USDA United States Department of Agriculture
Agricultural Research Service

Biology, Ecology and Management of Aquatic Weeds in Ponds

John D Madsen, PhD
Research Biologist, USDA ARS
Davis, CA jmadsen@ucdavis.edu

USDA

Knocking Out Noxious Weeds on Rangelands, NOV 17 2016, Fresno, CA

CAVEATS AND EMPTORS

- I am not certified as a PCA, so nothing should be construed as a RECOMMENDATION.
- I cannot possibly know all of the regulations in California concerning control measures applied to your water body. I have a day job.
- I am conveying what a person or persons have found works throughout the US, including places in which "y'all be careful" is the extent of regulation

My Usual Call
(for 11 years while in Mississippi)

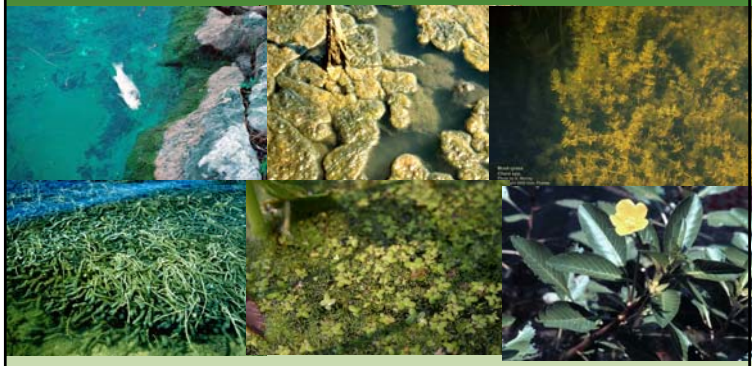
- Hey, Doc; I got some Moss in my Pond – How do I get Rid of It?"
- My response: "What kind of Moss?"
- Answer: "Well, it's kind of Green."

When you say moss, I literally think of an aquatic moss *(Sphagnum moss by Michael Luth)*

USDA

Kinds of Moss?

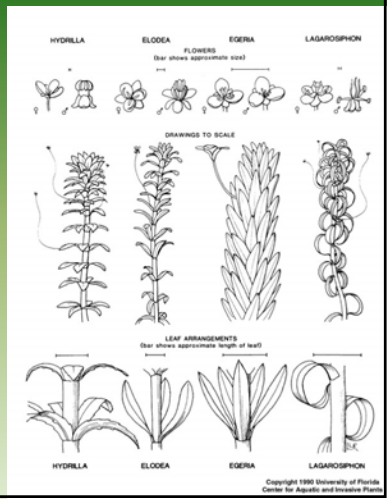
When you say moss, you could mean:



USDA

The Kind of Moss Matters…

- Proper identification is critical to selecting the correct herbicide
  - E.g., Aquathol-K is excellent for hydrilla, fair for elodea, and poor for egeria – and they are in the same family
- Proper identification will also indicate if there is an invasive problem or a localized native nuisance



USDA

Getting a Good ID

- Publications / guides
  - Enough said
- Online keys
  - More enough said
- Experts
  - Send a good picture

Treating a stormwater retention pond overgrown with waterlettuce

USDA

Ask an Expert – Send a Photo

- A number of people can identify aquatic plants in your region – and your extension agent likely knows who they are…
- Sending a good quality digital photo is the best way to get a good ID.
- DO NOT send a jar of plants in water to someone by parcel post, unless you want to get on their bad side

USDA

Taking Photographs

- Three types of photos are helpful in identifying a plant:
- "Habit" shots that show how the plant is growing. Distance is typically 12-24'
- Leaf arrangement or stem shots. Distance is typically 2-6' (twice your arm length, or your height.
- Close-ups of flowers. Distance is typically 4"-2' (arm length).

Habit

Stem detail (this is closer than necessary)

Floral detail (close-up lens or zoom may be required)

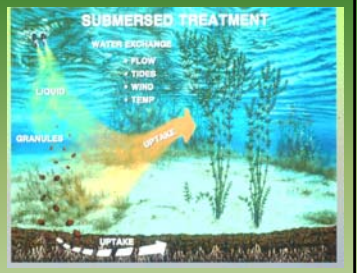
USDA

How Big is your Problem?

- For emergent and floating leaf plants, the AREA is typically the measurement needed (with a few exceptions)
- For submersed plants, the water VOLUME is the critical dimension
- A correct volume calculation will ensure both compliance with the label, and may save a lot of money

Calculating Volume

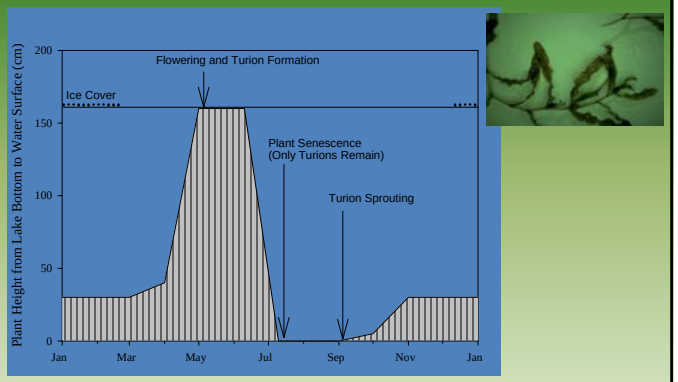
- Spend the time to take 20 or so depth soundings with a rod across the length of the pond
- Average these for the depth
- Volume = area x average depth



Life History of Target Plants

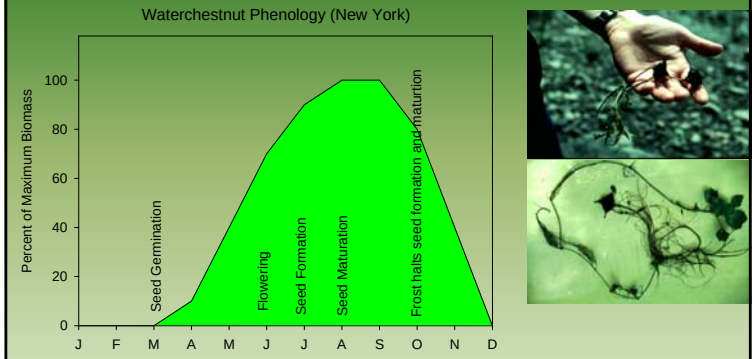
- For more extensive weed problems, knowing the life history of the plant will inform:
  - When the plant starts growing or forming a problem during the year
  - When management might halt seed or propagule production
  - When management might be enhanced in perennial plants

Curlyleaf Pondweed Lifecycle



Life Cycle in Minnesota

Waterchestnut Life History

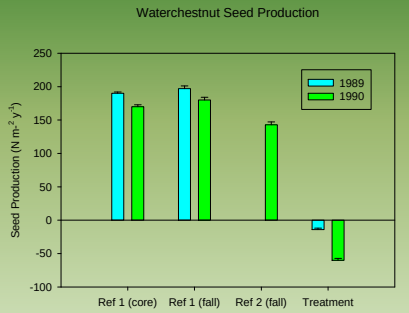


USDA

Cutting of Flowering Heads

- Waterchestnut managed using an airboat fitted with a cutting blade
- Cutting of waterchestnut flowering rosettes prevented seed production in Watervliet Reservoir

Data from Methe et al. 1993



USDA

Common Aquatic Weeds in California

Common Name	Scientific Name	Habit	Nonnative or native
Cattail	*Typha sp.*	Emergent	Native
Waterhyacinth	*Eichhornia crassipes*	Free-floating	Nonnative
Duckweed	*Lemna sp.*	Free-floating	Native
Elodea	*Elodea canadensis**	Submersed	Native
Coontail	*Ceratophyllum demersum*	Submersed	Native
Algae (Covered later)	*Various**	Phytoplankton, filamentous	Native*

Cattail (*Typha* sp.)

- Cattail are herbaceous perennial plants
- Regrow from rhizomes in sediment
- Very prolific

Cattail Management

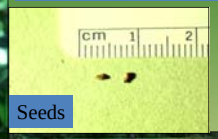
- Biocontrol
  - None
- Herbicides
  - Glyphosate, imazamox, imazapyr
- Mechanical
  - Cookie cutter
- Physical
  - Elevated water level, extended drawdown

Waterhyacinth

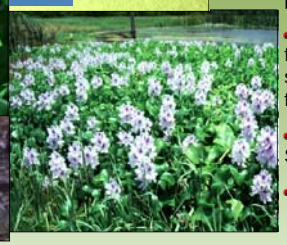
Eichhornia crassipes (Mart.) Solms

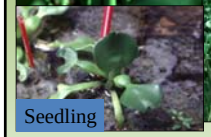
Parent and daughter plant

Inflorescence



Seeds





Seedling

- Floating rosette with showy purple flower
- Vegetative reproduction from daughter plants on stolons; some reproduction from seed
- Native to Central and South America
- Worldwide #1 aquatic weed

Waterhyacinth Management

- Biological
  - Two species of *Neochetina* weevils; *N. bruchi* and *N. eichhorniae*
- Chemical
  - 2,4-D, Glyphosate, penoxsulam (?)
- Mechanical
  - Harvesting, chopping
- Physical
  - Drawdown

Duckweed

- Native plant
- Weedy in nutrient-enriched and stagnant waters
- Smallest flowering plant
- Free-floating

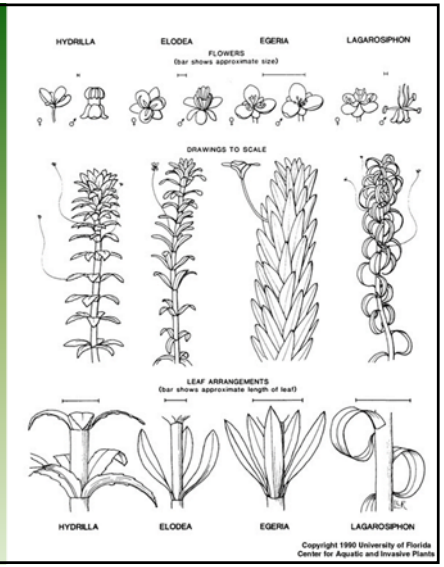
Duckweed Management

- Diquat at 1 gallon per surface acre, no surfactant
- Fluridone at 3.8 oz. per acre-foot (target 45 ppb) [or less]
  - Please note that a 5 acre pond averaging 3 feet deep would need 57 oz. or a little less than 2 quarts

Elodea or Waterweed

- *Elodea canadensis* and other species
- Common native plant
- Occasionally weedy
- Make sure it is not hydrilla (a state noxious weed) or egeria

Comparison

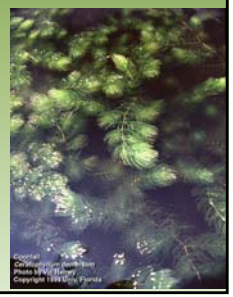


Elodea management

- Biocontrol
  - Grass carp
- Herbicides
  - Diquat, fluridone
- Mechanical
  - Harvesting
- Physical
  - Drawdown / dewatering

Coontail

- Coontail (*Ceratophyllum demersum*) free-floating, unrooted submersed plant
- Most common native submersed plant
- Occasionally causes nuisance



Coontail Management

- Biological
  - Grass carp
- Chemical
  - Diquat, endothall, fluridone
- Mechanical
  - Harvesting
- Physical
  - Dye, drawdown

Aquatic Plant Management Approaches

- Biological Control
- Chemical Control
- Mechanical Control
- Physical Control

USDA

Biological Control

- Insects (Classical or Naturalized)
- Grass carp
- Pathogens (Classical or Naturalized)

USDA

Chemical Control

EPA-Approved Aquatic Herbicides (see www.aquatics.org)

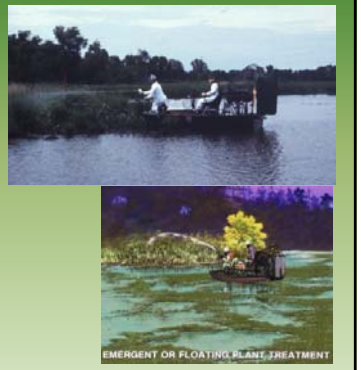
- 2,4-D (AquaKleen, DMA-IV, Navigate, others)
- Bispyribac sodium (Tradewind)
- Carfentrazone (Stingray)
- Complexed and chelated copper (A veritable host)
- Diquat (Reward, Weedtrine)
- Dyes (Aquashade, others)
- Endothall (Aquathol K, Aquathol Super K, Hydrothol 191)
- Flumioxazin (Clipper)
- Fluridone (Sonar)
- Glyphosate (Aquapro, Rodeo, others)
- Imazamox (Clearcast)
- Imazapyr (Habitat, others)
- Penoxsulam (Galleon SC)
- Peroxides (Greenclean, Pac-27)
- Topramezone (Oasis)
- Triclopyr (Renovate 3, others)

Off-label Uses

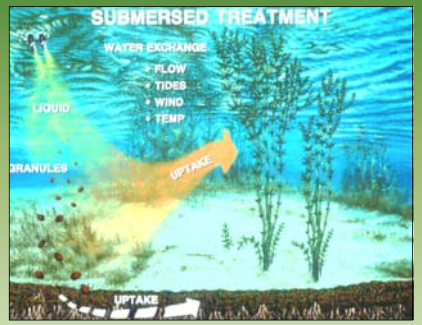
- The following are not legal for general aquatic use:
  - Diuron: Karmex, Direx
  - Roundup (Terrestrial formulation)
  - Dicamba
  - Dichlobenil
  - Any pesticide not specifically labeled for aquatic use
- Recommending them for use or using them in surface waters is against federal and state law.
- This is punishable by a fine and/or jail
- Bottom line: READ THE LABEL. It must include use in an aquatic site.

Emergent and Floating Plants

- Application to leaves above surface of water
- Most commonly-used for emergent plants is glyphosate
- Use aquatic-approved surfactant
- Cide-Kick, Cygnet Plus, Dyne-Amic, many others



Submersed Plant Herbicide Applications



K. Getsinger, USAERDC

- Herbicides are applied to water, and plants take up herbicide from water
- Water movement, residence time, and concentration are critical for effective treatment

Herbicide Selection

Herbicide	Cattail	Waterhyacinth	Duckweed	Elodea	Coontail
2,4-D	P	E	P	P	G
Copper	NA	NA	P	G	F
Diquat	F	G	E	E	E
Endothall	NA	NA	P	F	E
Flumioxazin	G	G	E	G	G
Glyphosate	E	G	P	NA	NA
Imazamox	E	?	P	?	?
Imazapyr	E	E	P	NA	NA
Fluridone	NA	NA	E	E	E
Penoxsulam	?	E	P	?	?
Triclopyr	P	E	P	P	F

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	0	7-25	0	7-25	7-25
Aquathol Super K	Endothall	7	1	0	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]
Galleon SC	Penoxsulam	0	0	0	0	[d]	[e]	[f]
Hardball	2,4-D	[g]	0	0	0	[h]	[h]	[h]
Habitat	Imazapyr	2	0	0	0	120[d]	120[d]	120[d]
Hydrothol 191	Endothall	7-25	1	0	7-25	7-25	7-25	7-25
Renovate OTF	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 (Sonar AS, Sonar SRP, Sonar PR, Sonar QR)	Fluridone	0	0	0	0	30[h]	30[h]	30[h]
Stingray	Carfentrazone ethyl	1[i]	0	0	1[i]	14[j]	14[j]	14[j]

[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]Water treated with Galleon SC can be used for turf irrigation if concentrations are less than 30 ppb.
[e]For other non-food crop irrigation or for other irrigation uses, contact SePRO Corporation prior to irrigation if concentrations exceed 1 ppb.
[f]Do not irrigate established food crops, other than rice, until Galleon SC residues are no more than 1 ppb in irrigation source water. Do not irrigate established rice if concentrations in treated water exceed 30 ppb.
[g]Drinking water can be used when the concentration of Hardball is less than 70 ppb.
[h]Do not use water from treated areas for irrigating plants (especially cotton, grapes, and tomatoes) or for mixing sprays for agricultural or ornamental plants unless an approved assay indicates that the 2,4-D concentration is 100 ppb or less or unless only growing crops and noncrop areas labeled for direct treatment with 2,4-D will be effected.
[i]Less if Habitat herbicide residue levels are determined by laboratory analysis or other appropriate means of analysis to be below 1 ppb.
[j]Drinking water can only be used when concentration of Renovate 3 is less than 0.4 ppm as determined by laboratory analysis.
[k]See label for drinking water or grazing restrictions for lactating dairy animals.
[l]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.
[m]Restrictions suggested by manufacturer.
[n]No restrictions if less than 20% of the water surface is treated.

Federal label restrictions from Weed Control Guidelines for Mississippi

Read current label!

Herbicide exposure time for submersed applications, plant response, and application rate.

Chemical	Exposure Time (Submersed)	Plant Response	Maximum Application Rate
2,4-D	Intermediate (18-72 hours)	7-10 days	0.5 gal/acre (emergent) 2.84 gal/acre-ft (submersed)
Carfentrazone-ethyl	Unknown	7-14 days	0.2 lb ai/acre (emergent) 0.296 gal/acre-ft (submersed)
Copper	Intermediate (18-72 hours)	7-10 days	1.5 gal/acre-ft (submersed)
Diquat	Short (12-26 hours)	7 days	2 gal/acre (both)
Endothall	Short (12-36 hours)	7-14 days	3.2 gal/acre-ft (submersed)
Glyphosate	NA	Up to 4 weeks	2 gal/acre (emergent only)
Imazapyr	NA	Up to 8 weeks	.75 gal/acre (emergent only)
Fluridone	Very long (60 to 90 days)	Up to 90 days	5 oz/acre-ft (submersed application only, generally use much less)
Triclopyr	Intermediate (12-60 hours)	Up to 2 weeks	6 lb ae/acre (emergent) 2.3 gal/acre-ft (submersed)

Mechanical Control

- Hand-pulling
- Cutting
- Harvesting
- Diver-operated suction harvesting
- Rotovating
- Other machines

Physical Control

- Environmental alteration
- Dredging
- Drawdown
- Benthic barrier
- Shading
- Nutrient inactivation




USDA

Algae

- Algal problems can be free-floating phytoplankton, free-floating filamentous algae, or attached algae.
- Nutrients, especially phosphorus, feeds algal growth



USDA

Why Algae Problems?

It's pretty simple – nutrients dissolved in the water

USDA

Phosphorus and Algae

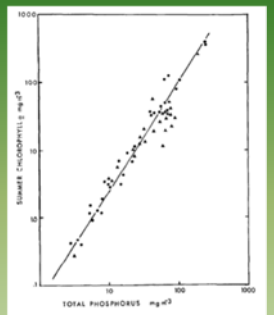


Fig. 1. Summer average chlorophyll concentration vs. total phosphorus concentration at spring overturn. Circles—data from Sakamoto (1966), chlorophyll measured by the method of Hogetsu and Ichimura (1954) and Ichimura (1956); triangles—data for other lakes reported in the literature, chlorophyll measured as chlorophyll *a*. The line shown is the regression line for Sakamoto's data.

Dillon and Rigler 1974. Limnology and Oceanography Vol. 19, No. 5, 767-773.

Increased phosphorus in water leads to more algal growth

While some increased algal growth will benefit fish production, too much algae leads to oxygen depletion, fish kills, and odor problems

Nutrients will also increase growth of free-floating plants

USDA

This is Your Pond

USDA

This is Your Pond on Fertilizer:

- Excessive planktonic and filamentous algae or duckweed is directly related to fertilizing ponds

USDA

Chemical Algal Control

- Primary control of algal growth is through reduction of nutrient inputs
- Algaecides are a short-term relief to algal growth
- Most algaecides are copper-based
  - Some copper tolerance and resistance is appearing in some species
  - Many states are restricting copper use

USDA

Algaecides

Chemical	Product	Formulation	Company	Plants
Copper	Aquatrine	liquid	Applied Biochemists	algae
	Captain	liquid	SePRO	algae, hydrilla
	Clearigate	liquid	Applied Biochemists	algae
	Cutrine Plus	liquid	Applied Biochemists	algae, hydrilla
	Cutrine Plus	granular	Applied Biochemists	algae, hydrilla
	K-Tea	liquid	SePRO	algae
Diquat	Reward	liquid	Syngenta	algae
	Weedtrine	liquid	Applied Biochemists	algae
Endothall	Hydrothol 191	liquid	UPI	algae
Peroxide	GreenClean	granular	BioSafe Systems	algae
	PAK-27	granular	Solvay Interox	algae

USDA

Mechanical Control

- Harvesters
- Nets pulled by boats or tractors
- Rake or hydrorake
- Ultra-violet light
- Filtration

USDA

Physical Control

- Aeration
- Dye
- Shading
- Nutrient inactivation
  - Chemical – alum, lime
  - Biological - bacteria

USDA

Algae Control Suggestions

- Cutrine Plus (copper complex) at 0.6 gal/acre-ft targeting 2 ppm
- Preventative control with PAK-27 for blue green algae (cyanobacteria) only
- Nutrient Reduction
- Pond dyes

USDA

Resources

- **BIOLOGY AND CONTROL OF AQUATIC PLANTS A Best Management Practices Handbook**
  - http://www.aquatics.org/bmp.html
- California Aquatic Weed School (next in 2018)
  - http://wric.ucdavis.edu
- **Calflora**
  - www.calflora.org
- **Cal-IPC**
  - www.cal-ipc.org
- **DRAAWP**
  - http://ucanr.edu/sites/DRAAWP/
- **WeedRIC**
  - **http://wric.ucdavis.edu/**

USDA

Contact Information

Dr. John D. Madsen
USDA ARS EIWRU
UC-Davis, Plant Sciences,
Mail Stop 4
274 Robbins Hall
Davis, CA 95616
jmadsen@ucdavis.edu
john.madsen@ars.usda.gov
ph 530-752-7870