Speaker Presentations & Course Materials

Aquatic Weed Control Short Course 2014

Aquatic Weed Control
Right-of-Way Weed Control
Forestry
Natural Areas Weed Control

May 5-8, 2014
Fort Lauderdale Marriott Coral Springs Hotel
Coral Springs, Florida

www.conference.ifas.ufl.edu/aw
Welcome to the 2014 UF/IFAS Aquatic Weed Control Short Course!

May 6, 2014

Dear Participants,

Welcome to the 2014 Aquatic Weed Control Short Course! If you are attending for the first time (and about 60% of you are), you will find that the presentations are very well done and the information can sometimes be overwhelming. Feel free to ask questions at the appropriate time as speakers like feedback and audience participation. If you’re here for CEU credits and have attended the Short Course before, you know that you’ll have a chance to learn new, updated information that is relevant to your daily weed management programs.

Certification exams will be given on Thursday afternoon. The statewide passing rate for the CORE, aquatics and natural areas category exams is less than 60%. This is why on the conference website we stress to first-time attendees the importance of obtaining and studying the training manuals and exam preparation materials BEFORE the Short Course. Don’t have them yet? Better get the books from the IFAS extension bookstore in the display room and start studying RIGHT NOW. You’ll have to make efficient use of your time over the next couple of days if you want to be prepared to take the certification exams on Thursday afternoon. This year we are offering multiple sessions to help you polish the math skills you’ll need to survive the calibration problems on the exams. The problem sets are included in your book of presentations; be sure you know how to work these problems because the exams have similar questions.

Once again we have well over 400 registrants for the Short Course. We know it’s often difficult to carve time out of your busy schedule to learn about new research, regulations and chemicals, so we certainly appreciate your attendance and participation this year. We also want to express our gratitude to our sponsors and speakers, and we owe special thanks to Jhanna Gilbert and the staff of the UF/IFAS Office of Conferences and Institutes for all the hard work they’ve done to ensure that the 2014 Short Course operates at maximum efficiency.

Our goal is to present you with a valuable training experience that will teach you the “basics” of weed management and the safe, legal use of pesticides. We think we’ve done our part; now you have to hold up your end of the bargain – attend the sessions and use the information that you learn to make your management program safer and more efficient.

If you have questions, suggestions or comments, please let us know. Again, thanks for joining us at the 2014 Aquatic Weed Control Short Course – we hope you have a safe and educational experience!

Sincerely,

Lyn A. Gettys  
Short Course Co-Organizer  
Fort Lauderdale Research and Education Center  
University of Florida IFAS  
3205 College Avenue | Davie FL 33314  
Phone 954-577-6331 | Email lgettys@ufl.edu

William T. Haller  
Short Course Co-Organizer  
Center for Aquatic and Invasive Plants  
University of Florida IFAS  
7922 NW 71 Street | Gainesville FL 32653  
Phone 352-392-9613 | Email whaller@ufl.edu
Welcome to the Center for Aquatic and Invasive Plants (CAIP) Information Office

The Center was established by the Florida legislature in 1978 and serves as a multi-disciplinary research, teaching, and extension unit directed to: develop environmentally sound techniques for the management of aquatic and natural area weed species; coordinate invasive aquatic plant research; and provide education and outreach about the impacts and management of invasive plants.

Utilizing expertise from many departments within UF/IFAS and its Agricultural Research and Education Centers around the state, much of our outreach is disseminated through the following web sites:

• [http://plants.ifas.ufl.edu](http://plants.ifas.ufl.edu)
  CAIP's main web site has been online since 1995 and includes news about aquatic plant management, links to special projects, educational publications, field guides, photographs and information on more than 500 plant species.

• [http://plants.ifas.ufl.edu/education](http://plants.ifas.ufl.edu/education)
  Developed for educators, this web site provides the resources needed to teach our next generation about the harmful impacts of invasive plants and issues related to natural resource management. The Center worked with dozens of teachers around the state to develop core presentations, hands-on lessons and activities, all of which correlate to the Florida Sunshine State and Common Core State Standards.

• [http://plants.ifas.ufl.edu/APIRS](http://plants.ifas.ufl.edu/APIRS)
  A searchable bibliographic database with nearly 85,000 annotated citations for scientific articles and reports on aquatic, wetland and invasive plants. Unlike many other databases, this one is free!

Additionally, we produce a variety of educational publications, field guides, audio-visual programs, photo displays/murals, and learning activities. As you work to learn more about Florida’s environment, we invite you to use our information services and resources.

Materials produced or compiled by this information office are the result of a longstanding partnership between the UF/IFAS Center for Aquatic and Invasive Plants and the Florida Fish and Wildlife Conservation Commission, Invasive Plant Management Section:

This handy 4” x 6” set, made up of 80 plant cards and 12 informational cards includes: a glossary of plant terminology; plants listed by both common and scientific names; a labeled set of illustrated plant parts; and bibliography. Cards can be written on with dry erase pen.

Aquatic Plant Identification Deck
UF/IFAS SM 050

This deck makes it easy to identify 67 aquatic and wetland plants commonly found in Florida's lakes, rivers, swamps and wetlands.

Grasses, Sedges & Rushes of Wetlands
UF/IFAS SP-255

Features 84 species of grasses, sedges and rushes; includes 11 non-native species and notes about use by wildlife such as ducks, cranes, geese, rabbits and deer.

Full color 3” X 4” laminated cards make it easy to identify or compare plants in the field. Both scientific and common names are indexed.

Educational DVDs About Florida’s Freshwater Environments

These programs cover various aspects of aquatic and wetland plant science and management for both technical and general audiences.

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

UF/IFAS DVD-084
Aquatic Plant Identification Series

UF/IFAS DVD-085
Aquatic Plant Management Series

UF/IFAS DVD-1238
Florida’s Aquatic Plant Story

UF/IFAS DVD-1237
What Makes a Quality Lake?

UF/IFAS DVD-1236
Careers in Florida’s Freshwater Environments

Order any of these items today from UF/IFAS Publications
www.ifasbooks.com • 1-800-226-1764
See IFAS Books for pricing - prices subject to change
Aquatic, Wetland and Invasive Plants in Pen-and-Ink
UF/IFAS DVD 347

Common and rare, native and non-native plant species of Florida and the Southeastern United States. 175 high resolution line drawing images on one DVD for print and web publishing; with full copyright permission.

For Land Managers

Identification and Biology of Nonnative Plants in Florida’s Natural Areas
UF/IFAS SP 257

Second Edition by K. A. Langeland, H. M. Cherry, C. M. McCormick, and K. A. Graddock Burks


Invasive and Other Non-Native Plants
UF/IFAS SP 349

A Recognition Guide for 94 Non-Native Plants

Freshwater Plants in the Southeastern United States
UF/IFAS SP 348

A Recognition Guide for 133 Plants

Fully laminated field guides. Folded Dimensions: 9” tall X 4” wide
Unfolded Dimensions: 18” tall X 17” wide

Photo Murals

Classroom-size, laminated photo murals feature 151 plant species found in Florida and the Southeastern United States. Comes with Teaching Points (commonly asked questions & answers) to help teachers plan lessons or activities.

175 line drawings at your fingertips...

175 line drawings at your fingertips...

Ask for our free annual newsletter!
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A Special Thank You to Our Sponsors

Gold Sponsor

Silver Sponsors

Bronze Sponsors

General Sponsors
A special thank you to the following organizations for donating their time, materials and plants to the 2014 short course

Florida Department of Agriculture,
Bureau of Compliance Monitoring

UF IFAS Fort Lauderdale
UNIVERSITY of FLORIDA Research & Education Center

Special Sessions

Live Aquatic Weed & Upland Plant Identification
Participants will have the opportunity to sign up for one of three aquatic and one of two natural area plant identification sessions. During sessions, participants will learn to identify numerous aquatic and natural area plant samples. The plants will be on open display Tuesday morning during non-session hours, and during refreshment breaks.

Sign-up in the Registration Office - Each session is limited to 50 people. These sessions fill quickly, so sign-up early.

Note: Sessions will take place in the Sandpiper Room and will run concurrent to oral presentations.
You may only earn credit for sessions attended.

Aquatic ID Session 1 – Tuesday, May 6th, 1:00-2:40pm | Sandpiper Room
Aquatic ID Session 2 – Wednesday, May 7th, 10:00-11:40am | Sandpiper Room
Aquatic ID Session 3 – Wednesday, May 7th, 7:00-8:40pm | Sandpiper Room

Wetland & Natural Area ID Session 1 – Tuesday, May 6th, 3:00-4:40 pm | Sandpiper Ballroom
Wetland & Natural Area ID Session 2 – Wednesday, May 7th, 1:00-2:40pm | Sandpiper Ballroom

Calibration Training: Herbicide Application Equipment Training and Math Review
Attendees will have the opportunity to sign-up for one of five calibration sessions. The session will feature math simulations similar to those on the category exams and will demonstrate common equipment calibration techniques and best practices.

Sign-up in the Registration Office - Each session is limited to 50 people.

Note: Sessions will take place in the Sandpiper and Cocoplum Rooms and will run concurrent to oral presentations.
You may only earn credit for sessions attended.
Be sure to bring your Book of Presentations and Calculator to Class.

Calibration Session A – Tuesday, May 6th, 3:00-4:40pm | Cocoplum Room
Calibration Session B – Wednesday, May 7th, 8:00-9:40am | Sandpiper Room
Calibration Session C – Wednesday, May 7th, 3:00-4:40pm | Sandpiper Room
Calibration Session D – Wednesday, May 7th, 7:00-8:40pm | Cocoplum Room
Calibration Session E – Thursday, May 8th, 8:00-9:40am | Sandpiper Room
### 2014 Aquatic Weed Control Short Course Agenda

**Monday, May 5, 2014 - Registration Only**

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<th>Time</th>
<th>Event</th>
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<tr>
<td>3:30-7:00pm</td>
<td>Pre-Conference Registration Open, Sponsor Display Set-Up [Palm Room, Ibis/ Egret and Pre-Function Area]</td>
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</tbody>
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**Tuesday, May 6, 2014 - First Day of Courses**

<table>
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<tr>
<th>Time</th>
<th>Event</th>
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<tr>
<td>7:00a-5:00pm</td>
<td>Registration Open [Palm Room]</td>
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<tr>
<td>7:00-7:50am</td>
<td>Morning Refreshments and Exhibits on Display [Ibis/ Egret and Pre-Function Area]</td>
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### CONTINUING EDUCATION SESSIONS

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
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<tbody>
<tr>
<td>7:50-8:00am</td>
<td>Welcome and Opening Remarks – Lyn Gettys, UF/IFAS</td>
</tr>
<tr>
<td>8:00-8:50am</td>
<td>Weed Control in Southeast - A Historical Perspective and Lessons Learned from Florida – Don Schmitz, Florida Fish and Wildlife Conservation Commission</td>
</tr>
<tr>
<td>8:50-9:40am</td>
<td>Adjuvants and the Water Droplet – Fred Whitford, Purdue University</td>
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<tr>
<td>9:40-10:00am</td>
<td>Refreshment Break and Networking [Ibis/ Egret and Pre-Function Area]</td>
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### SPECIAL SESSION - Repeats

<table>
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<tr>
<th>Time</th>
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<tr>
<td>10:00-10:20am</td>
<td>Label Updates from UPI</td>
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<td>10:20-10:40am</td>
<td>Label Updates Crop Production Services</td>
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<td>10:40-10:52am</td>
<td>Label Updates from Applied Biochemists, Lonza</td>
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<tr>
<td>10:52-11:04am</td>
<td>Label Updates from DuPont</td>
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<tr>
<td>11:04-11:16am</td>
<td>Label Updates from Winfield Solutions</td>
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<tr>
<td>11:16-11:28am</td>
<td>Label Updates from Syngenta</td>
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<tr>
<td>11:28-11:40am</td>
<td>Label Updates from NuFarm/ Valent</td>
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**Lunch Break – on your own**

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<th>Time</th>
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<td>11:40-1:00pm</td>
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### CONTINUING EDUCATION SESSION

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<th>Time</th>
<th>Event</th>
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<tr>
<td>1:00-1:50pm</td>
<td>Safe Transportation of Pesticides – Fred Whitford, Purdue University</td>
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<tr>
<td>1:50-2:40pm</td>
<td>Toxicity Categories of Herbicides – Fred Fishel, UF/IFAS</td>
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<tr>
<td>2:40-3:00pm</td>
<td>Refreshment Break and Networking [Ibis/ Egret and Pre-Function Area]</td>
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### SPECIAL SESSION - Repeats

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
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<tr>
<td>3:00-3:35pm</td>
<td>Weed Control in Everglades National Park – Tony Pernas, National Park Service</td>
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<tr>
<td>3:35-4:10pm</td>
<td>Weed Control in the Santee Cooper System – Larry McCord, Santee Cooper Power</td>
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<tr>
<td>4:10-4:40pm</td>
<td>Professionalism and Certified Applicators – Carlton Layne</td>
</tr>
<tr>
<td>3:00-4:40pm</td>
<td>Calibration Training: Herbicide Application Equipment Training and Math Review</td>
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<tr>
<td>3:00-4:40pm</td>
<td>Natural Areas ID: Wetland and Natural Areas Plant Identification</td>
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**Tuesday Evening Industry Social and Welcome Reception [Breezes Patio]**
### Wednesday, May 7, 2014

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<th>Exam Preparation #5B</th>
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<tr>
<td>7:00-8:00am</td>
<td>Morning Refreshments and Exhibits on Display [Ibis/ Egret and Pre-Function Area]</td>
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<td><strong>GRAND FLORIDIAN BALLROOM</strong></td>
<td><strong>COCOPLUM BALLROOM</strong></td>
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<td><strong>SANDPIPER ROOM</strong></td>
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<tr>
<td><strong>Moderator</strong></td>
<td>Jim Cuda, UF/IFAS</td>
<td>Jane Morse, UF/IFAS</td>
<td>Brent Sellers, UF/IFAS</td>
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<tr>
<td>**10:00-11:00am</td>
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<td>**10:00-11:00am</td>
<td>Integrating Insect Herbivory with Mechanical Harvesting – Jim Cuda, UF/IFAS</td>
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<td>**10:00-11:00am</td>
<td>Grass Carp for Biocontrol – Mike Sowinski, FWC</td>
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<td>**11:00-12:00pm</td>
<td>Biocontrol of Melaleuca – Paul Pratt, USDA</td>
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<td>**11:00-12:00pm</td>
<td>Biocontrol of Lygodium – Melissa Smith/Ellen Lake, USDA</td>
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<td>**11:00-12:00pm</td>
<td>Biocontrol of Air Potato – Rodrigo Diaz, UF/IFAS</td>
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<tr>
<td>**11:00-12:00pm</td>
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<td>**12:00-1:00pm</td>
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<td><strong>Moderator</strong></td>
<td>Bill Overholt, UF/IFAS</td>
<td>Jane Morse, UF/IFAS</td>
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<tr>
<td>**10:00-11:00am</td>
<td>Progress of Biocontrol on Brazilian Peppertree – Bill Overholt, UF/IFAS</td>
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<td>**11:00-12:00pm</td>
<td>Biocontrol of Air Potato – Rodrigo Diaz, UF/IFAS</td>
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<td>**11:00-12:00pm</td>
<td>Progress of Biocontrol on Brazilian Peppertree – Bill Overholt, UF/IFAS</td>
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<td>**11:40-1:00pm</td>
<td>Refreshment Break and Networking [Ibis/ Egret and Pre-Function Area]</td>
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<tr>
<td><strong>SESSION 7A</strong></td>
<td><strong>NATURAL AREAS AND RIGHT-OF-WAY WEED CONTROL</strong></td>
<td><strong>SESSION 7B</strong></td>
<td><strong>AQUATIC TRAINING</strong> (Exam Prep)</td>
<td><strong>ID# 17385</strong></td>
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<td>ID# 17383</td>
<td><strong>LOCATION</strong></td>
<td><strong>ID# 17384</strong></td>
<td><strong>AQUATIC TRAINING</strong> (Exam Prep)</td>
<td><strong>NATURAL AREAS PLANT ID 2</strong> space limited session</td>
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<td><strong>GRAND FLORIDIAN BALLROOM</strong></td>
<td><strong>COCOPLUM BALLROOM</strong></td>
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<td><strong>SANDPIPER ROOM</strong></td>
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<tr>
<td><strong>Moderator</strong></td>
<td>Bill Haller, UF/IFAS</td>
<td>Susan Haddock, UF/IFAS</td>
<td>Mike Bodle, SFWMD</td>
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<tr>
<td>**1:00-1:25pm</td>
<td>Identification and Control of Grasses – Sarah Lancaster, UF/IFAS</td>
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<td>**1:00-1:25pm</td>
<td>Control of Tallow Tree – Stephen Enloe, Auburn University</td>
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<td>**1:00-1:25pm</td>
<td>Control of Arundo and Napiergrass in the Everglades Agricultural Area – Calvin Odero, UF/IFAS</td>
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<td>**1:00-1:25pm</td>
<td>Control of Cogongrass – Stephen Enloe, Auburn University</td>
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<td>Refreshment Break and Networking [Ibis/ Egret and Pre-Function Area]</td>
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### Wednesday, May 7, 2014 - Continued

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<th>SPECIAL SESSIONS - Repeats</th>
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</table>
| SESSION 8A  
ID# 17386  
ALGAE AND POND MANAGEMENT | SESSION 8B  
ID# 17387  
NATURAL AREAS TRAINING  
(Exam Prep) | ID# 17388  
CALIBRATION & MATH C  
space limited session |
| LOCATION  
GRAND FLORIDIAN BALLROOM | COCOPLUM BALLROOM | SANDPIPER ROOM |
| Moderator Lyn Gettys, UF/IFAS | Mary Beth Henry, UF/IFAS | Brent Sellers, UF/IFAS |
| 3:00-4:00pm Nuisance Algae Characterization and Management Options – West Bishop, SePro | 3:00-4:40pm Natural Areas Weed Management Training (Exam Prep) | 3:00-4:40pm Calibration Training: Herbicide Application Equipment Training and Math Review  
(Same class as Calibration A or B) |
| 4:00-4:40pm Pond Management – Chuck Cichra, UF/IFAS | | |

#### Dinner on Own

**NIGHT SESSIONS**

Exam Review: Take the Wednesday Evening Calibration Session to review questions and address individual concerns on the math portion of the certification exams.

The evening Aquatic Plant ID is offered to accommodate those unable to attend one of the earlier Aquatic Plant ID Sessions.

### Thursday, May 8, 2014

#### CONTINUING EDUCATION SESSIONS

<table>
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<tr>
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| SESSION 9A  
ID# 17391  
AQUATIC WEED CONTROL | SESSION 9B  
#17392  
NATURAL AREAS AND RIGHT-OF-WAY AQUATIC CONTROL | ID# 17393  
CALIBRATION & MATH E  
ID# 17393 - space limited |
| LOCATION  
GRAND FLORIDIAN BALLROOM | COCOPLUM BALLROOM | SANDPIPER ROOM |
| Moderator Mike Netherland, UF/IFAS | Brent Sellers, UF/IFAS | Bill Haller, UF/IFAS |
| 8:00-8:50am Biology and Control of Salvinia – Dearl Sanders, LSU | 8:00-8:25am Control of Tropical Soda Apple – Brent Sellers, UF/IFAS | 8:00-9:40am Calibration Training: Herbicide Application Equipment Training and Math Review  
(Same class as Calibration A, B, C, or D) |
| 8:50-9:15am Hydrilla Control in Winter Park – Amy Giannotti, City of Winter Park | 8:50-9:15am Use Patterns for Aminomyclopyrachlor – Brent Sellers, UF/IFAS | |
| 9:15-9:40am Aquatic Weed Control – Mike Netherland, USACE | 9:15-9:40am Control of Old World Climbing Fern – Cheryl Millet, TNC | |
| 9:40-10:00am Refreshment Break and Networking [Ibis/ Egret and Pre-Function Area] | | |

#### AFTER THE SHORT COURSE:

- **1:15-4:30pm**  
  **CORE and Category Testing**  
  [Grand Floridian Ballroom]

- **1:00-4:45pm**  
  **Aquatic Restoration Mini-Course**  
  (must be pre-registered)  
  [Cocoplum Ballroom]
### 2014 Aquatic Weed Control Short Course Florida CEUs

<table>
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<tr>
<th>SESSION</th>
<th>Program ID #</th>
<th>CORE</th>
<th>AQU</th>
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<th>FOR</th>
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**TUESDAY 5/6/2014**

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<td>SESSION 2 - PESTICIDE LABEL UPDATES</td>
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<td>SESSION 3 - PESTICIDE SAFETY</td>
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**WEDNESDAY 5/7/2014**

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**THURSDAY 5/8/2014**

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**MAXIMUM CEUs POSSIBLE PER PERSON - TUESDAY**

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**MAXIMUM CEUs POSSIBLE PER PERSON - WEDNESDAY**

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**MAXIMUM CEUs POSSIBLE PER PERSON - THURSDAY**

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**MAXIMUM CEUs POSSIBLE PER PERSON**

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Florida Applicator License Renewal CEU Requirements

4 CORE Plus...

16 Aquatics
8 Forestry
16 Natural Areas
8 Right of Way
12 Ornamental & Turf
4 Demo & Research
4 Private
16 Aerial
8 Ag Row/ Tree Crop

Visit www.flaes.org for additional categories and further information on Florida certifications and regulations.
Tips for Exam Day:

- Be sure to arrive before 1:15pm. Those sitting in the front will be the first to start exams.
- There is no charge for taking exams.
- **What to bring with you (these are the only items you should bring):**
  - Your driver’s license or government-issued identification
  - The pocket calculator given to you at registration
- **What not to bring:**
  - Cell Phones or other electronic devices **(THE EXAM WILL NOT TAKE PLACE IF THESE ARE PRESENT)**
  - Exam study manuals
  - Scratch paper, allowable formulas, pencils, and any other testing supplies - these will be provided at the exam.

Questions:

- **Which exams do I need to take?** You will need to take and pass the General Standards (Core) exam and at least one category exam to qualify for a license. The categories are Private Applicator, Aerial Application, Agricultural Animal Pest Control, Agricultural Row Crop Pest Control, Agricultural Tree Crop Pest Control, Aquatic Pest Control, Demonstration & Research (secondary category), Forest Pest Control, Natural Areas Weed Management, Organotin Antifouling Paint, Ornamental & Turf, Raw Agricultural Commodity Fumigation, Right-of-Way Pest Control, Seed Treatment, Soil & Greenhouse Fumigation, and Wood Treatment.

- **How do I prepare for the exams?** During the short course we will review much of the material that will be covered on the General Standards (CORE) and certain popular category certification exams. Additionally, it is highly recommended that you review the appropriate Pesticide Application Training Manual (available from the IFAS Bookstore) for the categories in which you will be testing. Those who wish to seek additional instruction should plan to attend the Wednesday evening Calibration and Math Review Session, see the agenda for details.

- **If I attend the short course review sessions, is that all that I need to know to pass the exams?** YOU WILL NOT PASS BY SIMPLY ATTENDING THE REVIEW SESSIONS. The exam is derived from the study manuals; but, the review sessions will reinforce the content of the study manuals. IT IS HIGHLY RECOMMENDED THAT YOU OBTAIN THE STUDY MANUALS AND STUDY PRIOR TO THE EXAMS.

- **How long will exams take?** Each exam takes approximately one hour to complete, depending on the individual. If time allows, you are permitted to take more than one exam.

- **When do I find out if I pass the exam(s)?** The Florida Department of Agriculture and Consumer Services will notify you via email, 10 – 21 days after the exam and provide instructions for applying for your license.

- **Do I need a calculator?** Yes; most exams will have mathematical questions. The calculator given to you at the registration for this conference is the only one you are allowed to use. No other type of calculator may be used for the exams.
Land and Water Resources from the UF/IFAS Extension Bookstore

We offer educational resources that deliver practical solutions for the challenges Floridians face. Our products are the result of collaborations between research scientists and educators from the UF campus, 13 Research and Education Centers, and 67 Cooperative Extension Service offices statewide.

Applying Pesticides Correctly
Basic resource for the General Standards (Core) examination for pesticide applicators seeking to be certified and licensed to apply pesticides in Florida. SM 1, $20.00
Also available on interactive DVD. SM 69, $25.00

Aquatic Pest Control Training Manual
Exam preparation and general reference manual for commercial or public applicators seeking certification and licensure to apply pesticides for aquatic plant control in Florida. SM 3, $15.00
Also available on interactive DVD (SM 70, $25.00)

Invasive and Non-Native Plants You Should Know
IFAS experts have assembled these 3.75”x6” laminated cards to help professionals, students, and the general public learn to recognize 80 of the non-native and invasive plant species found throughout Florida. SP 431, $35.00

Natural Area Weed Management
Training manual for pesticide applicators who apply herbicides to control invasive vegetation in natural areas of Florida. The manual contains information on herbicide application and safety in natural areas. SP 295, $12.00
Also available on interactive DVD. SM 71, $25.00

UF/IFAS Camo Cap
One size fits all outdoor Gators. This camouflage hat keeps your head cool with its breathable mesh side and back with velcro closure. L058, $12.00

Florida Freshwater Plants
This valuable reference catalogs more than 100 species of common aquatic plants in Florida's lakes, from Pensacola to Miami. SP 189, $35.00

For more information call (800) 226-1764 or go to www.IFASbooks.com
Speaker Presentations
Tuesday, May 6, 2014 – 7:50AM

SESSION 1: DEFINING THE PROBLEM

“Welcome and Opening Remarks”

Lyn Gettys
University of Florida/IFAS
Ft. Lauderdale Research and Education Center
Welcome!!!

2014 Aquatic Weed Control Short Course

Housekeeping

Over 400 registered
Thank (and visit!) our sponsors in Ibis/Egret
UF/IFAS Bookstore in Ibis/Egret
Sign up for special sessions – limited space
CEUs – on the back of the program; FDACS
Gotta be here for the whole session…
Wear your nametag, check your beer tickets

More housekeeping

Certified Applicator’s License
Allows purchase and use of restricted use products
Allows your company to obtain liability insurance
Allows you to work for public or government agencies

License types

<table>
<thead>
<tr>
<th>Type</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private applicator</td>
<td>$100</td>
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<tr>
<td>Public applicator</td>
<td>$100</td>
</tr>
<tr>
<td>Commercial applicator</td>
<td>$250</td>
</tr>
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</table>

More info at http://www.flaes.org
Bureau of Compliance Monitoring

Why are you here?

Exams at Short Course

Thursday afternoon
Minimum 2 exams – core and at least one category
Categories:
- Aquatics
- Natural Areas
- ROW
- Forestry
- Row Crops
- And so on…
License renewal

Every 4 years by CEUs or exam

<table>
<thead>
<tr>
<th>Category</th>
<th># CEUs needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core</td>
<td>4 Plus…</td>
</tr>
<tr>
<td>Aquatics</td>
<td>16</td>
</tr>
<tr>
<td>Forestry</td>
<td>8</td>
</tr>
<tr>
<td>Natural Areas</td>
<td>16</td>
</tr>
<tr>
<td>Right of Way</td>
<td>8</td>
</tr>
</tbody>
</table>

Pass/fail rates

<table>
<thead>
<tr>
<th>Category</th>
<th>% pass: FL 2013*</th>
<th>SC 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core</td>
<td>62% (1,778/2,871)</td>
<td>61% (22/36)</td>
</tr>
<tr>
<td>Aquatics</td>
<td>56% (346/620)</td>
<td>65% (31/48)</td>
</tr>
<tr>
<td>Natural Areas</td>
<td>52% (197/377)</td>
<td>73% (11/15)</td>
</tr>
<tr>
<td>Right of Way</td>
<td>51% (245/484)</td>
<td>44% (8/18)</td>
</tr>
</tbody>
</table>

*Exams taken throughout Florida between Jan 1 2013 and Dec 31 2013
*Exams taken at the end of the 2013 Short Course

Tools for success

- Instructors
- Printed materials
- Calibration/math and identification workshops
- Sponsors
- Attendees

Thank you!

Thanks for coming to the 2014 Aquatic Weed Control Short Course – enjoy!

Lyn Gettys, Ph.D. • lgettys@ufl.edu • Go GATORS!!!
Tuesday, May 6, 2014 – 8:50AM

SESSION 1: DEFINING THE PROBLEM

“Adjuvants and the Water Droplet”

Fred Whitford
Purdue University
Adjuvants and the Water Droplet

Improving Dose-Transfer from the Tank to the Target

• Is there science behind adjuvants?
• Do they work?
• Can you buy with confidence?
• Are they worth the money?

Water Droplet Chemistry

Unlocking the Mysteries of the Water Droplet is Important Because It Forms Most of the Spray Mixture

• Water is not ‘just’ the carrier
• Water is not pure
• A very complex molecule

Water is a polar compound
Water droplets bounce, break, runoff, stick together

Droplets need to reach the leaf surface to work

Water repelled by waxes on surface

Water may contain minerals bind to the pesticide

1. Negative Charged Glyphosate Molecule

2. Negative Charged Glyphosate Molecule

3. Glyphosate Salt Complex

Water pH reacts with chemicals

Droplets need speed and size to reach target
The Spray Droplet Is The Delivery System

Adjuvants Added to Alter Water Chemistry and Droplet

All of These Are Adjuvants

- Antifoam
- pH adjusters
- Buffering agents
- Water conditioning agents
- Surfactants/ “wetters”
- Stickers
- Oil concentrates
- Humectants
- Drift control/deposition

Adjuvants are added to enhance the spray water droplet

Laundry detergent

Antifoam

pH adjusters and Buffering agents

Water conditioning agents (minerals)

1. Prevents minerals from reacting with herbicide.
Surfactants ("wetters")
—surface active agent or spreader—

With surfactant, waxy leaf

No surfactant, hairy leaf
Surfactants ("wetters") — surface active agent or spreader —

Stickers

Oil concentrates
Water Droplet Chemistry
Adjuvant Used to Alter Water Droplet

Testing Your Knowledge On Adjuvants

Hardness + pH
Hardness, no pH adjuster
Water Droplet Chemistry

Adjuvant Use to Alter Water

Testing Your Knowledge On Adjuvants

Pesticide and Adjuvant Labels

**Spray Additives**

Ammonium Sulfate (AMS): Control of annual and perennial weeds with Touchdown Total may be improved by adding dry ammonium sulfate at 1 to 2% by weight or 6 to 12.6 gallons per 100 gallons of water. Liquid formulations of AMS may be used at an equivalent rate. Do not reduce use rates of Touchdown Total when using AMS.

Drift Control Agents - Drift control agents may be used with Touchdown Total. When an adjuvant is to be used with this product, the use of an adjuvant that meets the requirements of the Chemical Manufacturers and Distributors Association (CMDA) adjuvant certification program is recommended.

Do not add surfactants, additives containing surfactants, buffering agents or pH adjusting agents to the spray solution when Boomshot Ultra herbicide is the only pesticide used. Ammonium sulfate, drift control additives, or dyes and colorants may be used. See the “MIXING” section of this label for instructions.
Always add a high quality nonionic surfactant containing at least 75% surface-active agent, at 0.25-0.5% v/v (% pint per 25 gallons) of the finished spray volume for ground sprays.

Additional instructions or use restrictions: Include a spray adjuvant with STREAMLINE™ when making postemergence applications. Refer to the adjuvant label for additional instructions or use restrictions. When tank mixing, use the most restrictive label limitations for each of the products being used in the tank mix.

ADJUVANTS
Methylated Seed Oils and Vegetable Oils: A methylated seed oil (MSO) or vegetable-oil based adjuvant may provide increased leaf absorption of STREAMLINE™. Include the MSO or vegetable-oil based adjuvant at 0.5% to 1% v/v (2 quarts to 1 gallon per 100 gallons of spray solution).
Non-ionic Surfactants: Use a non-ionic surfactant at a rate of 0.25% to 1% v/v (0.5 to 1 gallon per 100 gallons of spray solution). Surfactant products must contain at least 70% constituents effective as spray additives.
Crop Oil Concentrate (COC): Apply petroleum-based crop oil concentrate at 1% v/v (1 gallon per 100 gallons spray solution) or 2% under and conditions.
- Oil adjuvants must contain at least 80% high quality, petroleum (mineral) or modified vegetable seed oil with at least 15% surfactant emulsifiers.

Always add a high quality nonionic surfactant containing at least 75% surface-active agent, at 0.25-0.5% v/v (% pint per 25 gallons) of the finished spray volume for ground sprays.

Principal Functioning Agents:
- Surfactants, humectants, free fatty acids ................................ 90%
- Constituents ineffective as a spray adjuvant .......................... 10%
- TOTAL ................................................................. 100%
- Surfactant content: 70%

Apply 0.4-0.6 oz/100 sq. ft. (16-24 oz/A) of Fusilade II Turf and Ornamental Herbicide in sufficient water along with 0.25% (1/2 pt./gal.) of a nonionic surfactant. Use only nonionic surfactant on ornamentals. DO NOT USE A CROP OIL CONCENTRATE WITH FUSILADE II TURF AND ORNAMENTAL HERBICIDE ON ORNAMENTALS.

and high relative humidity may increase the risk of temporary discoloration. Use of surfactants is not recommended.

Mix According to Pesticide Label

Certain spray tank additives (adjuvants, wetting agents, surfactants), leuc fertilizers, and tank mixtures containing emulsifiable concentrates may reduce the selectivity on the turfgrass. Use adjuvants and spray additives or tank-mix combinations only when your experience indicates that the tank mixture will not result in objectionable turf injury.
Buying with Confidence

Water Droplet Chemistry
Adjuvant Use to Alter Water
Testing Your Knowledge On Adjuvants
Pesticide and Adjuvant Labels

Buying with Confidence—Percentage

PRINCIPAL FUNCTIONING AGENTS:
Paraffin Base Petroleum Oil ................................................. 83%
Nonionic Surfactants .......................................................... 17%
Total ............................................................................... 100%

is a nonionic blend of surfactants and highly refined paraffin oil. It is designed for use with a broad range of pesticides where an oil concentrate adjuvant is recommended. It increases contact activity and penetration of the spray while also providing uniform coverage on leaf surfaces. Always follow herbicide label recommendations.
Buying With Confidence—Registration in California and Washington

GENERAL INFORMATION
INTERLOCK™ is a spray adjuvant designed to increase pesticide performance by improving deposition of the spray application onto the intended target. INTERLOCK™ improves coverage and reduces drift and evaporation of pesticides being applied by ground or air.

CA Reg. No. 981-00025-MA
Val Reg. No. 1031-00094

Distributed by:
United Solutions, LLC
F.O. Box 649000, Ste. 111, MN 55164-0990

ACTIVE INGREDIENTS
• Nonionic Surfactant
• Antifoaming Agent

It’s all about the spray droplet!

• Is there science behind adjuvants?
• Do they work?
• Can you buy with confidence?
• Are they worth the money?

Are they worth the money?
Yes and No
• Label
• Add pesticide rate back
• Recommendations supported by data and experience
• Focus instead of shotgunning
New Publication in 2014

Understanding Adjuvants and the Water Droplet: Improving the Dose-Transfer From the Tank to the Target
Tuesday, May 6, 2014 – 10:20AM

SESSION 2: PESTICIDE LABEL UPDATES

“Label Updates from Crop Production Services”
Water Quality and Pesticide Performance
Aquatic Weed Short Course
Moe Finke
Consultant CPS/Timberland

How many applicators in this room check Water Quality?

U.S. Water Hardness Map

Understanding Water Quality Issues
• Water Hardness:
  – Total Concentration of hard water ions (cations)
  – Calcium (Ca²⁺) & Magnesium (Mg²⁺)
• Other Hard Water Cations
  – Sodium
  – Iron
  – Aluminum

Water Hardness Test Strip

Glyphosate Structure
Calcium Antagonism
pH (Alkalinity)

- pH is the value that describes the relativity of any solution
  - pH > 7 basic
  - pH = 7 neutral
  - pH < 7 acidic
- Water pH very important in stability and efficacy of pesticides (Weak Acid)

Effect of Adjuvants on pH

- Alkaline Hydrolysis:
  - Degradation of pesticide in spray solution
  - Permanent & Irreversible
  - Breaks bonds holding pesticides together
- Half-Life:
  - Stability of pesticide in spray solution
  - Degradation to 50% of original amount of pesticide

Total Alkalinity

- Measurement of the “resistance of change” in pH
Total Alkalinity

Turbidity

• Clay Platelets

Herbicide Deactivated

THANK YOU

QUESTIONS!!!
Tuesday, May 6, 2014 – 10:40AM

SESSION 2: PESTICIDE LABEL UPDATES

“Label Updates from Applied Biochemists, Lonza”
Aquatic Plant Communities

- Stabilize lake sediments, reduce re-suspension
- Increase sedimentation, reduce turbidity
- Provide habitat for insects, forage fish, fish spawning and YOY fish
- Provide food for waterfowl, other animals

Aquatic Plant Community Structure

Native Vs. Non-native

Threats to Community Structure

- Invasive aquatic plants
  - Competition with native species
  - Change in succession or community dynamics
  - Reduction in diversity
  - Alteration of food webs
  - Alteration of Ecosystem Processes
  - Endangered species impacts

Understanding Aquatic Plant Management

- Spread and distribution will be determined by many factors (e.g. environment, biology, ecology, and man)
- Effective management will also be determined by a number of these same factors
- Having an understanding of species specific ecology and response to management is crucial for a successful program
- Public perception often times has a role in shaping the outcome of management programs
Lonza’s Approach to Aquatic Plant Management

- New product development
- Product support
- Data collection at multiple scales
  - Lab
  - Mesocosm
  - Field
- Cooperative projects

Targeted Algal Management – Lab Scale

- Targeted Algal Management
- Algal Challenge Test (ACT)
  - Rapidly screen algae and algaecides based on site specific conditions
  - Allows for prescriptive algal management of target species in the field
  - We are the only company that can offer this level of testing reliably and consistency for algae management

Product Development – Lab Scale

- Capabilities to model formulation dissipation
- Formulation stability
- Establish formulation release rate curves

Product Development – Mesocosm Scale

- New mesocosm test facility
- Capacity: approximately 50 - 100 tanks depending on size
- Tank size: 100 – 1000 gallon
- Support research on submersed, floating, emergent plants and algae
- Use patterns, herbicide combinations, efficacy, new product screening, formulation testing, interactions, selectivity, and sensitivity

Product Development – Field Scale

- Product development and support under operational management conditions
- Growing list of cooperators including:
  - University scientists
  - Federal and State government scientists
  - Professional lake managers
  - Consultants
  - Applicators
  - Private citizens
Recent Studies

Dr. Skipper’s Pond (Six Mile, SC)

- Usages
  - Fishing, Irrigation, Recreation
- Size
  - 2,700 m² (2/3 Acre)
  - 1.3 m Avg. Depth
- Water Inputs
  - Runoff
  - Subsurface Flow

The Target

*L. magnifica*- A filamentous cyanobacterium impaired fishing, irrigation, and recreation in a farm pond:

Laboratory Methods

Exposures:
- Algimycin®-PWF Algaecide
- Clearigate® Algaecide/Herbicide
- Cutrine® Ultra Algaecide/Herbicide
- Phycomycin® SCP Algaecide/Oxidizer

Experimental Design:
- Four replicates
- 200 mL each
- 7 day toxicity tests
- 16h light / 8h dark
- Temperature 23°/1°C

EPA Method 600.4-91/002

Laboratory Results

*Skipper’s Pond L. magnifica*- Chlorophyll a

Before

After
Water Characteristics (Average)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pre-treatment</th>
<th>1 day post</th>
<th>4 days post</th>
<th>7 days post</th>
<th>10 days post</th>
<th>21 days post</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH (SU)</td>
<td>9.0</td>
<td>9.4</td>
<td>9.7</td>
<td>9.1</td>
<td>9.0</td>
<td>7.2</td>
</tr>
<tr>
<td>Hardness (mg/L as CaCO3)</td>
<td>36</td>
<td>42</td>
<td>38</td>
<td>38</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Alkalinity (mg/L as CaCO3)</td>
<td>32</td>
<td>34</td>
<td>34</td>
<td>36</td>
<td>32</td>
<td>32</td>
</tr>
<tr>
<td>Conductivity (µmhos/cm)</td>
<td>115.3</td>
<td>167.5</td>
<td>167.0</td>
<td>181.8</td>
<td>172.0</td>
<td>165.0</td>
</tr>
<tr>
<td>Dissolved O2 (mg/L)</td>
<td>9.0</td>
<td>12.5</td>
<td>9.9</td>
<td>8.2</td>
<td>8.8</td>
<td>10.1</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>19.1</td>
<td>19.2</td>
<td>18.5</td>
<td>17.7</td>
<td>16.9</td>
<td>15.5</td>
</tr>
</tbody>
</table>

Study Conclusions

• Laboratory results predicted an effective candidate field treatment (Phycomycin® SCP Algaecide and Oxidizer at 80 lbs/acre-ft)

• Phycomycin® SCP Algaecide and Oxidizer controlled Lyngbya magnifica in Dr. Skipper’s pond

• At this site, laboratory and field responses were analogous, however field responses were enhanced relative to the laboratory results

Lake John Hay

Evaluation of Auxin Herbicides Applied Alone and in Combination with Select Algaecides for Control of Eurasian Watermilfoil in Long Lake, Iosco County, MI

• Long Lake, MI (493 acres)

• Field project to support use of algaecide and herbicide combinations for enhanced control of Eurasian watermilfoil

• Navitrol® Landscape and Aquatic Herbicide (Triclopyr), Navigate® A Selective Herbicide (2,4-D), Cutrine Ultra® Algaecide/Herbicide, Phycomycin® SCP Algaecide and Oxidizer

• Biomass Sampling Schedule:
  • Pretreatment (June 4, 2013)
  • 8 WAT (August 4, 2013)
  • 1 YAT (TBD)

Study Objectives

• Quantitatively assess changes in Eurasian watermilfoil biomass between sampling times and treatment locations in Long Lake, MI

• Assess the impact on the native aquatic plant community from managing Eurasian watermilfoil in Long Lake, MI

• Determine if faster efficacy (initial knock down) can be achieved with the combination
  • Done visually in 2013

Materials & Methods

Figure 1. Locations of treatment plots and biomass sample points in Long Lake, Iosco County Michigan.
Materials & Methods

Herbicide and algaecide application rates for Long Lake based on depth contours.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>None</td>
<td>Navitrol® Landscape and Aquatic Herbicide (Triclopyr, Oxyacetic acid, triethylamine salt) 3 gal acre⁻¹</td>
<td>Navigate®, A Selective Herbicide (2,4-D, Butoxyethyl Ester of 2,4-Dichlorophenoxyacetic Acid) 150 lb acre⁻¹</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Cutrine Ultra® Algaecide/Herbicide (Copper Ethanolamine Complex, Mixed) 1 gal acre⁻¹</td>
<td>Navitrol® Landscape and Aquatic Herbicide (Triclopyr, Oxyacetic acid, triethylamine salt) 3 gal acre⁻¹</td>
<td>Navigate®, A Selective Herbicide (2,4-D, Butoxyethyl Ester of 2,4-Dichlorophenoxyacetic Acid) 150 lb acre⁻¹</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Cutrine Ultra® Algaecide/Herbicide (Copper Ethanolamine Complex, Mixed) 6.5 gal acre⁻¹</td>
<td>Navitrol® Landscape and Aquatic Herbicide (Triclopyr, Oxyacetic acid, triethylamine salt) 3 gal acre⁻¹</td>
<td>Navigate®, A Selective Herbicide (2,4-D, Butoxyethyl Ester of 2,4-Dichlorophenoxyacetic Acid) 150 lb acre⁻¹</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Phycomycin® SCP Algaecide and Oxidizer (Sodium Carbonate Peroxyhydrate) 10 lb acre⁻¹</td>
<td>Navitrol® Landscape and Aquatic Herbicide (Triclopyr, Oxyacetic acid, triethylamine salt) 3 gal acre⁻¹</td>
<td>Navigate®, A Selective Herbicide (2,4-D, Butoxyethyl Ester of 2,4-Dichlorophenoxyacetic Acid) 150 lb acre⁻¹</td>
<td></td>
</tr>
</tbody>
</table>

Materials & Methods

• Aquatic herbicides and algaecides were applied during the week of June 10, 2013
• Liquid herbicides and algaecides were used between the 0 and 10 ft. contour
• Granular 2,4-D was used between the 10 and 15 ft. contour

Results

Table 3. Herbicide and algaecide residues following applications in Long Lake, MI.

<table>
<thead>
<tr>
<th>Date</th>
<th>Site</th>
<th>Copper</th>
<th>Triclopyr</th>
<th>2,4-D</th>
</tr>
</thead>
<tbody>
<tr>
<td>06/18/2013</td>
<td>A</td>
<td>&lt; 50</td>
<td>154</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>&lt; 50</td>
<td>152</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>&lt; 50</td>
<td>159</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>&lt; 50</td>
<td>127</td>
<td>18</td>
</tr>
<tr>
<td>07/01/2013</td>
<td>A</td>
<td>0</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>95</td>
<td>&lt;10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>87</td>
<td>&lt;10</td>
<td></td>
</tr>
</tbody>
</table>

Limit of quantitation: 10 µg L⁻¹ for 2,4-D and Triclopyr; 50 µg L⁻¹ for copper

Copper and 2,4-D residues degraded rapidly after treatment

Results

• Eurasian watermilfoil biomass was similar (p=0.94) among all treatment sites during pretreatment sampling
• Eurasian watermilfoil biomass was less (p<0.01) 10 WAT
• By 10 WAT there was no difference (p=0.39) in Eurasian watermilfoil biomass between treatment sites

Results

• Achieved faster knock down of Eurasian watermilfoil with the copper combination
• No adverse impacts to the native plant community at 10 WAT
Study Conclusions

- Based on short-term results (10 weeks) the use of Cutrine Ultra® or Phycomycin® SCP in combination with Navitrol® and Navigate® can enhance control of Eurasian watermilfoil
- The removal of Eurasian watermilfoil from large areas of Long Lake allowed for native species to re-colonize areas of the lake that were dominated by Eurasian watermilfoil
- There was an increase in native plant biomass and native species richness (particularly monocotyledon species)

Summary

- Our goal is to develop new products based on sound science
  - By evaluation at multiple scales to develop reliable formulations and use patterns
- Offer our customers reliable products with reliable recommendations
Tuesday, May 6, 2014 – 10:52AM

SESSION 2: PESTICIDE LABEL UPDATES

“Label Updates from DuPont”
Dupont Land Management
Dan Mixson
4771 Bayou Blvd PMB-298
Pensacola, FL 32503
850-982-3836
william.d.mixson@dupont.com

The tools land managers need to help protect the safety of everyday life

DuPont™Viewpoint™
DuPont™Streamline™
DuPont™Perspective™

Results of Research and Development Plots
Central & South Florida

Brazilian Pepper
Melaleuca
Australian Pine
Leadtree
Old World Climbing Fern

Label Updates
Legacy
Brands

Stewardship Learning Series

landmanagement.dupont.com/stewardship
Tuesday, May 6, 2014 – 11:04AM

SESSION 2: PESTICIDE LABEL UPDATES

“Label Updates from Winfield Solutions”
Who Is WinField?

- Full-service chemical distributor
- Nationwide coverage

Marketing Update

- Brace name change to Syndetic
- Destiny HC name change to Atmos
- Level 7 name change to Breeze
- Silken name change to Aircover
- Class Act name change to AirTech
- Inergy name change to Turbulence

WinField Adjuvants – labeled for Aquatics

<table>
<thead>
<tr>
<th>Cornsorb™</th>
<th>Fast Break</th>
<th>Anti-Foam</th>
<th>Adjuvancy</th>
<th>Spreading</th>
<th>Humectancy</th>
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<tbody>
<tr>
<td>Aqua-King Plus™</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>AirCover™</td>
<td>Y</td>
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<td></td>
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<tr>
<td>Atmos™</td>
<td>Y</td>
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<td>Turbulence™</td>
<td>Y</td>
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<td>AirTech™</td>
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<td>Droplex™</td>
<td>Y</td>
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<td>Syndetic</td>
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<tr>
<td>Fast Break</td>
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</tr>
<tr>
<td>ProTank</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cornsorb™ technology

- Patented technology
- Corn syrup – surfactant blend
- Shown to increase uptake of product applied
- Helps expand pores to allow more product in
- Provides some spreading ability
- Helps with adhesion
Adjuvant Selection

- **Adverse** Environment
- **Previous** Spray Conditions
- **Turbulence** + AirTech
- **Atmos**
- **Aqua-King Plus + Aircover**
- **Aqua-King Plus**
- **Breeze**
- **AirTech**
- **AirCover**

% Weed Control

Reference charts

Mystic® Lake Dyes

- Blue and black liquid formulations
- Safe for wildlife and plants
- Water can be used for irrigation
- Do not apply to flowing water
- Will stain skin, clothing, equipment, etc.
- Rate: 4-16 fl oz per ac-ft
- 1 gallon size

Rugged™ Herbicide

- 2,4-D Acid (unique formulation)
- 3.49 lb ai/gallon
- Non-volatile
- Low odor
- Performance ≥ 2,4-D Amine, = Esters
- Provides post-emergent control of broadleaf weeds
- Mixes well with liquid fertilizers
- Labeled for turf, veg management, & aquatic uses

Committed to Research

- Evaluation of Breeze® (Level 7) and Rugged® on Water Hyacinth, Alligatorweed, Taro weed. Internal Study. Florida. 2013.

WinField Solutions, Service, Insights
Tuesday, May 6, 2014 – 11:28AM

SESSION 2: PESTICIDE LABEL UPDATES

“Label Updates with NuFarm/Valent”
Nufarm Product Portfolio Update

Bo Burns
National Aquatic Key Accounts Manager &
South East IVM Territory Manager

Valent and Nufarm Join Forces

Valent Corporation signed a formal agreement with Nufarm Americas giving them exclusive distributorship of its products. All of Valent’s Professional Products, including its aquatic products Clipper and Tradewind will now be sold by Nufarm.

Territory Managers
Growing Better Every Day!

Valent Corporation's growing forces are at work across the United States. Bo Burns, National Aquatic Key Accounts Manager, is committed to helping our valued customers and dealers grow their business. To learn more about Bo and the Nufarm sales team visit boburns@valent.com.

Aquatic Products

Nufarm Aquatic Products

Aquatic Neat Herbicide

Aqua Neat® contains glyphosate, the active ingredient used in AquaMaster®.
What the heck is Aquasweep?

- Aquasweep the first combination product fully labeled for Aquatics, R & P, Right of way, turf as well as terrestrial uses.
- An off shoot of Turflon II Amine from Riverdale early 90’s.
- A premier example of what Nufarm does best, combine actives, surfactants and emulsifiers to make better, safer, broader spectrum products.
- Nufarm was the first company to make a hard water formulation 2,4-D, (Weedestroy AM-40.)

Aquasweep™

- Advantages using Aquasweep.
  - Very versatile label. Can apply from top of a mountain to the bottom of a lake.
  - Peace of mind during selective weeding applications that are interspersed with aquatic and wetland areas
  - Easy on grasses. Selective mode of action. When controlling Purple Loosestrife, Salt Cedar, Russian Olive etc. grasses re-populate the area vacated by invaders providing competition.
  - Great tank mix partner.
  - AS ALWAYS coverage is important.
  - Updating label species.

Aquasweep™

- Terrestrial Use sites such as:
  - Pasture and Rangeland
  - Roadsides
  - Rights-of-Way
  - Non-crop areas
  - Fencerows
  - Non-irrigation ditchbanks
  - Turf, golf & sod farms

- Aquatic Use sites such as:
  - Ponds/Lakes/Reservoirs
  - Marshes/Bayous
  - Non-irrigation canals and ditches
  - Seasonal irrigation canals and ditches
  - Impounded rivers and streams

Salt Cedar

What we saw in August

Aquasweep applied at 2 qt./Acre
+1 qt/100 gal Liberate
Thank You!  
Bo Burns 919-605-8016  
Bo.burns@us.nufarm.com
Tuesday, May 6, 2014 – 1:00PM

SESSION 3: PESTICIDE SAFETY

“Safe Transportation of Pesticides”

Fred Whitford
Purdue University
Keep the Trailer Connected to the Truck
Understanding the “Hitch” System
Tuesday, May 6, 2014 – 1:50PM

SESSION 3: PESTICIDE SAFETY

“Toxicity Categories of Herbicides”

Fred Fishel
University of Florida/IFAS
Pesticide Information Office
Toxicity Categories of Herbicides

Fred Fishel
Professor, UF/IFAS Agronomy

Outline

• History
  – Where we were and how we got here
• Toxicity testing
• Toxicity of herbicides and surfactant study
• Exposure and exposure study
• Storage and the 3-year old

Paracelsus (1493 – 1541)

Swiss physician, botanist, astrologer, alchemist, etc...

“All things are poison, and nothing is without poison; only the dose permits something not to be poisonous.”

Or, more commonly

“The dose makes the poison.”

Poison Ivy Control

New Jersey Agricultural Experiment Station Circular 206 (1927)

• “Iron or copper sulfate used at a rate of ½ to ¾ pound to 1 quart of water, and arsenate of soda used at the rate of 1 ounce to 6 quarts of water”
• “For applications to be made on the soil for the purpose of destroying root parts, common salt may be used – 8 ounces/ft²”
  – 10.9 tons per acre

Myth or Reality?

• Herbicides have been seen as toxins that poison plants and are equally harmful to the applicator.
Poison Ivy Control

New Jersey Agricultural Experiment Station Circular 206 (1927)

• “Arsenate of soda is a dangerous poison…”
• “Under no circumstances should he (applicator) permit any of the material to get into his mouth or nose. This danger can be overcome by wearing a small wet sponge or fine piece of cloth over the nose while working the sprayer.”

Poison Ivy Control

New Jersey Agricultural Experiment Station Circular 206 (1927)

• “Oils of various kinds are also excellent weed exterminators. Kerosene or waste oil from garages…”
• “…oils of this kind should not be used around buildings.”

Poison Ivy Control

New Jersey Agricultural Experiment Station Circular 206 (1927)

• “Sulfuric, hydrochloric and nitric acids are positively destructive to the plant.”
• “...care must be exercised in their use, for they will burn clothing and flesh instantly. They will also result in blindness if spattered into the eyes.”

Poison Ivy Control

New Jersey Agricultural Experiment Station Circular 206 (1927)

• “Sodium arsenite, an effective chemical for poison ivy destruction, is not ordinarily purchased in ready-made form.”
• “A chemical formula which has proven valuable is 4 ounces of caustic soda and 8 ounces of white arsenic dissolved in 1 pint of water.”...”The water should be added slowly to the mixture and stirred constantly because of the heat developed.”...”About 1 pint to 10 ft² would seem a fair estimate.”
  - 544.5 gallons/acre

Sulfuric Acid Spray: A practical means for the control of weeds

University of Arizona Experiment Station (1928)

• 2 to 15% solution of sulfuric acid used, depending on species and size, which costs between $0.60 and $4.50 per acre at 200 gallons solution per acre

Killing field bindweed with sodium chlorate

Kansas State Agricultural College Circular 136 (1928)

• Salt
  – 20 tons per acre
• K.M.G. weed killer (sodium chlorate plus calcium chlorate)
  – 100 pounds in 100 gallons water per acre
The Control of Weeds

California Agricultural Extension Service Circular 54 (1931)

- According to San Joaquin County Agricultural Commissioner data, 2 men with power sprayer cover 10 acres in 8 hours with 3,000 gallons oil.
  - Costs: oil at 3.75 cents per gallon
  - Labor: $10 per day
  - Total cost per acre including depreciation: $12.25

- Chlorates are fire hazard (oxidizer)
  - “Clothing, chaff, straw, sacks, wood, etc., covered with chlorate will readily ignite when dry.”
  - “Ashes from smoking tobacco, a match thoughtlessly lighted, or a spark from an exhaust pipe of spray equipment may set a fire.”
  - “Men should not work alone when using chlorates.”

The Control of Weeds

California Agricultural Extension Service Circular 54 (1931)

- Chlorate is particularly combustible with sulfur
- Accidents more likely after spraying and clothes dry
  - “This danger can be eliminated by having two pairs of overalls.”
  - “Operators of chlorate sprays sometimes wear rubber boots.”

Insecticide Use

- Dutch Elm Disease (vectored by several beetles)
  - 3-5 lbs per tree (DDT or dieldrin)
  - 30-50 lbs per acre (DDT or dieldrin)
- Fire Ant Eradication
  - Million + acres/year
  - 1-2 lbs per acre (heptachlor and mirex)

Regulation Pre-1970

- By U.S. Department of Agriculture and Food and Drug Administration
- Legal to use any registered pesticide for any pest even if site and pest were not on the label
- Fisheries, Wildlife, Parks, Forestry, public health and other affected persons not represented (Environmentalists)
Advancing Technology

- 2,4-D
- 2,4,5-T + 2,4-D = Agent Orange

Advancing Technology

- 1200 BC: Biblical armies use salt and ash
- 1896: copper sulfate for weed control in grain fields
- 1942: 2,4-D
- 1944: 2,4,5-T
- 1958: atrazine and paraquat
- 1960: trifluralin
- 1971: glyphosate
- 1979: sulfonylureas

Weed control technology has advanced more since 1942 than in the previous million years!

Environmental Awareness Era

- Paul Müller: DDT (1939)

Advancing Technology

- Publication of Silent Spring, by Rachel Carson in 1962, created an awareness of pesticide misuse

Environmental Awareness Era

- Silent Spring
  - Leaves, soil, earthworms, birds
  - Overspray salmon streams, toxicity to insects
  - Broadcast spraying, bees, desirable insects, etc.
  - Eggshell thinning, endocrine disruption, resistance

U.S. Secretary of Agric. Ezra Taft Benson in a letter to President Dwight D. Eisenhower: concluded that because Carson was unmarried despite being physically attractive, she was “probably a Communist.”

Environmental Awareness Era

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Use</th>
<th>LD₅₀ (rat)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDT</td>
<td>Insecticide – flies, mosquitoes, ag insects &amp; rodents, etc.</td>
<td>87</td>
</tr>
<tr>
<td>Endrin</td>
<td>Insecticide – ag insects &amp; rodents</td>
<td>3</td>
</tr>
<tr>
<td>Mirex</td>
<td>Insecticide – fire ants</td>
<td>235</td>
</tr>
<tr>
<td>Chlordane</td>
<td>Insecticide – soil-borne insects (termites)</td>
<td>283</td>
</tr>
<tr>
<td>Heptachlor</td>
<td>Insecticide – soil-borne insects (termites)</td>
<td>40</td>
</tr>
<tr>
<td>Dieldrin</td>
<td>Herbicide</td>
<td>39</td>
</tr>
<tr>
<td>Aldrin</td>
<td>Herbicide</td>
<td>37</td>
</tr>
<tr>
<td>Dinosyl</td>
<td>Herbicide</td>
<td>375</td>
</tr>
<tr>
<td>2,4-D</td>
<td>Herbicide</td>
<td>375</td>
</tr>
</tbody>
</table>
Environmental Awareness Era

- Silent Spring
  - Never advocated a complete ban of all pesticides
  - Encouraged responsible and carefully managed use with an awareness of the chemicals’ impact on the entire ecosystem
  - Advised for spraying as little as possible to limit the development of resistance

Environmental Awareness Era

- FIFRA amended (1972)
  - Essentially rewritten
  - Mandates that EPA regulate the use and sale of pesticides
  - Strengthens the registration process by shifting the burden of proof to the chemical manufacturer (140 – 150 tests required to pass registration)
  - Enforce compliance against banned and unregistered products
  - Established an applicator education/licensing program
  - Each state given authority to enforce

Environmental Awareness Era

<table>
<thead>
<tr>
<th>THEN (Carson’s concerns)</th>
<th>NOW (EPA answers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadcast</td>
<td>Directed, spot</td>
</tr>
<tr>
<td>High Rate (gal, lb)</td>
<td>¼ oz/acre, 5-10 ppb</td>
</tr>
<tr>
<td>Persistent (mos, yrs)</td>
<td>Hours, days, weeks</td>
</tr>
<tr>
<td>Bioaccumulate</td>
<td>Not likely to be approved</td>
</tr>
<tr>
<td>Unknown effects</td>
<td>Much less likely</td>
</tr>
<tr>
<td>Untrained applicators</td>
<td>2,500 Florida Certified (Aquatic)</td>
</tr>
</tbody>
</table>

Food Quality Protection Act of 1996

- Significantly amended FIFRA and FFDCA
- Emphasized safety for infants and children
  - EPA adds 10x safety factor to tolerance settings for protection of infants and children

Testing Requirements for Registration

- Efficacy:
  - High degree of biological efficacy
  - Broad spectrum of efficacy
  - Good plant compatibility
  - Low risk for resistance development
- User friendly:
  - Low acute and chronic toxicity
  - Good formulation qualities
  - Easy to handle
  - Low application rate
  - Good storage stability
- Environmental profile:
  - Low toxicity to non-target organisms
  - Sufficient degradation in soil
  - Low leaching
  - No significant residues in food and animal feed
- Economy:
  - Favorable cost/benefit ratio
  - Competitiveness
  - Broad spectrum of uses
  - Patentability

The registration cost is $152 - $256 million per product – 1 in 139,000 make it.
The Development of Sonar

- 1974-75: Discovery
  - EUP granted in 1980 and fully registered in 1985!
- 1975-76: C14 nature in plants
- 1975-77: Acute toxicity
- 1975-76: Subchronic toxicity
- 1976-83: Efficacy and use patterns for aquatics
- 1975-78: Chronic toxicity/oncogenicity studies
- 1976-83: Efficacy and use patterns for aquatics
- 1975-78: Soil metabolism studies
- 1975-79: C14 soil metabolism studies
- 1975-77: Acute to toxicology
- 1976-77: Subchronic toxicology
- 1976-83: Chronic toxicology
- 1978-79: C14 animal metabolism studies
- 1978-80: Residue studies in potable water and mutagenicity studies
- 1978-81: Avian, aquatic, and nontarget organism toxicity
- 1979-80: Reproduction/teratology studies
- 1978-81: Residue studies in fish, livestock, poultry, milk, and eggs
- 1978-80: Residue studies in plants and irrigated crops
- 1979-80: Residue in potable water and mutagenicity studies
- 1978-85: Residue studies in fish, livestock, poultry, milk, and eggs

Toxicity

- The ability of a substance to produce adverse effects
  - Range from slight symptoms such as headaches to severe symptoms like coma, convulsions, or death
  - Most toxic effects are naturally reversible and do not cause permanent damage if prompt medical treatment is sought
  - Some cause irreversible (permanent) damage

Toxicity Testing

- All new pesticides are tested to establish the type of toxicity and the dose necessary to produce a measurable toxic reaction
- Testing is done with animals and plants
  - Generally in mice, rats, rabbits, and dogs
  - Results are used to predict the safety to humans

Toxicity Testing

- Toxicity tests are based on two premises
  1. Information about toxicity in animals can be used to predict toxicity in human
  2. Exposing animals to large doses of a chemical for short periods of time can predict human toxicity from exposure to small doses for long periods of time
- Both premises have been questioned

Toxicity Testing

- NOEL = no observed effect level
- LOEL = lowest observed effect level
- Plateau = level where there’s no increase in response
Toxicity Testing

- No single dose-response curve can describe the entire range of toxicological responses exhibited by an experimental animal
- End points may be indirect indicators of toxicity such as observations in behavior or food consumption patterns
- The dose required to produce a given effect (end point) may vary, depending on the pesticide

Toxicity

<table>
<thead>
<tr>
<th>LC50: common term to describe lethal concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Used with aquatic herbicides since fish and aquatic organisms are in direct contact with water</td>
</tr>
<tr>
<td>Test organisms are exposed for 96 hours</td>
</tr>
<tr>
<td>Commonly conducted with bluegill</td>
</tr>
<tr>
<td>LC50 = lethal concentration of herbicide to 50% of the test population</td>
</tr>
<tr>
<td>Measured in mg/l (ppm)</td>
</tr>
</tbody>
</table>

High Toxicity = Low LC50

Toxicity (Submersed Herbicides)

<table>
<thead>
<tr>
<th>LC50 (Mg/L)</th>
<th>Use Rate (ppm)</th>
<th>Safety Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diquat</td>
<td>14</td>
<td>0.4</td>
</tr>
<tr>
<td>Fluridone</td>
<td>14</td>
<td>0.02</td>
</tr>
<tr>
<td>Flumioxazin</td>
<td>&gt;21</td>
<td>0.4</td>
</tr>
<tr>
<td>Copper Sulfate</td>
<td>Variable</td>
<td>1.0</td>
</tr>
<tr>
<td>Endothing Amine</td>
<td>&gt;0.8</td>
<td>0.5-2</td>
</tr>
<tr>
<td>Endothing K Amine</td>
<td>1071</td>
<td>3</td>
</tr>
</tbody>
</table>

What the Heck is a Daphnia?

- Planktonic crustacean
- Aka water flea
- Eats algae
- Indicator species to test the effects of toxins
Toxicity of Surfactants to Bluegill

- Interest in aquatic use adjuvants initiated when Rodeo was introduced by Monsanto in early 1980s
- Label instructed user to add nonionic surfactant of user’s choice
- 96-hr bioassay in controlled conditions for 19 adjuvants
- Conducted in 7 l of aerated well water
- Adjuvants introduced 24-hr prior to fish
- 10 fish added per aquarium
- LC50 values calculated


<table>
<thead>
<tr>
<th>Product</th>
<th>Class</th>
<th>LC50 (Mg/L)</th>
<th>Safety Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON 0818</td>
<td>Tallow Amine</td>
<td>1.6</td>
<td>NA</td>
</tr>
<tr>
<td>Optima</td>
<td>Alcohol/Glycol</td>
<td>8.6</td>
<td>9X</td>
</tr>
<tr>
<td>Induce</td>
<td></td>
<td>9.0</td>
<td>19X</td>
</tr>
<tr>
<td>Timberland</td>
<td></td>
<td>9.6</td>
<td>20X</td>
</tr>
<tr>
<td>Cide-Kick</td>
<td>Limonene</td>
<td>10.2</td>
<td>6X</td>
</tr>
<tr>
<td>Sillenergy</td>
<td></td>
<td>18</td>
<td>38X</td>
</tr>
<tr>
<td>Kinetic</td>
<td>Silicone</td>
<td>20</td>
<td>42X</td>
</tr>
<tr>
<td>Dynamic</td>
<td></td>
<td>27</td>
<td>38X</td>
</tr>
<tr>
<td>Freeway</td>
<td></td>
<td>30</td>
<td>63X</td>
</tr>
<tr>
<td>Sunwet</td>
<td>MSO</td>
<td>53</td>
<td>113X</td>
</tr>
</tbody>
</table>

Assumptions:
- Maximum Label Rate 3.3 ft (1M) of water

Acute Toxicity

- LD50: common term to describe acute oral toxicity
- Acute toxicity tests measure mortality following a single exposure
- LD50: dose that’s acutely lethal to 50% of the test population of animals

LD50 values for a single chemical can vary by:
- Route of exposure
- Test species

Dichlorvos LD50

- Oral LD50 (rat) 75 mg/kg
- Dermal LD50 (rat) 15 mg/kg
- Inhalation LD50 (rat) 1.7 ppm
- Oral LD50 (rabbit) 10 mg/kg
- Oral LD50 (pigeon) 23.7 mg/kg
- Oral LD50 (dog) 100 mg/kg
- Oral LD50 (pig) 157 mg/kg

Dichlorvos is an insecticide commonly used in household pesticide strips

Acute Toxicity

- LD50 of 500 mg/kg is less toxic than LD50 of 5 mg/kg
- 1 kg = 1,000 g = 2.2 lb
- 1 mg = 0.001 kg = 0.0022 lb
- Mg/kg = ppm
- 1 ppm = 1 inch in 16 miles or 1 minute in 2 years

Acute Toxicity

Toxicity of Surfactants to Bluegill

Surfactant summary by chemical group

<table>
<thead>
<tr>
<th>Surfactant Group</th>
<th>LC50 (Mg/L) Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tallow Amines</td>
<td>1-3 ppm</td>
</tr>
<tr>
<td>Alcohol Glycols</td>
<td>4-10 ppm</td>
</tr>
<tr>
<td>Silicones</td>
<td>10-30 ppm</td>
</tr>
<tr>
<td>Meth Seed</td>
<td>50-60 ppm</td>
</tr>
<tr>
<td>Acids/Buffers</td>
<td>100-200 ppm</td>
</tr>
</tbody>
</table>

### Acute Toxicity

<table>
<thead>
<tr>
<th>Categories of Acute Toxicity</th>
<th>LD_{50} Oral (mg/kg)</th>
<th>LD_{50} Dermal (mg/kg)</th>
<th>LD_{50} Inhale (mg/l)</th>
<th>Oral Lethal Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Highly toxic</td>
<td>DANGER, POISON</td>
<td>0 to 50</td>
<td>0 to 200</td>
<td>0 to 0.2</td>
</tr>
<tr>
<td>II Moderately toxic</td>
<td>WARNING</td>
<td>50 to 500</td>
<td>200 to 2,000</td>
<td>0.2 to 2.0</td>
</tr>
<tr>
<td>III Slightly toxic</td>
<td>CAUTION</td>
<td>500 to 5,000</td>
<td>2,000 to 20,000</td>
<td>2.0 to 20</td>
</tr>
<tr>
<td>IV Relatively non-toxic</td>
<td>CAUTION (or no signal word)</td>
<td>5,000+</td>
<td>20,000+</td>
<td>20+</td>
</tr>
</tbody>
</table>

*Probable for a 150 pound person.

### How Do Herbicides Work?

- They inhibit essential plant process:
  - Photosynthesis
  - Chlorophyll
  - Certain amino acids
  - Cell wall

### Acute Toxicity Determines PPE

<table>
<thead>
<tr>
<th>Substance</th>
<th>Acute oral LD_{50} (rat)</th>
<th>Route oral LD_{50} (rat)/signal word</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nicotine</td>
<td>9</td>
<td>182/DANGER*</td>
</tr>
<tr>
<td>Caffeine</td>
<td>192</td>
<td>1,000/CAUTION</td>
</tr>
<tr>
<td>Bleach</td>
<td>192</td>
<td>2,000/CAUTION</td>
</tr>
<tr>
<td>Aspirin</td>
<td>200</td>
<td>2,574/DANGER*</td>
</tr>
<tr>
<td>Tylenol</td>
<td>318</td>
<td>5,000/CAUTION</td>
</tr>
<tr>
<td>Codeine</td>
<td>427</td>
<td>10,000/CAUTION</td>
</tr>
<tr>
<td>Table salt</td>
<td>3,000</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Substance</th>
<th>Route of Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquathol K (endothall potassium salt)</td>
<td>182/DANGER*</td>
</tr>
<tr>
<td>Weedar (2,4-D)</td>
<td>&gt;1,000/DANGER*</td>
</tr>
<tr>
<td>Captain (copper carbonate)</td>
<td>&gt;1,000/CAUTION</td>
</tr>
<tr>
<td>Oasites</td>
<td>&gt;2,000/CAUTION</td>
</tr>
<tr>
<td>Renovate (triclopyr)</td>
<td>2,574/DANGER*</td>
</tr>
<tr>
<td>Tradewind (bispyr/bac sodium)</td>
<td>11,111/male/CAUTION</td>
</tr>
<tr>
<td>Habitat (measapry)</td>
<td>&gt;5,000/CAUTION</td>
</tr>
<tr>
<td>Galion (pencicarium)</td>
<td>&gt;5,000/CAUTION</td>
</tr>
<tr>
<td>Clearcast (mazamaz)</td>
<td>&gt;5,000/CAUTION</td>
</tr>
<tr>
<td>Clipper (flumioxazin)</td>
<td>&gt;5,000/CAUTION</td>
</tr>
<tr>
<td>Rodeo (glyphosate)</td>
<td>5,600/CAUTION</td>
</tr>
<tr>
<td>Sonar AS (fluridone)</td>
<td>&gt;10,000/CAUTION</td>
</tr>
<tr>
<td>Corrosive</td>
<td></td>
</tr>
</tbody>
</table>

### Most Acute Reported Pesticide Illnesses to a Single Substance (2005-09)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Pesticide category</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pyrethroids</td>
<td>1,368</td>
<td>22.1</td>
</tr>
<tr>
<td>2</td>
<td>Chlorinated compounds</td>
<td>1,174</td>
<td>19.0</td>
</tr>
<tr>
<td>3</td>
<td>Organophosphates</td>
<td>600</td>
<td>9.7</td>
</tr>
<tr>
<td>4</td>
<td>Pyrethrin</td>
<td>358</td>
<td>5.8</td>
</tr>
<tr>
<td>5</td>
<td>DEET</td>
<td>292</td>
<td>4.7</td>
</tr>
<tr>
<td>6</td>
<td>Glyphosate</td>
<td>274</td>
<td>4.4</td>
</tr>
<tr>
<td>7</td>
<td>Carbamates</td>
<td>249</td>
<td>4.0</td>
</tr>
<tr>
<td>8</td>
<td>Triazines</td>
<td>168</td>
<td>2.7</td>
</tr>
<tr>
<td>9</td>
<td>Sulfur compounds</td>
<td>145</td>
<td>2.3</td>
</tr>
<tr>
<td>10</td>
<td>Ammonium/ammonia</td>
<td>32</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>6,187</td>
<td></td>
</tr>
</tbody>
</table>

### The LD_{50} Determines...

**PPE**
- Signal Word
- Precautionary Statements
- First Aid
Rat Oral LD₅₀ Values of Most Commonly-Applied Pesticides in Florida

<table>
<thead>
<tr>
<th>Insecticide active ingredient (LD₅₀)</th>
<th>Herbicide active ingredient (LD₅₀)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petroleum oils (&gt;5,000)</td>
<td>1. Glyphosate – isopropylamine salt (5,600)</td>
</tr>
<tr>
<td>Aldicarb (0.9)</td>
<td>2. Diamuron (&gt;5,000)</td>
</tr>
<tr>
<td>Carbaryl (150)</td>
<td>3. Simazine (&gt;5,000)</td>
</tr>
<tr>
<td>Endosulfan (18)</td>
<td>4. Sulfosate (750)</td>
</tr>
<tr>
<td>Sulfur (&gt;2,200)</td>
<td>5. Bromacil (5,200)</td>
</tr>
<tr>
<td>Methomyl (30)</td>
<td>6. Triclopyr (713)</td>
</tr>
<tr>
<td>Chlorpyrifos (96)</td>
<td>7. Pendimethalin (1,050)</td>
</tr>
<tr>
<td>Fenpropathrin (70.6)</td>
<td>8. Atrazine (1,869)</td>
</tr>
<tr>
<td>Imidacloprid (424)</td>
<td>9. Paraquat (150)</td>
</tr>
<tr>
<td>2,4-D (375)</td>
<td>10. 2,4-D (375)</td>
</tr>
</tbody>
</table>

Average LD₅₀: 859
Average LD₅₀: 2,571

Routes of Exposure
- Oral
  - Dietary
  - Drinking water
  - Hand to mouth
- Dermal
  - Occupational
  - Residential
  - Recreational
- Inhalation
- Eyes

Routes of Dermal Exposure
- Forehead
- Ear canal
- Genitalia
- Abdomen
- Forearm
- Scalp
- Ball of foot
- Palm of hands

I spray herbicides every day.... What is my exposure if I do everything correctly?

Smith, J.D. and H. Pullum. 1994. Air Monitoring of 2,4-D and Diquat Used in Aquatic Plant Control Programs. Aquatics 16(1):14-16

Air Monitoring of 2,4-D and Diquat Used in Aquatic Plant Control Programs
- Methods.....
  - 5 independent tests (2,4-D and diquat)
  - Conducted: Okeechobee, Clewiston, and Kissimmee
  - Glass filter on Tyvek lapels of both airboat driver and applicator
  - Suction pump air flow rate of 1 to 3 L/min (NIOSH 2,4-D test protocol standard)
  - OSHA test protocol used for diquat
  - Tested for 2 to 6+ hours

Air Monitoring of 2,4-D and Diquat Used in Aquatic Plant Control Programs
- 2,4-D

<table>
<thead>
<tr>
<th>Person</th>
<th>Hours Exposed</th>
<th>Conc. (Mg/Cu.M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprayer</td>
<td>6.5</td>
<td>&lt;0.04 (40ppt)</td>
</tr>
<tr>
<td>Driver</td>
<td>4.9</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Driver</td>
<td>4.4</td>
<td>&lt;0.07</td>
</tr>
<tr>
<td>Driver</td>
<td>6.5</td>
<td>&lt;0.04</td>
</tr>
<tr>
<td>Sprayer</td>
<td>4.5</td>
<td>BDL</td>
</tr>
<tr>
<td>Sprayer</td>
<td>4.5</td>
<td>BDL</td>
</tr>
</tbody>
</table>

Air Monitoring of 2,4-D and Diquat Used in Aquatic Plant Control Programs

<table>
<thead>
<tr>
<th></th>
<th>Person</th>
<th>Hours Exposed</th>
<th>Conc. (Mg/Cu.M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diquat</td>
<td>Sprayer</td>
<td>4.7</td>
<td>BDL</td>
</tr>
<tr>
<td></td>
<td>Driver</td>
<td>4.7</td>
<td>BDL</td>
</tr>
<tr>
<td></td>
<td>Sprayer</td>
<td>2.3</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td></td>
<td>Driver</td>
<td>7.0</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>Sprayer</td>
<td>6.6</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>Driver</td>
<td>6.5</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

2,4-D

<table>
<thead>
<tr>
<th></th>
<th>Person</th>
<th>Avg. Conc. (Mg/Cu.M)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Driver</td>
<td>&lt;0.06</td>
</tr>
<tr>
<td></td>
<td>Sprayer</td>
<td>&lt;0.06</td>
</tr>
</tbody>
</table>

OSHA Permissible Exposure Limit = 10 (Mg/Cu.M) (SF = 166X)

Diquat

<table>
<thead>
<tr>
<th></th>
<th>Person</th>
<th>Avg. Conc. (Mg/Cu.M)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Driver</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td></td>
<td>Sprayer</td>
<td>&lt;0.02</td>
</tr>
</tbody>
</table>

OSHA Permissible Exposure Limit = 0.5 (Mg/Cu.M) (SF = 25X)

Why such low exposure?
- Spray concentration <1% (<1gallon/100gallons)
- Spray directed from side of boat at idle speed
- Prevailing wind and idle speed combined to create a dilution/ventilation system to pull mist away from the breathing zone

Mitigating Exposure: Aquatic Herbicides

Regardless of pesticide risk – storage is the same for all

Consider these.....
- Would you ever store herbicides, even those with Caution labels, within reach of children?
- Would you ever allow pesticides near where you prepare food?
Under the kitchen sink at Jay Ferrell's house

What's the difference in these?

- Restricted use
- Must be licensed and trained to purchase
- Stored behind locked door with vent fan

- Anyone can purchase
- Can be stored anywhere

In your laundry room.....

In the garage at Jay Ferrell's house

National Poison Control Centers Summary (2012)

All Ages
- 2.3 million calls total
  - 69,000 Pesticides Total (3%)

Children 0-3 years old
- 973,000 Total Calls (43%)
  - 157,000 Cosmetics (15%)
  - 104,000 Pain Killers (10%)
  - 107,000 Household chemical (10%)
  - 36,000 Pesticides (3.4%)
Summary

• Risk = f(Toxicity x Exposure)
• Don’t get complacent

Point is this:
We are surrounded by “toxins”
Pesticides have greatly changed

*Train or have trained employees
*Provide PPE
*Store pesticides properly
*Emphasize use according to labeling
*Re-think household chemical storage

Thanks for your attention!
Tuesday, May 6, 2014 – 3:35PM

SESSION 4: LARGE-SCALE MANAGEMENT

“Weed Control in the Santee Cooper System”

Larry McCord
Santee Cooper Power
1940s

By 1943, invasive plant control began on the reservoir system. Alligatorweed (Alternanthera philoxeroides), an invasive aquatic plant native to South America had infested much of the shoreline of the system. The plant had previously infested ponds and rivers that would become part of the Santee Cooper system. Since 1980s acres were present in the reservoir in 1943 and by 1944 approximately 21,400 acres were infested. Initial control efforts involved a total application of alcohol fuel, which was commonplace during the period.

The herbicide 2,4,5-D was used during the period, however, due to its target crop damage and overall lack of effective control the use of the herbicide was discontinued in 1951.

Alligatorweed continued to be the primary aquatic plant problem until the 1960s.

1950s

From 1953 through 1958, very little aquatic plant control was performed on the Santee Cooper lakes, primarily due to the lack of appropriate herbicides. Alligatorweed control efforts did continue on a smaller scale with mechanical control by hand digging. In 1956, Santee Cooper did treat a large colony of Water hyacinth (Eichhornia crassipes) in Sumter County. This was the first of many aquatic plant control operations outside of the project boundary due to their proximity and threat to the lakes. Due directly to Santee Cooper’s efforts, Water hyacinth, Water chestnut and Alligatorweed were listed on the State’s new legislation controlling noxious weeds in 1958. In 1958, Santee Cooper was approached by the US Army Corps of Engineers and advised that funding for aquatic weed control under the Flood Control Act might be available. An agreement was finalized with the Corps in 1959, and a funding agreement was signed with the Corps in 1960. Santee Cooper’s General Manager at the time stated: “The age of miracles not having fully passed, Santee Cooper has reached an agreement with the Corps of Engineers to begin an attempt to reduce Alligatorweed growth in our project waters.”

1960s

During the 1960s, new invasive species found their way into the Santee Cooper lake system. Water primrose (Ludwigia sp.) was accidentally introduced into Lake Marion in 1966. The problem was discovered in 1967, and within the next few years, Santee Cooper and the US Army Corps of Engineers proved to be very beneficial to invasive plant control on the Santee Cooper system and a great credit to the state. A total of $220,000 was spent on control efforts targeted at invasive plants like Water chestnut and Water hyacinth. Control efforts proved very successful in reducing the number of invasive species in the Santee Cooper system. The project of water management and ecosystem health was a key factor in the reduction of invasive species in the project area. The success of these efforts proved critical in the control of invasive species in the Santee Cooper system.

1970s

Invasive species continued to be a major invasive species planted in the system during the 1970s. Due to the rapid spread of the plant, Santee Cooper resaenaciously petitioned the US Army Corps of Engineers on July 23, 1974, to add the plant to the list of noxious aquatic weeds under control. This petition was denied by the Corps. However, in 1987, the South Carolina General Assembly passed a bill extending liability to the Corps for Santee Cooper's petition. In 1988, the Corps responded by petitioning the state for a permit to control the plant. The permit was granted, and in 1989, the Corps began control efforts. The effort was successful in reducing the number of invasive species in the Santee Cooper system. The project of water management and ecosystem health was a key factor in the reduction of invasive species in the Santee Cooper system.
1980s

In 1981, the Santee Cooper Reservoir, known as Lake Marion in local folklore, was completed after a $75 million dollar investment. This project was significant as it marked the beginning of the conditionally sanctioned South Carolina Aquatic Plant Management Council. In 1982, an additional $30,000 was obtained from the same source. In both years, the funds were used for control of Brazilian elodea. In 1982, two significant events took place on the Santee Cooper system. First, Hydrilla (Hydrilla verticillata) was discovered growing in Lake Marion. As a result, the Santee Cooper Board of Directors approved an additional $30,000 for aquatic plant management programs in Lake Marion. In 1983, Santee Cooper received $11,000 from the Corps of Engineers through the NC Aquatic Plant Management Council for control efforts against Brazilian elodea and Hydrilla in the upper reaches of Lake Marion. This marked the first time control efforts were undertaken using aerial application of herbicides to treat submerged vegetation.

1990s

As a result of Hurricane Hugo's direct path through the Santee Cooper system in 1989, numerous fish kills, which included grass carp, occurred in the Hydrilla-infested areas of upper Lake Marion. This loss of grass carp would prompt an additional stocking in upper Lake Marion of 180,000 fish in 1992. Hydrilla tansis were also spread and spread downs streams to all areas of Lake Marion and into the Lake Moultrie.

2000s

During the late 1990s, Water Hyacinth was rapidly spreading in the upper Lake Marion swamp area. By 2000, the plant covered over 2,000 acres. Control efforts using submersed and aerial applications of herbicides were implemented as a result. The Army Corps of Engineers initiated a comprehensive management plan to control Water Hyacinth in Lake Marion. This program focused on research efforts rather than control operations. As a result, the program established a comprehensive research program to study the impact of Water Hyacinth on the ecosystem. The program included studies on the effects of Water Hyacinth on fish populations and the impact of herbicides on the environment.
A new invasive plant was discovered in Lake Marion in 2005. Crested Floating Heart (Nymphoides cristata), an Asian native, was identified in a small cove growing in a very small colony. This would be the first finding of this plant in the US, outside of the state of Florida, where the plant was apparently introduced in the early 1990s. By the end of 2006 it became evident that this plant would continue to spread within the Santee Cooper system.

In 2007 the Southeastern US was again subjected to severe drought, leading to near record low lake elevations which remained into early 2008. Lake elevations fell to 67 feet above sea level, or some 30 feet below full pool elevation. This lake level had not been seen since the mid 1950s.

Although extensive aquatic plant surveys, including aerial photography, had been performed since the mid 1990s, efforts were increased to focus on expansion of native plant communities within the lake system to provide scientific data to support the management plan. Hyperspectral imagery became a component of the annual aquatic plant survey program in 2005. This technology allowed for much improved identification of individual species of plants from aerial photography. Santee Cooper's ability to monitor native vegetation, as well as invasive plants throughout the lake system improved greatly. The aquatic plant surveys conducted in 2005-2006 documented increased presence of hydrilla in the system, leading to maintenance stocking of grass carp in 2007. This would mark the first stocking effort since 1996.

Combined Lakes' Vegetative Cover for Selected Species

Although many thought aquatic plant pneumatics would suffer under these conditions, native submerged plants such as Elodea canadensis and Potamogeton sp. continued to do well. By the end of the 2008 growing season hydrilla had spread to just 880 acres and an estimated 31,695 acres. By the end of 2009 growing season hydrilla had spread to over 890 acres and an estimated 43,619 acres. Early estimates for the area of hydrilla spread by 2009 were 83,740 acres. A water level study conducted in 2010 revealed a water level of 27 feet above mean lower low water in 2010, which is 7 feet higher than in 2009. 2009 was 81.710 feet.

Although other species have been identified in the Santee Cooper Lakes, such as Alethea, Charis (Charis cordiformis), and several species of milfoil – Chinese Nymphaeaceae (Nymphaeaceae spp.) and sustainable (Nymphaeaceae spp.) – control efforts have not yet been required.

No New Invasives – Must be Time to Recycle!
2010 – 2013: Aquatic Plant Management Summary

- Water Hyacinth – 5654 acres treated ........................................... $674,704.83
- Hydrilla – 2899 acres treated .......................................................... $935,387.44
- Crested Floating Heart – 4287 acres treated .............................. $1,466,479.45

† Herbicide Applications Totals – 14,114 acres treated .......... $3,458,498.52
† Grass Carp Stocking – 262,000 fish ............................................... $1,217,820.00

Total Cost for Aquatic Plant Control .............................................. $4,676,118.52
Tuesday, May 6, 2014 – 4:10PM

SESSION 4: LARGE-SCALE MANAGEMENT

“Professionalism and Certified Applicators”

Carlton Layne
Maintaining Professionalism

As a Certified Pesticide Applicator

The Label is the Law

CERTIFICATION

Anyone who uses or supervises the use of a Restricted Use Pesticide

TYPES

Private & Commercial

Commercil Categories

• Agricultural Plant
• Agricultural Animal
• Right-of-Way
• Aquatic
• Forestry
• Industrial

CERTIFICATION REQUIREMENTS

• Practical knowledge of the principles and practices of pest control and the safe use of pesticides
• Labels and labeling comprehension
• Safety
REQUIREMENTS (continued)

- Environmental concerns
- Pest identification
- Pesticides
- Equipment
- Application techniques
- Laws and regulations

FIFRA Section 12(a)(2)(G)

It shall be unlawful for any person to use any pesticide in a manner inconsistent with its labeling.

What is “use”?

- The site of application
- The rate of application
- Instructions for the frequency and timing of applications
- Restrictions and warnings
- Target pest
- Anything else to protect the public

EXCEPTIONS - 2(ee)

- Mixes
- Less than label rate
- Method of Application
- Unnamed target pest

Inspect Your Operation

- Option 1 – Get State inspection forms
- Option 2 – Design your own forms

What do I look for?

- Storage
- Inventory
- Transport
- Disposal
- Cleanout & Washdown area
- Equipment
- PPE
- Labels
- MSDS
- Signs
- Misc.
Recordkeeping

Commercial Applicator Records of use
RUPs
Organo-Auxin Rule (Florida Only)

What's the worse that can happen?

Armageddon

Penalties

- Civil Pesticides - $7,500 (EPA)
- $10,000 (FDACS)
- NPDES - $37,500 (EPA)

- Criminal – Misdemeanor
  1 year in jail and/or $25,000 - $50,000 fine

PPE – What should I wear?

Read the damn label!
Thank You!
Compliments of
Aquatic Ecosystem Restoration Foundation
Wednesday, May 7, 2014 – 8:00AM

SESSION 5A: BIOCONTROL IN AQUATIC SYSTEMS

“Basics of Biocontrol”

Mike Grodowitz
United States Army Corps of Engineers
ERDC
Integrated Pest Management and Biological Control

Michael J. Grodowitz
U.S. Army Engineer Research and Development Center
Vicksburg, MS

Important Questions
- What is IPM?
- What is biocontrol?
- Underlying concepts?
- Safety?
- Effectiveness?
- Integration?
- Players – Agents?
- Future?

What is IPM???

In simple terms:
A procedure to manage pest populations by HARMONIZING all available control methods.

Complement - Match - Balance

What is IPM??

Process of evaluating all available tools and then using those tools in a combination that will achieve management objectives for a given aquatic system (Hoyer and Canfield 1997).

What is IPM??

- Definition more detailed:
  - Examine if infestation impairs or benefits
  - Understand plant and water body ecology
  - Set management goals
  - Consider all tools and select the best options
  - Develop monitoring strategy
  - Implement educational program
While this approach can be effective it tends to provide only short term control by neglecting the underlying reasons for the formation of the infestations.

Example: ‘Successional' history of Caddo Lake, Texas

Ecological Approach to Aquatic Plant Management
Integration of approaches and methods into a pest management system, which takes into consideration the ECOLOGY of the environment and all relevant interactions that management practices may have upon the environment.

Ecological Approach to Aquatic Plant Management

- Ecosystem approach
  - Ecosystem management & restoration
- Addresses underlying causative factors
- Which leads to management:
  - Sustainable
  - Long-Term
**Reasons for Invasiveness???

- Beyond the scope…
- But certain characteristics stand out
- Bottom-line
  - Not dealing with:
  - “Killer plants”
  - “Super plants”
  - Goes against all science

**Invasiveness Characteristics

- Disturbance specialists
  - r-strategists or ruderal
- For example - Hydrilla
  - Rapid growth rates
  - Broad tolerance ranges
  - Early maturation and reproduction (fragmentation)
  - Dispersal adaptations (fragmentation)
  - Long-term survival (tubers)

**Environmental Factors

**Man-made and natural systems that lack vegetation

...Space to proliferate...

**Unvegetated systems ...

- Man-made systems
  - Reservoirs - flooded land
  - Mainly in 1950's and 1960's
  - No provisions for aquatic vegetation
- Natural systems
  - Many have only minimal vegetation
  - Due to continual disturbance
  - Management practices

...Ingredients to proliferate...

**High Nutrient Loads

- Recognized since early 1960’s
- Point source
- Non-point source
  - Sewers/septic systems
  - Fertilization
    - Homes
    - Farms
    - Industry
    - Erosion
- Human population increases
Underlying Causative Factors
Biological

- Most problem species are non-native
- Introduced with no competent herbivores and diseases
- A biological factor that can have profound impacts

Melaleuca quinquenervia – U.S.

Melaleuca quinquenervia – Australia

Casuarina spp. – U.S.

Hydrilla verticillata – U.S.
**What is Biocontrol?**

Introduction, by man, of parasitoids, predators, and/or pathogenic microorganisms to **SUPPRESS** populations of plant or animal pests.

**Suppression**

- Reestablish herbivores & diseases with plants
- Release small numbers
  - Population increase
  - Expansion in distribution
- Suppression is key
  - Stress the target
    - Reproduction
    - Growth
    - Height
    - Opening canopy
  - Long-term process
    - Takes years
    - Bring into lowered equilibrium
- Long-term sustainable control

**Biological Control**

- Differences due to:
  - Environmental factors
- More importantly:
  - Presence of herbivores
  - Impact of diseases
  - Not present in U.S.
- Example:
  - Melaleuca - > 150 herbivores
  - Hydrilla - > 110 herbivores/diseases
**Tremendous Capacity for Increase**

- Exponential Curve

  - Resulting offspring in just three months would number >325 trillion individuals
  - Encircle the equator >57,000 times

- Average generation time about 10 days
- Each female deposits about 120 eggs

**Factors regulating populations**

- Abiotic
  - Weather
  - Climate
  - Shelter availability
  - Geographic barriers
- Biotic
  - Mortality
  - Various competitive effects (intra/inter)
  - Development
  - Predators and parasites

**Maintenance at Realistic Levels**

- Logistic Curve

**Biocontrol**

- Minimize characteristics of disturbance specialist
- Decrease photosynthesis — decrease growth
- Decrease reproduction
- For example:
  - Waterhyacinth weevils
    - Smaller height
    - Decreased flowering — less seeds
    - Less productivity
  - Purple loosestrife agents
    - Reduced shoot/root growth
    - Fails to produce seeds

**Impact can be tremendous!**
**Herbivore Impact to Native Plants**

Entire ecology of pond was altered

---

**Hydrilla Agents**

**Leaf-Mining Flies**

- Two species established
  - *Hydrellia pakistanae* (1987)
  - *Hydrellia balciunasi* (1990)
- *H. pakistanae*
  - Widespread US distribution
  - Most damaging
  - Southeast
  - Northern Alabama

---

**Hydrellia pakistanae**

- Adult
- Larva feeding

---

**Graph**

- Model: $y=0.6377+0.0707x$
- $P_{\text{adj}} = 0.0003$ ($P_{\text{adj}} < 0.05$)
- $R^2 = 0.997$

---

**Bar Graph**

- 12% reduction in tuber numbers
- Current effect: $F(1, 116)=31.360, p=0.0000$
- Vertical bars denote 95% confidence intervals

---

**Bar Graph**

- 2.5% reduction in tuber numbers
- Current effect: $F(1, 116)=7.823, p=0.0063$
- Vertical bars denote 95% confidence intervals
What is the Role of Biocontrol?

- Think IPM in ecosystem context
- Reduce or eliminate underlying causative factors
  - Environmental factors
    - Nutrient loads
    - Empty niche
  - Biological factors
    - Host-specific agents
    - Suppresses weedy characteristics
      - Reduces photosynthesis
      - Decreases productivity
      - Impacts reproduction
      - Allows natives to compete more favorably

SPECIES RICHNESS = 1.3558 + 0.01821 * PERCENT
Correlation r = 0.0000

TUBERS PER m²

Hydrilla Ory
Hydrilla + tubers

Current effect: R²(1,15) = 0.0000, p = 0.9954
Vertical bars denote 0.05 confidence interval

Leaf Damage

Percent Rooted

Control Low Medium High

Lake Seminole, FL
1994

Lake Seminole, FL
1999
What is the Role of Biocontrol?

- Combine with native plant restoration
  - Reduce availability of space
  - Decrease nutrient loads – act as nutrient sinks
  - Alters competitive pressures
- Use traditional options in:
  - High priority areas
  - When other methods not feasible
  - To reduce overall biomass
  - Followed by biocontrol

Is it safe?

Host-specificity

Insects exhibit a range of feeding habits

Polyphagous – many food items - Generalist
Oligophagous – few food items
Monophagous – one food item - Specialist

Is it safe?

Host-specificity

- Thousands of species
  - Monophagous
  - Feed on single species
- Mechanisms
  - Nutritional
  - Defensive chemicals
- Millions of years of association
- Strong and binding relationship

Overseas

- Surveys
  - Lists of potential agents
- Field records
  - Host-specificity
  - Damage potential
- Host-specificity testing
  - Less expensive
  - Specimens available

Quarantine

- Safe?
- Host-specific?
  - Feed & develop
  - Only on target plant
- US and overseas locations
- Assess agent potential
- Gather information
  - Release petition
  - TAG request
- Environmental assessment?
Approval for Release

- Approval from:
  - Animal and Plant Health Inspection Service
  - Plant Protection and Quarantine
  - APHIS, PPQ
- APHIS, PPQ solicits recommendations from Technical Advisory Group (TAG)
- Major Areas of Concern
  - Taxonomy
  - Test Plant List
  - Host Range Tests
  - Impact to Non-Target Plants

Technical Advisory Group (TAG)

- Recommendations only to APHIS, PPQ
- TAG Membership
  - Bureau of Land Management
  - Bureau of Reclamation
  - Fish and Wildlife
  - National Park Service
  - National Biological Survey
  - Bureau of Indian Affairs
  - Canada & Mexico

TAG Membership Continued

- USDA, ARS
- USDA, APHIS
- USDA, CSREES
- Forest Service
- Documentation Center
- Corps of Engineers
- Environmental Protection Agency
- Weed Science Society
- National Plant Board

TAG Process

- Petitioner
- Completes pre-research and
- Submits proposal to APHIS/PPQ
- Submit TAG members and
- The proposal is reviewed
- TAG members
- TAG Executive Secretary
- Submitters recommendations
- TAG Chair
- Completes recommendation
- Submits TAG recommendations to APHIS/PPQ
- Petitioner
- Completes pre-research and
- Submits proposal to APHIS/PPQ
- Submit TAG members and
- The proposal is reviewed
- TAG members

Large Numbers for Release

- Classical biocontrol
  - Small numbers direct from overseas populations
  - Limitations – dependant on natural dispersal
- Move toward mass-rearing
- Large-scale efforts using:
  - Ponds
  - Greenhouse
  - Salvinia agents
  - Hydrilla agents
  - Waterhyacinth agents
- Quantity versus Quality
Several state and Federal agencies
- DWF-LA
- Corps Districts
- LSU Ag Center

Considerations
- Environmental conditions
  - Temperature
- Plant impacts
- Plant nutrition
- Herbivores
- Population size
- Shipping
- Monitoring
- Quality

Large Numbers for Release

Determining Efficacy
- Determine establishment
- Assess impact
  - Numbers of agents
  - Plant damage
- Monitoring important consideration
  - Standardized
  - Consistent
  - Repeatable
- Numbers of agents
  - Released and Present

Salvinia Weevil Rearing Pond
LSU: Near Houma, LA

- Characterize weevil distribution
- Changes over time
  - Plants
  - Weevil numbers
- Sampling efficiency

Google

Determining Efficacy
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- Assess impact
  - Numbers of agents
  - Plant damage
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Salvinia Weevil Rearing Pond
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- Changes over time
  - Plants
  - Weevil numbers
- Sampling efficiency

Google
Importance of Sampling

- Distribution has considerable impact
- Sample size extremely important
- Important to know how many released
  - Gauge establishment
  - Determine impact
    - How long it takes?
    - How big an area will be affected?
  - More released the better – but:
    - Agents cost money
    - Best to release the minimum to get the job done!

Objectives

What is Success?

- Establishment
- Range Expansion
- Population Increase
- Impact
  - Minimal
  - Biomass Decrease
  - Propagule Decrease

Evidence Types

- Laboratory/Greenhouse Experimentation
- Field Observations
- Abiotic/Biotic impacts

Criteria for Success

- Important that ALL agree what is success!!
  - Project managers
  - Property owners
  - Fishermen
  - Researchers
  - Lake Managers
- Compare to Realistic Expectations

Technology Transfer

- Reports
- Scientific Literature
- Oral Presentations
- Posters
- Videos
- Fact Sheets
- Information Systems

APIS Online

Players - Agents

- Insect agents available
- Variety of plants
  - Alligatorweed*
  - Waterhyacinth*
  - Waterlettuce*
  - Hydrilla*
  - Eurasian Watermilfoil*
  - Salvinia*
  - Purple Loosestrife
  - Salt Cedar
  - Melaleuca
- Biology, ecology, impact

Alternanthera philoxeroides
(Alligatorweed)

- Three agents released
- Highly effective
- Months instead of years

Agasicles hygrophila
(Alligatorweed Flea Beetle)

- Others include
  - Alligatorweed Thrips
  - Alligatorweed Stem Borer

Eichhornia crassipes
(Waterhyacinth)

- Three agents
- Effective
  - Height
  - Seeds
  - Biomass?
- Long term
- Controversial

Neochetina eichhorniae/N. bruchi
(Waterhyacinth Weevils)

Niphograpta albiguttalis
(Waterhyacinth Moth)

Formerly
Sameodes albiguttalis
**Waterhyacinth**

- **Effectiveness**
  - Long-term process
  - 3 to 5 years
  - Reduce plant height
  - Reduce flowering
  - Decrease biomass
    - Occurs
      - Flow
      - Winter conditions
      - Waterbody
      - ???

- **Disease**
  - Microsporidia
  - Reduce longevity
  - Egg production

**Megamelus scutellaris**

*(Waterhyacinth Planthopper)*

- **Approval Feb. 2010**
- **Colonies established**
  - Florida
  - Vicksburg
  - Louisiana
  - California
- **Releases in Florida, Texas, Louisiana**
- **Tentative establishment** – FL, LA, CA
- **Monitoring establishment success**
- **Probable high temperature limits??**
- **More work needed**

**Hydrilla verticillata**

*(Hydrilla)*

**Hydrilla Agents**

*Leaf-Mining Flies*

- **Hydrellia pakistanae**
- **Hydrellia balciunasi**
  - Established
  - Larva Damaging Stage
  - Feeds on Internal Leaf Tissues
  - Widespread U.S. Distribution

**Hydrilla**

- **Future**
  - Of no use:
    - True bug, moth
    - Both fed on pickerelweed
  - Possible new agents
    - *Thrypticus* spp.
    - *Taosa inexacta*
    - Warm strain hopper
  - **Implementation**
    - Patience is a virtue
    - Use on low priority sites – source infestations
    - Release large numbers
    - Minimize use of chemicals
    - Monitor

**Waterhyacinth**

- **Future**
  - Of no use:
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    - Both fed on pickerelweed
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    - *Thrypticus* spp.
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    - Minimize use of chemicals
    - Monitor
**Hydrellia pakistanae**

- Adult and Eggs
- Larva feeding

**Is it effective?**

- No herbivores
- Herbivores

**Lake Seminole, FL**

- 1994
- 1999

**How do you implement?**

- Learn to identify agents/damage
- Examine field sites
  - Presence/absence
  - Assess populations/damage
- Augment – if needed
  - In the past flies were expensive
    - > $0.50 per fly
    - < $0.01 per fly
  - Modern mass-rearing facilities
    - Lewisville, TX
    - Vicksburg, MS
    - Arkansas
    - Released > 30 million
- Continue to monitor field sites

**Myriophyllum spicatum**

(Eurasian Watermilfoil)

![Image of Myriophyllum spicatum](image)
Euhrychiopsis lecontei

- Native species
- Effective in some areas
- More research needed
- Overseas surveys???
- EnviroScience - MIDDFOIL

Salvinia molesta
(Giant Salvinia)

Cyrtobagous salviniae
(Salvinia Weevil)

Sepik River, Papua, New Guinea
Before

Sepik River, Papua, New Guinea
After
Mass Rearing Efforts

- Research
  - High numbers/quality
  - Lowered costs
- Several rearing facilities
- Pond-based
  - South Louisiana (LSU)
  - Vicksburg (ERDC)
- Box-Based
  - Texas (LAERF, Caddo)
  - Northern distribution
  - Cold frames

Pistia stratiotes
(Waterlettuce)

Neohydronomus affinis
(Waterlettuce)

- Highly effective
- Used throughout the world
- Method of choice
- Used extensively in Texas
- Active use in Louisiana
- Excellent control Orlando, FL

Fungal Pathogens

- Foundational/Basic
  - Biology/Ecology
  - Mechanisms of Control
- Applied
  - Development
    - Culturing
    - Formulation
  - Effectiveness

Applied

- Formulation development
- Cooperators
  - USDA, ARS – Peoria, IL
  - SePro – Rocky Mount, NC

- Agar Culture
- Liquid Culture
- Dry Granule

Neohydronomus affinis
(Waterlettuce)

- Identification
  - Small (1.5 – 2.4 mm) weevil
  - Brown and blue coloration
  - Characteristic “smiling face” on wing covers
  - Larvae – cream color, acute angle at rear
- Damage
  - Adults – shotgun blast on leaves
  - Larvae – Tunneling in leaves
  - Very effective throughout the world
  - Biomass reduction typically 1.5 to 2 years
- Collection techniques
  - Berlese funnel extraction
  - Moving infested plants
  - Can be mass-reared
**Foundational/Basic**

1 g dry Mt 2 g Mt+Gl 2 g Mt+CMC Control

**Integration with Chemicals**

**Synergistic Effect**

**Future Directions**

- In-country surveys
- Thirty three strains identified
  - Mean disease value of 3 or greater
- Further testing warrented
- Five strains
  - Mean disease value of 4
  - Four - Mycoleptodiscus terrestris
  - One - M. roridum
- Testing in progress
- Monoecious hydrilla pathogens

**Active vs. Passive**

- Biocontrol is NOT a passive technology
- Takes active participation
- Just like any traditional technology
- However, this rarely occurs
- Knowledge is the key
- Willingness to apply knowledge
  - Identification of agents and damage
  - Biology and ecology
  - Surveys
  - Re-release and augmentation
- Louisiana and Texas

**Potential Future Directions**

- Overseas
  - Eurasian watermilfoil
    - CABIVARS - 2013
  - Hydrilla
    - ARS: 2009 – 2013
    - Indonesia, southern China
    - New stem weevils?
    - Monoecious hydrilla
      - Northern China
      - Korea – 2014?
    - Origin - Genetics
  - Waterhyacinth Planthopper
    - Mass-rearing
      - State/local level
      - Quantity vs Quality
      - Reduce costs
    - Use of Pathogens

- Biocontrol
  - Agent approval
  - APHIS
  - Risk/Benefit
  - Tightened standard
  - FONSI
  - Harder to get agent approvals

- Overseas
  - Countries more reluctant
    - Allow potential agents to leave country
    - Protection of biodiversity
    - Money
    - Argentina
    - Impact - Warm climate strain – waterhyacinth planthopper
APCRP STATUS?

- Funding zeroed out for FY 2014
  - Corps budget
  - President’s budget???
- Congress
  - House - $0
  - Senate - $4 million
- ???
- CRA – Until Congress passes a budget
- Since we are zeroed out
  - No CRA funds
  - Permission to carryover small amount
- Budget negotiations
- It’s anybody’s guess…
- Trying to reinstate in 2015 budget
Wednesday, May 7, 2014 – 8:50AM

SESSION 5A: BIOCONTROL IN AQUATIC SYSTEMS

“Integrating Insect Herbivory with Mechanical Harvesting”

Jim Cuda
University of Florida/IFAS
Combining Different Control Tactics to Reduce Hydrilla Biomass

2014 Aquatic Weed Control Shortcourse, Coral Springs, Fl, 5-8 May 2014

James Cuda, Jennifer Gillett-Kaufman, William Overholt, Karen Stratman, Raymond Hix, Eutychus Kariuki, Judy Shearer, Emma Weeks, Joan Bradshaw, Ken Gioeli, Verena-Ulrike Lietze, Elroy Timmer

University of Florida, Florida A&M University, COE-ERDC, Citrus & St. Lucie Co. Extension, Aquatic Vegetation Control

Outline

• Background on hydrilla
• Options for hydrilla management
• Overview of Hydrilla IPM RAMP
• Introducing the new IPM model
• Current status of research
• Summary and resources

Hydrilla, *Hydrilla verticillata*

- Submersed, rooted aquatic plant, propagates 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

Worldwide Distribution of Hydrilla

[Image: https://www.discoverlife.org/mp/20m?kind=Hydrilla+verticillata&guide=Aquatic_Invasives]

- 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)
Why is hydrilla such a problem?

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

Hydrilla Genetic Studies

Why Cares? We Do!

- State and County Agencies
- Federal Government
- Anglers
- Duck Hunters
- Residents
- Boaters & Airboaters
- Lakefront Homeowners
- Local Businesses
- Elected Officials

Hydrilla's Impact on Wildlife

Algae-Harboring Hydrilla Causing Bald Eagle Deaths in the Southeast

Outline

- Background on hydrilla
- Options for hydrilla management

What are the options?

- "Cultural" control (drawdowns, limited use)
- Mechanical removal (harvesting)
- Chemical control (herbicides)
- Biological control (herbivores, pathogens)
- IPM- Preferred option
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

Augmentative BioControl

- One insect species (native range unknown)
  - 1957: First record in the U.S. (Louisiana)
  - 1976: First record in Florida (SW, specific location unknown)
- A fungal pathogen discovered in 1970s; isolated from several U.S. hydrilla populations in 1990s

Hydrilla Miner Life Cycle

- Female Larva Pupa Male

Importation BioControl

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

Hydrilla Miner

- Tip-mining midge
  - Larvae feed on living plant tissue
  - Rare occurrence
- Prevents “topping out”
- Naturalized in Florida
  - No swarms
  - Low dispersal distance
  - Easily mass reared

Larva and Associated Tip Damage

Credit: D. Demmon, RCID 125
Outline

• Background on hydrilla
• Options for hydrilla management
• Overview of Hydrilla IPM RAMP

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

Hydrilla IPM RAMP Objectives

• Evaluate compatibility of new hydrilla control technologies
  – Insect, pathogen, herbicide
• Demonstrate a novel integrated strategy for controlling hydrilla

Hydrilla IPM RAMP Collaborators
Why IPM?
Potential benefits
- Increased efficacy
- Decreased herbicide use rates & contact times
- Long term control
- Reduced reliance on herbicides alone
- Resistance management

Integrating BioControls & Herbicides


Outline
- Background on hydrilla
- Options for hydrilla management
- Overview of Hydrilla IPM RAMP
- Introducing the new IPM model

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 → branching
- New shoot tips → breeding sites for hydrilla tip miner
- Larvae develop within plant tissue (mining)
- Damage kills growing tips & increases susceptibility to infection by Mt

Integrating BioControl Agents with Herbicides

- Must confirm that herbicide does NOT negatively impact biocontrol agents
  - Directly- Causes mortality
  - Indirectly- Herbicide reduces plant density (= food source) below critical level
- Consider applying herbicides to maximize impact of biocontrol agents (tip miner & Mt)
  - Location
  - Timing

Outline

- Background on hydrilla
- Options for hydrilla management
- Overview of Hydrilla IPM RAMP
- Introducing the new IPM model
- Current status of research

Compatibility Studies

Replicated Tank Tests Conducted in Lewisville, TX & Vicksburg, MS
- Miner/Mt- Jan to Feb 2013
- Miner/Imazamox- Apr to Jun 2013

Compatibility Tests

- Mt and Tip Miner

Mycolestodiscus 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
Tank Test Methods

- Untreated Controls
- Low & High Treatments
  - Imazamox (Herbicide)
  - Mt (Pathogen)
  - Tip Miner (Insect)

Tank Test Results

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Hydrilla dry weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>a</td>
</tr>
<tr>
<td>Mt fungus</td>
<td>a</td>
</tr>
<tr>
<td>Tip miner</td>
<td>a</td>
</tr>
<tr>
<td>Mt fungus + Tip miner</td>
<td>b</td>
</tr>
</tbody>
</table>

Compatibility Tests

- Tip Miner and Imazamox

Outline

- Background on hydrilla
- Options for hydrilla management
- Overview of Hydrilla IPM RAMP
- Introducing the new IPM model
- Current status of research
- Summary and resources
Summary

- Research
  - Laboratory compatibility studies completed
  - Mt and tip miner (2013)
  - Tip miner and imazamox (2013)
  - Mesocosm tests
  - Tip miner and mechanical control (2014)
- Extension and Outreach
  - Field demonstration sites (2014)

Management Goals

- Integrate Different Control Tactics = IPM
- Eliminate Adverse Effects of Surface Mats
- Reduce Reliance on Herbicides
- Create More Favorable Habitat

Hydrilla IPM RAMP Expected Impacts

- Demonstrate compatibility of different low-risk control tactics
- IPM=> safe, sustainable & cost-effective control of both susceptible and fluridone-resistant hydrilla
- Develop Hydrilla IPM Guide for Florida & other states with hydrilla problems

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)

Food for Thought*

- “Are we as a weed science discipline choosing to ignore true integrated solutions to the herbicide resistance problem?”
- “More research on herbicide alternatives is required.”
- “Combinations of a diversity of tactics in [IPM] systems augment herbicide-based weed control . . . and lengthen the useful life of valuable herbicide tools.”

Thanx!
Wednesday, May 7, 2014 – 9:15AM

SESSION 5A: BIOCONTROL IN AQUATIC SYSTEMS

“Grass Carp for Biocontrol”

Mike Sowinski
Florida Fish and Wildlife Conservation Commission
Grass Carp for Biocontrol

A Brief History

- Scientific Name: *Ctenopharyngodon idella*
- Common Names: grass carp, white amur
- Native to large river systems in Asia
- Grass carp can now be found in 45 states (except: Alaska, Maine, Montana, Rhode Island, and Vermont)

A Brief History (cont.)

- First imported to the U.S. in 1963 to control aquatic vegetation in aquaculture ponds
- Reproducing population was discovered in 1971 in the Mississippi drainage system
- Sterile carp were first produced in the U.S. in 1979 as inter-specific crosses between female grass carp and male bighead carp *Arizichthys nobilis* (Malone 1982)
- Currently found in 93 countries

Commonly Reach 30 lbs or More

- Record weight is 99 lbs; length is 4.9 feet

Typically Live 10-15 Years, Unless...

Triploid Production

- Eggs are subjected to hydrostatic pressure resulting in three sets of chromosomes – rendering the fish sterile
Grass Carp Feeding Preferences

**Frequently Eaten**
- Brazilian elodea
- Duckweed
- Elodea
- Hydrilla
- Musk Grass (Chara)
- Pondweed
- Slender Spikerush
- Southern Naiad
- Widgeon Grass

**Sometimes Eaten**
- Baby Tears
- Bacopa
- Bladderwort
- Bulrush
- Cattail
- Coontail
- Fanwort
- Filamentous Algae
- Hygrophila
- Jointed Spikerush
- Maidencane
- Marine Naiad

**Rarely Eaten**
- Alligator Weed
- American Lotus/Water Lilies
- Azolla (Mosquito Fern)
- Coontail
- Fanwort
- Filamentous Algae
- Hygrophila
- Jointed Spikerush
- Maidencane
- Marine Naiad
- Pennywort (Dollarweed)
- Pickerelweed
- Salvinia
- Sedges
- Torpedo grass
- Water Hyacinth
- Water Lettuce

**Permit Status in Southeast US**

<table>
<thead>
<tr>
<th>State</th>
<th>Status</th>
<th>Genetic Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arkansas</td>
<td>Legal - no permits required</td>
<td>Diploid or triploid</td>
</tr>
<tr>
<td>Mississippi</td>
<td>Legal - permit required</td>
<td>Triploid only</td>
</tr>
<tr>
<td>North Carolina</td>
<td>Legal - permit required</td>
<td>Triploid only</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>Legal - no permits required</td>
<td>Diploid or triploid</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>Legal - permit required</td>
<td>Triploid only</td>
</tr>
<tr>
<td>Peru</td>
<td>Legal - permit required</td>
<td>Triploid only</td>
</tr>
<tr>
<td>Rhode Island</td>
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</tr>
<tr>
<td>Virginia</td>
<td>Legal - permit required</td>
<td>Triploid only</td>
</tr>
<tr>
<td>Virgin Islands</td>
<td>Legal - permit required</td>
<td>Triploid only</td>
</tr>
</tbody>
</table>

Florida Online Permitting

Permits may be obtained online if the following criteria are met:
- Single Owner
- No inlets or outlets exist where fish can escape
- Applying for 50 fish or less
- Size of the pond(s) is less than 5 acres
- No mitigation or water quality requirements by the Water Management Districts, county, city, etc.
Grass Carp Regions

Permits Issued Statewide

<table>
<thead>
<tr>
<th>Fiscal Year</th>
<th>Total Permits Issued</th>
<th>New Permits</th>
<th>Amendments</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008/2009</td>
<td>1,343</td>
<td>801</td>
<td>542</td>
</tr>
<tr>
<td>2009/2010</td>
<td>1,442</td>
<td>846</td>
<td>596</td>
</tr>
<tr>
<td>2010/2011</td>
<td>1,472</td>
<td>817</td>
<td>655</td>
</tr>
<tr>
<td>2011/2012</td>
<td>1,015</td>
<td>537</td>
<td>478</td>
</tr>
<tr>
<td>2012/2013</td>
<td>1,204</td>
<td>564</td>
<td>640</td>
</tr>
</tbody>
</table>

Fish Barriers

- Sturdy construction
- Gaps must be 1.5" or less
- Bars can be vertical or horizontal
- Overflow should allow for major rain events to alleviate flooding

Barrier Issues

- Poor Construction
- Need to be Maintained

Barrier Issues II

- Vandalism
- Poor Design
Stocking Rates

Stocking rates are difficult to predict due to:

- differences in vegetation coverage and densities (e.g., total plant acreage compared to total water body acreage)
- plant species present
- weather events (e.g., droughts, hurricanes)

For 100% coverage of small ponds (<5 acres), using only grass carp, the recommended stocking rates are:

- 10 fish/acre for Hydrilla and Elodea
- 15 fish/acre for Chara, Southern Naiad and Pondweeds
- 20 fish/acre for Slender Spikerush, Duckweed and Bladderworts
- 30 fish/acre for Filamentous Algae

Public Lakes

- A stocking request is sent to FWC

- The South/Southwest Regional Grass Carp Team:
  - Invasive Plant Management Regional Biologist
  - Waterfowl Biologist
  - Freshwater Fisheries Biologist
  - Aquatic Habitat Restoration & Enhancement Section Biologist

- The Regional Grass Carp Team reviews the request, inspects the waterbody (if necessary), and determines if the stocking of TGC will be a benefit to the waterbody

Quiz Time- Question #1

Which plant species will grass carp consume first?

- A: Duck Potato
- B: Water Hyacinth
- C: Spatterdock
- D: Slender Spikerush

138
Quiz Time- Question #2
Which barrier is the best?

Quiz Time- Question #3
What’s wrong with this barrier?

Quiz Time- Question #3
What’s wrong with this barrier?

Gaps larger than 1.5”
Barrier material conducive to clogging

Just a Reminder!
- Better to be very conservative in large water bodies using acres of vegetation instead of water surface acres
- There is always the possibility of the lake becoming totally cleared of aquatic vegetation
- Use an adaptive management approach
- Be patient!!!
- Questions call Rhonda Howell at 352-357-2951

Michael Sowinski – Florida Fish & Wildlife Conservation Commission
2001 Homeland-Garfield Road, Bartow FL 33830
michael.sowinski@myfwc.com
Office: 863-534-7074 x230, Fax: 863-534-7181
Wednesday, May 7, 2014 – 8:00AM and 10:00AM

SESSION 5B/6B: CORE TRAINING PART 1 and 2

“CORE Training Part 1 and 2”

Jane Morse
University of Florida/IFAS
Pinellas County
General Standards/Core Exam Review

Jane Morse
University of Florida Extension/IFAS
Pinellas County
www.pinellascountyextension.org

Review/Test Structure

- Principles of Pest Control (6 questions)
- Pesticide Labeling (6 questions)
- Formulations (7 questions)
- Pesticides in the Environment (5 questions)
- Special Environmental Concerns; Protecting Ground Water and Endangered Species (1 question)
- Harmful Effects and Emergency Response (6 questions)

What is a Pest?
What is a Pesticide?

Types of Pests

- Insects
- Insect-like organisms
- Microbial organisms
- Vertebrates
- Weeds
- Mollusks
Categories of Pests

- Continuous
- Sporadic, migratory, or cyclical
- Potential

Principles of Pest Control

- Prevention – kept it from becoming a problem
- Suppression – reduce pest numbers to an “acceptable” level
- Eradication – destroy entire pest population in an area

Integrated Pest Management

- The combining of appropriate pest control tactics into a single plan to reduce pests and their damage to an acceptable level
- To solve pest problems
  - Identify pest
  - Select pest control methods based on benefits, risks, and effectiveness of each available method of control

Integrated Pest Management (IPM) for Pests of Lawn & Garden

IPM Practices

- **First step! Identify pests correctly**
- Monitor and scout pests
- Follow control-action guidelines
  - Injury level, action threshold, timing
- Prevent pest problems
- Use different IPM practices together (integrate)

IPM Control Methods

- Natural controls: climate, natural enemies, geographic barriers, food and water supply, shelter
- Applied controls: host resistance, biological controls, cultural controls, mechanical controls, chemical controls
Host Resistance

• Host has physical characteristics that protect the plant
• Host is more vigorous or tolerant than other varieties
• Chemicals in the host protect the host

Biological control: predators, parasites, pathogens

Cultural Control

• Crop rotation
• Mowing, cultivating
• Harvest timing

Mechanical Control

• Screens and barriers
• Sanitation
• Traps

Integrated Pest Management

Pest Control Failures

• Pest resistance occurs when pesticides are applied repeatedly in the same situation.
• Rotating pesticides reduces resistance
• Other reasons for failures
Pesticide Labeling

• If you remember nothing else, remember this – “The pesticide label is the LAW!!!”

Classification of Pesticide Uses

• Unclassified: formulations that can be purchased without a license
• Restricted-Use: A pesticide that can cause harm to humans or the environment unless applied by a certified applicator. Only a certified applicator may use or supervise the use of RUP’s.

Pesticide Names

• Brand name – manufacturer’s name for the product
• Chemical name – identifies the chemical components and structure of the pesticide
• Common name – a shorter way of identifying the chemical, officially accepted by the EPA

Ingredient Statement

• Active ingredient
  – Common name
  – Chemical name
• Inert ingredients
  – Not active
  – Must be listed by percentage, but not by name
  – Foaming agents, wetting agents, surfactants, etc.

Dissecting a Label

<table>
<thead>
<tr>
<th>Brand name</th>
<th>Sevin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ingredient statement</td>
<td>% active and inactive</td>
</tr>
<tr>
<td>Common name (active)</td>
<td>Carbaryl</td>
</tr>
<tr>
<td>Chemical name (active)</td>
<td>Naphthyl N-methylcarbamate</td>
</tr>
<tr>
<td>Inert ingredients</td>
<td>Not always specified</td>
</tr>
<tr>
<td>Registration number</td>
<td>3120-280-AA</td>
</tr>
<tr>
<td>Establishment number</td>
<td>5840-AZ-1</td>
</tr>
<tr>
<td>Manufacturer name/address</td>
<td>DuPont, Wilmington, DE</td>
</tr>
<tr>
<td>Net contents</td>
<td>Pounds, ounces or gallons</td>
</tr>
<tr>
<td>Type of pesticide</td>
<td>Insecticide</td>
</tr>
<tr>
<td>Directions for use</td>
<td>Sites, rates, app. Info., etc.</td>
</tr>
</tbody>
</table>

Signal Word

![Signal Word Image]
What do signal words mean?

- **CAUTION** – slightly toxic
- **WARNING** – moderately toxic
- **DANGER** – highly toxic

*with skull/crossbones/POISON = acute illness; without = skin/eye irritation

Also on the front of the label

- EPA registration number
- EPA establishment number
- Net contents
- Name and address of the manufacturer
- Type of pesticide
- Type of formulation

Precautionary Statements

**Statement of Practical Treatment**

- **First aid**
  - Includes instructions on how to respond to an exposure situation, including information for a doctor
  - Located on the front of the label

Personal Protective Equipment

Environmental Hazards
Physical or Chemical Hazards

- Storage concerns
  - Flammability
  - Corrosiveness

Directions for Use

Storage and Disposal

Formulations

- Active Ingredients: chemicals that actually control the target pest
- The active ingredient is represented by the number before the letters that describes the formulation

Types of Formulations

- Liquid formulations
- Dry formulations
- Solutions
- Aerosols
- Fumigants
Liquid Formulations – Pounds per Gallon

- Emulsifiable concentrates (EC or E)
- Solutions (S)
- Ready to Use (RTU)
- Concentrate Solutions (C or LC)
- Ultra-low-volume (ULV)
- Flowables (F or L)

Dry Formulations: Percent Active Ingredient

- Dusts (D)
- Baits (B)
- Granular (G)
- Wettable powder (WP or W)
- Soluble powder (SP or WSP)
- Dry flowable (DF)
- Water dispersible granule (WDG)

Pesticide Movement

Air: pesticide movement away from the release site into the air is called DRIFT

Water: moves in through drift, leaching, and runoff from nearby applications

On or in objects, plants or animals: pesticides may stick to shoes, animal fur, or to blowing dust and plant surfaces

Drift Control

- Droplet size
- Spray pressure
- Drift control agent
- Nozzle selection
- Distance from target
- Wind speed and direction
Spray Droplet Size and Its Effect on Spray Drift

<table>
<thead>
<tr>
<th>Droplet diameter</th>
<th>Type of droplet</th>
<th>Time required to fall 10 ft. in still air</th>
<th>Distance droplet will travel in falling 10 ft. (3 mph breeze)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Fog</td>
<td>66 min.</td>
<td>3 miles</td>
</tr>
<tr>
<td>100</td>
<td>Mist</td>
<td>10 sec</td>
<td>409 feet</td>
</tr>
<tr>
<td>500</td>
<td>Light rain</td>
<td>1.5 sec</td>
<td>7 feet</td>
</tr>
<tr>
<td>1000</td>
<td>Moderate rain</td>
<td>1.0 sec</td>
<td>4.7 feet</td>
</tr>
</tbody>
</table>

Harmful Effects on Non-Target Plants and Animals

– From direct contact: poorly timed applications can harm honey bees and wildlife in or near a target site.
– From residues: residues - part of the pesticide that remains in the environment.

Pesticide Breakdown

- Residues
- Persistence
- Tolerance

Special Environmental Concerns: Protecting Ground Water

- Soil Permeability: influences how fast pesticides move downward
- Solubility of the pesticide: the ability of the pesticide to dissolve in water

Personal Protective Equipment

- Clothing and devices worn to protect your body from contact with pesticides or residues
- The pesticide label lists the minimum you must wear while handling the pesticide
- You are required by law to follow all PPE instructions on the pesticide label
Personal Protective Equipment

• Not all PPE will protect you from all chemicals
• Type of solvent in the chemical determines what type of PPE is resistant
• Rubber gloves will only protect you from water-based or dry pesticides

Hand and Foot Protection

• Leather, canvas or cloth shoes are NOT the best choice for applicators.
• Avoid contaminating the inside of your gloves and footwear.
• Gloves, boots, or coveralls should not be worn with certain types of fumigants.

Eye Protection

The job dictates how PPE should be worn.

Respirators

Cleaning PPE

• Dispose of single use PPE
• Wash reusable PPE with detergent and hot water, then dry.
• Wash your hands with soap and water.
Contaminated Clothing

- If you spill chemicals on your clothing, remove immediately.
- Place clothes in a plastic bag
- Wash your body with soap and water
- Put on clean clothes

Laundering Fabrics

- Separate from family wash
- Wash a few items at a time
- Rinse twice
- Line dry

Routes of Entry

- Skin
- Eyes
- Mouth
- Respiratory system

Risk = Toxicity \times Exposure

Skin

- Most pesticide exposures are to skin (dermal).
- Wash contaminated areas immediately with soap and water.
- Oil-based products will be most readily absorbed by your skin.

Eyes

- Immediately wash your eyes out with clean water for at least 15 minutes if pesticide gets into your eyes
Respiratory System

• Immediately get to clean air outside the treatment area

Mouth

• If you swallow a pesticide you will need to follow the first aid directions on the label.
• Inducing vomiting can be harmful in some situations.

Effects of Pesticide Exposure

• Acute – within 24 hours after exposure
• Delayed or Chronic – after repeated exposures
• Allergic or Sensitization - reaction that others do not experience

Routine Decontamination

• Before you eat, drink, use the bathroom, chew gum, use tobacco, or do anything where you will touch your body.
• Wash your hands with soap and water, then dry your hands.
• Water, soap and paper towels should be carried at all times.

Heat Stress

– Take breaks in a cool area
– Inform your supervisor if you are taking medications
– Dress in loose-fitting, light colored clothing
– The factor that influences heat stress that the applicator can control is the amount of liquid consumed

Mixing, Loading & Calibration

• Mixing
• Loading
• Calibrating
Environmental Factors
• Surface moisture: moderate is best
• Rain or irrigation water: may move pesticides off target
• Temperature: low temps slow down or stop action; high temps increase the likelihood that some pesticides will vaporize.

Mixing, Loading & Application
• Safe Mixing & Loading Practices
  – Protect your water source: the main purpose of an anti-siphoning device on your pump is to prevent water source contamination
  – Always wear the proper PPE.

Mixing, Loading & Application
• Safe Mixing & Loading Practices
  – Keep the pesticide container below face level to avoid injury from splashing
  – If clothing is contaminated remove immediately, dispose of it, and wash yourself

Applying the Pesticide
• Make sure to inspect all equipment daily to insure personal safety

Combining Pesticides
• Always add pesticides to the diluent using the W-A-L-E Plan:
  – 1. Add Wettable powders & Water dispersibles
  – 2. Agitate thoroughly
  – 3. Add the Liquid products
  – 4. Add Emulsifiable concentrates last
• W-A-L-E: wettables, agitation, liquids, emulsifiables.

After Mixing, Loading and Application
• Always clean your equipment according to label instructions
• Always clean yourself
• Make sure that you keep appropriate records of the application
Applying the Correct Amount

• How much to apply
  – Under dosing
  – Over dosing

• If a pesticide label indicates a range of rates...
  • use the lowest possible label rate that achieves adequate pest control

Transporting Pesticides

Transport in a non-passenger area of the vehicle. Keep vehicle attended.

Never transport with food or other items that might be contaminated.

Pesticide Storage

Safe Storage Guidelines

• Building designed for storage
• Outside marked with sign and placard
• Impervious flooring
• Good lighting
• Good ventilation
• Temperature/humidity control
• Log of stored pesticides
• Spill clean up supplies
• MSDS
• Fire extinguisher
• PPE
• Locked/secure!!!

Safe Storage Guidelines

• All chemicals should be stored in their original, labeled container.
• Pesticides should NEVER be stored in food or drink containers.

Disposal
Spill Clean Up

- Control
- Contain
- Clean Up
- Make sure to wear the right PPE!!

Control – Stop the Source

Control – Protect Others and Stay at the Site

Contain the Spill

Clean Up the Spill

After Cleaning Up the Spill

- Clean up the equipment
  - Use bleach, dish soap, and water
- Clean up yourself
  - Use soap and water
- Contact appropriate authorities if necessary
Florida Laws and Regulations

- Agencies responsible for laws and rules governing pesticide use in Florida
  - Florida Dept. Of Community Affairs: pesticide storage facilities that contain more than a TPQ of an active ingredient listed as extremely hazardous
  - Florida Dept. Of Environmental Protection: waste management and container burning
  - Florida Dept. Of Agriculture and Consumer Services: pesticide applicator licensing

Florida Mosquito Control Law, Chapter 388 F.S.- mosquito control, public health
Structural Pest Control Act, Chapter 482 F.S.- pest control, landscaping
Florida Pesticide Law, Chapter 487 F.S. – agriculture, ag-related areas

Pest Control Categories:

- Private applicator Ag
- Aerial applicator
- Ag row crop
- Ag tree crop
- Ag animal
- Soil/greenhouse fum.
- Raw Ag commodity fum.
- Regulatory
- Natural areas
- Forest pest control
- Ornamental & turf
- Seed treatment
- Aquatics
- Organotin paint
- Right of way
- Wood treatment
- Chlorine gas infusion
- Demo/Research

Types & Costs of Licenses

- Private - $100
- Public - $100
- Commercial - $250

Thank you!
Wednesday, May 7, 2014 – 10:00AM

SESSION 6A: BIOCONTROL IN NATURAL AREAS

“Biocontrol of Melaleuca”

Paul Pratt
USDA
Melaleuca biological control: The good, the bad, and the ugly

Paul Pratt, Ph.D.
USDA-ARS
Invasive Plant Research Laboratory
Fort Lauderdale, Florida

Broad-leaved paperbark tree *Melaleuca quinquenervia*

- Native to eastern Australia (New Caledonia)
- Introduced in late 1800s
  - Ornamental
  - Forestry
  - Soil stabilization
  - "dry up the Everglades"

*Melaleuca quinquenervia*

- Related to "tea tree oil" species, *M. alternifolia*
- Large tree up to 100' tall
- Large tap root
- Coppices readily
- Evergreen
  - 4 yr leaf life span
- White papery bark
- Paper bark tree, white bottle brush tree, punk tree, melaleuca

*Melaleuca quinquenervia*

- Melaleuca:
  - black and white
- quinquenervia:
  - five veins

*Melaleuca quinquenervia*
Melaleuca quinquenervia

- Can flower within 1 yr
- Flowers winter and summer
- White bottle brush flowers
- Capsular fruit
  - Arranged in clusters
  - Open when damaged
- Seeds
  - 200-300 seeds
  - 56 million seeds on adults
  - Most land 500' from parent
  - Hurricane: 11 miles

Species displacement

Increased fire intensity

Soil accretion
“Active” Melaleuca Management

- 1975 - Two Melaleuca workshops (FL FWCC)
- 1980 - Melaleuca symposium (FL Div. Forestry)
- 1982 - Exotic woody plant conference (Fairchild)
- 1984 - Exotic Woody Plant workshop (ENP)
- 1986 - Melaleuca Management Plan
  - Herbicide recommendations
  - Regional effort
  - Recommended strategy

**Melaleuca Management Plan**

**Strategy**
- Eliminate stands
- Prevent Regrowth & Recruitment
- Herbicidal Control & Mechanical Removal
- Biological Control

**Biological Control Agents**
- Melaleuca snout weevil (Oxyops vitiosa)
  - Released 1997
- Melaleuca psyllid (Boreiglycaspis melaleucae)
  - Released 2002
- Melaleuca gall fly (Fergusonina turneri)
  - Released 2005
- Melaleuca midge (Lophodiplosis trifida)
  - Released 2008

**The Melaleuca weevil**
- Spreading at 1 km/yr
- > 500K individuals released
- At >150 sites
The *Melaleuca* psyllid

- Spreading at a rate of 7 km/yr
- > 3.3 million redistributed
- Now released at >95 sites

The *Melaleuca* midge

- Released at 24 sites
  - Variable founding pop. size
  - Variable stand size
- Uniform establishment initially
- Dispersing at 20 km/yr

Ask your doctor if biological control is right for you...

- Do these introductions help meet the goals of the *Melaleuca* Management Plan?
  - Reduce regrowth and recruitment
Herbivory reduces stump regrowth:
• Replicated insect exclusion studies:
  – 76% reduction in regrowth
  – 80% mortality of cut stumps

Herbivory decreases reproduction

Herbivory decreases reproduction
• Insect exclusion studies of seedling survival:
  • Density dependent
    – Growth: shrinking!
    – mortality: 40 to 80%

Herbivory decreases plant height

Herbivory reduces plant density
We have bugs, now what?

- Past: release a few insects at a few locations
  - Slow spread
  - Slow impacts
- Future: release many at many locations
- Comprehensive Everglades Restoration Plan
  - Construction of a mass rearing lab
  - Releases of insects on CERP lands

Mass rearing facility

- Name this building:
  - Bug barn
  - IDOL: Insect Development and Operations Lab
  - MBLT: More Bugs, Less Talk
  - ???

CERP plan

- Divide CERP lands into grids
- Goal:
  - Establish insects in 25 cells per year
  - Monitor impacts
- Where are the weeds?
  - SRF, sketch mapping, your help...
- Where are you spraying?
- Site access?

Control integration

How can biological control be integrated with conventional control tactics?
Control integration

- Prioritize invaded lands:
  - Immediate control: chemical and mechanical
  - Slow down invasion, maintenance: Biological control
- "Help" your neighbors
- Biocontrol agents should:
  - Reduced "follow up" costs
  - Option to focus on other target weeds

Brown is beautiful

Paul.Pratt@ars.usda.gov
Wednesday, May 7, 2014 – 10:20AM

SESSION 6A: BIOCONTROL IN NATURAL AREAS

“Biocontrol of Lygodium”

Melissa Smith and Ellen Lake
USDA
Biocontrol of *Lygodium microphyllum*

Aquatic Weed Control Short Course  
7 May 2014  
Melissa C. Smith  
Ellen C. Lake  
Paul D. Pratt  
USDA-ARS Invasive Plant Research Lab  
Fort Lauderdale, Florida

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*Lygodium microphyllum* in South Florida…and beyond

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**Lygodium in Conservation Areas**

- Flatford Swamp
- Greenswamp Wilderness Preserve
- A.R.M. Loxahatchee NWR
- Everglades National Park

---

**L. microphyllum** reproduction

Propagule pressure:

- Each sorus has ~ 215 spores
- Each fertile leaflet has ~ 133 sori
- \(215 \times 133 = 28,500\) spores per fertile leaflet (Volin et al. 2004)

---

**Lygodium biological control:**

Moths that were, moths that are, and some moths that have not yet come to pass (and a mite)

- *Austromusotima camptozonale*
- *Neomusotima conspurcatalis*
- *Lygomusotima atla*

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**Neomusotima conspurcatalis**  
(Lepidoptera: Crambidae)

- Egg
- Pupa
- Adult

Life cycle of brown *lygodium* moth

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Neomusotima releases 2008 - 2009

Neomusotima range 2012 - 2013

Neomusotima in the field

Neomusotima in the field

Neomusotima in the field

Neomusotima research

Feeding preference
• Do *N. conspurculalis* larvae preferentially feed on fertile fronds?
• Effects of fertile frond feeding on spore germination
• Effects of fertile frond feeding on larval development time
**Neomusotima research**

Feeding preference
- 1st and 2nd Instar Larvae preferentially feed on fertile fronds in choice tests (p<0.02, Hotelling’s $T^2$).

**Neomusotima research**

Spore germination
- Passage through the gut of the caterpillar only resulted in 2 prothalli (~99.5% germination reduction).

**Neomusotima research**

Development time
- Fertile frond feeding did not significantly affect larval development time or successful emergence to adult.
- Did not measure “downstream” effects in adults or larval size.

**Neomusotima research**

To be completed:
- Oviposition preference
- Fecundity effects in adults

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**Integrated weed management**

- Control
- *Neomusotima* only
- Herbicide only
- *Neomusotima* and herbicide

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**Floracarus perrepae** (Eriophyidae)

- Transfers of galled material 2008 – 2010
- Very low establishment success measured in 2011
- Thought to be haplotype specific?
- Does wet or dry season release timing determine establishment?

Freeman et al. 2005
**F. perrepae damage**

- Australia: Goosby et al. (2004)
  - Reduced aboveground biomass by 49%
  - Reduced belowground biomass by 35%
- In Florida:
  - Reduction of formation of fertile fronds?
  - Are mite and moth damage synergistic?

**F. perrepae releases 2008**

**F. perrepae range 2013**

**Lygodium and CERP**

- Mass rearing and release of *N. conspurcatalis* and *F. perrepae*
- Follow up to determine “success” (establishment, impact, dispersal)
- Priorities given to natural areas

**Future directions**

- Determine the relative impacts of the moth alone, the mite alone, and the two together
- Build occupancy models to predict “patches” where moths could occupy and focus releases
- More thorough investigation of haplotype mismatch – genotyping of introduced and native range *Lygodium* and *F. perrepae*
Acknowledgments
Wednesday, May 7, 2014 – 10:40AM

SESSION 6A: BIOCONTROL IN NATURAL AREAS

“Biocontrol of Air Potato”

Eric Rohrig
Florida Department of Agriculture and Consumer Services
Biological Control of Air Potato, *Dioscorea bulbifera*, in Florida.

Eric Rohrig

Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Gainesville, Florida

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**Multiagency Effort**

- USDA-ARS-IPRL, UF-IFAS-BCRCL, and FDACS-DPI are conducting extensive research on APB and *D. bulbifera*.
- FDACS-DPI is collecting information on current air potato infestations and beetle releases throughout Florida and storing in a geodatabase, managing requests for beetles, and coordinating releases.
- Utilizing an electronic form for vine reports/beetle requests and releases.
- FDACS, USDA, and UF are mass rearing APB for release and research needs.

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**Growth and Spread**

- Air potato is an herbaceous, perennial, twining vine.
- Can grow 30 cm (12 in) per day and reach heights over 20 m (65 ft).
- Aerial tubers, called bulbils, are primary means of spread.
  - Humans; animal; water
- Bulbils grow in summer and drop to the ground or remain on dead vines after vines senesce in late fall. Spread following spring.
- Fallen bulbils form underground tubers which will sprout every spring and create more bulbils.

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**Distribution**

- Native range throughout much of Asia, Africa, and parts of Australia.
- Preliminary molecular work suggests Asian origin of Florida vines.
- Introduced in the US in Florida, Georgia, Hawaii, Louisiana, Mississippi, and Texas.
- Most natural and disturbed habitats are susceptible to air potato infestations including floodplain forests, marshes, scrub forest, shrublands, tropical and sub tropical hammocks, waterways, and urban lots.

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**Impact**

- Forms dense blankets smothering native vegetation and displacing native organisms.
- Listed as a noxious weed by the Florida Department of Agriculture.
- Category 1 invasive plants—"species which are altering native plant communities by displacing native species, changing community structures or ecological functions, or hybridizing with natives" by the Florida Exotic Pest Plant Council (FEPIC, 2003).
Control

Chemical

Non-target effects of metsulfuron to palms
- Toxic to environment.
- Transient injury of foliage occurring.
- Repeat every year (multiple times per year).
- Risk to birds.

Mechanical

- Must remove underground tuber to eliminate air potato
- Time consuming, difficult

Biological Control

*Host Specificity*
- Can not release an exotic organism without demonstrating, through host specificity testing, that it will not attack non target organisms.

The Candidate

- Liliocerus sp. was discovered attacking D. bilbifera in 2002 in Nepal. Imported into the USDA-ARS Invasive Plant Research Laboratory quarantine (IPRL) in Ft. Lauderdale in 2005 for host specificity testing.
- Later identified as Lilioceris cheni by Dr. Alex Konstantinov at the USDA-ARS-Systematic Entomology Laboratory (2010).
- Species identification verified through molecular and taxonomic study.

APB Biology

- Adults
  - 1 cm long x 0.5 cm wide
  - Solid black with reddish orange elytra
  - Leaf feeder
  - Longevity several months average up to a year
  - Mating begins ~2 wks after adult emergence
  - Oviposition begins ~1 wk after mating or in May-June in overwintered individuals
  - Oviposition period of ~49 days
  - Fecundity averages 1,200 eggs per female

APB Biology

- Eggs
  - White upon lay, then turn yellow
  - Laid in bunches within “cupped” leaves
  - Eggs hatch in 2-4 days (25°C)

Taxonomy

Order: Coleoptera
Family: Chrysomelidae
Subfamily: Criocerinae
Genus: Lilioceris Reitter
Species: cheni
Common name: None, but we like air potato beetle (APB)

APB Biology

- Larvae
  - Heavy feeders
  - Feed extensively, skeletonizing leaf tissue
  - 5 instars
  - Larval development ~7 days
  - Pupaema black, then darken from brown to a grey before puparium
  - Place food onto back to deter predators
  - Drop, crawl to soil surface to pupate in substrate or under debris
  - Only secret white foam which hardens to form puparium
  - Pupal stage ~14 days

APB Biology

- Newly hatched
- 1st instar
- 2nd instar
- 3rd instar
- 4th instar
- Pupa
### Host Testing Results

- L. cheni was found to be host specific to target weed, Dioscorea bulbifera.
- L. cheni laid eggs on D. floridana and D. villosa but no larvae were able to develop to the adult stage.
- Very small amounts of test feeding by adults on D. floridana and D. villosa, a naturalized weed (D. polystachya), and a Brazilian species naturalized in Puerto Rico (D. antilloides), in no choice tests but larvae were unable to feed or survive on any of these Dioscorea species. In addition, there was no feeding or development by L. cheni on any Dioscorea species tested. Note that these were not representatives of monocot plants.
- The Technical Advisory Group for the Biological Control of Weeds (TAG) recommended the release of L. cheni in 2009 along with USDA-APHIS-PPQ.

### APB Release

#### 2012:
- FDACS-DPI and USDA-ARS-IPL conducted initial releases in late summer and fall of 2012 at select research locations (public lands) in Alachua, Broward, Dade, and Manatee Counties.

#### 2013:
- **Total released:** ~150,000 L. cheni by FDACS-DPI and USDA-ARS.
- **Counties:** 32 (Alachua, Bradford, Brevard, Charlotte, Citrus, Collier, Desoto, Glades, Hardee, Hendry, Hernando, Highlands, Hillsborough, Indian River, Lake, Lee, Manatee, Marion, Martin, Miami-Dade, Okeechobee, Orange, Osceola, Pasco, Pinellas, Polk, Putnam, Sarasota, Seminole, St. Lucie, St. Johns, and Union).
- **Sites:** city, county, state, and federal parks/preserves/forests and some residential areas.

### APB Request/Release Forms

- Request sheets are emailed or faxed to all interested individuals, agencies, or organizations.
- Release sheets are returned to Eric Rohrig following a release.
- Request beetles year round for multiple sites, requests filled in order, public land priority.

### APB Request/Release Forms

- Limited beetle numbers, overwhelming demand, strategic releases for maximum impact:
  - Priority sites include town, city, county, state, federal parks, preserves, and conservation lands.
  - As large populations build at these sites, beetles disperse to surrounding residential and commercial lands. So far, so good.
  - Begin residential releases in 2014 with UF-IFAS?

### Mass Rearing
- **Spring:** field cages, greenhouses, lab cages
- **Winter:** lab cages, greenhouse cages

### Mass Rearing – Field Insectaries

- Utilize numerous field insectaries.
  - sites with little human traffic, no herbicide use.
  - release large numbers of larvae and adults in early spring.
  - revisit throughout summer to collect larvae and adults for lab or field release.
APB Geodatabase

Yellow pin= request
Blue pin= DPI release
Red pin= USDA release
Orange pin= UF release

Release Results

1 Year post release results
- Widespread overwintering
- Large population increases
- Extensive beetle dispersal. Over 10 miles in some areas.
- Light – heavy damage (10-20%)
- Vine height reduced
- Re-growth of native vegetation in areas with heavy vine damage
- Significant reduction in bulbil production

Release Results - Research Sites

Control (Aloft CG-Systemic)

Current Multiagency Research

- Effects of beetle releases on D. bulbifera infestations and surrounding native plant communities (as vines are reduced).
- Beetle establishment and dispersal ability.
- Vine biomass (vine, tuber, and bulbil production by vine morphotype = brown vs tan bulbils).
- Life tables for population growth.
- Beetle longevity and fecundity.
- Dispersal, cold storage, and overwintering ability.
- Mating (Chinese x Nepalese biotypes).
- Volatile induced behaviors.
- Field host specificity testing.
- Lilioceris egena quarantine host specificity testing.

Soon to Join the Battle

1) Lilioceris cheni from Nepal (Summer 2014)
   - Tolerate freezes/frost

2) Lilioceris egena (Summer 2015?)
   - Voracious bulbil feeder
   - Host range testing at USDA-ARS-IPRL
Acknowledgements

**Program:** USDA-ARS, UF-IFAS, FDACS-DPI, countless land managers throughout Florida (DEP, FDOT, WMD, FFS, USFS, BSA, NPS, NWR). Too many to list!

**Funding:** FDACS-DPI mass rearing and release of *Lillocerus cheni* is funded, in part, by a Cooperative Agreement from United States Department of Agriculture-Animal and Plant Health Inspection Service (USDA-APHIS).
Wednesday, May 7, 2014 – 11:00AM

SESSION 6A: BIOCONTROL IN NATURAL AREAS

“Biocontrol of Tropical Soda Apple”

Rodrigo Diaz
University of Florida/IFAS
Indian River REC
Biological Control of Tropical Soda Apple in Florida

Rodrigo Díaz
William A. Overholt
Amy Rota
Julio Medal
Ken Hibbard

Aquatic Weed Control Short Course
May 3rd, 2014

This talk covers the successful implementation of a biological control program of tropical soda apple

1. Background of TSA
2. Biological control agent: Gratiana boliviana
3. Mass release program of beetles
4. Establishment and impact of beetles

Tropical soda apple (Solanum viarum) is a species of the nightshade family, Solanaceae

- Shrub, perennial, up to 1.5m tall
- Racemes of white flowers
- Leaves and stems covered with prickles
- Leaves are sticky due to trichomes

Tropical soda apple is a prolific seed producer

- TSA can flower and fruit all year
- 400 seeds per fruit that remain viable in soil for 2 years (Mullahey 2002)

Movement of TSA is facilitated by mammals, and the transport of contaminated hay and turf

TSA has been reported in several states; however, it is a major problem only in Florida

Source: EDDMaps

First report in Florida: 1988
TSA is invasive in open pastures as well as in shaded hammocks

Dense TSA infestation disrupts cattle and wildlife movement

Lack of shade increases heat stress in cattle

Florida ranchers lose $6.5 to 16 million annually due to increased control costs

Increased mechanical control
Reduction in stocking rates
Increased chemical control

TSA is an alternative host for insect pests and diseases of tomato, eggplant, pepper

Colorado Potato Beetle
Stink bugs
Tomato hornworm
Mosaic Virus

2. Biological control agent: Gratiana boliviana

Gratiana boliviana is a leaf feeding beetle found in Paraguay, Argentina and Brazil

Larvae and adults produce a ‘shot hole’ damage on the leaves

Shot holes
Skeletons

Larvae and adults feed voraciously on TSA leaves and wounds facilitate the entrance of diseases
Adults are reproductive from April to October and migrate to the ground during winter.

Before the release of the beetle its host specificity was extensively studied under quarantine. Host range testing on 118 plants revealed that G. boliviana would only feed and reproduce on tropical soda apple.


Mass rearing was conducted at several locations across Florida. This project was successful in part due to close collaboration of agencies.

Releases targeted initially to counties with large TSA infestations.

Releases were conducted by ranchers, extension agents and researchers.
4. Establishment and impact of beetles

After five year of releases, a survey was conducted to monitor the establishment and impact of beetles

38 counties with a total 113 of random sites

Plants and beetle variables collected

Beetle densities were higher in St. Lucie and Okeechobee

Furthest beetles were found from a release site was 32.4 km

Average distance travelled / year = 4.7 km

Furthest distance travelled/year = 8.1 km

Highest density was 38 beetles per plant

Beetles negatively affected TSA performance

Long term monitoring study revealed a decrease in TSA densities after 2 years of beetle release

Quarterly sampling of 16, 4 m² quadrates

Before and after the beetle: St. Lucie Co.

July 2006

October 2007
Before and after the beetle: St. Lucie Co.

July 2006

October 2007

Before and after the beetle: Polk Co.

May 2003

June 2007

Before and after the beetle: Okeechobee Co.

June 2005

July 2005

August 2007

Survey of ranchers to assess the effectiveness of the program

Ranchers were more aware of the beetle in Central and South Florida

Ranchers told us the beetle is helping at controlling TSA

North Florida

Central Florida

South Florida

How common are the beetle in the ranch?

54% of cattle owners in C and S-FL stated that the beetles were responsible for TSA control in their properties

Pamphlets, how-to manuals and videos used to communicate to a wider audience

Videos include the ‘rancher perspective’, ‘how to recognize beetles and plants’ and ‘how biological control works’.
Each step in the biological control program of TSA was crucial for the overall success

1. Recognition of impact of TSA
2. Availability of host specific agent
3. Effective release program
4. Reduction in TSA densities in C and S-FL

Questions?
Wednesday, May 7, 2014 – 11:20AM

SESSION 6A: BIOCONTROL IN NATURAL AREAS

“Progress of Biocontrol on Brazilian Peppertree”

*Bill Overholt*
University of Florida/IFAS
Indian River REC
Introduction history and prospects for biological control of Brazilian peppertree

Jim Cuda
Rodrigo Diaz
Veronica Manrique
Greg Wheeler

Bill Overholt
University of Florida

Outline
- Background
- Introduction history
- Biological control

Background
- Native to Brazil, Paraguay, Uruguay and northern Argentina
- Introduced into FL as an ornamental in 1880s
- Invades a variety of habitats including disturbed areas as well as pinelands, hardwood hammocks and mangrove forests

Invasive characteristics
- Fast growth
- Prolific seed production
- Vectored by birds
- Year round growth
- Vigorous resprouting
- Tolerant of a wide range of conditions
  - Salinity
  - Extremes in moisture
  - Shade
  - Allelopathy

Reasons for concern
- Ecological costs
  - Displacement of native vegetation
- Economic costs
- Management
- Human health costs
  - Respiratory problems
  - Contact dermatitis

Introduction history
1842-49: Specimen collected in Florida by Ferdinand Rugel
1898: Introduction of seeds from France and Algeria into USDA Plant Introduction Center in Miami
1900: Introduction from ‘somewhere in Brazil’ into west coast Florida.
Invasion of natural habitats

Results – chloroplast DNA

Molecular evidence of introduction history

Chloroplast DNA

Nuclear DNA

Nuclear DNA reveals extensive hybridization

Origin of Florida BP types

Overwintering experiment
**Mortality of plants in Flagler Co.**

<table>
<thead>
<tr>
<th>Percent mortality</th>
<th>Fernandina plants</th>
<th>Punta Gorda plants</th>
<th>Miami plants</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>a</td>
<td>a</td>
<td>b</td>
</tr>
</tbody>
</table>

**How Biological Control Works**

- **Native home**
- **Invaded area**

**Brazilian peppertree thrips, *Pseudophilothrips ichini***

- *Pseudophilothrips ichini*
  - Feeds on growing tips
- *Calophya spp.*
  - Pit galls on leaves
- *Apocnemidophorus pipitzi*
  - Defoliator, wood borer

**Variation in thrips performance on different Brazilian peppertree types**

- Curitiba: from type D BP
- Ouro Preto: from type A
- Salvador: from type B

**Thrips reduced BP growth and biomass in the greenhouse**

- Control plant (no herbivory)
- Two-months after herbivory
Host Range Testing of P. ichini

<table>
<thead>
<tr>
<th>Family</th>
<th>Scientific Name</th>
<th>Common Name</th>
<th>N</th>
<th>Percentages</th>
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<tbody>
<tr>
<td>Anacardiaceae</td>
<td>Enterolobium argutum</td>
<td>Goldenrod</td>
<td>4</td>
<td>90.0 ± 2.0</td>
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<tr>
<td>Anacardiaceae</td>
<td>Enterolobium x chinense</td>
<td>Goldenrod</td>
<td>4</td>
<td>90.0 ± 2.0</td>
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<tr>
<td>Anacardiaceae</td>
<td>Rhus copallinum</td>
<td>Brazilian sumac</td>
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<td>62.2 ± 2.0</td>
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<tr>
<td>Anacardiaceae</td>
<td>Pistacia chinensis</td>
<td>Pistachio</td>
<td>5</td>
<td>54.0 ± 2.0</td>
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<tr>
<td>Anacardiaceae</td>
<td>Pistacia smithiana</td>
<td>Pistachio</td>
<td>4</td>
<td>54.0 ± 2.0</td>
</tr>
<tr>
<td>Anacardiaceae</td>
<td>Rhus sandwicensis</td>
<td>Rhus</td>
<td>5</td>
<td>54.0 ± 2.0</td>
</tr>
<tr>
<td>Anacardiaceae</td>
<td>Rhus aromatica</td>
<td>Rhus</td>
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<td>54.0 ± 2.0</td>
</tr>
<tr>
<td>Anacardiaceae</td>
<td>Magnolia x soulangeana</td>
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<td>42.6 ± 2.0</td>
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<td>Magnolia virginiana</td>
<td>Magnolia</td>
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<td>42.6 ± 2.0</td>
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<td>Anacardiaceae</td>
<td>P. ichini</td>
<td>P. ichini</td>
<td>4</td>
<td>42.6 ± 2.0</td>
</tr>
</tbody>
</table>

Dual-choice Testing of P. ichini

<table>
<thead>
<tr>
<th>Family of non-target</th>
<th>Non-target species</th>
<th>#1 adults on</th>
<th>#1 adults on non-target</th>
</tr>
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<tbody>
<tr>
<td>Anacardiaceae</td>
<td>Salix alba</td>
<td>3.0</td>
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<tr>
<td>Anacardiaceae</td>
<td>Salix babylonica</td>
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<td>0</td>
</tr>
<tr>
<td>Anacardiaceae</td>
<td>Salix caprea</td>
<td>3.0</td>
<td>0</td>
</tr>
<tr>
<td>Anacardiaceae</td>
<td>Salix purpurea</td>
<td>3.0</td>
<td>0</td>
</tr>
<tr>
<td>Anacardiaceae</td>
<td>Salix viminalis</td>
<td>3.0</td>
<td>0</td>
</tr>
</tbody>
</table>

Calophya latiforceps
Calophya terebinthifolii

Leaf galling psyllids

Damage
No-choice host range testing

<table>
<thead>
<tr>
<th>Scientific name</th>
<th>Common name</th>
<th>Eggs laid per female</th>
<th>Survival to adult (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Schinus</em> terebinthifolia - FL Pure A</td>
<td>Brazilian peppertree</td>
<td>7.4 ± 3.2</td>
<td>8.8 ± 7.7</td>
</tr>
<tr>
<td><em>Schinus</em> terebinthifolia - FL Pure B</td>
<td>Brazilian peppertree</td>
<td>8.4 ± 6.6</td>
<td>12.8 ± 6.7</td>
</tr>
<tr>
<td><em>Schinus</em> terebinthifolia - FL Hybrids</td>
<td>Brazilian peppertree</td>
<td>6.7 ± 5.3</td>
<td>9.7 ± 5.0</td>
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<tr>
<td><em>Schinus</em> molle</td>
<td>Peruvian peppertree</td>
<td>0.4 ± 0.7</td>
<td>0</td>
</tr>
<tr>
<td><em>Anacardium occidentale</em></td>
<td>Cashew</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>Cotinus coggyria</em></td>
<td>European smoke tree</td>
<td>0</td>
<td>0</td>
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<tr>
<td><em>Malus laurina</em></td>
<td>Laurel sumac</td>
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<td>0</td>
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<tr>
<td><em>Metopium toxiferum</em></td>
<td>Florida poxentree</td>
<td>0</td>
<td>0</td>
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<tr>
<td><em>Pistacia chinensis</em></td>
<td>Chinese pistache</td>
<td>0</td>
<td>0</td>
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<tr>
<td><em>Rhus aromatica</em></td>
<td>Fragrant sumac</td>
<td>0.1 ± 0.3</td>
<td>0</td>
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<tr>
<td><em>Rhus copallinum</em></td>
<td>Winged sumac</td>
<td>0.2 ± 0.5</td>
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<tr>
<td><em>Rhus typhina</em></td>
<td>Staghorn sumac</td>
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<tr>
<td><em>Spondias purpurea</em></td>
<td>Purple mombin</td>
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<td>0</td>
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<tr>
<td><em>Spondias dulcis</em></td>
<td>Jew’s mallow</td>
<td>0</td>
<td>0</td>
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<tr>
<td><em>Toxicodendron radicans</em></td>
<td>Eastern poison ivy</td>
<td>0.2 ± 0.2</td>
<td>0</td>
</tr>
</tbody>
</table>

Apocnemidophorus pipitzi

Larvae bore in stems and adults feed on leaf tissue

Apocnemidophorus pipitzi (Faust)
(Col: Curculionidae)

Adult Feeding Preference

No-Choice Test

Complete Development
Multiple-Choice Tests

No-choice adult survival
Insect | Petition status
--- | ---
Apocnemidophorus pipitzi | Submitted October 2012, additional tests requested in November 2013
Calophya latiforceps | To be submitted by May, 2014
Pseudophilothrips ichini | To be submitted by June, 2014

To summarize

- Two types of Brazilian peppertree were introduced into Florida
- The two types hybridized, which we believe may have increased the tree’s aggressiveness and allowed expansion into cooler areas
- Several candidate biological control agents are currently under investigation
- A petition for release of the wood boring weevil is pending approval
- Two types of Brazilian peppertree were introduced into Florida
Wednesday, May 7, 2014 – 1:00PM

SESSION 7A: NATURAL AREAS AND RIGHT-OF-WAY WEED CONTROL

“Identification and Control of Grasses”

Sarah Lancaster
University of Florida/IFAS
Range Cattle REC
GRASS CONTROL IN RIGHTS-OF-WAY & NATURAL AREAS
Sarah Lancaster

Outline
- General management techniques
- Identification
- Management recommendations
- Current research

Pest management programs
- Identify the target
- Evaluate population
  - Know action threshold
- Select control method
  - Mechanical, biological, chemical, cultural
- Monitor control

Cogongrass

Cogongrass 
*(Imperata cylindrica)*
- Native to Southeast Asia
- Introduced into Florida in 1930's
  - Forage and soil stabilization
- Perennial, spreads through rhizomes
  - Up to 4 feet
  - Most in top 6 inches
- Found in a variety of habitats
  - Pyrogenic species

Cogongrass
- Inflorescence
  - Fluffy, white spike
  - Primarily in spring

Cogongrass
- 1-4 feet tall
  - No/short stem
- Leaf blades
  - 0.5-0.75 inches wide
  - Serrated margins
  - White mid-rib usually off-center
Torpedograss
(*Panicum repens*)
- Native to Africa and or Asia
- Introduced into Florida in late 1800's
  - wetland forage grass
- Perennial, spreads through rhizomes
- Roots on shore, extends into shallow water
  - Forms dense monoculture along shoreline of lakes and ponds

Para grass
(*Urichloa mutica*)
- Native to Africa
- Introduced into Florida in late 1800's
  - wetland forage grass
- Perennial, spreads through stolons and seeds
- Prefers water fluctuations

**Torpedograss**
- 3-8 m tall
- Leaf sheath with or without hairs
  - usually at the upper sheath margin
- Ligule a short ciliate membrane
- Leaf blades
  - Flat or folded
  - Stiff
  - Upper usually hairy, near collar
  - Lower with or without or hairs

**Para grass**
- 3 ft tall erect
- 5 ft long when creeping
- Leaf sheath with dense stiff hairs
- Nodes swollen and hairy
- Ligule a ciliate membrane
- Leaf blades
  - Flat
  - 0.5 in. wide, 10 in. long
  - Small fine hairs near collar
**Para grass**
- Inflorescence
  - Terminal panicle
  - 8 in. long
  - 8 to 20 ascending, alternate branches
  - Often purple-tinted
- Seed
  - Reportedly very low seed production and viability

**West Indian marsh grass**
(Hymenachne amplexicaulis)
- Native to Caribbean
- Introduction to Florida uncertain
- Perennial, spreads through stolons and seeds
- Prefers water fluctuations and high nutrients

**West Indian marsh grass**
- 3 to 8 ft tall
- Leaf sheath glabrous
  - some hairs on upper margins
- Ligule membranous
- Leaf
  - Flat
  - 14 in. long by 1.6 wide
  - Clasping at the stem
  - Long hairs on lower margin
- Pithy stem

**West Indian marsh grass**
- Inflorescence
  - Dense, terminal spike
  - 0.3 in wide by 20 in. long
- Seeds
  - Stick to animals, clothes
  - 98% germination

**Limpograss**
(Hemarthria altissima)
- Native to Africa
- Introduced into Florida in 1964
  - wetland forage grass
- Perennial, spreads through stolons
- Four cultivars released; similar attributes
Limpograss
- 3 to 6 feet tall
- Leaf sheath usually glabrous,
  - red coloration
  - sometimes with fringe of hairs
- Ligule a ciliate membrane
- Leaf blade-2 to 6 in. long; 3-4 mm wide
  - can depend on cultivar

Limpograss
- Inflorescence
  - Single spike
  - Panicle of several spikes
  - 2 to 8 in. long
- Seed
  - Few produced
  - Highly viable

Control of Perennial Grasses
- Two products of choice:
  - Glyphosate
    - Terrestrial (Roundup, etc.) vs. Aquatic (Rodeo, etc.)
    - 4 to 7.5/2 pints/acre
    - Retreatment necessary when plants partially submerged
  - Imazapyr
    - Terrestrial (Arsenal, etc.) vs. Aquatic (Habitat, etc.)
    - 2 to 4 pints/acre
    - Retreatment necessary depending on the species

Cogongrass
- Glyphosate
  - Spring and fall
  - 3-5 lb ae/A
  - 2-5% v/v depending on the product
- Imazapyr
  - Spring, summer, or fall
  - 0.5-1 lb ai/A
  - 0.5%-2% v/v depending on the product
- Combination similar to imazapyr alone
  - Less control with single glyphosate application

Cogongrass
- Alternative is to farm it out
  - Repeated, frequent tillage that breaks up the entire rhizome layer is effective
  - Infrequent tillage spreads cogongrass rhizomes and seed
- Only get suppression with mowing
  - Mow when cogongrass is greening up
  - Avoid mowing during and just after flowering

Torpedograss
- 7.5 pints of glyphosate/acre (2-3% solution)
  - Only translocates in tissues above water
  - Retreatment necessary when a portion of the plant is below water
- 4 pints/acre of imazapyr (0.5 to 1% solution)
  - Translocates throughout plant even below water line
  - Retreatment likely with dense infestations
Para grass
- 6 pint/acre glyphosate
- Best if applied to lush growth; may require burning and treating new regrowth
- Will have to retreat escapes
- 2 to 4 pint/acre imazapyr
- Use higher rate for long-established stands
- Expect quicker recovery of native species when water standing

West Indian marsh grass
- 7 pint/acre glyphosate
- Para grass tended to invade our research plots
- 4 to 6 pint/acre imazapyr
- No para grass within 1 yr of treatment
- Native species quick to reestablish if water present at application
- Water depth at application not an issue with either herbicide

Limpograss
- Very sensitive to glyphosate
- 6 pints/acre – even to very old growth
- Do not treat young growth
- Imazapyr
- 2 pints/acre very effective
- No information on water depth available

Selective herbicides
- Control grasses only
- 24c Label
- “Public good” provision for off-patent products
- 7 years patent protection
- Several show potential
  - clethodim, sethoxydim, fenoxaprop, fluazifop, quizalofop, and nicosulfuron

Results
6 weeks after treatment

Conclusions
- Identify properly
- Herbicide choices are glyphosate and/or imazapyr
- Potential for selective herbicides
- Retreatment VERY likely
- Scout for regrowth
Wednesday, May 7, 2014 – 1:50PM

SESSION 7A: NATURAL AREAS AND RIGHT-OF-WAY WEED CONTROL

“Control of Arundo and Napiergrass in the Everglades Agricultural Area”

Calvin Odero
University of Florida/IFAS
Everglades REC
Control of Giant Reed and Napiergrass in the Everglades Agricultural Area

Calvin Odero
UF-IFAS Everglades Research & Education Center, Belle Glade, FL

May 7, 2014
Coral Springs, FL

Everglades Agricultural Area (EAA)

Organic "Muck" Soils
320,000 A
82 %

Sandy Soils
87,000 A
18 %

Giant reed (Arundo donax)

- Synonym: Spanish reed
- Perennial grass
- Native to East Asia & Mediterranean region
- Introduced in 1800’s in US for erosion control
- Distribution: southern half of continental US, from Atlantic to Pacific coasts

Giant reed in Florida

- Not listed as invasive by FLEPPC
- Has high invasive potential in much of Florida
- Reported in 24 counties

Biology and Identification

- Stems: erect, ¾ - 1½ inch wide, cane-like, smooth, hollow, unbranched, 6-30 ft in height
- Leaves: smooth, long, linear, flat or folded, thick mid-vein
- Sheath: smooth
- Ligule: large, membranous, minute fringe trichomes

Biology and Identification

- Inflorescence: large, dense, panicle, 1-2 ft long, silvery, whitish or purplish
  - Spikelets are stalked, solitary, long silky awns
  - Seldom produce seeds, not viable
- Roots: fibrous from knotty rhizomes
  - Rhizomes: thick, scaly, forming a dense network
- Reproduction: vegetative (stalks, rhizomes)
  - Spreads primarily through rhizome elongation and fragmentation
Habitat

- Prefers wet conditions
  - Roadsides, fields, pastures, stream banks
- Once established in wetland and riparian habitats, it quickly forms thick, dense monocultures that displace native species
- Uses large amounts of water causing a reduction in ground water availability
- Dead and dry stands can pose a fire hazard
- Interferes with rivers and lakes
  - Increasing sedimentation and narrowing water channels which leads to flooding and erosion

Management

- Mechanical
  - Repeated close mowing
    - Remove mowed material from site
  - Repeated tillage
    - Deplete root zones and rhizome masses
- Chemical
  - Systemic herbicides to eradicate established populations
    - Glyphosate: 2 to 5% solution, 1.5 pt/A
    - Imazapyr: 1.5-2.0 pt/A
    - Imazapyr (2% solution) + glyphosate (2% solution)
  - Repeat applications necessary
  - Cut stem treatments effective if glyphosate is applied within 1-2 minutes of cutting
  - Aquatic areas, make sure the herbicide is registered for use
  - Follow the LABEL

Nappiergrass (*Pennisetum purpureum*)

- Synonym: elephantgrass
- Perennial grass
- Native to tropical Africa
- Introduced as a forage in 1913 in the US
- Widely distributed in California, Texas, Florida and Hawaii

Nappiergrass in Florida

- Introduced to Florida in 1915
- Category I noxious weed in 29 counties in Florida (FLEPPC)

Biology and Identification

- Stems: erect, cane-like up to 15 ft tall, solid, often branched above, young nodes hairy, later smooth
- Leaves: linear, flat, abrasive with long stiff hairs on upper surface, smooth/abrasive on the bottom, midrib strongly ridged
- Sheath: extremely hairy near bottom of stem, smooth towards top of stem
- Ligule: thin with hairy rims

Biology and Identification

- Inflorescence: dense terminal panicle, spike-like, bristly, bottle bush shape, 4-13 inch long
  - Spikelets are solitary or in clusters of 4-6 flowers with long silky awns
- Roots: creeping rhizomes 6-10 inch with fine hairs at nodes
- Reproduction: vegetative (stalks, rhizomes)
  - Inconsistent seed producer, low viability
Habitat

- Naturalized in central and south Florida
- Roadsides, canal and ditch banks, pastures, fields, swamps, prairie habitats, public water bodies
- Once established, it quickly forms thick clumps or colonies from basal offshoots or shoot rhizomes
- Blocks access to canals, reducing water flows, and overgrowing pump stations

Management

- Mechanical
  - Cultivation
    • Should not be used on mature plants
    • Cultivation equipment should be cleaned thoroughly when moving into clean fields from infested fields
- Cultural
  - Crop rotation in the EAA
    • Sugarcane to fallow
    • Sugarcane to vegetables
    • Sugarcane to rice
  - Clean seed cane from none infested fields

Management

- Chemical
  - No herbicides labeled for selective control in cane in the EAA
  - Glyphosate
    • 2% solution for seedling and mature plants
    • 1.5 pt/A
  - Imazapyr
    • 1.0-1.5 pt/A
  - Addition of surfactant and ammonium sulfate to spray solution improves efficacy
  - Follow the LABEL

References


Contact Information

Calvin Odero
Everglades Research and Education Center
3200 E Palm Beach Road
Belle Glade, FL 33430
Email: dcobero@ufl.edu,
Phone: 561-992-1336

THANK YOU

QUESTIONS?
Wednesday, May 7, 2014 – 1:00PM

SESSION 7B: AQUATIC TRAINING

“Aquatic Weed Control Training”

Susan Haddock
University of Florida/IFAS
Hillsborough County
Water Blindness

- Gulf of Mexico & Atlantic Ocean surround us
- 54,836 miles of rivers & streams (1,700 rivers & streams)
- 49,128 miles of canals & ditches
- 1.8 million acres of lakes, reservoirs & ponds
- 1,000 springs
- 11 million acres of wetlands
- 1,350 miles coastal shoreline, largest in 48 contiguous states
- Underlying aquifers supply freshwater needs

**Renewable but finite**

**Navigable**

**Clear for drainage**

Water Facts

- Population growth increases water needs
  - 1990 - 12,937,926
  - 2011 - 19,057,542

- Population Rank - 4th in U.S. behind California, Texas & New York

Why is this Training Important?

**Water Facts**

- Water is Florida’s most valued resource
- Florida’s #1 concern is water conservation & water quality
- The past 20 years, surface waters in Florida have become very sensitive to small additions of pollutants
- Caused widespread ecosystem changes in estuaries, lakes, rivers & the Everglades

Exam Questions

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<td>13</td>
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</tbody>
</table>

Recommended Study Guides

- Aquatic Pest Control Study Manual
- Aquatic Pest Control DVD
- Florida Wetland Plants
- ID & Biology of Nonnative Plants in FL Natural Areas
Florida population estimated to increase at least 25% by 2020 to 22 million
Florida will need 26% more water – 9.1 billion gallons of fresh water every day
Water supply needs already exceed capacity in some areas
Water accessibility
Competition between urban, agricultural & recreational uses
Costs of mitigation

Phosphorous & Nitrogen are naturally occurring
In some areas, can be in short supply in water
Limits plant growth
Abundant phosphate deposits in underlying soils
In FLORIDA, waters are naturally productive, why?

Water bodies receive N & P inputs from fertilizer runoff
High nutrient levels in water results in high growth of aquatic plants, especially algae & floating plants
Can be a problem if aquatic plants interfere with intended use of water body

Nonnative plants out-compete native plants, form monocultures & interfere with wildlife that depends on native plants
Obstruct water flow, hinder navigation, reduce recreation uses, destroy aesthetics
Shade native plant beds, decrease dissolved oxygen levels, increase mosquito breeding, reduce fish spawning, reduce water fowl habitat

Selectively control nonnative plants for the benefit of native plants communities

Water-Hyacinth
Hydrilla
Alligatorweed
Torpedo grass
Hygrophila
Management Goals Are Site Specific

In multi-use water bodies, management goals may require a compromise relative to vegetation management.

Aquatic plant manager (YOU) must determine & use the best combination of integrated management methods to achieve the goals of the water body.

Integrated Pest Management

IPM
Uses various combinations of pest control methods in a compatible manner to:
- Achieve satisfactory control
- Ensure favorable economic & environmental consequences

Economical injury thresholds vs.
Reproductive potential & Rapid growth rate

Herbicides
Biological Control
Physical Removal

Integrated Pest Management

Maintenance Control
Techniques used in a coordinated manner on a continuous basis in order to maintain the plant populations at the lowest feasible level

Herbicides
Biological Control
Physical Removal

Maintenance Control

Minimizes detrimental impacts of aquatic weeds:
- on water uses
- on waterbodies
- reduces the efforts to control invasive plants

History of Aquatic Plant Management

1884 - Introduction of Water-Hyacinth in - St. Johns River near Palatka from Cotton States Exposition, New Orleans

1898 - River became unnavigable - reach docks, pass thru bridge openings or narrow areas

Alligatorweed from South America via ballast dumping
Aquatic Exam Prep

History of Aquatic Plant Management

1899 - River & Harbor Act
Authorizes Army Corp of Engineers to construct & operate vessels for removal & containment of water-hyacinth

1902 - Congress authorizes extermination & removal of water-hyacinth by any mechanical, chemical or other means
• muriatic acid, sulfuric acid, kerosene, sodium arsenate, formaldehyde

1905 - Congress prohibits use of any chemical injurious to cattle or man
• Repellents (adjuvants) use to keep cattle from eating plants
cow manure, tobacco, rotten eggs, decaying meat, macerated blood

1944 - 1947 - 1st synthetic herbicide - 2,4-D discovered
• Not toxic to fish, cattle or humans
1947 - ground & aerial spraying to control miles of infested streams
1948 - 63,000 acres of water-hyacinth in Florida alone

1958 - 5 year plan for eradication & control of water-hyacinth, alligatorweed & other noxious weeds
1963 - USACE "Operation Clean Sweep" on St. John’s River
1971 - FDEP named cooperator
1974 - “Maintenance Control” incorporated into law

Laws Pertaining to Pesticides

Environmental Protection Agency (EPA)
Regulates manufacture, transportation, use, marketing of all pesticides in U.S.

Federal Insecticide, Fungicide, & Rodenticide Act (FIFRA)
• Requires all pesticides used in U.S. be labeled according to EPA
• Must be labeled for each crop &/or site where it is intended to be used
• Any pesticide that is applied directly to water must be registered for aquatic use
Laws Pertaining to Pesticides

Florida Department of Agriculture & Consumer Sciences (FDACS)

Regulates pesticide use in Florida:
- All pesticides used in Florida must be registered by FDACS for use in the state
- State registrations may be more restrictive than federal registrations

Florida Pesticide Law (Ch. 487 Florida Statute)
- Pesticide Registration & Label Laws
- Enforced by FDACS

FDACS - Bureau of Compliance Monitoring:
- Product registration
- Record keeping
- Worker protection
- Storage, disposal
- Applicator licensing
- Environmental protection

Regulation of Aquatic Plants

Florida Fish & Wildlife Conservation Commission
- Directs noxious weed:
  - Control
  - Eradication
  - Regulation
- Guides & coordinates activities of:
  - All public water bodies
  - Authorities, agencies & special districts charged with the management of aquatic plants

Florida Fish & Wildlife Conservation Commission

“Any person or public agency wanting to control, eradicate, remove, or otherwise alter any aquatic plants in waters of the state must:
- Obtain a permit for the activity from FWC
- Unless the activity or waters are exempted by FWC rules”
Aquatic Exam Prep

Aquatic Plant Control Permit Exemptions
- Waters wholly owned by one person other than the state, provided there is no connection to Waters of State Concern
- Artificially created waters used exclusively for agricultural purposes, provided there is no connection to Waters of State Concern

Aquatic Weed ID
Based on line drawings & verbal descriptions
Resource for study: http://plants.ifas.ufl.edu

Aquatic Weed ID
Leaves in whorls of 4-8 (usually)
Leaves have course-toothed margins & make plant rough to touch
Midvein is typically red & often armed with 1 or more spines or bumps underneath
Turions (specialized overwintering bud) in the leaf axis & tubers at the end of rhizomes (stem) may be present

Aquatic Weed ID
Showy blue or purple flowers form a spike whose uppermost petal is marked with yellow
Leaves have parallel veins & sometimes contain bulbous petioles
Fibrous roots are numerous, dark colored & hang beneath in a mass
Growth often results in large mats of connected daughter plants

Aquatic Weed ID
Primitive plant
Multi-cellular with cells attached end to end
Form long threads

Hydrilla
Hydrilla verticillata

Water Hyacinth
Eichhornia crassipes

Filamentous Algae
Aquatic Weed ID

Native plant
Small, silvery-white flowers (single), roots & rhizomes
Leaf veins are branched (net veination)

Aquatic Weed ID

Emersed, leafless, spongy, rounded, 3-angled stems
3-10 feet tall that arise from thick runners
Flower clusters occur at the ends of the stem with a bract that appears as a continuation of the stem

Aquatic Herbicides

Herbicides:
Chemicals:
• Killing plants
• Severely interrupting their normal processes
~200 herbicide active ingredients in the U.S.
12-14 registered for aquatic use in FL

Aquatic Herbicides

Herbicide Goal:
Crops:
• Kill many species
• Leave crop alone
Aquatics:
• Kill one species (selectivity)
• Leave many alone

Definitions

Active Ingredient (AI) – Controls the pest
Absorption –
  Movement of a herbicide into a plant
Adsorption –
  Association of a herbicide onto a surface (bonds to)
Translocation –
  Movement of a herbicide within a plant
Herbicide mode of action –
  How a herbicide kills or affects plants

Definitions

Selective herbicide:
A chemical that is more toxic to some plant species than to others

Broad spectrum herbicide:
A chemical that is toxic to a large number of plant species

Selective application:
Applying a herbicide in such a way as to control only a target species
Definitions

Contact herbicide:
• Kills only those plants that it contacts
• Plant response is quick
• Not effective on perennial plants
• Usually non-selective

Systemic herbicide:
• Taken up & translocated (moves) within plants
• Plant response is slow
• More effective on perennial plants
• May be selective

Aquatic Herbicide AI

<table>
<thead>
<tr>
<th></th>
<th>CONTACT</th>
<th>SYSTEMIC</th>
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</thead>
<tbody>
<tr>
<td>Copper</td>
<td>Inhibits photosynthesis</td>
<td>Broad spectrum</td>
</tr>
<tr>
<td>Diquat</td>
<td>Inhibits photosynthesis</td>
<td>Broad spectrum</td>
</tr>
<tr>
<td>Endothall</td>
<td>Inhibits respiration</td>
<td>Broad spectrum</td>
</tr>
<tr>
<td>2,4-D</td>
<td>Disrupts tissue development</td>
<td>Selective</td>
</tr>
<tr>
<td>Fluridone</td>
<td>Inhibits photosynthesis</td>
<td>Some selective</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>Inhibits enzyme activity</td>
<td>Broad spectrum</td>
</tr>
<tr>
<td>Imazamox</td>
<td>Inhibits enzyme activity</td>
<td>Broad spectrum</td>
</tr>
<tr>
<td>Imazapyr</td>
<td>Inhibits enzyme activity</td>
<td>Broad spectrum</td>
</tr>
<tr>
<td>Penoxsulam</td>
<td>Inhibits enzyme activity</td>
<td>Broad spectrum</td>
</tr>
<tr>
<td>Triclopyr</td>
<td>Growth regulator</td>
<td>Selective</td>
</tr>
</tbody>
</table>

Mode of Action

Synthetic auxins (auxins = plant hormones):
Mimic naturally occurring auxins
Abnormal growth - twisting, curling
aka organo-auxin herbicides: 2,4-D
Organo-auxin rule - special precautions, restrictions, record keeping

Photosynthesis inhibitors:
Interferes with food production
Direct interference - fast: Diquat, copper
Inhibit pigment production - slow: Fluridone

Enzyme inhibitors:
ALS (acetolactate synthase) - slow:
Imazamox, Imazapyr, Penoxsulam
PPO (protop) - fast: Carfentrazone

Cell membrane disruptors:
Leaky - improper cell function - fast:
Endothall, hydrogen peroxide

Fate of Herbicides in the Environment
Herbicides sold as a concentrate & diluted before use:
✓ Concentration in spray tank is 20-200 times more dilute than concentrate
✓ Little herbicide reaches the water in foliar applications on dense mats
✓ Herbicides are applied to water for submersed weeds at concentrations of 10-10,200 ppb & may not be detectable shortly after application
Aquatic Exam Prep

Transformation

- Changes that occur to a herbicide after it is applied
- It is no longer toxic to plants

**Inactivation** – Herbicide combines chemically or physically with another substance that cause it to no longer have biological activity
  - Chemical example - copper + carbonates
  - Physical example - Diquat + organic particles in water & sediment

**Breakdown** – Herbicide chemically transforms into non-toxic compounds
  - Photolysis
  - Hydrolysis
  - Microbes
  - Combination

Toxicity

**LD**<sub>50</sub>
- The amount of herbicide required to provide a lethal dose to 50% of the test population

**96-hr LC**<sub>50</sub>
- Concentration of herbicide in water that kills 50% of the test organisms in 96 hours - expose fish & organisms at different concentrations for 96 hours

**Toxicity**

- Fish tend to avoid water with toxic concentrations
- Herbicide diluted to nontoxic by surrounding water
- Applications made with extreme care
- Copper is more toxic in soft water
  - In hard water settles to the bottom in 24 hrs after application

**Endothall alkylamine salt & copper**
- Can be toxic to algae
- Can cause fish kills at concentrations below the labeled rate
- So used for spot treating or treating parts of water bodies

Aquatic Herbicide Toxicity

<table>
<thead>
<tr>
<th></th>
<th>Application Rate (ppm)</th>
<th>Bluegill (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>0.5-3.0</td>
<td>Soft water: 0.88</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hard water: 7.3</td>
</tr>
<tr>
<td>Diquat</td>
<td>0.12-1.50</td>
<td>245</td>
</tr>
<tr>
<td>2,4-D</td>
<td>0.5-3.0</td>
<td>263</td>
</tr>
<tr>
<td>Endothal</td>
<td>1.0-3.0</td>
<td>Dipotassium salt: 342</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alkylamine salt: 0.96</td>
</tr>
<tr>
<td>Fluridone</td>
<td>0.01-0.09</td>
<td>14.3</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>NA</td>
<td>120</td>
</tr>
<tr>
<td>Imazamox</td>
<td>0.05-0.50</td>
<td>122</td>
</tr>
<tr>
<td>Penoxsulam</td>
<td>0.01-0.15</td>
<td>103</td>
</tr>
</tbody>
</table>
**Aquatic Herbicides & the Public**

**Goal:** improve & enhance the environment
- You are highly visible
- Follow label instructions
- Know potential

**Knowledge is power**
- Avoid "poison in the water" mentality
- Educate the public

---

**Residue Tolerance**

Maximum amount of pesticide that is legally allowed in or on a commodity

---

**Aquatic Herbicides & the Public**

**Residue Tolerance**

- Set at 100 or 1,000 times lower than the concentration tolerated by animals
- Ensures that the public will not come in contact with herbicide concentrations that may cause harmful effects

---

**Aquatic Habitats**

- **Submersed** – grow completely below water
- **Emersed** – rooted in the bottom, extend above water surface
- **Floating** – float on water surface

---

**Aquatic Habitats**

Consist of aquatic plants including:
- **Macrophytes** – aquatic plants with vascular tissue, not algae
- **Phytoplankton** – free floating algae
- **Invertebrates** – insects, clams
- **Fish, bird & mammals**
Aquatic Exam Prep

Aquatic plants are a natural & important component of aquatic habitats

Aquatic Plants

**Free Floating Algae** (Phytoplankton) –
- Primary producers
- Used as food source for all other organisms

**Zooplankton** (Free Floater, drifters) –
- Primary consumers
- Feed on phytoplankton

**Fish, insects, crustaceans** –
- Secondary consumers
- Feed on zooplankton

**Aquatic Plants** –
- Provide habitat for animals & cover for fish

Aquatic Habitats

All are interrelated & require physical & chemical conditions such as nutrients, oxygen, light & space

Aquatic weed control can affect one or more organisms or the water chemistry in the habitat that can in turn affect other organisms

Aquatic Plants

In Florida’s subtropical climate water is often naturally rich in the plant nutrients N & P

Aquatic plants may grow so vigorously that they become a nuisance

Aquatic Plants

When large amounts of macrophytes are present:
- They accumulate N & P in their tissue
- Nutrients not available for phytoplankton growth

When large amounts of macrophytes are killed by herbicides or consumed, digested & excreted by grass carp
- N & P are released
- N & P allow increased phytoplankton growth
- Causes water to take on green coloration (bloom)
- Water clarity is reduced

Dissolved Oxygen & Fish Kills

**Fish kill - when large numbers of fish die in a water body**

Related to changes in:
- Temperature
- pH
- Oxygen
- Stress from spawning
- Disease
- Dissolved oxygen
Low dissolved oxygen is a common cause of fish kills

- Optimum health = 5 ppm
- Survive brief periods of lower levels, but may not recover when below 2 ppm
- Below 1 ppm for prolonged periods is lethal

Oxygen enters water by:
- Diffusion from air
- Photosynthesis from plants growing in the water

Dissolved oxygen varies depending on:
- Wind - waves increase at water's surface
- Temperature - decreases as temperature increases
- Sunlight - decreases in low light due to decreased photosynthesis
- Biota - those that do not photosynthesize consume oxygen
- Time of day - no photosynthesis at night, oxygen consumed during night, lowest just before sunrise

Minimizing chance of fish kills:
- Apply herbicides that have little effect on phytoplankton
- Applications to cooler water
- Avoid applications during prolonged cloudy conditions
- Treat portions of water body, not entire body
- Pesticide applicator error is most likely to cause fish kill

Nonherbicide Methods
- Physical removal
- Water level manipulation
- Nutrient limitation
- Biological controls
- Reducing light penetration - dyes blocks light needed for photosynthesis

Label Interpretation
- Selective/non-selective
- Contact/systemic
- PPE
- How & when to apply
- How much to apply
- Susceptible species
- Adjuvants
Label Interpretation
Which best describes this herbicide? (Hint – pg 1)

a) Non-selective, contact
b) Non-selective, systemic
c) Selective, contact
d) Selective, systemic

Label Interpretation
What is the maximum number of Galleon applications that can be made per annual growth cycle if each application is to be 30 ppb?
(Hint – pg 5)

Label Interpretation
Which resistance management strategy is recommended? (Hint – pg 6)

a) Apply maximum rates
b) Use alternate modes of action in subsequent treatments
c) Make repeated applications during a single year
d) Tank mixing with other herbicides that target ALS enzyme

Label Interpretation
What is the common name of the active ingredient in this product? (Hint – Pg 1)

Common Name
Chemical Name
Brand Name

Label Interpretation
What is the weight of the active ingredient in this product? (Hint – pg 1)

Label Interpretation
Which of the following is not a legal practice in using this product? (Hint - Core Training)

a) Application to a weed not listed on the product’s label
b) Application to a site not listed on the product’s label
c) Application rates less than listed on the product’s label
d) Application in tank mixes with other herbicides
Label Interpretation

What is the recommended rate range for an exposed sediment application of this product?

(Hint – pg 6)

Label Interpretation

What is recommended for determining the active ingredient concentration in treated water?

(Hint – pg 2)

Label Interpretation

What is the threshold concentration for treated water to be used for irrigation of food crops?

(Hint – pg 2)

Label Interpretation

For which species of vascular aquatic plant would you expect variable susceptibility after treatment with this product? (Hint – pg 4)

a) Water lettuce
b) Water pennywort
c) Arrowhead
d) Eurasian watermilfoil

Label Interpretation

Which type of surfactant is not recommended for use with this product?

(Hint – pg 2)

Label Interpretation

What is the maximum number of Galleon applications that can be made per annual growth cycle if each application is to be 30 ppb? (Hint – pg 5)

150 ppb maximum = 5 applications

30 ppb/application
Label Interpretation

To treat the exposed sediments of a pond with the maximum rate of Galleon, how many ounces (nearest ounce) of product would be added to each full 50-gallon tank if the equipment applies 28 gallons of spray mix per acre? (Hint – pg 6)

\[
\text{oz. product} = \frac{\text{max. oz. per acre}}{\text{tank volume}} \times \text{apply 28 oz. per acre}
\]

\[
\text{oz. product} = \frac{11.2}{50} \times 28 = 20
\]

Label Interpretation

How much product (to nearest tenth) is required to treat 7-acre lake with an average depth of 4 feet if the target concentration is 30 ppb? (Hint – pg 5)

\[
\text{acre ft} = 7 \text{ acres} \times 4 \text{ ft depth} = 28 \text{ acre ft.}
\]

\[
0.174 \text{ fl. oz.} \times 30 \text{ ppb} \times 28 \text{ acre ft.} = 146 \text{ fl. oz.}
\]

\[
146 \text{ fl. oz.} = \frac{1.14 \text{ gallons}}{128 \text{ fl. oz./gallon}}
\]

Label Interpretation

\[
\text{oz. product} = \frac{\text{max. oz. per acre}}{\text{tank volume}} \times \text{apply 28 oz. per acre}
\]

\[
x = \frac{11.2}{50} \times 28
\]

\[
x = 560
\]

Wrap Up

Good Luck on Your Exam

You should have learned about how your job impacts Florida’s water quality

Math Sessions Highly recommended

Questions about this material???

Susie Haddock, Commercial/IPM Agent II
UF/IFAS Hillsborough County Extension
(813)744-5519 ext. 54103
szcrmchz@ufl.edu
Wednesday, May 7, 2014 – 3:00PM

SESSION 8A: ALGAE AND POND MANAGEMENT

“Nuisance Algae Characterization and Management Options”

West Bishop
SePro
Nuisance algae characterization and management

West M. Bishop
Algae and Aquatic Research Scientist

Outline

1. Identification/Classification/Description
2. Negative Impacts
3. Ecology and Proactive Management
4. Reactive Management
**Introduction to Algae Phyla**

- **Chlorophyta**
  - Green algae

- **Cyanophyta**
  - Blue-green algae

- **Euglenophyta**
  - Flagellated, eye spot (some red)

- **Charophyta**
  - Plant like, erect

- **Pyrrophyta**
  - Dinoflagellates, transverse flagellum

- **Bacillariophyta**
  - Diatoms, silica wall

- **Chrysophyta**
  - Yellow-green

- **Haptophyta**
  - Golden algae

<table>
<thead>
<tr>
<th>Algae name</th>
<th>Phylum</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lyngbya</td>
<td>Cyanophyta</td>
<td>filamentous, toxin/taste and odor producer, muclaginous, mat-former</td>
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<tr>
<td>Prymnesium parvum</td>
<td>Haptophyta</td>
<td>unicellular, toxin producer, planktonic, flagellated</td>
</tr>
<tr>
<td>Algae name</td>
<td>Phylum</td>
<td>Characteristics</td>
</tr>
<tr>
<td>-----------------</td>
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<td>-----------------------------------------------------</td>
</tr>
<tr>
<td>Microcystis, Anabaena, Aphanizomenon, Planktothrix, etc.</td>
<td>Cyanophyta</td>
<td>Colonial, filamentous, toxin producer, mucilaginous, planktonic, scum-former</td>
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<tr>
<td>Euglena</td>
<td>Euglenophyta</td>
<td>Unicellular, potential toxin-producer, planktonic, scum-former, flagellated</td>
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<tr>
<td>Spirogyra</td>
<td>Chlorophyta</td>
<td>Filamentous, mucilaginous, mat-former</td>
</tr>
</tbody>
</table>

Algae name: Microcystis, Anabaena, Aphanizomenon, Planktothrix, etc.
Phylum: Cyanophyta
Characteristics: Colonial, filamentous, toxin producer, mucilaginous, planktonic, scum-former

Algae name: Euglena
Phylum: Euglenophyta
Characteristics: Unicellular, potential toxin-producer, planktonic, scum-former, flagellated

Algae name: Spirogyra
Phylum: Chlorophyta
Characteristics: Filamentous, mucilaginous, mat-former
<table>
<thead>
<tr>
<th>Algae Name</th>
<th>Phylum</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pithophora</td>
<td>Chlorophyta</td>
<td>Filamentous, mat-former, branched, Akinetes</td>
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<tr>
<td>Nostoc</td>
<td>Cyanophyta</td>
<td>Colonial, softer gel balls</td>
</tr>
<tr>
<td>Chara</td>
<td>Charophyta</td>
<td>Plant-like, smelly, rough</td>
</tr>
<tr>
<td>Nitellops/Nitello</td>
<td>Charophyta</td>
<td>Plant-like, smoother</td>
</tr>
</tbody>
</table>
The Algae
- Diverse Classification (many kingdoms)
- Elaborate Characteristics
  - No true roots, stems or leaves
  - Over 30,000 species
  - Identification
    - Important in determining management

Characteristics
- Mucilaginous
- Planktonic
- Periphytic
- Mat-Forming

Dispersion
- Humans
- Wildlife
  - Birds, Fish
- Air
- Movement

The good?

The bad

Problematic Algae
- Algal impacts
  - Economic
  - Ecological

Economic
- Drinking/irrigation
- Tourism
- Property values

Ecological
- Toxins/taste & odor compounds
- Disrupt habitat/Outcompete
- Water characteristics

(Speziale et al. 1991; Falconer 1996; WHO 2003)
Algae Impacts

• Secondary Compounds
  – Toxins
    • Hepatotoxins “liver”
    • Neurotoxins “brain”
    • LPS “stomach”
    • Aplysiatoxins “skin”
  – Taste and odor
    • Geosmin “dirty”
    • MIB “fishy”

Harr et al. 2008

Hepatotoxins
Microcystins, Nodularin, Cylindrospermopsin

(Also nephrotoxin; affects kidneys)

Harr et al. 2008

Neurotoxins
Anatoxins, Saxitoxin, Neosaxitoxin, BMAA (β-N-methylamino-L-alanine)

Avian Vacuolar Myelinopathy (AVM)

Parkinsons Dementia Complex (PDC) and Alzheimer’s

Elk deaths

Taste and Odor Compounds

Geosmin 2-

MIB 2-

Watson, 2003

How are we exposed?

Who is impacted?

• Dogs

• Cows
  – Kerr 1987; Mez et al. 1997; Loda et al. 1999

• Pigs, ducks
  – Cook et al. 1989

• Sheep
  – Carbis et al. 1995

Watson,
2003
Exposure Analysis

<table>
<thead>
<tr>
<th>Toxin Group</th>
<th>Toxin Name</th>
<th>Exposure Signs &amp; Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hepatotoxins (liver/kidney)</td>
<td>Micotoxins</td>
<td>Numbness of lips, tingling in fingers/toes, dizziness, headache, diarrhea, jaundice, shock, abdominal pain/distention, weakness, nausea/vomiting, acute pain, acute psychosis</td>
</tr>
<tr>
<td></td>
<td>Neolignans</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cylindrospermopsin</td>
<td></td>
</tr>
<tr>
<td>Neurotoxins (brain)</td>
<td>Arachidoxan</td>
<td>Tingling, burning, numbness, dizziness, muffled speech, paralysis, weakness, staggering, convulsions, difficulty in breathing, vomiting, muscle twitching, geophagia, backward arching of neck in birds, and death</td>
</tr>
<tr>
<td></td>
<td>Anatoxins</td>
<td></td>
</tr>
<tr>
<td>Dermatitis/Gastrointestinal (skin/digestive)</td>
<td>Aplysioxan</td>
<td>Rash, redness, burning, skin irritation, acute dermatitis, hives, blisters, abdominal pain, vomiting, diarrhea</td>
</tr>
<tr>
<td></td>
<td>Lipopolysaccharides</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lyngbyotoxin</td>
<td></td>
</tr>
</tbody>
</table>

Modified Codd et al. 1999; WHO 1999; Graham 2007; Jewet et al. 2008

Ecological drivers and proactive management

An ounce of prevention is worth a pound of cure

2007 EPA National Lakes Assessment

- 46% of waters are eutrophic/hyper-eutrophic
- Nutrient levels are second biggest issue threatening waters
- Regulations
  - NPDES


Nutrients

- Fertilizer
- Pet waste
- Wildlife
- Livestock/agriculture
- Municipal wastewater
- Industrial effluent
- Atmospheric deposition
- Internal cycling

Sources of Nutrients

Intensity of Management

- Biomass correlation
  - Liebig's law of the minimum
  - Critical burden
    - Mass/mass relationship
    - Rate calculation

Phosphorus is key

Cyanobacteria and phosphorus

- Fix Nitrogen (dependent on P availability)
  - (Paerl 1990, 1991; Stewart and Alexander 1971)
- Low N:P ratio dominate
  - (Smith 1983; Seale et al. 1987; Ghadouani et al. 2003)
- Migrate to sediments to acquire phosphorus
  - (Perakis et al. 1996; Barbiero and Welch 1992)
- Store phosphorus
  - (Garf and Oliver 1982; Kromkamp et al 1989)
- Rapidly uptake
  - (Jacobson and Halman 1982)

Phosphorus (Evil P) Mitigation

- External Inputs
  - Fertilizer, stormwater runoff BMP, atmosphere, biota
- Internal accumulation
  - TN:TP ratio 5:1 cyanobacteria overwhelmingly dominant artificially induced (Ghadouani et al. 2003)
  - Low TN:TP cyanobacteria dominate (Lake Michigan) (Seale et al. 1987)
  - TN:TP ratio 25:1, dominated by green algae (Smith 1983; 12 lakes throughout the world)
  - Si:P < 25:1 Microcystis dominates, more silica more Asterionellae (Holm & Armstrong 1981)
- Carbon, Light, Temperature (>24C), Moving water

Phosphorus Management Options

- In situ management
  - Lanthanum modified bentonite (Phoslock®, specific, no buffer, permanent)
  - Aluminum sulfate (Alum, non-specific, pH/other impacts)
  - Algaecide combined with phosphorus remover (SeClear)
  - Polymers (Floc Log, Chitosan)
  - Iron (non-specific, release)/ Calcium (high pH only, release)
- Other
  - Aeration (oxygenate benthic layers)
  - Dredging (remove/re-suspension possible)
  - Bacteria?

Phosphorus Mitigation Efficacy

- 8.2 surface acres; Lake Lorene, WA
- Avg. depth 5 feet, max. depth 12 feet
- Multi-purpose lake, community focal point
- Cyanobacteria blooms, toxins (may >2,000 ppb, atx >100ppt)

Lake Lorene, WA Summary

- August 2011
- July 2012
- Lanthanum/Bentonite (Phoslock®) Application
Discussion/Summary

• Phosphorus is a factor in water resource management
• Phosphorus tied to intensity of management and nuisance algae selection
• *In situ* mitigation is critical to address cause of negative water quality
  – Legacy P
• Phosphorus mitigation integration can have significant impacts
Turbulent mixing

- Huisman et al. 2005

Aeration

- Take the buoyancy (scum) advantage out of play
- Temperature homogenation
- Carbon addition
- Keep circulated to select for better types of algae, usually
- Oxygenated benthic zone to decrease internal phosphorus cycling, other sediment gas release

Algae name | Phylum | Characteristics
---|---|---
*Raphidiopsis* /*Anabaena planctonica* | Cyanophyta | Unicellular, planktonic, growing in moving water

Pretty good name for *full toxic cyanos*

### Light Harvesting Pigments

- Absorb light at different wavelengths
  - Reflect different colors
- Different functions
- Diagnostic of different groups

- Carotenoids
  - Carotenes vs. xanthophylls
- Chlorophylls
- Phycobilins

![Diagram of Light Harvesting Pigments](image)

![Absorption spectrum of chlorophylls and phycobilins](image)
**Control Techniques**

- **Action Options**
  - Mechanical
    - harvesters, sonication
  - Physical
    - dyes, aeration, raking
  - Biological
    - bacteria, grass carp, tilapia
  - Chemical

**Biological**

- Grass carp preferences
  - *Hydrilla >> Lyngbya*
- Viability of algae
- Other

**USEPA Registered Algaeicides**

- Diquat Dibromide
- Endothall
- Peroxides
- Copper
  - Chelated v. free ion
- Adjuvants

**How copper works (dose)**

- Electron transport chain disruption (Jursinic and Stemler 1983)
- Combine with glutathione (GSH) prevents cell division (Stauber and Florence 1997)
- Inhibits enzyme catalase and others, free radical susceptibility (Stauber and Florence 1997)
- Interfere with cell permeability and binding of essential elements (Sunda and Huntsman 1983)
Copper formulation comparison

Algae bio-adsorption factor

\[ ABaF = \frac{[\text{Cu}] \text{ absorbed}}{[\text{Cu}] \text{ adsorbed} + [\text{Cu}] \text{ in water}} \]

**INFUSION**

- Penetrates mucilage, colonies, filaments, mats, cell walls
- Independent of typical uptake mechanisms
- Not subject to desorption or amelioration factors

Peroxide algaecides

- Oxidize algae and other organic compounds
- Can be selective to some blue-green algae
- Breaks down into oxygen and water
- Relatively safe to desirable non-target species

Drinking Water Reservoir: Algae control

**Pre-treatment:** 5-21-12
High density filter clogging cyanobacteria

**Post-treatment (PAK® 27):** 05-31-12
Increased water clarity – significant control

Summary

- Algae are diverse and becoming more problematic in freshwater resources
- Algae can restrict uses of a water resource and pose threats to wildlife and humans
- Both Proactive and Reactive techniques should be considered for efficient algae management
- Algae characteristics, algaecide formulation, and water chemistry can all impact control
Wednesday, May 7, 2014 – 4:00PM

SESSION 8A: ALGAE AND POND MANAGEMENT

“Pond Management”

Chuck Cichra
University of Florida/IFAS
School of Forest Resources and Conservation
Ponds: Careful of the Fish!

Dr. Chuck Cichra
Extension Fisheries Specialist
University of Florida / IFAS
SFRC - Program of Fisheries & Aquatic Sciences

All Plants Need Water, Light, and Nutrients

Aquatic Plants are No Different

Algae are simply small plants!

New Ponds are “Clean”

Over Time – Ponds Become More Fertile, Plants Become More Abundant

Eutrophication = Enrichment (increased nutrients – P and N) of a water body
Unacceptable – Looks Bad!

Where Do the Nutrients Come From????

Natural Phosphate Deposits in Florida (soils)

Well Water is Often Full of Phosphorus

Stormwater Ponds are Built to Catch Storm Runoff / Nutrients (P and N)

Fish Feed

Lawn fertilizers, leaves, sticks, grass clippings, ...
Livestock and Other Agriculture

Algae (phytoplankton)

Macrophytes (large plants)

Amount of Chlorophyll (algae) in the Water is Closely Related to the Amount of Nitrogen and Phosphorus in the Water

Data from 60 Florida Lakes

Human Waste

Fertilization – Purposeful Addition of Nutrients to the Water

Water clarity decreases as algae (phytoplankton) increases

Nutrients = Plants

Water clarity and algae

Fertilization – Purposeful Addition of Nutrients to the Water

Data from 60 Florida Lakes
Fish blocknet data on 60 Florida lakes

Bird survey data from 48 Florida lakes

Alligator survey data from 60 Florida lakes

So, is Eutrophication "Good" or "Bad"?

- A 'natural' process
- Can be 'spend up' by humans
- Results in more plants (large / small) and more animals (inverts, fish, birds, etc.)
- "Good" or "Bad" depends on our personal perspective / view / goal
- So, "eutrophication" does not mean that a water body is "dead!"

Water vs Macrophytes

- Greener - less macrophytes
- Browner (more color) – less macrophytes
- More clay and suspended bottom sediments - less macrophytes
- Plants grow to ~1.7 x the Secchi depth
- Pond construction / Pond dyes

Macrophytes vs Water

- More macrophytes – less planktonic algae
- More macrophytes – less suspended matter
- Macrophytes affect fish community composition
Role of Plants as Fish Habitat?

- Spawning areas
- Refuge - cover from predators (fish/birds)
- Refuge - places for predators to “hold”
- Food / Feeding areas
  - Fish may eat the plants directly
  - Many fish can shift their diets from invertebrates that live on plants to those that live in/on the bottom

Can get shifts in fish community composition (plants → algae)

How Many Plants are Needed?

- Just Enough!
- Too many!

So if nutrients don’t kill fish, then what causes fish kills?

A lot of People Believe that Toxins Cause Most Fish Kills

Aquatic Herbicide Toxicity (ppm)

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Expected application rate</th>
<th>Bluegill 96-hr LC-50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper – low alkalinity</td>
<td>0.5-1.0</td>
<td>0.88</td>
</tr>
<tr>
<td>Endothall alkylamine salt</td>
<td>0.1-1.0</td>
<td>0.94</td>
</tr>
<tr>
<td>Copper – high alkalinity</td>
<td>0.5-1.0</td>
<td>7.3</td>
</tr>
<tr>
<td>2,4-D</td>
<td>0.5-3.0</td>
<td>168</td>
</tr>
<tr>
<td>Diquat</td>
<td>0.12-0.37</td>
<td>245</td>
</tr>
<tr>
<td>Endothall dipotassium salt</td>
<td>1.0-3.0</td>
<td>343</td>
</tr>
<tr>
<td>Fluoridone</td>
<td>0.01-0.09</td>
<td>891</td>
</tr>
<tr>
<td>Carfentrazine</td>
<td>1.0-3.0</td>
<td>&gt;1000</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>NA</td>
<td>&gt;1000</td>
</tr>
<tr>
<td>Imazapyr</td>
<td>NA</td>
<td>&gt;1000</td>
</tr>
</tbody>
</table>
Humans Can Directly Cause Fish Kills

However, Most Fish Kills are "Natural"

Generally due to Low Dissolved Oxygen in the Water

Sources of Oxygen:
- Diffusion
- Agitation
- Photosynthesis

Diffusion of Oxygen Into Water

Response of Fish to Low Oxygen

Agitation Speeds up Diffusion of Oxygen into Water

Natural Agitation = Waves
Man-Made Agitation = Aerators

Photosynthesis

Air
Water → O₂

(85-95% of oxygen in ponds/lakes)

24 Hour Cycle of Dissolved Oxygen Concentrations

Dissolved Oxygen Concentration (ppm)
Dawn, Dusk, Dawn

Dissolved Oxygen on Clear Days

Dissolved Oxygen on Days With Continuous Cloud Coverage

Dissolved Oxygen Concentration (ppm)
Dawn, Dawn, Dawn, Dawn

So how much oxygen is enough?

Figure 4.3 Effects of dissolved oxygen (DO) on warm-water pond fish.
Sometimes the Algae Die!
Lots of Dead Fish!

Too Many Floating Plants can Block Sunlight and Prevent Pond Mixing

Effect of Submersed Plants on the Vertical Distribution of Oxygen in the Water Column

Density Differences due to Water Temperature Differences Prevent Mixing

Cross-sections of Deep and Shallow Lakes

Summer Thunderstorm!

‘Bad’ Water: High H₂S, Low Dissolved Oxygen, High CO₂, High BOD
So, How do we use this Information in Aquatic Plant Management?

Submersed Plants – Spray Portion of Plants, Herbicide Selection, Time of Year, Aerate -- Weather

Floating Plants – Use of Herbicides: Partial Treatments, Herbicide Selection, Weather – Bite the Bullet and Spray?

Floating Plants – Grass Carp: Aerate & Use Herbicides to Improve Efficacy

Shift between large plants and phytoplankton (algae) – be careful!

Algae - Should We Spray? How Much? -- Watch the Weather!

Education – If you kill the plants, the nutrients are still there!

Herbicides
Grass Carp
Nutrients still in the pond!
Effects of Drought?

No Water: No Fish!

(Fish stir up bottom sediments and water is hot.)

For more information: UF/IFAS Extension Circulars
Wednesday, May 7, 2014 – 3:00PM

SESSION 8B: NATURAL AREAS TRAINING

“Natural Areas Weed Management Training”

Mary Beth Henry
University of Florida/IFAS
Polk County
Natural Areas Weed Management Certification Training

IFAS Short Course 2014

Presented by Mary Beth Henry,
UF/IFAS Polk County Extension
Material provided by Ken Langeland
and Jeff Hutchinson
UF/IFAS Agronomy Department
Center for Aquatic and Invasive Plants

Disclaimer:

• The use of trade names in this presentation is solely for the purpose of providing specific information. UF/IFAS does not guarantee or warranty the products named, and references to them in this publication does not signify our approval to the exclusion of other products of suitable composition.

• Pesticide users must review and comply with all conditions set forth in the pesticide label.

Additional Study Material

• Study Questions for the Certified Pesticide Applicator Examination: Natural Areas Weed Management
  http://conference.ifas.ufl.edu/aw/more%20resources/Natural%20Areas%20Study%20Questions.pdf

• Garlon 4 Label
  http://www.cdms.net/ldat/ld0B0010.pdf

Natural areas are protected in > nine million acres of conservation lands in Florida.

Invasive Plant Species
Non-native (exotic) species that form self-sustaining expanding, populations within natural plant communities.

NOTE: 1,180 of 3,834 plant species in Florida are non-native (31%)

Over half of Florida’s land area is in agriculture or urban land uses and natural habitats are continually being lost.

Weeds vs. Invasive Plants?
### Invasive Plant or Weed

| **Invasive Plant:** |
|---------------------|---------------------|
| Spreads beyond intended area and invades natural areas | Weeds: |
| Displaces native vegetative and disrupts natural processes | |

<table>
<thead>
<tr>
<th><strong>Weed:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>A plant growing where it is not wanted (yards, gold courses, etc.)</td>
</tr>
</tbody>
</table>

### Why the Concern?

- Competition with native plants
  - Water
  - Nutrients
  - Space
- Alter hydrology
- Alter fire ecology
- Hybridize with native species

### What Plants Are Invasive

**Prohibited – Legislative Authority**

- USDA - Federal Noxious Weed List
- FL DACS - Florida Noxious Weed List
- FL DEP - Prohibited Aquatic Plant List
- Local Ordinances

**No statutory authority**

- FLEPPC List of Invasive Species
- FLEPPC/FNGA agreement

### Florida Exotic Pest Plant Council List of Invasive Plants

**Category I** - Invasive exotics that are altering native plant communities by displacing native species, changing community structures or ecological functions, or hybridizing with natives. *This definition does not rely on the economic severity or geographic range of the problem, but on the documented ecological damage caused.*

Ex. Melaleuca, Brazilian pepper, Australian pine, OWCF, shoebutton ardisia and others.

**Category II** - Invasive exotics that have increased in abundance or frequency but have not yet altered Florida plant communities to the extent shown by Category I species. *These species may become ranked Category I, if ecological damage is demonstrated.*

Ex. Guinea grass, castor bean, queen palm, and wedelia and others.

### Questions Regarding the ID of a Plant -

- Contact any major herbarium at a Florida University (UF, USF, UM, FSU)

### Questions Regarding Listed Species -

- Florida Natural Areas Inventory (FNAI) maintains a list of endangered plants and animals for each county in Florida.

### Questions Regarding a Specific Plant –

- DEP/FWC Regional Biologists or County Agricultural Extension Agent
Land managers, natural resource specialists, invasive plant technicians, and biologists should become familiar with the non-native plant species in this book.

Know: characteristics of some of the most invasive plants

- Australian Pine
- Brazilian Pepper
- Melaleuca
- Old World Climbing Fern
- Japanese Climbing Fern
- Chinese Tallow

Ex. leaves, fruits, growth habit, bark, etc.

- Brazilian Pepper
  - Alternate Leaves
  - Odd-Pinnate Compound
  - Toothed Margins

- Old World Climbing Fern
  - Once Compound (2-pinnate)

- Japanese Climbing Fern
  - Twice Compound (3-pinnate)

- Australian Pine
  - "pine like needles"

- Chinese Tallow
  - "simple leaves, milky sap"
Melaleuca
“simple leaves”
“paper-like bark”
“parallel venation”

Integrated Pest Management (IPM)

• The coordinated use of multifaceted pest and environmental information with available pest control methods to prevent unacceptable levels of pest damage by the most economical means and with the least possible hazard to people, property, and the environment.

• What IPM is not:
  – Use of “least toxic pesticides”
  – Minimum use of synthetic pesticides
  – Maximum use of biological controls
  – Alternation of control methods

Five Methods to Control Invasive Plants

Manual
Mechanical
Cultural
Biological
Herbicides

Managing Invasive Plants (5 methods)

Herbicides

Primary focus of this training session

Biological control
Examples:
Melaleuca - snout beetle, psyllid
**Herbicides Used in Natural Areas**

- **Triclopyr amine**
  - Garlon 3A
- **Triclopyr ester**
  - Garlon 4, Pathfinder II
- **Glyphosate**
  - Terrestrial: Roundup Pro, Glyphos, Glypro Plus
  - Aquatic: Rodeo, Aquamaster, Aquaneat, Eagre, Aquapro, Glypro

**Herbicides Used in Natural Areas**

- **Imazapyr**
  - Arsenal, Stalker
- **2,4-D**
  - Riverdale products, Amine 400 2,4-D Weed Killer, Weed Rhap A-4D, Weedar 64
- **Hexazinone**
  - Velpar L, Velpar ULW
- **Metsulfuron methyl**
  - Escort XP

**Herbicide Characteristics**

- Solubility
- Absorption and Translocation
- Persistence
  - Mobility in soil
  - Breakdown
- Toxicity
- Mode of Action

**Herbicide Solubility**

- **Water soluble**
  - Polar (electrical charge)
    - Salts of acids (e.g. amines)
- **Oil Soluble**
  - Nonpolar
    - Esters

**Herbicide Solubility**

- **Amine** – readily dissolve in water
- **Ester** – do not mix with water
  - dissolve in oil

**Herbicide Solubility**

- **Triclopyr amine (Garlon 3A)**
  - Polar (charged)
  - mixes with H₂O
- **Triclopyr ester (Garlon 4)**
  - Non-polar (no charge)
  - does not mix with H₂O
Herbicide Solubility

- **Water soluble (Polar - amine)**
  - Glyphosate
  - Triclopyr amine
  - 2,4-D amine
  - Imazapyr
  - Hexazinone
  - Metsulfuron

- **Oil soluble (Non-polar - ester)**
  - Triclopyr ester
  - 2,4-D ester

**Emulsifiable Concentrates (EC)**

- Oil soluble products with emulsifiers
- Form emulsions in water
- Examples:
  - Garlon 4 (triclopyr ester)
  - Stalker (imazapyr)

*can be mixed in oil or water*

**Herbicide Formulations**

- **S or WS = Water-soluble**
- **OS = Oil-soluble**
- **W or WP = Wettable powder**
- **DF = Dry-flowable**
- **E or EC = Emulsifiable concentrate**
- Others: granules, pellets

**Absorption:** Movement of a substance (herbicide) into the plant

**Adsorption:** Retention of a substance on a surface such as soil particle or plant surface

**Translocation:** Movement of a substance within a plant

**Diffusion:** Herbicide moves from an area of high concentration to low concentration

**Active Transport:** Energy requiring; herbicide movement up a gradient from low concentration to high concentration
Lipid bilayer

Concentration gradient

Diffusion
Channel transport
Carrier mediated
Active transport

Routes of Herbicide Absorption
- Leaves
  - Foliar application
- Stems
  - Basal bark application
  - Cut stump application
- Roots
  - Soil application

Foliar Absorption — move downward in the phloem
- Epidermis
  - Hairs
    - Surface tension
  - Cuticle (diffusion)
    - Waxy
  - Cell Wall (diffusion)
  - Plasma membrane (active uptake)

Leaf Cross-section

Root Absorption — move upward in the xylem
- Availability
  - Adsorption
    - Humus
    - Clay
  - Root Hair (no cuticle) (Diffusion)
  - Move upward in xylem
  - Cell wall (Diffusion)
  - Plasma membrane (Active transport)

Stem Absorption — move upward in the xylem and/or move downward in the phloem
- Herbaceous
  - Epidermis
    - Cuticle
    - Cells Wall
    - Plasma membrane
- Woody
  - Bark
    - Corky
    - Waxy
Herbicide Translocation - determines ultimate fate of herbicide in plants

- **Deactivation**
  - Adsorbed, hydrolyzed, precipitated

- **Vascular tissue movement**
  - **Xylem**
    - Non-living - wood
    - Upward with transpiration stream
  - **Phloem**
    - Living
    - Downward with photosyntheate

### Breakdown and Persistence

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Breakdown</th>
<th>Half-life</th>
<th>Mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,4-D</td>
<td>Microbial</td>
<td>10 days</td>
<td>Low</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>Microbial</td>
<td>47 days</td>
<td>Bound (none)</td>
</tr>
<tr>
<td>Hexazinone</td>
<td>Microbial, Photolysis</td>
<td>90 days</td>
<td>High (leaching to non-target area)</td>
</tr>
<tr>
<td>Imazapic</td>
<td>Microbial</td>
<td>120 days</td>
<td>Moderate</td>
</tr>
<tr>
<td>Imazapyr</td>
<td>Microbial</td>
<td>25-142 days</td>
<td>Moderate</td>
</tr>
<tr>
<td>Metsulfuron</td>
<td>Microbial</td>
<td>30 days</td>
<td>Moderate</td>
</tr>
<tr>
<td>Triclopyr</td>
<td>Microbial, Hydrolysis</td>
<td>30 days</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

### Breakdown of Herbicides

- **Photolysis** – energy (heat) absorbed by light causes the chemical bonds of molecules to break.

- **Hydrolysis** – chemical bonds are broken when herbicide reacts with water.

- **Microbial** – metabolism (degradation) of herbicides by soil microbes.

(Note: herbicide loss also occurs by leaching and adsorption)

### Absorption, Translocation And Mode of Action

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Absorption</th>
<th>Translocation</th>
<th>MOA</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,4-D</td>
<td>Foliage, roots</td>
<td>Phloem</td>
<td>Organo-auxin</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>Foliage, Phloem</td>
<td>Phloem</td>
<td>Protein synth.</td>
</tr>
<tr>
<td>Hexazinone</td>
<td>Roots</td>
<td>Xylem</td>
<td>Photosynthesis</td>
</tr>
<tr>
<td>Imazapic</td>
<td>Foliage, roots</td>
<td>Xylem, phloem</td>
<td>Protein synth.</td>
</tr>
<tr>
<td>Imazapyr</td>
<td>Foliage, roots</td>
<td>Xylem, phloem</td>
<td>Protein synth.</td>
</tr>
<tr>
<td>Metsulfuron</td>
<td>Foliage, roots</td>
<td>Xylem, phloem</td>
<td>Protein synth.</td>
</tr>
<tr>
<td>Triclopyr</td>
<td>Foliage, roots</td>
<td>Phloem</td>
<td>Organo-auxin</td>
</tr>
</tbody>
</table>

(Note: organo-auxin herbicides require additional record keeping under Florida Pesticide Law)

### Herbicide Movement

- **Foliar Uptake (Phloem):**
  - Glyphosate

- **Root Uptake (Xylem):**
  - Hexazinone

- **All others:**
  - Primarily by foliar but also with some root uptake

### Illustrations

- Phloem Translocation
- Xylem Translocation

- Xylem and Phloem Translocation
## Modes of Action

1. Auxin interference (tissue development)
2. Amino acid or protein synthesis interference
3. Photosynthesis inhibitor

Herbicides target biological processes unique to plants

## Mode of Action

- Inhibit Photosynthesis
  - Hexazinone
- Auxin Interference
  - 2,4-D, Triclopyr
- Amino Acid or Protein Inhibitors
  - Glyphosate, Imazapic, Imazapyr, Metsulfuron

## Other Modes of Action

1. Cell membrane disruptors (contact herbicides) – diquat
2. Growth inhibitors (interfere with cell division) – soil applied / root uptake
3. Pigment synthesis inhibitors (bleachers) – fluridone
4. Lipid / fatty acid inhibitors – effective on grasses and small seeded broadleaf plants

These are seldom used in natural areas weed mgmt.

## Factors That Affect Herbicide Activity

- Rainfall
  - Wash-off
  - Soil moisture
- Drought
  - Transpiration
  - Soil moisture
- Wind
  - Coverage
  - Stomata closure
- Temperature
  - Stress/growth
- Humidity
  - Drying
- Growth stage
  - Morphology
- Season
  - Translocation

## Factors that adversely affect herbicide activity

- Low relative humidity
- High or cold temperature
- Drought
- Rainfall immediately after application
- High winds

## Spray Adjuvants

- **Surfactants** – allow spray mixes to overcome surface tension and stick to leaves
  - Nonionic surfactants usually recommended
- **Drift control agents** – control droplet size
- **Penetrants** – enables a water-based herbicide to overcome the waxy barrier on many leaf types
- **Anti-foaming agents** – reduce foaming during mixing
- **Emulsifiers** – allow oil-based herbicides to mix with water
- **Colorants** – keep track of vegetation treated (limit spray on non-target damage)
Environmental Considerations

- Wildlife toxicity
- Endangered species
  - Florida Natural Areas Inventory
- Selectivity
  - Ability to control the target plant without harming nontarget plants

Herbicide Toxicity

1. Low activity to higher forms of life

2. Target unique biological processes that are unique to plants
   - Photosynthesis
   - Specific growth regulators (auxins)
   - Amino Acids and Proteins (ALS and EPSP)

   ---These biological processes or pathways do not occur in animals---

Herbicide selection

- Broad spectrum herbicides
  - Control most plants (monocots and dicots)
  - EX. Glyphosate

- Selective herbicides
  - Control either monocots (grasses) or dicots (broad-leaved plants)
  - EX. Triclopyr

- Lots of variability

Herbicide placement

- Best method to control target species

- Method of application
- Colorants
- Minimize “drift”
  - Droplet size
  - Use smallest nozzle
- Use lowest pressure
- Use largest nozzle
- Watch wind

Florida Natural Areas Inventory (FNAI)

- Maintains a list of endangered plants and animals for each county in Florida.

- Contact if there are questions regarding a T or E species in the area to be treated with herbicide

Toxicity (LD50 mg/kg)

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<tr>
<th></th>
<th>Bobwhite quail</th>
<th>Laboratory Rat</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,4-D amine</td>
<td>&gt;5,620</td>
<td>&gt;1000</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>&gt;4,640</td>
<td>4,300</td>
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<tr>
<td>Hexazinone</td>
<td>&gt;10,000</td>
<td>1,690</td>
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<tr>
<td>Imazapic</td>
<td>&gt;2,150</td>
<td>&gt;5,000</td>
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<tr>
<td>Imazapyr</td>
<td>&gt;5,000</td>
<td>&gt;5,000</td>
</tr>
<tr>
<td>Metsulfuron</td>
<td>&gt;5,620</td>
<td>&gt;5,000</td>
</tr>
<tr>
<td>Triclopyr amine</td>
<td>&gt;10,000</td>
<td>2,574</td>
</tr>
<tr>
<td>Triclopyr ester</td>
<td>9,026</td>
<td>1,581</td>
</tr>
<tr>
<td>Caffeine</td>
<td>192</td>
<td></td>
</tr>
</tbody>
</table>
Minimizing spray drift:
- Do not spray into wind (spray downwind)
- Use a large-orifice nozzle tip
- Use the lowest possible hydraulic pressure
- Spray during calm (no wind) periods
- Add drift control agents to spray mixture

Application Methods
1) Foliar
2) Basal bark
3) Hack and squirt
4) Cut stump
5) Soil application

Foliar Applications
- Herbicides
  - Rodeo, Roundup, etc
  - Garlon 3A
  - Arsenal
- Surfactants
  - Penetration
  - Spreading
  - Organosilicones are long chain polymers with good spreading abilities

Minimizing Spray Drift
- Spray downwind (do not spray into wind)
- Do not spray under windy conditions
- Use low spray pressure
- Use a nozzle tip with a large orifice (i.e., larger spray droplets)
- Add drift control agents

Flat Fan Tips Coding
- TP1502
  - 15 degrees spray angle
  - Delivers 0.2 gallons per minute at 40 psi
- TP2503
  - 25 degrees spray angle
  - Delivers 0.3 gallons per minute at 40 psi

Basal Bark Applications
- Herbicides
  - Oil soluble (EC)
    - Pathfinder
    - Garlon 4
    - Stalker
- Diluents
  - Vegetable oil
    - Most readily breaks down
  - Mineral oil
  - Do not use Diesel fuel
  - Toxic to wildlife
Hack and Squirt Applications

- Herbicides
  - Arsenal
  - Roundup, etc.
  - Triclopyr

- Equipment
  - Machete
  - Squirt bottles

Cut Stump Applications

- Herbicides
  - Roundup, Rodeo, etc.
  - Garlon 3A
  - Garlon 4
  - Arsenal

- Treat as soon as possible (within 15 min)

- Cut as level as possible – less runoff

Soil Application

- Granular herbicides applied by hand, spreaders, or blowers.

- Do not apply where the roots of non-target plants may occur.

- Highly water soluble, leach readily, and may contaminate groundwater (refer to label)

Best Treatment Methods (Examples)

- Treatment of a dense stand of torpedograss with no native vegetation nearby:
  - Low volume broadcast foliar spray

- Treatment of scattered Brazilian pepper trees among dense native vegetation:
  - Basal bark treatment with a hand-held sprayer

Application methods that can selectively control invasive plants

- Basal bark application
- Hack and squirt
- Cut stump
- Low volume foliar application with hand-held sprayer

When would you use broadcast application?
Laws Pertaining to Pesticides

- **Federal Insecticide, Fungicide, And Rodenticide Act (FIFRA)**
  - Requires all pesticides to be applied in accordance with product labeling and that containers are properly disposed of

- **Florida Pesticide Law (Chapter 487 FS)**
  - Pesticides are registered and label laws enforced by Florida Department of Agriculture and Consumer Services

- **Florida Department of Environmental Protection**
  - Aquatic plant control permits
  - Funding for aquatic plant control
  - Aquatic Plant importation, transportation, transportation, and cultivation

Final Legal Interpretation of Label

- **Florida Department of Agricultural and Consumer Services (FDACS)**

Department of Environmental Protection

- Approve permit application of a herbicide to a body of water located on public land

Label Interpretation

- Active ingredient
- Directions for use
- PPE
- Mixing instructions, conversions
- Maximum rate per acre

Garlon 4 Label

- Active ingredient
- Acid equivalent
- Environmental hazards
- Mixing instructions
- Maximum label rate
- Applications methods
- PPE required
- Safety
How many pounds of triclopyr, expressed as acid equivalent, are contained in one gallon of Garlon 4?

- Active ingredient (AI) = chemical in the formulated product responsible for herbicide effects on plants
- Acid equivalent (AE) = the percentage of acid in the active ingredient
- Product = formulated herbicide under a trade name to include active ingredient + inert ingredients

A.I. vs A.E.

- Active ingredient (AI) – represents the unaltered form of the chemical molecule. Yet in some cases, the herbicide molecule has been altered by adding some additional characteristics to improve solubility, foliar penetration, and greater translocation without destroying the herbicide property.
- Acid equivalent (AE) – that portion of the original salt or ester molecule that represents the acid form of the molecule

Key: Just know how to find AI and AE on the label

Site Descriptions on Label!

- “Natural areas” does not appear on most labels
- Products registered for use in forestry or noncropland sites are defensible choices for non-aquatic natural areas
- Label must specify “aquatic use” if it is to be used over standing water.
- Herbicides may be used in wetlands when water is not present unless specifically prohibited by the label

Special Local Need Label (SLN)

- Special registration for controlling specific weeds
- Allows a state to further specify how the pesticide is applied
- Applicators must have copy in their possession when applying a SLN herbicide
- Current Example: Metsulfuron (Escort XP) for treating Lygodium microphyllum

Workers Protection Standard (WPS)

- Pertains to people performing tasks related to agricultural activities
- Does not pertain to people performing tasks related to non-cropland sites

So, natural area herbicide applicators should follow NON-WPS PPE instructions listed on the label

Note: Know differences between agricultural applicators and non-agricultural applicators

REQUIRED Personnel Protective Equipment (PPE)

Non-agricultural Sites

- Long-sleeved shirt
- Long pants
- Shoes
- Socks

Note: Chemical resistant gloves are not required (but refer to label)
NOW for some “herbicidal” calculations

Two Methods (of many)

- Method 1
  - Convert each variable one at a time to get to desired rate or mixture

- Method 2
  - Set up equation
  - Cross multiply

KEY IS TO PRACTICE WORKING THESE EQUATIONS

Constants Used for Preparing Spray Mixes and Determining Herbicide Rates

- One gallon = 128 ounces
- One gallon = 8 pints
- 1 pint = 16 ounces
- 1% Solution = 1.28 ounces per gallon
- One Acre = 43,560 square feet (ft²)

Other Constants for Tank Mixes

- 1.0% / gal = 1.28 oz gallon
- 1.5% / gal = 1.92 oz gallon
- 2.0% / gal = 2.56 oz gallon
- 3.0% / gal = 3.84 oz gallon
- 5.0% / gal = 6.40 oz gallon
- 10.0% / gal = 12.80 oz gallon

Calculating Dilutions

- How much Garlon 4 should you add to prepare 4 gal of spray solution equivalent to mixing 20 gal Garlon 4 in 100 gal spray mix?

1) 20 gal ÷ 100 gal = 0.2 (20% herbicide product in spray mix)
2) 0.2 x 4 gal = 0.8 gal (20% herbicide product x 4 gallon spray mix)
3) 0.8 gal x 128 oz/gal=102 oZ (convert to oz or pints)
   Or 102 oz x 1 pt/16 oz = 6.4 pt

---Don’t forget to convert to the amount requested in the question---
Calculating Dilutions
• How much Garlon 4 should you add to prepare 4 gal of 1.5% spray solution?

1) \( 4 \text{ gal} \times 0.015 = 0.06 \text{ gal} \) (1.5% product in 4 gallons)

2) \( 0.06 \text{ gal} \times 128 \text{ oz/gal} = 7.68 \text{ oz} \) (Convert gal to oz)

4 gal x 1.92 oz = 7.68 oz
Recall that 1.5% / gal = 1.92 oz per gallon

Spray Volume Per Acre
• How many gallons spray mix would be applied per acre if 60 oz are applied to 400 sq ft?

1) \( \frac{400 \text{ sq ft}}{43560 \text{ sq ft/acre}} = 0.0092 \text{ acres} \) (Convert 400 sq ft to acres)

2) \( \frac{60 \text{ oz}}{128 \text{ oz/gal}} = 0.4688 \text{ gal} \) (Convert 60 oz to gallons)

3) \( \frac{0.4688 \text{ gal}}{0.0092 \text{ acres}} = 51 \text{ gal/acre} \) (Divide gal by acres to get gal per acre)

Spray Volume Per Acre
• How many gallons spray mix would be applied per acre if a sprayer delivers 40 oz per minute and 400 sq ft are treated in 5 min?

1) \( \frac{400 \text{ sq ft}}{43560 \text{ sq ft/acre}} = 0.0092 \text{ acres} \)

2) \( \frac{40 \text{ oz/min}}{128 \text{ oz/gal}} = 0.3125 \text{ gal/min} \)

3) \( \frac{5 \text{ min}}{0.0092 \text{ acres}} = 543.5 \text{ min/acre} \)

4) \( 0.3125 \text{ gal/min} \times 543.5 \text{ min/acre} = 170 \text{ gal/acre} \)

Herbicide Per Tank
• How much Roundup (oz) should be added to a 3 gallon spray tank to apply 7 pints of Roundup per acre for a sprayer that delivers 167 gal per acre?

1) \( 7 \text{ pt/acre} \times 16 \text{ oz/pint} = 112 \text{ oz/acre} \)

2) \( 112 \text{ oz/acre} \div 167 \text{ gal/acre} = 0.67 \text{ oz/gal} \)

3) \( 0.67 \text{ oz/gal} \times 3 \text{ gal} = 2.01 \text{ oz} \)
Determined Amount of Herbicide Needed
Surface Area Applications

Herbicide needed =
recommended pounds per acre x surface area to be treated
or
recommended gallons per acre x acres to be treated

Example

How much Velpar ULW is required to treat an area that measures 270 feet by 470 feet with Velpar ULW (granules) at a rate of 2 pounds product per acre?

1) Determine acreage:
   Acres = 270 ft x 470 ft ÷ 43,560 ft² pr acre
   Acres = 2.9 acres

2) Determine herbicide needed
   2.9 acres x 2 lbs per acre = 5.8 lbs

Determining Amount of Herbicide Needed for Proportion or % Solution in Spray Solution

• If recommendation is given as herbicide volume per final spray volume
  – Herbicide volume = (Given herbicide ÷ Given spray volume) x spray volume

• If recommendation is given as percent solution
  – Herbicide volume = Spray volume x (% recommended ÷ 100)
Thursday, May 8, 2014 – 8:00AM

SESSION 9A: AQUATIC WEED CONTROL

“Biology and Control of Salvinia”

Dearl Sanders
Louisiana State University
GIANT SALVINIA
THE BLOB THAT ATE LOUISIANA
DEARL SANDERS
LSU AGCENTER

SALVINIA MOLESTA
- TAXONOMY
- MORPHOLOGY
- DISTRIBUTION
- ECOLOGICAL DAMAGE
- ECONOMIC DAMAGE
- HISTORY IN LOUISIANA
- CONTROL

Taxonomy
(all are called giant salvinia)
- One of the Salvinia auriculata complex:
  - Salvinia auriculata
  - Salvinia biloba
  - Salvinia herzogii
  - Salvinia molesta

Dr. Jim Oard (molecular biologist/gene jockey) confirmed all samples examined from LA and TX were S. molesta.

Giant Salvinia

Common Salvinia
- In LA since early 1980’s
- Nuisance but not a lake killer
- Much easier to control
- Does not form mats
- Florida has existing populations of common salvinia weevil
Common Salvinia

Morphology

- No true roots. Submerged leaves (ramets) often confused with roots.
- Three plant forms:
  Primary – isolated plants often confused with common salvinia. Small oval leaves that lie flat on water.
  Secondary – larger boat shaped leaves, no folding
  Tertiary – growing in crowded mats with folding

Tertiary Form

Submerged Leaves and Sporocarps

Reproduction

- Plant is pentaploid, chromosome number of 45, incapable of sexual reproduction. Confirmed by Dr. Oard.
- Reproduction is asexual, forms axillary buds that can break off.

Growth

- Here is where this talk diverges from all other weed talks I have given.
- Mitchell: “One plant can cover 40 square miles in one year”.
- Can form mats up to 1 m in thickness.
- BS or reality???
The Facts

- Without inter or intra-specific competition and adequate inputs it reaches an 80% per day coverage rate at about 38 days after introduction. DOUBLES COVERAGE AREA EVERY 1.5-2 DAYS.
- Literature supports this, Mitchell says double biomass every 2 days.

This Is What Separates This Weed From All The Others

- Must have higher levels of control than other weeds to be effective.
- A few escaped plants can repopulate area in 30-40 days.
- Has greatly limited our chemical control options due primarily to physical misses.

Distribution

- Native to southern Brazil
- US – South Carolina (1995), Texas, Louisiana, Alabama, Mississippi, Arizona, California, Georgia, Oklahoma, Hawaii and FLORIDA
- Grows best in quiescent water with minimal wave action: EVERGLADES

Ecological Damage

- Taken over 100,000 acres of waterfowl overwintering sites.
- Thick mat formation causes oxygen depletion, killing aquatic animal life that can not escape. Study showed normal 6-8 inch mat cut off 99.87% of available sunlight.
- Absence of light kills off other submerged vegetation.
- Forms structure for other emergent vegetation.
Economic Damage

- Fishing, Boating, Waterfowl hunting (usual suspects for aquatic weed interference).
- Property values!!!
History in Louisiana

- ID’d at Toledo Bend Reservoir in 1998.
- ID’d in Cameron Parish and near Houma, LA in 1999.
- Sale of giant salvinia prohibited in 1999.
- Problem increased on Toledo Bend Reservoir 1999-2005. But no spread to other locations.
- 2000-2002 major outreach program to try to limit spread.
- 2006 (following Hurricane Katrina??) had spread state wide.
- LA Wildlife and Fisheries increased spraying budget from $3 million/year to $9 million/year.
- Started industrial scale weevil releases in 2008.
- Decent control in south Central LA very little control in NW LA.
- 2011 – Salvinia spreads to rice country SW LA and the Lake Pontchartrain Basin.

CONTROL

- Mechanical
- Chemical
- Biological
- Hair Brain Ideas

Hair Brain

- Use for biofuel
- Use for animal feed
- Use for mulch
- Kill with salt water
- Kill with cooking oil
- Kill with vinegar
Mechanical

- Have tried a grinding type machine, results in regrowth because axial buds are so small.
- Complete removal has been attempted-difficult in ponds, impossible in lakes due to trees.
- 1 acre weighs 90,000 lbs. Can not remove fast enough to keep up with regrowth.

Herbicides

- 1st trials at Toledo Bend Reservoir 1999, most recent trial 1 week ago.
- Counted up 17 different replicated trials since 1999.
- Certain herbicides are effective.
- NONE ARE THE SILVER BULLET.
- Repeat applications are essential.

Herbicides Tested Alone

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Rating</th>
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</thead>
<tbody>
<tr>
<td>Galleon</td>
<td>Excellent (Requires 60 day contact)</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>Good (Rate/label dependent)</td>
</tr>
<tr>
<td>Diquat</td>
<td>Good</td>
</tr>
<tr>
<td>Clipper</td>
<td>Fair-Good</td>
</tr>
<tr>
<td>Stingray</td>
<td>Fair-Good</td>
</tr>
<tr>
<td>Tradewind</td>
<td>Poor</td>
</tr>
<tr>
<td>2,4-D</td>
<td>Poor</td>
</tr>
<tr>
<td>Triclopyr</td>
<td>Poor</td>
</tr>
<tr>
<td>Ignite</td>
<td>Excellent</td>
</tr>
<tr>
<td>Imazapyr</td>
<td>Poor</td>
</tr>
<tr>
<td>Aminocyclopyractic</td>
<td>Poor</td>
</tr>
<tr>
<td>Callisto</td>
<td>Poor</td>
</tr>
<tr>
<td>Sharpen</td>
<td>Fair</td>
</tr>
<tr>
<td>Endothall</td>
<td>Poor</td>
</tr>
<tr>
<td>Sonar</td>
<td>Good</td>
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Tank Mixes That Work

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glyphosate 3 qts + Diquat 1 pt</td>
<td>Excellent</td>
</tr>
<tr>
<td>Clipper 6 oz + Glyphosate 3 qts</td>
<td>Excellent</td>
</tr>
<tr>
<td>Sharpen 4 oz + Glyphosate 3 qts</td>
<td>Excellent</td>
</tr>
<tr>
<td>Clipper 6 oz + Aquathol K 12 oz</td>
<td>Excellent</td>
</tr>
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</table>

Glyphosate Rate Trial 2000

% Control 28 DAT
Biological Control

- Grass Carp (never again)
- Salvinia weevils

Biological Control

- *Cyrtobagous salviniae*

  Successfully used in 13 countries on 3 continents.
  Successful in Florida.
All but one have been on private land.

An acre of giant salvinia weighs approximately 45 tons.

We have distributed 330 tons of salvinia.

Containing approximately 13 million weevils (6 million adult weevils).

Sounds like a lot, but takes 600-800 thousand weevils per acre to have an impact.

Need about 10-15 generations (2-3 years) of weevils to reach that point at current stocking rates.
Weevils do not survive well in north Louisiana, looking for cold tolerant weevil.

Total water treatment herbicides (Galleon) have not worked well in lakes with large watersheds.

Foliar sprays work but coverage is crucial.

Easy to spread.

Problems

Dense Cypress Stands Can Not Effectively Spray

How it has spread

After 10 Days
Thursday, May 8, 2014 – 8:50AM

SESSION 9A: AQUATIC WEED CONTROL

“Hydrilla Control in Winter Park”

Amy Giannotti
City of Winter Park
HYDRILLA SHOWS INCREASED TOLERANCE TO FLURIDONE AND ENDOTHALL IN THE WINTER PARK CHAIN OF LAKES: CONSIDERATIONS FOR RESISTANCE MANAGEMENT AND TREATMENT OPTIONS

- Resistance theory
- History of WP Chain hydrilla
- Resistance development
- Irrigation study

Amy L. Gianotti & Timothy J. Egan
Michael D. Netherland, Ph.D.

City of Winter Park
Michael D. Netherland, Ph.D.

Winter Park Chain of Lakes

What IS herbicide resistance?
- Susceptible – control achieved using normal use rates
- Tolerant – never controlled at label use rates
- Resistant – originally susceptible, but over time, control is lost as resistant plants survive; repeated product failure
- Multiple resistance – resistant to herbicides with different modes of action (MOA)

Lake Minnehaha, July 2007

Resistance – how does it happen?
- Naturally resistant plants exist within the population
- Resistant plants survive the treatment
- After regrowth, percentage of resistant strain increases
- With repeated use, resistant plants become dominant strain

Semi-Resistant  Resistant

Susceptible

Winter Park Chain of Lakes

Seasonal Weir

Navigable Canal

Stream Inflow

Stream Outflow

No barrier

Orlando

City of Winter Park

- 28,000 residents
- 600+ lakefront homes
- 23 lakes and ponds
- Aquatic plant management activities since 1960’s

Lake Virginia c. 1968

- Residents irrigate from the lakes
- Keeping residents informed about lake management efforts is essential

Lake Osceola c. 1968

Challenges affecting hydrilla management
- Deep lakes = $$$ treatments
  - Average depth of Lake Maitland = 13.5’, Killarney = 12.5’
- Excellent urban fishery
  - Highest overall largemouth bass catch rate in any central FL stream since 1999
- Average sale price of lakefront homes 2011-2013 = $2M
- “Open” system/no carp barrier on north end
- Migratory bird population affects carp stocking
- Extensive ornamental landscaping
  - Residents accustomed to irrigation restrictions >30 days (concentration-based/upto 120 days)
  - “New” systemic products have irrigation restrictions in excess of 90 days
- Diverse and abundant native plant community
  - Alum injection, stormwater infrastructure, street sweeping, active public education
  - 2,300+ inlets, 46 miles of pipe treat 37 mb land

Lake Minnehaha, July 2007

Lake Minnehaha, July 2007
What is happening in Winter Park and WHY?

- 1960s – relied on mechanical harvesting
- 1970s-1990s – infestations intensively targeted with Hydout (endothall)
- 1990s – Sonar (fluridone)
- 2007 – fluridone discontinued after multiple failed treatments
- 2008 – lakes stocked with low rates of triploid grass carp; widespread spot-treatments with endothall
- 2009 – entered FWC state-funded program
- Late 2009/early 2010 – two failed whole lake endothall treatments; **first documented case of endothall resistance (Lakes Maitland & Minnehaha)

Multiple Resistance – fluridone and endothall

Maitland
- Reliance on Hydout in the 1970s-80s
- Carp fluridone treatment was in 1995
- Discontinued use of fluridone in 2002 after repeated double spot treatment failures; spot-to-endothall with mixed results (temp?)
- Stocked with TSG in 2008
- 2005 – Failed WLT w/ endothall – **documented resistance
- Implemented combos, bumped carp stock, & emphasized rotation
- Limited by irrigation restrictions for new products

Minnehaha
- 1990s – managed by WP
- Frequent turnover of City lakes staff delayed problem recognition w/ fluridone
- Discontinued use of fluridone in 2007 after repeated failures; spot-to-endothall with mixed results (temp?)
- Stocked with TSG in 2008
- 2010 – Failed WLT w/ endothall – **documented resistance
- Implemented combos, bumped carp stock, & emphasized rotation
- Limited by irrigation restrictions for new products

Lake Maitland – 6 WAT – Feb. 2010

WLT-Aquathol K
Dec. 16, 2009 – 436 acres
Applied in blocks at 3 ppm in littoral zone
Lakewide concentration of 1 ppm
Targeted lethal rates achieved
> 1 ppm for 3 DAT
> 0.75 ppm for 6 DAT

Thankfully, our best defense...
...is a good offense

So, now what?

- Maitland and Minnehaha hydrilla produce higher levels of protein phosphatase, which endothall normally inhibits...so having more enzymes means this biotype can tolerate higher levels of endothall.
- Since then – 5 combinations utilizing 3 different MOA & increased reliance on grass carp
- 1) Diquat, 2) Endothall+diquat, 3) hydrothol, 4) flumioxazin, 5) imazamox 6) bispiribac (2014) 7) penoxsulam (2014)
- Fluridone resistance still an issue
- Bumped carp stocking rate
- Hydrilla leaf miner & Mt fungus (2013)
Modes of Action (MOA) for Hydrilla Herbicides

- Diquat – PS inhibition
- Fluridone – carotenoid/pigment/chlorophyll disruption
- Flumioxazin – captures energy and destroys cell membrane
- Endothall – UNDEFINED
- Imazamox – ALS inhibition*
- Bispyribac – ALS inhibition*
- Penoxsulam – ALS inhibition*

*but different chemistries involved

Endothall’s MOA is not specific to any particular plant process, which is unlike other compounds used for hydrilla control.

Current Focus: New herbicides

- FWC encouraging herbicide rotation for resistance prevention & wanted WP to include all new products into our management program
- Public hearings
  - Lakes and Waterways Advisory Board
  - City Commission
- Newsletter articles
  - Multiple issues
- Website
  - Direct mail
    - General to all lakefront homes
    - Specific treatment notices

Concerns

- Winter Park needed to address likely public concern over using new systemic herbicides
  - New products have irrigation restrictions up to 120 days
  - Historically, residents accustomed to < 14 day restriction
- **Impacts on terrestrial landscaping are not well understood**
- City Commission & USACOE supported in-house irrigation experiment to evaluate
- Information and time provided to decide whether or not to employ alternative irrigation sources

Reaction to the last 14+ day restriction...

Experimental Design

- 12 weeks
- 240 plants
- 5 common landscape species
  - Japanese yew (Podocarpus spp.)
  - Sand cordgrass (Spartina bakeri)
  - Viburnum (Viburnum spp.)
  - Burford holly (Ilex cornuta burfordii)
  - Border grass (Liortcp spicata)
- 2 herbicides – bispyribac & penoxsulam
- 8 treatment rates
  - 0 ppb, 5 ppb, 10 ppb*, 15 ppb, 20 ppb, 30 ppb, 80 ppb, 160 ppb, 320 ppb
  - * bispyribac target; † = penoxsulam target
- 3 replicates for each rate
- Irrigation – every week along with one supplemental watering
- No fertilizer or weed control
- Pallets/concrete block as plant holders
- Randomly distributed
- Full exposure to sun and rain
- Stock solution & treatment concentrations confirmed via Dr. Netherland throughout

BOTH are used at low rates and require extended exposures for effective control. However, these herbicides break down slowly which results in long-term residual exposures (90d+) in the water column.
Penoxsulam – 13 WAT (0 ppb & 320 ppb)

Our findings
• No apparent effect on growth and/or survivability of these 5 species with either product
• Some treated plants seemed to exhibit weed control

• ONLY looking for survivability - did not control for rainfall, soil type/amount, initial plant age, grazers, etc.
• Based upon these results, Winter Park will incorporate these herbicides into our treatment regime after an intensive public education campaign

Resistance Summary
• Does NOT result from a chemical-induced change in plant genetics
• Theory: every plant species has biotypes that are resistant to every herbicide (true of many pests in nature); these “resistant biotypes” can be exceedingly rare and are not necessarily a component of every population in a lake.
• “Applicator Roulette” – each population in each lake has a varying degree of genetic diversity/biotypes present

***Has THAT biotype been sprayed yet? With what, how much, and how often?

➤ ROTATE, ROTATE, ROTATE…..

Thanks for hanging around!

www.cityofwinterpark.org/lakes
Thursday, May 8, 2014 – 8:00AM

SESSION 9B: NATURAL AREAS AND RIGHT-OF-WAY WEED CONTROL

“Control of Tropical Soda Apple”

Brent Sellers
University of Florida/IFAS
Range Cattle REC
USE PATTERNS FOR AMINOCYCLOPYRACHLOR
Brent Sellers and Sarah Lancaster
Range Cattle Research & Education Center

Outline
1. Aminocyclopyrachlor overview
2. Application methods, rates
3. Species of concern controlled
4. Results of ACP research
5. Use considerations

Aminocyclopyrachlor
- MAT 28
- MAT
- AMCP
- ACPC
- ACP

Aminocyclopyrachlor
- New class of herbicides
  - Pyrimidine carboxylic acid
- Control of broadleaf weeds, trees and brush, vines, and some grasses in rights of ways, natural areas
- Low use rates
- Moderate persistence in environment
  - Low toxicity to mammals, birds, fish

Aminocyclopyrachlor Products
Perspective®
premix with chlorsulfuron
Streamline®
premix with metsulfuron
Viewpoint®
premix with metsulfuron and imazapyr

Other products
- Plainview
  - Non-crop market
  - Premix with chlorsulfuron and sulfometuron
- Range and pasture products
  - Perspective R&P
    - Premix with chlorsulfuron
    - Invora
  - Premix with triclopyr
  - Rejuvra
    - Premix with metsulfuron
Other products

- Imprelis
  - Professional turfgrass market
  - Recently removed from the market due to tree sensitivity issues
  - Considered ester formulations

Synthetic auxin herbicides

- Oldest synthetic organic herbicides
- Foliar and root absorption
- Affects plant growth regulation
- Multiple targets within plant
- Moderate risk of resistance
- Symptoms in days
- Limited grass activity

ALS-inhibiting herbicides

- Relatively new herbicide family
- Foliar and root absorption
- Affects amino acid production
  - Reduces enzyme activity
- High risk of resistance
- Symptoms in 1-2 weeks
- Selectivity varies by chemical

Allowable uses

- Terrestrial sites
  - Uncultivated areas
    - Agricultural and non-agricultural
  - Industrial sites
  - Natural areas

Targeted uses

<table>
<thead>
<tr>
<th>Product</th>
<th>Targeted use areas</th>
</tr>
</thead>
</table>
| Perspective | roadside rights of way  
|            | native grass restoration               |
| Streamline  | utility and roadside rights of way      |
| Viewpoint   | utility rights of way                   |

Turfgrass tolerance of Perspective

- Rate dependent tolerance:
  - Bahiagrass
  - Bermudagrass

- No tolerance
  - St. Augustine
**Application methods**

- Foliar application
  - Ground equipment – low and high volume
  - Helicopter (in rights of way only) – 15-25 GPA
- Cut stubble application
- Spot application

**Use rates**

<table>
<thead>
<tr>
<th>Product</th>
<th>Minimum use rate</th>
<th>Maximum use rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perspective</td>
<td></td>
<td></td>
</tr>
<tr>
<td>39.5% aminocyclopyrachlor + 15.8% chlorsulfuron</td>
<td>1.75 ounces per acre</td>
<td>11.0 ounces per acre</td>
</tr>
<tr>
<td>39.5% aminocyclopyrachlor + 1.75 ounces perl 5 gal</td>
<td>0.35 ounces per 5 gal</td>
<td>2.2 ounces per 5 gal</td>
</tr>
<tr>
<td>Streamline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>39.5% aminocyclopyrachlor + 12.6% metsulfuron-methyl</td>
<td>1.75 ounces per acre</td>
<td>11.5 ounces per acre</td>
</tr>
<tr>
<td>39.5% aminocyclopyrachlor + 0.35 ounces per 5 gal</td>
<td>2.3 ounces per 5 gal</td>
<td></td>
</tr>
<tr>
<td>Viewpoint</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31.6% imazapyr + 22.8% aminocyclopyrachlor + 7.3% metsulfuron</td>
<td>1.3 ounces per acre</td>
<td>20 ounces per acre</td>
</tr>
<tr>
<td>31.6% imazapyr + 2.6 ounces per 5 gal</td>
<td>4.0 ounces per 5 gal</td>
<td></td>
</tr>
</tbody>
</table>

**Adjuvants**

- MSO* - 0.5-1.0% v/v
- NIS - 0.25-0.5% v/v (Perspective)
- 0.25-1.0% v/v
- COC - 1.0-2.0% v/v (Perspective and Streamline)

**Labeled Species**

**Perspective**
- scouring rush
- bull thistle
- Scotch thistle
- cogongrass – seedhead suppression

**Streamline**
- bull thistle
- dogfennel/yankeeweed
- poison ivy
- firewheel
- Old World climbing fern

**Viewpoint**
- blackberry
- Scotch thistle
- bull thistle
- scounging rush
- Chinese tallow
- St. Johnswort
- dogfennel/yankeeweed
- sowthistle
- poison ivy
- bahiagrass
- Japanese honeysuckle
- St. Johnswort
- Old world climbing fern
RESEARCH RESULTS

Bahiagrass Tolerance

Perspective 2.4 oz Perspective 4.75 oz Perspective 9.5 oz

Stand reduction (%)

Data from J. Ferrell

Perspective 9.5 oz/a 60 DAT

Climbing fern 30 DAT

* Similar letters indicate similar means (P < 0.05)

Australian pine 120 DAT

* Similar letters indicate similar means (P < 0.05)
**Brazilian pepper 90 DAT**

* Similar letters indicate similar means (P < 0.05)

**Melaleuca 90 DAT**

* Similar letters indicate similar means (P < 0.05)

**Sweetgum 12 MAT - Spot Spray**

* Data from J. Ferrell

**Oak 12 MAT**

**Palmetto 12 MAT**

* Data from J. Ferrell
Lantana

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Rate</th>
<th>6 months</th>
<th>12 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vista (fall)</td>
<td>2.6 pt</td>
<td>65</td>
<td>30</td>
</tr>
<tr>
<td>Vista (fall/spring)</td>
<td>2.6 pt</td>
<td>50</td>
<td>80</td>
</tr>
<tr>
<td>Vista + Milestone (fall)</td>
<td>2.6 pt + 7 fl oz</td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td>Vista + Milestone (fall/spring)</td>
<td>2.6 pt + 7 fl oz</td>
<td>70</td>
<td>95</td>
</tr>
<tr>
<td>Perspective (fall)</td>
<td>7.7 oz</td>
<td>98</td>
<td>93</td>
</tr>
<tr>
<td>Perspective (fall/spring)</td>
<td>7.7 oz</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

* Data from J. Ferrell

8 MAT

Perspective 7.7 oz/a fall + spring

Perspective 7.7 oz/a fall

Spanish needle 4 MAT

Matchstick weed 4 MAT

Perspective 4.75 oz 60 DAT

Cogongrass 92 WAT
Invasive grasses
Greenhouse*

<table>
<thead>
<tr>
<th>Species</th>
<th>I$_{50}$</th>
<th>I$_{90}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paragrass</td>
<td>0.1</td>
<td>&gt; Max label rate</td>
</tr>
<tr>
<td>West Indian marshgrass</td>
<td>&gt; Max label rate</td>
<td>&gt; Max label rate</td>
</tr>
<tr>
<td>Torpedograss</td>
<td>&gt; Max label rate</td>
<td>&gt; Max label rate</td>
</tr>
<tr>
<td>Cogongrass</td>
<td>0.08</td>
<td>0.2</td>
</tr>
</tbody>
</table>

0.2 lb ACP/acre = 8 oz/A of Perspective or Streamline

*Based on dry weight of plant regrowth 4 weeks after clipping (8 weeks after treatment).

Suggested Plant Back Restrictions

<table>
<thead>
<tr>
<th>Species</th>
<th>I$_{50}$ (lb ACP/acre)</th>
<th>Plant Back Time*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chalky bluestem</td>
<td>**</td>
<td>0 days</td>
</tr>
<tr>
<td>Spreading panicum</td>
<td>0.09</td>
<td>139 days</td>
</tr>
<tr>
<td>Purple lovegrass</td>
<td>0.06</td>
<td>176 days</td>
</tr>
<tr>
<td>Longleaf pine</td>
<td>0.06</td>
<td>178 days</td>
</tr>
<tr>
<td>Wiregrass</td>
<td>0.06</td>
<td>194 days</td>
</tr>
<tr>
<td>Live oak</td>
<td>0.02</td>
<td>319 days</td>
</tr>
<tr>
<td>Goldenrod</td>
<td>0.008</td>
<td>&gt;365 days</td>
</tr>
<tr>
<td>Blazing star</td>
<td>***</td>
<td>&gt;365 days</td>
</tr>
</tbody>
</table>

*Based on 90 day half life of ACP applied at 0.25 lb/a
** no injury observed
*** injury observed at all rates evaluated

*Data from A. Greis

SPECIAL CONSIDERATIONS

Not labeled for aquatic applications!

ENVIRONMENTAL HAZARDS

Do not apply directly to water, or to areas where surface water is present, or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwaters or rinsate.

This herbicide is injurious to plants at extremely low concentrations. Nontarget plants may be adversely affected from drift and run-off.

Herbicide drift

- Restrictions listed on label
- Coarse droplets
- Low nozzle height
- Winds less than 10 MPH
### Movement in soil

- Heavy rainfall
- Wet soils
- Root uptake by non-target plants

### A new herbicide chemistry

- Plant growth regulating mode of action
- Three premixed products
  - Perspective, Streamline, Viewpoint
  - Labeled for use in non-cropland

### Controls broadleaf weeds and brush

- Oak, palmetto, lantana – good control > 1 YAT
- Climbing fern, Brazilian pepper, melaleuca, Australian pine – early results promising
- Expect transient injury to bermudagrass and bahiagrass

### Cautions

- Take care to avoid drift!
Thursday, May 8, 2014 – 8:25AM

SESSION 9B: NATURAL AREAS AND RIGHT-OF-WAY WEED CONTROL

“Biology and Control of Salt Cedar”

Jessica Spencer
United States Army Corps of Engineers
Early Detection Rapid Response Effort:
*Tamarix canariensis* and Other Species in Northeast Florida

Jessica Spencer
Invasive Species Management Branch
Jacksonville District
US Army Corps of Engineers
May 6, 2014
Aquatic Weed Control Short Course

**Tamarix canariensis**
- Native to the Mediterranean
- Easily hybridizes with other introduced Tamarix species
- The genus Tamarix was introduced to the US in the 1800s
- It has invaded millions of acres in the U.S., displacing native vegetation

**Identifying Characteristics**
- Large woody shrub to small tree (most species are deciduous)
- Foliage is grey-green or bluish-green in color
- New stems are red, turning reddish brown with age
- Eventually, bark thickens & furrows

**Flowers and Seeds of Tamarix**
- Prolific seed producer (can flower entire growing season)
- Reproduces vegetatively and by seed
- Grows quickly and can produce seed within first year
- Forms dense monocultures, altering native habitat
- Alters soil chemistry so native plants cannot survive

**Invasive Characteristics**
- Leaves are scale-like, similar to cedars
- Flowers are pink to pinkish-white
- Leaves are usually encrusted with a fine layer of salt

Close up of new Tamarix stem
Close up of Tamarix leaves
4 month old seedling with flowers
**Habitat Requirements**

- Require moist soils for 2-4 weeks after germination
- Produce a long tap root to access groundwater
- Grow in a variety of soil types (including sand, loam and clay)
- Need full sun
- Seedlings do not compete well

**A Brief History of Tamarix in NE Florida**

- USACE has been treating *Tamarix canariensis* on our DMMAs since 2008
- Surveys have identified 14 locations where Tamarix has established along the St. Johns River and Intracoastal Waterway
- Initial populations have been treated at all but 1 location (Reed Island)
- 8 out of 14 locations have been Tamarix-free for over a year, the remaining sites continue to be monitored and treated

**Continued Efforts**

- Continue monitoring of treated areas and perform follow-up treatments as needed
- Survey for new Tamarix populations
- Report findings in EDDMapS
- Coordinate with partner agencies (Coastal GA CISMA) to treat populations in Georgia

- Jessica Spencer – Co-Chair of First Coast Invasive Working Group
First Coast Invasive Working Group

- CI SMA covering Baker, Clay, Duval, Nassau and St. Johns counties
- Federal, state and local partners
- Organizes "volunteer work days" to perform invasive species control and EDRR

Cradle Creek Preserve, Jax Beach

- Largest population of Brazilian pepper in Jacksonville
  - 100's of mature shrubs
  - 1000's of seedlings
- Reported to local CI SMA by trail group in Dec. 2013

Old World Climbing Fern
(Lygodium microphyllum)

- Populations in Duval & St. Johns County have jumped significantly from the I-4 corridor
- Closest known populations are in Volusia County (Tomoka State Park and Tiger Bay State Forest)
- Equestrian Park population was found in August 2012
- SJ-14 population was found in October 2012
- Vectors of dispersal??? Horses, heavy equipment, mowers, etc.
Early Detection Rapid Response

- Equestrian Park
  - Discovered in August 2012
  - Initial treatment in September and October of 2012
  - Follow-up treatments continuing through 2014

- SJ-14
  - Discovered in October 2012
  - Initial treatment in late October of 2012
  - Follow-up treatments continuing through 2014
  - FIND has kept mowing equipment on site

First Coast Invasive Working Group

- Responding rapidly to new invasions
- Addressing invasive species issues across borders
- Leveraging resources, personnel and time to effectively combat invasive species

Questions

Jessica Spencer
U.S. Army Corps of Engineers
Invasive Species Management Branch
904-232-1996
jessica.e.spencer@usace.army.mil
SESSION 9B: NATURAL AREAS AND RIGHT-OF-WAY WEED CONTROL

“Use Patterns for Aminocyclopyrachlor”

Brent Sellers
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Range Cattle REC
**Use Patterns for Aminocyclopyrachlor**

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- Moderate persistence in environment  
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**Aminocyclopyrachlor Products**
- Perspective® premix with chlorsulfuron
- Streamline® premix with metsulfuron
- Viewpoint® premix with metsulfuron and imazapyr

**Other products**
- Plainview  
  - Non-crop market  
  - Premix with chlorsulfuron and sulfometuron  
- Range and pasture products  
  - Perspective R&P  
  - Premix with chlorsulfuron  
  - Invora  
  - Premix with triclopyr  
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Other products

- Imprelis
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  - Considered ester formulations

Synthetic auxin herbicides

- Oldest synthetic organic herbicides
- Foliar and root absorption
- Affects plant growth regulation
- Multiple targets within plant
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Allowable uses

- Terrestrial sites
  - Uncultivated areas
    - Agricultural and non-agricultural
  - Industrial sites
  - Natural areas

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</tr>
<tr>
<td></td>
<td>native grass restoration</td>
</tr>
<tr>
<td>Streamline</td>
<td>utility and roadside rights of way</td>
</tr>
<tr>
<td>Viewpoint</td>
<td>utility rights of way</td>
</tr>
</tbody>
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Turfgrass tolerance of Perspective

- Rate dependent tolerance:
  - Bahiagrass
  - Bermudagrass
- No tolerance
  - St. Augustine
Application methods
- Foliar application
  - Ground equipment – low and high volume
  - Helicopter (in rights of way only) – 15-25 GPA
- Cut stubble application
- Spot application

Use rates

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<td></td>
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<td>31.6% imazapyr + 22.8% aminocyclopyrachlor + 7.3% metsulfuron</td>
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Adjuvants
- MSO* 0.5-1.0% v/v
- NIS 0.25-0.5% v/v (Perspective)
- 0.25-1.0% v/v
- COC 1.0-2.0% v/v (Perspective and Streamline)

Labeled Species
Perspective
scouring rush
bull thistle
Scotch thistle
cogongrass – seedhead suppression

Streamline
bull thistle
dogfennel/yankeeweed
poison ivy
firewheel
Old World climbing fern
Scotch thistle
scouring rush
St. Johnswort
bahiagrass

Labeled Species
Viewpoint
blackberry Scotch thistle
bull thistle scouring rush
Chinese tallow sowthistle
dogfennel/yankeeweed St. Johnswort
poison ivy bahiagrass
Japanese honeysuckle
Kudzu
Old world climbing fern
RESEARCH RESULTS

Bahiagrass Tolerance

Perspective 9.5 oz/a 60 DAT

Climbing fern 30 DAT

Australian pine 120 DAT

* Similar letters indicate similar means (P < 0.05)
Brazilian pepper 90 DAT

<table>
<thead>
<tr>
<th>Product</th>
<th>Defoliation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Streamline 7.5 oz</td>
<td>C</td>
</tr>
<tr>
<td>Streamline 9.5 oz</td>
<td></td>
</tr>
<tr>
<td>Streamline 11.5 oz</td>
<td></td>
</tr>
<tr>
<td>Viewpoint 13 oz</td>
<td></td>
</tr>
<tr>
<td>Viewpoint 16.5 oz</td>
<td></td>
</tr>
<tr>
<td>Viewpoint 20 oz</td>
<td></td>
</tr>
<tr>
<td>Rodeo 3 qt</td>
<td></td>
</tr>
<tr>
<td>Nontreated</td>
<td></td>
</tr>
</tbody>
</table>

* Similar letters indicate similar means (P < 0.05)

Melaleuca 90 DAT

<table>
<thead>
<tr>
<th>Product</th>
<th>Injury (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Streamline 9.5 oz + fozamine 48 oz</td>
<td>AA BA A AB A A</td>
</tr>
<tr>
<td>Streamline 9.5 oz + fozamine 64 oz</td>
<td></td>
</tr>
<tr>
<td>Streamline 9.5 oz + fozamine 96 oz</td>
<td></td>
</tr>
<tr>
<td>Streamline 9.5 oz + Roundup 4 qt/a</td>
<td></td>
</tr>
</tbody>
</table>

Sweetgum 12 MAT - Spot Spray

<table>
<thead>
<tr>
<th>Product</th>
<th>Control (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Streamline 9.5 oz</td>
<td>B</td>
</tr>
<tr>
<td>Streamline 11.4 oz</td>
<td></td>
</tr>
<tr>
<td>Viewpoint 13 oz</td>
<td></td>
</tr>
<tr>
<td>Viewpoint 16.5 oz</td>
<td></td>
</tr>
<tr>
<td>Viewpoint 20 oz</td>
<td></td>
</tr>
<tr>
<td>Garlon 4 qt</td>
<td></td>
</tr>
</tbody>
</table>

* Data from J. Ferrell

Oak 12 MAT

<table>
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<tr>
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Palmetto 12 MAT

<table>
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<td></td>
</tr>
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</table>

* Data from J. Ferrell
### Lantana

<table>
<thead>
<tr>
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<td>7.7 oz</td>
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<tr>
<td>Perspective (fall/spring)</td>
<td>7.7 oz</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

* Data from J. Ferrell

### Matchstick weed 4 MAT

- 25 oz: Perspective 89%
- 4.8 oz: Perspective 40%
- Milestone 70%
- 2,4-D 1 qt: 80%

* Data from J. Ferrell

### Cogongrass 92 WAT

- ACP 0.25 lb: Perspective 92%
- ACP + Imaz 0.3 lb: Perspective 92%
- ACP + Imaz 0.6 lb: Perspective 92%
- ACP + Gly 1.5 lb: Perspective 92%
- ACP + Gly 3.0 lb: Perspective 92%

* Data from J. Ferrell
Invasive grasses
Greenhouse*

<table>
<thead>
<tr>
<th>Species</th>
<th>I$_{50}$ (lbs ACP/acre)</th>
<th>I$_{90}$ (lbs ACP/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paragrass</td>
<td>0.1</td>
<td>&gt; Max label rate</td>
</tr>
<tr>
<td>West Indian marshgrass</td>
<td>&gt; Max label rate</td>
<td>&gt; Max label rate</td>
</tr>
<tr>
<td>Torpedograss</td>
<td>&gt; Max label rate</td>
<td>&gt; Max label rate</td>
</tr>
<tr>
<td>Cogongrass</td>
<td>0.08</td>
<td>0.2</td>
</tr>
</tbody>
</table>

0.2 lb ACP/acre = 8 oz/A of Perspective or Streamline

*Based on dry weight of plant regrowth 4 weeks after clipping (8 weeks after treatment). Data from A. Greis

Suggested Plant Back Restrictions

<table>
<thead>
<tr>
<th>Species</th>
<th>I$_{50}$ (lb ACP/acre)</th>
<th>Plant Back Time$^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chalky bluestem</td>
<td>**</td>
<td>0</td>
</tr>
<tr>
<td>Spreading panicum</td>
<td>0.09</td>
<td>139</td>
</tr>
<tr>
<td>Purple lovegrass</td>
<td>0.06</td>
<td>176</td>
</tr>
<tr>
<td>Longleaf pine</td>
<td>0.06</td>
<td>178</td>
</tr>
<tr>
<td>Wiregrass</td>
<td>0.06</td>
<td>194</td>
</tr>
<tr>
<td>Live oak</td>
<td>0.02</td>
<td>319</td>
</tr>
<tr>
<td>Goldenrod</td>
<td>0.008</td>
<td>&gt;365</td>
</tr>
<tr>
<td>Blazing star</td>
<td>***</td>
<td>&gt;365</td>
</tr>
</tbody>
</table>

$^*$Based on 90 day half life of ACP applied at 0.25 lb/a

**no injury observed
***injury observed at all rates evaluated

Data from A. Greis

Not labeled for aquatic applications!

ENVIRONMENTAL HAZARDS

Do not apply directly to water, or to areas where surface water is present, or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwaters or rinsates.

This herbicide is injurious to plants at extremely low concentrations. Nontarget plants may be adversely effected from drift and run-off.

Herbicide drift

- Restrictions listed on label
- Coarse droplets
- Low nozzle height
- Winds less than 10 MPH
Movement in soil

- Heavy rainfall
- Wet soils
- Root uptake by non-target plants

CONCLUSIONS

A new herbicide chemistry

- Plant growth regulating mode of action
- Three premixed products
  - Perspective, Streamline, Viewpoint
  - Labeled for use in non-cropland

Controls broadleaf weeds and brush

- Oak, palmetto, lantana – good control ≥ 1 YAT
- Climbing fern, Brazilian pepper, melaleuca, Australian pine – early results promising
- Expect transient injury to bermudagrass and bahiagrass

Cautions

- Take care to avoid drift!
Thursday, May 8, 2014 – 9:15AM

SESSION 9B: NATURAL AREAS AND RIGHT-OF-WAY WEED CONTROL

“Old World Climbing Fern - How do we kill you?”

Cheryl Millett
The Nature Conservancy
**Old World climbing fern - How do we kill you?**

**Old World climbing fern** *(Lygodium microphyllum)*

- Grows Fast
- Spreads easily and quickly
- Growth form difficult to control
- Fire tolerant
- Invades a wide variety of habitats
- Can grow in very remote and undisturbed areas
- Has been found as far north as Sumter across to Volusia County and Duval in 2012

**How to identify:** Leaflets usually without lobes & without hairs on the lower surface; leaf stalks articulate (left behind when leaf drops)
Japanese climbing fern
(\textit{Lygodium japonicum})

- Grows Fast
- Spreads easily and quickly
- Growth form difficult to control
- Fire tolerant
- Invades a wide variety of habitats
- Grows on higher and drier ground than OWCF
- Has now been found as far south as Collier and Miami-Dade Counties.

How to Identify:
Leaflets usually lobed & with some hairs on the lower surface; leaf stalks not articulate (they remain attached to leaflet blades)

Central Florida Lygodium Strategy is...

- A partnership:

Find it

- Aerial surveys:
  - past SFWMD, APAFR, LH
  - present SWFWMD
  - missing east coast
- Getting the word out to CISMAs in the northern zone:
  - limited resources
  - phone and email contact
  - in-person only if combined with something else

CFLS is...

- A goal:
  - create a “Lygodium-free” zone across central Florida
  - prevent northward spread
- A strategic program:
  - stay north
  - public and private lands
  - detect and remove \textit{Lygodium microphyllum}
Kill it

- **If new and small** - pull out by the root* and bag up tightly, or spray
- **Small or low-growing infestations** - spray-to-wet leaf surfaces with herbicide
  - Plants must be growing, not stressed
- **If climbing into trees**: _poodle cut & spray_
  - cut at waist height
  - 10-12 inch gap
  - treat lower, rooted portion of the plant with herbicide
- **Re-treat**

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Use rates</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glyphosate</td>
<td>Spray to wet: 2%-3%</td>
<td>Aquatic; symptoms w/i 3 weeks; broad spectrum, some hardwoods tolerant</td>
</tr>
<tr>
<td>4lb ae/gal</td>
<td>Aerial: 5-7.5 pt/ac</td>
<td></td>
</tr>
<tr>
<td>Imazapic</td>
<td>Spray to wet: 0.32%</td>
<td>No aquatic; symptoms w/i 3 weeks; highly selective</td>
</tr>
<tr>
<td>2lb ae/gal</td>
<td>Aerial: No information</td>
<td></td>
</tr>
<tr>
<td>Metsulfuron</td>
<td>Spray to wet: 0.07-1.4 oz/100 gal</td>
<td>Aquatic; symptoms ≥ 3 months; highly selective</td>
</tr>
<tr>
<td>60%</td>
<td>Aerial: 1-2 oz/ac</td>
<td></td>
</tr>
<tr>
<td>Triclopyr amine</td>
<td>Spray to wet: 0.5%</td>
<td>Aquatic use; broad spectrum, broadleaf plants and hardwoods; symptoms w/i days</td>
</tr>
<tr>
<td>3lb ae/gal</td>
<td>Aerial: NA</td>
<td></td>
</tr>
</tbody>
</table>

Biocontrols

defoliating moth, _Austromusotima camptonozale_, 2005, FAIL

defoliating moth, _Neomusotima conspurcatalis_, 2008-09

leaf-galling mite, _Floracarus perrepae_, 2007, Jupiter

Success or failure?

- **Failure? A goal:**
  - create a “Lygodium-free” zone across central Florida- found on “firebreak”
  - prevent northward spread- found so far north
- **Success? A strategic program:**
  - stay north
  - public and private lands
  - detect and remove _Lygodium microphyllum_
  - EDRR

Big picture in Florida

- >38 private properties treated
- >5.2K acres
- 38 conservation areas buffered
- 130 sentinel sites to measure success
- Public managers reporting sightings
- Orange County roadways

Vision for the future

- Continue approach and partnership
- More creative ways to partner
  - FFS to manage sentinel site monitoring
  - FWC position to help with field work
  - Aerial surveys this-a-way: ideas?
  - Need your sighting data
Contact us

If you see Old World climbing fern in Pasco, Sumter, Lake, Seminole, Volusia or Duval Counties Let us know!!

call: 863.604.3352
Cheryl Millett
or email: cmillett@tnc.org

For additional information and pictures of Old World and Japanese climbing ferns:

• Institute of Food and Agricultural Science (IFAS) publication "Identification and Biology of Non-Native Plants in Florida's Natural Areas" edited by K.A. Langeland and K. Craddock Burks
• UF-IFAS Center for Aquatic and Invasive Plants website at http://plants.ifas.edu
• Florida Exotic Pest Plant Council website at www.fleppc.org
Thursday, May 8, 2014 – 10:25AM

SESSION 10A: AQUATIC WEED CONTROL

“Modes of Action and Resistance to Aquatic Herbicides”

Greg MacDonald
University of Florida/IFAS
Agronomy
How Herbicides Work
Greg MacDonald
Agronomy Dept. / IFAS
University of Florida, Gainesville

How Do Plants Grow?
- It’s all about carbon dioxide - CO₂
  - Water flow
  - Sugar movement
  - Nutrient uptake
  - Gas exchange - oxygen

Terrestrial vs. Aquatic
- Water movement is critical for many herbicides
- Dramatically changed when herbicides are placed in the aquatic environment

What Do Herbicides Do?
- Controlled/selective plant poisoning
  - Applied to soil (root uptake), water, and/or leaves (foliar uptake)
  - Contact or systemic
  - Selective vs. non-selective

How Do Herbicides Work?
- Mode and/or mechanism of action
- Specific plant process is targeted
  - Photosynthesis
  - Enzymes
  - Growth, hormonal balance
  - Unknown?

Mechanisms of Tolerance
- Herbicide X not absorbed
- Sequestered in vacuole
- X does not bind to enzyme Y
- X metabolized to Z
<table>
<thead>
<tr>
<th>Aquatic</th>
<th>Terrestrial</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,4-D</td>
<td>2,4-D*</td>
</tr>
<tr>
<td>Diquat (Reward)</td>
<td>Triclopyr (Garlon)*</td>
</tr>
<tr>
<td>Fluridone (Sonar)</td>
<td>Imazapyr (Arsenal, etc.)*</td>
</tr>
<tr>
<td>Triclopyr (Renovate)</td>
<td>Glyphosate*</td>
</tr>
<tr>
<td>Endothall (Aquathol, Hydrothol)</td>
<td>Metsulfuron, Chlorsulfuron</td>
</tr>
<tr>
<td>Copper (chelates, copper sulfate)</td>
<td>Imazapic, Imazamox*</td>
</tr>
<tr>
<td>Glyphosate (Rodeo)</td>
<td>Aminopyralid*</td>
</tr>
<tr>
<td>Imazapyr (Habitat)</td>
<td>Aminocyclopyrachlor</td>
</tr>
<tr>
<td>Carfentrazone (Stingray)</td>
<td>Chlorpyrid</td>
</tr>
<tr>
<td>Penoxulam (Galleon)</td>
<td>Fluazifop</td>
</tr>
<tr>
<td>Bispyribac (Tradewind)</td>
<td>Diuron</td>
</tr>
<tr>
<td>Flumioxazin (Clipper)</td>
<td>Hexazinone</td>
</tr>
<tr>
<td>Imazamox (Clearcast)</td>
<td>Tebuthiuron</td>
</tr>
</tbody>
</table>

2,4-D, triclopyr, aminopyralid, chlorpyralid, aminocyclopyrachlor

- Absorbed by foliage or underwater tissues
- Moves to areas of new growth
- Causes a disruption in hormone levels
  - Acts like a growth stimulant in some plant tissues and a growth retardant in others
  - Vascular tissue becomes crushed, stops movement of essential nutrients and sugars
- Plant essentially grows itself to death

Growth regulators

Growth Regulator Symptoms

- Twisting
- Discoloration in terminal bud
- Leaves may show strapping or puckering effect

2,4-D & Triclopyr

Diquat

- Absorbed by foliage or underwater tissues
- Does not move within the plant – contact
- Disrupts photosynthesis by stealing electrons
- These electrons are then passed on to oxygen, creating toxic radicals
- Radicals cause the cell membrane to leak

Growth Regulator Symptoms

- Twisting
- Discoloration in terminal bud
- Leaves may show strapping or puckering effect
Diquat Symptoms
- Browning of leaf tissues
- Rapid, within 1-2 days

Endothall
- Absorbed by foliage or underwater tissues
- Does not move within the plant – contact
- Appears to act directly on the cell membrane but how is unknown
- The cell membranes become leaky, cell contents spill out
- Without membranes the cells cannot make energy

Fluridone
- Absorbed only by underwater tissues
- Does not move within the plant, but not contact – takes weeks for control
- Prevents the formation of carotenoids which are chlorophyll protecting pigments
- Unprotected chlorophyll photo-oxidizes (self-destructs), leading to plant starvation

Fluridone Symptoms
- Bleached, white tissue
- Sometimes pinkish
- Symptoms can persist for weeks
**Fluridone**

- Absorbed by foliar tissues only
- Moves to areas of new growth
- Prevents the formation of essential aromatic amino acids in plants
- Without these essential amino acids, the plant cannot make proteins, enzymes, etc.
- Plant cannot continue growing and eventually starves and dies

**Glyphosate**

- Absorbed by foliar tissues only
- Moves to areas of new growth
- Prevents the formation of essential aromatic amino acids in plants
- Without these essential amino acids, the plant cannot make proteins, enzymes, etc.
- Plant cannot continue growing and eventually starves and dies

**Glyphosate Injury**

- yellowing
- massive budding

**Imazapyr, Imazamox, Imazapic, Penoxulam, Bispryribac, Metsulfuron, Chlorsulfuron (ALS)**

- Absorbed by foliar tissues only
- Moves to areas of new growth
- Prevents the formation of essential branched chain amino acids in plants - ALS
- Without these essential amino acids, the plant cannot make proteins, enzymes, etc.
- Plant cannot continue growing and eventually starves and dies

**ALS Injury Symptoms**

- Stunted, yellow to purple discoloration
- New growth most affected
**ALS herbicides in Water**

- Absorbed by foliage or underwater tissues
- Does not move within the plant – contact
- Appears to act on cell membranes or photosynthesis but how is unknown
- The cell membranes become leaky, cell contents spill out
- Without membranes the cells cannot make energy
- Synergy with other herbicides – diquat

**Copper**

- Absorbed by foliar tissues only
- Does not move within the plant – contact
- Causes the formation of a light absorbing chlorophyll precursor outside the chloroplast
- This compound absorbs energy from sunlight, but cannot pass through the Z-scheme
- The energy is passed on to oxygen, creating radical oxygen and eventual cell membrane disruption

**Carfentrazone & Flumioxazin**

- Speckling or bronzing of leaf tissue
- Tolerant plants generally outgrow injury within 2-3 weeks

**Carfentrazone & Flumioxazin Injury Symptoms**

- Absorbed by foliar tissues only
- Does not move within the plant – contact
- Causes the formation of a light absorbing chlorophyll precursor outside the chloroplast
- This compound absorbs energy from sunlight, but cannot pass through the Z-scheme
- The energy is passed on to oxygen, creating radical oxygen and eventual cell membrane disruption
Hexazinone, Diuron & Tebuthiuron

- Absorbed by foliage or roots
- Contact from foliar, systemic from root uptake
- Blocks photosynthesis
- No electron flow, buildup of excessive energy, creates toxic radicals
- Radicals cause the cell membrane to leak
- Yellowing and browning of leaf tissue

How Herbicides Work

- Mode/mechanism of action, where a specific plant process is targeted
  - photosynthesis
  - pigments
  - enzymes
  - growth, hormonal balance

Hardin 1985

“every good pesticide selects for its own failure”

Resistance Terminology

- Susceptible - controlled using normal use-rates
- Tolerant - species never susceptible to herbicide at label use rates
- Resistant - originally susceptible to herbicide; over time control lost through the selection of resistant plants
- Cross resistance - resistant to 2 or more herbicides with similar modes of action
- Multiple resistance - resistant to herbicides with different modes of action
Herbicide Resistance

- A shift in the *population* of a once susceptible biotype to a biotype that is resistant to normal application rates

---

**2000**

- No resistant weeds to glyphosate
- Glyphosate resistance conferred to corn, soybeans, cotton...
- 60+ million acres of RoundUp Ready crops
- **2014**: over 22 terrestrial weeds resistant to glyphosate
One herbicide-resistant plant:
- Ranges depending on herbicide and mechanism of action/tolerance
  - 0.000003% or 1 in 3 million to...
  - 0.00000001% or 1 in a billion

Chance of selecting...

What do farmers do?
- Switch to different herbicides, specifically different modes of action
- Rotate crops - corn:soybean:cotton:peanuts, etc., etc. Fallow......?
- Change tillage, implement other weed control strategies - mechanical primarily
- Aquatics and Natural Areas???

Resistance in Aquatics?
- Hydrilla resistance to fluridone

Resistance in Aquatics?
- Landoltia resistance to diquat

Resistance in Aquatics?
- Hydrilla resistance to fluridone

Herbicide Resistance
1. Shift in the amount (rate) required to achieve a similar level of control
2. Complete lack of control
### Superweeds?
- No.... the repeated use has selected for an alternative biotype
- the herbicide *did not* cause the mutation, it was pre-existing in the population

### Consequences of Resistance
1. Increase the Rate
   - increase costs/acre
   - decrease in selectivity
   - postponing the inevitable
2. Change control tactics, herbicides
3. May show cross resistance to other herbicides

### What Enhances the Chances?
- single site of action
- multiple applications per season, persistence of herbicide in environment
- repeated use of same material
- stand alone treatments
- low, sublethal rates????

### Resistance Management
- rotate herbicides with different mechanisms (altered target site)
- tank mix multiple mechanisms of action
- integrate other management methods
Thursday, May 8, 2014 – 11:15AM

SESSION 10A: AQUATIC WEED CONTROL

“Maximizing Product Performance of Aquatic Herbicides”

Fred Fishel
University of Florida/IFAS
Pesticide Information Office
Maximizing Product Performance of Aquatic Herbicides

Fred Fishel
Professor, UF/IFAS Agronomy

Learning Objectives
• Understand the importance of correct weed identification
• Describe the main types of adjuvants available and the proper selection for use with aquatic herbicides
• Be aware of water quality conditions that impact the effectiveness of herbicides
• Understand the influence of how product formulation affects its proper measurement for mixing

Why do herbicides fail?
• Improper weed identification (incorrect pesticide selection)
• Incorrect herbicide dosage
• Improper application timing
• Herbicide does not reach target weed
• Unfavorable environmental conditions
• State of poor herbicide condition
• Selecting the correct adjuvant, if needed
• Herbicide resistance

Why do herbicides fail?
Many of those reasons for failure share a commonality
You’ve got to know what you’re doing!

Why do herbicides fail?
Many of those reasons for failure share a commonality
You’ve got to read the label!

Why do herbicides fail?
A man’s gotta know his herbicide’s limitations!
Herbicide Limitations

• Species-specific (there is no perfect herbicide for control of all species a manager faces)
• Require a long-term management commitment
• Can.....
  – be slow-acting
  – move off-site
  – injure desirable vegetation
  – be expensive
  – leave a negative public perception

General Characteristics of Aquatic Herbicides

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Activity</th>
<th>MOA</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,4-D</td>
<td>Growth regulator</td>
<td></td>
</tr>
<tr>
<td>Triclopyr</td>
<td>Systemic</td>
<td>ALS enzyme</td>
</tr>
<tr>
<td>Bispyribac</td>
<td>Systemic</td>
<td>ALS enzyme</td>
</tr>
<tr>
<td>Imazamox</td>
<td>Systemic</td>
<td></td>
</tr>
<tr>
<td>Imazapyr</td>
<td>Systemic</td>
<td></td>
</tr>
<tr>
<td>Penoxsulam</td>
<td>Systemic</td>
<td>EPSP enzyme</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>Systemic</td>
<td>Photosynthesis (pigment inhibitor)</td>
</tr>
<tr>
<td>Toprimatez</td>
<td>Systemic</td>
<td>Photosynthesis/enzyme</td>
</tr>
<tr>
<td>Fluridone</td>
<td>Systemic</td>
<td>Photosynthesis</td>
</tr>
<tr>
<td>Carfentrazone</td>
<td>Systemic</td>
<td>Photosynthesis</td>
</tr>
<tr>
<td>Flumioxazin</td>
<td>PPO enzyme</td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>Contact</td>
<td>Photosynthesis/enzyme</td>
</tr>
<tr>
<td>Diquat</td>
<td>Systemic</td>
<td></td>
</tr>
<tr>
<td>Endothall</td>
<td>Systemic</td>
<td>Cell membrane disruptor</td>
</tr>
</tbody>
</table>

Weed Identification

Elodea<br>(Egeria)

Pondweed<br>(Potamogeton spp., except Illinois pondweed)<br>Watermilfoil<br>(Myriophyllum spp., except variable-leaf milfoil)

Fanwort<br>(Cabomba)

Eurasian<br>watermilfoil

Illinois<br>pondweed

Long leaf<br>pondweed

Para<br>grass

Maidencane
Weed Identification

Clearcast label (imazamox)

Concentration rate range of 50 to 500 ppb

10X Difference!!!

Adjuvants

- Adjuvants can be confusing
- Dozens of manufactures
  - Dozens of different products
- Dozens of types
  - What do I use when?
- Make a large difference
  - Many claim very lofty results
  - Allows reduced rates, reduced regrowth, etc.

What is an adjuvant?

Adjuvant: any substance that has no pesticidal activity applied alone but when added to the formulation or the spray tank can improve pesticidal activity or application characteristics

- 2 classes of adjuvants:
  - Activators - improve performance
  - Utility - improve ease of application

Adjuvants

Activators
- Wetter-sprayer
  - Non-ionic surfactant
  - Silicone surfactant
- Penetrate
  - Crop oils
  - Basal oils
- Sticker

Utility
- Compatibility agent
- Defoamer
- Anti-drift
- Water conditioner
- pH modifiers
- Polymers

How do I know if an adjuvant is needed?

- Some product labels.....
  - Require
  - Suggest
  - Don’t specify
- Recommend the use of an adjuvant certified by the Council of Producers and Distributors of Agrotechnology (CPDA)

CPDA

- Adjuvant registrants submit packet to CPDA:
  - Product label
  - MSDS
  - 1 – 2 page summary of required toxicity studies
- Currently has a list of 70 certified adjuvants
- Users assured that the product will meet its performance claims and that all product labeling guidelines have been followed
Adjuvants

Surfactants

- Flattens out the spray drop
  - Leaves are covered with wax
  - Wax repels water
  - Surfactants overcome the repulsion
- Reduces bounce
- These are nonionic surfactants

Adjuvants

Pay attention to spray volume

Foliar Application to Floating and Emergent Weeds
Galileo SC can be applied as a foliar application to control weeds such as water hyacinth, water lettuce, water pennywort and other susceptible floating and emergent species. Applications should be conducted in a manner to maximize spray interception by target weeds while minimizing the amount of overspray that inadvertently enters the water.

Surfactant retention – 1 squirt
Surfactant retention – 3 squirts

Adjuvants

Which brand of surfactant is best?
- All of them are practically interchangeable
- Any nonionic type with >80% active ingredient will generally be fine

Adjuvants

Beware of these!
- Adjuvants that claim:
  - Equal weed control at reduced herbicide rates
  - Products that “reduce regrowth of weeds”
  - Cocktails (spreader + sticker + compatibility + etc)
  These are usually more costly and give little benefit
  - Anything that sounds too good to be true

Stick with what you know!

State of Poor Pesticide Condition

Mix up a load and spray till it’s gone, right?

State of Poor Pesticide Condition

- Pesticides start to break down when they are in water
  - water
  - light
  - microbes
- These processes can be fast or slow. It depends...
State of Poor Pesticide Condition

Water Source

- Adsorption: process of accumulation at an interface
- Colloid: refers to the microscopic inorganic and organic particles in the soil

Pond water...
- Often has organic matter floating in it
- This can tie up and deactivate almost any herbicide
- Differences in clarity can impact the efficacy of the herbicide

Roundup Ultra Label

SPECIFIC USE DIRECTIONS

7.0 MIXING

Clean sprayer parts immediately after using this product by thoroughly flushing with water.

Note: Reduced results may occur if water containing soil is used. Such as water may be used for water from ponds and ditches that is not clear. Herbicides may be used for water with greater concentrations of high levels, water color, or trace metals.

Parts per million (ppm) | World Health Organization Water Classification
---|---
0 - 114 | Soft
114 – 342 | Moderately hard
342 – 800 | Hard
> 800 | Extremely hard
State of Poor Pesticide Condition

**Water Source**

- Several herbicides (including 2,4-D, dicamba, and glyphosate) have an overall negative charge
- These herbicides can be influenced by hard water cations
- Strong complexes can form when mixed with hard water
- Negatively charged pesticide molecules attach to the positively charged cations Ca**⁺** and Mg**⁺**

**State of Poor Pesticide Condition**

- Studies have shown that increasing ion concentration decreases glyphosate activity
- Calcium will bind to the negatively charged glyphosate
- Glyphosate + calcium has no herbicidal activity

**State of Poor Pesticide Condition**

- The effects of hard water can be reversed with a water conditioner - commonly ammonium sulfate

- **Ammonium Sulfate**

  7.4 Ammonium Sulfate

  **DIRECTIONS FOR USE**

  - The addition of 1 to 2 percent dry 100 gallons of water may increase hard water conditions, drought å herbicides, on an annual and prevent water formation or dissolved in the spray tank before adding water under use to reverse

**State of Poor Pesticide Condition**

- pH – Indicator of alkalinity or acidity
- Scale from 0 to 14
- Logarithmic concentration scale of:
  - If H⁺ = OH⁻: then pH is 7.0 or neutral
  - If H⁺ > OH⁻: then pH is acidic
  - If H⁺ < OH⁻: then pH is alkaline (basic)

**State of Poor Pesticide Condition**

- Some pesticides lose effectiveness when mixed with alkaline water
- pH 8 to 9 can greatly diminish or cause complete loss of effectiveness
- Most common with some insecticides: carbamates and organophosphates
- Few fungicides and herbicides susceptible
State of Poor Pesticide Condition

Water Source

- Most water sources in FL derive from limestone aquifers
- Contain high levels of carbonates — removes H\(^+\) from water, thus increases pH

State of Poor Pesticide Condition

Water Source

<table>
<thead>
<tr>
<th>Pesticide</th>
<th>pH 6</th>
<th>pH 7</th>
<th>pH 8</th>
<th>pH 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>flumioxazin</td>
<td>---</td>
<td>24 h</td>
<td>---</td>
<td>15 min</td>
</tr>
<tr>
<td>captan</td>
<td>---</td>
<td>8 h</td>
<td>---</td>
<td>2 min</td>
</tr>
<tr>
<td>carbaryl</td>
<td>125 days</td>
<td>27 days</td>
<td>2-3 days</td>
<td>1-3 days</td>
</tr>
<tr>
<td>dimethoate</td>
<td>12 h</td>
<td>---</td>
<td>---</td>
<td>1 h</td>
</tr>
<tr>
<td>disulfoton</td>
<td>32 h</td>
<td>---</td>
<td>---</td>
<td>7 h</td>
</tr>
<tr>
<td>malathion</td>
<td>8 days</td>
<td>3 days</td>
<td>19 h</td>
<td>---</td>
</tr>
<tr>
<td>phosmet</td>
<td>---</td>
<td>1 day</td>
<td>4 h (pH 8.3)</td>
<td>1 min (pH 10)</td>
</tr>
<tr>
<td>trichlorfon</td>
<td>4 days</td>
<td>6 h</td>
<td>1 h</td>
<td>---</td>
</tr>
</tbody>
</table>

State of Poor Pesticide Condition

APPLICATION AND SPRAYER INFORMATION

IMPORTANT: Read these entire Directions and Conditions of Sale, including the Warranty and Limitation of Damages provision, before using.

For USE WITH PRODUCTS REGISTERED FOR: AGRICULTURAL, AQUATIC, FORESTRY, INDUSTRIAL, MUNICIPAL, NON-CROPLAND, ORNAMENTAL, RIGHTS-OF-WAY, TURF AND OTHER USES.

Use 4 oz to 2 parts of BUFFER XTRA STRENGTH per 100 gallons of water to lower and stabilize the pH of the spray solution. The rate of BUFFER XTRA STRENGTH may vary with water conditions and will depend upon the alkalinity of the water used or the presence of other products in the spray mix. The use of a pH measuring device is recommended for determining the optimum rate of BUFFER XTRA STRENGTH. Final spray solution pH for many pesticides should be in the 4-7 range.

Proper Measurement

8 fluid ounces = 1 cup = 236.5882 milliliters

Proper Measurement
Proper Measurement

Is this any better?

How do you measure 14 ounces with this?

Proper Measurement

• Dry vs wet measure
  – An ounce is an ounce, right?
• Dry
  – Based on weight – 1/16 of a pound
• Wet
  – Based on volume – 1/128 of a gallon

These can be very different!

Proper Measurement

All these jars have 4 dry ounces, by weight, of material.

The volume occupied by dry material depends directly on the density and particle size.

Proper Measurement

How would you measure less than 10 oz with this container?

Taller, narrower measuring containers typically have more graduation marks and more space between lines on the container compared to shorter, wider ones.

This one starts at 10 oz.

Proper Measurement

You can’t use a liquid measure for dry material!

1 liquid oz = 1/128 gal
1 dry oz = 1/16 lb

Proper Measurement

• The specific volume of a dry wettable granule product depends on its density
• The volumes of WG products vary by their ingredients and the size and shape of their granules
Proper Measurement

The volume of 1 dry ounce of material varies greatly by device and product.

Proper Measurement

Same product, but different batches – notice slightly different amounts to make 1 ounce.

Proper Measurement

6 ounces of 4 different dry products compared to 6 fluid ounces of a liquid product.

Proper Measurement

Liquid product  Dry products

Proper Measurement

• Things you need to know about retail-supplied measuring devices:
  – Make sure you know whether a measuring device is meant for fluid ounces or dry ounces
  – Be cautious of measuring devices for closely related products that are formulated differently
  – Many devices clearly state that they must be used for the products they came with, then discarded
  – Be cautious of containers that have different sets of graduation marks indicating both liquid and dry ounces
Proper Measurement

The most accurate and consistent way to measure dry formulations is to weigh them on a scale.

Review

What is the overall primary factor for why herbicides fail to control a weed?

A. It is some form of human error. V
B. Incorrect pest identification.
C. Improper application timing.
D. Pesticide resistance.

Review

Which type of measuring container for liquid pesticides would be expected to be most precise?

A. A measuring cup marked in ounces.
B. The cap from the product’s container.
C. A tall, narrow cylinder marked in milliliters. V
D. A short cup marked in quarts and pints.

Review

Why can’t liquid and dry measuring devices be used interchangeably?

A. An ounce of any liquid formulation always occupies the same amount of volume.
B. The volume of a dry formulation depends directly on its density and particle size.
C. An ounce of a liquid formulation and an ounce of a dry formulation would occupy the same volume.
D. Both A and B are correct. V

Review

Why do water sources containing silt and organic matter used for mixing with herbicides cause weed control failures?

A. They cause pesticides to bind with the calcium and magnesium ions which inactivates them.
B. They cause an alkaline hydrolysis reaction which quickly decomposes them.
C. They adsorb pesticides leaving them unavailable for uptake. V
D. They have been shown to enhance the development of pesticide resistance.

Review

What is a practical method for preventing antagonism of glyphosate mixed in hard water?

A. Add a buffering agent to lower the mix water’s pH to a range of 4.5 to 6.0.
B. Add a nonionic surfactant of at least 80% active ingredient to the mix water at a volume of 1%.
C. Increase the application rate of glyphosate.
D. Add ammonium sulfate to the mix water prior to adding glyphosate. V
Thanks for your attention!
Thursday, May 8, 2014 – 10:00AM

SESSION 10B: NATURAL AREAS AND RIGHT-OF-WAY WEED CONTROL

“Advances in Aerial Application”

Pat Minogue
University of Florida/IFAS
North Florida NEC
Advances in Aerial Herbicide Application for Drift Mitigation

Dr. Andrew Hewitt

2014 Aquatic Weed Control Short Course
Pat Minogue, Ph.D., R.F.

Associate Professor of Silviculture
University of Florida
School of Forest Resources and Conservation

Topics for Discussion

- Factors affecting drift potential
- Application of solids
- Aerial spraying, deposition efficiency
- Aircraft and equipment selection
- Effect of spray additives
- Environmental factors affecting drift potential and herbicide performance

Factors Affecting Drift Potential

- **Application parameters**, especially droplet size and spraying technique (nozzle selection, booms, aircraft, etc.)
- **Weather effects**, especially wind speed and direction, height of inversion layer
- **Tank mix effects**, product formulations, surfactants, emulsifiers, drift control agents

- Research by the Spray Drift Task Force and others provides some useful information for minimizing drift

Fixed-Wing Application

Helicopter Spraying
Rotor Vs. Fixed Wing

- **HELICOPTER**
  - Remote Landing
  - Maneuverable
  - Slow Air Speed
  - Used in Sensitive areas
- **FIXED WING**
  - Greater Payload
  - Lower Costs
  - More Potential for Off-Site Movement
  - Not Permitted with Some Herbicides

Solids: Iso-Lair Bucket

Aerial Application of Solids

- Modified seeders and fertilizer spreaders are used to broadcast herbicide granules
- More difficult to control rate per acre and uniformity across the swath than sprays
- Carrier evaporation is not a concern
- Fines or dust in product formulations increase potential for off-site movement
- To avoid streaks or drift, do not apply when winds are gusty or exceed 5 mph

Small Droplets Give Good Coverage on the Leaf Surface

<table>
<thead>
<tr>
<th>Droplet Diameter (Microns)</th>
<th>Droplets on Leaf (Per Sq. Inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>92,250</td>
</tr>
<tr>
<td>100</td>
<td>11,750</td>
</tr>
<tr>
<td>200</td>
<td>1,425</td>
</tr>
<tr>
<td>400</td>
<td>180</td>
</tr>
<tr>
<td>800</td>
<td>22</td>
</tr>
</tbody>
</table>

Akesson and Yates, 1987, WSSA

Small Droplets Drift!!!!

<table>
<thead>
<tr>
<th>Droplet Diameter (Microns)</th>
<th>Wind 1 mph</th>
<th>Wind 5 mph</th>
<th>Wind 10 mph</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1.5 miles</td>
<td>7.5 miles</td>
<td>14.5 miles</td>
</tr>
<tr>
<td>100</td>
<td>75 feet</td>
<td>375 feet</td>
<td>750 feet</td>
</tr>
<tr>
<td>300</td>
<td>8 feet</td>
<td>42 feet</td>
<td>83 feet</td>
</tr>
<tr>
<td>600</td>
<td>2 feet</td>
<td>11 feet</td>
<td>21 feet</td>
</tr>
<tr>
<td>800</td>
<td>1 foot</td>
<td>6 feet</td>
<td>12 feet</td>
</tr>
</tbody>
</table>

Hansen, 1965; see Akesson and Yates, 1987, WSSA

Evaporation Rate & Droplet Size

20 ft, 1 mph Wind, 25°C, 55%RH

<table>
<thead>
<tr>
<th>Droplet Diameter (Microns)</th>
<th>Droplet Disappears (Fall Distance)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>--</td>
</tr>
<tr>
<td>150</td>
<td>15 ft</td>
</tr>
<tr>
<td>120</td>
<td>7 ft</td>
</tr>
<tr>
<td>100</td>
<td>3.5 ft</td>
</tr>
<tr>
<td>80</td>
<td>2 ft</td>
</tr>
</tbody>
</table>

Akesson and Yates, 1987, WSSA
Application Parameters Affecting Droplet Size Spectrum

- Orifice size and type of nozzle
- Nozzle discharge angle
- Pressure at the nozzle
- Application height
- Droplet shear, turbulence, airspeed
- Evaporative losses while airborne

Nozzle Selection

- Flat fans, disc-cores, cone nozzles can produce fairly coarse sprays by VMD if operated at low pressures and low nozzle angles
- Solid stream nozzles can produce even coarser sprays by VMD if operated at medium pressures
- All of these also tend to produce some “fines”

- Multiple-orifice solid stream nozzles such as TVB and Accu-Flo tend to produce very coarse sprays and few “fines” if operated optimally

Aerial Spray Equipment

- **CONVENTIONAL**
  - Simplex(R) Boom
  - Warnell(R) Boom
  - Teejet(R) Disc-Core Nozzles
  - Raindrop(R) Nozzles

- **CONTROLLED DROPLET**
  - Microfoil(R) Boom
  - Thru-Valve(R) Boom
  - Microfoil(R) Nozzles
  - TVB(R) Nozzles
  - Accu-Flo(R) Nozzles

Microfoil® Boom

Thru-Valve Boom & Nozzle (TVB)

TVB 0.045 Pattern
Comparison of the percentage of fines with various nozzles spraying water

<table>
<thead>
<tr>
<th>Nozzle Type</th>
<th>% &lt; 15.3 µm</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP helicopter</td>
<td>1.8</td>
</tr>
<tr>
<td>DY-48</td>
<td>1.2</td>
</tr>
<tr>
<td>CP deflector 30</td>
<td>0.6</td>
</tr>
<tr>
<td>CP solid stream</td>
<td>0.6</td>
</tr>
<tr>
<td>Accu-Flo 0.028</td>
<td>0.0</td>
</tr>
</tbody>
</table>

- **Boom Length**
  - Shorter boom lengths can greatly reduce drift, for rotary and fixed wing aircraft
  - For fixed-wing aircraft, the greatest benefit is obtained when booms are <65% of wing length
  - Will not necessarily decrease swath width sufficiently to require significantly more flight passes

- **GPS: Global Positioning Systems**
  - Documents path of the aircraft
  - Delineates treatment area
  - Very useful to determine airspeed to ensure correct calibration of spray volume and herbicide rates per acre.
  - Can be integrated with injection systems to control delivery rate.
AG-NAV GPS

- Direction to Swath
- Cross-Track
- Direction to Intercept

Application Practices:
Swath Adjustment

- Most applicators already practice swath adjustment, a practice which can have a very large effect on reducing drift
- Offset varies by wind speed and droplet size
- Fly the pattern

Tank Mix Effects

- Tank mix selection can have a large effect on droplet size from some nozzle types
- Avoid the use of excessive non-ionic surfactant where possible (especially polyethoxylates)
- Emulsion adjuvants such as emulsified seed oils and organosilicones can reduce “fines”
- “Drift Control” Polymers tend to increase VMD, but often also increase % “fines”, and may be affected by pumping and tank mix partners; not suitable with some nozzle types

Herbicide/ Modified Seed Oil Tank Mixes

Minogue and Dexter, 2002, BASF Research Rpt. 2002-02

Polyethoxylate surfactants increase fines.

Minogue and Dexter, 2002, BASF Research Rpt. 2002-02
Meteorological Effects

- Wind speed and direction are key parameters affecting drift
- Temperature and relative humidity can affect evaporation rates, so may also be important
- Air stability important - most labels recommend not spraying under local surface temperature inversion condition

Conclusions

- Select nozzle type to avoid fine droplets
- Carefully consider application methods and conditions
- Avoid great release heights
- Avoid high wind speeds
- Use short boom lengths and good application practices
- Avoid excessive (NIS) surfactant
- Use emulsion carrier to reduce fines
Thursday, May 8, 2014 – 10:25AM

SESSION 10B: NATURAL AREAS AND RIGHT-OF-WAY WEED CONTROL

“Invasive Species Control in the "Heart" of Everglades Restoration”

Angie Huebner
United States Army Corps of Engineers
CENTRAL EVERGLADES PLANNING PROJECT

Overview

- Authorities, Policy and Guidance
- Implementation of CW Policy Memo - PIR’s & other Implementation Documents
- GCM 62

Invasive Species in the “Heart” of Everglades Restoration

Presented by
Angie Huebner
US Army Corps of Engineers
Jacksonville District
8 May 2014

Policy & Guidance

- Rivers and Harbors Act of 1899
- Executive Order 13112
- CW Policy Memo, Invasive Species
- CW Policy Memo, PIR’s & Other Implementation Documents
- CGM 62 Invasive Species

Policy and Guidance

- Rivers and Harbors Act of 1899

Policy & Guidance

- Executive Order 13112 – 3 Feb 1999 – Federal agencies shall not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species in the US or elsewhere…”

- Federal Agency Duties
  - Prevent
  - Detect and respond rapidly
  - Monitor
  - Research and develop new technologies
  - Promote public education
- Invasive Species Council
- National Invasive Species Management Plan

Policy & Guidance

- CW Policy Memo - Invasive Species (2009)
  - Applicable to all aspects of CW
  - Measures to prevent or reduce invasive species
  - O&M, CW project implementation & planning documents
- CW Policy Memo - PIR’s & other Implementation Documents (2010)
  - Specific to CERP projects
  - Address management and potential impacts
  - Reduce OMRR&R costs by managing during construction
Policy & Guidance

- Implementation of CW Policy Memo - PIR's & other Implementation Documents
  - PDT formed
  - Site visits
  - Planning process - CERP
  - Draft guidance developed
  - Coordination, review & input from other divisions, agencies and stakeholders
  - Final - CGM 62 - Invasive Species

Policy & Guidance

CGM 62 Invasive Species

- Signed 11 July 2012
- Provides guidance for assessing invasive species
- Identifies items to consider for each phase of a project
- Focuses efforts to minimize cost during the OMRR&R Phase
- Assists in achieving ecological restoration benefits

Benefits to be realized:

- Decreased OMRR&R Phase Cost
- Overall Project Cost Decreased
- Increased Ecological Benefits
- Aids in Project Success

Design & Construction Phases

- Implement INSM Plan
- Design to prevent & minimize invasive & nuisance species & promote native species
- Consider treating prior to construction
- Minimize ground disturbance
- Manage during construction phase & include specifications in contracts
- Project Partnership Agreement & Transfer Agreement

CGM 62 Invasive Species

- CERP Projects should:
  - Describe species, distribution and potential impacts
  - Identify current management activities
  - Assess for future management
  - Provide plans & cost estimates
  - Include management in construction or service contracts
  - Include management details in OMRR&R Phase and manual

Design & Construction Phases

- Specification #01 57 20
  - Environmental Protection – Include “Prevention of Invasive and Native Nuisance Species Transfer” language
OMRR&R Phase
- Implement the INSM Plan
- Manage during entire phase
- Incorporate Biological Controls
- Implement measures for Early Detection & Rapid Response
- Include Prevention of Invasive & Nuisance Species Transfer language

Ecosystem Restoration

New Species in Everglades National Park Since CERP
- Known Species: Brazilian pepper, melaleuca, Australian Pine, hydrilla, Torpedograss, Napier Grass
- Potential Species per County
  - Broward – 187
  - Collier – 157
  - Monroe – 163
  - Hendry – 72
  - Miami-Dade – 272
  - Palm Beach - 192

Invasive Plant Species - CEPP
- Key Reptile Species
  - Burmese python
  - Argentine black and white Tegu
  - Nile monitor
- Other Species of Concern
  - Island apple snail
  - Purple swamphen
  - Asian swamp eel
  - Monk parakeet
  - Feral pig
  - Red bay ambrosia beetle & associated fungus

Preventative Measures
- Specifications for Equipment Cleaning
- Planting Native Vegetation
- Exclusion Devices
- Treatment & Removal
- Management for OMRR&R Phase
- Minimize Soil Disturbance
- Selection of Fill/Topsoil Material
- Education/Training/Reporting
Summary
Thursday, May 8, 2014 – 10:50AM

SESSION 10B: NATURAL AREAS AND RIGHT-OF-WAY WEED CONTROL

“Evaluating the Invasion Risk of Non-Native Plants in Florida's Natural Areas”

*Deah Lieurance*
University of Florida/IFAS
Agronomy
Evaluating the invasion risk of non-native plants in Florida’s natural areas

Deah Lieurance, PhD
Coordinator, UF/IFAS Assessment of Non-native Plants in Florida’s Natural Areas
Gainesville, FL

Invasive species: an organism (plant, animal, fungus, or bacterium) that is not native and has negative effects on our economy, our environment, or our health.

- Unique geography makes Florida particularly susceptible
- ~85% of all non-native plants enter through Florida
- 1400 non-native species established/142 in state parks
- Significant impacts to recreation/expensive to manage
- Cost $500 million/year to control exotic species in Florida

Outline

- Traits & ecology of invasive plants
- The assessment: history & tools
- The website

Biological Traits of Invasive Plants

- Higher relative growth rates
- Longer flowering & fruiting periods
- Greater seed production
- Efficient dispersal
- Fast germination/short minimum generation times
- Tolerant to a wide range of habitats/conditions
- Efficient resource utilization

Fast Growth
High Reproduction

Efficient Dispersal

Tolerance

Ecosystem Effects
- Erosion/sedimentation
- Changes in water & nutrient cycling
- Altered disturbance regimes
- Reduction of native species
- Increases in resource competition
  = Changes in stand structure

Ties to Landscaping
Many prominent invasive plant species introduced for hort/landscaping
ex: Lantana, Nandina, Coral Ardesia

...but not all bad
Many non-native species are economically beneficial
What is The Assessment?

• Tool to assess the status of species currently present in the state
  – Reduce cost & increase efficiency of management efforts

History & Purpose

• Developed in 1999
• UF/IFAS Invasive Plants Working Group
• Descriptions & recommendations for use & management
• 2008 Predictive Tool & Infra-specific Taxon Protocol added

Outline

• Traits & ecology of invasive plants
• The assessment: history & tools
• The website

Status Assessment

• Evaluates species already in Florida
  • 3 zones
    • Describe the status of the species
      – Ecological impacts
      – Potential for expanded distribution in Florida
      – Management difficulty
      – Economic value
    • Incorporates field data from experts
Status Assessment

- Ecological impacts
  - Document natural areas where present/\#acres
  - Long term alterations to ecosystem processes?
  - Overall changes in community structure?
  - Interactions with federal/state threatened or endangered species?

- Management impacts
  - Control methods?
  - Is species difficult to control?
  - Require retreatment?
  - Costs of control >$1500/acre?
  - Viable propagules?

Status Assessment

1. **Not considered a problem** species at this time & may be recommended (reassess in 10 years)
2. **Caution** - may be recommended but manage to prevent escape (reassess in 2 years)
3. **Invasive & not recommended** (except for any specified & limited use) approved by IFAS Invasive Plants Working Group (reassess in 2 years)
4. **Invasive & not recommended** (reassess in 10 years)

Predictive Tool

- Series of 49 questions
  - Domestication/cultivation
  - Climate/distribution
  - Weed elsewhere?
  - Weedy traits
  - Plant type
  - Reproduction
  - Dispersal mechanisms
  - Persistence attributes
- Scoring
  - <3 Low Risk for Invasion
  - 1-6 Evaluate Further
  - >6 High Risk for Invasion

Secondary Screening

Pacific second screening: decision rules for species with WRA scores between 1 and 6 (from Daniel et al. 2014)

- Tree or tree-like shrub
  - (shade tolerant OR known to form dense stands) AND it has attractive wood density

- Herb or low stature shrub
  - (not a weed of cultivated food)

Views must pass both tests
Invasion risk of biofuels

- 40 biofuels, 40 introduced in Hawaii
- Biofuels 2-4x more likely to be invasive

Buddenhagen et al. 2009

Biomass Planting Rule

“to control the introduction into, or movement within, Florida of plant species intended for biomass plantings.”

- Requires permit to plant >2 contiguous acres
- By law, include weed risk assessment

Research Article
Assessing the Invasion Risk of Eucalyptus in the United States Using the Australian Weed Risk Assessment

Doris R. Gordon,1 S. Luke Flory,1 Almea L. Cooper,2 and Sarah K. Morris2

- 37 species with WRA results
  - 22 → low probability of invasion
  - 8 → high probability of invasion
  - 7 → further evaluation

Infraspecific Taxon Protocol

- Cultivars, varieties, or sub-species of resident species
- Determine if recommendations for resident species apply
- Request submitted to IFAS Assessment staff
  - Supporting evidence indicating the taxon is a distinct entity
  - Reasons for expecting the taxon to behave differently resulting in different recommendations

Nandina

- North, Central = Invasive
  - Specified limited use (if approved)
- South = Caution
  - May be recommended/manage to prevent escape
Nandina cultivars

Firepower, Harbour dwarf, & Gulf Stream: ok to recommend All zones

Jaytee (Harbour Belle) = Same as resident species
(North, Central = No unless limited use approved; South = Caution)

~800 species evaluated
120 re-evaluations scheduled for 2014

Status re-assessment

QUESTIONNAIRE – Status Assessment

Please answer ALL the following questions with regard to the species indicated below. The information requested will be incorporated in the IAS Assessment to determine whether control efforts, management and containment measures for the species indicated. Conclusions derived from the IAS Assessment are intended to prevent or reduce the likelihood of further invasions of natural areas by non-native plants. Superiace numbers refer to rows at the end of this document. Your input is most welcome!

Plant Species:
Scientific Name:
Biological/Species:
Aridity:
Professional Title/Location:

Part I: Ecological Impacts
1. Please list all natural areas (e.g. parks, wildlife refuge) where the plant is found or likely to be found. If multiple areas, list the natural area number and name (e.g. p-park name). The Natural Area (NA) number is a reference number; the order of listing is not important.
2. Natural Area
   Natural Area Name
   County

3. Please estimate the number of hectares of natural area occupied by the species in each county:
   NA #
   Area occupied A
   Additional area A
   NA #
   Area occupied B
   Additional area B

   Comments:

5. Does this species cause long term alterations in ecosystem processes? (Species that are excessively competing for light with neighboring species will be addressed in Question 8)
   YES
   Please list all natural areas (NA numbers) that apply.
   Because:
   Biogeochecology
   Disruption of the fire regime
   Invasion
   Plants
   Hydrology
   Increase sedimentation
   Other
   LIKELY
   Please list all natural areas (NA numbers) that apply.
   Because:
   Biogeochecology
   Disruption of the fire regime
   Invasion
   Plants
   Hydrology
   Increase sedimentation
   Other
   NO
   UNKNOWN

Management Impacts – Part II

15. What control methods are you aware of that could eliminate individuals of this species? Please include the name(s) of herbicides and/or provide a specific control method if “other” is chosen.
   - Herbicide
   - Mechanical
   - Hand pulling
   - Fire/Prescribed burn
   - Biological control
   - Nothing eliminates species
   - Other
   - Unknown
   Herbicide names, biological control species, and other control methods:
Outline

• Traits & ecology of invasive plants

• The assessment: history & tools

• The website

Website

View results
- Comprehensive list
- By zone
- By recommendation

New website

• Anticipated launch mid summer 2014
• User friendly
• Search by species
• Useful links
• Generate lists

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

Follow Us On Twitter/ Like Us On Facebook
@IFASassessment
UF IFAS Assessment

dmlieurance@ufl.edu
SPECIAL SESSION

AQUATIC PLANT ID

“Aquatic ID: Aquatic Plant Identification”

*Lyn Gettys*
University of Florida/IFAS
Ft. Lauderdale Research and Education Center
Aquatic Plant Identification

Why are you here?
Besides for the CEUs, of course…
Provenance
Growth potential
Control requirements
Control methods

Terminology

Plant type

Growth habit
Emergent
Rooted in the sediment
Some parts above the waterline
Submersed
Rooted or anchored in the sediment
Most or all parts below the waterline
Floating
Roots below the waterline but not anchored
Most or all other parts above the waterline

Plant parts
Vegetative
Leaf shape
Leaf margin
Leaf arrangement
Other…

Flowers
Leaves

Leaf parts
- Blade
- Lamina
- Apex
- Base
- Petiole

Appendages
- Stipules
- Ligules

Simple vs. compound

Leaf shape

Based on apex and base
- Elliptic – narrow oval; narrower at apex and base
- Cordate – heart-shaped; notched base
- Lanceolate – lance-shaped; length > width
- Linear – long and narrow; parallel sides
- Sagittate – arrowhead-shaped; basal lobes point down (hastate – basal lobes point out)

Illustrations from: http://www.echocamp.org/gp/ed/flower/term/leaf/shape.html

Leaf margin

Blade edge
- Entire – smooth
- Serrate – sharp teeth pointing forward
- Cleft – cut about halfway to the base
- Palmate – deeply lobed from a common point

Leaf attachment

How the leaf is attached to the stem
- Basal/rosette – at the base of the plant
- Alternate – one leaf per node
- Opposite – two leaves per node
- Verticillate (whorled) – three or more leaves per node

Other vegetative traits...

On stem or leaves
- Hairs
- Texture
- Coloration, speckling
- Stipules
- Ligules

Flowers

Flower parts
- Petals (corolla)
- Sepals (calyx)
- Stamens (male)
- Pistils (female)

Support
- Peduncle
- Pedicels
- Sessile
**Flowers**

- Solitary flower (peduncle)
- Inflorescence with multiple flowers
  - Panicle – branched
  - Raceme – unbranched with pedicellate flowers
  - Spike – unbranched with sessile flowers
- Spathe and spadix – large bract surrounding a spike

**Now for the main event…**

**Plants!**

- Emergent
- Floating-leaved
- Shoreline – herbaceous and woody
- Floating – small and large
- Submersed – vascular and algae
- Grasses and grass-like
- Rushes

**Emergent plants**

Rooted in the sediment; wet feet
At least part of the plant is above the waterline

Examples:
- Alligatorweed – *Alternanthera philoxeroides*
- East Indian hygrophila – *Hygrophila polysperma*
- Smartweed – *Polygonum* spp.
- Bacopa – *Bacopa caroliniana, B. monnieri*
- Creeping primrose willow – *Ludwigia repens*
- Roundleaf toothcup – *Rotala roundifolia*

**Alligatorweed 😒**

- Shallow, wet feet
- Leaves:
  - Simple
  - Elliptic
  - Smooth margins
  - Opposite
  - Hollow stems
- Small papery white flowers
**East Indian hygrophila**

- Streams, slow-moving water
- Most of plant is submerged
- Leaves:
  - Simple
  - Elliptic
  - Smooth margins
  - Opposite
- Square stems
- Blue to white flowers in leaf axils

**Smartweed**

- Fresh and brackish water, wet feet
- Mostly shallow water
- Shoreline, ditches
- Leaves:
  - Simple, sessile, clasping
  - Lanceolate
  - Smooth margins
  - Alternate with swelling where leaf attaches to stem
- Small pink to white flowers borne on a spike

**Bacopa**

- Fresh and brackish water, wet feet
- Leaves:
  - Simple
  - Fleshy
  - Smooth margins
- Nearly round leaves
- Blue flowers

**Lemon bacopa**

- Nearly round leaves
- Blue flowers
**Bacopa ☺**

Oblanceolate leaves  
White flowers

**Creeping primrosewillow ☺**

Fresh and brackish water, wet feet  
Most of plant is submerged  
Upper few inches above waterline  

Leaves:  
Simple  
Nearly round  
Smooth margins  
Opposite  
Underside reddish  
Green stems  
Small yellow flowers

**Creeping primrosewillow ☺**

Shallow water, wet feet  

Leaves:***  
Simple, smooth margins  
Opposite  
Heterophyllous  
Bright red stems  
Bright rose flowers borne on terminal spike

**Rotala ☺**

Easily confused…

Bacopa, primrosewillow and rotala  

Fleshy green stems and leaves → bacopa  

Thinner green stems, red under leaves → primrosewillow  

Thin bright red stems → rotala
Floating-leaved plants

Rooted in the sediment
Most of the plant is below the waterline
Examples:
- Bananalily, floatingheart, snowflake – *Nymphoides* spp.
- Spatterdock – *Nuphar luteum* (*N. advena*)
- Waterlilies – *Nymphaea* spp.
- American lotus – *Nelumbo lutea*

*Nymphoides* spp. ☺ ☻

Still and slow-moving water
Leaves:
- Simple
- Round to cordate
Cluster of roots/rhizomes just below the leaves looks like a bunch of bananas
Small showy flowers

Bananalily (*N. aquatica*) ☺

Leaves:
- Nearly round
- Notched apex, round base
Flat papery flowers

Crested floatingheart (*N. cristata*) ☻

Leaves:
- Cordate, round base
- Dark red markings
Flowers with central crest

Water snowflake (*N. indica*) ☻

Leaves:
- Round to cordate, rounded base
White/yellow “fuzzy” flowers

Easily confused...

*Nymphoides* spp.
- Green notched leaves, papery white flowers → *N. aquatica* ☻
- Red on cordate leaves, crested white flowers → *N. cristata* ☻
- Green leaves, fuzzy white/yellow flowers → *N. indica* ☻
**Spatterdock 😊**

Still and slow-moving water
Leaves:
- Simple, up to 10”
- Cordate to sagittate
- Basal
- Floating, emergent, submersed

Yellow flowers that look partially open
Basal peduncle

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**Nymphaea spp. 😊**

Still and slow-moving water
Leaves:
- Simple, up to 8”
- Nearly round
- Cleft

Basal peduncle

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**Fragrant white waterlily 😊**

*Nymphaea odorata*: fragrant white flowers

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**American lotus 😊**

Still and slow-moving water
Leaves:
- Simple, up to 12”
- Round
- Peltate
- Basal
- Floating, emergent
- Rhizome – corn-dog

BIG yellow flowers
Basal peduncle
American lotus 😊

Herbaceous shoreline plants
Rooted in the sediment
Most or all of the plant is above the waterline
Somewhat soft and flexible
Examples:
- Wild taro – *Colocasia esculenta*
- Lizard’s-tail – *Saururus cernuus*
- Alligatorflag – *Thalia geniculata*
- Pickelweed – *Pontederia cordata*
- Arrowhead – *Sagittaria lancifolia*, *S. latifolia*

Wild taro 😊
Shallow water, wet feet, terrestrial
Leaves:
- Simple, up to 2’ long
- Sagittate
- Peltate
- Dark green and velvety
- Petiole up to 4’ long
- Basal
- White to cream flowers
- Basal spathe and spadix

Lizard’s-tail 😊
Shallow water, wet feet
Plant height to 2’
Leaves:
- Simple, up to 4’ long
- Cordate to sagittate
- Clasping
- Alternate
- White flowers borne on a bottlebrush spike
**Alligatorflag**

- Shallow water, wet feet
- Leaves:
  - Simple, up to 8” x 2.5’
  - Lanceolate, broad base
  - Petiole to 4’ long
  - Basal
- Pairs of inflorescences (scoploid cyme) with small purple flowers borne on peduncles up to 7” long

**Pickerelweed**

- Shallow water, wet feet
- Leaves:
  - Simple, up to 8” long
  - Cordate to lanceolate
  - Petiole to 4’ long
  - Basal
- Blue, purple or white flowers borne on a spike inflorescence

**Sagittaria spp.**

- Shallow water, wet feet
- Leaves:
  - Simple, up to 2’ long
  - Petiole to 4’ long
  - Basal
- White 3-petaled flowers

**S. lancifolia**

- Narrow-leaf arrowhead, bull-tongue, duck potato
**S. latifolia 😊**

Broad-leaf arrowhead, common arrowhead

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**Woody shoreline plants**

Rooted in the sediment
Most or all of the plant is above the waterline
Rigid and woody (shrubby, tree-like)
Examples:
- Buttonbush – *Cephalanthus occidentalis*
- Marsh hibiscus – *Hibiscus coccineus*
- Peruvian primrosewillow – *Ludwigia peruviana*

---

**Buttonbush 😊**

Habitat: shallow water, wet feet
Plant height to 6’
Leaves:
- Simple, up to 3’ long
- Lanceolate
- Coarse
- Verticillate/whorled
- Nifty white to cream
- Ball-shaped inflorescence

---

**Marsh hibiscus 😊**

Habitat: shallow water, wet feet
Plant height to 6’
Leaves:
- Simple, up to 6” long
- Juvenile – cleft
- Mature – palmate
- Alternate
- Large red flowers

---
**Peruvian primrosewillow**

Habitat: shallow water, wet feet  
Plant height to 7’  
Leaves:  
- Simple, up to 4” long  
- Lanceolate  
- Alternate  
- Bright yellow flowers

**Primrosewillow**

**Small floating plants**

Not rooted in the sediment  
Most or all of the plant is above the waterline except for the roots  
Examples:  
- Mosquitofern – *Azolla caroliniana*  
- Common salvinia – *Salvinia minima*  
- Giant salvinia – *Salvinia molesta*  
- Landoltia duckweed – *Landoltia punctata*  
- Native duckweeds – *Lemna spp.*, *Spirodela polyrhiza*  
- Watermeal – *Wolffia* spp.

**Mosquitofern**

True fern  
Habitat: slow or still water  
Up to ¼” across  
Roots up to 2” long  
Fronds:  
- Cleft/lobed  
- Green to red

**Common salvinia**

True fern  
Habitat: slow or still high-organic water  
Up to ¾” across  
“Roots” = fronds  
Upper fronds:  
- Oval  
- Joined in pairs  
- Stiff hairs
**Common salvinia**

Habitat: slow or still high-organic water

“Roots” = fronds

Upper fronds: “Egg-beater” hairs

---

**Giant salvinia**

True fern

Habitat: slow or still high-organic water

MUCH larger

“Roots” = fronds

Upper fronds: “Egg-beater” hairs

---

**Giant salvinia**

Old name: *Spirodela punctata*

Habitat: still or stagnant water

Smallish

Up to 5 roots

Leaves:

- Shoe-shaped
- Usually joined in pairs
- May have red margin on the underside

---

**Landoltia duckweed**

Habitat: still or stagnant water

Giant (*Spirodela polyrrhiza*)

- Larger than exotic
- Many roots
- Round leaves, dark red underside

Common (*Lemna* spp.)

- Small
- Single root
- Shoe-shaped leaves

---

**Native duckweeds**

Habitat: still or stagnant water

Giant (*Spirodela polyrrhiza*)

- Larger than exotic
- Many roots
- Round leaves, dark red underside

Common (*Lemna* spp.)

- Small
- Single root
- Shoe-shaped leaves
Native duckweeds 😊...

Watermeal 😊

Habitat: slow or still water
REALLY tiny – smallest flowering plant
Easier to feel than see

Watermeal 😊

Large floating plants

Not rooted in the sediment
Most or all of the plant is above the waterline except for the roots
Examples:
  - Waterhyacinth – *Eichhornia crassipes*
  - American frogsbit – *Limnobium spongia*
  - Waterlettuce – *Pistia stratiotes*

Waterhyacinth 😊

Habitat: almost any fresh water
Height: up to 2’
Leaves:
  - Round
  - Leathery
  - Spongy or inflated petioles
  - Basal
Roots
  - Dark
  - Feathery

Waterhyacinth 😊
American frogsbit 😊

Habitat: almost any fresh water
Height: up to 2’
Leaves:
  Round or cordate
  Leathery
  Stiff petioles with ridges
  Basal
Roots
  Lighter
  Smoother

Easily confused…

Waterhyacinth and American frogsbit
  Inflated petioles, dark feathery roots → Waterhyacinth 😊
  Stiff petioles, light smooth roots → American frogsbit 😊

Waterlettuce 😐? 😐?

Habitat: almost any fresh water
Width: up to 2’
Leaves:
  Thick
  Dull green
  Sessile
Roots
  Light
  Feathery

Submersed vascular plants

Rooted or anchored in the sediment
Most or all of the plant is below the waterline
Examples:
  Coontail – Ceratophyllum demersum
  Fanwort – Cabomba caroliniana
  Parrotsfather – Myriophyllum aquaticum
  Egeria – Egeria densa
  Hydrilla – Hydrilla verticillata
  Southern naiad – Najas guadalupensis
  Illinois pondweed – Potamogeton illinoensis
  Bladderwort – Utricularia spp.
  Tapegrass, eelgrass – Vallisneria americana
**Coontail 😊**

Habitat: shallow to deep sluggish water

Raccoon

Leaves:
- Finely cut
- Verticillate/whorled
- Feathery
- Small teeth on midribs
- Coarse feel

No roots
- Free-floating or may be anchored

Flowers tiny and rare

---

**Fanwort 😊 (😊 in NE/NW)**

Habitat: shallow to deep sluggish water

Leaves:
- Finely cut
- Opposite or verticillate
- Feathery
- Smooth/soft

Rooted in sediment

Flowers are pink, white or purple and up to ½" across

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**Easily confused…**

Coontail and fanwort

No roots, coarse feel, tiny flowers → coontail 😊

Rooted, smooth feel, larger flowers → fanwort 😊

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**Parrotsfeather 😊**

Habitat: shallow water, shoreline

Leaves:
- Emergent – cut
- Verticillate – 4 to 6 leaves
- Feathery
- Trail along surface
- Erect at tips

Rooted in sediment
Parrotsfeather 🐦

Egeria 🌸
Habitat: almost any water
Leaves:
- Strap-shaped
- Serrate margin
- Very fine teeth (lens)
- Verticillate – 3 to 6 leaves
Rooted in sediment
White flower ¾” across on short peduncle

Egeria 🌸

Hydrilla 🌸
Habitat: almost any water
Leaves:
- Strap-shaped, pointed apex
- Serrate margin
- Coarse “saw-teeth”
- Verticillate – 4 to 8 leaves
Rooted in sediment
Tiny white flower on long peduncle

Hydrilla 🌸

Easily confused...
Egeria and hydrilla
- Fine teeth on margin, large flowers → egeria 🌸
- Coarse teeth, small flowers → hydrilla 🌸
**Southern naiad**

**Habitat:** still or slow-moving water

**Leaves:**
- Narrow (< 1/16" x 1")
- Serrate margin
- Distinct tiny teeth (lens)
- Opposite or verticillate
- Green to purplish
- Rooted in sediment

**Illinois pondweed**

**Habitat:** almost any water

**Leaves:**
- Floating: elliptic, to 8"
- Submersed: lanceolate
- Long petioles
- Opposite or verticillate
- Rooted in sediment
- Greenish flowers on short spike

**Bladderwort**

**Habitat:** still or slow-moving water

**Leaves:**
- Finely cut
- Opposite or verticillate
- Feathery
- Smooth/soft
- No roots
  - Free-floating or may be anchored
- Bladders on leaf segments are carnivorous...
- Yellow or purple two-petaled flowers on long petioles
**Tapegrass, eelgrass 😊**

Habitat: almost any water

Leaves:
- Up to 1" wide
- Long, strap-like
- Rounded apex
- Basal

Rooted in sediment

Female flowers on long spiral peduncles

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**Muskgrass 😊**

Habitat: almost any water

“Leaves” (actually branchlets):
- Very narrow, thread-like
- Verticillate
- Very coarse

No roots – only anchored in sediment

Aromatic...

Mistaken for coontail and fanwort - smelly

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**Stonewort 😊**

Habitat: almost any water

“Leaves” (actually branchlets):
- Very narrow, thread-like
- Verticillate
- Soft

No roots – only anchored in sediment

Not aromatic...

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**Submersed algae**

Look like vascular plants but they aren’t...

Anchored in the sediment – no roots

Examples:
- Muskgrass – *Chara* spp.
- Stonewort – *Nitella* spp.

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Stonewort

Grasses and grass-like plants

Rooted in the sediment
Most or all of the plant is above the waterline
Examples:
  - Maidencane – *Panicum hemitomon*
  - Torpedograss – *Panicum repens*
  - Giant reed – *Arundo donax*
  - Paragrass – *Urochloa mutica* (*Brachiaria purpurascens*)

Maidencane

Habitat: shallow water, wet feet
Stem length to 6’
Leaves:
  - Simple, up to 1” x 12”
  - Linear
  - Loose smooth or hairy ligule
  - Bright green
Small green flowers on inflorescence up to 12”

Torpedograss

Habitat: shallow water, wet feet
Stem length to 2 ½’
Leaves:
  - Simple, up to ¼” x 10”
  - Linear
  - Clasping hairy ligule
  - Bluish cast
Small yellow flowers on inflorescence up to 9”
Easily confused…

Maidencane and torpedograss
Wider bright green leaves, loose ligule \(\rightarrow\) maidencane \(\heartsuit\)
Narrow bluish leaves, clasping ligule \(\rightarrow\) torpedograss \(\clubsuit\)

Giant reed \(\heartsuit\)
Habitat: shallow water, wet feet
Stems to 2” x 20’ (!!!)
Leaves:
- Simple, up to 2’ x 3’
- Lanceolate
- Papery ligule with hairy margin
Dense feathery whitish to brown inflorescence up to 2’ long

Giant reed \(\heartsuit\)

Paragrass \(\heartsuit\)
Habitat: shallow water, wet feet
Stem length to 12’
Leaves:
- Simple, up to ¾” x 12”
- Linear
- Loose hairy overlapping ligule
Small purplish flowers on inflorescence

Paragrass \(\heartsuit\)

Rushes
Rooted in the sediment
Most of the plant is above the waterline
Examples:
- Spikerushes – *Eleocharis cellulosa*, *E. cellulosa*
- True rushes – *Juncus effusus*, *J. megacephalus*
**Spikerushes (Eleocharis)**

Habitat: Shallow water, wet feet
No leaves – just a sheath at the base of the stem
No branching
Inflorescence is a single spikelet borne on the tip of the stem

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**Club-rush 😊**

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**True rushes (Juncus)**

Habitat: Shallow water, wet feet
May have leaves (or not…)
Open sheath at the base of the stem
Rounded stems
Multi-branched inflorescence

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**Soft rush 😊**

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**Big-headed rush 😊**
Resources

Plant Identification Terminology: An Illustrated Glossary (Harris and Harris)

CAIP website: http://plants.ifas.ufl.edu

vPlants: A Virtual Herbarium of the Chicago Region: http://www.vplants.org/plants/glossary/index.html

That's all, folks…

You can remember all that, right?

Questions?

Check out the plants!

Thank you!!!

Thank you!

Thanks for coming to the 2014 Aquatic Weed Control Short Course – see you next year!

Lyn Gettys, Ph.D. • lgettys@ufl.edu • Go GATORS!!!
SPECIAL SESSION

CALIBRATION & MATH

“Calibration Training: Herbicide Application Equipment Training and Math Review”

Brent Sellers
University of Florida/IFAS
Range Cattle REC

and

Bill Haller
University of Florida/IFAS
Center for Aquatic and Invasive Plants
1. Joe Gator wants to spray water hyacinth in a canal that is 2.5 miles long and 30 feet wide. What is the area of the canal to be treated in acres?

2. Once Gator gets out to the canal he realizes his truck mounted handgun will only be able to spray a distance of 10 feet on each side of the canal. Therefore, what will be his actual area treated in acres?
3. On his way home, Gator passes by a lake that is 1.75 miles across. What is the surface area of this circular lake in acres?

4. In Gator’s housing division, there is a rectangular pond that is 780 feet wide, 1450 feet long and has an average depth of 6 feet. How many acre-feet are in this pond?
5. Gator just bought a new 14 foot fiberglass airboat. The tank on his new boat is 300 gallons and is calibrated to apply 40 gallons of solution per acre. How many acres can Gator treat per tank?

6. While reading a label, Gator reads that a surfactant needs to be added to the tank at 2% v/v. If his tank is 300 gallons, how many gallons of surfactant does Gator need to add to the tank?
7. Gator decides to determine the speed of his new boat. If his spray width is 15 feet wide while moving forward at a rate of 80 feet every 35 seconds, what is Gator’s speed in feet per minute?

8. Once again being the careful young man he is, Gator decides to check the calibration of his new equipment. He collects 13 gallons of water during a 4 minute period. What is the output rate (gallons/minute) of his new pump?
9. Gator is asked to come out and spray a canal that is 2.5 miles long; however, he can only spray 10 feet on each side. His equipment is calibrated to deliver 50 gallons per acre. How many total gallons of mix will it take Gator to spray the canal?

10. Gator has had a rough week and decides to spray a canal via his truck using a handgun. He calculates his speed along the canal bank to be 200 feet per minute. If his handgun will cover a swath 25 feet wide and the handgun will discharge 4 gallons of spray per minute, what is the spray volume (gallons per acre)?
11. Gator has a bad problem with algae in a 4 acre pond with an average depth of 7.5 feet. He decides to use an algaecide containing 3 pound of active ingredient (3 EC) per gallon. Being the great calibration specialist he is, Gator reads the label which specifies a 0.5 ppm active ingredient treatment rate. How many gallons of product does Gator need to purchase?

12. Gator is called to treat a section of canal with a 5% pelleted herbicide at a rate of 25 pounds of pellets per acre. If the canal section is 6 miles long and 40 feet wide, what is the total amount of pellets to be applied?
13. Gator has another boat that has a centrifugal spreader mounted on it. He wants to apply a 10% pelleted herbicide at a rate of 50 pounds of pellets per acre. Gator tests his boat and determines his boat will treat 0.3 acres per minute. How many pounds of pellets must be broadcast each minute?

14. Ole Gator wants to do some touch up on torpedograss around a condo pond and only needs to mix up glyphosate and surfactant for 1/3 of an acre. He typically uses 3 quarts of glyphosate with 0.5% surfactant per acre in a total mix of 60 gallons per acre. How much glyphosate, diluent (water), and surfactant should he add to his 100 gallon tank to do the 1/3 acre treatment?
15. Gator wants to do a bit of backpack work on some cattails with his 3 gallon backpack sprayer. To make a 3 gallon mix of 2% glyphosate and 0.25% surfactant, how much herbicide and how much surfactant does he add to the tank?

16. How do you determine the output in gallons per minute of a boom sprayer and a handgun? How do you determine the output of a granular spreader in pounds of granules per minute?
SPECIAL SESSION

NATURAL AREAS PLANT ID

“Natural Areas ID: Wetland and Natural Areas Plant Identification”

Mike Bodle
South Florida Water Management District
Invasive Exotic Plants and Animals in South Florida: Variations on Similar Themes

Mike Bodle
Invasive Species Operations
South Florida Water Mgmt District

Florida’s Non-native Flora & Fauna

- 1200 plant species (~170 invasive, 4270 total plant species)
- 1150 Insect species
- 106 Bird species
- 47 Reptile species
- 32 Fish species
- 30 Mammal species
- 6 FW Invert. species
- 4 Amphibian species
- ?? Marine species

- Water Hyacinth (Eichhornia crassipes)
  South American native
  Early 1880s intro to N. America
  St. Johns River impassable by 1889
  1889 Rivers and Harbors Act
  Severe problems world-wide

- Water lettuce, Pistia stratiotes

- Melaleuca: Our First Upland Plant From Hell
  Melaleuca quinquenervia
  - Australian native
  - Arrived early 1900s
  - Imported for:
    - timber
    - landscaping
    - possibly to dry out wetland

- Melaleuca Management
  Historical Background
  - 1975 - Two Melaleuca workshops (FL FWCC)
  - 1980 - Melaleuca symposium (FL Div. Forestry)
  - 1982 - Exotic woody plant conference (Fairchild)
  - 1984 - Exotic Woody Plant workshop (ENP)
  - 1984 - Exotic Pest Plant Council formed
  - 1986 - ENP Initiates Control Program
  - 1988 - EPPC Exotic Pest Plant Symposium
  - 1990 - Melaleuca Task Force
**Melaleuca Task Force**  
**January 1990**

- Jointly convened by
  - Florida Exotic Pest Plant Council
  - South Florida Water Management District
- >30 participants:
  - Federal, state, & local government representatives, scientists, NGOs, private industry
- Objective:
  - Develop a comprehensive strategy for managing melaleuca throughout its range in Florida

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**Melaleuca Management Plan: Approach**

- Summarize current ecological knowledge  
  - identify research gaps
- Summarize existing control technologies  
  - what is working, for whom, and where
- Identify control technology research needs  
  - developing biological controls, improving chemical and mechanical controls
- Develop plan to integrate and coordinate efforts regionally

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**Melaleuca Management Plan**  
**Defining the Problem**

**Extent of infestations:**
- South of Hwy 60
- Mainly concentrated near areas of early plantings

**How much is out there?**
- Various techniques tried
  - satellite images
  - false color infrared
  - aerial reconnaissance
- Estimates varied
  - 495,300 - 2.5 million acres

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**Melaleuca Management Plan**  
**Defining the Problem**

- Sawgrass prairies
- Cypress heads
- Pinelands

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**Melaleuca Management Plan**  
**Defining the Problem**

- Leaf oils fuel hot crown fires
- Leaf litter fuels fires
- Fires release seed

- Native species do not recover as quickly

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**Melaleuca Management Plan**  
**Defining the Problem**

- Millions of seeds per tree
- Many herbicides tried
- Effectiveness varied
- Treatments result in dense, even-aged seedling stand
- Treated trees often resprout
- Mechanical removal very expensive & unsuited for most natural areas
Melaleuca Management Plan
Implementing the Plan

How quickly do infestations grow?

- Aerial photos of 1 mi² areas (1:3600 scale)
- 8 areas in Dade & Broward Counties
- 25 yrs to go from 5% (30 acres) to 95% (600 acres) cover

Melaleuca Management Plan
Implementing the Plan

Ecological studies:

- Reproductive ecology
  - large (21 m) trees hold up to 51 million seeds
  - 15% of seeds have embryo
  - seeds can germinate under water
- Florida vs. Australia
  - more seeds germinate
  - seedlings more abundant
  - greater tree density
  - greater stand biomass

Melaleuca Management Plan
Implementing the Plan

Strategy

Eliminate existing stands
- mechanical removal
- treat with herbicides

Halt expansion
- Seed/sapling mortality
  - hand-pull saplings
  - treat with herbicides
  - damage by biocontrol insects
- Reduce seed production
  - damage by biocontrol insects

Biocontrol studies:

- >400 herbivores on Melaleuca in Australia
- Several candidate insects identified
- Quarantine testing
- Built new quarantine lab

Melaleuca Management Plan
Implementing the Plan

How much is out there?

- Aerial surveys (SFWMD)
  - flight lines every 2.5 mi
  - coordinates (GPS) & density recorded for every occurrence
  - Conducted every 2 yrs
    - 488,000 acres in 1993
    - 453,000 acres in 1995
    - 393,000 acres in 1997
    - 104,000 acres in 2010

Melaleuca Management Plan
Implementing the Plan

Herbicide studies:

- Ground application
  - Hack/squirt & Cut/stump
  - completely girdle tree
  - treat stumps shortly after cut
- Aerial application
  - Novel microfoil boom with small (0.02) nozzle
  - overlap spray paths by 50%
  - treat twice
Next Upland “Plant from Hell”

Old World Climbing Fern
(Lygodium microphyllum)

Millions of dust-like spores spread on winds

Melaleuca: Became serious problem in ~ 75 yrs

Lygodium: Became serious problem in ~ 20 years

Stem fronds

Covers and kills Everglades tree islands

“Normal” fires kill tree islands due to ladder fuel

Fertile fronds

Next Upland “Plant from Hell”
Melaleuca: Became serious problem in ~ 75 yrs
Lygodium: Became serious problem in ~ 20 years

MH24000 – October 2002
Winter treatments over buttonbush (Cephalanthus occidentalis)

Okeechobee gourd (Cucurbita okeechobeensis) Federal and State-listed endangered species

Florida’s Non-native Flora & Fauna

- 1200 Plant species (~170 invasive, 4270 total plant species)
- 1150 Insect species
- 196 Bird species
- 47 Reptile species
- 32 Fish species
Lionfish in the Atlantic Basin
- Native to Indo-Pacific
- Now present from Carolinas to Venezuela
- Aquarium trade release
- Prolific spawning and survival of young
- Ambush predator
- Native ambush predators don’t expect mouthful of venomous spines
- Lionfish Roundups – Yum!
- Native name: “Butterfly Cod”

Island apple snail and endangered Everglade Snail Kite
- Much larger non-native apple snails overwhelming Florida apple snail
- Young kites can’t open exotic snails, energy deficit = death
- Exotic snail lays many more eggs

Pythons
- Perfect predators
- Everglades public lands cover same area as 2 Rhode Islands

Perfect aquatic predators, too

How Did Pythons Get Into the Everglades?
- Est. U.S. pet snake population is 900,000
- Illegal for sale in Florida since July 1, 2010
- 20% of U.S. snake dealers carry pythons
- Burmese Python most popular large snake
- Sell for as little as $20
- Grow to 6-8 feet in one year
- Messy, unwanted and liability when grown
Burmese Python Facts

- Southeast Asia home similar to ‘Glades
- Generalist in terms of diet, habitat & behavior
- Lays large clutch of eggs (up to 100)
- Long lived (> 25 years)
- Average adult snake in glades 10’-15’
- Can grow to > 20’ and weigh over 200 lbs
- Sightings and captures on the increase

South Florida Range of Burmese Pythons

United States Geological Survey
Climatological Prediction of Potential U.S. Range of Burmese Python

What a python eats in 5-7 years to reach 13 feet in length
Food items found inside pythons:
- gray squirrel
- opossum
- cotton rat
- black rat
- house wren
- pied-billed grebe
- and...

What Next?
- Survey, destroy & collect for study (SFMWD one armed employee)
- Public harvest in FFWCC areas
- Trapping
- Sniffing
- Winter surveys in cooperation with FFWCC & ENP
- Transport carcasses to ENP wildlife biologist
- Support existing study of snake biology in Everglades
- Identify and manage known refuge areas
- Engage with area veterinarians, snake owners and the pet industry

Giants Collected in Everglades
- Burmese python
- Reticulated python
- Common boa constrictor

Reticulated Python in ENP

Acknowledgements
- Helicopter Applicators, Inc.
- Coastal Air, Inc.
- Applied Aquatic Mgmt., Inc.
- SFWMD Veg. Mgmt. division
- SFWMD Watersheds Mgmt. divisions
- Florida Exotic Pest Plant Council
Invasive Plants in Florida’s Natural Areas

**Scratchthroat (Coral Ardisia)**
*Ardisia crenata*
- Multi-stemmed clumps to 6’
- Overwhelming densities
- Moist soils
- Bird/wildlife spread fruit
- Wavy leaf edge
- Resembles native Marlberry (*A. escallonioides*)
- Native from Japan to India

**Shoebutton**
*Ardisia elliptica*
- Multi-branched shrub to 20 ft
- Leaves alternate, simple, elliptical
- Pale lavender, star-shaped flowers
- Copious production of fertile black wildlife-dispersed fruit
- Very invasive in wetlands
- Established in FL, HI
- FLEPPC Category I invasive
- Native to S.E. Asia

**Eugenia uniflora**
Surinam cherry
- Large shrub/small tree, 20’
- Native to tropical Americas
- Edible red/orange fruit
- Widely cultivated in tropics
- Fragrant white flowers
- FLEPPC Category I
- Fruit dispersed by wildlife
- Broad ecological tolerances

**Shrubverbena (Lantana)**
*Lantana camara*
- Multi-stemmed clumps to 6’ or more
- Simple opposite, aromatic leaves
- Small multi-colored flowers in clusters
- “100 World’s Worst Weeds”
- Contaminates native lantana gene pool
- Fruit dispersed by wildlife
- Overwhelms understory in well-drained soils
- Toxic to livestock
Tuberous sword fern  
*Nephrolepis cordifolia*
- Clump-forming fern on other plants, rocks, soil to 3'
- Densest growth in partial to full shade, drained soils
- Blunt pinnae tips
- Overlapping pinnae conceal stem
- Asian native

Britton’s wild petunia  
(Mexican petunia)  
*Ruellia brittoniana*
- Evergreen perennial shrub to 3'
- Leaves linear, lanceolate, serrate
- Purple, pink, white flowers
- Purple stems, leaf veins
- Aggressively self-seeds
- Frost intolerant
- Native to Mexico

Small-leaf spiderwort  
*(Tradescantia fluminensis)*
- Weedy in its native Brazil, Argentina
- Glossy forest-green, parallel-veined leaves
- Spreads most rapidly in moist forests
- Small clusters of 3-petaled flowers
- Forms dense overwhelming blankets
- Spreads by fragmentation

Monk Orchid, Spotted Oeceoclades  
*Oeceoclades maculata*
- Terrestrial orchid
- Dark green ovoid pseudobulbs to 2 inches
- Leaves nearly erect, mottled green to 12 in long by 2 in wide
- Spread by minute seed
- Flowers light brown to pinkish green, ½ x ½ inches
- Established in FL, Bahamas, Americas
- Native to Africa

Grass-leafed Orchid  
*Eulophia graminea*
- Terrestrial orchid
- Inflorescence spike to two-feet
- Flowers ½-inch across
- Leafless when flowering
- Ovoid pseudobulbs at ground level
- Spread by minute seeds
- Mulch contaminant
- Leaves linear, lanceolate to one foot long
- Native to subtropics of eastern Asia
- Also introduced to Australia

Wedelia  
*Sphagneticola trilobata*  
(syn. *Wedelia trilobata*)
- Perennial, evergreen, mat-forming
- Native to South and Cef America
- FLEPPC Category II
- Wide ecological tolerances
- Naturalized around the globe
- Little fertile seed produced
- Expands quickly, rooting from nodes
- Spread by discarded yard waste
GRASSES

Giant reed (Arundo donax)
- Erect perennial cane grass to 25'
- Large plume-like flat flower spikes
- Leaves broad, 2-ranked
- Thick, hollow, branching rootstock
- Blade basal lobes nearly surround stem
- Aggressive riparian invader
- Eurasian native

Napier grass, elephant grass (Pennisetum purpureum)
- Dense monocultures to 15 feet
- Native to tropical Africa
- FLEPPC Category I
- Leaf blades to 2 ½ feet long, white mid-rib
- “Bottlebrush” cylindrical seedhead to 1 ft
- Grows along dikes, ditches
- Wide range of ecological tolerance

Common reed (Phragmites australis)
- World-wide distribution with varying haplotypes
- Invasive European haplotype spreading quickly in N. America
- To date, Florida Phragmites native — Overholt
- Sheaths overlap, ligule a ring of stiff hairs

Tropical American Watergrass (Luziola subintegra)
- Discovered in 2007 in Lake Okeechobee
- New to North America
- Separate male and female panicles
- Opportunistic seed, mostly viable
- Hundred of seeds per plant annual
- Tremendously invasive, rapid overwhelming growth.
- Flat, ridged leaf blade
- Ligule large triangular membrane

VINES

430
**Abras precatorius**
*Rosary pea*
- Aggressive vine
- Native to S.E. Asia
- Broadly naturalized in southern states
- FLEPPC Category I
- Poisonous bicolor red/black seed
- Single seed may cause blindness or death

**Autumn virginsofbower (Clematis ternifolia)**
- Semi-evergreen vine native to Asia
- Climbing, overwhelming growth
- Showy, fragrant flowers with four petals
- Extremely hardy, drought tolerant, etc.
- FLEPPC and SE-EPPC listed
- Spread by seed
- Native C. virginiana has serrate leaves

**Arrowhead vine**
*Syringonium podophyllum*
- High-climbing epiphytic vine
- Young leaves heart-shaped, mature leaves 5 to 11 lobed, to 2 feet
- Flowers in clusters on column within fleshy-spath
- Fruit orange-red poisonous berry
- Central American native
- FLEPPC Category I

**Japanese climbing fern**
*Lygodium japonicum*
- Delicate twining fronds to 100'
- Pinnae along stemlike rachis
- Prefers moist, part-shade - pinelands
- Pinnae triangular, pinnately divided
- Sterile frond edges deeply incised
- Fertile fronds less elongated
- Windborne spores
- Contaminant of pine straw bales

**Old-world climbing fern**
*Lygodium microphyllum*
- Delicate twining fronds to 100'
- Pinnae along stemlike rachis
- Pinnae oblong, not divided
- Sterile pinnae lance-shaped
- Fertile pinnae fringed with spore lobes
- Lygodium moth (Neomusitima) establishing in FL
- Native to much of Old World tropic - Africa, Asia, China

**Staghorn fern**
*Platycerium bifurcatum*
- Epiphytic fern
- Fleshy, hairy, light to dark green fronds
- Frond hairs star-shaped
- Sheathing fronds cover rhizomes
- Fertile fronds forked, erect or drooping, to 3 feet, patches of sori underneath
- Spread by wind-borne spores
- Introduced to FL, HI
- Native to Australia, SE Asia
Catclaw Vine
*Macfadyena unguis-cati*
- High-climbing woody vine
- Tuberous roots
- 3-lobed tendrils with tips stiffly hooked, clawlike
- Showy yellow trumpet-like flowers
- Fruit linear capsule with oblong, winged seeds
- Rapidly overtops any structures
- Difficult to control – tubers
- Native from Caribbean to Argentina

Bischofia javanica
*Bishopwood*
- Evergreen tree to 60'
- Native to Asia, Australia
- Leaves, papery, bronzy-green, trifoliate, toothed margins
- Smooth bark at maturity
- Heavy seed producer, tan berries
- Fruit dispersed by wildlife
- FLEPPC Category I

Chinese privet
*(Ligustrum sinense)*
- Thicket-forming shrub to 30 feet
- Showy clusters of small white flowers
- Deep purple ovoid berries
- Bird and wildlife dispersal of berries
- Serious pest of tree plantations

Carrotwood
*Cupaniopsis anacardiodes*
- Compact, evergreen single-trunk tree to 30'
- FLEPPC Category I, Florida – prohibited plant
- Leaves oblong, compound, leathery
- Numerous yellow fruit contain red seeds
- Birds, wildlife disperse fruit widely
- Wide range of FL habitats invaded
- Native to Australia

Ficus benjamina
*Weeping fig*
- Large evergreen tree to 100'
- Native to S.E. Asia, Australia
- Invasive roots lift pavement, clog pipes
- Ficus whitefly spreading and defoliating
- Numerous cultivars, variegated foliage, etc.
- Specific pollinator wasp not in FL
- No fertile seed yet in FL
- Most overplanted plant in FL
Brazilian pepper

*Schinus terebinthifolius*

- Shrubby evergreen tree to 40’
- Leaves opposite, once-compound
- Leaflets usually 7-9, toothed
- Flowers unisexual, small white
- Copious bright red drupes in clusters
- Forms dense, vast thickets
- Birds/wildlife transport berries
- Family includes poison ivy, strong
  control insects in FL release
- Native to Argentina, Brazil, Paraguay

References and Credits

- Pacific Islands Ecosystems At Risk website: (http://www.hear.org/Pier/)
Incoming! New plants find their ways into Florida...

Tropical American Watergrass
*Luziola subintegra*, Swallen
1st No. American report

Feathered mosquitofern
*Azolla pinnata*, R. Br.
1st Florida report

Wild sugarcane
*Saccharum spontaneum*, L.
1st Florida report

...and we learn how to MELT an old one

African elm
*Trema orientalis*

Giant salvinia
*Salvinia molesta*

Red root floater
*Phyllanthus fluitans*

...and we learn how to MELT an old one

*Luziola subintegra* Swallen

- First report in North America
- Literature very sparse, no English common name
- Native to tropical So. and Ctr. Americas
- Found as dry lake bottom re-hydrated in Fall 2007
- Single plants found in upland areas
- Not invasive in dry conditions
- Mature plant 2-3 feet height above waterline
- Has immature, semi-floating stage w/o emergent leaves
- Stoloniferous - perennial
- Hundreds of acres w/i six months of identification
- Ecology, phenology of plant?
- Seed viability?
- Means of spread?

Luziola subintegra Swallen

- Male panicle, flowers and seed
- Female panicle, flowers and seed

Tropical American Watergrass

-Louise Overholtz, Estero Bay, Sept 2007-
Luziola subintegra Swallen

- Male panicle - aerial, upright, open, yellow anthers w/pollen
- Female panicle - down-turned, near waterline, congested, barely emerging from base of leaf sheath

Leaf blades papery and ridged with prominent mid-vein
Leaf sheath bases flattened, spongy

Native southern watergrass

- Luziola fluitans (syn. Hydrochloa caroliniensis)
  - Submersed stems with surface-floating leaves to 2' length
  - To 4-foot depths
  - Complete flowers in raceme cluster
  - Not stoloniferous

“New” watergrass

- Luziola subintegra
  - Immature growth stage: surface-floating leaves
  - Mature stage: erect, aerial leaves to 3' height in 4' depths
  - Separate male and female flowers on branched panicles
  - Stoloniferous

“It ain’t so tough”
- Kurt Ramsey, Applied Aquatic - 2007

“But look, Kurt, it’s choking out water hyacinth”

Luziola subintegra Swallen

- Initial glyphosate treatment affected only emergent growth
- Rapid regrowth from stolons, immature, semi-submerged form
- Subsequent treatments added imazospyr, variety of adjuvants
- 2009 added to Category I FEEPRC Invasive Plants List - quickest addition yet

Initial range est., Oct. 2007
Range est., April 2011

Spring 2009 - Found in Caloosahatchee River downstream of Lake Okeechobee
Summer 2009 - Found in Miami-Dade County

Estimated range 2020
**Luziola subintegra** Swallen
Tropical American Watergrass

Inconsistent control led to varied surfactants
Trials finally yielding consistent control

1 MAT: 2 qt imazamox +
7 ½ pint glyphosate/A

---

**Feathered mosquito fern**
*Azolla pinnata* R. Br.

- Found in northern PB County, July 2007
- First Florida report
- 1999 report in N. Carolina - control ongoing
- Asian native, disseminated for N-fixation in rice
- Covering many sections of canals, private ponds
- Federal Noxious Weed - might indicate risk, might not

**Azolla pinnata** R. Br.
- Diquat dibromide control effective, ongoing
- Floating ferns tough to contain, minute spores, plants move w/flows

**Azolla caroliniana** Lam.
USDA biocontrol evaluation – Will native *A. caroliniana* waterfern insects feed on and damage *Azolla pinnata*?

**Waterfern Flea Beetle**
*Pseudolampsis guttata*
- Damage can be devastating
- Single adult may daily eat 250 of lobes on *A. caroliniana* plant
- Introduced to S. Africa to control *A. filiculoides*

**Waterfern weevil**
*Stenopelmus rufinasus*
- Known to decimate mats of *A. caroliniana*
- Found in *A. pinnata* collected in Jupiter

**Wild sugarcane**
*(Saccharum spontaneum, L.)*
- Federal Noxious Weed – so what?
- 2009 First Florida voucher/report
- Likely “unvouched” in other sugar States
- Eurasian native to 6-foot height
- Multi-decadal Lake Okeechobee presence
- Not very invasive – but persistent
- Used for “hybrid vigor” crosses with
  Sugarcane (*Saccharum officinarum*)

**Wild sugarcane**
- Seedling stage
- Panicle – open, feathery
- Ligule – hairy, 2-4 mm tall

**Red Root Floater**
*Phyllanthus fluitans*
- New to North America 2010
- S. American native
- Peace River, DeSoto Co., 15+ Sites
- Popular aquarium plant
- Some survival from diquat dibromide treatment
- Will it misbehave badly?

**Giant salvinia**
*Salvinia molesta*
- 2000 First Florida report
- Native to Brazil
- Persists in Collier, Lee Counties
- Overwhelming surface mat
- Biocontrol in U.S., Asia, Australia via Brazilian insects

*Salvinia minima* trichomes:
- “Eggbeater”

*Salvinia molesta* trichomes:
- Open, separate tips
**African elm**
*Trema orientalis*
- African/Asian tree valued for rapid growth, tolerance of poor conditions (alert!)
- Florida report 2001 in Miami-Dade
- New reports from Broward, PB
- Celtidae like 2 native Tremas (*T. lamarckiana* and *T. micrantha*) and Hackberry (*Celtis laevigata*)
- Leaves larger, longer than natives.
- Fruit:
  - *T. micrantha*, L.
  - *T. lamarckiana*, R.

**Wild taro**
*Colocasia esculenta*
- Category 1 FLEPPC Invasive Plants List
- Agricultural relic in many FL wetlands
- Endangered plant threat (Okee gourd)
- Overwhelms habitats
- 1,000+ acres on Lake Okeechobee
- Starchy tuber eaten across world’s tropics
  - “Elephant ear”

**Wild taro management**
- Tuberous plant – great re-growth potential
- Multi-year control in St. Johns WMD trials w/imazamox (CLEARCAST™)
- 1, 2, 3 % imazamox trials yield same results on Lake Okeechobee: 100% control > one year
- Haller sez “Go with 1 ½% treatment
- FWC approves funds

**Wild taro control**
- Backpack applications 1 ½ % imazamox
  - with differing surfactants - 100 acres complete control three years
- Aerial application 1 ½ % imazamox - 200 acres complete control two years

**Kripa (Lumnitzera racemosa)**
- Strongly resembles white mangrove
- Fairchild Tropical Garden escape
- No distinct leaf petiole
- Eradication may soon be achieved

**Wild Taro stands 2 Months After Treatment**
- Kripa (Lumnitzera racemosa)
  - Strongly resembles white mangrove
  - Fairchild Tropical Garden escape
  - No distinct leaf petiole
  - Eradication may soon be achieved
Mile-a-Minute
(*Mikania micrantha*)

- 11 Miami-Dade Co. sites
- Very threatening rapid growth
- Minute windborne seeds
- 10,000 seeds/plant/yr
- 1 of world’s 100 most invasive plants
- Eradication effort underway
- Upland disturbed sites, unlike *M. scandens*

THANKS!!!
Study Tools
Preface

The workbook is designed for use by agricultural pesticide applicators intending to complete the Aquatic Weed Control restricted-use pesticide license exam under the provisions of the Florida Pesticide Law (Chapter 487 Florida Statutes) and its rules (Chapters 5E-2 and 5E-9 of the Florida Administrative Code). Any herbicides discussed in this workbook are solely for educational purposes and does not imply endorsement of the product.

About the Author

Ken Gioeli is the Natural Resources Extension Agent for St Lucie County. He conducts educational campaigns designed to teach professional land managers as well as general homeowners how to adopt practices and innovative technologies that will result in improved natural resource management.
Section 1: Order of Operation

Arithmetic Review

Arithmetic problems must be calculated according to a specific order of operations. The order of operations are as follows:

- Parentheses
- Exponents
- Multiplication / Division
- Addition / Subtraction

Calculations within parentheses must be conducted first. Exponents are then calculated followed by multiplication and division. Addition and subtraction is conducted last.

1. Directions: Complete each math problem below using the correct order of operations. Show your work and be prepared to share your answer.

   a. $3 \times 4 + 2 =$

   b. $15 \div 3 =$

   c. $20 \div 4 + 6 =$

   d. $4^2 =$

   e. $3^2 + 5 =$

   f. $4 \times 2^2 + 3 =$

   g. $(4 \times 2)^2 + 3 =$

   h. $25\%$ of $75 =$
### Section 2: Area & Volume Calculations

2. Use the following example to help you calculate area.

<table>
<thead>
<tr>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>d = 1/2 r</td>
</tr>
<tr>
<td>Area of a circle: $\pi r^2$</td>
</tr>
<tr>
<td>[$\pi$=3.14] [r (radius) = ½ diameter]</td>
</tr>
</tbody>
</table>

**Example:** Determine the surface area (in acres) of a circular lake that measures 50 feet across.

- d = 50 ft
- $r = \frac{1}{2} d$
- $r = 25$ ft
- Area = $\pi r^2$
- Area = (3.14) $(25^2)$
- Area = (3.14) (625)
- Area = 1962.5 ft$^2$
- Area = 1962.5
  - 43560
- Area = .05 Acres

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>Determine the surface area (in acres) of a circular lake that measures 100 feet across.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>Determine the surface area (in acres) of a circular lake that measures 2 miles across.</td>
</tr>
</tbody>
</table>
3. Use the following formula to calculate acre-feet.

<table>
<thead>
<tr>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acre-Feet = Surface Acres x Average Depth (ft)</td>
</tr>
</tbody>
</table>

Example: Determine how many acre-feet are in a rectangular pond that has an average depth of 6 ft, is 500 feet wide, and is 1500 ft long.

\[
\frac{(6)(500)(1500)}{43560} = 103 \text{ Acre Feet}
\]

a. Determine how many acre-feet are in a rectangular pond that has an average depth of 7.5 ft, is 600 feet wide, and is 1200 ft long.

b. Determine how many acre-feet are in a rectangular pond that has an average depth of 6 ft, is 750 feet wide, and is 2000 ft long.

c. Determine how many acre-feet are in a rectangular pond that has an average depth of 5.5 ft, is 625 feet wide, and is 1425 ft long.
4. Determine the quantity of spray mix needed.

Example: Determine the total gallons of spray mix needed to treat 1 mile of canal bank when the treatment swath is 20 feet per side and the application equipment has been calibrated to apply 60 gallons of spray mix per treated acre.

1 mile = 5280 ft

Area = Length x Width
Area = (5280 x 20) = 105600 per side
Area in Acreage = 105600 ÷ 43560 = 4.8 Acres

60 gal / acre x 2.42 acres = 145 gallons

a. Determine the total gallons of spray mix needed to treat 2 miles of canal bank when the treatment swath is 25 feet per side and the application equipment has been calibrated to apply 65 gallons of spray mix per treated acre.

b. Determine the total gallons of spray mix needed to treat .5 miles of canal bank when the treatment swath is 20 feet per side and the application equipment has been calibrated to apply 60 gallons of spray mix per treated acre.

c. Determine the total gallons of spray mix needed to treat 2000 ft of canal bank when the treatment swath is 25 feet per side and the application equipment has been calibrated to apply 55 gallons of spray mix per treated acre.
5. Determine how many gallons of surfactant are needed.

Example: Determine the number of gallons of surfactant needed in a 200-gallon spray tank in order to have a 1.5% concentration of surfactant in a tank full of spray mix.

1.5% is the same as .015 in decimal format when conducting calculations.

200 x .015 = 3 gallons of surfactant

a. Determine the number of gallons of surfactant needed in a 250-gallon spray tank in order to have a 1.5% concentration of surfactant in a tank full of spray mix.

b. Determine the number of gallons of surfactant needed in a 200-gallon spray tank in order to have a 2% concentration of surfactant in a tank full of spray mix.

c. Determine the number of gallons of surfactant needed in a 300-gallon spray tank in order to have a 3% concentration of surfactant in a tank full of spray mix.
6. Determine the pump output rate.

Example: Determine the output rate (in gallons per minute) of a pump that delivers exactly 20 gallons during a 5 minute trial period.

\[ 20 \div 5 = 4 \text{ gallons per minute} \]

a. Determine the output rate (in gallons per minute) of a pump that delivers exactly 15 gallons during a 3 minute trial period.

b. Determine the output rate (in gallons per minute) of a pump that delivers exactly 18 gallons during a 6 minute trial period.

c. Determine the output rate (in gallons per minute) of a pump that delivers exactly 20 gallons during a 2 minute 30 second trial period.
7. Determine the spray volume rate.

Example: Determine the spray volume rate (in gallons per acre) being delivered by a handgun that discharges 4.5 gallons of spray per minute as it treats a swath 15 feet wide. The handgun is being operated from a truck traveling along the canal bank at a speed of 135 feet per minute.

Determine Acreage
135 x 15 = 2025 ft sq
2025 / 43560 = .0464876 Acres

Determine gallons per acre

\[
\begin{align*}
4.5 \text{ gal} & = x \text{ gal} \\
.0464876 \text{ acres} & = 1 \text{ acre}
\end{align*}
\]

\[x = 96.8 \text{ gal}\]

a. Determine the spray volume rate (in gallons per acre) being delivered by a handgun that discharges 2.5 gallons of spray per minute as it treats a swath 15 feet wide. The handgun is being operated from a truck traveling along the canal bank at a speed of 135 feet per minute.

b. Determine the spray volume rate (in gallons per acre) being delivered by a handgun that discharges 3.5 gallons of spray per minute as it treats a swath 10 feet wide. The handgun is being operated from a truck traveling along the canal bank at a speed of 135 feet per minute.

c. Determine the spray volume rate (in gallons per acre) being delivered by a handgun that discharges 2.5 gallons of spray per minute as it treats a swath 15 feet wide. The handgun is being operated from a truck traveling along the canal bank at a speed of 125 feet per minute.
8. Determine the number of acres the sprayer-equipped boat can treat per tank.

<table>
<thead>
<tr>
<th>Example: A sprayer-equipped boat fitted with a 150 gallon spray tank is configured to apply 40 gallons per acres. How many acres can the sprayer-equipped boat be expected to treat per tank full of spray?</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 ÷ 40 = 3.75 acres</td>
</tr>
</tbody>
</table>

a. A sprayer-equipped boat fitted with a 200 gallon spray tank is configured to apply 30 gallons per acres. How many acres can the sprayer-equipped boat be expected to treat per tank full of spray?

b. A sprayer-equipped boat fitted with a 80 gallon spray tank is configured to apply 25 gallons per acres. How many acres can the sprayer-equipped boat be expected to treat per tank full of spray?

c. A sprayer-equipped boat fitted with a 90 gallon spray tank is configured to apply 20 gallons per acres. How many acres can the sprayer-equipped boat be expected to treat per tank full of spray?
9. Determine the pounds of pellets the spreader must broadcast per minute.

Example: A boat-mounted centrifugal spreader needs to apply a 15% palletized herbicide at a rate of 100 pounds of pellets per acre. Testing reveals the boat treats 1 acre per minute. How many pounds of pellets does this spreader broadcast per minute?

\[ 100 \times 0.3 = 30 \text{ pounds of pellets} \]

a. A boat-mounted centrifugal spreader needs to apply a 15% palletized herbicide at a rate of 100 pounds of pellets per acre. Testing reveals the boat treats 0.3 acres per minute. How many pounds of pellets does this spreader broadcast per minute?

b. A boat-mounted centrifugal spreader needs to apply a 15% palletized herbicide at a rate of 100 pounds of pellets per acre. Testing reveals the boat treats 0.35 acres per minute. How many pounds of pellets does this spreader broadcast per minute?

c. A boat-mounted centrifugal spreader needs to apply a 15% palletized herbicide at a rate of 100 pounds of pellets per acre. Testing reveals the boat treats 0.5 acres per minute. How many pounds of pellets does this spreader broadcast per minute?
10. Determine pump output rate in gallons per minute.

<table>
<thead>
<tr>
<th>Example: Determine how many acre per minute are treated by a boat-mounted sprayer that treats a swath 18 ft wide while moving 90 ft an average of 36 seconds.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determine feet per minute</td>
</tr>
</tbody>
</table>
| \[
\frac{90 \text{ ft}}{36 \text{ sec}} = \frac{x \text{ ft}}{60 \text{ sec}}
\] |
| 150 ft = x |
| Determine acreage |
| 150 ft x 18 ft = 2700 |
| \[
\frac{2700}{43560} = 0.06 \text{ Acres}
\] |

a. Determine how many acre per minute are treated by a boat-mounted sprayer that treats a swath 20 ft wide while moving 90 ft an average of 36 seconds.

b. Determine how many acre per minute are treated by a boat-mounted sprayer that treats a swath 18 ft wide while moving 90 ft an average of 48 seconds.

c. Determine how many acre per minute are treated by a boat-mounted sprayer that treats a swath 20 ft wide while moving 85 ft an average of 36 seconds.
11. Determine gallons of herbicide

Example: Determine the number of gallons of an algicide containing 4 pounds of active ingredient per gallon of formulation needed to treat a 1-acre pond that has an average depth of 10 ft. The product label specifies a 0.5 ppm active ingredient treatment rate.

Step 1: Determine acre-ft

\[ 1 \times 10 = 10 \text{ acre ft} \]

Step 2: plug in numbers

\[ \text{PPM} \times \text{acre-ft} \times 2.7 \]

\[ .5 \times 10 \times 2.7 = 13.5 \]

Step 3: Cross multiply

\[
\frac{4 \text{ lbs a.i.}}{1 \text{ gal}} = \frac{13.5 \text{ lbs}}{x \text{ gal}}
\]

\[ 3.4 \text{ lbs} \]

a. Determine the number of gallons of an algicide containing 5 pounds of active ingredient per gallon of formulation needed to treat a 2-acre pond that has an average depth of 10 ft. The product label specifies a 0.5 ppm active ingredient treatment rate.
12. Determine gallons of herbicide

Example: Determine the maximum number of Galleon aquatic herbicide applications that can be made per growth cycle if each application is to be 30 ppb. The label indicates that the sum of all applications must not exceed 150 ppb maximum per year.

\[
150 / 30 = 5 \text{ applications}
\]

a. Determine the maximum number of Galleon aquatic herbicide applications that can be made per growth cycle if each application is to be 15 ppb. The label indicates that the sum of all applications must not exceed 150 ppb maximum per year.
Study Questions for the Certified Pesticide Applicator Examination: Natural Areas Weed Management

Ken A. Langeland

The following questions are intended to help prepare you for taking the Natural Areas Weed Management Certified Pesticide Applicator Examination. It should be used along with IFAS publications SP 295 Natural Area Weed Management - A Training Manual for Restricted Use Pesticide Applicators and SP 257 Identification & Biology of Non-Native Plants in Florida’s Natural Areas, which can be obtained from the IFAS Extension Book store by calling 800-226-1764 (local 359-392-1764) or from http://ifasbooks.ufl.edu. For some questions you will need a copy of a Garlon 4 herbicide label, which can be obtained from http://www.cdms.net/manuf/manuf/manuf.asp. Answers to all questions can be found in these publications. You will greatly improve your ability to achieve a passing examination score by locating the answers to the study questions and writing them down.


2. K. A. Langeland, professor, Agronomy Department, Center for Aquatic and Invasive Plants; Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL 32611. The use of trade names in this publication is solely for the purpose of providing specific information. UF/IFAS does not guarantee or warranty the products named, and references to them in this publication does not signify our approval to the exclusion of other products of suitable composition.
Chapter 1

What is the similarity between the terms weed and invasive plant?

What is different between the definitions of weed and invasive plant?

List five control methods that may be coordinated into an integrated pest management (IPM) program.

Chapter 2

Name three plant lists that have legislative authority.

What is the best method to obtain a positive identification on a new weed species and provide a record of its occurrence?
Chapter 3

Relative to solubility, what is the main difference between herbicide active ingredients with polar, i.e. salts of acid herbicides, molecules compared to those with non-polar, i.e. esters, molecules?

List two non-polar herbicide active ingredients and five polar herbicide active ingredients.

<table>
<thead>
<tr>
<th>Non-polar (esters)</th>
<th>Polar (salts of acids)</th>
</tr>
</thead>
</table>

What is the name of the outer layer of a leaf that herbicide must pass through to enter the plant and what are three components of this layer, which are barriers to herbicide absorption associated with this layer?

<table>
<thead>
<tr>
<th>Layer</th>
<th>Components</th>
</tr>
</thead>
</table>

What is the term that describes the most important factor that affects herbicide uptake from soils?

What is the term that is used to describe uptake of herbicides by plant roots?
Draw a cross section of a woody (dicot) plant stem and show the location of the living tissue.

List four plant processes that are affected by herbicides (herbicide mode of action).

Herbicides with which mode of action require additional record keeping under Florida Pesticide Law (core training)?

What is the term used for a herbicide that can be use for broadcast application and kill a target weed and not certain non-target plants that it comes in contact with?

List three application methods that can be used to selectively control target vegetation.

List five methods to reduce drift.

List five factors that adversely affect herbicide activity.
List four ways in which herbicides can disappear from soil.

List five ways in which herbicides may be deactivated once absorbed by plants.

Chapter 4

List two circumstances under which a broadcast herbicide application may be used.

What characteristic do all herbicides that are used for basal bark application have in common?

How quickly after felling a tree should herbicide be applied to the stump to optimize control?

What special care should be taken to prevent non target damage when applying soil active herbicides?

Chapter 5

What must be listed on a herbicide label so that it can be legally applied to a particular site?

What state agency should you contacted for legal interpretation of label instructions?

What state agency issues permits for control of aquatic plants?
When applying a herbicide to control an invasive plant species on a site that is allowed by Special Local Need registration (SLN), what must the applicator have and where should this be?

Consider the following list of herbicide active ingredients as indicated:

- 2,4-D
- glyphosate
- hexazinone
- imazapyr
- metsulfuron
- triclopyr

Which are likely to be absorbed by plant roots.

List under the appropriate Mode of action:

- Auxin interference
- Amino acid (protein) syntheses inhibitor
- Photosynthesis inhibitor

Which are likely to leach:

Which have the greatest persistence:
Chapter 6

Who does the “Worker Protection Standard” (WPS) referred to on pesticide labels pertain to?

Why is diesel fuel not recommended as a herbicide diluent for use in natural areas?

List two types of surfactants and how they modify performance of a herbicide solution applied to a leaf surface.

List three ways by which the use of colorants can be helpful to a herbicide application.

How many ounces of herbicide product are needed to prepare 4 gallons of spray solution if the herbicide label requires mixing 20 gallons of product per 100 gallons of spray solution?
How many ounces of herbicide solution are needed to prepare 4 gallons of 1.5% spray solution?

How many gallons of spray mix would be applied per acre if 60 ounces are applied to 400 sq ft?

How many ounces of liquid herbicide product should be added to a 3-gallon spray tank to apply 7 pints of product per acre for a sprayer that delivers 167 gallons per acre?

How much ultra low weight granular herbicide product is required to treat an area that measures 270 ft by 470 ft at a rate of 2 pounds product per acre?
For the following question refer to: “Identification and Biology of Non-Native Plants in Natural Areas of Florida”

Match the following non-native plants with the characteristics that best describe them.

____ Australian pine
____ Brazilian pepper
____ Melaleuca
____ Old World climbing fern
____ Japanese climbing fern

1. Climbing fronds with pinnae that are often twice compound.
2. Wiry rhizomes, climbing fronds, pinnae once compound.
3. Soft, whitish, peeling, bark.
4. Evergreen shrub or tree, leaves alternate, odd-pinnately compound.
5. Evergreen tree to 150 feet tall with needle-like branchlets.

For the remaining questions refer to a Garlon 4 label, which can be obtained from http://www.cdms.net/manuf/manuf.asp.

How many pounds of triclopyr, expressed as acid equivalent, are contained in one gallon of Garlon 4?

What PPE must be worn by an applicator who is applying Garlon 4 to control an invasive plant in a natural area?

What should not be done if Garlon 4 is swallowed?

What precautions must be made with respect to bodies of water when using Garlon 4?
What is the maximum rate of Garlon 4 that can be applied to a conservation land where cattle (other than lactating dairy animals) are allowed to graze with no grazing restrictions?

What is the maximum use rate of Garlon 4?

What is the maximum percent concentration of Garlon 4 that can be used to control woody plants with “foliar treatment with ground equipment” and “high volume foliar treatment?”

What is the maximum percent concentration of Garlon 4 that can be used to control woody plants with foliage when using “broadcast applications with ground equipment?”

Give two differences between “basal bark treatment” and low volume basal bark treatment.”
Labels
A selective systemic aquatic herbicide for management of freshwater aquatic vegetation in: ponds; lakes; reservoirs; marshes; wetlands; bayous; drainage ditches; non-irrigation canals; and slow-moving or quiescent bodies of water; including shoreline and riparian areas within or adjacent to these and other aquatic sites.

Active Ingredient:
penoxsulam: 2-(2,2-difluoroethoxy)-6-(trifluoromethyl)-N-(5,8-dimethoxy[1,2,4]triazolo-[1,5c]pyrimidin-2-yl)-benzenesulfonamide ........................................... 21.7%

Other Ingredients ................................................. 78.3%

TOTAL .............................................................. 100.0%

Contains 2 pounds of active ingredient per gallon.

Keep Out of Reach of Children

CAUTION

Hazardous to Humans and Domestic Animals

Harmful If Inhaled. Avoid breathing spray mist.

First Aid

If inhaled
• Move person to fresh air.
• If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth if possible.
• Call a poison control center or doctor for further treatment advice.

Personal Protective Equipment (PPE)

For all types of applications, mixers and loaders must wear:
• Long-sleeved shirt and long pants;
• Shoes plus socks; and
• Chemical-resistant gloves made of any waterproof material.

For in-water (i.e. subsurface) applications, applicators must wear:
• Short-sleeved shirt and long pants;
• Shoes plus socks; and
• Chemical-resistant gloves made of any waterproof material.

For non-water applications, applicators must wear:
• Long-sleeved shirt and long pants;
• Shoes plus socks; and
• Chemical-resistant gloves made of any waterproof material.

Remove and wash contaminated clothing before reuse. Follow manufacturer’s instructions for cleaning/maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

User Safety Recommendations

Users should:
• Wash hands before eating, drinking, chewing gum, using tobacco or using the toilet.
• Remove clothing immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.

ENVIRONMENTAL HAZARDS

Follow use directions carefully so as to minimize adverse effects on non-target vegetation.

Notice: Read the entire label. Use only according to label directions. Before using this product, read Terms and Conditions of Use, Warranty Disclaimer, Inherent Risks of Use and Limitation of Remedies at end of label booklet. If terms are unacceptable, return at once unopened.

For product information, visit our web site at www.sepro.com.

Agricultural Chemical: Do not ship or store with food, feeds, drugs or clothing.

Shake well before using.

EPA Reg. No. 62719-546-67690
FPL081908

*Trademark of SePRO Corporation.
SePRO Corporation 11550 North Meridian Street, Suite 600, Carmel, IN 46032 U.S.A.
Directions for Use

Shake Well Before Using.

It is a violation of Federal law to use this product in a manner inconsistent with its labeling. Read all Directions for Use carefully before applying.

IMPORTANT
Do not use water from any treated site for food crop irrigation until residues are determined to be less than or equal to 1 ppb (see exceptions under Applications to Waters Used for Irrigation section of this label). Concentrations in food-crop irrigation water must be monitored until concentrations are 1 ppb or less. Water samples must be collected and analyzed using ELISA or other approved analytical methods. Please refer to all precautions and restrictions under the Applications to Waters Used for Irrigation section of this label.

Do not make in-water applications to areas subject to rapid dilution of treated water and/or where sufficient exposure with targeted vegetation can not be maintained, such as small spot or shoreline treatments in larger bodies of water.

GENERAL INFORMATION
Galleon SC herbicide is a selective systemic aquatic herbicide for management of freshwater aquatic vegetation in: ponds; lakes; reservoirs; marshes; wetlands; bayous; drainage ditches; non-irrigation canals; and slow-moving or quiescent bodies of water; including shoreline and riparian areas within or adjacent to these and other aquatic sites.

Galleon SC may be applied directly into water or sprayed onto emergent foliage of aquatic plants or exposed sediment after drawdown. Depending upon method of application and target plant, Galleon SC is absorbed by aquatic vascular plants through emergent or floating leaves, from water through submerged plant shoots, or from hydrosol by roots. For in-water treatments, rapid water movement or any condition resulting in rapid dilution of Galleon SC in treated water will reduce its effectiveness.

Herbicidal symptoms of Galleon SC include: immediate growth inhibition, a chlorotic growing point with some tissue reddening, necrosis of the terminal bud after 2 or more weeks of exposure, and slow plant death over a period of 60 to 120 days or longer depending upon conditions for in-water applications. The level of control will depend upon timing of initial application, application rate or concentration, exposure period, and weed species. Species susceptibility to Galleon SC may vary depending upon time of year, stage of growth, and water movement. For best results, apply Galleon SC immediately after weeds begin active growth. Application to mature target plants may require higher application rates and longer exposure periods to achieve control.

This label describes both required and recommended uses of a chemical analysis for the active ingredient. SePRO Corporation recommends the use of an Enzyme-Linked Immunoassay (ELISA) test for the determination of the active ingredient concentration in water. Contact SePRO Corporation for the incorporation of this analysis in your treatment program. Other proven chemical analysis for the active ingredient may also be used. The ELISA analysis is referenced in this label as the preferred method for the rapid determination of the concentration of the active ingredient in the water.

GENERAL USE PRECAUTIONS AND RESTRICTIONS
• Consult with appropriate state or local water authorities before applying this product. Permits and posting or treatment notification may be required by state or local public agencies. Consult the agency responsible for pesticide regulations for specific details.
• Galleon SC must be applied by SePRO Corporation authorized applicators trained in Best Management Practices for use of the product.
• There are no restrictions on the use of treated water for recreational purposes, including swimming and fishing.
• Chemigation: Do not apply Galleon SC through any type of irrigation system.
• For post-emergence foliar applications or exposed sediment treatments, Galleon SC should be mixed with a surfactant. Use only surfactants that are approved or appropriate for aquatic use. Use of organosilicone surfactants with Galleon SC is not recommended.
• For treatments out of water, do not permit spray mists containing Galleon SC to drift onto desirable broadleaf plants as injury may occur. Further information on spray drift management is provided in the Spray Drift Management section of this label.

APPLICATION TO WATERS USED FOR IRRIGATION
Irrigation using water treated with Galleon SC may result in injury to sensitive irrigated vegetation. The following restrictions are required for irrigation use of treated water:
• Do not use water treated with Galleon SC for hydroponic farming.
• Do not apply Galleon SC to water to be used for irrigation of greenhouse or nursery plants. Do not use water treated with Galleon SC for irrigating greenhouse or nursery plants.
• Do not irrigate established food crops, other than rice, if concentrations of Galleon SC in irrigation source water exceed 1 ppb as determined using ELISA or other analytical techniques. Do not irrigate established rice if concentrations in treated water exceed 30 ppb.
• There is no restriction on use of water treated with Galleon SC for turf irrigation, if concentrations are less than 30 ppb. For other non-food crop irrigation (e.g., landscape ornamentals) or for other irrigation uses not described above, confer with SePRO Corporation prior to commencing irrigation if concentrations in treated water exceed 1 ppb as determined using ELISA or other analytical techniques.
Areas previously irrigated with water treated with Galleon SC may be planted in rice or turf. For other food crops and in areas irrigated with Galleon SC at concentrations exceeding 1 ppb, consult with SePRO Corporation for site-specific risk evaluations before planting.

Do not apply Galleon SC to actively moving or running waters (i.e. lotic waters) used for irrigation, including rivers and streams. When making applications near an active irrigation water intake, the intake must be shut-off until concentrations in the water are 1 ppb or less as determined using ELISA or other analytical techniques, except when irrigating turf or rice (see restrictions under Applications to Waters Used for Irrigation). The intakes must be shut-off for a sufficient period of time to allow penoxsulam in treated water to decrease to 1 ppb or less at the intake before use can resume. Consult with state, federal, or local water authorities before making application near an active irrigation intake.

Application to Exposed Sediments: Galleon SC may be applied to exposed sediments of dewatered areas of aquatic sites. Upon inundation, all label restrictions apply to the use of water from these treated areas.

SPRAY DRIFT MANAGEMENT

Avoiding spray drift at the application site is the responsibility of the applicator. The interaction of many equipment- and weather-related factors determine the potential for spray drift. Make applications only when there is little or no hazard from spray drift. The applicator is responsible for considering all these factors when making decisions.

Avoid all direct or indirect contact with non-target plants.

Do not apply near desirable vegetation. Allow adequate distance between target area and desirable plants to minimize exposure.

The following drift management requirements must be followed to avoid off-target drift movement from aerial applications:

1. The distance between the outer most nozzles on the boom must not exceed 70% of the wingspan of fixed-wing aircraft or 80% of the helicopter rotor width.

2. Nozzle set up must use a coarse spray quality category per ASABE S-572 Standard.

Where states have more stringent regulations, they must be followed.

The applicator should be familiar with and take into account the information covered in the Aerial Drift Reduction Advisory. In general, the best drift management strategy is to apply the largest droplets that provide sufficient coverage and control.

AERIAL DRIFT REDUCTION ADVISORY

Information on Droplet Size: For S-572 ASABE Standard compliance, see nozzle manufacturer catalogs, NAAA booklet, or USDA literature or website http://apmru.usda.gov for nozzle and application conditions. The best drift management strategy is to apply the largest droplets that provide sufficient coverage and control. Larger droplets reduce drift potential, but will not prevent drift if applications are made improperly, or under unfavorable environmental conditions (see Wind, Temperature and Humidity, and Temperature Inversions).

Controlling Droplet Size:

- Volume - Use high flow rate nozzles to apply the highest practical spray volume. Nozzles with higher rated flows produce larger droplets.

- Pressure - Do not exceed the nozzle manufacturer’s recommended pressures. For many nozzle types lower pressure produces larger droplets.

- Number of Nozzles - Use the minimum number of nozzles that provide uniform coverage.

- Nozzle Orientation - Orienting nozzles so that the spray is released parallel to the air stream produces larger droplets than other orientations and is the recommended practice.

- Nozzle Type - Use a nozzle type that is designed for the intended application. With most nozzle types, narrower spray angles produce larger droplets. Consider using low-drift nozzles. Solid stream nozzles oriented straight back produce the largest droplets and the lowest drift.

Boom Length: Reducing the effective boom length to 70% of the wingspan of fixed-wing aircraft or 80% of the helicopter rotor width may further reduce drift without reducing swath width.

Application Height: Applications should not be made at a height greater than 10 feet above the top of the largest plants unless a greater height is required for aircraft safety. Making applications at the lowest height that is safe reduces exposure of droplets to evaporation and wind.

Swath Adjustment: When applications are made with a crosswind, the swath will be displaced downwind. Therefore, the applicator must compensate for this displacement by adjusting the path of the aircraft or boom on-off. Swath adjustment distance should increase, with increasing drift potential (higher wind, height, smaller drops, etc.).

Wind: Drift potential is lowest between wind speeds of 2 to 10 mph. However, many factors, including droplet size and equipment type determine drift potential at any given speed. Application should be avoided below 2 mph due to variable wind direction and high inversion potential.

NOTE: Local terrain can influence wind patterns. Every applicator should be familiar with local wind patterns and how they affect spray drift.

NOTE: State and local regulations with regard to minimum and maximum wind speeds during aerial application may be more restrictive. Aerial applicators should be familiar with these regulations.

Temperature and Humidity: When making applications in low relative humidity, set up equipment to produce larger droplets to compensate for evaporation. Droplet evaporation is greatest when conditions are both hot and dry.

Temperature Inversions: Applications should not occur during a local, low level temperature inversion because drift potential is high. Small droplets can move in unpredictable directions due to the light variable winds common during inversions. Temperature inversions are characterized by increasing temperatures with altitude and are common on nights with limited cloud cover and light to no wind. Their presence can be indicated by ground fog;
however, if fog is not present, inversions can also be identified by the movement of the smoke from a ground source or an aircraft smoke generator. Smoke that layers and moves laterally in a concentrated cloud (under low wind conditions) indicates an inversion, while smoke that moves upward and rapidly dissipates indicates good vertical air mixing.

Sensitive Areas: Galleon SC should only be applied to the intended treatment area when the potential for drift to adjacent sensitive areas (e.g., residential areas, known habitat for threatened or endangered species, non-target vegetation) is minimal (e.g., when wind is blowing away from the sensitive areas). Refer to the section of this label on Wind under Spray Drift Management for more specific details.

AQUATIC PLANTS CONTROLLED
Performance and selectivity of Galleon SC is dependent upon dosage, time of year, stage of growth, method of application, and water movement. The following categories—controlled and partially controlled—are provided to describe expected efficacy under ideal treatment conditions using typical treatment rates. Plants listed as partially controlled are less susceptible under most use conditions but may show herbicide stress or partial control during active treatment phase. Use of lower rates will increase selectivity on some species listed below. Consult with SePRO Corporation prior to applying Galleon SC to determine best treatment protocols for given target vegetation.

VASCULAR AQUATIC PLANTS CONTROLLED

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floating Plants</td>
<td></td>
</tr>
<tr>
<td>duckweed</td>
<td>multiple incl. Lemna spp.¹</td>
</tr>
<tr>
<td>frog's bit</td>
<td>Limnobium spongia</td>
</tr>
<tr>
<td>mosquito fern</td>
<td>Azolla caroliniana</td>
</tr>
<tr>
<td>water fern</td>
<td>Salvinia minima and molestia</td>
</tr>
<tr>
<td>water hyacinth</td>
<td>Eichhornia crassipes</td>
</tr>
<tr>
<td>water lettuce</td>
<td>Pistia stratiotes</td>
</tr>
<tr>
<td>Emerged Plants</td>
<td>Hydrocotyle umbellata</td>
</tr>
<tr>
<td>Submersed Plants</td>
<td></td>
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<tr>
<td>baby's tears</td>
<td>Micranthemum spp.</td>
</tr>
<tr>
<td>cabomba</td>
<td>Cabomba caroliniana</td>
</tr>
<tr>
<td>egeria, Brazilian elodea</td>
<td>Egeria densa</td>
</tr>
<tr>
<td>Eurasian watermilfoil</td>
<td>Myriophyllum spicatum</td>
</tr>
<tr>
<td>hydrilla</td>
<td>Hydrilla verticillata</td>
</tr>
<tr>
<td>sago pondweed</td>
<td>Stuckenia pectinatus</td>
</tr>
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VASCULAR AQUATIC PLANTS PARTIALLY CONTROLLED

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floating Plants</td>
<td></td>
</tr>
<tr>
<td>common watermeal</td>
<td>Wolffia columbiana</td>
</tr>
<tr>
<td>Emerged Plants</td>
<td></td>
</tr>
<tr>
<td>alligatorweed</td>
<td>Alternanthera philoxeroides</td>
</tr>
<tr>
<td>arrowhead</td>
<td>Sagittaria spp.¹</td>
</tr>
</tbody>
</table>

MIXING INSTRUCTIONS

In-Water Application to Submersed or Floating Aquatic Weeds
Galleon SC can be applied undiluted or diluted with water for in-water applications. To dilute with water, it is recommended to fill spray tank to one-half full with water. Start agitation. Add correct quantity of Galleon SC. Continue agitation while filling spray tank to required volume and during application.

Foliar Application to Floating and Emergent Weeds
Dilute Galleon SC with water to achieve proper coverage of treated plants. To dilute with water, it is recommended to fill spray tank to one-half full with water. Start agitation. A surfactant must also be used with all post-emergent foliar applications of Galleon SC. Use only surfactants that are approved or appropriate for aquatic use. Based upon surfactant label recommendations, add appropriate volume of surfactant when adding Galleon SC to spray tank. Read and follow all use directions and precautions on aquatic surfactant label. After adding Galleon SC and surfactant, continue agitation while filling spray tank to required volume and during application.

Exposed Sediment Application for Pre-Emergence Control of Aquatic Weeds
Galleon SC must be diluted with water for pre-emergence, exposed sediment applications. To dilute with water, it is recommended to fill spray tank to one-half full with water. Start agitation. Add correct quantity of Galleon SC. When using a surfactant, add appropriate volume of surfactant (based upon surfactant label recommendations) when adding Galleon SC to spray tank. Read and follow all use directions and precautions on surfactant label. After adding Galleon SC and any surfactant, continue agitation while filling spray tank to required volume and during application.

Tank-mixes with Other Aquatic Herbicides
Galleon SC may be mixed with some approved herbicide products prior to treatment. Consult with SePRO Corporation for latest recommendations prior to such use.

¹ Susceptibility will likely vary between species within this genus
In-Water Application to Submersed or Floating Aquatic Weeds

Galleon SC can be applied as an in-water application to control weeds such as hydrilla, Eurasian watermilfoil, water hyacinth, and other susceptible weed species.

Do not make in-water applications to areas subject to rapid dilution of treated water and/or where sufficient exposure with targeted vegetation can not be maintained, such as small spot or shoreline treatments in larger bodies of water.

Where greater plant selectivity is desired such as when controlling hydrilla and Eurasian watermilfoil or when targeting more susceptible species, choose an application rate lower in the rate range. SePRO Corporation recommends contacting an aquatic specialist to determine when to choose application rates lower in the range to meet specific plant management goals.

Single In-Water Application to Treatment Zone: Where single applications to whole ponds, lakes, and reservoirs are desired, under typical treatment conditions Galleon SC should be applied at a minimum effective concentration of 25 to 75 ppb. Choose an application rate to meet the aquatic plant management objectives. Application rates necessary to obtain these concentrations in treated water are shown below. It may be necessary to re-treat the body of water if mature or more tolerant vegetation is present in the treated area or heavy rainfall has diluted the treatment.

NOTE: The concentration of any single application or sum of all applications must not exceed 150 ppb per annual growth cycle.

Split or Multiple In-Water Applications to Treatment Zone:

Split or multiple applications of Galleon SC may be desirable to ensure efficacy overtime, maintain exposure, and enhance selectivity. Under typical treatment conditions or when targeting the most susceptible species, Galleon SC should be applied initially at the minimum effective dose of 10 to 30 ppb to the treatment zone and, through the use of water analysis, add additional Galleon SC to maintain the concentration to achieve specific plant management objectives. Re-treat the water to maintain a sufficient concentration for a minimum of 60 days or until satisfactory weed control is achieved. Higher concentrations and longer exposure times may be necessary when targeting less susceptible species, mature plants, and/or under conditions favorable for slower plant growth. Water analysis using ELISA is recommended to determine the actual concentration of Galleon SC in the water overtime.

NOTE: The concentration of any single application or sum of all applications must not exceed 150 ppb per annual growth cycle.

Apply Galleon SC to the treatment area at the appropriate rate to achieve target concentration. Define both size (in acres) and mean water depth (in feet) of the treatment zone prior to treatment. For each part per billion (ppb) of final concentration of active ingredient in the treatment zone, apply 0.174 fl oz per acre-foot of water. For example, for a 50 ppb treatment of 5 acres with a mean depth of 5 ft (25 acre-ft):

\[ 0.174 \text{ fl oz} \times 50 \text{ ppb} \times 25 \text{ acre ft} = 217.5 \text{ fl oz (6.8 quarts or 1.7 gallon)} \text{ Galleon SC applied} \]

The rate needed to treat 1 surface acre of water should be selected according to the rate chart below.

<table>
<thead>
<tr>
<th>Average Water Depth (ft)</th>
<th>Target Concentration of Penoxsulam in Water (ppb)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fl oz (Qt) of Galleon SC per Surface Acre at Specified Depth</td>
</tr>
<tr>
<td></td>
<td>5</td>
</tr>
<tr>
<td>1</td>
<td>0.9 (0.03)</td>
</tr>
<tr>
<td>2</td>
<td>1.7 (0.05)</td>
</tr>
<tr>
<td>3</td>
<td>2.6 (0.08)</td>
</tr>
<tr>
<td>4</td>
<td>3.5 (0.11)</td>
</tr>
<tr>
<td>5</td>
<td>4.4 (0.14)</td>
</tr>
<tr>
<td>6</td>
<td>5.2 (0.16)</td>
</tr>
<tr>
<td>7</td>
<td>6.1 (0.19)</td>
</tr>
<tr>
<td>8</td>
<td>7.0 (0.22)</td>
</tr>
<tr>
<td>9</td>
<td>7.8 (0.24)</td>
</tr>
<tr>
<td>10</td>
<td>8.7 (0.27)</td>
</tr>
</tbody>
</table>

For in-water applications, the maximum target concentration in any treated area is 150 ppb active ingredient per annual growth cycle.

Foliar Application to Floating and Emergent Weeds

Galleon SC can be applied as a foliar application to control weeds such as water hyacinth, water lettuce, water pennywort and other susceptible floating and emergent species. Applications should be conducted in a manner to maximize spray interception by target weeds while minimizing the amount of overspray that inadvertently enters the water.

For all foliar applications, apply Galleon SC at the rate of 2 to 5.6 fl oz per acre. Use of a surfactant is required for all foliar applications of Galleon SC. Use only surfactants that are approved or appropriate for aquatic use. Use of organosilicone surfactants with Galleon SC is not recommended. Refer to the surfactant label for use directions. Apply Galleon SC to actively growing weeds only. Do not apply to emerged weeds that are not actively growing due to moisture stress or stress due to adverse weather conditions.
Aerial Foliar Application to Floating and Emergent Weeds
Apply Galleon SC in a spray volume of 10 gallons per acre (gpa) or more when making a post-emergence application by air. Apply with coarse droplet category per S-572 ASABE standard; see NAAA, USDA or nozzle manufacturer guidelines. Follow guidelines in the Spray Drift Management and Aerial Drift Reduction Advisory sections to minimize potential drift to off-target vegetation. Aircraft should be patterned per Operation Safe/PAASS program for calibration and uniformity to provide sufficient coverage and control.

Boat or Ground Foliar Application to Floating and Emergent Weeds
When applying Galleon SC by boat or with ground equipment to emergent or floating-leaved vegetation, use boom-type, backpack or hydraulic handgun equipment. Apply Galleon SC in a sufficient spray volume (up to 100 gpa) to provide accurate and uniform distribution of spray particles over the treated vegetation while minimizing runoff. Use higher spray volumes for medium to high density vegetation. For boom spraying, use coarse or coarser nozzle spray quality per S-572 ASABE standard; see USDA literature or nozzle manufacturer guidelines. Follow nozzle manufacturer's recommendations for nozzle pressure, spacing and boom height to provide a uniform spray pattern. Follow appropriate spray drift management information where drift potential is a concern.

Exposed Sediment Application for Pre- and Post-emergence Control of Aquatic Weeds
Galleon SC may be applied to exposed sediments of dewatered aquatic sites for post- and pre-emergent control of susceptible weed species. Apply Galleon SC at the rate of 5.6 to 11.2 fl oz per acre in a total spray volume of 20 to 100 gpa to the target area of exposed sediment using boom-type, backpack, or hydraulic handgun equipment for pre-emergence weed control. For boom spraying, use coarse or coarser nozzle spray quality per S-572 ASABE standard; see USDA literature or nozzle manufacturer guidelines. Follow nozzle manufacturer's recommendations for nozzle pressure, spacing and boom height to provide a uniform spray pattern. Follow appropriate spray drift management information where drift potential is a concern. Best treatment timing and rates will be based on various factors including current and historical rainfall, soil type, and timing of reflood, all of which should be discussed with SePRO Corporation prior to treatment. A surfactant should also be used according to its label instructions. When present, do not apply to target emerged weeds that are not actively growing due to moisture stress or stress due to adverse weather conditions.

Refer to Applications to Waters Used for Irrigation section of this label for irrigation restrictions following exposed sediment applications. Consult with SePRO Corporation for site specific recommendations for sampling water upon inundation.

RESISTANCE MANAGEMENT
The mode of action of Galleon SC is the inhibition of the acetolactate synthase (ALS) enzyme. Weed populations may develop biotypes that are resistant to different herbicides with the same mode of action. If herbicides with the same mode of action are used repeatedly at the same site, resistant biotypes may eventually dominate the weed population and may not be controlled by these products.

This product should be used as part of an Integrated Pest Management (IPM) program that may include biological, cultural, and chemical practices aimed at preventing economic and environmental pest damage. Application of this product should be based on appropriate IPM and resistance management strategies that delay or reduce the development of resistant weed biotypes. Such practices include, but are not limited to, tank mix combinations with dual-modes of action, herbicide rotation (i.e., use of alternate modes of action in subsequent treatment cycles), target plant susceptibility testing, GPS-assisted field survey and application methods, detailed in-treatment monitoring of herbicide concentrations to ensure proper dose and exposure period, and determination of optimal timing for treatment of target vegetation based on plant physiology and resource management goals for treated sites.

To delay development of herbicide resistance, the following practices are recommended:

• Treatment with Galleon SC in successive years is not recommended unless conducted in combination with an herbicide with a different mode of action.

• Intensive target plant susceptibility testing in combination with rigorous and quantitative assessments of target plant distribution and health are strongly recommended before, during and after treatment.

• In conjunction with susceptibility testing, follow-up management of any surviving target plants found following treatment with Galleon SC is recommended in the period immediately following treatment with Galleon SC. This proactive follow-up management to contain or limit the spread of any potential resistant biotypes can include the use of contact herbicide or systemic herbicide with a different mode of action.

STEWARDSHIP GUIDELINES FOR USE
When making application to public waters, Galleon SC must be applied by a SePRO Corporation authorized applicator; this does not apply to applications made to private waters or to waters not used for irrigation. This product should be applied in compliance with Best Management Practices (BMP) that include: site assessment, prescription, and implementation. BMP have been developed to maintain and/or monitor target concentrations over large areas, ensure accurate applications and maximize treatment performance, minimize resistance development, and to monitor residues in water used for potential irrigation. SePRO Corporation technical specialists will work with authorized applicators and resource managers to ensure compatibility with potential uses of the water and management objectives. State or local water authorities should be consulted as appropriate before applying this product to obtain necessary permits and to comply with local posting and treatment notification requirements.
Most effective use of Galleon SC, especially in larger treatment areas, requires knowledge of the concentration of Galleon SC in treated water. This knowledge provides critical information for maximum performance, resistance management, irrigation restrictions, and overall product stewardship. This label describes both required and recommended uses of a chemical analysis for the active ingredient. SePRO Corporation recommends the use of an Enzyme-Linked Immunoassay (ELISA) test for the determination of the active ingredient concentration in water. Contact SePRO Corporation for the incorporation of this analysis in your treatment program.

**NOTE:** For all forms of Galleon SC use, water sampling must be conducted as necessary to meet other label requirements for treated water use. Concentrations in food-crop irrigation water must be monitored until concentrations are 1 ppb or less before treated water may be used for irrigation.

In order to accurately determine the concentrations of Galleon SC in treated water, recommendations for the minimum number of water sampling locations per treated area are provided below. The number of sampling locations will vary by site based on site morphology, bathymetry, inflows, presence of irrigation intakes, and other plant management objectives. Site locations for such sampling should be geographically referenced (i.e., GPS coordinates) and evenly distributed throughout the treated water body. Consult with SePRO Corporation for site specific recommendations.

Depending upon the application method and site specific information, water sample(s) should be collected every 10 to 30 days. Sampling should be conducted more frequently as necessary to comply with any water use restrictions and to ensure efficacy.

<table>
<thead>
<tr>
<th>Size of Treated Area (acres)</th>
<th>Number of Water Sample Locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;100</td>
<td>1</td>
</tr>
<tr>
<td>101 – 1,000</td>
<td>1 – 3</td>
</tr>
<tr>
<td>1001 – 2,500</td>
<td>3 – 5</td>
</tr>
<tr>
<td>2501 – 5,000</td>
<td>5 – 8</td>
</tr>
<tr>
<td>5001 – 10,000</td>
<td>8 – 15</td>
</tr>
<tr>
<td>&gt;10,001</td>
<td>1 additional site for every 1000 acres</td>
</tr>
</tbody>
</table>

Best practices for use of any aquatic herbicide demand the highest level of environmental assessment and stewardship. Treatment prescriptions should be tailored to meet site-specific resource management plans. Implementation of treatment programs should be conducted with equipment and protocols designed to increase treatment success through precision and quick reaction to changing environmental conditions.

Product specific stewardship guidelines for use of Galleon SC are available from SePRO Corporation. These guidelines are routinely updated to provide the latest best management practices for use of Galleon SC, including assessment protocols, treatment techniques, and record keeping requirements.

Contact SePRO Corporation for further information.

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**Storage and Disposal**

Do not contaminate water, food, or feed by storage or disposal.

**Pesticide Storage:** Store in cool dry place in original container.

**Pesticide Disposal:** Wastes resulting from the use of this product must be disposed of on site or at an approved waste disposal facility.

**Container Reuse:** Nonrefillable container. Do not reuse or refill this container. Offer for recycling if available. Triple rinse or pressure rinse container (or equivalent) promptly after emptying. **Triple rinse as follows:** Empty the remaining contents into application equipment or a mix tank and drain for 10 seconds after the flow begins to drip. Fill the container 1/4 full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Drain for 10 seconds after the flow begins to drip. Repeat this procedure two more times. **Pressure rinse as follows:** Empty the remaining contents into application equipment or a mix tank and continue to drain for 10 seconds after the flow begins to drip. Hold container upside down over application equipment or mix tank or collect rinsate for later use or disposal. Insert pressure rinsing nozzle in the side of the container, and rinse at about 40 psi for at least 30 seconds. Drain for 10 seconds after the flow begins to drip.
Terms and Conditions of Use

If terms of the following Warranty Disclaimer, Inherent Risks of Use, and Limitation of Remedies are not acceptable, return unopened package at once to the seller for a full refund of purchase price paid. Otherwise, use by the buyer or any other user constitutes acceptance of the terms under Warranty Disclaimer, Inherent Risks of Use and Limitation of Remedies.

Warranty Disclaimer

Seller warrants that this product conforms to the chemical description on the label and is reasonably fit for the purposes stated on the label when used in strict accordance with the directions, subject to the inherent risks set forth below. TO THE EXTENT PERMITTED BY LAW, SELLER MAKES NO OTHER EXPRESS NOR IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR ANY OTHER EXPRESS OR IMPLIED WARRANTY.

Inherent Risks of Use

It is impossible to eliminate all risks associated with use of this product. Plant injury, lack of performance, or other unintended consequences may result because of such factors as use of the product contrary to label instructions (including conditions noted on the label, such as unfavorable temperature, soil conditions, etc.), abnormal conditions (such as excessive rainfall, drought, tornadoes, hurricanes), presence of other materials, the manner of application, or other factors, all of which are beyond the control of Seller. To the extent permitted by law, all such risks shall be assumed by Buyer.

Limitation of Remedies

To the extent permitted by law, the exclusive remedy for losses or damages resulting from this product (including claims based on contract, negligence, strict liability, or other legal theories), shall be limited to, at Sellers election, one of the following:

1. Refund of purchase price paid by buyer or user for product bought, or
2. Replacement of amount of product used.

To the extent permitted by law, Seller shall not be liable for losses or damages resulting from handling or use of this product unless Seller is promptly notified of such loss or damage in writing. In no case shall Seller be liable for consequential or incidental damages or losses.

To the extent permitted by law, the terms of the Warranty Disclaimer, Inherent Risks of Use, and Limitation of Remedies cannot be varied by any written or verbal statements or agreements. No employee or sales agent of the Seller or the seller is authorized to vary or exceed the terms of the Warranty Disclaimer or this Limitation of Remedies in any manner.

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Printed in U.S.A. Revised 1-28-09.
For the control of woody plants and annual and perennial broadleaf weeds in non-crop industrial manufacturing and storage sites, rights-of-way such as electrical power lines, communication lines, pipelines, roadsides, railroads, forests and in the establishment and maintenance of wildlife openings. Use on these sites may include application to grazed areas.

Active Ingredient:
triclopyr: 3,5,6-trichloro-2-pyridinyloxyacetic acid, butoxyethyl ester.......................... 61.6%
Other Ingredients ......................................................... 38.4%
Total................................................................. 100.0%

Contains petroleum distillates
Acid equivalent: triclopyr - 44.3% - 4 lb/gal

EPA Reg. No. 62719-40

Keep Out of Reach of Children

CAUTION PRECAUCION
Si usted no entiende la etiqueta, busque a alguien para que se la explique a usted en detalle. (If you do not understand the label, find someone to explain it to you in detail.)

Precautionary Statements
Hazards to Humans and Domestic Animals

Causes Moderate Eye Irritation • Harmful If Swallowed • Prolonged Or Frequently Repeated Skin Contact May Cause Allergic Reactions In Some Individuals

Avoid contact with eyes or clothing. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, or using tobacco.

Personal Protective Equipment (PPE)
Applicators and other handlers who handle this pesticide must wear:
• Long-sleeved shirt and long pants
• Shoes plus socks

Follow manufacturer’s instructions for cleaning/maintaining PPE. If no such instructions for washables are given, use detergent and hot water. Keep and wash PPE separately from other laundry.

Engineering Controls
When handlers use closed systems, enclosed cabs, or aircraft in a manner that meets the requirements listed in the WPS (40 CFR 170-240(d)(4-5), the handler PPE requirements may be reduced or modified as specified in the WPS.

User Safety Recommendations
Users should:
• Wash hands before eating, drinking, chewing gum, using tobacco, or using the toilet.
• Remove clothing immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.

First Aid
If in eyes: Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a poison control center or doctor for treatment advice.
If swallowed: Immediately call a poison control center or doctor. Do not induce vomiting unless told to do so by a poison control center or doctor. Do not give any liquid to the person. Do not give anything by mouth to an unconscious person.

Note to Physician: This product may pose an aspiration pneumonia hazard. Contains petroleum distillates.

Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may also contact 1-800-992-5994 for emergency medical treatment information.

Environmental Hazards
This pesticide is toxic to fish. Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwater or rinsate.

This chemical has properties and characteristics associated with chemicals detected in groundwater. The use of this chemical in areas where soils are permeable, particularly where the water table is shallow, may result in groundwater contamination.

Physical or Chemical Hazards
Combustible. Do not use or store the product near heat or open flame.

Notice: Read the entire label. Use only according to label directions. Before using this product, read Warranty Disclaimer, Inherent Risks of Use, and Limitation of Remedies elsewhere on this label. If terms are unacceptable, return at once unopened.
In case of emergency endangering health or the environment involving this product, call 1-800-952-5994. If you wish to obtain additional product information, visit our website at www.dowagro.com.

Agricultural Chemical: Do not ship or store with food, feeds, drugs or clothing.

Directions for Use
It is a violation of Federal law to use this product in a manner inconsistent with its labeling. Read all Directions for Use carefully before applying.

Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application. For any requirements specific to your state or tribe, consult the agency responsible for pesticide regulation.

Agricultural Use Requirements
The requirements in this box apply to forestry uses.

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR Part 170. This standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment (PPE) and restricted-entry intervals. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard.

Do not enter or allow worker entry into treated areas during the restricted entry interval (REI) of 12 hours.

PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water, is:
- Coveralls
- Chemical-resistant gloves
- Shoes plus socks
- Protective eyewear

Non-Agricultural Use Requirements
The requirements in this box apply to all use sites on this label except for forestry uses.

The requirements in this box apply to uses of this product that are NOT within the scope of the Worker Protection Standard for Agricultural Pesticides (40 CFR Part 170). The WPS applies when this product is used to produce agricultural plants on farms, forests, nurseries, or greenhouses.

Entry Restrictions for Non-WPS Uses: For applications to non-cropland areas, do not allow entry into areas until sprays have dried.

Storage and Disposal
Do not contaminate water, food, or feed by storage and disposal. Open dumping is prohibited.
Pesticide Storage: Store above 28°F or agitate before use.
Pesticide Disposal: Wastes resulting from the use of this product must be disposed of on site or at an approved waste disposal facility.

Storage and Disposal (Cont.)
Nonrefillable containers 5 gallons or less:
Container Reuse: Nonrefillable container. Do not reuse or refill this container. Offer for recycling if available. Triple rinse or pressure rinse container (or equivalent) promptly after emptying. Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank and drain for 10 seconds after the flow begins to drip. Fill the container 1/4 full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Drain for 10 seconds after the flow begins to drip. Repeat this procedure two more times. Pressure rinse as follows: Empty the remaining contents into application equipment or a mix tank and continue to drain for 10 seconds after the flow begins to drip. Hold container upside down over application equipment or mix tank or collect rinsate for later use or disposal. Insert pressure rinsing nozzle in the side of the container, and rinse at about 40 psi for at least 30 seconds. Drain for 10 seconds after the flow begins to drip.

Nonrefillable containers 5 gallons or larger:
Container Reuse: Nonrefillable container. Do not reuse or refill this container. Offer for recycling if available. Pressure rinse as follows: Empty the remaining contents into application equipment or a mix tank and continue to drain for 10 seconds after the flow begins to drip. Hold container upside down over application equipment or mix tank or collect rinsate for later use or disposal. Insert pressure rinsing nozzle in the side of the container, and rinse at about 40 psi for at least 30 seconds. Drain for 10 seconds after the flow begins to drip.

Refillable containers 5 gallons or larger:
Container Reuse: Refillable container. Refill this container with pesticide only. Do not reuse this container for any other purpose. Cleaning the container before final disposal is the responsibility of the person disposing of the container. Cleaning before refilling is the responsibility of the refiller. To clean the container before final disposal, empty the remaining contents from this container into application equipment or a mix tank. Fill the container about 10% full with water and, if possible, spray all sides while adding water. If practical, agitate vigorously or recirculate water with the pump for two minutes. Pour or pump rinsate into application equipment or rinsate collection system. Repeat this rinsing procedure two more times.

Nonrefillable containers 5 gallons or larger:
Container Reuse: Nonrefillable container. Do not reuse or refill this container. Offer for recycling if available. Triple rinse or pressure rinse container (or equivalent) promptly after emptying. Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank and drain for 10 seconds after the flow begins to drip. Fill the container 1/4 full with water and, if possible, spray all sides while adding water. If practical, agitate vigorously or recirculate water with the pump for two minutes. Pour or pump rinsate into application equipment or rinsate collection system. Repeat this rinsing procedure two more times.

Pressure rinse as follows: Empty the remaining contents into application equipment or a mix tank and continue to drain for 10 seconds after the flow begins to drip. Hold container upside down over application equipment or mix tank or collect rinsate for later use or disposal. Insert pressure rinsing nozzle in the side of the container, and rinse at about 40 psi for at least 30 seconds. Drain for 10 seconds after the flow begins to drip.

General Information
Use Garlon® 4 specialty herbicide for the control of woody plants and annual and perennial broadleaf weeds in non-crop industrial manufacturing and storage sites, rights-of-way such as electrical power lines, communication lines, pipelines, roadsides, railroads, forests and in the establishment and maintenance of wildlife openings. Use on these sites may include application to grazed areas.
Garlon 4 is an oil soluble, emulsifiable liquid product containing the herbicide triclopyr. Garlon 4 may be applied to woody or herbaceous broadleaf plants as a foliar spray or as a basal bark or cut stump application to woody plants. As a foliar spray, Garlon 4 controls only herbaceous plants that have emerged from the soil or woody plants that are in full leaf at the time of application. Small amounts of Garlon 4 can kill or injure many broadleaf plants. To prevent damage to crops and other desirable plants, follow all directions and precautions.

**General Use Precautions and Restrictions**

In Arizona: The state of Arizona has not approved Garlon 4 for use on plants grown for commercial production; specifically forests grown for commercial timber production, or on designated grazing areas.

When applying this product in tank mix combination, follow all applicable use directions, precautions, and limitations on each manufacturer’s label.

**Chemigation:** Do not apply this product through any type of irrigation system.

Apply no more than 1/2 gallon of Garlon 4 (2 lb ae of triclopyr) per acre per growing season on rights-of-way or any area where grazing or harvesting is allowed.

On forestry sites, Garlon 4 may be used at rates up to 6 quarts (6 lb ae of triclopyr) per acre per year.

Garlon 4 may be used at rates up to 8 quarts (8 lb ae of triclopyr) per acre per year on non-crop industrial manufacturing and storage sites, rights-of-way such as electrical power lines, communication lines, pipelines, roadsides and railroads, fence rows, non-irrigation ditch banks. Portions of grazed areas that intersect treated non-cropland, rights-of-way and forestry sites may be treated at up to 8 lb ae per acre if the area to be treated on the day of application comprises no more than 10% of the total grazable area.

Do not apply Garlon 4 directly to, or otherwise permit it to come into direct contact with, cotton, grapes, peanuts, soybeans, tobacco, vegetable crops, flowers, citrus, or other desirable broadleaf plants. Do not permit spray mists containing Garlon 4 to drift onto such plants.

It is permissible to treat non-irrigation ditch banks, seasonally dry wetlands (such as flood plains, deltas, marshes, swamps, or bogs) and transitional areas between upland and lowland sites where surface water is not present except in isolated pockets due to uneven or unlevel conditions. Do not apply to open water (such as lakes, reservoirs, rivers, streams, creeks, salt water bays, or estuaries).

Do not apply on ditches currently being used to transport irrigation water. Do not apply where runoff or irrigation water may flow onto agricultural land as injury to crops may result.

Do not apply this product using mist blowers unless a drift control additive, high viscosity inverting system, or equivalent is used to control spray drift.

Sprays applied directly to Christmas trees may result in conifer injury. When treating unwanted vegetation in Christmas tree plantations, care should be taken to direct sprays away from conifers.

Garlon 4 is formulated as a low volatile ester. However, the combination of spray contact with impervious surfaces, such as roads and rocks, and increasing ambient air temperatures, may result in an increase in the volatility potential for this herbicide, increasing a risk for off-target injury to sensitive crops such as grapes and tomatoes.

**Grazing and Haying Restrictions**

Except for lactating dairy animals, there are no grazing restrictions following application of this product.

- **Grazing Lactating Dairy Animals:** Do not allow lactating dairy animals to graze treated areas until the next growing season following application of this product.
- **Do not harvest hay for 14 days after application.**
- Portions of grazed areas that intersect treated non-cropland, rights-of-way and forestry sites may be treated at up to 8 lb ae per acre if the area to be treated on the day of application comprises no more than 10% of the total grazable area.

**Slaughter Restrictions:** During the season of application, withdraw livestock from grazing treated grass at least 3 days before slaughter.

**Avoiding Injurious Spray Drift**

Make applications only when there is little or no hazard from spray drift. Small quantities of spray, which may not be visible, may seriously injure susceptible plants. Do not spray when wind is blowing toward susceptible crops or ornamental plants that are near enough to be injured. It is suggested that a continuous smoke column at or near the spray site or a smoke generator on the spray equipment be used to detect air movement, lapse conditions, or temperature inversions (stable air). If the smoke layers or indicates a potential of hazardous spray drift, do not spray.

**Aerial Application:** Garlon 4 may be aerially applied by fixed wing aircraft or helicopter. For aerial application on rights-of-way or other areas near susceptible crops, apply through a Microfoil or Thru-Valve boom, or use an agriculturally labeled drift control additive. Other drift reducing systems or thickened sprays prepared by using high viscosity inverting systems may be used if they are made as drift-free as mixtures containing agriculturally labeled thickening agents or applications made with the Microfoil or Thru Valve boom. Do not use a thickening agent with the Microfoil or Thru Valve booms, or other systems that cannot accommodate thick sprays. Spray only when the wind velocity is low (follow state regulations). Avoid application during air inversions. If a spray thickening agent is used, follow all use recommendations and precautions on the product label.

1Reference within this label to a particular piece of equipment produced by or available from other parties is provided without consideration for use by the reader at its discretion and subject to the reader’s independent circumstances, evaluation, and expertise. Such reference by Dow AgroSciences is not intended as an endorsement of such equipment, shall not constitute a warranty (express or implied) of such equipment, and is not intended to imply that other equipment is not available and equally suitable. Any discussion of methods of use of such equipment does not imply that the reader should use the equipment other than is advised in directions available from the equipment’s manufacturer. The reader is responsible for exercising its own judgment and expertise, or consulting with sources other than Dow AgroSciences, in selecting and determining how to use its equipment.
Spray Drift Management

Avoiding spray drift at the application site is the responsibility of the applicator. The interaction of many equipment and weather related factors determine the potential for spray drift. The applicator and the grower are responsible for considering all these factors when making decisions.

The following drift management requirements must be followed to avoid off-target drift movement from aerial applications:

1. The distance of the outer most operating nozzles on the boom must not exceed 3/4 the length of the rotor.
2. Nozzles must always point backward parallel with the air stream and never be pointed downwards more than 45 degrees.

Where states have more stringent regulations, they should be observed.

The applicator should be familiar with and take into account the information covered in the following Aerial Drift Reduction Advisory. [This information is advisory in nature and does not supersede mandatory label requirements.]

Aerial Drift Reduction Advisory

Information on Droplet Size: The most effective way to reduce drift potential is to apply large droplets. The best drift management strategy is to apply the largest droplets that provide sufficient coverage and control. Applying larger droplets reduces drift potential, but will not prevent drift if applications are made improperly, or under unfavorable environmental conditions (see Wind, Temperature and Humidity, and Temperature Inversions).

Controlling Droplet Size:
- Volume - Use high flow rate nozzles to apply the highest practical spray volume. Nozzles with higher rated flows produce larger droplets.
- Pressure - Do not exceed the nozzle manufacturer’s recommended pressures. For many nozzle types lower pressure produces larger droplets. When higher flow rates are needed, use higher flow rate nozzles instead of increasing pressure.
- Number of Nozzles - Use the minimum number of nozzles that provide uniform coverage.
- Nozzle Orientation - Orienting nozzles so that the spray is released parallel to the airstream produced larger droplets than other orientations and is the recommended practice. Significant deflection from horizontal will reduce droplet size and increase drift potential.
- Nozzle Type - Use a nozzle type that is designed for the intended application. With most nozzle types, narrower spray angles produce larger droplets. Consider using low-drift nozzles. Solid stream nozzles oriented straight back produce the largest droplets and the lowest drift.

Boom Length: For some use patterns, reducing the effective boom length to less than 3/4 of the wingspan or rotor length may further reduce drift without reducing swath width.

Application Height: Applications should not be made at a height greater than 10 feet above the top of the largest plants unless a greater height is required for aircraft safety. Making applications at the lowest height that is safe reduces exposure of droplets to evaporation and wind.

Swath Adjustment: When applications are made with a crosswind, the swath will be displaced downwind. Therefore, on the up and downwind edges of the field, the applicator must compensate for this displacement by adjusting the path of the aircraft upwind. Swath adjustment distance should increase, with increasing drift potential (higher wind, smaller drops, etc.).

Wind: Drift potential is lowest between wind speeds of 2 to 10 mph. However, many factors, including droplet size and equipment type determine drift potential at any given speed. Application should be avoided below 2 mph due to variable wind direction and high inversion potential. Note: Local terrain can influence wind patterns. Every applicator should be familiar with local wind patterns and how they affect spray drift.

Temperature and Humidity: When making applications in low relative humidity, set up equipment to produce larger droplets to compensate for evaporation. Droplet evaporation is most severe when conditions are both hot and dry.

Temperature Inversions: Applications should not occur during a local, low level temperature inversion because drift potential is high. Temperature inversions restrict vertical air mixing, which causes small suspended droplets to remain in a concentrated cloud. This cloud can move in unpredictable directions due to the light variable winds common during inversions. Temperature inversions are characterized by increasing temperatures with altitude and are common on nights with limited cloud cover and light to no wind. They begin to form as the sun sets and often continue into the morning. Their presence can be indicated by ground fog; however, if fog is not present, inversions can also be identified by the movement of the smoke from a ground source or an aircraft smoke generator. Smoke that layers and moves laterally in a concentrated cloud (under low wind conditions) indicates an inversion, while smoke that moves upward and rapidly dissipates indicates good vertical air mixing.

Sensitive Areas: The pesticide should only be applied when the potential for drift to adjacent sensitive areas (e.g., residential areas, bodies of water, known habitat for threatened or endangered species, non-target crops) is minimal (e.g., when wind is blowing away from the sensitive areas).

Ground Equipment: To aid in reducing spray drift, Garlon 4 should be used in thickened (high viscosity) spray mixtures using an agriculturally labeled drift control additive, high viscosity invert system, or equivalent as directed by the manufacturer. When using a spray thickening or inverting additive, follow all use directions and precautions on the product label. With ground equipment, spray drift can be reduced by keeping the spray boom as low as possible; by applying 20 gallons or more of spray per acre; by keeping the operating spray pressures at the lower end of the manufacturer’s recommended pressures for the specific nozzle type used (low pressure nozzles are available from spray equipment manufacturers); and by spraying when wind velocity is low. In handgun applications, select the minimum spray pressure that will provide adequate plant coverage (without forming a mist). Do not apply with nozzles that produce a fine droplet spray. Select nozzles and pressures which provide adequate plant coverage, but minimize the production of fine spray particles.

High Volume Leaf-Stem Treatment: To minimize spray drift, keep sprays no higher than brush tops and keep spray pressures low enough to provide coarse spray droplets. An agriculturally labeled thickening agent may be used to reduce drift.
Mixing Directions

Garlon 4 may be foliarily applied by diluting with water or by preparing an oil-water emulsion. For woody plant control, an oil-water emulsion performs more dependably under a broader range of conditions than a straight water dilution and is recommended for aerial applications.

Oil-Water Mixture Sprays
Prepare a premix of oil, surfactant and Garlon 4 in a separate container using diesel fuel, fuel oil, or kerosene plus an emulsifier such as Sponito 712 or Triton X-100. Use a jar test to check spray mix compatibility before preparing oil-water emulsion sprays in the mixing tank. Do not allow any water or mixtures containing water to get into the premix or Garlon 4 since a thick "invert" (water in oil) emulsion may form that will be difficult to break. Such an emulsion may also be formed if the premix or Garlon 4 is put into the mixing tank before the addition of water. Fill the spray tank about one-half full with water, then slowly add the premix with continuous agitation and complete filling the tank with water. Continue moderate agitation.

Ground Application: Add oil to the spray mix at a rate of 5 to 10% of the total mix, up to a maximum of 1 gallon of oil per acre, using agricultural spray emulsifiers according to mixing instructions below.

Aerial Application: Use oil and water in the spray mixture in a 1:5 ratio (1 part oil to 5 parts water), up to a maximum of 1 gallon of oil per acre according to mixing instructions below.

Oil Mixture Sprays for Basal Treatment
Prepare oil-based spray mixtures using either diesel fuel, No. 1 or No. 2 fuel oil, kerosene or a commercially available basal oil. Substitute other oils or dilluents only as recommended by the oil or diluent's manufacturer. When preparing an oil mixture, read and follow the use directions and precautions on the manufacturer's product label. Add Garlon 4 to the required amount of oil in the spray tank or mixing tank and mix thoroughly. If the mixture stands over 4 hours, reagitation is required.

Oil Mixtures of Garlon 4 and Tordon K: Tordon K and Garlon 4 may be used in tank mix combination for basal bark treatment of woody plants. These herbicides are incompatible and will not form a stable mixture when mixed together directly in oil. Make a stable tank mixture for basal bark application by first combining each product with a compatibility agent prior to final mixing in the desired ratio. (See product bulletin for mixing instructions.) Tordon K is not registered for use in the states of California and Florida.

Water Dilutions
For water dilutions, an agricultural surfactant at the manufacturer’s recommended rate may be added to the spray mixture to provide improved wetting of foliage. To help minimize spray drift, a drift control and deposition aid cleared for application to growing crops is recommended.

Tank Mixing
Garlon 4 may be applied in tank mix combination with labeled rates of other herbicides provided (1) the tank mix product is labeled for the timing and method of application for the use site to be treated; and (2) tank mixing is not prohibited by the label of the tank mix product. When tank mixing Garlon 4 with other materials, a compatibility test (jar test) using relative proportions of the tank mix ingredients should be conducted prior to mixing ingredients in the spray tank. Use a clear glass quart jar with lid and mix the tank mix ingredients in the required order and their relative proportions. Invert the jar containing the mixture several times and observe the mixture for approximately 1/2 hour. If the mixture balls-up, forms flakes, sludges, jels, oily films or layers, or other precipitates, it is not compatible and the tank mix combination should not be used.

Mixing Order for Tank Mixes: Add one-half of the needed water to the mixing tank and start agitation. Add different materials in the order indicated below, allowing time for complete dispersion and mixing after addition of each product.

1. Water soluble herbicide (if used)
2. Premix of oil, emulsifier, Garlon 4 and other oil-soluble herbicide (if used); see below

Add the remaining water. During the final filling of the tank, add a drift control and deposition aid cleared for application to growing crops (if used), plus an agricultural surfactant (if a water dilution rather than an oil-water emulsion spray is used). Maintain continuous agitation of the spray mixture during mixing, final filling and throughout application to ensure spray uniformity.

Premixing: Prepare a premix of oil, emulsifier (if oil-water emulsion), and Garlon 4 plus other oil-soluble herbicide (if used), e.g., 2,4-D ester. Note: Do not allow water or mixtures containing water to get into the premix or Garlon 4 since a thick "invert” (water in oil) emulsion may form that will be difficult to break. Such an emulsion may also be formed if the premix or Garlon 4 is put into the mixing tank before the addition of water.

Tank Mixing Precautions:
• Read carefully and follow all applicable use directions, precautions, and limitations on the respective product labels.
• Do not exceed recommended application rates. If products containing the same active ingredient are tank mixed, do not exceed the maximum allowable active ingredient use rates.
• For direct injection or other spray equipment where the product formulations will be mixed in undiluted form, special care should be taken to ensure tank mix compatibility.
• Always perform a (jar) test to ensure the compatibility of products to be used in tank mixture.
Mixing with Liquid Fertilizer for Broadleaf Weed Control
Garlon 4 may be tank mixed with liquid nitrogen fertilizer and foliarly applied for weed control and fertilization of grass pastures. Use Garlon 4 in accordance with recommendations for grass pastures as given on this label. Apply at rates recommended by supplier or Extension Service Specialist. Note: Garlon 4 is not recommended for use with liquid fertilizers on woody plants (brush). Foliage burn caused by liquid fertilizer may reduce herbicide effectiveness on woody plants. Test for mixing compatibility using desired procedure and spray mix proportions in clear glass jar before mixing in spray tank. A compatibility aid such as Unite or Complex may be needed in some situations. Compatibility is best with straight liquid nitrogen fertilizer solutions. Mixing with N-P-K solutions or suspensions may not be satisfactory even with the addition of compatibility aid. Premixing Garlon 4 with 1 to 4 parts water may help in difficult situations.

Plants Controlled by Garlon 4

Woody Plant Species

<table>
<thead>
<tr>
<th>Alder</th>
<th>Cottonwood</th>
<th>Maple (except bigleaf, vine)</th>
<th>Sweetbay magnolia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrowwood</td>
<td>Crataegus (hawthorn)</td>
<td>Milkweed vine</td>
<td>Sweetgum</td>
</tr>
<tr>
<td>Ash</td>
<td>Dogwood</td>
<td>Mulberry</td>
<td>Sycamore</td>
</tr>
<tr>
<td>Aspen</td>
<td>Douglas-fir</td>
<td>Osage orange</td>
<td>Tanoak</td>
</tr>
<tr>
<td>Bear clover</td>
<td>Elderberry</td>
<td>Pepper vine</td>
<td>Thimbleberry</td>
</tr>
<tr>
<td>Beech</td>
<td>Elm (except winged elm)</td>
<td>Persimmon, eastern</td>
<td>Tree-of-heaven</td>
</tr>
<tr>
<td>Birch</td>
<td>Gallberry</td>
<td>Pine</td>
<td>(Ailanthus)</td>
</tr>
<tr>
<td>Blackberry</td>
<td>Gorse</td>
<td>Poison ivy</td>
<td>Trumpet creeper</td>
</tr>
<tr>
<td>Blackbrush</td>
<td>Granjeno</td>
<td>Poison oak</td>
<td>Tulip poplar</td>
</tr>
<tr>
<td>Blackgum</td>
<td>Guajillo</td>
<td>Poplar</td>
<td>Twisted acacia</td>
</tr>
<tr>
<td>Boxelder®</td>
<td>Guava</td>
<td>Salmonberry</td>
<td>Virginia creeper</td>
</tr>
<tr>
<td>Brazilian pepper</td>
<td>Hazel</td>
<td>Saltbush</td>
<td>Wax myrtle (top growth)</td>
</tr>
<tr>
<td>Buckthorn</td>
<td>Hickory</td>
<td>(Brachys spp.)</td>
<td>Wild rose</td>
</tr>
<tr>
<td>Cascara</td>
<td>Hornbeam</td>
<td>Salt cedar</td>
<td>Willow</td>
</tr>
<tr>
<td>Ceanothus</td>
<td>Huísache (supresseion)</td>
<td>Scotch broom</td>
<td>Willow primrose</td>
</tr>
<tr>
<td>Cherry®</td>
<td>Locust</td>
<td>Sumac</td>
<td>Winged elm</td>
</tr>
<tr>
<td>Chinquapin</td>
<td>Madrone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Choke cherry</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1For best control, use either a basal bark or cut stem treatment.
2For complete control, re-treatment may be necessary.
3Basal or dormant stem applications only.

Annual, Biennial and Perennial Broadleaf Weeds

Note: Numbers in parentheses refer to footnotes below table.

<table>
<thead>
<tr>
<th>Black medic</th>
<th>Dandelion (top growth)</th>
<th>Oxalis</th>
<th>Vetch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bull thistle</td>
<td>Dogfennel</td>
<td>Plantain</td>
<td>Wild carrot</td>
</tr>
<tr>
<td>Burdock</td>
<td>Field bindweed</td>
<td>Purple loosestife</td>
<td>(Queen Anne's lace)</td>
</tr>
<tr>
<td>Canada thistle</td>
<td>Goldenrod</td>
<td>Ragweed</td>
<td>Wild lettuce</td>
</tr>
<tr>
<td>Chicory</td>
<td>Ground ivy</td>
<td>Soroa lespedeza (1)</td>
<td>Wild violet</td>
</tr>
<tr>
<td>Cincifoil</td>
<td>Lambsquarters</td>
<td>Smartweed</td>
<td>Yarrow</td>
</tr>
<tr>
<td>Clover</td>
<td>Lespedeza</td>
<td>Sulfur cinquefoil (2)</td>
<td></td>
</tr>
<tr>
<td>Creeping beggarweed</td>
<td>Matchweed</td>
<td>Sweet clover</td>
<td></td>
</tr>
<tr>
<td>Curry dock</td>
<td>Mustard</td>
<td>Tropical soda apple (3)</td>
<td></td>
</tr>
</tbody>
</table>

1. *Sericea lespedeza*: Apply 1 to 2 pints of Garlon 4 per acre. For best results, apply after maximum foliage development in the late spring to early summer, but prior to bloom.
2. *Sulfur cinquefoil*: Apply 1 to 2 pints of Garlon 4 per acre. For best results, apply to plants in the rosette stage.
3. *Tropical soda apple*: Apply 2 pints of Garlon 4 per acre when tropical soda apple plants reach the first flower stage. For best results, apply in a total spray volume of 40 gallons per acre using ground equipment. An agricultural surfactant may be added at the manufacturer's recommended rate to provide more complete wetting and coverage of the foliage. Spot treatments may be used to control sparse plant stands. For spot treatment use a 1 to 1.5% solution of Garlon 4 in water (1 to 1 1/2 gallons of Garlon 4 in 100 gallons total spray mixture) and spray the entire plant to completely wet the foliage. In Florida, control of tropical soda apple may be improved by using the following management practices:
• Mow plants to a height of 3 inches every 50 to 60 days or whenever they reach flowering. Continue the mowing operation through April.
• In late May to June (50 to 60 days after the April mowing), apply Garlon 4 as a broadcast treatment.
• Use spot treatment to control any remaining plants or thin stands of plants that germinate following a broadcast treatment.

Application Methods

Use Garlon 4 at rates of 1 to 8 quarts per acre to control broadleaf weeds and woody plants. It is suggested that rates higher in this rate range be used to control woody plants. In all cases, use the amount specified in enough water to give uniform and complete coverage of the plants to be controlled. The order of addition to the spray tank is water, spray thickening agent (if used), surfactant (if used), additional herbicide (if used), and Garlon 4. If a standard agricultural surfactant is used, use at a rate of 1 to 2 quarts per acre. Use continuous adequate agitation.

Before using any recommended tank mixtures, read the directions and precautions on both labels.

For best results apply when woody plants and weeds are actively growing. When hard to control species such as ash, blackgum, choke cherry, elm, maples (other than vine or big leaf), oaks, pines, or winged elm are prevalent, during applications made during late summer when the plants are mature, or during drought conditions, use the higher rates of Garlon 4 alone or in combination with Tordon® 101 Mixture specialty herbicide or Tordon K herbicide. Tordon 101 Mixture and Tordon K are restricted use pesticides. Tordon 101 Mixture and Tordon K are not registered for use in the states of California and Florida.

When using Garlon 4 in combination with 2,4-D low volatile ester herbicide, generally the higher rates of Garlon 4 should be used for satisfactory brush control.

Use the higher dosage rates when brush approaches an average of 15 feet in height or when the brush covers more than 60% of the area to be treated. If lower rates are used on hard to control species, respouting may occur the year following treatment.

On sites where easy to control brush species dominate, rates less than those listed may be effective. Consult state or local extension personnel for such information.

Foliage Treatment With Ground Equipment

Use sufficient spray volume to completely and uniformly cover foliage. For ground application, apply 10 gallons or more of total spray volume per acre. Use higher spray volumes for ground applications to ensure adequate coverage with increased depth and density of foliage, particularly for treatment of woody plants.

High Volume Foliage Treatment

For control of woody plants, use Garlon 4 at the rate of 2 to 6 quarts per 100 gallons of spray mixture, or Garlon 4 at 2 to 4 quarts may be tank mixed with labeled rates of 2,4-D low volatile ester herbicide, Tordon 101 Mixture, or Tordon K and diluted to make 100 gallons of spray. Do not apply more than 2 gallons of Garlon 4 per acre. On rangeland and permanent pasture sites, make 1 application per year and apply no more than 2 quarts of Garlon 4 (2 lb ae of triclopyr) per acre. Apply at a volume of 100 to 400 gallons of total spray per acre depending upon size and density of woody plants. Tordon 101 Mixture and Tordon K are not registered for use in the states of California and Florida. When tank mixing, follow applicable use directions and precautions on each manufacturer’s label.

Depending upon the size and density of the woody plants, apply sufficient spray volume to thoroughly wet all leaves, stems, and root collars. To minimize spray drift, select the minimum spray pressure that provides adequate plant coverage without forming a mist and direct sprays no higher than the top of the target plants. Use a drift control additive cleared for application to growing crops to reduce spray drift. Before using any tank mixture, read the directions and use precautions on both labels. For best results, apply when woody plants and weeds are actively growing.

Table 1: The following table is provided as a guide to the user to achieve the proper rate of Garlon 4.

<table>
<thead>
<tr>
<th>Total Spray Volume (gallons/acre)</th>
<th>Rate of Garlon 4</th>
<th>Forestry Sites (qt/100 gallons of spray)</th>
<th>Non-Cropland Sites (qt/100 gallons of spray)</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>1.5</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>300</td>
<td>2</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>6</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>12</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>15</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>20</td>
<td>26.7</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>30</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>60</td>
<td>80</td>
<td></td>
</tr>
</tbody>
</table>

Do not exceed the maximum use rate of 6 qt of Garlon 4 (6 lb ae of triclopyr) per acre per year.

Do not exceed the maximum use rate of 8 qt of Garlon 4 (8 lb ae of triclopyr) per acre per year for non-grazable areas, or 2 qt (2 lb ae of triclopyr) per acre per year for grazed areas, except on portions of grazed areas that meet the following requirement. Portions of grazed areas that intersect treated non-cropland, rights-of-way and forestry sites may be treated at up to 8 lb ae per acre if the area to be treated on the day of application comprises no more than 10% of the total grazable area.
coverage of target plants including the surfaces of foliage, stems, and density of target woody plants and kind of spray equipment used. When treating tall, dense brush, a truck mounted spray gun with spray tips that deliver less than 1 gallon per minute may be appropriate for short, low to moderate density brush.

Tank Mixing: As a low volume foliage spray, up to 12 quarts of Garlon 4 may be applied in tank mix combination with labeled rates of Tordon K or Tordon 22K in 10 to 100 gallons of finished spray. Tordon 101 Mixture and Tordon K are not registered for use in the states of California and Florida.

Table 2

<table>
<thead>
<tr>
<th>Garlon 4 Plus Tank Mix Product</th>
<th>Rate (qt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 -4 qt</td>
<td>--</td>
</tr>
<tr>
<td>1 - 2 qt</td>
<td>Grazon® P+D specially herbicide</td>
</tr>
<tr>
<td>1 - 2 pt</td>
<td>2,4-D low volatile ester herbicide</td>
</tr>
<tr>
<td>1 - 2 qt</td>
<td>Tordon 22K</td>
</tr>
<tr>
<td>2 qt</td>
<td>Reclaim® specialty herbicide</td>
</tr>
</tbody>
</table>

1 Reclaim is registered for use only in Arizona, Texas, Oklahoma and New Mexico.

2 See directions for Mesquite Control Using High Volume Foliage Treatment below.

Mesquite Control Using High Volume Foliage Treatment: For control of mesquite infestations of low to moderate density, apply Garlon 4 and Reclaim in a tank mixture to individual plants with backpack or hand-held sprayers or a vehicle-mounted sprayer with hand-held spray wand or spray gun. For individual plant treatment, use 2 quarts of Garlon 4 in combination with 2 quarts of Reclaim per 100 gallons of total spray solution (1/2% v/v each product). Apply in water or as an oil-water emulsion as described in Mixing Directions. If using an oil-water emulsion, add the oil at a rate of 5% of the total spray volume. Apply as a complete spray-to-wet foliar application, including all leaves. Thorough coverage is necessary for good results, but do not spray to the point of runoff. Do not apply when mesquite foliage is wet. The total amount of Garlon 4 applied should not exceed 1 1/3 pints per acre. For best results, follow information given elsewhere in this label concerning effect of environmental conditions and application timing on control. This application method works best for brush less than 8 feet tall since efficient treatment and thorough coverage of taller brush is difficult to achieve with this method. To minimize drift, select a spray nozzle and pressure that provides good coverage while forming a coarse spray. Additionally, drift may be reduced by using the minimum pressure necessary to obtain plant coverage without forming a mist and by directing sprays no higher than the top of target plants. If desired, a spray dye may be added to the spray mixture to mark the treated plants.

Low Volume Foliage Treatment

To control susceptible woody plants, mix up to 20 quarts of Garlon 4 in 10 to 100 gallons of finished spray. The spray concentration of Garlon 4 and total spray volume per acre should be adjusted according to the size and density of target woody plants and kind of spray equipment used. With low volume sprays, use sufficient spray volume to obtain uniform coverage of target plants including the surfaces of foliage, stems, and root collars (see General Use Precautions and Restrictions). For best results, a surfactant should be added to all spray mixtures. Match equipment and delivery rate of spray nozzles to height and density of woody plants. When treating tall, dense brush, a truck mounted spray gun with spray tips that deliver up to 2 gallons per minute at 40 to 60 psi may be required. Backpack or other types of specialized spray equipment with spray tips that deliver less than 1 gallon of spray per minute may be appropriate for short, low to moderate density brush.

Broadcast Applications With Aerial or Ground Equipment

Environmental conditions and application timing influence brush and weed control results. For best results, apply when woody plants and weeds are actively growing. For woody species, apply after the rapid growth period of early spring when leaf tissue is fully expanded and terminal growth has slowed. Brush regrowth should be at least 4 ft high prior to treatment to insure adequate foliage for herbicide absorption. Adequate soil moisture before and after treatment as well as the presence of healthy foliage at the time of application are important factors contributing to optimal herbicidal activity.

Use sufficient spray volume to completely and uniformly cover foliage. For ground application, apply 10 gallons or more of total spray volume per acre. For aerial application, apply at least 2 gallons of total spray volume per acre. Use higher spray volumes for ground or aerial applications to ensure adequate coverage with increased depth and density of foliage, particularly for treatment of woody plants.

Mesquite: The herbicidal response of mesquite is strongly influenced by foliage condition, growth stage and environmental conditions. For best results, apply when new growth foliage has turned from light to dark green, when the soil temperature is above 75°F at a depth of 12 to 18 inches, and soil moisture is adequate for plant growth. Apply within 60 days after the 75°F minimum soil temperature at the 12- to 18-inch depth has been reached. Product performance may be adversely affected if application is made before mesquite foliage has turned from light to dark green or if foliage has been injured or removed by late frost, insects, hail or plant diseases. Do not treat if mesquite exhibits new (light green) terminal growth in response to recent heavy rainfall during the growing season. Rate of soil warm-up at the 12- to 18-inch depth may vary with soil texture and drainage. Coarse-textured (sandy) soils warm up sooner than fine-textured (clay soils) and dry soils warm up more quickly than wet soils. Mesquite regrowth should be at least 4 ft high prior to treatment to insure adequate foliage for herbicide absorption.

Mesquite Only

Apply 1/2 to 1 pint of Garlon 4 per acre in combination with 2/3 to 1 1/3 pint per acre of Reclaim. See label for Reclaim for additional treatment recommendations and information on mesquite control. Apply aerially as an oil-water emulsion in 4 gallons or more total volume per acre or with ground equipment in 10 gallons or more total volume per acre. Use a maximum of 1 gallon of oil per acre for aerial or ground application.

Mesquite and Pricklypear Cactus

If pricklypear cactus is a target species in association with mesquite, apply a tank mix of 1/2 to 1 pint of Garlon 4 with 1 to 2 pints of Tordon 22K per acre. (The 2 pint per acre rate of Tordon 22K provides a higher and more uniform plant kill of pricklypear.) Tordon 22K may also be applied in combination with Reclaim to control pricklypear while providing improved control of mesquite. See labels for Tordon 22K and Reclaim for additional information and treatment recommendations. Apply aerially as an oil-water emulsion in 4 gallons or more total volume per acre or with ground equipment in 10 gallons or more total volume per acre. If mesquite canopy is dense, use higher spray volumes. Use a maximum of 1 gallon of oil per acre for aerial or ground application.
South Texas Mixed Brush (Mesquite, Pricklypear Cactus, Blackbrush, Twisted Acacia and Granjeno)

Use 1 to 2 pints of Garlon 4 in a tank mix with 2 pints of Tordon 22K per acre if pricklypear is a problem, or with 2/3 to 1 1/3 pints of Reclaim per acre if mesquite is the prevalent species. Garlon 4 contributes to the control of non-legume species such as granjeno and oaks. However, if woody legume species are predominant, apply 2 pints of Tordon 22K per acre in combination with 2/3 to 1 1/3 pints of Reclaim per acre for improved control. See labels for Tordon 22K and Reclaim for additional information and treatment recommendations. Apply aerially in an oil:water emulsion in 4 gallons or more total volume per acre or with ground equipment in 15 gallons or more total volume per acre. Use a maximum of 1 gallon of oil per acre for aerial or ground application. The use of an oil:water emulsion is critical and good spray coverage is essential for acceptable brush control.

Sand Shinnery Oak Suppression

In Texas, New Mexico and Oklahoma, apply Garlon 4 alone at a rate of 1/2 to 2 pints per acre for suppression of shinnery oak growing on sandy soils. Grass response following suppression may be impressive where rainfall is adequate. Grazing deferment following application together with proper grazing management is recommended to allow for the reestablishment of grass stands.

Post Oak and Blackjack Oak - Regrowth Stands

Apply in the late spring (May) to early summer (June-July) when oak leaves are fully developed (expanded). Use 2 quarts of Garlon 4 alone or in tank mix combination with 0.5 to 1 pints of 2,4-D low-volatile ester herbicide per acre. Apply in an oil:water emulsion or water surfactant dilution in sufficient total volume per acre to assure thorough coverage, usually 5 gallons or more per acre by fixed-wing aircraft or helicopter or 15 to 25 gallons per acre by ground equipment. Use a maximum of 1 gallon of oil per acre for aerial or ground application. Lower rates may be used for suppression only. Control will require at least 3 consecutive treatments. Note: Regrowth plants have a large root mass relative to top growth when compared to undisturbed plants. In order for top growth to intercept and translocate enough herbicide to control the roots, delay broadcast treatment until top growth is at least 4 ft tall.

High Volume Foliage Treatment: For regrowth less than 4 ft tall, apply 2 quarts of Garlon 4 per 100 gallons of water and 2 quarts of ag surfactant alone or in tank mix combination with 1 gallon of Grazon P+D or 1 quart of Tordon 22K. Apply a high volume leaf-stem treatment to individual plants using ground equipment.

Post Oak and Blackjack Oak - Mature Stands

For control of mature stands (greater than 5 ft tall), apply 2 quarts of Garlon 4 per acre in late spring (May) to early summer (June-July) when oak leaves are fully developed (expanded). Understory species such as winged elm, buckbrush, tree huckleberry and ash occurring in some areas will not be controlled (only suppressed or defoliated) by using Garlon 4 alone. Where these understory species occur, control may be improved by tank mixing 2 quarts of Garlon 4 with 1 quart of Tordon 22K or 4 quarts of Grazon P+D per acre. For best results, apply as an oil:water emulsion in a total volume of 5 gallons per acre or more by fixed-wing aircraft or helicopter.

Other Susceptible Woody Plants

Apply 2 to 4 pints of Garlon 4 alone or in combination with 2 to 3 quarts of 3.8 lb/gal 2,4-D low volatile ester or amine formulation per acre. If difficult to control species such as ash, choke cherry, elm, maple or oaks are prevalent, and during applications made when plants are mature late in the summer or during drought conditions, use the higher rates of Garlon 4, alone or with 2,4-D. Garlon 4 may also be applied in a tank mixture with Grazon P+D or Tordon 22K for increased control of certain species. See labels for Grazon P+D and Tordon 22K for additional information and treatment recommendations. Apply aerially in 4 gallons or more total volume per acre or with ground equipment in 10 gallons or more total volume per acre. For best results on blackberry, apply during or after bloom. For management of kudzu, apply 1 quart of Garlon 4 per acre. Repeat application may be necessary to achieve desired level of control.

Susceptible Broadleaf Weeds

Use 2 pints of Garlon 4 alone in a water spray. Apply as a broadcast spray in a total volume of 10 gallons or more per acre by ground equipment or aerially in a total volume of 2 gallons or more per acre. Apply anytime the weeds are actively growing. Garlon 4 at 1/2 to 3 pints may be tank mixed with 1 to 2 quarts of 3.8 lb/gal 2,4-D amine or low volatile ester.

Woody Plant Control

Foliage Treatment: Use 4 to 8 quarts of Garlon 4 in enough water to make 5 gallons or more per acre of total spray, or 1 1/2 to 3 quarts of Garlon 4 may be combined with labeled rates of 2,4-D low volatile ester, Tordon 101 Mixture, or Tordon K in sufficient water to make 5 gallons or more per acre of total spray. Tordon 101 Mixture and Tordon K are not registered for use in the states of California and Florida.

Broadleaf Weed Control

Use Garlon 4 at rates of 1 to 4 quarts in a total volume of 5 gallons or more per acre as a water spray mixture. Apply anytime weeds are actively growing. Garlon 4 at 0.25 to 3 quarts may be tank mixed with labeled rates of 2,4-D amine or low volatile ester, Tordon K, or Tordon 101 Mixture to improve the spectrum of activity. For thickened (high viscosity) spray mixtures, Garlon 4 can be mixed with diesel oil or other inverting agent. When using an inverting agent, read and follow the use directions and precautions on the product label. Tordon 101 Mixture and Tordon K are not registered for use in the states of California and Florida.

Foliage Treatment (Utility and Pipeline Rights-of-Way)

Use 4 to 8 quarts of Garlon 4 alone, or 3 to 4 quarts of Garlon 4 in a tank mix combination with labeled rates of 2,4-D low volatile ester, Tordon 101 Mixture or Tordon K and apply in a total spray volume of 10 to 30 gallons per acre. Use the higher rates and volumes when plants are dense or under drought conditions. Tordon 101 Mixture and Tordon K are not registered for use in the states of California and Florida.

Portions of grazed areas that intersect treated non-cropland, rights-of-way and forestry sites may be treated at up to 8 lb ae per acre if the area to be treated on the day of application comprises no more than 10% of the total grazable area.
Basal Bark, Dormant Stem and Cut Surface Treatments

Individual plant treatments such as basal bark and cut surface applications may be used on any use site listed on this label at a maximum use rate of 8 lb ae of triclopyr per acre. These types of applications are made directly to ungrazed parts of plants and, therefore, are not restricted by the grazing maximum rate of 2 lb ae of triclopyr per acre.

Basal Bark Treatment

To control susceptible woody plants with stems less than 6 inches in basal diameter, mix 1 to 5 gallons of Garlon 4 in enough oil to make 100 gallons of spray mixture. Apply with a backpack or knapsack sprayer using low pressure and a solid cone or flat fan nozzle. Direct the spray at a point approximately 4 feet above ground. Vary spray mixture concentration with size and susceptibility of the species being treated. Better control is achieved when spray is applied to thin juvenile bark and above rough thickened mature bark. This technique is not recommended for scrub and live oak species, including blackjack, turkey, post, live, bluejack and laurel oaks, or bigleaf maple. Apply anytime, including winter months, except when snow or water prevents spraying to the ground line. Mixing with oil requires vigorous agitation to form an oil solution. Once a solution is formed it will stay stable.

Low Volume Basal Bark Treatment

To control susceptible woody plants with stems less than 6 inches in basal diameter, mix 20 to 30 gallons of Garlon 4 in enough oil to make 100 gallons of spray mixture. Apply with a backpack or knapsack sprayer using low pressure and a solid cone or flat fan nozzle. Direct the spray at a point approximately 4 feet above ground. Vary spray mixture concentration with size and susceptibility of the species being treated. Better control is achieved when spray is applied to thin juvenile bark and above rough thickened mature bark. This technique is not recommended for scrub and live oak species, including blackjack, turkey, post, live, bluejack and laurel oaks, or bigleaf maple. Apply anytime, including winter months, except when snow or water prevents spraying to the desired height above ground level. Note: Best results with some hardwood species occur when applications are made from approximately 6 weeks prior to leaf expansion in the spring until approximately 2 months after leaf expansion is completed. Mixing with oil requires vigorous agitation to form an oil solution. Once a solution is formed it will stay stable.

Low Volume Stem Bark Band Treatment (North Central and Lake States)

To control susceptible woody plants with stems less than 6 inches in basal diameter, mix 20 to 30 gallons of Garlon 4 in enough oil to make 100 gallons of spray mixture. Apply with a backpack or knapsack sprayer using low pressure and a solid cone or flat fan nozzle. Direct the spray in a 6- to 10-inch wide band that completely encircles the stem. Spray in a manner that completely wets the bark, but not to the point of runoff. The treatment band may be positioned at any height up to the first major branch. For best results, apply the band as low as possible. Spray mixture concentration should vary with size and susceptibility of species to be treated. Applications may be made anytime, including winter months. Mixing with oil requires vigorous agitation to form an oil solution. Once a solution is formed it will stay stable.

Thinline Basal Bark Treatment

To control susceptible woody plants with stems less than 6 inches in diameter, apply Garlon 4, either undiluted or mixed at 50 to 75% v/v with oil, in a thin stream to all sides of the lower stems. The stream should be directed horizontally to apply a narrow band of Garlon 4 around each stem or clump. Use a minimum of 2 to 15 milliliters of Garlon 4 or oil mixture with Garlon 4 to treat single stems and from 25 to 100 milliliters to treat clumps of stems. Use an applicator metered or calibrated to deliver the small amounts required. Mixing with oil requires vigorous agitation to form an oil solution. Once a solution is formed it will stay stable.

Streamline Basal Bark Treatment (Southern States)

To control or suppress susceptible woody plants for conifer release, mix 20 to 30 gallons of Garlon 4 in enough oil to make 100 gallons of spray mixture. Streamline basal bark treatments are most effective on stems less than 4 inches in basal diameter. Apply with a backpack or knapsack sprayer using equipment that provides a directed straight stream spray. Apply the spray in a 2- to 3-inch wide band to one side of stems less than 3 inches in basal diameter. When the optimum amount of spray mixture is applied, the treated zone should widen to encircle the stem within approximately 30 minutes. Treat both sides of stems which are 3 to 4 inches in basal diameter. Direct the spray at bark that is approximately 12 to 24 inches above ground. Pines (lobolly, slash, shortleaf, and Virginia) up to 2 inches in diameter breast height (dbh) can be controlled by directing the spray at a point approximately 4 feet above ground. Vary spray mixture concentration with size and susceptibility of the species being treated. Better control is achieved when spray is applied to thin juvenile bark and above rough thickened mature bark. This technique is not recommended for scrub and live oak species, including blackjack, turkey, post, live, bluejack and laurel oaks, or bigleaf maple. Apply anytime, including winter months, except when snow or water prevents spraying to the desired height above ground level. Note: Best results with some hardwood species occur when applications are made from approximately 6 weeks prior to leaf expansion in the spring until approximately 2 months after leaf expansion is completed. Mixing with oil requires vigorous agitation to form an oil solution. Once a solution is formed it will stay stable.

Garlon 4 Plus Tordon K in Oil Tank Mix: Garlon 4 and Tordon K may be used in tank mix combination as a low volume basal bark treatment to improve control of certain woody species such as ash, elm, maple, poplar, aspen, hackberry, oak, oceanspray, birch, hickory, pine, tanoak, cherry, locust, sassafras, and multiflora rose. (See product bulletin for mixing instructions.) Tordon K is not registered for use in the states of California and Florida.
Dormant Stem Treatment

Dormant stem treatments control susceptible woody plants and vines with stems less than 2 inches in diameter. Plants with stems greater than 2 inches in diameter may not be controlled and resprouting may occur. This treatment method is best suited for sites with dense, small diameter brush. Dormant stem treatments of Garlon 4 can also be used as a chemical side trimming for controlling lateral branches of larger trees that encroach onto roadside, utility, or other rights-of-way.

Mix 4 to 8 quarts of Garlon 4 in 2 to 3 gallons of crop oil concentrate or other recommended oil and add this mixture in enough water to make 100 gallons of spray solution. Use continuous adequate agitation. Apply with knapsack or power spraying equipment, using low pressure (20 to 40 psi). In western states, apply anytime after woody plants are dormant and most of the foliage has dropped. In other areas apply anytime within 10 weeks of budbreak, generally February through April. Thoroughly wet the upper parts of the stems and use the remainder to wet the lower 12 to 15 inches above the ground to the point of runoff. For root suckering species such as sumac, sassafras and locust, also spray the ground under the plant to cover small root suckers which may not be visible above the soil surface. For oil-water mixture application, mix 6 quarts of Garlon 4, 25 gallons of oil and 1.5 gallons of an approved agricultural spray emulsifier such as Sponto 712 or Triton X-100 as indicated in the mixing directions. Treat as above. Garlon 4 may be mixed with 4 quarts of Weedone 170 herbicide to improve the control of black cherry and broaden the spectrum of herbicidal activity. Do not apply to wet or saturated bark as poor control may result.

Cut Stump Treatment

To control resprouting, mix 20 to 30 gallons of Garlon 4 in enough oil to make 100 gallons of spray mixture. Apply with a backpack or knapsack sprayer using low pressures and a solid cone or flat fan nozzle. Spray the root collar area, sides of the stump, and the outer portion of the cut surface, including the cambium, until thoroughly wet, but not to the point of runoff. Spray mixture concentration should vary with the size and susceptibility of species treated. Apply anytime, including in winter months, except when snow or water prevent spraying to the ground line. Mixing with oil requires vigorous agitation to form an oil solution. Once a solution is formed it will stay stable.

Cut Stump Treatment in Western States

To control resprouting of salt cedar and other Tamarix species, bigleaf maple, tanoak, Oregon myrtle, and other susceptible species, apply undiluted Garlon 4 to wet the cambium and adjacent wood around the entire circumference of the cut stump. Treatments may be applied throughout the year; however, control may be reduced with treatment during periods of moisture stress as in late summer. Cut stumps so that they are approximately level to facilitate uniform coverage of Garlon 4. Use an applicator which can be calibrated to deliver the small amounts of material required.

Growing Point and Leaf Base (Crown) Treatment of Yucca

Prepare a 2% v/v solution of Garlon 4 in diesel or fuel oil (13 fl oz of Garlon 4 in 5 gallons of spray mixture). Thoroughly wet the center of the plant including growing point and leaf bases to the soil surface. Complete coverage of leaves is not necessary.

Forest Management Applications

For broadcast applications, apply 1 to 6 quarts of Garlon 4 per acre in a total spray volume of 5 to 25 gallons per acre by air or 10 to 100 gallons per acre by ground. Use spray volumes sufficient to provide thorough coverage of treated foliage. Nozzles or additives that produce larger droplets of spray may require higher spray volumes to provide adequate coverage.

Plant Back Interval for Conifers: Conifers planted sooner than 1 month after treatment with Garlon 4 at less than 4 quarts per acre or sooner than 2 months after treatment at 4 to 6 quarts per acre may be injured. When tank mixtures of herbicides are used for forest site preparation, labels for all products in the mixture should be consulted and the longest recommended waiting period before planting observed.

Forest Site Preparation (Not for Conifer Release)

Southern States including Alabama, Arkansas, Delaware, Florida, Georgia, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia: To control susceptible woody plants and broadleaf weeds, apply Garlon 4 at a rate of 4 to 6 quarts per acre. To broaden the spectrum of woody plants and broadleaf weeds controlled, apply 2 to 4 quarts of Garlon 4 per acre in tank mix combination with labeled rates of Tordon 101 Mixture or Tordon K. Tordon 101 Mixture and Tordon K are not registered for use in the state of Florida. Where grass control is also desired, Garlon 4, alone or in tank mix combination with Tordon K or Tordon 101 Mixture, may be applied with labeled rates of other herbicides registered for grass control in forests. Use of tank mix products must be in accordance with the most restrictive of label limitations and precautions. Do not exceed labeled application rates. Garlon 4 cannot be tank mixed with any product containing a label prohibition against such mixing.

Western, Northeastern, North Central, and Lake States (States not Listed Above as Southern States): To control susceptible woody plants and broadleaf weeds, apply Garlon 4 at a rate of 3 to 6 quarts per acre. To broaden the spectrum of woody plants and broadleaf weeds controlled, apply 1.5 to 3 quarts of Garlon 4 per acre in tank mix combination with labeled rates of Tordon 101 Mixture, Tordon K, or 2,4-D low volatility ester. Tordon 101 Mixture and Tordon K are not registered for use in the state of California. Where grass control is also desired, Garlon 4, alone or in tank mix combination with Tordon 101 Mixture or Tordon K, may be applied with labeled rates of other herbicides registered for grass control in forests. When applying tank mixes, follow applicable use directions and precautions on each product label.

Southern Coastal Flatwoods: To control susceptible broadleaf weeds and woody species such as gallberry and wax-myrtle, and for partial control of saw-palmetto, apply 2 to 4 quarts of Garlon 4 per acre. To broaden the spectrum of species controlled to include fetterbush, staggerbush, ti, and grasses, apply 2 to 3 quarts of Garlon 4 per acre in tank mix combination with labeled rates of Arsenal Applicator’s Concentrate herbicide. Where control of gallberry, wax-myrtle, broadleaf weeds, and grasses is desired, apply 2 to 3 quarts of Garlon 4 per acre in tank mix combination with labeled rates of Accord Concentrate or Accord SP herbicide.

These treatments may be broadcast during site preparation of flat planted or bedded sites or, on bedded sites, applied in bands over the top of beds. For best results, apply in late summer or fall. Efficacy may not be satisfactory when applications are made in early season prior to August. Note: Do not apply after planting pines.
Directed Spray Applications for Conifer Release

To release conifers from competing hardwoods and brush such as red maple, sugar maple, striped maple, sweetgum, red and white oaks, ash, hickory, alder, birch, aspen, pin cherry, Ceanothus spp., blackberry, chinquapin, and poison oak, mix 4 to 20 quarts of Garlon 4 in enough water to make 100 gallons of spray mixture. This spray mixture should be directed onto foliage of competitive hardwoods using knapsack or backpack sprayers with flat fan nozzles or equivalent anytime after the hardwoods and brush have reached full leaf size, but before autumn coloration. The majority of treated hardwoods and brush should be less than 6 feet in height to ensure adequate spray coverage. Care should be taken to direct spray away from contact with conifer foliage, particularly foliage of desirable pines. See Table 1 for relationship between mixing rate, spray volume and maximum application rate.

Note: Spray may cause temporary damage and growth suppression where contact with conifers occurs; however, injured conifers should recover and grow normally. Over-the-top spray applications can kill pines.

Broadcast Applications for Mid-Rotation Understory Brush Control in Southern Coastal Flatwoods Pine Stands (Ground Equipment Only)

For control of susceptible species such as gallberry and wax-myrtle and broadleaf weeds, apply 2 to 4 quarts of Garlon 4 per acre. To broaden the spectrum of woody plants controlled to include fetterbush, staggerbush, and tili, apply 2 to 3 quarts of Garlon 4 per acre in tank mix combination with labeled rates of Arsenal Applicator’s Concentrate. Saw-palmetto will be partially controlled by use of Garlon 4 at 4 quarts per acre or by mixtures of Garlon 4 at 2 to 3 quarts per acre in tank mix combination with either Arsenal Applicator’s Concentrate or Escort herbicide. These mixtures should be broadcast applied over target understory brush species, but to prevent injury to pines, make applications underneath the foliage of pines. Apply sprays in 30 gallons or more per acre of total volume. For best results, apply in late summer or fall. Efficacy may not be satisfactory when applications are made in early season prior to August.

Broadcast Applications for Conifer Release in the Pacific Northwest and California

Dormant Conifers Before Bud Swell (Excluding Pines): To control or suppress deciduous hardwoods such as vine maple, bigleaf maple, alder, scotch broom, or willow before leaf-out, or evergreen hardwoods such as madrone, chinquapin, and Ceanothus spp., use Garlon 4 at 1 to 2 quarts per acre. Use diesel or fuel oil as a diluent, or use water plus 1 to 2 gallons per acre of diesel oil or a suitable surfactant or oil substitute at manufacturer’s recommended rates. Mixing with oil as the only diluent requires vigorous agitation to form an oil solution. Once a solution is formed it will stay stable.
Terms and Conditions of Use
If terms of the following Warranty Disclaimer, Inherent Risks of Use, and Limitation of Remedies are not acceptable, return unopened package at once to the seller for a full refund of purchase price paid. Otherwise, use by the buyer or any other user constitutes acceptance of the terms under Warranty Disclaimer, Inherent Risks of Use and Limitation of Remedies.

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1. Refund of purchase price paid by buyer or user for product bought, or
2. Replacement of amount of product used.

To the extent permitted by law, Dow AgroSciences shall not be liable for losses or damages resulting from handling or use of this product unless Dow AgroSciences is promptly notified of such loss or damage in writing.

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Revisions:
1. Product may be applied by fixed wing aircraft or helicopter.
2. Added mixing directions section.
3. Added blackbrush, granjeno, guajillo, guava, milkweed vine, osage orange, pepper vine, trumpet creeper, twisted acacia, Virginia creeper and willow primrose to list of woody plants controlled.
4. Added biennial broadleaf weeds to list of weeds controlled.
5. Added dormant stem and cut surface treatments.
Resources
Invasive aquatic plants harm Florida’s natural environment and lead to a loss of biodiversity. They usually cannot be completely eradicated and will grow back quickly if not managed. The Florida Legislature designated the Florida Fish and Wildlife Conservation Commission (FWC) as the lead agency to “direct the control, eradication, and regulation of noxious aquatic weeds and direct the research and planning related to these activities . . . so as to protect human health, safety, and recreation and, to the extent possible, prevent injury to plant and animal life and property.” FWC currently controls about 12 of the most problematic aquatic invasive plants. In Florida, hydrilla and water hyacinth are two of the the worst aquatic weeds, requiring constant attention and management.

**Hydrilla** (*Hydrilla verticillata*) was first introduced into Florida from Sri Lanka as an aquarium plant during the early 1950s. Hydrilla can cover an entire waterbody in as little as a few seasons, and grow from 30% coverage to 70% coverage of a lake in just a few months. Hydrilla can spread by fragmentation, so nearly every fragment that breaks off can start a new plant. This can lead to dense stands of hydrilla where nothing else grows. Hydrilla now infests tens of thousands of acres in Florida public waters. It also has spread to about 30 states as far away as Massachusetts and California. Hydrilla requires constant management, most often using chemical and mechanical control methods. Management costs for this plant in Florida public waters approach $20 million each year.

**Water hyacinth** (*Eichhornia crassipes*) is a floating plant native to South America. It was introduced into Florida during the late 1800s. Water hyacinth is one of the fastest growing plants; it can double its population in 6-18 days. When it covers the water’s surface, sunlight is prevented from reaching native plants below. Control programs in recent decades have successfully reduced water hyacinth to low levels in most public waterways in Florida. This was not the case in earlier times. Florida has been managing aquatic invasive plants, beginning with water hyacinth, for over 110 years.

The goal of the FWC Invasive Plant Management Section is to manage small infestations of invasive plants **before** they get out of control. Decades of experience and applied research taught us that keeping problem plants at low levels is the most economical and environmentally sound strategy for managing invasive plants. This approach is known as “maintenance control.” Many of us use the same strategy with our lawns or cars; keeping something maintained is easier and cheaper than waiting for a problem to develop, which leads to “crisis management.”
Practice good stewardship: never transport Florida’s aquatic or wetland plants to other areas, and never empty your aquarium into a body of water or canal.

Learn to identify which plants are invasive in your area.

When disposing of plants, completely dry or freeze them, and put in the trash (not the compost).

Avoid chopping aquatic plants with boat propellers as some plant fragments can grow into new infestations.

Remove plant matter from boats/trailers after use.

In Florida, “maintenance control” of invasive aquatic plants:

- Reduces the environmental impact of noxious weeds;
- Provides greater use of our waters;
- Incorporates integrated management methods;
- Uses less herbicide;
- Greatly reduces the cost of long-term management;
- Promotes public confidence and cooperation.

The FWC Invasive Plant Management Section oversees the maintenance control program for aquatic plants in Florida’s public waters. They collaborate with Water Management Districts, city and county governments, and others charged with managing public waters.

Aquatic plants are managed with mechanical, biological, physical, or chemical treatment methods. Treatment is based on the specific conditions and circumstances of each waterbody.

- **Mechanical control** involves using large machines in the water to harvest and remove aquatic plants.
- **Biological control** involves the use of animals, insects or bacteria that feed on targeted plants. Grass carp are an example of a biological control agent.
- **Cultural or physical control** entails hand-pulling, raking, and water-level manipulation.
- **Chemical control** involves the use of registered aquatic herbicides to manage plants. Before an aquatic herbicide is used in Florida waters, it must undergo extensive testing and risk-analysis for human health, fish, wildlife, and the environment and be registered for use by the United States Environmental Protection Agency (US EPA). FWC only uses EPA-registered herbicides that are accepted for use in state waters by the Florida Department of Agriculture and Consumer Services (FDACS).

Since no one knows what the next aquatic invasive plant will be, prevention and education are needed to protect our water resources. **We can be part of the solution by following these easy steps:**

- Practice good stewardship: never transport Florida’s aquatic or wetland plants to other areas, and never empty your aquarium into a body of water or canal.
- Learn to identify which plants are invasive in your area.
- When disposing of plants, completely dry or freeze them, and put in the trash (not the compost).
- Avoid chopping aquatic plants with boat propellers as some plant fragments can grow into new infestations.
- Remove plant matter from boats/trailers after use.

View the video, “Why We Manage Aquatic Invasive Plants”

[plants.ifas.ufl.edu/manage/videos](plants.ifas.ufl.edu/manage/videos)

For more information on plant management in Florida:

[myfwc.com/wildlifehabitats/habitat/invasive-plants](myfwc.com/wildlifehabitats/habitat/invasive-plants)

For information on aquatic herbicides:

[epa.gov/pesticides/regulating](epa.gov/pesticides/regulating)
Of the nearly 4,000 plant species growing in the wild in Florida, about 1,000 are non-native or “exotic.” Most of them are not a problem. However, about 130 plant species are considered invasive.

An invasive plant is a non-native plant that causes harm to the environment, economy, or public health. In Florida, approximately 24 aquatic plant species are currently considered invasive.* Many of them have been introduced largely from global commerce and trade (imported aquarium and water garden plants and ballast water from ships) and also from recreational boat travel. Once introduced into a waterbody, plants are easily spread by boats and other recreational equipment.

**To protect native species and their habitat**

Florida is home to over 2.5 million acres of fresh water, which includes lakes, rivers, springs and wetlands. Aquatic invasive plants threaten native species and habitats, flood control structures, natural areas and resources, and recreation. Without management of invasive aquatic plants, boats would not be able to navigate, people could not safely swim, fish populations would be stunted or move elsewhere, bird populations would be threatened, tourists might go elsewhere, and agriculture crops and neighborhoods could be flooded during storm events.

Native aquatic plants provide food and shelter to native fish and wildlife, lend stability to shorelines, produce oxygen in the water, improve water clarity, and provide aesthetic beauty. Because native plants usually do not take over their home range, there is biodiversity—a number of species growing in balance within the aquatic ecosystem.

Florida is famous for its biodiversity. Biodiversity exists when species are constrained in their growth by natural factors, so they can’t overrun their neighboring species. Because non-native invasive plants are usually here without the natural conditions that kept them in check in their native ranges, they can outgrow and replace native plants.

Florida’s native wildlife evolved with native plants and often cannot use non-native plants. Some aquatic invasive plants can completely fill the water or cover the surface of our lakes and rivers, resulting in degraded conditions and loss of native plant communities. The destruction and replacement of native plants has several significant consequences:

- Natural biodiversity is reduced or destroyed;
- Rare and endangered species can be eliminated;
- Wildlife does not thrive;
- Native fish may be driven out or fish kills may occur from low oxygen problems caused by the degraded conditions.

* Florida Administrative Code 62C-52.011 Prohibited Aquatic Plants
To protect infrastructure

Dense stands of invasive plants can block or damage infrastructure such as bridges, dams, and flood control facilities, resulting in threats to public safety and millions of dollars in damage.

To protect natural resources

The nearly 8,000 lakes in Florida are some of the most biologically rich systems in the world. Florida’s climate and nutrient-rich soils provide year-round growing seasons for aquatic plants and animals. This means Florida lakes are even more susceptible to invasive plants and algae blooms. Proper plant management in freshwater lakes is an important element in maintaining healthy lake ecosystems and ensuring their intended functions.

To protect our playgrounds

Florida is also home to more than 600 springs, and nearly 1,700 rivers and streams that stretch across the state; many are vulnerable to invasive plant species and their associated ecological impacts. Known as the “fishing capital of the world,” Florida benefits from a world-renowned fishery. Freshwater fishing alone contributes over $2.5 billion annually and nearly 25,000 jobs to the Florida economy. Aquatic plant management is essential to the future of such an important recreational and economic resource.

To enjoy, protect, and manage Florida waters

Goals for managing invasive aquatic plants include:

- Preserving healthy habitats for native fish, wildlife, and plants;
- Maintaining lake and canal functions for flood control;
- Ensuring a healthy water supply for drinking and irrigation;
- Facilitating navigation for fishing and other recreation.

Most of the time, it is not possible to completely remove an invasive plant infestation. Once the plants are established, it is more realistic to control them at low levels and prevent them from spreading.

Since it is extremely difficult to predict which plants can become invasive, prevention is another crucial strategy for protecting our waters. Help us spread the message about aquatic invasive plants and protect the unique and treasured natural resources of Florida.

View the video “Florida Waters: Ours to Protect”
plants.ifas.ufl.edu/manage/why-manage-plants/introduction

For information on plant management in Florida:
plants.ifas.ufl.edu/manage
myfwc.com/wildlifehabitats/habitat/invasive-plants

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