Herbicide Use near the Coastal Marshlands
Prepared for GA DNR – Coastal Resources Division

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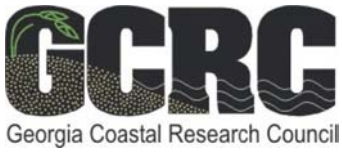

Background

Herbicides represent a potential risk for non-target plants and animals living in adjacent environments. Where herbicides are used near coastal marshes, there is a concern that they may have direct effects not only on marsh grasses but on other primary producers as well (i.e. benthic algae and phytoplankton). Various animals living in the marsh (i.e. insects, larval fish, shrimp, crabs) may also be sensitive to specific chemicals. There are also indirect effects that can stem from reductions in plant growth, as the plants are at the base of the marsh food web and also function to provide protection from storms and prevent erosion.

Lytle and Lytle (2001) prepared an excellent review on the use of plants for testing the effects of pollutants (including atrazine and other herbicides) on estuarine ecosystems. Results of the field and laboratory studies they presented clearly demonstrate that aquatic primary producers, including *Scirpus* (a grass found in fresh and brackish marshes), *Chlorella* (a freshwater alga), and *Potamogeton* (pondweed) are sensitive to broad-spectrum herbicides. Recent literature also suggests that even at sub-lethal levels, herbicides can reduce photosynthesis (and productivity) in both algae and in marsh grasses (Mason et al. 2003).

The effects of herbicides on the health of the marsh can be minimized by using herbicides that do not persist in the environment. To protect *Spartina* and other marsh grasses, one can choose herbicides that do not target perennials. Note that, although our focus is on *Spartina alterniflora*, Georgia marshes contain other plants that also need to be considered, such as *Juncus roemerianus, Distichlis spicata* and *S. cynosuroides*. Freshwater marshes characteristically contain a greater diversity of species, including wild rices, *Zizania aquatica* and *Zizaniopsis miliacae*, as well as *Typha latifolia*, *Cladium jamaicense*, *Sagittaria latifolia*, and *Scirpus spp*. (Gallagher and Reimold 1973; Latham et al. 1994). Herbicide sensitivity information concerning these species was less readily found. However, since many of them are grasses, they may exhibit responses similar to that of *Spartina*.

Herbicide-specific information

Below we provide information on seven common aquatic herbicides. This was largely drawn from the Plant Management in Florida Waters website,

http://aquat1.ifas.ufl.edu/guide/sup3herb.html -- "Details about the Aquatic Herbicides used in Florida".

Atrazine

Atrazine (a common, non-selective herbicide) will affect *Juncus*, but not *Spartina* (U.S. EPA 2003). However, since triazine herbicides are chemically stable in water, there are significant concerns about environmental effects when used in aquatic areas. More information: http://www.epa.gov/waterscience/criteria/atrazine/atrazinefacts.html

Fluridone

Fluridone herbicides (e.g. *Sonar* brand) are used to control submerged and floating plants such as duckweed or waterlilies. The activity of the herbicide is against carotenoid biosynthesis (pigment production necessary for protecting plants from harmful side reactions of photosynthesis). Fluridone is relatively ineffective against algae but will act against *Spartina*. More information[1]: http://www.doh.wa.gov/ehp/ts/Fluridone.doc

Glyphosate

Glyphosate-containing herbicides (e.g. *Rodeo* and *Roundup* brands) are amino acid synthesis inhibitors. There are significant differences in performance and toxicity depending on formulation. Glyphosate is a non-selective herbicide used in rights of way, recreation areas and aquatic environments. Glyphosate-containing products are used on the west coast to control *Spartina alterniflora* which in those areas is a non-native marsh grass species invading mud flats and competing with native grass species. [Note: *Spartina* is only killed when sprayed directly.] Generally speaking, *Roundup* is used for terrestrial applications (as it contains a surfactant) and *Rodeo* (or *Aquapro*) is used for weed control in aquatic environments. The latter are among the least restricted herbicides for wetland applications because it breaks down fairly rapidly. More information: http://npic.orst.edu/factsheets/glyphogen.pdf See also emails from Profs. K. Langeland and J. Madsen.

Imazapyr

Arsenal is a brand of imazapyr-containing herbicides being used in Florida against certain intractable invasives (melaleuca and torpedograss). Another formulation, *Habitat*, is used for some aquatic applications in Mississippi and South Carolina (Mississippi State Univ. Extension Service, 2005 and Clemson Extension Service). It has a long environmental half-life. Imazapyr does not affect algae, but is active against broadleaved plants, shrubs, trees and grasses (including *Spartina* [Patten 2003]). More information: http://www.spartina.org/referencemtrl/ImazapyrFactSheet.pdf

[1] An aside: During discussions about the Georgia salt marsh dieback, Dr. Gerard Krewer (Univ. of Georgia Extension Service) mentioned that such aquatic herbicides might be (or may have been) used by some Georgia coastal communities to control weeds in their lakes or freshwater ponds. Specifically, he suggested that the area near Isle of Wight/Twin Rivers has several large lakes and that it might be worthwhile looking for the drainage/overflow and see if the salt marsh vegetation in those areas was affected by the dieback. There was no known follow-up to this lead.

Sulfonylurea

A common class of agricultural herbicides used along roadways and railroads by DOT (and perhaps forestry industries/agencies) is the sulfonylureas. These include *Oust* brand. They are ALS (acetolactate synthesis) inhibitors, causing deficiency in the branched chain amino acids. These herbicides are potent, broad spectrum ones which can be taken in by the roots or the leaves. Leaf uptake is significant since drift (when the herbicide is applied from the air) can result in damage to vegetation away from the targeted area. It is expected to be active against *Spartina* since it is used against other perennial grasses (Information Ventures). More information:
http://www.oregon.gov/ODF/PRIVATE_FORESTS/docs/chem/sulfometuronmethyl.pdf

Triclopyr

Garlon, *Pathfinder*, and *Renovate* are herbicide brands containing triclopyr. This herbicide is moderately selective: algae and some grasses are less susceptible to the mode of action than are floating/ immersed aquatics, trees, shrubs, vines and broadleaf weeds. It is used against actively growing plants and is applied directly to the leaves (or stumps, in the case of trees) as it is not readily absorbed by the roots. Triclopyr is effectively broken down in the soil by microbial activity and it does not affect *Spartina*. More information:
http://extoxnet.orst.edu/pips/triclopy.htm , http://npic.orst.edu/factsheets/triclogen.pdf See also email from Prof. Madsen.

2,4-dichlorophenoxyacetic acid (2,4-D)

2,4-D is a selective herbicide (most grasses are resistant to a degree) used in some aquatic applications. It is generally used to control broadleaf weeds in grassy areas (turf or grass crops such as wheat), but is also effective against some aquatic weeds. There are many different formulations, some of which are toxic to fish and other aquatic species. However, persistence in the environment is quite low and it does not affect *Spartina*. More information:
http://npic.orst.edu/factsheets/2_4-D.pdf, http://extoxnet.orst.edu/pips/24-D.htm See also email from Prof. Madsen.

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Patten, K. (2003). *Evaluating imazapyr in aquatic environments: searching for ways to stem the tide of aquatic weeds*. Agrichemical and Environmental News, issue 205. http://www.spartina.org/referencemtrl/Patten%202003.pdf

U.S. Environmental Protection Division, Office of Water (2003). *Ambient aquatic life water quality criteria for atrazine*, revised draft. 178 pp. http://www.epa.gov/waterscience/criteria/atrazine/rev-draft.pdf

OTHER USEFUL RESOURCES

National Pesticide Telecommunications Network, http://npic.orst.edu

Pesticide Action Network, North America, http://www.pesticideinfo.org/Index.html, and an especially good section on "Chemical Toxicity Studies on Aquatic Organisms": http://www.pesticideinfo.org/Search_Ecotoxicity.jsp

Herbicide Application in Washington
http://depts.washington.edu/propplnt/Chapters/Herbicides%20washington.htm

Aquatic Weed Control Use Restrictions, Georgia Pest Management Handbook
http://www.ent.uga.edu/pmh/Aquatic/Aquatic.htm

Control of Non-native Plants in Natural Areas of Florida, K.A. Langeland and R. K. Stocker
http://edis.ifas.ufl.edu/WG209

Kenneth Langeland, Professor and Extension Specialist (via email)
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He wrote: "Any of the herbicides registered for non-cropland use would be appropriate and the choice of herbicide will depend on the target plant(s). While some of the herbicide labels prohibit use "below the high water mark" in estuarine habitats, they are appropriate for use adjacent to estuarine habitats. Glyphosate will only kill spartina if it is sprayed directly on to it. Likewise toxicity to fish nor invertebrates is a concern if the glyphosate is used according to label instructions and there is a wide margin of safety. Glyphosate itself is essentially non-toxic to fish, invertebrates, or other higher organisms. While it is known that glyphosate plus the surfactant in some formulations has higher toxicity to fish and amphibians than glyphosate by itself, the margin of safety is still very high and not a concern unless sprayed directly into the water at high concentrations and this is not permitted by the label of these formulations. Your questions should be answered in the following publication: http://edis.ifas.ufl.edu/WG209."

John Madsen, Assistant Professor (via email)

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He wrote: "The problem with "terrestrial" glyphosate, Roundup, is the surfactant that they use in the formulation. Aquatic glyphosate (Rodeo) does not have a surfactant, so you add an approved aquatic surfactant. You can also use Habitat, which is a broad-spectrum herbicide for emergents.

The freshwater aquatic approved herbicides are listed in our attached recommendations for Mississippi [file p1532aquatic.pdf, see next pages]. I am not sure if there are separate restrictions for saltwater areas, but I don't think so.

If you are controlling broad-leaf weeds, you could use Renovate [triclopyr] or DMA-IV [2,4-D] without affecting Spartina."

Scott Senseman, Professor and Laboratory Director (via email)

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He wrote: “I am not sure that I understand fully what your issues are with regard to swales. Do you mean a grass buffer zone or something else? However, the material that probably would be easiest and cheapest to use for controlling vegetation on a broadscale would be glyphosate with the least environmental impact if the material is sprayed on vegetation directly. Glyphosate has minimal activity in soil at spray solution concentrations and should be bound to the soil and virtually unavailable to water sources from runoff. Indeed, the surfactants are another story and at this point with the literature related to the frogs, I am uncertain as to the impact of runoff surfactant concentrations to the wildlife in this case.

Another option might be glufosinate. It is also a non-selective material that should have similar adsorptive capacities to glyphosate on soil. However, it is more expensive (I don't know how much more if you buy it in Georgia) and may or may not work depending on the species that you have to get rid of.

Great question [concerning use of herbicides in swales designed for storm-water treatment, does it make sense?]. The thing about swales (if I am using the definition correctly) is that at least in these areas, there is infiltration of water to the soil which is a great filter. If one has the opportunity to filter the water a little prior to the water filling the pond, river, stream, etc., then it obviously will be better than the alternative. Flawed...yes. Nothing is perfect. If you have an area with vegetation, you will have to keep unwanted plants out by whatever means are available to you.

Finally, you might also contact Dr. Tim Grey at Tifton. He may have some other thoughts and also has some expertise in this area.

Let me know if I can help further.”

AQUATIC WEEDS

Rates are expressed on basis of active ingredient unless trade product is named. Where weed growth is heavy treat only a portion of the area at one time to avoid depleting oxygen in the water during decomposition of vegetation. Treatment of entire ponds or lakes heavily infested with aquatic weeds can result in death of fish.

Calculations for amount of herbicide needed on basis of parts per million by weight (ppmw)

Ditch or canal
W = A x L x C x 0.0000625

W = pounds of active ingredient needed
A = cross section area of channel in sq. ft.
L = length of channel in feet
C = desired concentration of herbicide in ppmw

Pond or lake
W = A x D x C x 2.7

W = pounds of active ingredient needed
A = area of water surface in acres
D = average depth in feet
C = desired concentration of herbicide in ppmw

TREATED WATER USE RESTRICTIONS (NUMBERS OF DAYS).

Trade Name	Common Name	Human			Animal	Irrigation		
		Drinking	Swimming	Fish Consumption	Drinking	Turf	Forage	Food Crops
Aquathol K	Endothall	7-25	1	3	7-25	0	7-25	7-25
Aquathol Super K	Endothall	7	1	3	7	0	7	7
Various	Copper Complexes	0	0	0	0	0	0	0
	Copper Sulfate	0	0	0	0	0	0	0
Aqua-Kleen, DMA 4 IVM, Navigate	2,4-D	21[a]			0	21[b]	21[b]	21[b,c]
Habitat	Imazapyr	2	0	0	0	120[d]	120[d]	120[d]
Hydrothol 191	Endothall	7-25	1	3	7-25	7-25	7-25	7-25
Renovate 3	Triclopyr	-[e]	0	0	0[f]	0[g]	120[g]	120[g]
Reward, Weedtrine-D	Diquat	1-3	0	0	1	1-3	5	5
Rodeo, AquaPro	Glyphosate	0	0	0	0	0	0	0
Sonar	Fluridone	0	0	0	0	30[h]	30[h]	30[h]

[a]See label for distance allowed from potable water intake.

[b]Shorter interval may be used if approved assay indicates less than 0.1 ppm 2,4-D.

[c]Do not use in ditches where water is used to irrigate highly susceptible crops, such as cotton, grapes, and tomatoes.

[d]Less if Habitat herbicide residue levels are determined by laboratory analysis or other appropriate means of analysis to be below 1 ppb.

[e]Drinking water can only be used when concentration of Renovate 3 is less than 0.4 ppm as determined by laboratory analysis.

[f]See label for drinking water or grazing restrictions for lactating dairy animals.

[g]If Renovate 3 residue levels are determined to be nondetectable by laboratory analysis, there is no restriction for use of irrigation water on established grasses.

[h]Restrictions suggested by manufacturer.

Consult labels for approved adjuvants.

Weed resistance to recommended use-rates of certain herbicides has been documented in Mississippi — SEE PAGE 4.

CONTROL OF SOME COMMON AQUATIC WEEDS WITH HERBICIDES.

	Copper Complexes Copper Sulfate[1]	Hydrothol 191	Reward	2,4-D	Aquathol K or Super K	Glyphosate	Sonar	Habitat	Renovate 3
Algae									
plankton (single cell)	•								
filamentous and water net	•	•	•						
Chara and Nitella	•	•							
Floating Weeds (not attached to bottom)									
duckweed			•				•	•	
giant salvinia			•			•			
watermeal			•					•	
water hyacinth			•	•		•		•	•
Emersed Weeds (attached to bottom)									
American lotus			•	•			•		•
watershield				•			•		•
white waterlilly				•			•	•	•
frogbit				•				•	•
water pennywort			•					•	
Submersed Weeds (not attached to bottom)									
bladderwort			•		•		•		
coontail			•		•		•		•
Submersed Weeds (attached to bottom)									
bushy pondweeds (Najas)			•		•		•		
parrottfeather			•	•	•		•	•	•
Eurasian watermilfoil			•	•	•		•		•
fanwort							•		•
pondweeds (Potamogeton)			•		•		•		
hydrilla and elodea	•		•				•		
spikerush				•			•		
Marginal Weeds									
alligator weeds				•		•	•	•	•
water primrose				•		•	•	•	•
smartweed				•		•	•	•	•
arrowhead				•			•	•	•
willows				•		•		•	•
cattail and cutgrass			•			•		•	
bulrush						•		•	
burweed				•					
water leaf (Hydrolea)				•		•	•		

NOTE: It is not intended that any suggested usage in this table be in violation with existing regulations or manufacturer's label.
[1]Use products containing copper with caution because its toxicity to fish and its effectiveness in controlling aquatic weeds depend on total alkalinity of the water.

Aquatic weeds	Treatment	Rate	Comments
Floating			
algae	copper sulfate (pentahydrate)	1 to 2 ppmw	Toxicity to fish and algae increases with temperature but decreases with water alkalinity. For water with less than 50 ppm total alkalinity, do not use copper sulfate. For water above 50 ppm, determine the amount of copper to use by dividing total alkalinity (ppm) by 100. This equals the desired copper concentration in the water. Catfish are not very tolerant to copper. Always leave untreated aquatic areas for fish to move into.
	copper complex	0.67 to 0.75 gal/A foot water	Complexed forms of copper are more active in alkaline water than the sulfate. For water with less than 50 ppm alkalinity, catfish may be killed. Apply a surface spray. Apply when algae begin to grow and water temperature is above 60 °F. Best results when applied on sunny days.
		1.25 to 1.5 gal/A foot water	Apply when total alkalinity is above 50 ppm.
duckweed	diquat	1 gal/surface acre	Foliar spray or injection in nonflowing water. **Do NOT** apply diquat to muddy water. Apply as overall spray in 50 to 150 gallons of water plus 1 pint nonionic surfactant. Spray marginal areas to reduce reinfestation. Retreat if necessary.
water hyacinth	2,4-D Amine IVM 44 2,4-D Amine 4 DMA 4 IVM	2 to 4 lb/A	Spray when plants are actively growing. Delay use of treated water for irrigation or domestic purpose for 3 weeks or until approved assay shows no more than 0.1 ppm 2,4-D acid. For use in water bodies that are still or slow moving. Must be applied by trained or licensed applicators. **Do not** treat more than one-half lake or pond at one time to avoid oxygen depletion and fish kill. In large lakes, leave 100-foot buffer strip.
Submerged			
elodea	diquat	2 gal/A	Inject or apply on surface of nonflowing water. **Do NOT** apply diquat to muddy water.
	(Hydrothol-191) Endothall liquid or granular	2 to 4 ppmw	Spray on or inject underwater. Broadcast granular over surface. **Do not** treat more than 1/10 of the lake at one time. Treatments greater than 0.3 ppm will kill fish. Fish will leave treated area if outlets to untreated waters are available.
Eurasian milfoil	2,4-D amine	10 to 40 lb/A	**Do not** treat more than one half lake or pond at one time to avoid oxygen depletion and fish kill. In large lakes leave 100-foot buffer strip. **Do not** treat within 1/2 mile of potable water intakes. Treat in spring when milfoil starts to grow. Spray on or inject under water.
	diquat	1 to 2.0 gal per surface acre	Distribute evenly over infested area. Inject or apply on surface of slow-flowing water. **Do NOT** apply diquat to muddy water.
	Endothall (Aquathol K and Aquathol granular)	0.5 to 2.5 ppmw	Safer to fish than dimethyalkylamine salts. Spray or inject liquids under water. Apply granules evenly with cyclone seeder. Apply as soon as possible after weeds begin to grow and water temperature is above 65 °F. When treating in sections, treat on 5- to 7-day interval. Use higher rates when spot treating.

Aquatic weeds	Treatment	Rate	Comments
Submersed and Emersed			
Milfoil	2,4-D (20% granules)	100 lb/A	Best results when applied in spring to early summer during early growth stage. Apply uniformly using portable spreader (cyclonic seeder). Rate depends upon weed species, weed mass, water depth, and water pH. Repeat application if needed. **Do not** use water for agricultural purposes, watering dairy animals, or domestic purposes.
bladderwort waterlily watershield coontail pondweed		150-100 lb/A	Rates are based on type of water body treated and average water depth. See label for details. **Do not** use water for irrigation from ponds for 30 days or lakes for 7 days after treatment.
elodea naiad pondweed coontail milfoil water primrose water purslane	Sonar AS Sonar PR Sonar SRP	0.5-4 qt/A 10-80 lb/A	
Emersed (Shoreline)			
alligatorweed	Biological control		Chemical treatment may not be necessary if specific biocontrol insects, the alligatorweed flea beatle (*Agasicle hygrophila*) and/or stem borer moth (*Vogtia malloi*), are present. The flea beetle is more active in the southern part of the state and the stemborer is active throughout the state. These insects may not provide control in areas adjacent to fields subject to heavy insecticide usage; e.g., near cotton fields. Contact your county agent or a qualified entomologist for positive identification.
arrowhead	2,4-D	4 to 8 lb/A	Spray on foliage. Use only formulations labeled for aquatics.
cattail	Rodeo	3 to 5 qt/A	Spray on foliage/See Rodeo entry below.
cattail lilies	Habitat 2 lb ae/gal	2-3 pt/A or 1% solution	Spray on foliage. Add 1 qt aquatic approved nonionic surfactant per 100 gallons spray solution.
Actively growing (floating or emersed) grasses, broadleafs and brush	Rodeo (glyphosate)	1.5 to 7.5 pt/A or spot treatments use 0.75 to 1.5% solution	For application to floating or emerged vegetation, undesirable shoreline weeds and brush by air, booms, or handheld equipment using 3 to 20 gal spray per acre. Do not expect control of vegetation that has a majority of the leaf surface submerged. Add 1 to 2 qt nonionic surfactant to 100 gal spray but use only X-77 if applications are made to aquatic sites. For hand guns, use 3 to 6 qt Rodeo in 100 gal water depending upon weed species. Spray to wet. For broadcast application use 1.5 to 2.5 pt for small annuals and 3 to 7.5 pt for perennial weeds and brush.
Emerged broadleafs	2,4-D (amine), 2,4-D Amine, and 2,4-D Amine No. 4	1.2 to 2.1 lb ai/A	For control of aquatic weeds in lakes, ponds, drainage ditches, and marshes. Apply 2.5 to 4.5 pt/A of 3.8 lb/gal or 1.67 to 3.0 pt/A of 5.64 lb/gal formulation in 50 to 100 gal water. Spray to wet foliage thoroughly. Apply when leaves are fully developed, actively growing, and are above the water level. Restrict applications to one-third to one-half of lake or pond. Repeat treatment once if needed.