

Choosing the Right Aquatic Herbicide

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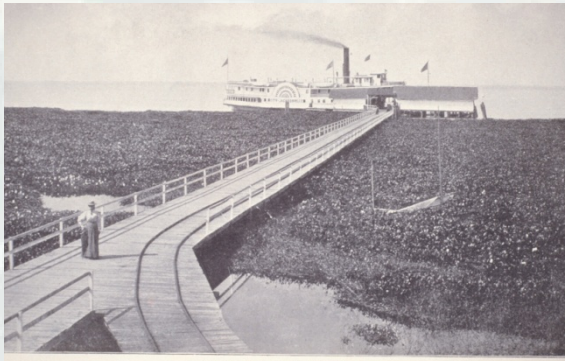
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The US Army Corps of Engineers has been involved in water hyacinth and alligatorweed management for over 115 years

- Rivers and Harbors Act – 1899
- Aquatic Plant Control Research Program - 1973



LAKE MONROE, SANFORD, FLORIDA



Our Motto Should Be

“We were Managing Invasive Species Before it Became Cool”



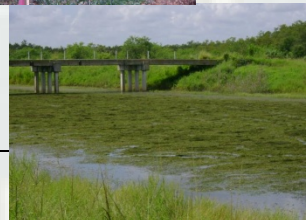
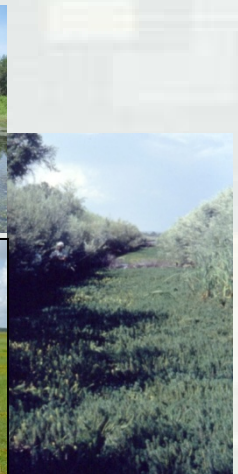
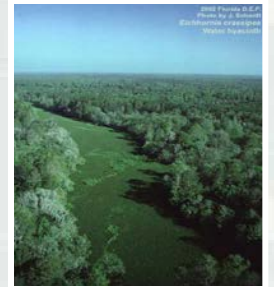
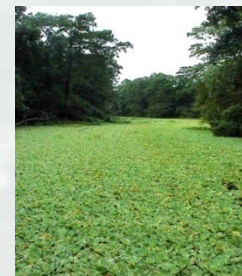
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Multiple Factors in Choosing a Herbicide

Site type, Selectivity, Uses of the Water, Timing, Scale, Label restrictions, Cost, Treatment Objectives....



Social Dimension: We often treat where people live & recreate



Milfoil is foiled by herbicide on Minnetonka bays

As milfoil spread, so does interest in using chemicals to control it on Lake Minnetonka.

By [LAURIE BLAKE](#), Star Tribune



Weed-spraying planned for Lake Harris

1:28 p.m. EST, February 16, 2012

The Florida Fish and Wildlife Conservation Commission plans to kill invasive hydrilla on 1150 acres in Lake Harris.



14 Herbicides Labeled for Aquatic Use

(~223 labeled for terrestrial use)

Copper (1900's)

Endothall (1960)

Glyphosate (1977)

2,4-D (1950's)

Diquat (1962)

Fluridone (1986)

Triclopyr (2002)

Imazapyr (2003)

Carfentrazone (2004)

Imazamox (2008)

Bispyribac (2011)

Penoxsulam (2007)

Flumioxazin (2010)

Topramazone (2013)

Blue = Plant Enzyme Specific Inhibitors



* Multiple compounds cancelled in 1987 – e.g. dicamba, fenac, dalapon, simazine

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Invasive Plant Mgmt.

- There is broad political support for Invasive species issues in the US
 - ▶ Federal and State Level
 - Prevention, State Coordinators, Research, Mgmt.
 - ▶ Great Lakes Restoration Initiative
- The thorny issues occur at the local level when management plans are put forward
 - ▶ Can be hard to convince local stakeholders that herbicides are a sound approach



An Invasive Elite 8

(Note Regional Differences)

- 1. **Hydrilla** – (spreading nationwide)
- 2. Giant Salvinia (SE)
- 3. Eurasian/Hybrid watermilfoil (NE, MW, NW)
- 4. Water hyacinth/lettuce- floating (SE, CA)
- 5. Southern Grasses (Torpedo, Luziola,) (SE)
- 6. Phragmites – (MW, NE, W)
- 7. Curlyleaf pondweed - submersed (NE, MW)
- 8. Ludwigia spp. (CA, FL)

Bubble Plants – *Egeria, Nymphoides, Spartina Trapa, Typha, Hygrophila...*



If aquatic plants are beneficial, why is there such a strong emphasis on mgmt. of Exotic Invasive Species ?



- Disturb native habitat
- Create new habitat

Invasive Plants can impede identified uses & functions of a water body

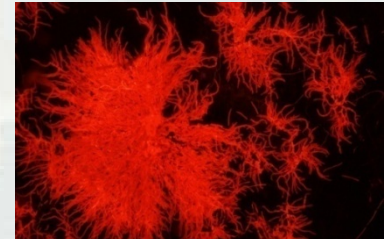
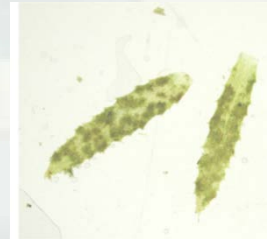


Algae as Invasive Plants ?

Microcystis bloom in FL



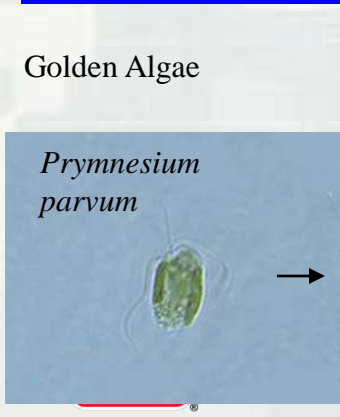
AVM – linked to bird deaths



Limited Management Alternatives - # 1 use of Copper-based products

Golden Algae

Prymnesium parvum



→
Toxin



Massive Fish
Kills in TX

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Herbicide Labels

www.cdms.net

Should find the most up to date version
of any herbicide label



EPA requires about 140 research studies for herbicide registration

Proof that the herbicide works on a target plant is not required




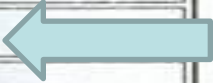


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Environmental Fate Data Requirements

160-5	Chemical Identity (see also 61-1)	
161-1	Hydrolysis	
161-2	Photodegradation in Water	
161-3	Photodegradation in Soil	
161-4	Photodegradation in Air	
162-1	Aerobic Soil Metabolism Study	
162-2	Anaerobic Soil Metabolism Study	
162-3	Anaerobic Aquatic Metabolism Study	
162-4	Aerobic Aquatic Metabolism Study	
163-1	Leaching and Adsorption/Desorption	
163-2	Laboratory Volatility Study	
163-3	Field Volatility Study	
164-1	Soil Field Dissipation Study	
164-3	Forestry Field Dissipation Study	
164-2	Aquatic Sediment Field Dissipation Study	
164-5	Long-Term Soil Dissipation Study	
164-4	Combinations and Tank Mixes	
165-1	Confined Rotational Crop Study	
165-3	Accumulation in Irrigated Crops	
165-4	Accumulation in Fish	
165-5	Accumulation in Aquatic Non-Target Organisms	
Groundwater Studies Requirements		
166-1	Small Scale Prospective Groundwater Monitoring Study	
166-2	Small Scale Retrospective Groundwater	
166-3	Large Scale Retrospective Groundwater	

The Herbicide Label

- We are constantly reminded to “read the label and follow directions”
 - ▶ “The label is the law”
 - ▶ The applicator/contractor - subject to inspection
- Following label directions can be a fairly complex task with several nuances
- My objective in this talk is to highlight some of the issues that cause confusion



What Can We Find in a Label?

- Use Instructions
 - ▶ Rates, timing, surfactants, mixes, application methods
- Use Restrictions
 - ▶ Fishing, swimming, potable water, irrigation
 - ▶ Maximum amount allowed per year
 - E.g. triclopyr = 2.5 ppm/yr ; Endothall = no maximum # of apps
- Species Controlled– herbicides labeled for the site
 - ▶ NY, CA – rules are more stringent



Nuances of the English Language

- “Do not make in-water applications to areas subject to rapid dilution
 - (e.g. small spot or shoreline treatments in larger bodies of water)
- For the management of aquatic vegetation in slow moving or quiescent waters
 - Reservoirs ?
- Irrigation from a blank treated area may result in injury to the irrigated vegetation (SCALE!!)
- Application to muddy water may result in reduced control



Herbicide Labeling

- 14 active ingredients (a.i.) labeled for aquatic use
- There may be multiple generic labels for the same mode of action
 - ▶ FL – 44 different Trade names used in 2013
- Use restrictions can vary widely between products
- Label language can vary within an a.i.
 - ▶ Not all labels are written alike
- Terrestrial Herbicides “DO NOT APPLY DIRECTLY TO WATER OR WETLANDS”



Generic = multiple Tradenames vs. Proprietary = a Single Tradename

Herbicide Class	Tradename	EPA Reg #	Measure	Lbs active applied in FL
2,4 –D (1950's)	2,4-D Amine	5905-72	3.8 lb/gal	96
	2,4-D Amine 4	42750-19-5905	3.8 lb/gal	1253
	DMA 4	62719-3	3.8 lb/gal	2198
	Platoon	228-145	3.8 lb/gal	1148
	Sculpin G	67690-49	20%	198
	Weed Destroy 40	228-145	3.8 lb/gal	2283
Bispyribac (2012)				
	Tradewind	59639-165	80% ai wp	346



* Generic Labels Can Have Different Language

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How can label language impact use?

- Renovate liquid vs. Renovate OTF (granular)
 - ▶ same active ingredient and registrant
- Eurasian watermilfoil – whole bay (~300 ac)
- Under environmental hazards – language
 - ▶ “do not treat more than 1/2 of the water area in a single operation and wait at least 10 to 14 days between treatments”
 - ▶ OTF granular – slightly broader language
 - “do not treat more than 1/2 when susceptible plants are mature and have grown to the water surface or when treatments will result in significant reductions in total plant biomass”



Changes in Label Language can Drive New Use Patterns

- Aquathol (1960) in 2007 –
 - ▶ 3-day fishing restriction
 - ▶ Irrigation restriction (7 to 14 d)
- Aquathol in 2010 –
 - ▶ removed fishing restriction
 - ▶ removed Irrigation restriction
 - ▶ Removal required multiple studies over a period of years (why do this ?)





Label Change = Large-scale
Hydrilla Use Patterns in FL

Treat 1000's of acres with no
restrictions



Registration of endothall in
irrigation canal market –
top use of aquatic herbicide in
US

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Use Restrictions

- Most current aquatic labels allow immediate fishing / swimming / recreation
- Livestock watering restrictions are for “intentional use of water”
 - ▶ Not incidental exposure (e.g pets)
 - Ingestion of small quantities of water is considered when setting limits and restrictions for the label



Potable Water

- 8/14 products have no restriction regarding consumption/application in potable water
 - ▶ Copper, Fluridone, Penoxsulam, Flumioxazin
 - ▶ Carfentrazone, Imazamox, Bispyribac, Topramazone
- 4/14 require restrictions (MCL, setback, or time)
 - Diquat – < 0.02 mg/L MCL or 1 to 3 days
 - Endothall – < 0.1 mg/L or setback of 600 ft.
 - 2,4-D - < MCL (70 ppb) or setback of 600 ft (floating)
 - Triclopyr – < MCL (0.4 ppm) – setbacks = acres treated/rate
 - ▷ Treat < 0.4 ppm = no potable water restriction



Potable Water

- Glyphosate and Imazapyr
 - ▶ Emergent Use Only !
 - ▶ No MCL's listed on the label
- 0.5 mile setback from potable water intakes
 - ▶ Upstream in a flowing water site
- Intake can be turned off for 48 hrs



Irrigation Language = READ THE LABEL

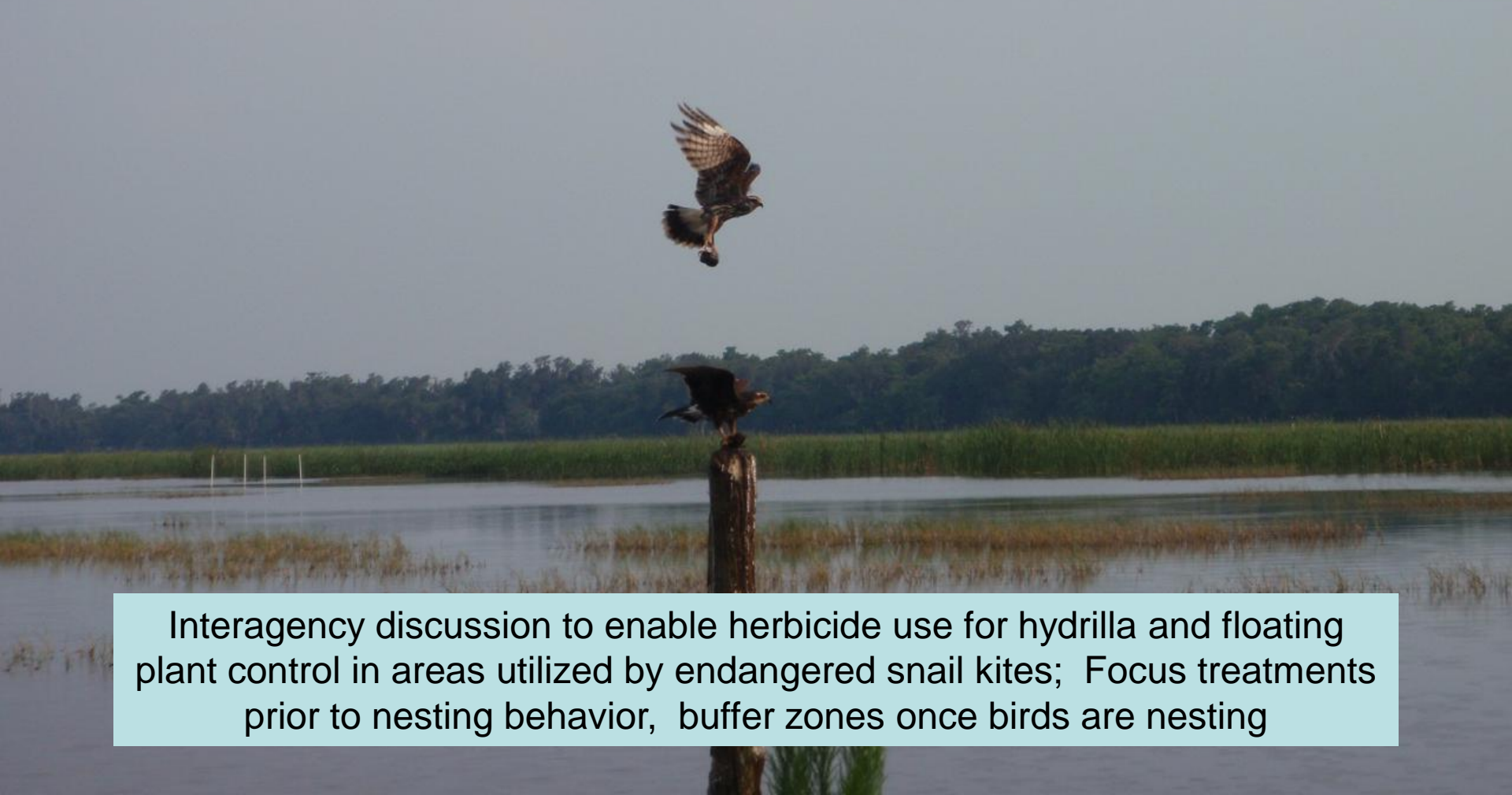
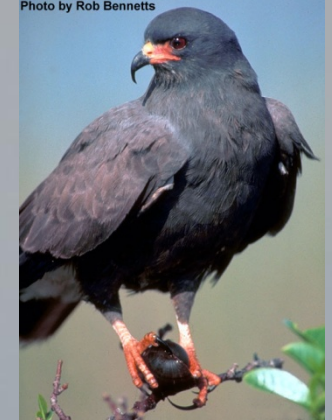
- Imazapyr and Triclopyr – 120 days or < 1ppb
 - Lack of crop tolerance data (Forestry herbicides)
- Penoxsulam, Bispyribac < 1 ppb
 - Rice herbicides
- < 10 Days
 - ▶ Flumioxazin, carfentrazone, diquat
- 2,4-D – crop and site specific language
- Glyphosate and Endothall – no restriction
 - ▶ Imazamox and copper are also exempt



Endangered Species Language

- Some labels - Users should/must consult with State Fish and Game Agency or the US FWS before making applications
 - ▶ Environmental hazards statement
 - ▶ Clearcast – Endangered species section
- Several labels have no specific language on Endangered Species
 - ▶ E.g. Diquat-Reward, Habitat-Imazapyr
 - ▶ Reward – consult responsible state agencies





Interagency discussion to enable herbicide use for hydrilla and floating plant control in areas utilized by endangered snail kites; Focus treatments prior to nesting behavior, buffer zones once birds are nesting

Endangered Species in Lake Pend Oreille, ID

- Issue with Bull Trout (federally endangered) and treatment of federal water
- USFWS requested additional data
- Private Industry supported studies
- USFWS conducted trials on endothall, triclopyr, and Fluridone
- Products were approved for use in water
- This is a permitting vs. labeling question



Resistance Mgmt. Language

- Newly registered herbicides – reflects concern with resistance at EPA
 - ▶ Penoxsulam 2008 – ALS inhibitor
 - ▶ Flumioxazin 2010 – Protox inhibitor
 - ▶ Bispyribac 2011 – ALS inhibitor
 - ▶ Topramazone 2013 – HPPD inhibitor
- May ultimately be required for other herbicides



Aquatic Site ?

- High water pool of a reservoir – even if area is dry, this is considered an aquatic site
- Ephemeral wetland – if dry, then this is a terrestrial site (can have limited standing water)
 - ▶ River floodplain (if dry = terrestrial)



Aminopyralid GLP study
for aquatic sites

-overspray into water





DuPont Crop
Protection



SPECIAL LOCAL NEED
24(c) LABELING
DUPONT™ ESCORT® XP
HERBICIDE
FOR CONTROL OF OLD WORLD
CLIMBING FERN

FOR DISTRIBUTION AND USE ONLY WITHIN THE STATE OF FLORIDA

DUPONT™ ESCORT® XP HERBICIDE

EPA Reg. No. 352-439

**CONTROL OF OLD WORLD CLIMBING FERN
IN THE STATE OF FLORIDA**

EPA SLN No. FL-030010

Active Ingredient: Metsulfuron methyl Methyl 2-[[[(4-methoxy-6-methyl-1,3,5-triazin- 2-yl)amino]carbonyl]amino]sulfonyl]benzoate	60% (by weight)
Inert Ingredients	40% (by weight)
TOTAL 100%	

GENERAL INFORMATION:

DuPont ESCORT® XP Herbicide (ESCORT XP) is a dispersible granule that is mixed in water and applied as a spray. The use of ESCORT® XP under this Special Local Need registration is specific to application(s) for control of Old World Climbing Fern (*Lygodium microphyllum*) in/on freshwater marshes (sloughs, wet prairies, and sawgrass marshes), mesic forests (flatwoods and hammocks), hydric forests (flatwoods, floodplains, hammocks, and swamps), Everglades tree islands, and Everglades prairie scrub.

DIRECTIONS FOR USE:

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

Target Pest: Old World Climbing Fern (*Lygodium microphyllum*)

Application Sites: Freshwater marshes, mesic forests, hydric forests, Everglades tree islands, and Everglades prairie scrub.

Application Rate: Apply 1/2 - 2 ounces of ESCORT® XP per acre for broadcast application, or the equivalent of 1/2 - 2 ounces of ESCORT® XP per 100 gallons of diluent for spot applications made on a spray-to-wet basis.

Methods of Application: Aerial applications may be made by helicopter only. Spot applications may be made with high pressure sprayer and hand gun, or portable equipment such as backpack sprayers, hand-held sprayers, or spray bottles.

Frequency of Applications: Do not apply more than 2 ounces of ESCORT® XP, via broadcast application(s), per acre per year (i.e., once every 12 months). Spot applications to limit regrowth may be made on an as-needed basis.

Do not apply this product through any type of irrigation system.

Applications should be made only to areas where the surrounding and/or receded waters are not used for irrigation or drinking water wells.

For product information, call 1-888-6-DUPONT. You may also contact 1-800-441-3637 for emergency medical treatment information.

For product information call 1-888-6-DUPONT

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H - 64550

Page 1 of 2

EPA SLN NO. FL-030010

24(c) Special Local Needs Labels

Allows use of Escort (metsulfuron-methy)

- Control of Old world climbing fern in FL
 - Freshwater marshes
 - Mesic forests
 - Everglades tree islands
- 2 ounces/acre/year



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Herbicide Modes of Action and Use Patterns

14 herbicide actives
9 modes of action



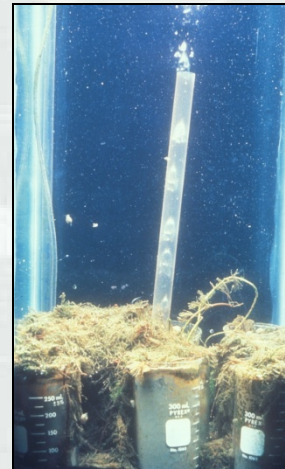
What is the most effective way to discuss mode of action ?

- Can get very detailed
 - ▶ Diquat is a photosystem I inhibitor causing formation of hydroxyl radicals that destroy unsaturated lipids including membrane fatty acids and chlorophyll
- Can also be quite broad
 - ▶ Too Broad – Kills stuff fast
 - ▶ Diquat destroys plant membranes and results in rapid leaf wilting and desiccation
- A 3rd Way – Important features of similar products and distinguishing characters



Auxin-Mimic Herbicides

- 2,4-D and Triclopyr -disrupt growth & metabolism of sensitive species
 - ▶ Epinasty (bending of leaves and stems)
 - ▶ Translocated in phloem (moves through the plant)
 - ▶ Many monocots are tolerant - Selective
 - ▶ Used for both submersed and emerged plants



Key Use Patterns

Selective Milfoil Control (NE, MW, NW)



Water hyacinth maintenance control (SE)



Contact Herbicides - Diquat and Endothall

- What does “contact” mean in Aquatics?
 - Do not Kill on Contact (e.g. bleach)
 - Must come in “Contact” with the plant tissue for an appropriate / critical period of time
 - Not readily translocated in the plant tissue
 - Application techniques are important for these compounds (emergent and submersed)



Diquat (1962)

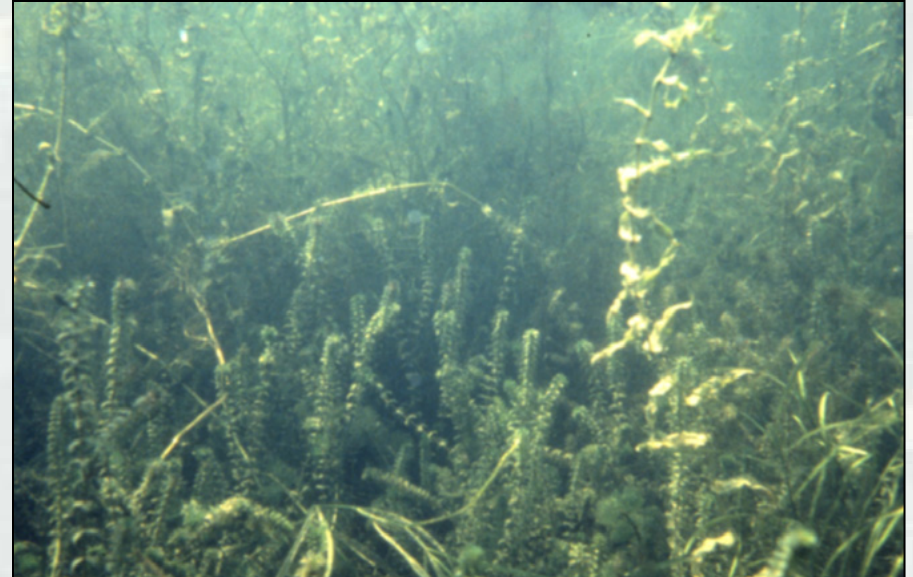
- Not translocated
- Acts rapidly -symptoms often notable within hrs
 - ▶ Short exposure requirements for submersed
 - ▶ DO depletion (warm water & high biomass)
- Used for floating (qts/ac) and submersed (gal/ac) weeds
- Generally broad-spectrum – spatial selectivity



Key Use Patterns

Waterlettuce, Giant Salvinia

General SAV Control – Multi-species



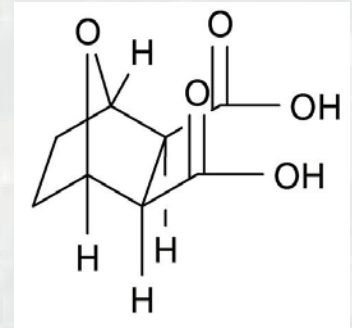
Much more active in clear water
(MW, NE, NW)

Good Control of Cuban Bulrush in FL (floating mats)

Good Control of Flowering Rush in MN (NW ?)



Endothall (1960)



- Submersed plant control
 - ▶ Not impacted by turbidity
 - ▶ Requires hours to days of contact with target plants
- Simple molecule - inhibits protein phosphatases
- Use pattern- significant change in past decade
 - ▶ ERDC-APCRP research
 - Large-scale hydrilla
 - Curlyleaf pondweed phenology
 - Irrigation uses



Key Use Patterns



Hydrilla
Large-scale



Curlyleaf Pondweed
Whole-lake



Western Irrigation
17 States

All 3 of these use patterns were developed since 2000 –
Can still innovate with older chemistries



Need to Understand Target Plant Biology

- E.g. Curlyleaf pondweed –
 - ▶ Rapid early growth, senescence in summer - algae blooms
 - ▶ Turions - quiescent and viable for 3+ years (role of sediment burial)
 - Sprout in Fall, dormant in winter, bolt in spring
- Management strategies – take turions into account
 - ▶ 1 treatment = seasonal control & limited impact next year
 - ▶ Once turions have formed – Plant is ready for next year
 - ▶ Treat prior to turion formation



Fast-Acting Enzyme Inhibitors



- Carfentrazone and Flumioxazin
- Inhibit a plant enzyme (Protox)
 - ▶ (protoporphyrinogen oxidase)
- Rapid Plant Membrane Destruction
- Short Exposure Requirements (hrs)
- pH dependent degradation
- Use patterns still being developed
 - ▶ Emergent and submersed uses



Key Use Patterns



Selective waterlettuce control
submersed and emergent use

Variable Milfoil and Cabomba (NE)



Add to Glyphosate - Emergents
-area of current research interest



Many applicators are adding flumioxazin to treatments
To improve control

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Bleachers: Fluridone & Topramazone

- Submersed use patterns
- Whole-lake or large-scale management
 - ▶ Strong tox packages and limited use restrictions
- Bleaching of new growth – carotene
 - ▶ Inhibition of phytoene desaturase (pds) enzyme
- Extended exposure required for “control”
 - ▶ Bleaching is a symptom: does not = control
 - ▶ Exposure requirements from 45 to 100+ days
- Use rates < 30 ppb



Fluridone has been used at a LARGE SCALE

Whole-lake exposures on
> 70,000 acres (\$5+ million)



Multiple ongoing hydrilla eradication programs

- multi-year
- CA, IN, MA, ME NY, WA
- 5 to 12 yrs



Slow Acting Enzyme Inhibitors

- Glyphosate (8+ generics = lower cost)
- Imazapyr, Penoxsulam, Imazamox, Bispyribac
 - ▶ 4/14 target the ALS enzyme
- All target a plant specific enzyme
 - ▶ Slower Acting with immediate cessation of growth
 - ▶ Strong toxicology profiles favor aquatic registration
- Target Amino acids and prevent protein synthesis

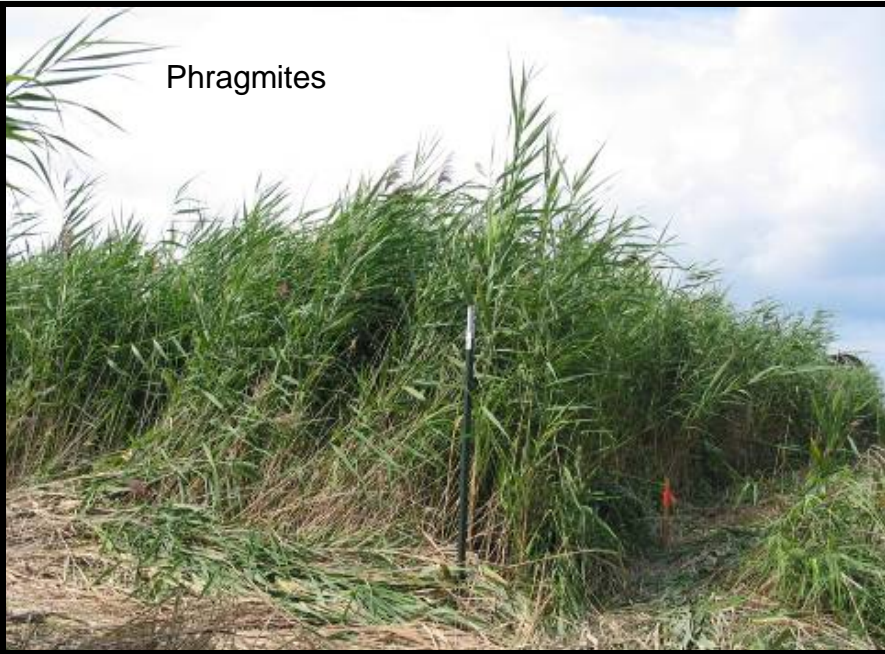


Glyphosate and Imazapyr

- Emergent Use Only
- Glyphosate- most used herbicide in the world
 - ▶ Recent resistance issues in agriculture
- Both are readily translocated
- Big difference in irrigation restrictions
 - ▶ One has crop tolerances the other doesn't
- The Major Tools - rooted emergent invasive plants
- Both are Broad-spectrum
 - ▶ Often used in combination



Phragmites



Torpedograss



Lygodium and Melaleuca



Arundo



Invasive Grasses

- Phragmites, Reed Canary, Reed Sweetgrass, Torpedo grass, Arundo, Luziola,
- Glyphosate or Imazapyr
- Use restrictions/ irrigation
- Selectivity or revegetation
 - ▶ Multiple applications
- Fall – considered the most effective timing
- Imazapyr – dry ground vs. standing water



Imazapyr/glyphosate plots for Torpedograss Control on Lake Okeechobee



Cattail Control (invasive ?)

- MN, FL – cattails degrading desirable habitat
- Glyphosate and Imazapyr – standards
- Recent work with Imazamox (Clearcast)
 - ▶ Highly effective at 8 to 32 oz.
 - ▶ Much more selective
- Similar results with Chinese Tallow & Colocasia



Giant Salvinia –
Early days – we have to eradicate it
Now – we hope the biocontrol works



Many Managers working on “combinations”

Glyphosate 3 qts + Diquat 1 pint + 2 surfactants

Glyphosate 3 qts + 2-4 oz. flumioxazin

Evaluating diquat over dormant cypress

Penoxsulam – submersed



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Ludwigia and Alligatorweed (gifts from South America)

Establishes in existing native plant beds and then overwhelms them



Extensive underwater mass, but can be lightly rooted

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Ludwigia Control

- Imazapyr and Imazamox effective
 - ▶ Maximum rates of glyphosate + 2,4-D (operations)
- Triclopyr in areas of native grasses
- Recent work suggests that combination of Glyphosate + Flumioxazin was highly effective
 - ▶ Neither is particularly active on their own



Submersed use of endothall
(Aquathol/Hydrothol)

High volume and cost

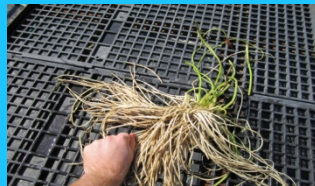
Recent use of glyphosate + flumioxazin

Research is behind operations

Leaf morphology -rapid herbicide wash-off from boat wakes/waves

6000+ acres of Crested Floating Heart on Santee Cooper Lakes, SC

- 1+ million grass carp
- spreading in Florida
- Impacts on Fishing



Large-scale hydrilla



Use ERDC as a resource

Submersed = more technical and costly

Floating 20 acres to 1000 acres

Product cost increase from \$500 to \$25,000

Submersed 20 acres to 1000 acres

Product cost increase from \$8000 to \$400,000

Significant operational experience with:

Fluridone

Endothall

Penoxuslam*

Diquat + Copper

Endothall + Penoxsulam*

Bispyribac*



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*The majority of use has focused on hydrilla;
other use patterns are being evaluated

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Large-scale Eurasian Milfoil

Curlyleaf or Egeria

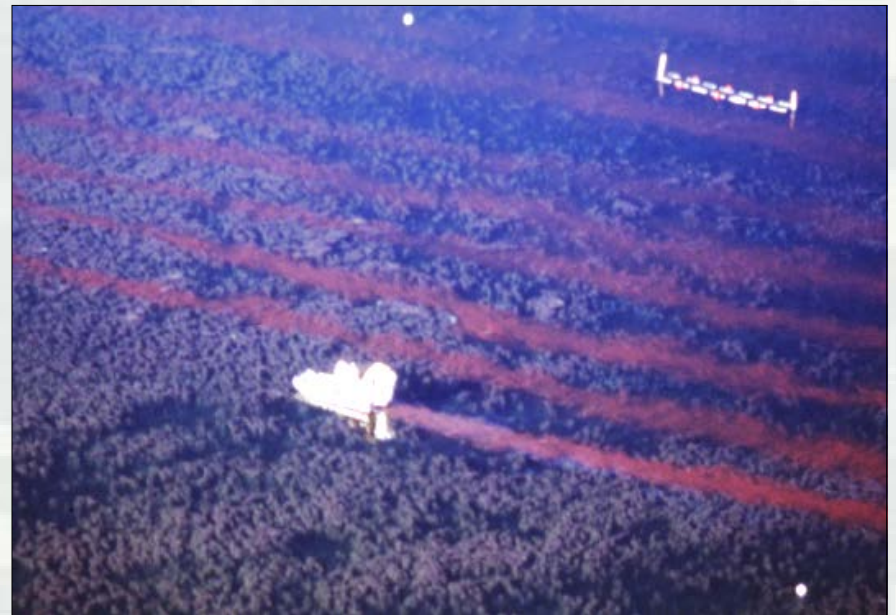


Use ERDC as a resource

Experience with hybrid milfoils, variable milfoil, lakes, large reservoirs, rivers

Significant operational experience with:

Fluridone
Endothall
2,4-D
Triclopyr
Diquat



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Resources on Aquatic Herbicides

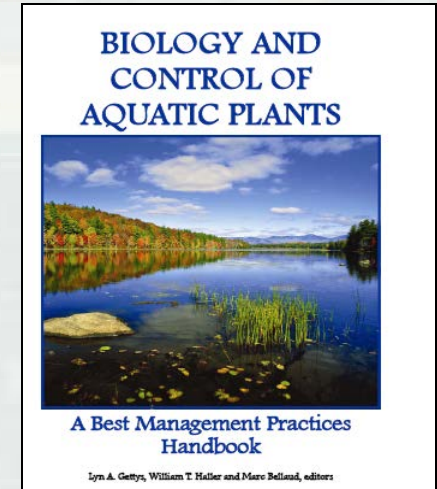
- ERDC

- ▶ Dr. Kurt Getsinger (Vicksburg, MS)
- ▶ Dr. Chris Mudge (Baton Rouge, LA)
- ▶ LeeAnn Glomski (Lewisville, TX)

- University specialists

- Use your industry reps

- ▶ Reputable reps can be a valuable resource
- ▶ Many tricks to the trade



APCRP – Ongoing Herbicide Research

- Focus on developing new use patterns
 - Selectivity Flumioxazin/penoxsulam - hyacinth/lettuce
 - Efficacy – Glyphosate + flumioxazin interaction
- Data for Grass-specific herbicides
 - Complement imazapyr and glyphosate
 - Enhance restoration efforts
- Monoecious hydrilla, Ludwigia, Crested Floating Heart, Giant Salvinia
 - Linking plant biology and response to herbicides



A Healthy Respect for Resource Managers

- They have to make decisions that will make someone unhappy
 - ▶ Even no decision = unhappy stakeholders
- They are the nexus between science, public expectations, political pressure, agency pressure
- Often have to work with imperfect information
 - ▶ How invasive will the plant become?
 - ▶ Will management “enhance and conserve” ?

