Use of Herbicides to Control Aquatic Plants:

Special Challenges Posed by the Submersed Environment

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What Challenges?

- Regulatory requirements
  - Aquatic Label, State Permits, Federal Permits
- Stakeholder Pressure
  - Public waters = heavy public scrutiny
    - Too much control, not enough control, timing….
  - Private waters = high expectations
- Technical Aspects of Submersed Use Patterns
We treat where people live, work, & play!
# 12 Herbicides Labeled for Aquatic Use
(223 labeled for terrestrial use)

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Year(s)</th>
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<tbody>
<tr>
<td>Copper (1900’s)</td>
<td></td>
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<tr>
<td>Endothall (1960)</td>
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<tr>
<td>Glyphosate (1977)</td>
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<td>2,4-D (1950, 76)</td>
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<tr>
<td>Diquat (1962)</td>
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<td>Fluridone (1986)</td>
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<td>*Amitrole, Dicamba, Dalapon Simazine, Fenac, Dichlobenil, Silvex (most cancelled in 1987)</td>
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<tr>
<td>Triclopyr (2002)</td>
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<td>Carfentrazone (2004)</td>
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<tr>
<td>Imazapyr (2003)</td>
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<td>Penoxsulam (2007)</td>
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<td>Imazamox (2008)</td>
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<td>Flumioxazin (2010)</td>
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* BUILDING STRONG®
A Further look at Aquatic Herbicides

- 8 Modes of action (16 defined MOA)
- 7 Enzyme specific inhibitors (3 ALS inhibitors)
- Glyphosate, Imazapyr – emergent use only
- No Aquatic Label
  - ACCase inhibitors, PS II inhibitors, Mitosis inhibitors, Lipid biosynthesis inhibitors
- Are any herbicides used for aquatics only?
  - Fluridone, Endothall
  - All have a terrestrial history
Aquatic Herbicides – a wide variety of sites, plants, application methods, formulations
Treatment Principles - the Same

- Proper Plant I.D.
- Know the Strengths and Weaknesses of the Herbicides
- How might Environmental Conditions Impact the Treatment?
- Concentration and Exposure Relationships
  - Submersed
Plant Identification

- Numerous submersed plants
  - Beneficial and Invasive
- Some sites require mgmt. regardless of species
  - Use of water body
- Proper Identification = Proper Mgmt.
Hydrilla

Monoecious or Dioecious?

Egeria densa  E. najas

Elodea?
Eurasian  Hybrid  Northern

Variable Milfoil

Cabomba
Algae as Invasive Plants?

- Microcystis bloom in FL
- AVM – linked to bird deaths
- Golden Algae
- Massive Fish Kills in TX
- Prymnesium parvum
Submersed Plant Control

Targeting a moving three-dimensional environment

“Maintaining adequate exposure is crucial”
Product Dispersion – An issue of Scale

Race Between Vertical Mixing And Lateral Dispersion

Diquat – hrs of exposure
Endothall – 1-7 days of exposure
Fluridone – 60+ days of exposure

Product Dispersion

TARGET Control Area

Thermal Gradient

US Army Corps of Engineers
Engineer Research and Development Center
Use of Herbicides for Submersed Plants

- You Treat the Water to Achieve a Desired Aqueous Concentration
  - You are Targeting the Plants!

- Each Herbicide Has a Plant Species Unique Concentration/Exposure Profile
  - Concentrations can range from 5 to 5000 ppb
  - Exposure requirements can range from a few hours to months
Misconceptions with Aquatic Herbicides

- Aquatic plants “take up” most of the herbicide
  - Plant uptake = 1 to 5% of herbicide
- Herbicides mix rapidly top to bottom
  - Herbicide trapped via thermal gradients
- Dispersion is a minor factor
  - e.g. All 3 ppm treatments should work the same
  - Wind/Flow move herbicide off-target
- Herbicides Are Just Dumped Into the Water
Many Factors Impact Submersed Applications

- Plant Density & Growth Rate
- Conditions on the DOT
- Conditions can change
- Water quality / temp / epiphytes
- Water exchange (CET)
- Trmt. Block & edge/ acre
If you know the water flow rate (CFS), you can Inject a desired concentration for a known time!!
- single injection site = 100’s of miles of control

- Endothall - registered in 1960 completed food tolerance studies in 2009 and significantly changed an entire market
Linear Flow Systems (2)

Short distance canals – significant challenge
e.g. 1 mile canal flowing at 10 CFS
Flow estimates can be crude (dye)

Easy → Hard → Hygrophila

Hydrilla
What Makes Hygrophila so Challenging?

Emergent form is susceptible to several herbicides
- Excellent control on dry ground

Long concentration and exposure requirements =
- high cost and high volume
Submersed Treatment Strategies for Floating and Floating Leaf Plants?

Giant Salvinia

Deep in the Cypress
Hydrilla – Moving North

Eurasian Watermilfoil –
- Northern Lakes
- Hybridization

Curlyleaf Pondweed – Northern Lakes
Endangered species

Native Plant Impacts, Monitoring

Flood Control /Structures

AVM and waterfowl mortality

Multi-agency jurisdiction - Access/Navigation/Recreation
Why Manage Milfoil or Hydrilla?

- Provides Structure and Food
  - Hydrilla - same role as native plants
  - Clears up the water
- Do Not Produce Toxins (e.g. golden algae)
- Valued by the Fishing and Hunting Communities
  - “Fishing the Edge” “Ringneck duck buffet”
- Growth Rate and Ability to Occupy Vast Contiguous Areas are the Problem
  - Access, Flood Control, Fishery Mgmt.
  - Water Quality
  - “Just leave us a little”
Is there a right amount of an invasive plant? (Do we want 30% coverage for fisheries?)

If so, then how do you maintain that level?
Management of Submersed Aquatic Vegetation

**Vallisneria or Eel Grass**

**Illinois Pondweed**

*Potamogeton illinoensis*

**Southern Naiad**

*Najas guadalupensis*
Maximizing Selectivity

- Timing can have a major impact on selectivity
  - Different species have maximum growth at different times
- Species composition is very important in herbicide selection
  - Lack of impacts to non-targets may be equally or more important than impacts on the target.
Slow Acting Enzyme-Specific Inhibitors

  - Low mammalian and fish toxicity
    - No restrictions on drinking, swimming, fishing
  - Use rates in the range of 5 to 20 ppb
  - Long-term exposures required
  - Whole-lake or large scale use
  - Large body of research on whole-lake fluridone for control of EWM
Auxin-Mimic Herbicides

- 2,4-D (1959, 1976) and Triclopyr (2002)- disrupt growth & metabolism
  - Epinasty (bending of leaves and stems)
  - Translocated in phloem
  - Many monocots are highly tolerant
  - Used for both submersed and emerged plants
Contact Herbicides (Diquat, Endothall, Flumioxazin)

- What does that 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
  - Application techniques are very important
  - Not readily translocated in the plant tissue
Environmental Fate

Photolysis – fluridone & penoxsulam (7-30 d), triclopyr and imazamox (4-10 d)

Microbial – 2,4-D (4-10 d), endothall (2-10 d)

Hydrolysis – carfentrazone, flumioxazin (hrs to 1 day – pH)

Deactivation –
   diquat – negatively charged particles (sediments – minutes to days – WQ)
   Glyphosate – binds to cation ions (Ca,Mg) – minutes
Once Initiated - Herbicide Approach Requires Vigilance

- Rare for one treatment to “solve” a problem
  - Early detection /rapid Response Programs
- Eradication programs – multiple years
- Invasive Plant Mgmt. – multiple years
- Rare for one treatment to “ruin” a lake
  - Wrong herbicide or use rate – possibly
  - Right herbicide and use rate - No
Advantages of Herbicide Use

- Can treat small as well as large areas
  - Target site is reasonably defined
- Proper choice & rate = selectivity
- Newer Products – strong toxicology profiles
- Compatible with other tools
- Best tool for initially removing large amounts of invasive vegetation
Disadvantages of Herbicide Use

- Commitment to long-term management
- Cost
- Can sometimes select for a worse problem
- Target Plants will ultimately recover
- Public perception of chemical use
Questions to Ask

- What is the Major Use of the Water?
  - Irrigation, retention, recreation, multipurpose

- Where Does the Treated Water Go?
  - What is downstream & how fast does it get there

- Are Fish an Important Resource?
  - Pay attention to water temp., DO, plant mass

- Is site susceptible to rapid turnover?
  - Flow, significant rain event