Appendix B: Aquatic Herbicide Application Methods

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Introduction

All pesticide labels contain very specific information regarding how they are to be stored, handled and used. It is illegal to use any herbicide in, on or over water unless it is registered for that purpose and has aquatic use directions on the label. States may have pesticide use regulations that are more strict than federal regulations; thus, several states require that aquatic pesticide applicators be certified and licensed before they may purchase, handle and apply pesticides and that permits are obtained before pesticides are applied. Potential users of pesticides should contact state agencies such as county cooperative extension offices, state game and fish agencies or state environmental authorities to ensure compliance with any additional state-specific use restrictions.

A few herbicides may be applied directly from the container; for example, the labels of some copper sulfate herbicides suggest placing the dry granules in a cloth bag and towing the filled bag behind a boat to ensure uniform application throughout the water column. However, the majority of aquatic herbicides must be diluted or mixed with water before application. The purpose of the diluent (water) is to ensure consistent coverage of the target weeds so the herbicide can be absorbed into the plants. Most herbicide labels state that applicators should "use sufficient diluent to obtain uniform coverage of the target weed." Some labels are more restrictive and specify the amount of diluent to be used during application of the herbicide. For example, a label may specify "apply in 50 to 150 gallons of water per acre for adequate coverage." The public often believes that the mixture being applied to weeds is concentrated herbicide, but this is rarely—if ever—the case because herbicides are mixed with large volumes of water. Applicators are required by law to have the label at the application site and it is critical that they read the label carefully before aquatic herbicides are diluted, mixed and applied to ensure that the herbicide is applied in a legal, appropriate and effective manner.

Foliar applications

Foliar herbicides are mixed with water and sprayed on the foliage of floating or emergent plants in a given area. The goal during foliar application of an aquatic herbicide is to obtain good coverage and ensure that the maximum amount of herbicide is taken up by the target weed. Most floating and emergent plants have a waxy layer (cuticle) on their leaves and stems that must be penetrated in order for the herbicide to be taken up by the plant. The labels of some aquatic herbicides suggest or require the addition of surfactants (Chapter 12) that dissolve the cuticle and facilitate uptake of the herbicide by the plant. For example, a label may state that "a surfactant may be applied at a rate of 0.25 to 0.5% (1 to 2 quarts per 100 gallons) with the tank mix to get best results." In this example, the addition of a surfactant is not required by the label so its use is optional; other labels require the use of surfactants.

Just as carpenters and electricians have specialized equipment for their work, aquatic applicators often have tank- and pump-equipped boats and trucks for the application of herbicide treatments.

A typical boat may hold a pump (calibrated to apply from 4 to 10 gallons per minute of a herbicide mix) and a 50- to 100-gallon mix tank. This equipment is calibrated to apply the correct amount of herbicide over the area to be treated. Selectivity, or the ability to control weeds growing among native plants, is usually accomplished by choosing the appropriate herbicide or by using a handgun to apply the herbicide mix only to the weeds and not to the desired native species. This is not always possible but is practiced as much as equipment and herbicide selection allow.

Most homeowners have small "pump-up" garden sprayers or backpack sprayers for lawn and garden use. Herbicide labels may include use directions for mixing the herbicide for small or localized spot treatments using small equipment. For example, if control of clumps of purple loosestrife along a shoreline is desired, the herbicide label may state "mix a 1 to 2% solution of herbicide in a backpack sprayer and spray weeds to wet." A gallon of water contains 128 fluid ounces, so the applicator would add 1.28 fluid ounces of herbicide to 127 fluid ounces of water to get a 1% solution. A 2% herbicide solution would be 2 x 1.28 fluid ounces, or 2.5 fluid ounces of herbicide per gallon of total tank mix. Be careful; some herbicides cannot be used in sprayers that will also be used for garden or ornamental plants, as some leftover herbicides can be quite toxic to other plants. Where is this information? On the label that is attached to every herbicide container!

The foliar application of herbicides to emergent and floating-leaved plants is generally well understood by homeowners because this is common practice on ornamental lawn and garden plants. The application of herbicides for submersed weed control, however, is often more complicated and thus more difficult to understand.

Submersed aquatic applications

The control of submersed aquatic weeds is much more difficult than control of emergent aquatic plants for the following reasons:

- Fewer herbicides are registered for submersed treatments
- The dilution effect of water depends on the depth of the water
- Wind, waves and currents dilute herbicides
- It takes more time to treat and cover submersed plants
- Submersed weeds are generally much more expensive to treat
- The growth stage and area covered by the plants are important
- Use of treated water for irrigation and drinking may be restricted

These general factors – and additional site-specific ones – determine which herbicides should be used to control submersed aquatic weeds. Water flow, dilution and water use are often the critical factors to consider when choosing a herbicide. Water flow and dilution may result in herbicide

concentration/exposure times (CET) that are insufficient for herbicides to be effective (Chapter 11). There are also water restrictions on many herbicides for use in and adjacent to potable water intakes and for water used for irrigation. There are two general types of submersed aquatic weed applications, depending upon the CET requirements for the herbicides.

Contact herbicides

Contact herbicides are applied at relatively high concentrations, have very short half-lives in water and require a contact time of hours to a few days to kill plants. They include copper products, diquat, endothall and carfentrazone which may be applied along strips of shoreline and in relatively small areas where dilution is high, provided contact of the herbicide with the target weed is maintained for an amount of time sufficient to achieve control. The decision to use a contact herbicide is site-specific and the greatest chance of success occurs when herbicide applications are done on calm days to optimize contact times. Contact herbicides in general provide 3 to 6 months of weed control, depending upon the weed, geographical area of application (northern US vs. southern US) and length of growing season (Chapter 11).

Systemic or enzyme-inhibiting herbicides

Systemic enzyme-inhibiting herbicides are generally applied at concentrations lower than contact herbicides, must remain in contact with target weeds for relatively long times (up to 45 days or more) and are very slow to control submersed aquatic weeds. These herbicides are often applied as low-dose whole-lake treatments to control weeds throughout the lake. Systemic enzyme-inhibiting herbicides include fluridone, penoxsulam and imazamox. The former two herbicides are applied at rates of 5 to 20 ppb (parts per billion); concentrations can be maintained with additional treatments over several weeks to control hydrilla (Chapter 15.1), Eurasian watermilfoil (Chapter 15.2) and other submersed species. Imazamox is applied at 50 to 75 ppb and requires a contact time of several days. Penoxsulam and imazamox were registered in 2007 and 2008, respectively, and use patterns are still being developed (Chapter 11).

Systemic herbicides with short contact times

There are always exceptions to the rule, and 2,4–D and triclopyr are the exceptions in this case. Both are systemic herbicides but are absorbed in lethal doses by the target weeds in a relatively short time (1 to 4 days), depending upon the concentration applied. These two herbicides are effective for selective control of Eurasian watermilfoil and other dicot (non-grass) weeds. Concentrations of these herbicides for submersed weed control generally range from 1 to 2 ppm (parts per million). 2,4–D and triclopyr are applied at the highest labeled dose in areas where dilution is most likely to occur (such as small treatment areas and in strip treatments along shorelines) and on dense mature plants. Lower doses may be used in large treatment areas and in protected coves and bays with little water exchange.

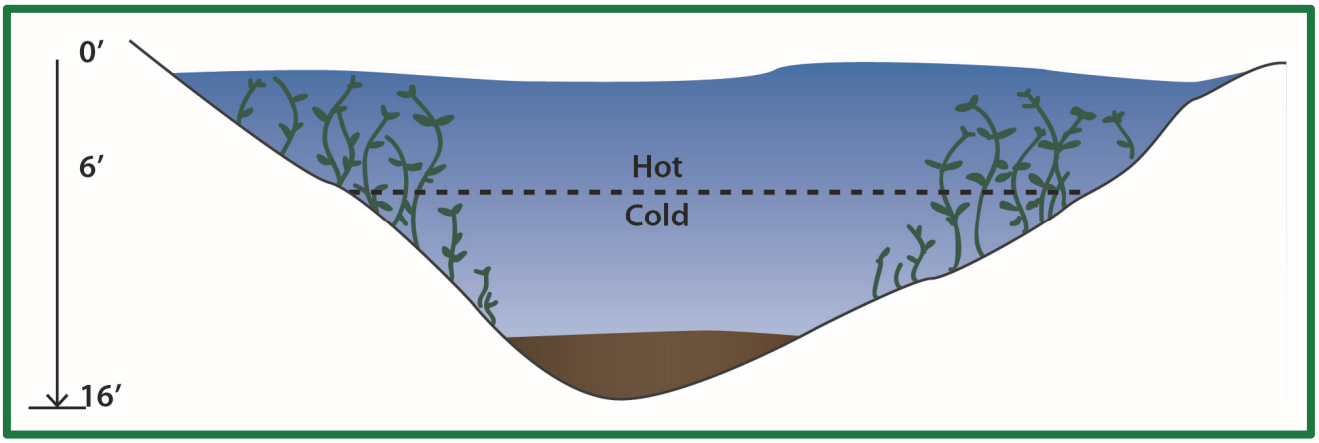
Application of formulations

Herbicide formulation refers to how a herbicide is sold (as a liquid, granular or other form) and this determines the type of equipment needed for application of the herbicide. Many aquatic herbicides are sold as both liquid and granular formulations because many are used for both foliar and submersed aquatic weeds. For example, you would not apply 2,4–D as a granular formulation for foliar applications to purple loosestrife (Chapter 15.12); you would use a liquid formulation. The formulations of common aquatic herbicides are listed in Chapter 11.

Liquid formulations can be applied to submersed aquatic weeds in several ways, with the type of application determined by the specific location, size and depth of the treatment area. Surface applications are typically done along shorelines and under or around boathouses and docks where water depths average 3 to 6 feet deep. Granular and deep-hose applications are often used in deeper water, particularly in water where submersed weeds are growing in water from 6 to 20 feet deep. The objective of these deep-water treatments is to ensure that the herbicide mixes in the water column and reaches the plant beds where they can be taken up by the target weeds.

Effect of thermoclines

Temperature-dependent thermoclines often develop in lakes and other non-flowing waters during summer, particularly in northern regions. A thermocline occurs when the upper and lower portions of the water separate into warm and cool layers. Swimmers are often familiar with this phenomenon; for example, water in the upper layer of a lake feels warm, but diving down to depths of 6, 8 or 12 feet can be shockingly cold. This thermal stratification is well-known to applicators of aquatic herbicides as well and can reduce the effectiveness of herbicide treatments because the warm upper and cool lower layers of the water do not mix. Herbicides applied to the surface of the water may control upper portions of weeds, but treatments do not penetrate into the deeper cool layers. As a result, root crowns, rhizomes and low-growing plants below the thermocline are not



controlled by the herbicide. The depth of the thermocline is influenced by water clarity and varies among lakes, but water temperature typically drops 2 °F for each 3′ change in depth. If aquatic weeds are growing above and below the thermocline, deep-water injection of liquid herbicides or application of granular herbicides may be used to control weeds in both thermal zones.

Foliar and submersed concentrations

The labels of glyphosate, 2,4–D, carfentrazone, triclopyr, diquat, endothall, copper, imazamox, imazapyr and penoxsulam products allow foliar applications for specific weed problems. Foliar-

applied herbicides are usually mixed with 50 to 200 gallons of water per acre treated according to label directions and a surfactant is usually added to the tank mix to facilitate herbicide absorption or to ensure even coverage of the target plants. These herbicides are typically applied in "pounds per acre" with one pound of the herbicide's active ingredient in 100 gallons of water, resulting in a 0.1% concentration (1000 ppm). This relatively high concentration is needed to ensure that the plant absorbs enough herbicide to kill the weed on contact or through translocation to the site where the herbicide kills the plant.

Fortunately, application of herbicides for control of submersed aquatic weeds requires much lower concentrations of herbicides. This is because most submersed plants lack the waxy cuticles that slow herbicide uptake in many emergent plants and the leaves of many submersed plants are only a few cells thick. Tank mixes may still call for one pound of herbicide in 100 gallons of water, but in one acre-foot of water, the concentration of herbicide that contacts submersed plants is only 1/2.7 or 0.370 ppm (370 ppb) due to the dilution effect of the water being treated. Eurasian watermilfoil can be controlled with as little as 10 ppb of fluridone, but control of this weed with triclopyr or 2,4–D may require up to 2 ppm (2000 ppb). The ability of herbicides to control submersed weeds at such low concentrations contrasts sharply with the concentrations required to control larger, more tolerant floating and emergent weeds.

Although less herbicide is used per acre-foot of water for submersed weed control, submersed weeds often grow in water that is 8, 12 or 16 feet deep. Thus, submersed weed control often requires more herbicide per acre than foliar treatments due to increased water depth.

Selectivity

Weed control in an aquatic ecosystem is very different from weed control in an agricultural setting. For example, farmers want to control all the weeds in a cornfield without affecting the corn, whereas managers of natural and aquatic areas often wish to control a single weed species growing among 50 to 100 desirable native species. Research regarding selectivity of aquatic herbicides is ongoing and depends upon the following factors:

• Choice of herbicide: some herbicides control submersed weeds without affecting a number of other desirable nontarget plants, but the choice of herbicides that work in this manner is limited and complete selectivity is not always possible. As a result, herbicide selection is often dictated by the types of native species present in the proposed treatment area. In general, herbicides applied for submersed weed control have little effect on rooted emergent species due to the relatively low concentrations of herbicides used to control submersed weeds.
• Dose or amount of herbicide: not all plants are equally susceptible to herbicides. Application rates needed to control different weeds are usually listed on the herbicide label.

• Stage of plant growth: some herbicides used for submersed weed control can be applied in very early spring when weeds are actively growing and native plants are still dormant.
• Selective foliar application: handguns can be used to target and apply herbicides only to the weeds and minimize damage to nontarget species. However, this method is not feasible in most submersed treatments.

Although selective treatment of submersed weeds is more difficult than treatment of floating and emergent weeds, the reduction in growth and coverage of submersed weeds generally results in less weed competition and quick recovery of native species in the treated area. This occurs because most submersed weeds reproduce using vegetative means and many nontarget native plants reproduce by seeds. Elimination of dense weed canopies and the reduction of competition from invasive weeds often results in germination and growth of desirable species during the season of the herbicide treatment or soon thereafter.

Summary

Small-scale foliar application of herbicides to emergent and floating weeds is easily within the capabilities of most riparian homeowners, provided the correct herbicide is chosen and label directions are followed. The application of herbicides to aquatic weeds in large areas or for submersed weed control is more expensive, complicated and often requires specialized equipment to obtain the most cost-effective control. Selectivity results from a combination of factors, including herbicide choice, time of year and nontarget desirable species in the proposed treatment area. The size or area of the treatment site also affects the concentration-exposure time requirements for herbicides. In addition to label requirements, all these factors that affect submersed weed control clearly indicate that experienced state agencies responsible for permitting and managing aquatic resources be contacted prior to undertaking weed control projects.

For more information:

•How to build weighted trailing hoses. http://plants.ifas.ufl.edu/guide/building_weighted_trailing_hoses.html
•http://www.ecy.wa.gov/programs/wq/plants/management/aqua028.html
•http://aquat1.ifas.ufl.edu/guide/herbcons.html
•http://ohioline.osu.edu/a-fact/0015.html
•http://aquatplant.tamu.edu/index.htm
•University of Florida Center for Aquatic and Invasive Plants. http://plants.ifas.ufl.edu

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Page 196 lower: Thermocline; Joshua Huey, University of Florida Center for Aquatic and Invasive Plants
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