Using registered herbicides for aquatic plant control is a widely employed technique for both private and public waters. Treatments can be applied with a 1-gallon pump sprayer for a spot treatment, a helicopter or airboat for a whole lake treatment, or anything in-between. Treatment objectives could be the control of a single invasive plant species or a broad spectrum control of numerous species.

All herbicides listed have undergone EPA review and are approved for aquatic use in Arkansas, when used in accordance to the instructions included on the label. There are approximately 300 herbicides registered in the U.S., but only 16 of these are labeled for aquatic use.

Like all pesticides, herbicides have three names: a trade name, a common name and a chemical name. An example of this is the common herbicide Rodeo. Rodeo is the trade name, the common name is glyphosate and the chemical name is N-(phosphono-methyl) glycine, isopropylamine salt. In this publication, the common name will be used the majority of time.

All herbicides come with a label. Included on the label is the product form and instructions for safe handling and effective use. It cannot be stressed too strongly that the label is the law, and not using herbicides according to the labeled directions can have legal ramifications for the applicator.

Often included is a listing of species that are controlled by the chemical and sometimes the extent of the control. If the target species is not included on a particular label, the herbicide may still be used as long as the herbicide is labeled for use at the desired site of application, though effectiveness may be unknown.

Herbicide Types

Herbicides can be classified in several ways. One way is by their activity in the plant: systemic or contact. This classification refers to whether or not the herbicide is translocated, or moves within the plant. Whether the herbicide moves within a plant or not has implications on its effectiveness, application and how quickly it acts upon the plant.

Contact herbicides do not move and will cause death to only those parts of the plant they contact. Contact herbicides also tend to cause more rapid injury to treated plants, but require more complete spray coverage of all plant tissue during application. If a contact herbicide is used on submersed plants, the chemical must remain in the treatment area long enough for the entire plant to be exposed to a lethal concentration. Since contact herbicides tend to cause rapid plant death, in areas with dense plant populations and warm water, the decomposing plant tissue can lead to a low dissolved oxygen fish kill. Care must be taken to treat only 33-50% of a pond or have supplemental aeration available.

Systemic herbicides are mobile in plant tissue and move through the plant's vascular tissue to their action site. This gives them the ability to affect all parts of the plant, not just those parts they contact. One implication is effects on the plant take longer to become apparent. Additionally, complete plant coverage may not be necessary to attain control. Finally, with correct timing, some herbicides will be stored within the plant's root tissues. The following season, as sugars move upward in the plant, the herbicide moves with it, leading to a second season of activity.

Adjuvants

Herbicides that are applied as a foliar treatment will include a recommendation to include an adjuvant. The two most common are a crop oil or a nonionic surfactant. While different in chemistry, they serve the same function. Both of these reduce the surface tension of the herbicide solution and increase the herbicide coverage and penetration into plant stems and leaves. A third type of adjuvant often used in aquatic plant control acts as a "sinker" when added to a spray solution. When the solution is sprayed onto the water surface, the "sinker" will help carry the herbicide down through the water column, into the weeds growing on the pond bottom.

Contact Herbicides	Systemic Herbicides
Copper and Copper products	2,4-D
Diquat*	Glyphosate
Endothall*	Fluridone
Carfentrazone	Triclopyr
Sodium Carbonate Peroxyhydrate	Imazapyr
Flumioxazin	Imazamox
	Penoxsulam
	Bispyribac Sodium
	Topramezone
	Florpyrauxifen

*Systemic herbicide that acts like a contact herbicide.

Why Treatments Fail

Oftentimes a herbicide treatment for a submersed plant will not have the desired results. Sometimes this results from inaccurate plant identification, leading to incorrect herbicide selection. Another cause is using the herbicide under suboptimal conditions. For example, selecting diquat for a submersed plant in a muddy pond. Diquat binds with suspended particles, rendering it inactive. Water temperature can also affect effectiveness. As a general rule, most herbicides shouldn't be used when the water temperature is below 50-60°F. While still growing, reduced plant metabolism may prevent sufficient herbicide uptake.

However, the most common reason is some form of dilution. Every plant and herbicide has a unique concentration and exposure time relationship. If the exposure time is reduced or the concentration is lower than required, the treatment results will be suboptimal. Exposure time can be shortened by increased degradation due to bacteria, sunlight, high pH or a water current carrying the herbicide away, to list some examples. Inaccurately estimating a pond's volume can also reduce the herbicides' target concentration. The end result of these things is that plants are not exposed to a concentration of herbicide sufficient to lead to plant control. Please take the time to carefully read the label and correctly estimate the water body's size and conditions prior to an herbicide application.

Further Information

Like most weed control, the sooner the nuisance plants are treated, the better the results. With few exceptions, most aquatic plants start actively growing when water temperatures reach 50-60 F, and their growth increases with increasing temperatures until they begin die back or senesce in the fall. Also take into account the time a selected herbicide takes to reach maximum effectiveness. Consult the label for further information. Another source of relevant information is extension publications MP556 Aquatic Vegetation Control in Arkansas which can be found at https://www.uaex.uada.edu/publications/pdf/MP556.pdf.

WEED RESPONSE RATINGS FOR AQUATIC HERBICIDES[1]

Aquatic Weed Group	Copper Sulfate and Copper Complexes	2,4-D	Diquat	Endothall	Fluridone	Glyphosate	Triclopyr	Imazapyr	Imazamox	Carfentrazone	Penoxsulam	Sodium Carbonate Peroxyhydrate	Flumioxazin	Bispyribac Sodium	Topramezone	Florpyrauxifen	Grass Carp
Algae																	
Planktonic	E	P	P	G	P	P	P	P				G-E					
Filamentous	E[2]	P	G	P-G[3]	P	P	P	P				G-E	G-E				F-P
Chara	E	P	P-G	P-G[3]	P	P	P	P									E
Nitella	E	P	P-G	P-G[3]	P	P	P	P									G
Free Floating Weeds																	
Bladderwort	P	P-G[4]	E	F	G			G-E			G		G		G		E-G
Duckweed	P	F	G	P	E			G		G-E	E		E	E			P-F
Watermeal	P	P	F		G	P	P	P		G	G		E	E			
Azolla	P	F	G		G-E	F				E	E		E	E		G-E	P-F
Water hyacinth	P	E	E		P	F	E	E	E	G-E	E			E	E	G-E	P
Rooted Floating Weeds																	
American lotus	P	E	P	P	F	G	E	G	G						G	G-E	P
Water lily (fragrant and white)	P	E	P	P	E	E	E	E	G								P
Spatterdock	P	E	P	P	E	G		G									P
Watershield	P	E	P		G	G		E	G	G						G-E	F-P
Emersed Weeds																	
Alligator weed	P	F	P	P	G	E	E	E	G	G	G		E	E		G-E	P
Arrowhead	P	E	G	G		P		E	E		G				E		F-P
Buttonbush	P	E	F	P	P	G	G	G									
Cattails	P	G	G	P	F	E	P	E	E								
Common reed	P	F	F	P	F	E	G	E									
Ducksalad	P	E	G	P		E		E	G-E								P
Frogbit	P	E	E					E	E	G	E		E				P
Maidencane	P	P	F		F	E	P	E									F-P
Pickerelweed	P	G	G			P	E	E	E		G						P
Pond edge annuals	P		G		E	E		E									
Sedges and rushes	P	F	F	P		G	P	E	G								P
Slender spikerush	P		G		G	P	P	E			G					G-E	
Smartweed	P	G	F		F	E	E	E	E		G						P
Water pennywort	P	G	G	P	P	G	E	E			E		E	E		G-E	F-P
Water primrose	P	E	F-G		F	E	E	E	E	G			G-E			G-E	P
Willows	P	E	F	P	P	E	E	E									

[1] E = excellent control, G = good control, F = fair control, P = poor control.
[2] For Pithophora, only F-G control.
[3] Hydrothol formulation only.
[4] Granular 2,4-D formulation.
[5] Copper complexes only (ex. Komeen, Captain, K-Tea).

(Continued on page 150)

WEED RESPONSE RATINGS FOR AQUATIC HERBICIDES[1] [cont.]

Aquatic Weed Group	Copper Sulfate and Copper Complexes	2,4-D	Diquat	Endothall	Fluridone	Glyphosate	Triclopyr	Imazapyr	Imazamox	Carfentrazone	Penoxsulam	Sodium Carbonate Peroxyhydrate	Flumioxazin	Bispyribac Sodium	Topramezone	Florpyrauxifen	Grass Carp
Submersed Weeds																	
Coontail	P	G	E	E	E	P							E			G-E	G-F
Egeria	P-G[5]	P	G	G	E	P		P			E						E
Elodea	P-G[5]	G	E	F	E	P		P			E		E				E
Fanwort	P	F	G	E	E	P		P					E				E
Hydrilla	P-E[5]	P	G	G	E	P		P	G		E		E	E	E	E	E
Naiads	P	F	E	E	E	P		P			G		E		G		E
Parrotfeather	P	E	E	E	E	F	F	G (when emerged)	G	E	G		E	E		G-E	F-P
Pondweeds	P-G[5]	P	G	E	E	P		F	E		E		E	E	E		G-P
Water milfoil (broadleaf)	P		E	E	E	P	G	P	G	G	E						P
Water milfoil (Eurasian)	P	E	E	E	E	P	G	P	G	G-E	E		E	E	G		F-P

[1] E = excellent control, G = good control, F = fair control, P = poor control.
[2] For Pithophora, only F-G control.
[3] Hydrothol formulation only.
[4] Granular 2,4-D formulation.
[5] Copper complexes only (ex. Komeen, Captain, K-Tea).

GRASS CARP FOR AQUATIC WEED CONTROL

Grass carp (*Ctenopharyngodon idella*), or white amur, is a member of the minnow family native to Asia. They feed almost exclusively on aquatic plants. Their short digestive tract requires grass carp to feed almost continuously when water temperatures are above 68ºF, which means they can eat two to three times their body weight each day. This makes them an excellent biological control of certain nuisance aquatic plants.

Grass carp are capable of fast growth and may gain 5 to 10 pounds per year, reaching their final size of 20 to 30 pounds within a few years, and can live for 10 to 15 years. Unfortunately, when they reach maturity, their rate of weed consumption declines, and restocking of additional fish is required every 3 to 5 years.

Grass carp have definite preferences of the type of vegetation they consume. They prefer tender, succulent vegetation that is under water. This makes them best suited for submerged vegetation, and they will not generally control tough, fibrous plants that grow up out of the water. The extent to which they are able to control a particular weed depends upon many factors, including their feeding preferences, the aquatic plant density, water temperature and the number and size of grass carp stocked. As more preferred vegetation becomes scarce, grass carp will eat less preferred types of vegetation. Water chemistry can affect weed palatability. Grass carp will consume floating fish food as well as aquatic plants.

Grass carp are readily available in Arkansas, and the *Sport Fish Supplier List* provides a listing of the fish farms that sell grass carp. This publication is available at the county office or online at http://www.uapb.edu/sites/www/Uploads/SAFHS/sportsfish_suppliers.pdf. Unlike many states, Arkansas permits the stocking of either diploid (normal) or triploid (sterile) grass carp in ponds and lakes. Because grass carp require flowing water to reproduce, stocking fertile grass carp in your pond will not result in more grass carp. New ponds can be stocked with 2- to 6-inch grass carp, but if largemouth bass are present, the grass carp stocked should be 8 to 10 inches in length. The stocking rates can vary depending on the amount of weeds. A standard recommendation is 5 to 10 per acre, but if the pond has plant coverage of greater than 50 percent, a stocking rate of 20 or more per acre may be required.

As a biological control agent, they will not provide immediate results. Assuming the target plant is readily consumed by grass carp, 1 to 2 years are required for control. If the pond/lake owner wants quicker results, applying an aquatic herbicide followed by stocking grass carp 2 to 3 weeks later may be the best solution. Stocking should take place after much of the dead plant material has had a chance to decompose.

Grass carp are natural inhabitants of rivers and readily escape ponds that overflow. Barriers on spillways are a good idea to prevent fish losses. Ponds with grass carp often develop a green or yellow color as grass carp promote greater phytoplankton growth in the water by the release of nutrients from the plants they eat.

After the grass carp reach maturity, the pond/lake owner may want to remove them. These large fish can be removed by snagging, bow fishing, spearing or angling. Their habit of hanging near the surface can make bow fishing especially simple. Because of their jumping ability, seining is often not effective. Their flesh is white, firm and not oily, but the muscle mass contains “Y” bones that can make cleaning more difficult. Their flesh is considered a delicacy by many seafood enthusiasts.

For more information, ask your county extension agent for Southern Regional Aquaculture Center (SRAC) Fact Sheet #3600, *Using Grass Carp in Aquaculture and Private Impoundments*, or it can be downloaded from https://srac.tamu.edu/.

GOLDFISH (*CARASSIUS AURATUS*) FOR WATERMEAL AND DUCKWEED

Duckweed (*Lemna* spp.) and Watermeal (*Wolffia* spp.) are free-floating aquatic plants commonly found together. Watermeal is the smallest and simplest of flowering plants. It is rootless and tiny, usually less that 1 mm, and appears as little green pinheads floating on the surface. To the touch, it feels somewhat like dry grits. Duckweed is a little bigger but still very small, usually ⅛ to ¼ of an inch across. The fronds tend to be elliptical, and a small root is present on the lower surface of each frond.

The growth of these plants is linked to high nutrient levels, which is why they are common in cattle ponds. Both of these plants tend to grow in dense colonies in quiet waters. Individual plants stick readily to birds, animals and equipment that may be in ponds that have these plants. As a result, they spread easily from one pond to another. Once in a new pond, their growth can be quite explosive if the conditions are right. Both species can reproduce by budding and, in some cases, double their population every 24 hours.

Both watermeal and duckweed tend to disappear from the pond surface in the late fall. During the summer, the plants have buoyancy due to trapped oxygen from photosynthesis. In the fall, photosynthesis slows down, leading to less oxygen in the plant, and the accumulated starch from a season of growth makes the plant heavier, so it sinks to the sediments. In the spring, the plants start photosynthesizing, accumulate oxygen and float to the surface again.

Under certain conditions, goldfish can provide a biological control option for watermeal. It is recommended that they be stocked into small ponds at a rate of 35 to 65 pounds per acre. Like any biological control, results take time and are not universal. In ponds where goldfish failed to control watermeal, it may have been due to predation from largemouth bass or some other factor. Stocking them is fairly inexpensive and will cause no harm, but success is not guaranteed.

AQUATIC DYES

Aquatic dyes are made from EPA registered non-toxic dyes (typically blue), that might control unwanted filamentous algae and submersed plants in natural and man-made lakes and ponds. They do not kill plants; they prevent growth by blocking light penetration, which reduces photosynthesis. They are less effective when plant growth is near the surface (2 ft or less). Aquatic dyes should only be applied to water bodies entirely within the control of the applicator, and only those with little or no outflow. If water is continuously released from the pond/lake, product is wasted and their effectiveness reduced. The effects on an aquatic dye typically last for up to 6 weeks.

Dye should be applied in the early spring before weed growth begins, or applied when weeds may be seen on the bottom of the pond. When applied to ice, it will melt a hole and disperse underneath. Additional applications will be necessary throughout the year to maintain an acceptable level of dye in the water. These dyes may be used at any time of the year.

Do not apply to water that will be used for human consumption. Water may be used for swimming after complete dispersal of the dye in water. Dyes are non-toxic to livestock.

At present, while there are many aquatic dye formulations available for purchase, only two dyes, Aquashade and Admiral, are registered with the EPA for aquatic plant control. As such, they are the only two that can make control claims. For the liquid formulations, the rate is typically 1 ppm, or one gallon/acre*ft. To restrict hydrilla growth, the rate should be doubled, due to its ability to grow at very low light levels. See label for rates.

USE RESTRICTIONS FOR AQUATIC HERBICIDES
(Number of Days After Treatment and Before Use)

Chemical	Active Ingredient Formulation	Withdrawal PPM	Drinking	Swimming	Eating Fish	Dairy	Other Stock	Withdrawal Crop Irrigation
Copper	Copper Sulfate Crystals, Copper Sulfate Solution, Copper Complexes		0	0	0	0	0	0
2,4-D	Amine, Ester, Acid formulation		(*a)	0	0	0	0	(*b)
Diquat			1-5 (*c)	0	0	1	1	5
Endothall	Dipotassium Salt		(*d)	0	0	7-25 (*e)	7-25 (*e)	0
Endothall	Mono (N,N-dimethylalkylamine) Salt		(*d)	0	0	7-25 (*e)	7-25 (*e)	0
Fluridone		0.15	0 (*f)	0	0	0	0	7-30 (*g)
Glyphosate		0.7	2 (*h)	0	0	0	0	0
Imazapyr			(*i)	0	0	0	0	120 or (*j)
Triclopyr			(*k)	0	0	0	0	120 or (*l)
Imazamox			(*m)	0	0	0	0	(*n)
Carfentrazone			0-1 (*o) (*m)	0	0	0-1 (*o)	0-1 (*o)	0-14 (*o)
Penoxsulam			0	0	0	0	0	(*p)
Sodium Carbonate Peroxyhydrate			0	0	0	0	0	0
Flumioxazin			0	0	0 (*q)	0	0	5 (*r)
Bispyribac-sodium			0	0	0 (*q)	(*s)	(*s)	(*s)
Topramezone			(*t)	0	0	0	0	(*u)
Florpyrauxifen			0	0	0	(*v)	(*v)	(*w)

(*a) Read the label. Restrictions will vary based upon formulation.

(*b) Read the label. Restrictions will determined by rate, crop to be irrigated, intake setbacks, and may require an Assay.

(*c) Withdrawal period will be determined by rate and formulation. An Assay may be required.

(*d) Restrictions are to ensure treated water exceeding Maximum Concentration Level (MCL) of less than 0.1 ppm. 600 foot setback from potable water intake in Lakes, Ponds and Quiescent Water bodies. For flowing water bodies, if intakes can be closed, they must remain closed until tested levels are below 0.1 ppm. If intakes can't be closed, the application must be below intake.

(*e) Withdrawal period is based upon application rate. If water is flowing, the water can be used immediately.

(*f) Do not apply within ¼ mile of water intake at rates above 20 ppb.

(*g Withdrawal period may depend upon crop to be irrigated and soil type. FasTEST assay may be required prior to use as irrigation.

(*h) Can't be applied within ½ mile upstream of active potable water intake. Water intakes must remain off for 48 hours if application made within ½ mile of intake, unless assay determines glyphosate level below 0.7 ppm.

(*i) not apply within ½ mile of active potable water intake.

(*j) Application to water used for irrigation that results in residues > 1.0 ppb must not be used for 120 days or until residue level is 1.0 ppb or less.

(*k) Potable water intakes must be turned off till triclopyr levels are determined to be 0.4 ppm or less.

(*l) Until residue is 1.0 ppb or less by assay.

(*m) May be applied to potable water at concentrations up to 500 ppb to within ¼ mile of active intake. Within ¼ mile, water concentrations can't exceed 50 ppb.

(*n) Restrictions based upon crop or location to be irrigated and rate used.

(*o) Read label. Restrictions based upon surface area treated. Do not apply within ¼ mile of potable water intake. Water intake may be turned back on less than 24 hours if assay shows carfentrazone-ethyl and degradate levels are below 0.2 ppm.

(*p) Treated water cannot be used for crop irrigation until below assay shows levels below 1 ppb, or 30 ppb if used to irrigate rice.

(*q) Do not use for water applied to crayfish ponds

(*r) 5 days for food crops. Turf and Landscape ornamental restriction determined by rate, water depth, and what is to be irrigated. Consult label.

(*s) Assay indicating concentration of less than or equal to 1ppb.

(*t) Application concentrations must be below 45 ppb.

(*u) Residue concentration assay must be below 1 ppb.

(*v) Do not allow livestock to drink treated water due to potential exposure of crops through compost.

(*w) Read label. Do not use for irrigation. For non-agricultural irrigation, waiting period depends upon treated water body area and rate.

Aquatic Herbicide Toxicity to Some Fish

The 96-hour LC_{50} is given in ppm columns. The lb column gives the pounds of active ingredient needed per acre*ft to reach the 96-hour LC_{50}

Herbicide	Bluegill		Channel Catfish		Rainbow Trout	
	ppm	lb	ppm	lb	ppm	lb
Endothall (Aquathol)	343	933	150	408	230	625.6
Endothall (Hydrothol)	1.0	2.72	0.5	1.4	1.7	4.6
Copper	Toxicity dependent upon alkalinity of water. The lower the alkalinity, the greater the toxicity.					
Diquat	14	38			15	41
Rotenone (a fish toxicant)	0.02	0.05	0.002	0.005	0.03	0.08
Glyphosate	25	68	13	35	28	76
2,4-D (Amine) Weedar 64, Weed Rhap A-4D, DMA 4 IVM	263	715	166	452	222	604
2,4-D (Ester) Navigate, Aqua-Kleen	2	5.4	1	2.7	1	2.7
Imazapyr	336	914	>100	>272	>100	>272
Triclopyr	681	1,852	446	1,213	400	1,088
Imazamox	119	324			122	332
Carfentrazone	2.0	5.4			16	44
Penoxsulam	103	280			102	277
Sodium Carbonate Peroxyhydrate	26(*a)	71(*b)	24(*a)	65(*b)	22(*a)	60(*b)
Flumioxazin	21	111.3			2.3	12.2
Florpyrauxifen	Practically non-toxic to fish at normal use rates.(LC50 > 100ppm)					
Bispyribac-sodium	>100	272			>100	>272
Topramezone					>100	>272

-The 96-hour LC_{50} is the amount of material needed to kill 50% of a population within 96 hours.
-ppm values are for the amount of active ingredient.
(*a) - Toxicity as ppm Hydrogen Peroxide.
(*b) - Expressed as pounds Hydrogen Peroxide. User will need to calculate the amount of product this equals from label information.