Lesson 3

Practical Examples of Situations in Aquatic Sites that Challenge Traditional Herbicide Resistance Management Practices

APMS
The Aquatic Plant Management Society

Lesson 3

Practical Examples of Situations in Aquatic Sites that Challenge Traditional Herbicide Resistance Management Practices

1) **Windows of opportunity for large-scale hydrilla control**

APMS
The Aquatic Plant Management Society

Lesson 3

Practical Examples of Situations in Aquatic Sites that Challenge Traditional Herbicide Resistance Management Practices

1) Windows of opportunity for large-scale hydrilla control
2) Repeated applications on a diminishing plant population

APMS
The Aquatic Plant Management Society

Lesson 3

Practical Examples of Situations in Aquatic Sites that Challenge Traditional Herbicide Resistance Management Practices

1) **Windows of opportunity for large-scale hydrilla control**
2) **Repeated applications on a diminishing plant population**
3) **Time between large-scale applications of the same MOA**

APMS
The Aquatic Plant Management Society

Lesson 3

Practical Examples of Situations in Aquatic Sites that Challenge Traditional Herbicide Resistance Management Practices

1) Windows of opportunity for large-scale hydrilla control
2) Repeated applications on a diminishing plant population
3) Time between large-scale applications of the same MOA
4) Alternating strategies where no evidence of resistance exists after long term use or where few alternatives exist

APMS
The Aquatic Plant Management Society

Lesson 3

Practical Examples of Situations in Aquatic Sites that Challenge Traditional Herbicide Resistance Management Practices

1) **Windows of opportunity for large-scale hydrilla control**
2) **Repeated applications on a diminishing plant population**
3) **Time between large-scale applications of the same MOA**
4) **Alternating strategies where no evidence of resistance exists after long term use or where few alternatives exist**
5) **Alternate strategies that may be less cost-effective, more restrictive, or have little public support**

APMS
The Aquatic Plant Management Society

Example 1:

Windows of opportunity for large-scale hydrilla control on Lake Toho, Florida

Windows of Opportunity for Large-scale Hydrilla Control on Lake Toho

Condition	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Perceived optimum hydrilla control												

Lake Toho is a 20,000-acre multiple use reservoir in central Florida that has supported as much as 15,000 acres of the invasive submersed plant hydrilla. Stakeholders routinely request that large-scale hydrilla control be scheduled for a time of year that does not coincide with their use of the lake, suggesting that any time of year is suitable for large-scale hydrilla control as indicated in the green bar above.

Windows of Opportunity for Large-scale Hydrilla Control on Lake Toho

Condition	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Perceived optimum hydrilla control												
High temperature / low dissolved oxygen						Control not advisable						

The following three environmental events have significant influence on the timing and herbicide MOA selected for large-scale hydrilla control in Lake Toho. High summer temperatures equate to warm or hot surface water and lower dissolved oxygen to buffer plant decomposition, increasing the risk of fish kills and making large-scale hydrilla management unadvisable during these months.

Windows of Opportunity for Large-scale Hydrilla Control on Lake Toho

Condition	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Perceived optimum hydrilla control												
High temperature / low dissolved oxygen						Control not advisable						
High Rainfall / flushing / flood control					Control not advisable							

Lake Toho is part of a flood control system. The chance of rainfall that could flush herbicide applications from the lake increases in central Florida from May through November, limiting MOAs that require several months of contact time for hydrilla control. Additionally, hydrilla needs to be under control in areas that could interfere with water flow prior to the June-October peak of tropical storm and hurricane season.

Windows of Opportunity for Large-scale Hydrilla Control on Lake Toho

Condition	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Optimum hydrilla control												
High temperature / low dissolved oxygen						Control not advisable						
High Rainfall / flushing / flood control					Control not advisable							
Peak native plant growth / susceptibility			Control not advisable									

Native plants begin robust growth toward the end of March through November, increasing their susceptibility to certain herbicides intended to control hydrilla. Native plants are important for fish and wildlife habitat in this world-class bass fishing lake. Therefore, selectivity concerns reduce the types of herbicides and amount of control applied.

Windows of Opportunity for Large-scale Hydrilla Control on Lake Toho

Condition	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Optimum hydrilla control												
High temperature / low dissolved oxygen						Control not advisable						
High Rainfall / flushing / flood control					Control not advisable							
Peak native plant growth / susceptibility			Control not advisable									

Adjusting for environmental events, the window of opportunity for large-scale hydrilla control in Lake Toho has now receded to about four months. The following five slides show how human uses and values combine with environmental conditions to further reduce the window of opportunity for large-scale hydrilla control in Lake Toho.

Windows of Opportunity for Large-scale Hydrilla Control on Lake Toho

Condition	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Optimum hydrilla control												
High temperature / low dissolved oxygen						Control not advisable						
High Rainfall / flushing / flood control					Control not advisable							
Peak native plant growth / susceptibility			Control not advisable									
Waterfowl scouting / hunting	Na								Not advisable			

Certain waterfowl are attracted to hydrilla and Lake Toho has a fair amount of waterfowl hunting activity by a very engaged stakeholder group, with scouting beginning in September and several hunting seasons running through January.

Windows of Opportunity for Large-scale Hydrilla Control on Lake Toho

Condition	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Optimum hydrilla control												
High temperature / low dissolved oxygen						Control not advisable						
High Rainfall / flushing / flood control					Control not advisable							
Peak native plant growth / susceptibility			Control not advisable									
Waterfowl scouting / hunting	Na									Not advisable		
Sportfish spawn		Control not advisable										

The sportfish spawn runs roughly from February through May on Lake Toho and although there is no evidence of adverse impacts from large-scale hydrilla control during the spawn, like waterfowl interests, there is a very engaged angling stakeholder group that implores plant managers to not conduct large-scale hydrilla control during the spawn.

Windows of Opportunity for Large-scale Hydrilla Control on Lake Toho

Condition	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Optimum hydrilla control												
High temperature / low dissolved oxygen						Control not advisable						
High Rainfall / flushing / flood control					Control not advisable							
Peak native plant growth / susceptibility			Control not advisable									
Waterfowl scouting / hunting	Na									Not advisable		
Sportfish spawn		Control not advisable										
Large national fishing tournaments	Not advisable											

Lake Toho is often the site of large national fishing tournaments that can generate several million dollars to local economies. Consequently, local stakeholder groups and businesses compel managers to postpone large-scale hydrilla control during the month preceding and during these large tournaments.

Windows of Opportunity for Large-scale Hydrilla Control on Lake Toho

Condition	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Optimum hydrilla control												
High temperature / low dissolved oxygen						Control not advisable						
High Rainfall / flushing / flood control					Control not advisable							
Peak native plant growth / susceptibility			Control not advisable									
Waterfowl scouting / hunting	Na									Not advisable		
Sportfish spawn		Control not advisable										
Large national fishing tournaments	Not advisable											
Small local fishing tournaments			Control not advisable									

Smaller fishing tournaments are held on Lake Toho throughout the year, focusing in spring through fall months. These activities are held during months that large-scale hydrilla control is generally not advisable, so by themselves do not have a strong influence on large-scale hydrilla control timing.

Windows of Opportunity for Large-scale Hydrilla Control on Lake Toho

Condition	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Optimum hydrilla control												
High temperature / low dissolved oxygen						Control not advisable						
High Rainfall / flushing / flood control					Control not advisable							
Peak native plant growth / susceptibility			Control not advisable									
Waterfowl scouting / hunting	Na									Not advisable		
Sportfish spawn		Control not advisable										
Large national fishing tournaments	Not advisable											
Small local fishing tournaments			Control not advisable									
Endangered Everglades Kite nesting / fledging	Control not allowed near nests and foraging area											

Endangered Everglades kites utilize habitat in much of Lake Toho. Courtship and nesting begin in January and fledging may not end until September. Hydrilla provides substrate and feeding sites for apple snails, the kite's sole prey source. Large-scale hydrilla control in key nesting and foraging areas is not only not advisable, it may not be allowed.

Windows of Opportunity for Large-scale Hydrilla Control on Lake Toho

Condition	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Optimum hydrilla control												
High temperature / low dissolved oxygen						Control not advisable						
High Rainfall / flushing / flood control					Control not advisable							
Peak native plant growth / susceptibility			Control not advisable									
Waterfowl scouting / hunting	Na									Not advisable		
Sportfish spawn		Control not advisable										
Large national fishing tournaments	Not advisable											
Small local fishing tournaments			Control not advisable									
Endangered Everglades Kite nesting / fledging	Control not allowed near nests and foraging area											

The optimum large-scale hydrilla control window is now reduced to a few weeks in November and December, between waterfowl hunting seasons. This also reduces herbicide options to a few-fast acting, contact-type herbicide control strategies.

Example 2:

Repeated herbicide applications on a diminishing plant population

APMS
The Aquatic Plant Management Society

Example 2:

Repeated herbicide applications on a diminishing plant population

There is significant debate regarding eradication strategies for monoecious hydrilla which often rely on repeated use of fluridone herbicide. Likewise there has been discussion regarding curlyleaf pondweed turion reduction strategies that have relied on repeated annual applications of endothall.

APMS

The Aquatic Plant Management Society

Example 2:

Repeated herbicide applications on a diminishing plant population

In both cases the management strategy is to treat plants annually until the tuber / turion bank is exhausted - implementing management prior to the formation of new propagules. The initial plant infestation can be fairly dense while subsequent treatments target a much lower density of plants that are sprouting from dormant vegetative propagules formed prior to herbicide exposure.

APMS
The Aquatic Plant Management Society

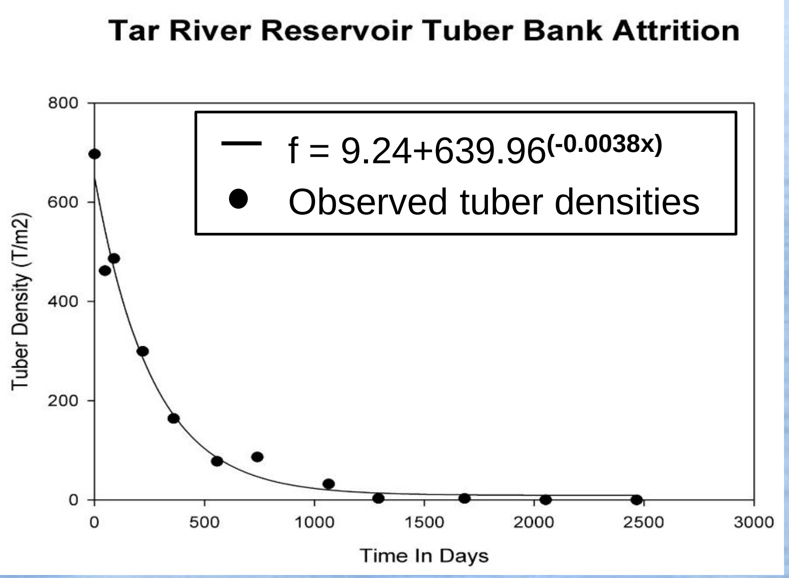
Example 2:

Repeated herbicide applications on a diminishing plant population

It is argued by some that these multiple treatments are “recipes for resistance” by repeatedly treating the same plant species with the same herbicide MOA. Given the ample evidence of resistance development in annual weed systems, these repeated treatments can be problematic.

Example 2:

Repeated herbicide applications on a diminishing plant population



Diminishing tuber bank following repeated annual fluridone applications to control hydrilla in Tar River Reservoir, NC

The counter argument is that aquatic managers are treating a rapidly diminishing vegetative propagule bank (numbers are much lower than seed densities) that represents new plants that have sprouted each year. While annual treatments suggest a sustained selection pressure, this pressure is placed on a smaller population each treatment cycle.

APMS
The Aquatic Plant Management Society

Example 3:

Time between large-scale applications of the same herbicide mode of action

Example 3:

Time between large-scale applications of the same herbicide mode of action

There is uncertainty among aquatic plant managers regarding a reasonable or prescribed length of time between large-scale treatments with the same mode of action that may reduce the possibility of resistance development.

Example 3:

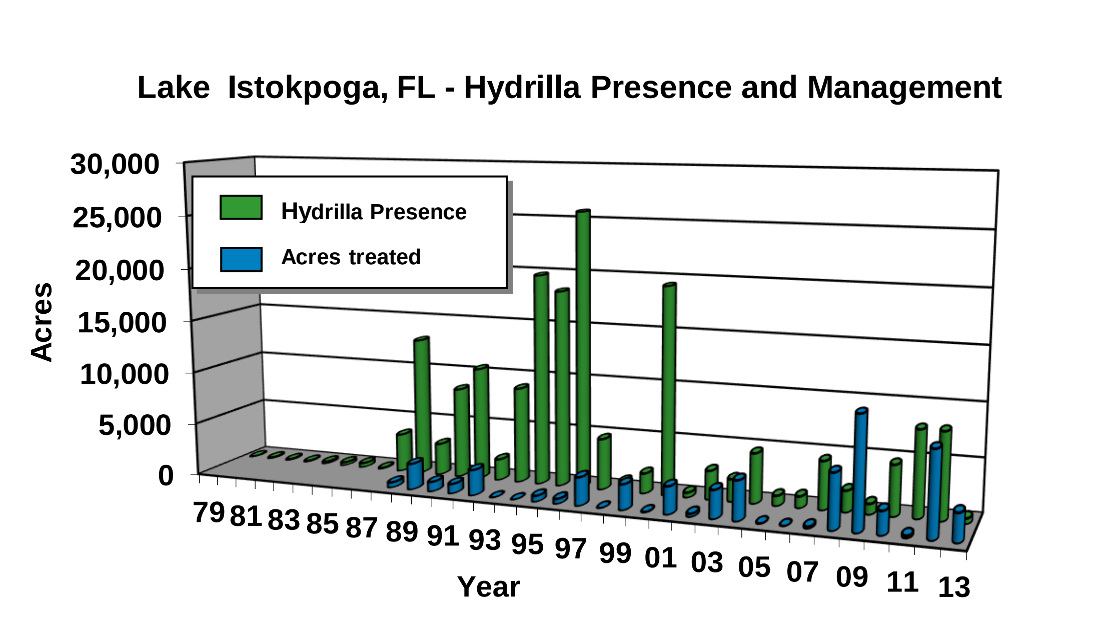
Time between large-scale applications of the same herbicide mode of action

In contrast to terrestrial weed control, particularly in row crop production venues, annual large-scale aquatic applications are not always necessary, especially when controlling plants in natural areas.

Example 3:

Time between large-scale applications of the same herbicide mode of action

Large-scale herbicide applications are conducted periodically to control hydrilla on 28,000-acre Lake Istokpoga in southern Florida with smaller scale applications conducted during interim years to slow recovery.

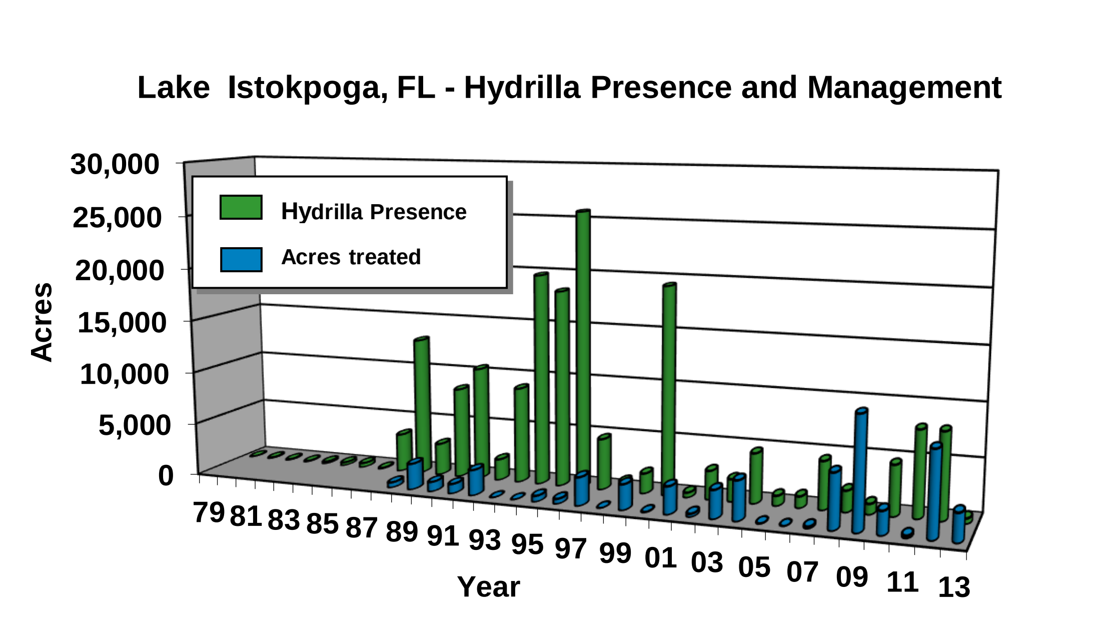


Large-scale treatment with products like fluridone, 2,4-D, or an ALS inhibitor may result in near complete control of the target vegetation for two to three years. The slow recovery of the target plants may result in small-scale spot applications in the intervening years.

Example 3:

Time between large-scale applications of the same herbicide mode of action

Large-scale herbicide applications are conducted periodically to control hydrilla on 28,000-acre Lake Istokpoga in southern Florida with smaller scale applications conducted during interim years to slow recovery.



This issue is likely one that will continue to resonate as managers, applicators, and researchers debate how long between treatments with the same mode of action is long enough.

APMS
The Aquatic Plant Management Society

Example 4:

Alternating strategies <u>where no evidence of resistance exists after long term use</u> or where few alternatives exist

APMS
The Aquatic Plant Management Society

Example 4:

Alternating strategies <u>where no evidence of resistance exists after long term use</u> or where few alternatives exist

Thousands of acres of water hyacinth have been controlled in Florida since the early 1950s using 2,4-D.

APMS

The Aquatic Plant Management Society

Example 4:

Alternating strategies <u>where no evidence of resistance exists after long term use</u> or where few alternatives exist

A similar amount of water lettuce has been controlled over the past several decades with a near exclusive reliance on diquat.

Example 4:

Alternating strategies <u>where no evidence of resistance exists after long term use</u> or where few alternatives exist

Should resistance management measures now be implemented for water hyacinth and water lettuce after more than 50 years of intensive use without incident?

APMS
The Aquatic Plant Management Society

Example 4:

Alternating strategies where no evidence of resistance exists after long term use or <u>where few alternatives exist</u>

There are only three active ingredients labeled to inject into flowing water for in-season irrigation water treatment in the western states: acrolein, copper, and endothall.

APMS
The Aquatic Plant Management Society

Example 4:

Alternating strategies where no evidence of resistance exists after long term use or <u>where few alternatives exist</u>

Due to NPDES regulatory issues related to discharge of acrolein-treated water, many irrigation companies have shifted to endothall for economic, efficacy, and regulatory reasons.

Example 4:

Alternating strategies where no evidence of resistance exists after long term use or <u>where few alternatives exist</u>

While multiple endothall applications through time do not suggest a resistance management strategy, convincing irrigators to incorporate acrolein or copper in the name of resistance management may prove difficult due to regulatory complexity.

APMS
The Aquatic Plant Management Society

Example 4:

Alternating strategies where no evidence of resistance exists after long term use or <u>where few alternatives exist</u>

Given the time and costs to register a new product in the aquatics market, it is unlikely that additional modes of action will provide immediate relief. Additionally, irrigators may chose the most cost-effective approach that results in the fewest regulatory hurdles.

APMS
The Aquatic Plant Management Society

Example 5:

Alternate strategies that may be less cost-effective, more restrictive, or have little public support

Example 5:

Alternate strategies that may be less cost-effective, more restrictive, or have little public support

Development of extensive operational herbicide use patterns in aquatics often requires many years of research, monitoring, and treatment refinement from laboratory studies to small-scale pond applications, especially in natural areas where conserving or enhancing non-target vegetation is as important as cost-effective management of invasive or nuisance plants.

APMS
The Aquatic Plant Management Society

Example 5:

Alternate strategies that may be less cost-effective, more restrictive, or have little public support

Once use patterns are established, managers, regulatory agencies, and stakeholders develop a level of acceptance for a given approach. This creates difficulties for introducing a new mode of action into an established program.

APMS
The Aquatic Plant Management Society

Example 5:

Alternate strategies that may be less cost-effective, more restrictive, or have little public support

There typically needs to be a compelling reason (e.g. reduced cost, fewer water use restrictions, increased selectivity) to incur the costs associated with developing a major new use pattern. Resistance management is not currently viewed as a compelling reason for altering the vast majority of large-scale herbicide use patterns in aquatic plant management.

APMS
The Aquatic Plant Management Society

Thank you for viewing the Aquatic Plant Management Society presentation on herbicide resistance management in aquatic plant control venues. For more information on APMS, please visit our website at:

www.apms.org

APMS

The Aquatic Plant Management Society