochee River, FL, 1997

Lake Tohopekaliga, FL, 2008

Negative Impacts

Native vegetation

Drainage canals

Boating

Resistance

Costs

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Hydrilla IPM RAMP

- Hydrilla Integrated Pest Management (IPM) Risk Avoidance and Mitigation Project (RAMP)
- USDA-funded
- Collaboration between research and extension experts
- Innovative methods for managing hydrilla in Florida freshwater bodies
- Expertise provided by an Extension Advisory Committee

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Hydrilla IPM RAMP Collaborators

Citrus County, Florida

Osceola County Florida

St. Lucie County Florida

Florida Agricultural Mechanical University

Indian River Research And Education Center

US Army Corps of Engineers®

extension
more mind reach

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Who Cares? Stakeholders Do!

State and County agencies

Federal government

Anglers

Residents

Duck hunters

Boaters

Lakefront Homeowners

Airboaters

Photo by Vic Ramey: Wakulla Springs, Florida

Local businesses

Elected Officials

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Needs Assessment Survey

- Extension Advisory Committee
- Survey Title: Florida Water Bodies with Hydrilla Needs Assessment Survey
- UF IRB 02 # 2011-U-0450
- Hosted on SurveyMonkey
- Distributed by Florida County Extension Offices
- Open for 6 weeks
- 541 participants

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Selected Survey Results

Are you familiar with hydrilla?

- 93% (504/541) yes
- 6% (33/541) no

Do you think hydrilla is a problem in the water body you visit most?

- 34% (185/541) yes
- 42% (229/541) no
- 8% (41/541) not sure

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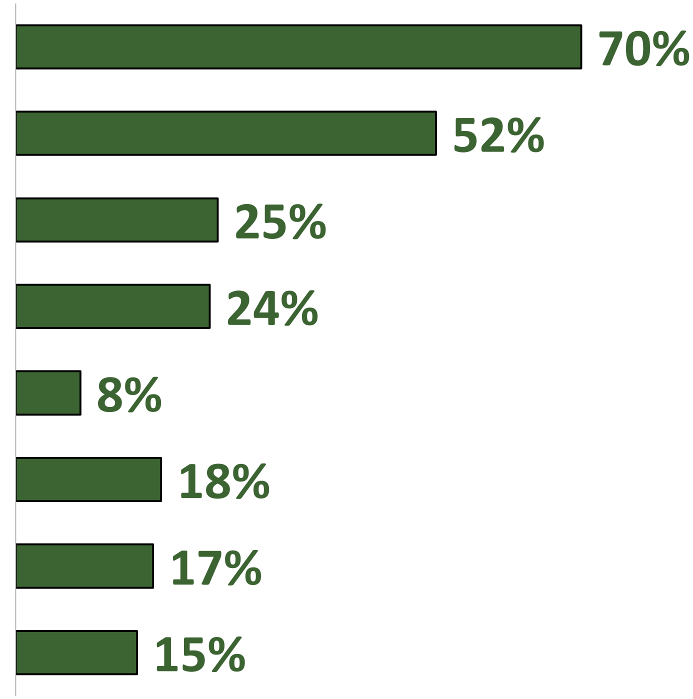
Survey Results (cont.)

Why do you visit Florida water bodies?



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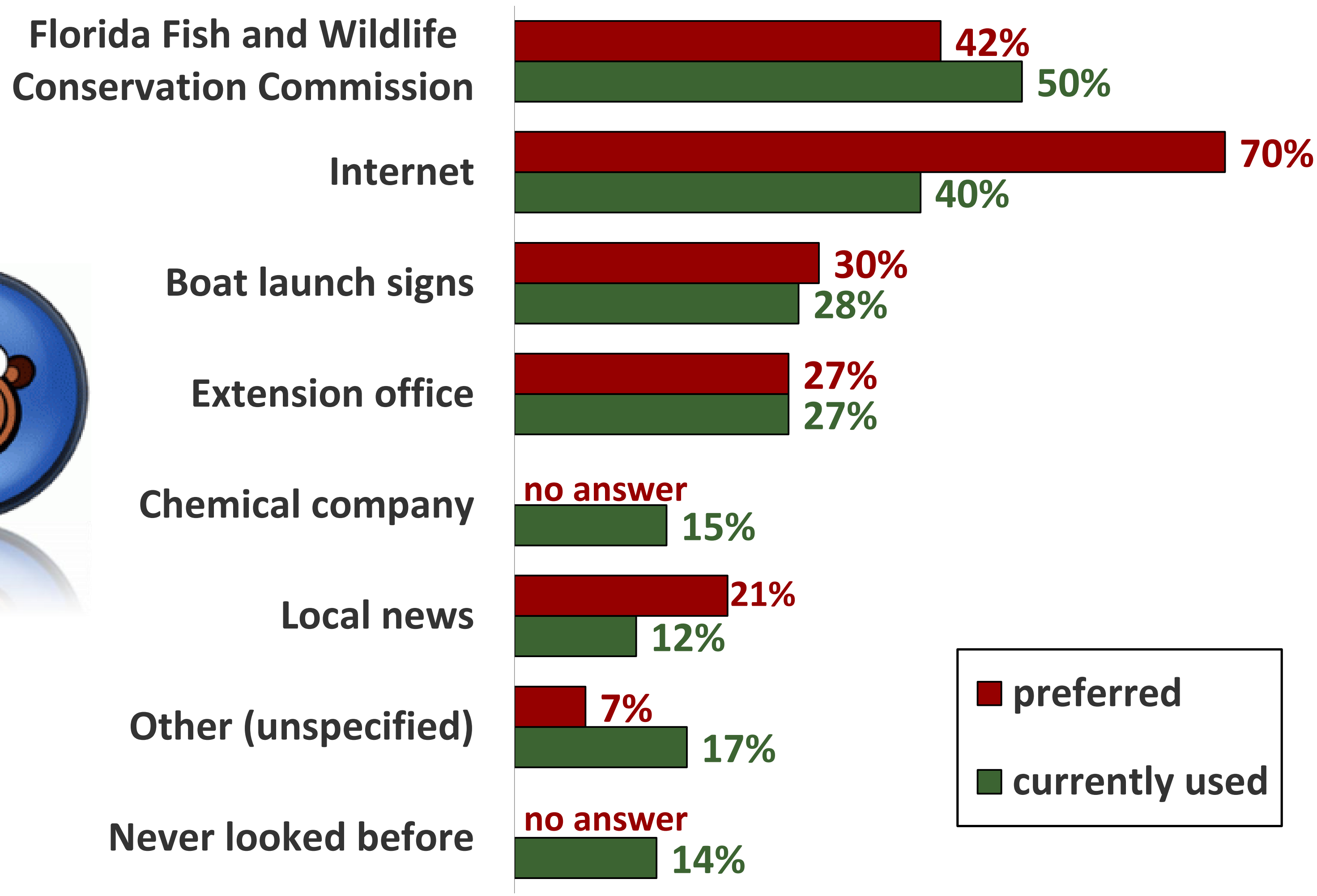
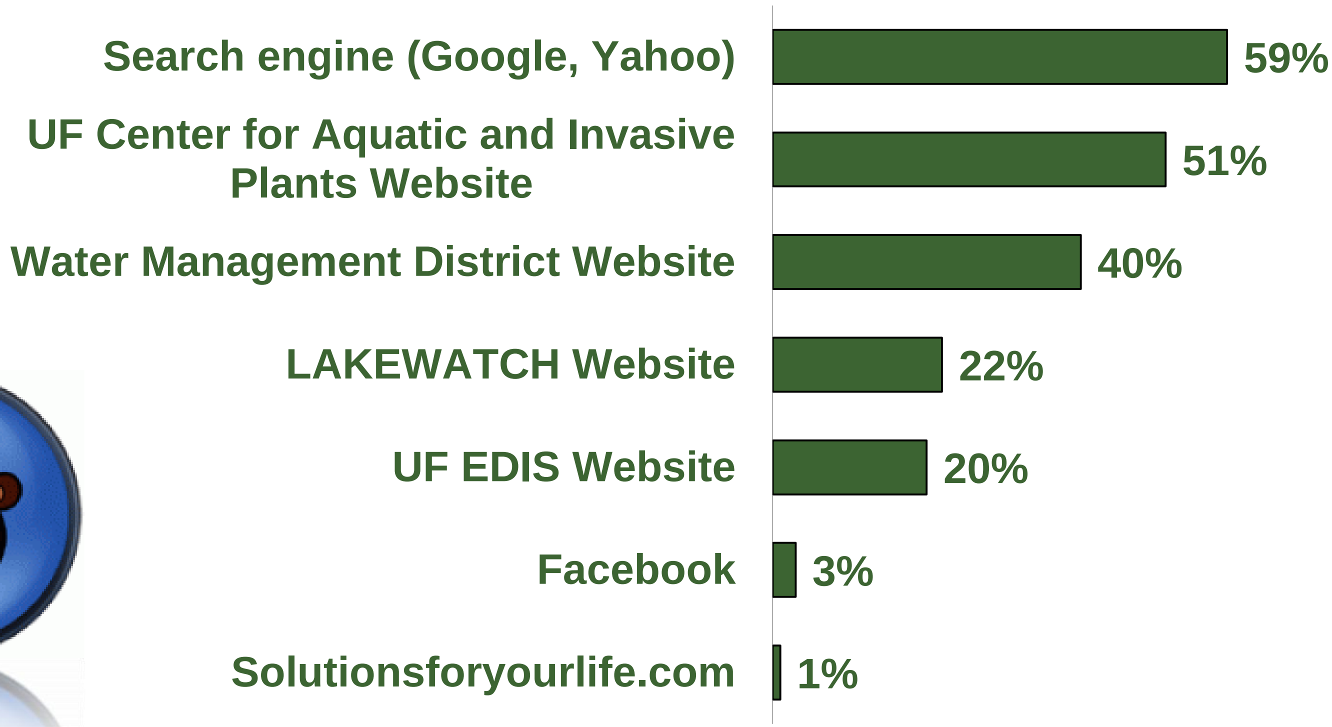
Survey Results (cont.)

Comparison of currently used and preferred information channels:



Survey Results (cont.)

Internet sources for hydrilla information



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Our Response: http://entomology.ifas.ufl.edu/hydrilla

Educational Materials & More

- Campaigns with local newspapers and television stations
- Signs for boat ramps are being developed

Problem

- Widely spread and repeated use of fluridone
- Resistance / tolerance
- Hydrilla can grow >1 inch per day
- Few months to grow from 30% to 70% coverage

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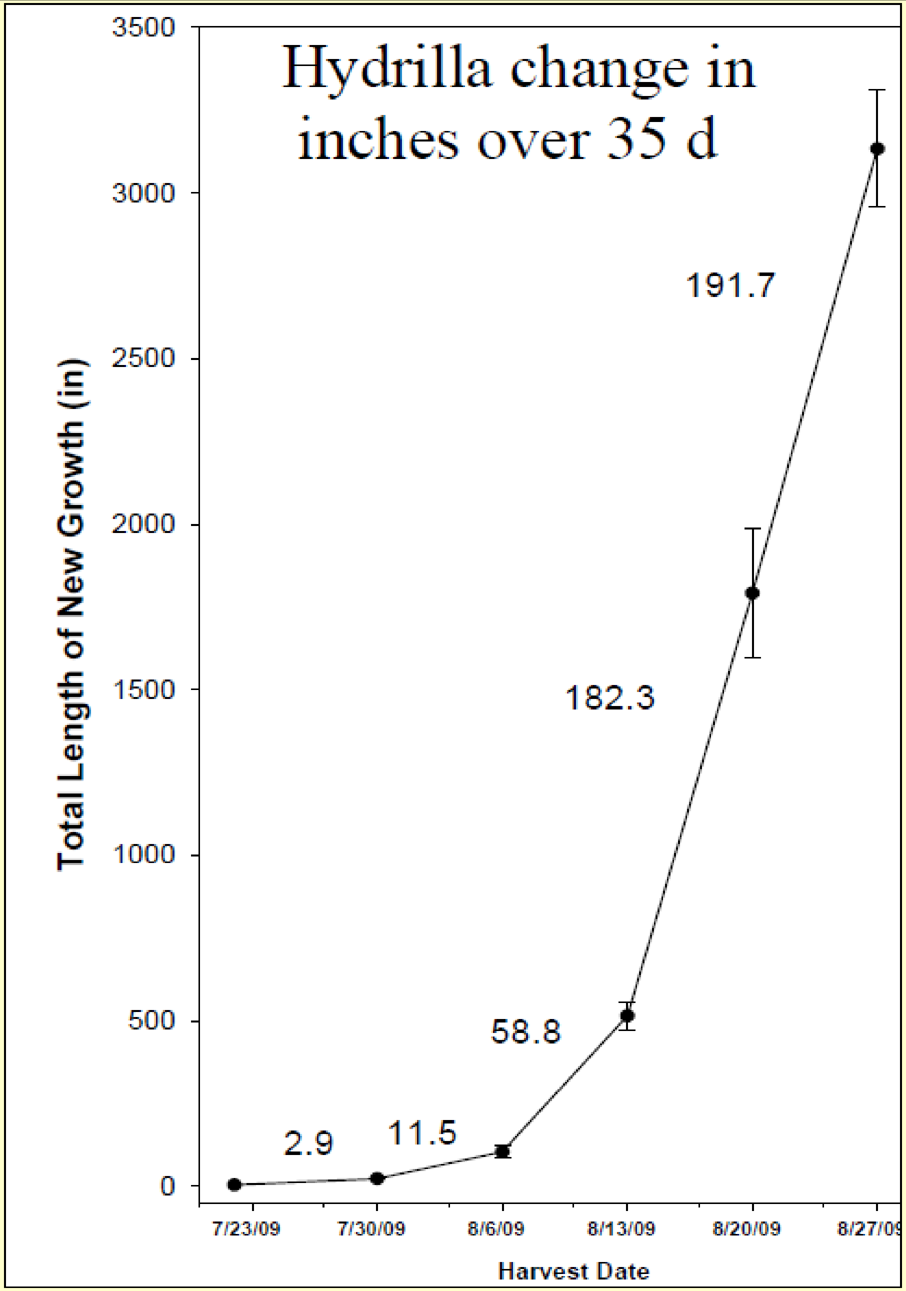
Slide available at: http://www.conference.ifas.ufl.edu/aw10/presentations/Thurs/Session%20A/1000%20Netherland.pdf

Courtesy of M. Netherland, US ACE ERDC



	Week 1	Week 2	Week 3	Week 4	Week 5
Laterals	2 ± 2	13 ± 6	43 ± 11	109 ± 29	137 ± 38
New Stems	2 ± 0	6 ± 1	34 ± 13	71 ± 16	130 ± 63
Runners	0 ± 0	1 ± 1	3 ± 2	9 ± 6	35 ± 20

- A single 9 inch shoot resulted in over 3200 inches of growth in 5 weeks

-Established 1 foot tall plants took 8 days to reach the surface in 10 ft water depth

- Elongation = 1+ foot /day

Problem

- Widely spread and repeated use of fluridone
- Resistance / tolerance
- Hydrilla can grow WAY MORE THAN 1 inch per day
- Few months to grow from 30% to 98% coverage
- Infestations in Florida far beyond possible eradication
- Innovative maintenance control methods (IPM plan)

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What are the options?

- “Cultural” control (drawdowns, limited use)
- Mechanical removal (harvesting)
- Chemical control (herbicides)
- Biological control (herbivores, pathogens)
- Integrated pest management

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Chemical Control

As of 2011, 14 chemical compounds are approved for aquatic use in Florida (grey = for emergent plants only):

Contact herbicides:

- Copper (1900s)
- Endothall (1960)
- Diquat (1958, 1962)
- Hydrogen peroxide

Auxin-mimics:

- 2,4-D (1950s)
- Triclopyr (2002)

Specific plant enzyme inhibitors

- Glyphosate (1977)
- Fluridone (1986) - PDS
- Imazapyr (2003) - ALS
- Carfentrazone (2004)
- Penoxsulam (2007) - ALS
- Imazamox (2008) - ALS
- Flumioxazin (2010)
- Bispyribac (2011) - ALS

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Chemical Control - Advantages

- Applicable for both small and large areas
- Relatively fast action
- Useful for initial removal of large amounts of biomass
- Selectivity possible through proper choice and rate
- Newer products have good toxicology profiles
- Compatible with other control methods

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Chemical Control - Disadvantages

- Cost
- Weeds will recover over time
- Long-term management required
- May select for worse problem, may induce resistance
- Negative public perception of chemical use

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Biological Control

- Classical Biological Control
  - Searching for host-specific natural enemies in the native range of the weed species
  - Long process of testing in quarantine and approval
  - Releasing the natural enemies in the invasive range of the weed
- Augmentative Biological Control
  - Mass rearing and releasing endemic natural enemies to supplement natural populations
  - Natural enemies can be native or naturalized

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Classical Biological Control of Hydrilla

- Researched since the 1970s
- Foreign exploration in Asia, Africa, and Australia
- Four insect species approved for release – only one established populations with significant impact
- Sterilized grass carp – successful in closed systems

Hydrellia pakistanae

Hydrellia balciunasi

Bagous hydrillae

Bagous affinis

Asian grass carp

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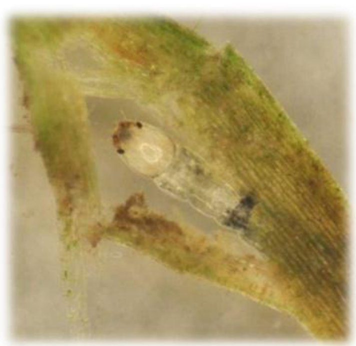
Augmentative Biological Control of Hydrilla

- One insect species (native range unknown)
  - 1957: First record in the U.S. (Louisiana)
  - 1976: First record in Florida (SW, specific location unknown)
  - 1992: Detected in Crystal River, Florida
- A fungal pathogen discovered in the 1970s and isolated from several hydrilla populations in the U.S.



Cricotopus lebetis

Mycoleptodiscus terrestris

Why IPM?

Potential benefits

- Increased efficacy
- Decreased use rates
- Reduced contact time requirements
- Improved selectivity
- Reduced reliance on herbicides alone
- Resistance management

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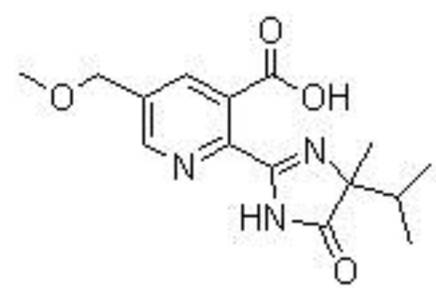
Players in the New Hydrilla IPM Model

Target weed:
Hydrilla verticillata
(hydrilla)

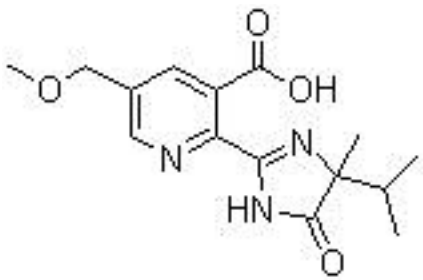
Herbivorous insect:
Cricotopus lebetis
(hydrilla tip miner)

Plant-pathogenic fungus:
Mycoleptodiscus terrestris (Mt)

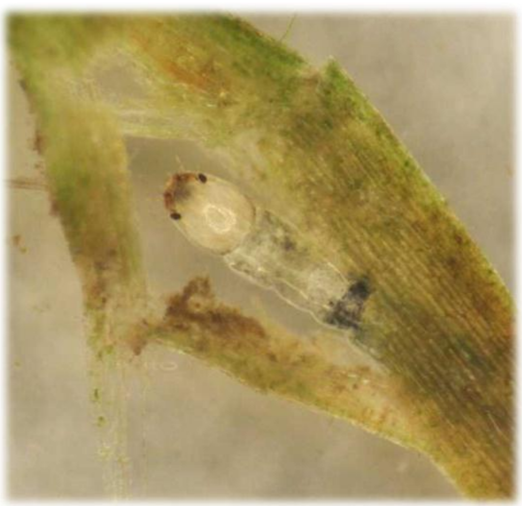
New chemical herbicide:
imazamox
(inhibits acetolactate synthase, ALS)



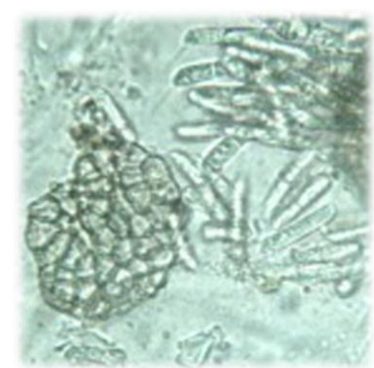
Expected Interactions

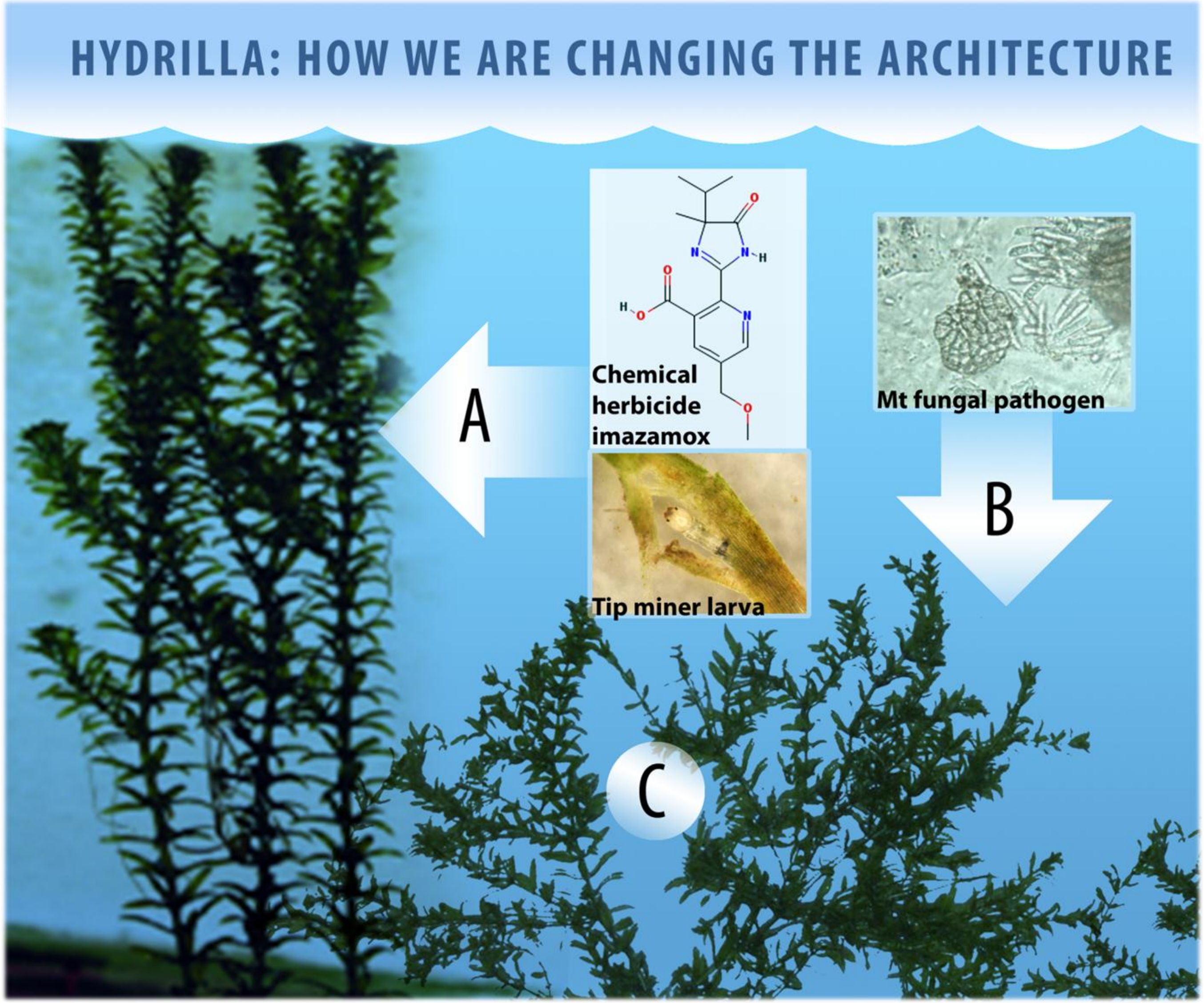


- Imazamox $\rightarrow$ branching
- New shoot tips $\rightarrow$ breeding sites for hydrilla tip miner



- Larvae develop within plant tissue (mining)
- Damage kills growing tips & increases susceptibility to infection by Mt





- Combining these three tactics will reduce hydrilla growth (no "topping out")
- Consequence: plants are not chopped up by boat propellers (no spread)
- Reduced risk of resistance development towards any of the individual tactics

Hydrilla IPM RAMP Expected Impacts

- Demonstration that different low-risk control tactics are compatible
- Safe and cost-effective control of both susceptible and fluridone-resistant hydrilla
- Create more favorable habitats and recreational areas on Florida's lakes and rivers
- Hydrilla IPM Guide for Florida and other states with hydrilla problems

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Current Status of Research

- Tip miner temperature requirements and host range
- Compatibility tests (integration)

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Temperature Requirements (Methods)

Experiments conducted by Karen Stratman, UF graduate (supervisor: William Overholt), UF Indian River REC

- 40 hydrilla tips placed in individual culture tubes
- 2 larvae per tube exposed to temperatures between 10-36°C
- Environmental growth chambers, 14:10 (L:D) photoperiod
- Development time and survival recorded
- Additional experiments examined cold tolerance (survival at 5 and 7.5°C)

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Courtesy of K. Stratman and W. Overholt

Temperature Requirements (Summary)

– Ideal range: 20-30°C
  - Temperatures in hydrilla mats may be too warm

– Cannot tolerate prolonged exposure to cold
  - Water bodies experiencing cold temperature (≤5°C) unsuitable for establishment

– Distribution models (isothermal lines and niche mapping) show that establishment throughout Florida is possible

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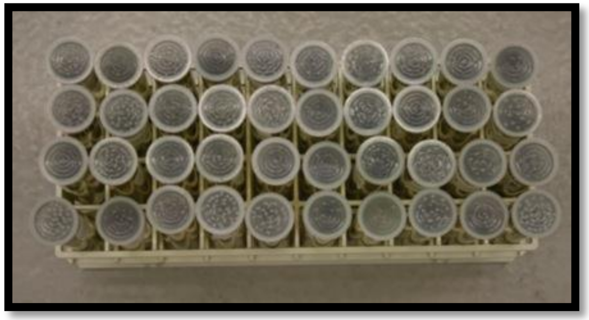
Stratman et al. 2013, Biocontrol Sci. Technol. 23: 317-334

Tip Miner Host Range (Methods)

No-choice larval development



3 test plants, 1 hydrilla control

Environmental growth chamber: 25°C, 14:10 (L:D) photoperiod

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Stratman et al. 2013, Biocontrol Sci. Technol. 23: 317-334

Tip Miner Host Range (Methods)

List of plants tested in no-choice larval development tests:

Family	Species	Origin	Common Name
Hydrocharitaceae	*Elodea canadensis*	Native	Canadian Waterweed
	Egeria densa	Exotic	Common Waterweed
	Vallisneria americana	Native	American Eelgrass
	Hydrilla verticillata (monoecious)	Exotic	Hydrilla
Najadaceae	*Najas guadalupensis*	Native	Southern Naiad
Potamogetonaceae	*Potamogeton illinoensis*	Native	Illinois Pondweed
Ceratophyllaceae	*Ceratophyllum demersum*	Native	Coontail
Alismataceae	*Sagittaria kurziana*	Native	Strap-leaf Sagittaria
Cyperaceae	*Eleocharis baldwinii*	Native	Road-grass
Lentibulariaceae	*Utricularia macrorhiza*	Native	Bladderwort
Characeae	*Chara vulgaris*	Native	Muskgrass

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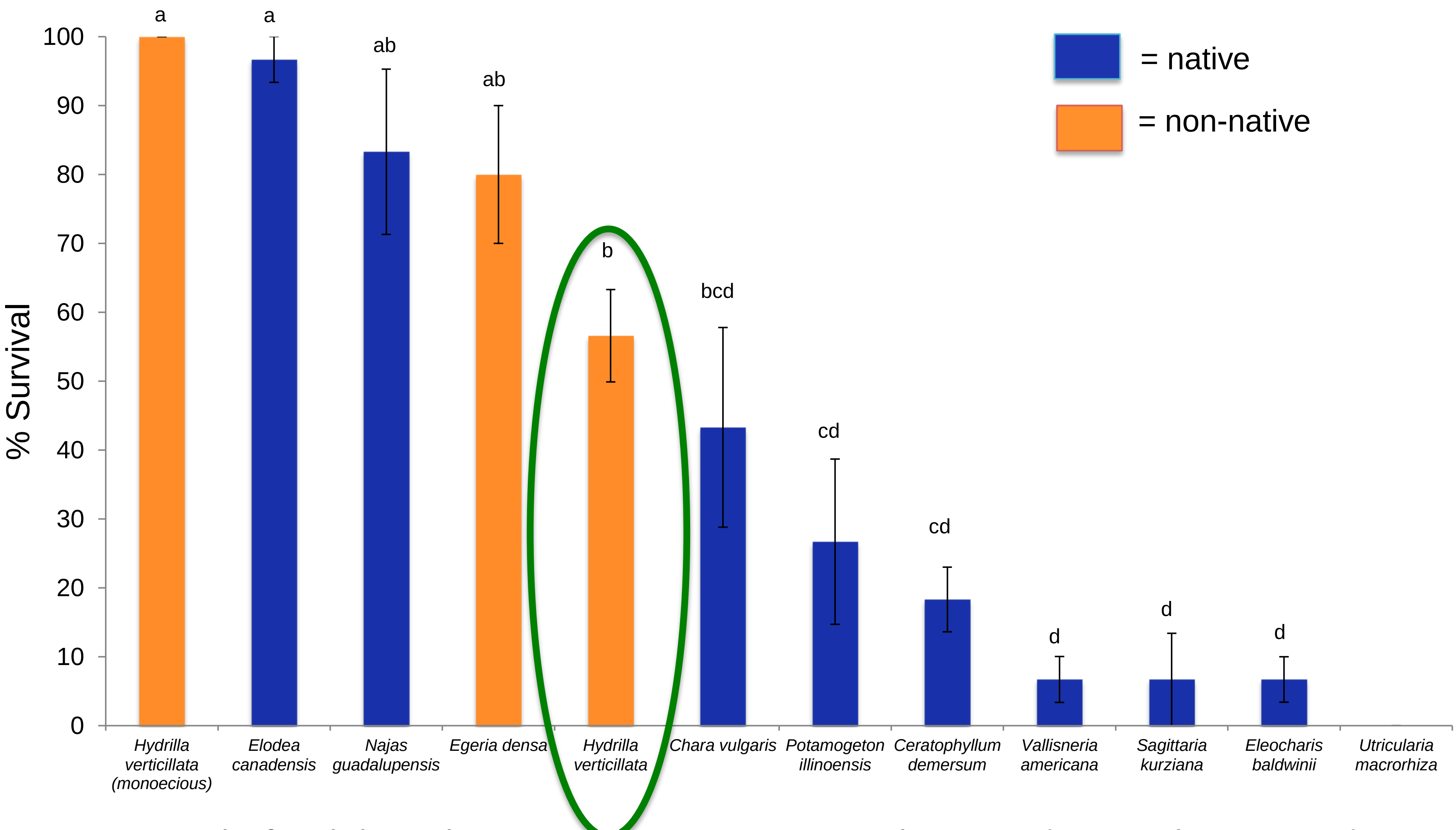
Stratman et al. 2013, Biocontrol Sci. Technol. 23: 317-334

Tip Miner Host Range (Results)



Survival of *C. lebetis* larvae on various aquatic plants under no-choice conditions

Data analysis: ANOVA, Student-Newman Keuls (SAS Institute, 2008)

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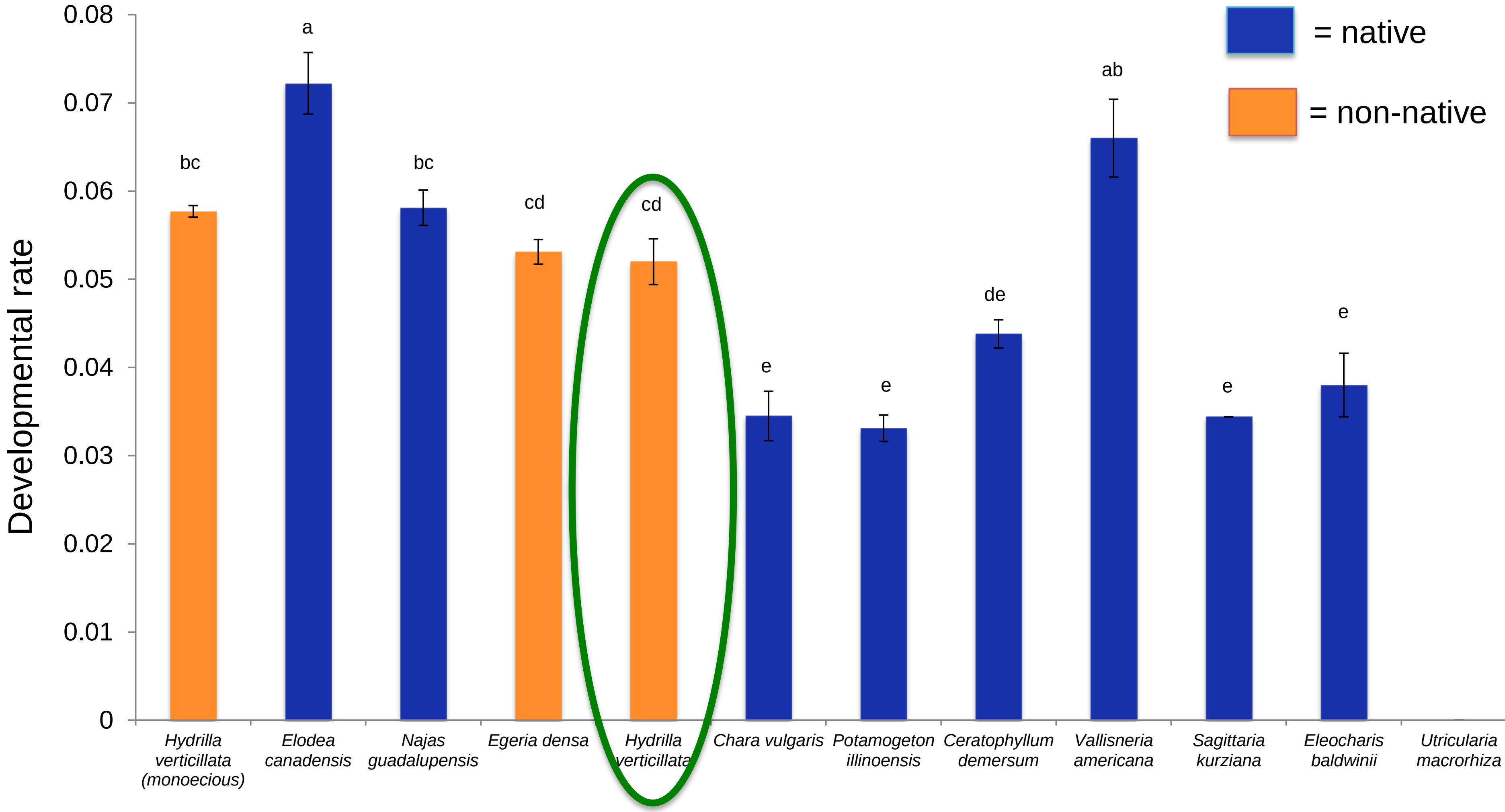
Stratman et al. 2013, Biocontrol Sci. Technol. 23: 317-334

Tip Miner Host Range (Results)



Developmental rate of *C. lebetis* larvae on aquatic plants under no-choice conditions

Data analysis: ANOVA, Student-Newman Keuls (SAS Institute, 2008)

Stratman et al. 2013, Biocontrol Sci. Technol. 23: 317-334

Tip Miner Host Range (Methods)

Dual-choice test (larvae)

- Pairs tested
  - Hydrilla vs. *Najas guadalupensis*
  - Hydrilla vs. *Egeria densa*
  - Hydrilla vs. *Elodea canadensis*
- Each plant species placed on one side of container and separated using screen – 40 tips per species
- 100 neonates placed in center of arena, given equal access to plant tips
- Plant tips dissected before adult emergence
  - Damage and presence of larvae recorded
    - Score damage on 0-5 scale

      0 = no damage

      1 = minimal damage not visible to naked eye

      2 = light damage 10-20%

      3 = moderate damage 20-50%

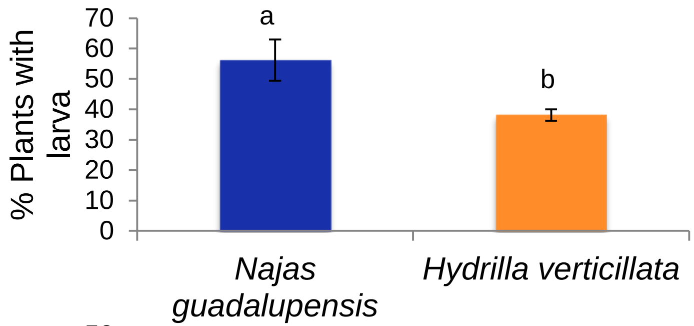
      4 = significant damage >50%

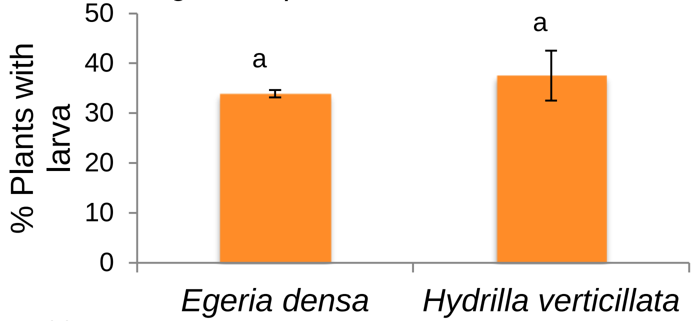
      5 = tip abscission

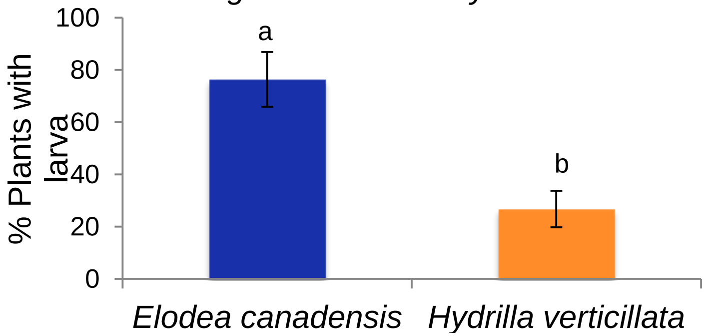
Stratman et al. 2013, Biocontrol Sci. Technol. 23: 317-334

Tip Miner Host Range (Results)

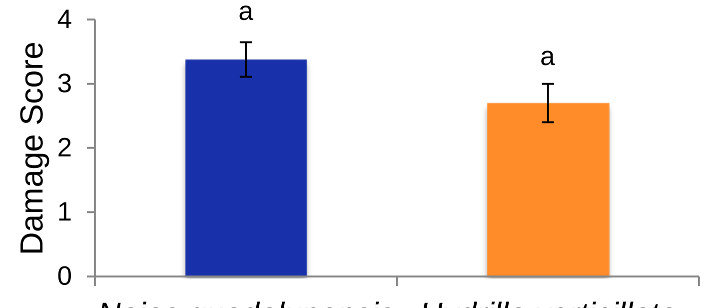
Dual-choice test (larvae)

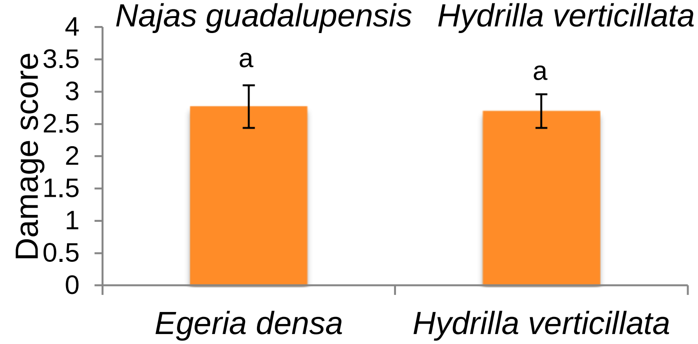


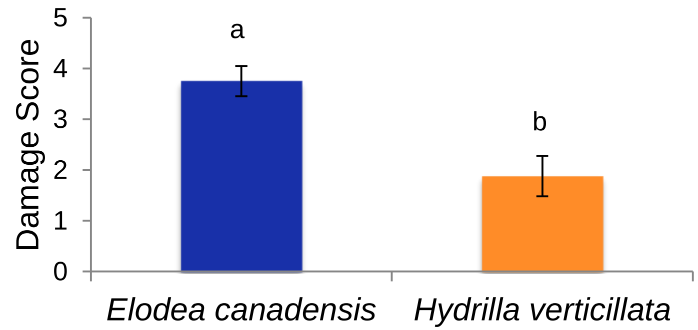




Percent of plant tips infested with *C. lebetis* larvae under dual-choice conditions







Damage scores to plants by *C. lebetis* larvae under dual-choice conditions

Data analysis: ANOVA, Student-Newman Keuls (SAS Institute, 2008)

Stratman et al. 2013, Biocontrol Sci. Technol. 23: 317-334

Tip Miner Host Range (Methods)

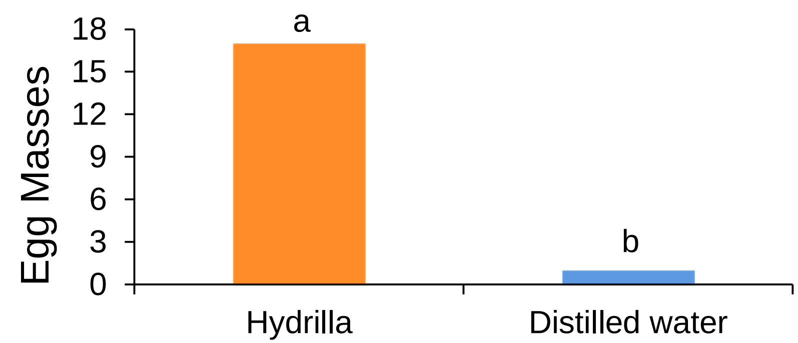
Dual-choice test (adults)

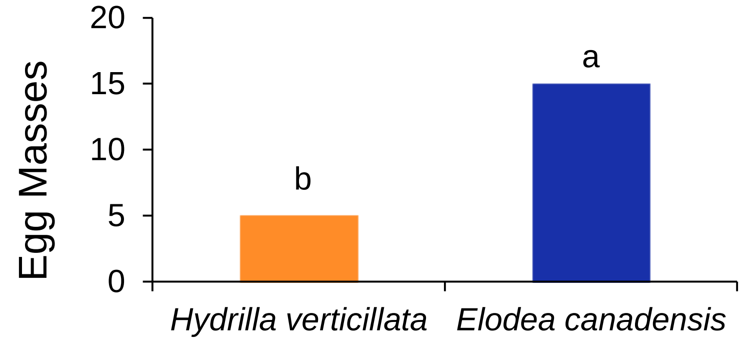
- Pairs tested
  - Hydrilla vs. distilled H_2O
  - Artificial hydrilla vs. distilled H_2O
  - Hydrilla vs. artificial hydrilla
  - Hydrilla vs. *Elodea canadensis*
  - Hydrilla vs. *Najas guadalupensis*
- Plastic divider in bottom of cage
- 4 couples released for 48 hours
- Number and location of egg masses recorded

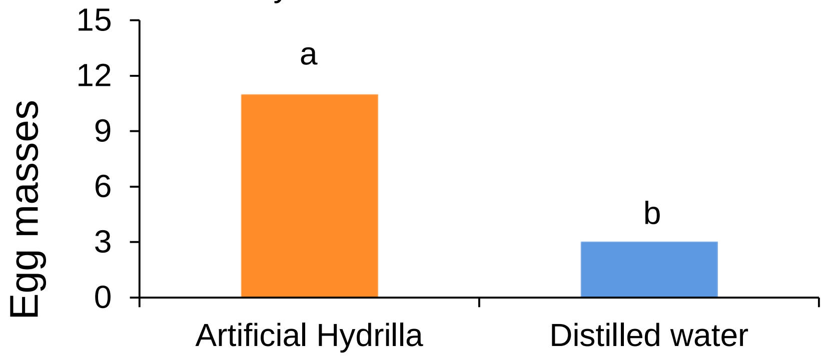
Stratman et al. 2013, Biocontrol Sci. Technol. 23: 317-334

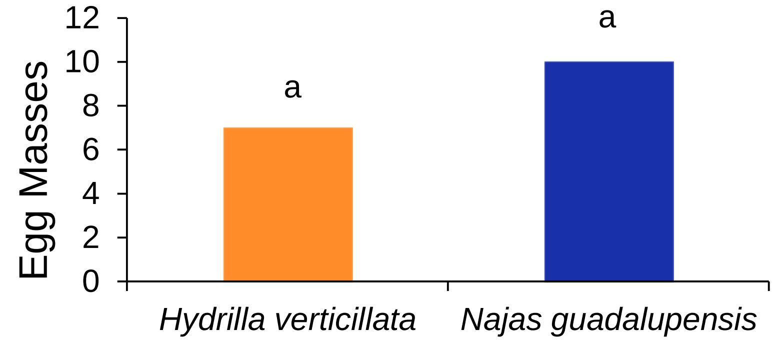
Tip Miner Host Range (Results)

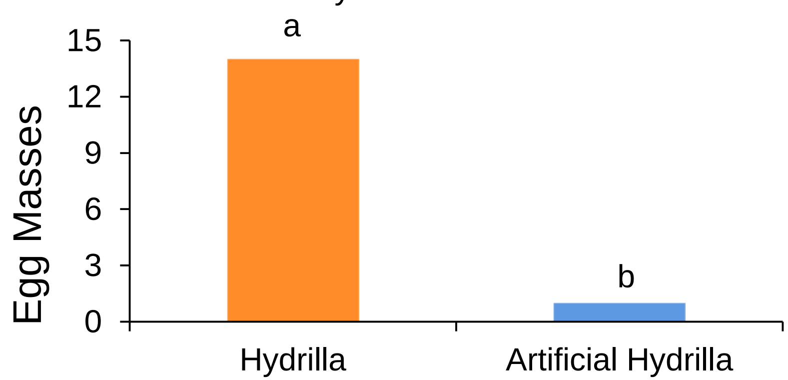
Dual-choice test (adults)











Total number of egg masses laid in each dual-choice adult oviposition trial

Data analysis: G test of independence

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Stratman et al. 2013, Biocontrol Sci. Technol. 23: 317-334

Tip Miner Host Range (Summary)

- **Fundamental** host range
  - Polyphagous
  - Hydrilla not most suitable host in the lab
  - Adult females responsible for choosing suitable sites for larval development
  - Chironomid egg masses can drift and be influenced by wind
    - Supporting evidence for generalist life strategy
- **In field conditions, *C. lebetis* has been found to attack only hydrilla except for one insect recovered from *Potamogeton* spp.**
- Compare fundamental and ecological host range
- Continue exploration for natural enemies of hydrilla

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Compatibility Tests

- Mt and chemical herbicides

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The following nine slides are available online at:
http://www.icais.org/pdf/2009abstracts/Linda_Nelson.pdf

Integrating Herbicides with *Mycoleptodiscus terrestris* to Control Hydrilla

Linda Nelson and Judy Shearer
US Army Engineer R&D Center

Courtesy of L. Nelson & J. Shearer, US ACE ERDC

Mycoleptodiscus terrestris (Mt)

- Indigenous fungal pathogen
- 1990's - isolated in Texas
- Acts similar to contact herbicide
- Rapid infection
- Disease symptoms within 4-7 days
- Cell lysis
- Under development as bioherbicide
    - Compositional Patent in May 2003

Courtesy of L. Nelson & J. Shearer, US ACE ERDC

Methods

Treatments

- Untreated Control
- 5 ppb fluridone for 21 days
- 5 ppb fluridone for 35 days
- 0.05 g L^{-1} Mt dry
- 0.05 ml L^{-1} Mt liquid
- All combinations

Hydrilla, 2 native plants

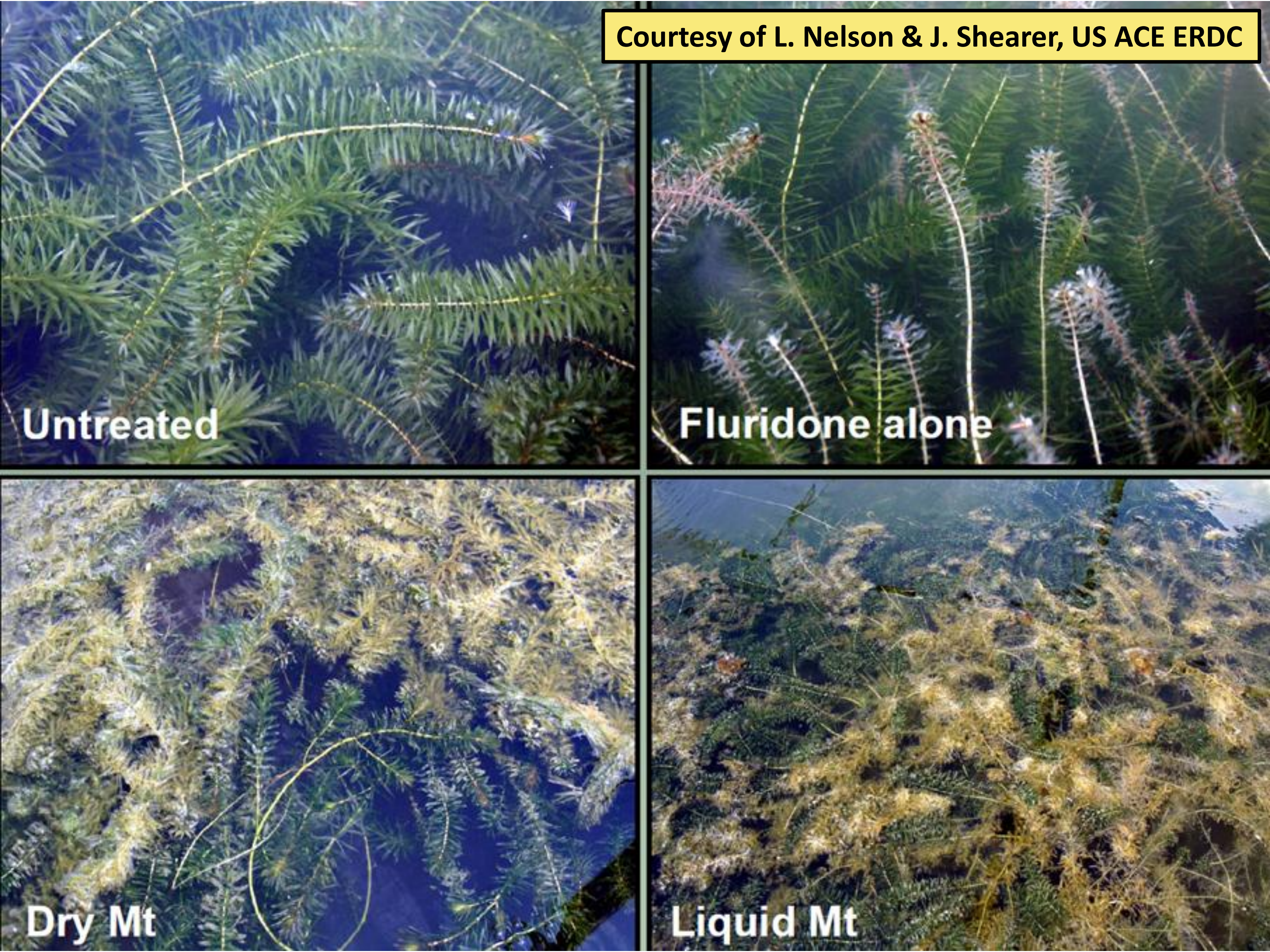
Biomass at 30 and 60 DAT


Dry Mt


Liquid Mt

Sonar AS

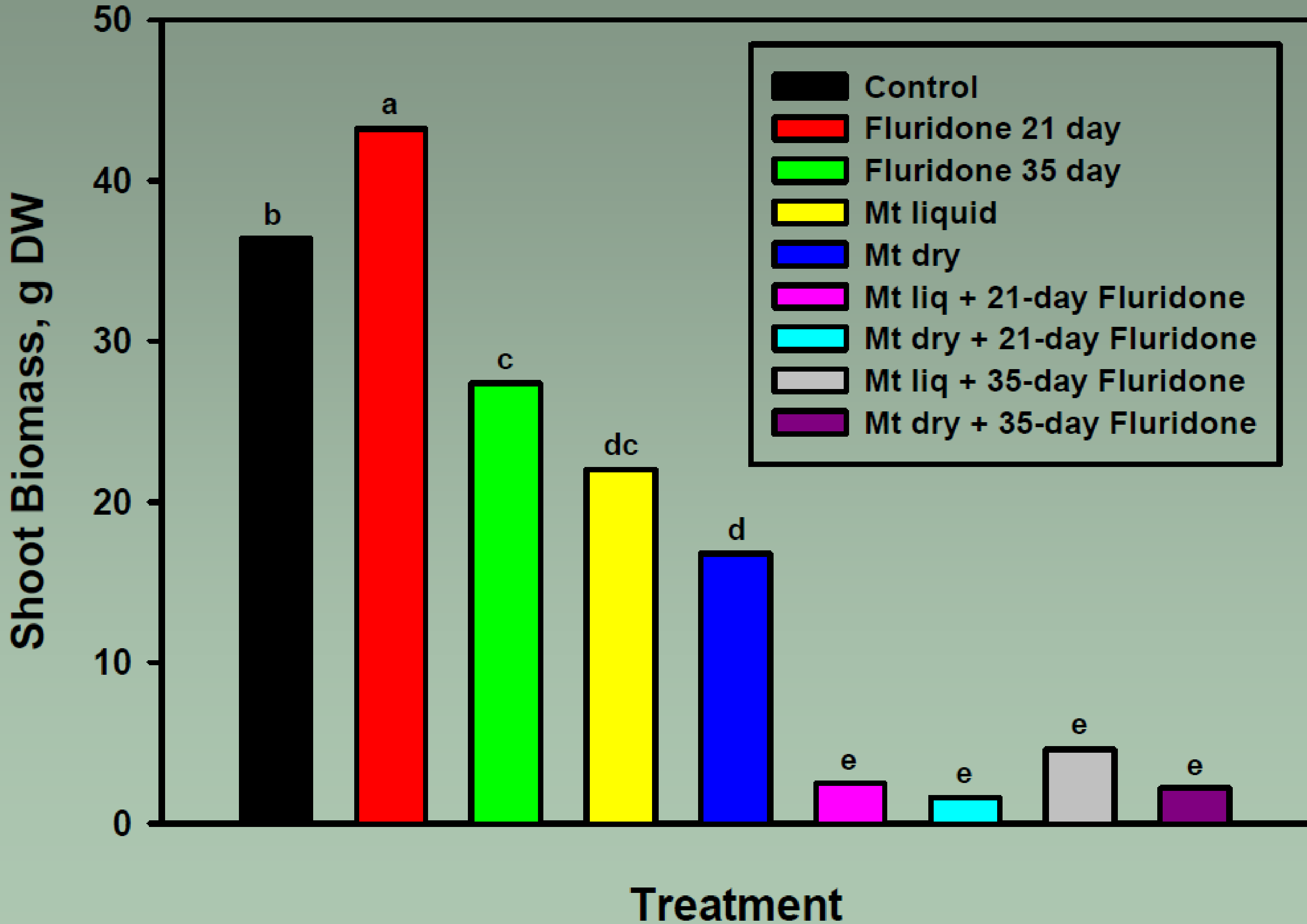

Courtesy of L. Nelson & J. Shearer, US ACE ERDC
Fluridone + Mt Study
Lewisville Aquatic Ecosystem Research Facility
Lewisville, TX


Courtesy of L. Nelson & J. Shearer, US ACE ERDC
Untreated
Fluridone alone
Dry Mt
Liquid Mt


Courtesy of L. Nelson & J. Shearer, US ACE ERDC
Untreated
Fluridone + Mt dry
Fluridone + Mt dry
Fluridone + Mt liquid

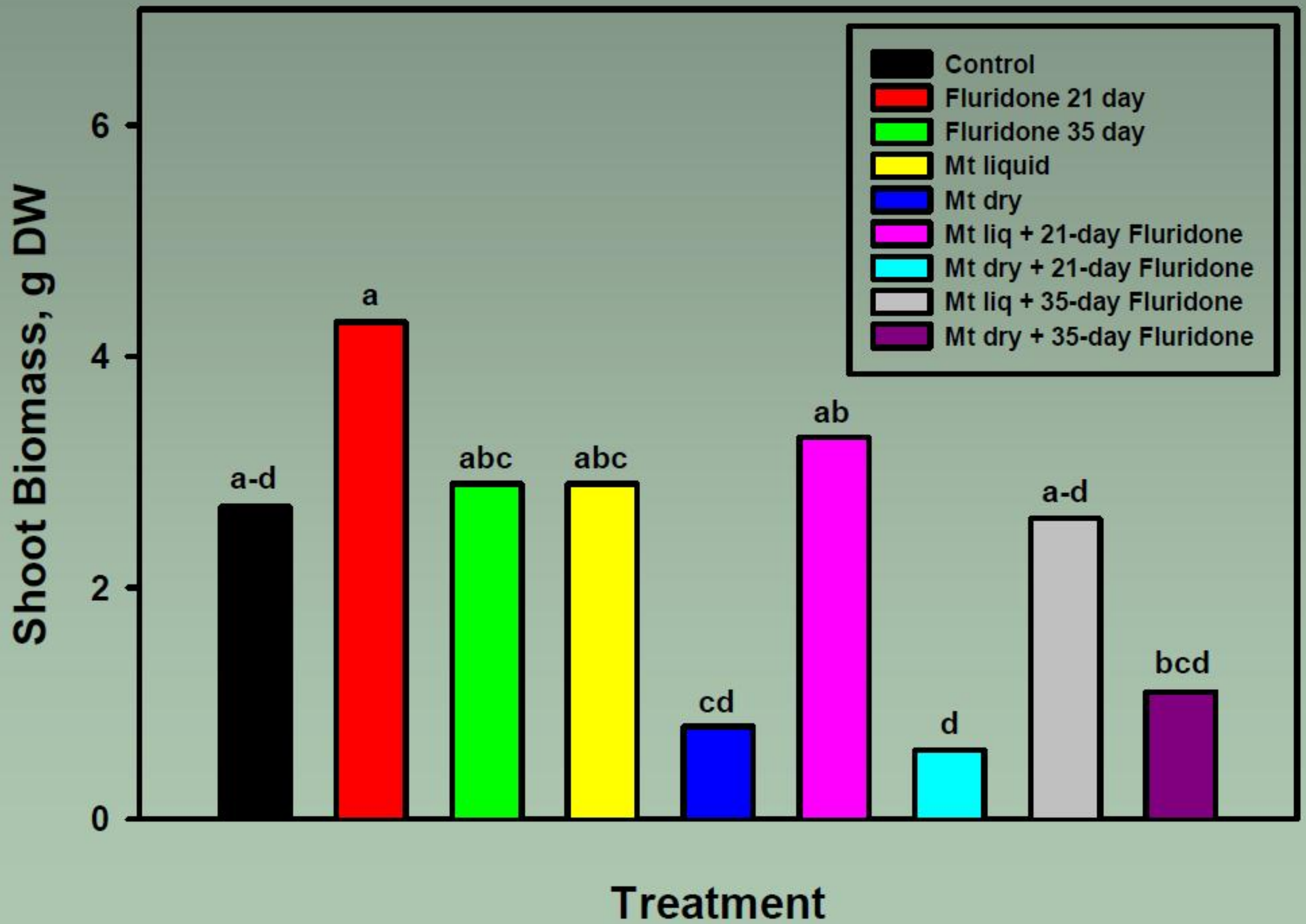
Courtesy of L. Nelson & J. Shearer, US ACE ERDC

Hydrilla – 30 DAT

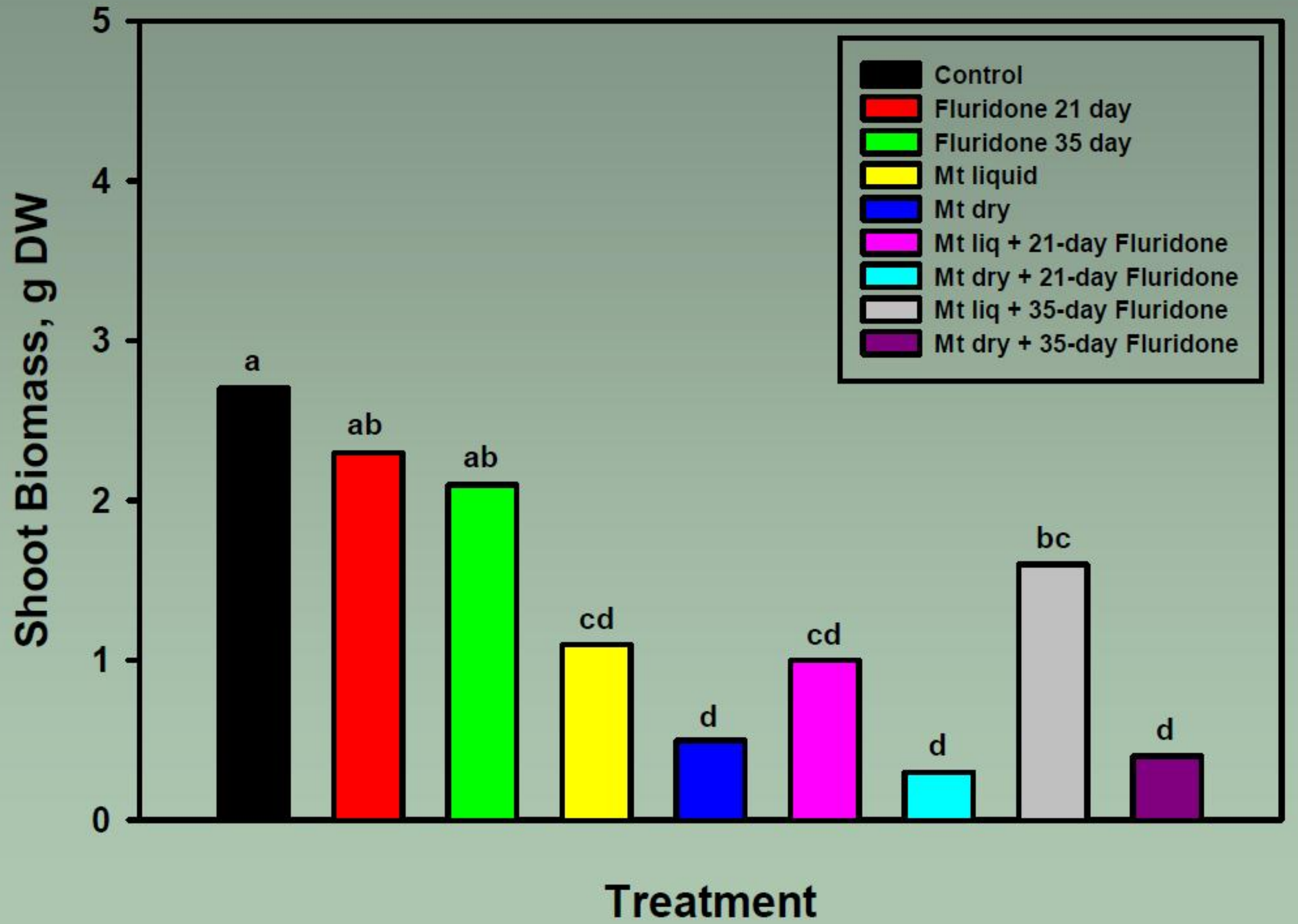


Courtesy of L. Nelson & J. Shearer, US ACE ERDC

Illinois Pondweed – 30 DAT



Vallisneria – 30 DAT



Courtesy of L. Nelson & J. Shearer, US ACE ERDC

Conclusions

- Combining herbicides with Mt works!
  - Improved hydrilla control
  - Synergistic response
  - Reduced herbicide rate & contact time
- Dry Mt inoculum effective; lab and outdoor studies
- Effects on native plants?
  - No impact on Illinois pondweed (liquid Mt + short FL)
  - Vallisneria sensitive to Mt, FL + Mt

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Research, Extension & Outreach

- Research
  - Compatibility studies
    - Mt and imazamox (done)
    - Mt and tip miner (ongoing)
    - Tip miner and imazamox (this spring)
  - Field tests
- Extension and Outreach
  - Field demonstration sites

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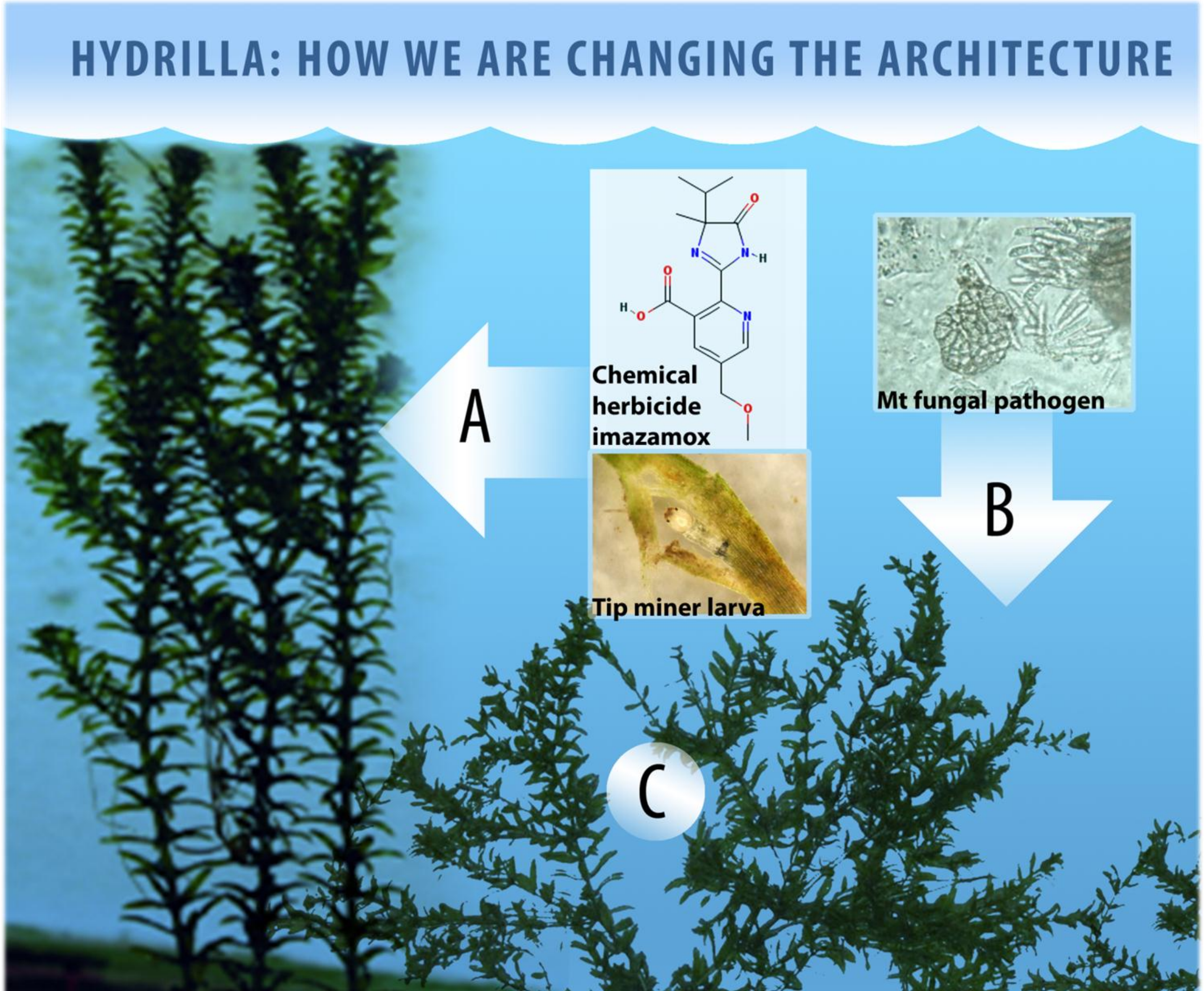
HYDRILLA IPM PROJECT

Summary


HYDRILLA: HOW WE ARE CHANGING THE ARCHITECTURE
Chemical herbicide imazamox
Mt fungal pathogen
Tip miner larva
A
B
C

Resources

- Hydrilla IPM Risk Avoidance and Mitigation Project, http://entomology.ifas.ufl.edu/hydrilla
- Osceola County Hydrilla and Hygrophila Demonstration Project (link available)
- UF/IFAS Center for Aquatic and Invasive Plants (link available)
- Featured Creatures of the UF/IFAS Entomology and Nematology Department (link available)
- Cooperative Extension System (eXtension)

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Research team:

- Dr. **James Cuda**, UF
- Dr. **Judy Shearer**, US ACE
- Dr. **William Overholt**, UF
- **Karen Stratman**, UF graduate
- Dr. **Raymond Hix**, FAMU
- **Eutychus Kariuki**, FAMU

Extension team:

- Dr. **Joan Bradshaw**, CED, Citrus Co.
- Dr. **Jennifer Gillett-Kaufman**, UF
- **Kenneth Gioeli**, St. Lucie Co.
- **Stacia Hetrick**, formerly Osceola Co.
- Dr. **Verena-Ulrike Lietze**, UF

Extension Advisory Committee:

- **Lorrie Bush**, Aquatics Division Director Saint Lucie West Services District
- Dr. **Moses Kairo**, former Director Center for Biological Control, FAMU
- Dr. **Stephen Hight**, Research Entomologist, USDA-ARS CMAVE
- **Jerry Renney**, President Applied Aquatic Management
- **Bridgett Tolley**, Lakes Advocate Community Res. Osceola County
- **Kelle Sullivan**, Regional Biologist Florida Fish and Wildlife Conservation Commission

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