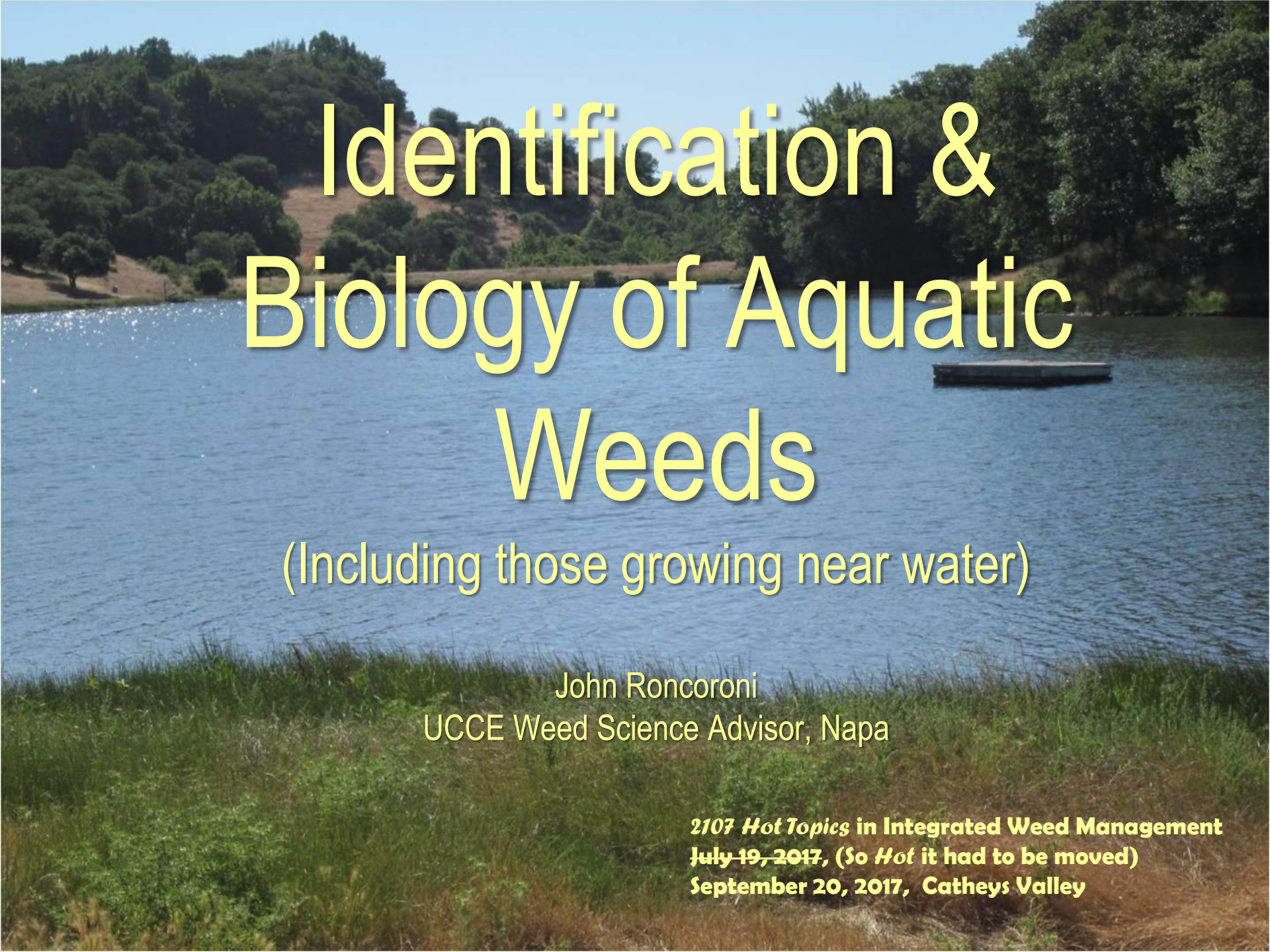
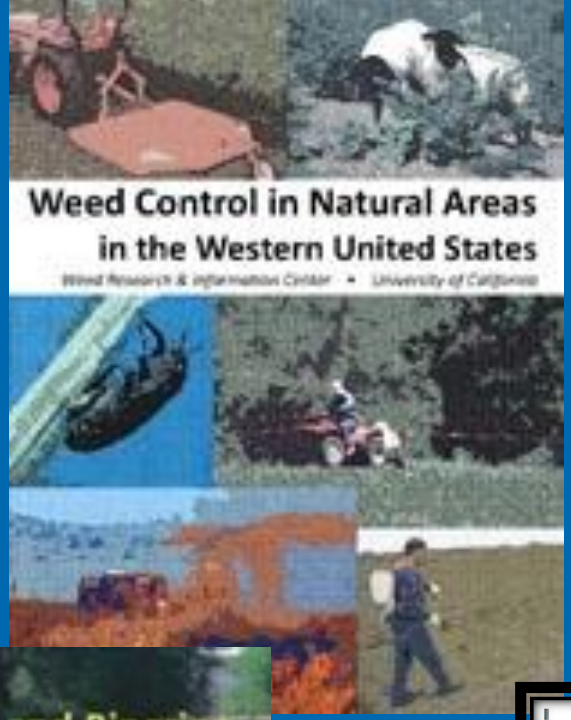


Identification & Biology of Aquatic Weeds

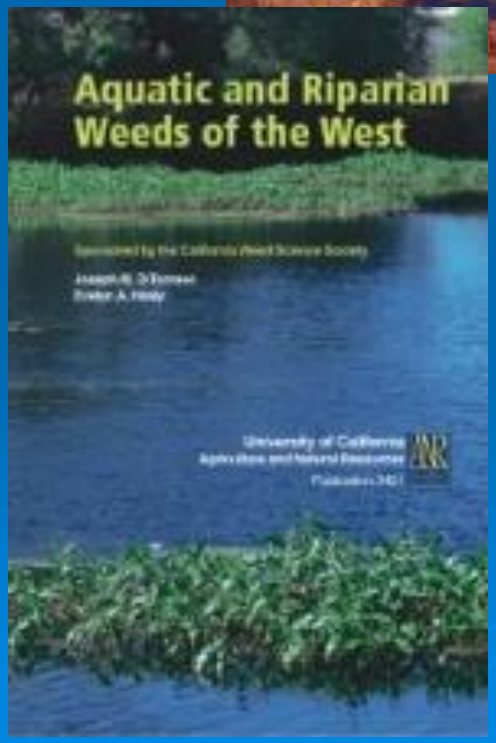
(Including those growing near water)

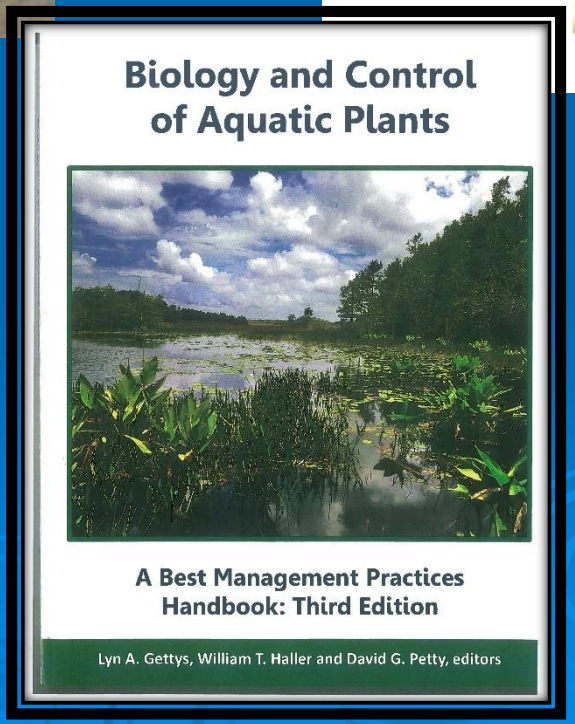
John Roncoroni
UCCE Weed Science Advisor, Napa

2107 Hot Topics in Integrated Weed Management
~~July 19, 2017~~, (So *Hot* it had to be moved)
September 20, 2017, Catheys Valley

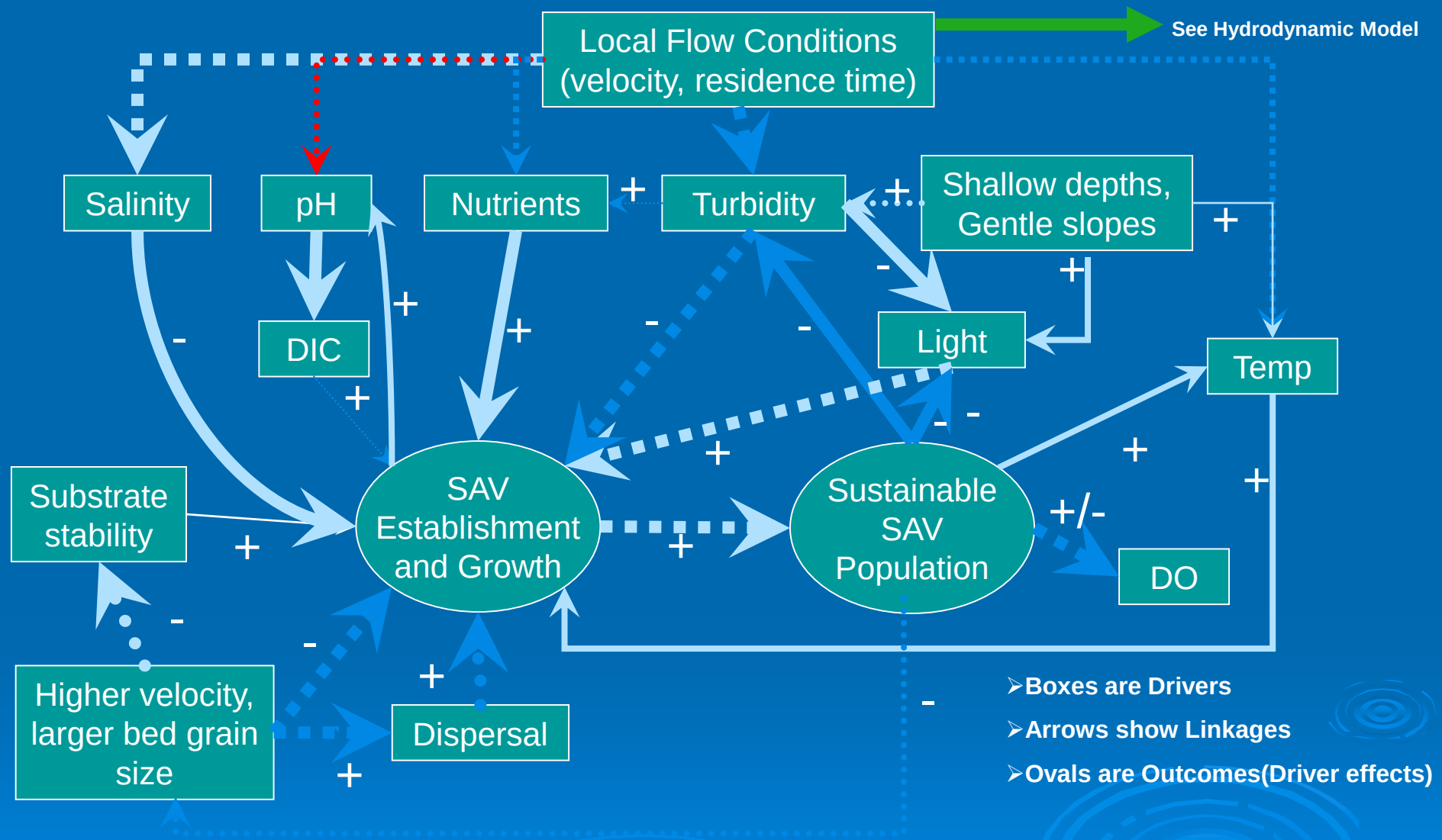

Weed Control in Natural Areas
in the Western United States


Weeds of California and Other Western States
Vol. 1
Weeds of California and Other Western States


Aquatic and Riparian Weeds of the West


Biology and Control of Aquatic Plants
A Best Management Practices Handbook: Third Edition
Lyn A. Gettys, William T. Haller and David G. Petty, editors

Submersed Aquatic Vegetaton Establishment, Growth and Dispersal Sub Model



- Boxes are Drivers
- Arrows show Linkages
- Ovals are Outcomes(Driver effects)

Importance:
- High – thick line
- Med – medium line
- Low – thin line

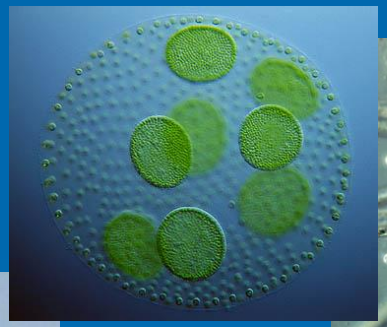
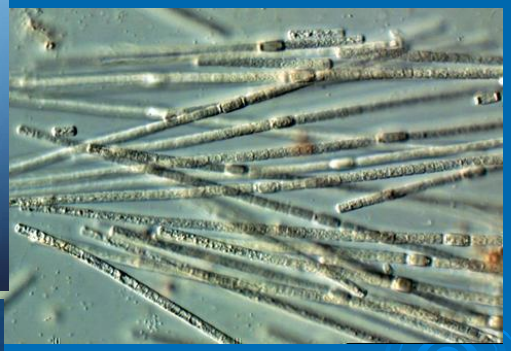
Understanding:
- High – green arrow
- Med – blue arrow
- Low - red arrow

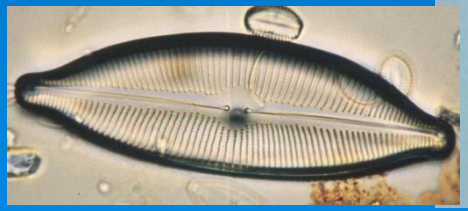
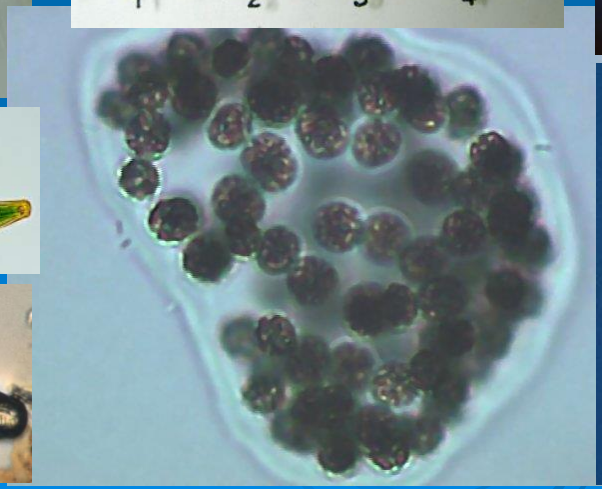
Predictability:
- High – solid line
- Med – dashed line
- Low – dotted line

Algae Identification

“Algae” refers to a loose group of organisms that have all or most of these characteristics:

- Aquatic
- Photosynthetic
- Do not have conducting structures
- Reproductive structures do not have layers of protective cells around them

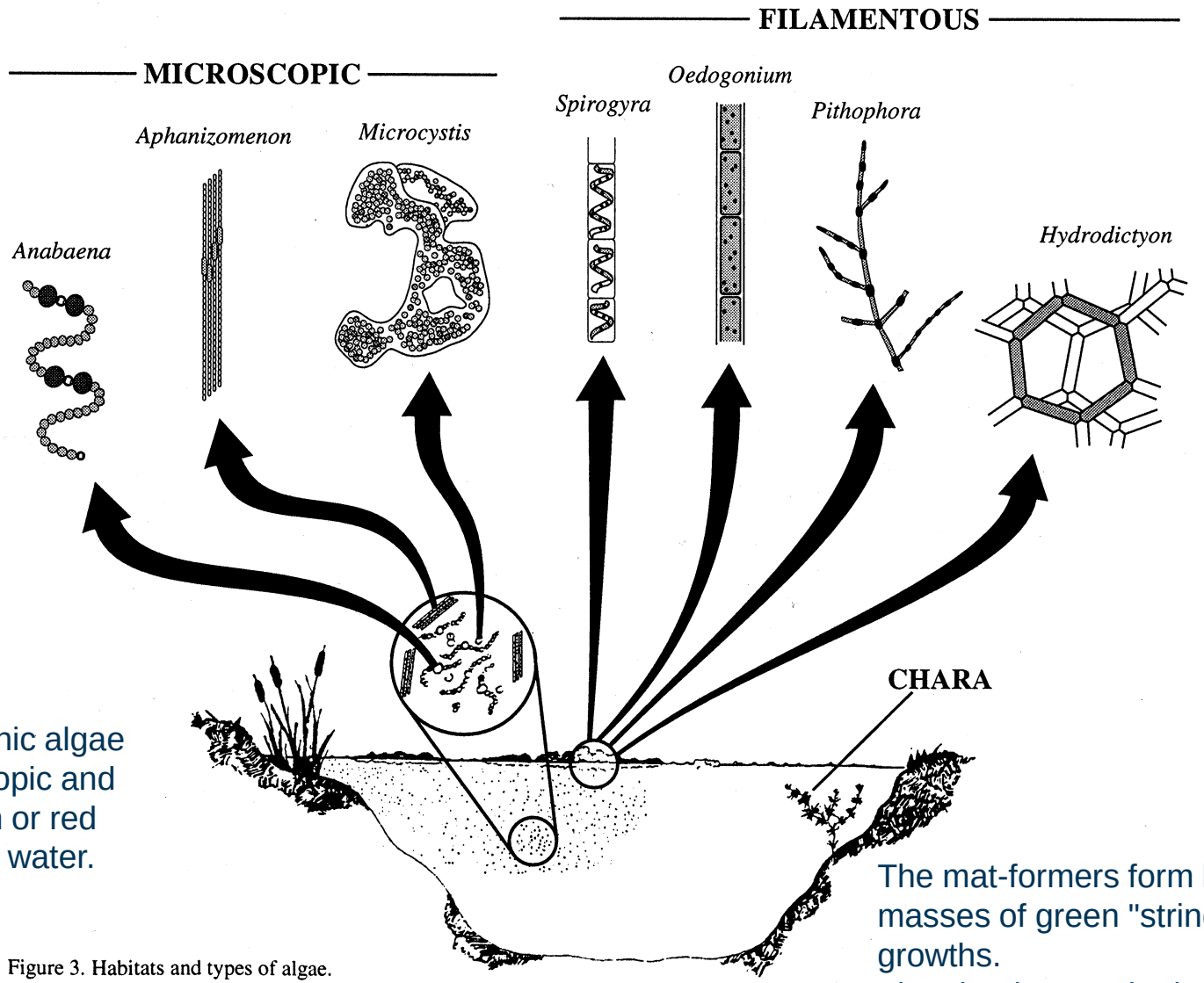


Figure 3. Habitats and types of algae.

The planktonic algae are microscopic and cause green or red colors in the water.

The mat-formers form large masses of green "string-like" growths.
They begin growth along the edges or on the bottom of the pond in the spring and float to the surface as the summer progresses.

From C. A. Lembi
1997

Microscopic or Planktonic Algae

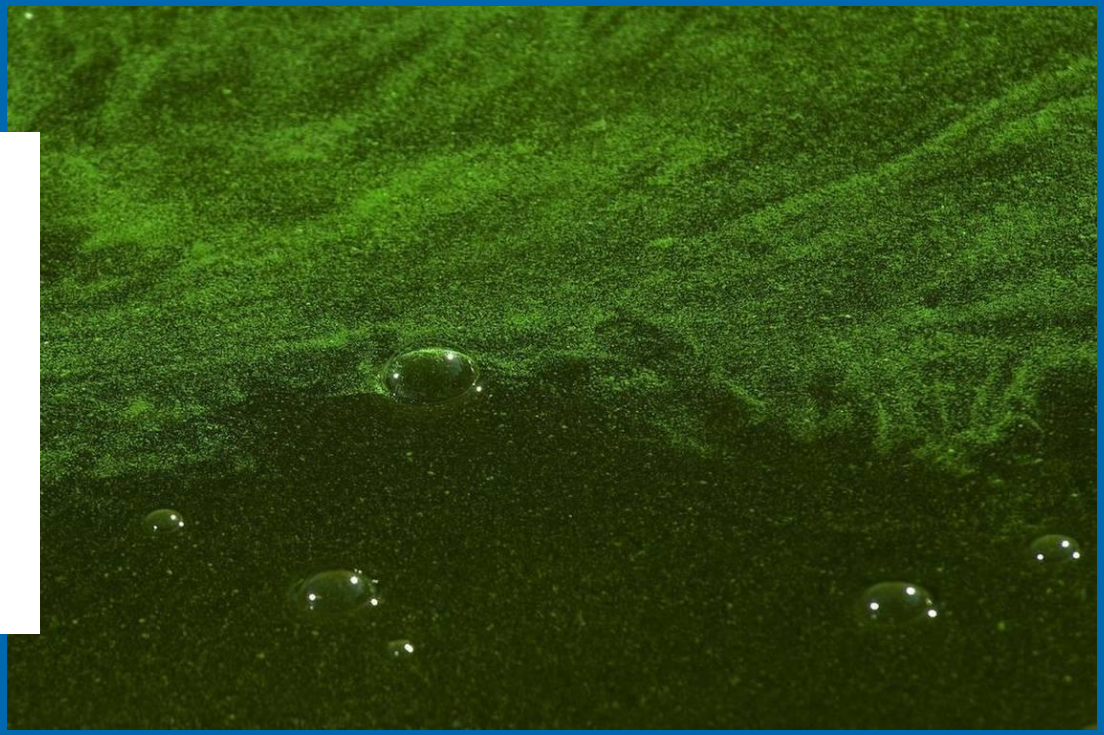
Microscopic or Planktonic Algae

- Not really algae, actually bacteria.
- Anabaena, Aphanizomenon, Microsystis
- known as ‘Anie, Phani and Mike.’
- Produce toxins, but poisonings rare.


Algae Bloom

Toxic algae bloom kills two dogs in Napa as warnings proliferate

BY DON SWEENEY (from Sacramento Bee July 2, 2017)



Two dogs have been killed by toxic blue-green algae in a Napa County pond as warnings of similar blooms proliferate in California.The dogs died last week after swimming in a pond off Milton Road in Napa, report Napa County health officials. Warnings about similar blue-green algae blooms also have been issued for Lake San Antonio in southern Monterey County, Lake Temescal in Oakland and San Luis Reservoir in Merced County.

Health officials advise people to avoid close contact with bodies of water containing blue-green algae and not to eat fish caught there.“Be aware of posted signs that indicate the presence of blue-green algae. Also, if the body of water has a lot of algae or scum floating in it … it may be best for you and your pets to avoid the water.” Napa County Public Health Officer Karen Relucio warned in a release. “These algae produce toxins that can cause eye irritation, skin rashes, mouth ulcers, vomiting, diarrhea, and flu-like symptoms.”Pets are the most common victims of blue-green algae poisoning because they tend to drink water while swimming, Relucio said. But children and adults can suffer serious liver, kidney and nervous system damage from swallowing water containing the algae.

Algae Bloom

- Bloom caused by warm water and nutrient introduction
- ‘Fish Kills’ occur during respiration or when algae die- oxygen depletion.

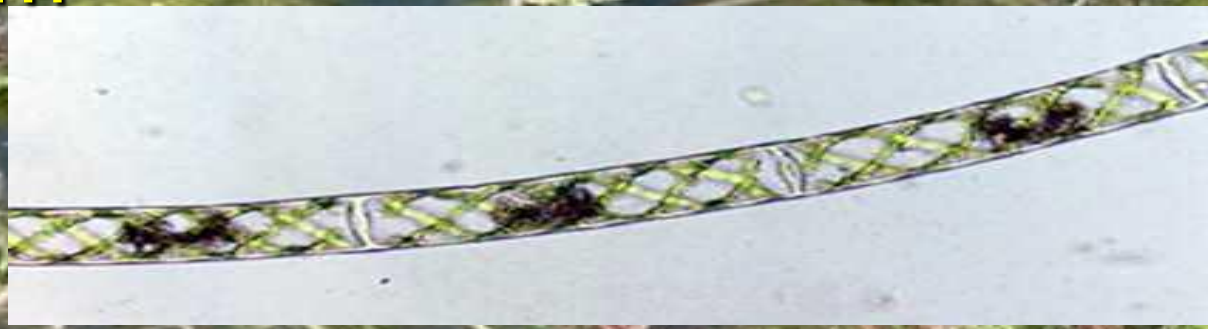

Filamentous Algae-
Floating Mats

Filamentous Algae- Floating Mats

- Often incorrectly called ‘moss’
- Growth usually starts on edges and bottoms of pond in spring

Filamentous Algae- Floating Mats

- Often incorrectly called ‘moss’
- Growth usually starts on edges and bottoms of pond in spring
- Segments are single cells.
- Common Species: Cladophora, Rhizoclonium



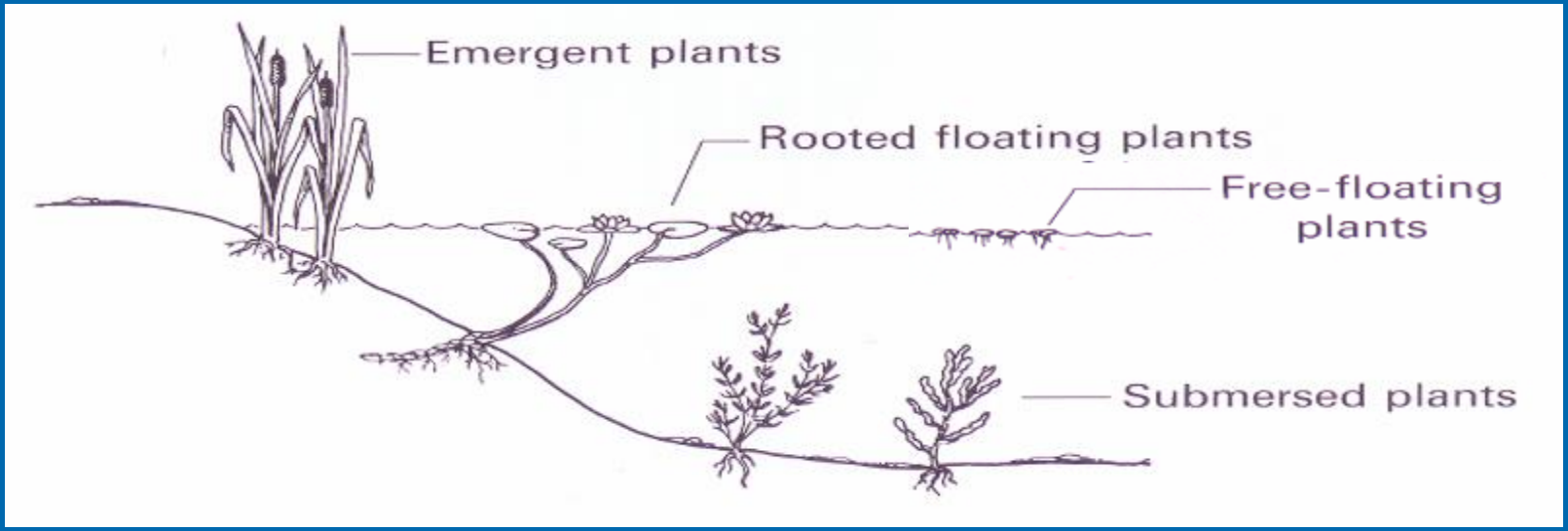
Submersed Algae

Chara-stonewort

Chara-stonewort

- Usually grows in very hard water
- Often confused with flowering plant
- Rough feel and distinctive musky smell
- Where it is low growing it is voluble habitat for fish

Types of Aquatic Plants

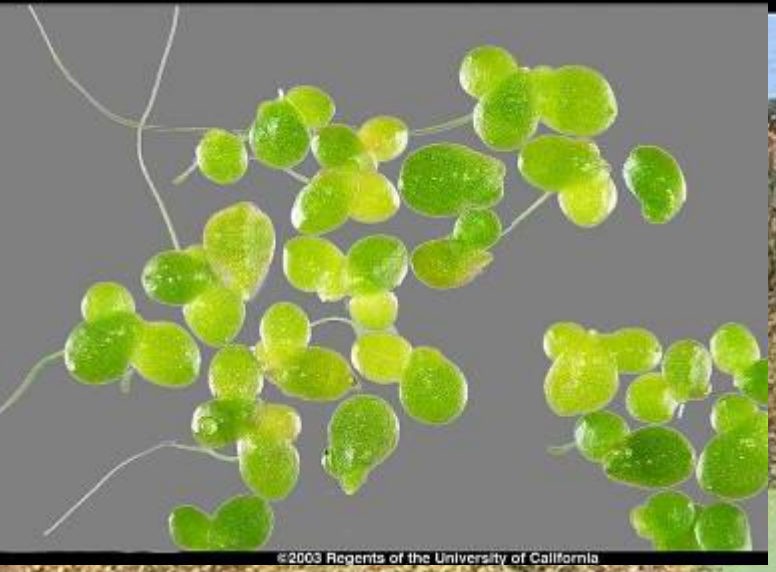


Free-floating plants


Pacific mosquitofern
Azolla filiculoides

Pacific mosquitofern
Azolla filiculoides

- Fern- reproduces by spores and stem fragments
- Desirable native species in natural habitat
- Population increases in late winter through spring. Will usually decrease in heat of summer.
- Infestations ‘worse’ in years after heavy rains.



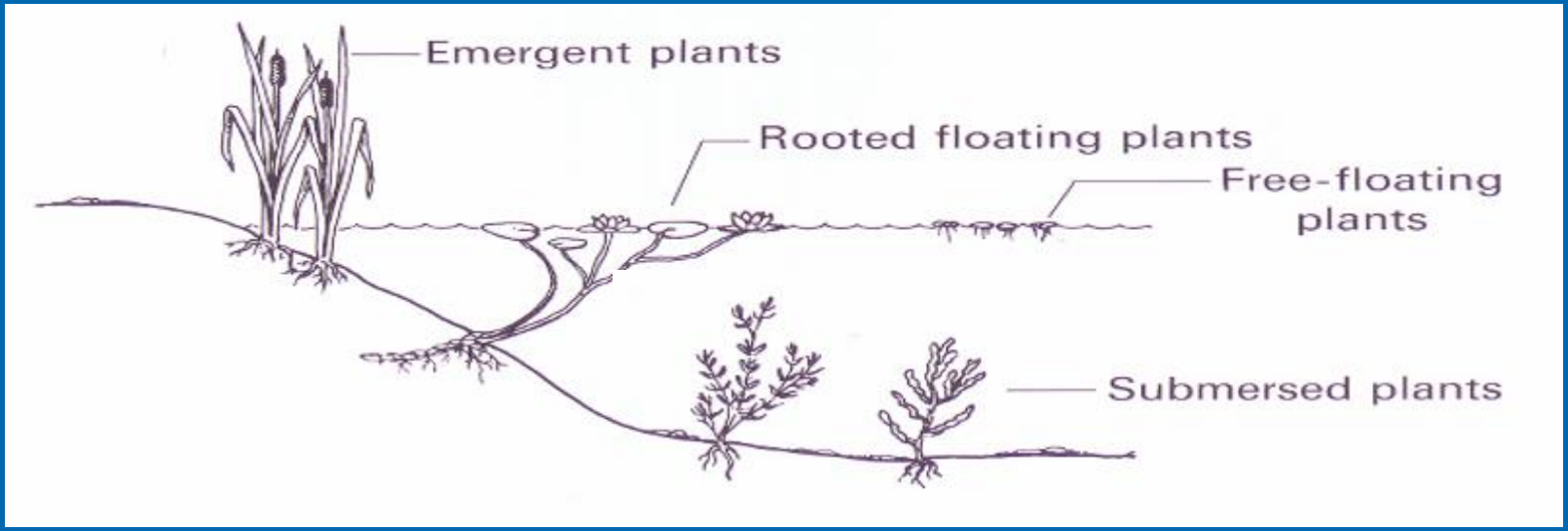
Common duckweed

Lemna minor

Common duckweed

- Very small floating perennial native
- In high fertility site can double in number every 3 days
- Reproduces by budding (daughter plant)
- One root per frond

Types of Aquatic Plants



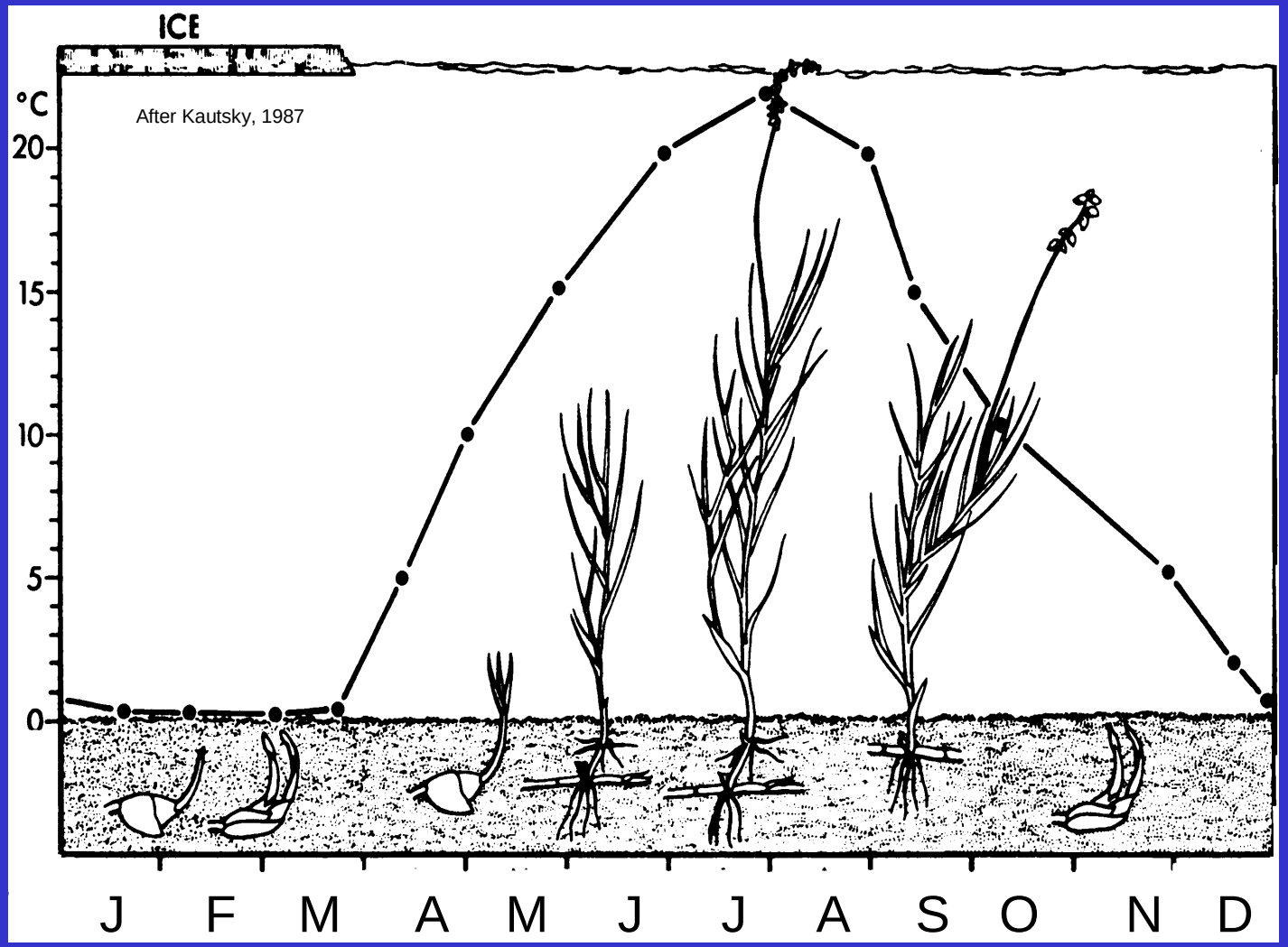
Submersed plants

Pondweeds

- All Potamogeton and Stuckenia species are native to the Western US, except Potamogeton crispus-curlyleaf pondweed (Eurasia)
- Important components of wildland aquatic habitats-
- Perennials most with rhizomes
- Curlyleaf produces turions and Sago produces tubers

Sago pondweed
Stuckenia pectinatus

Seasonal Development of Sago Pondweed



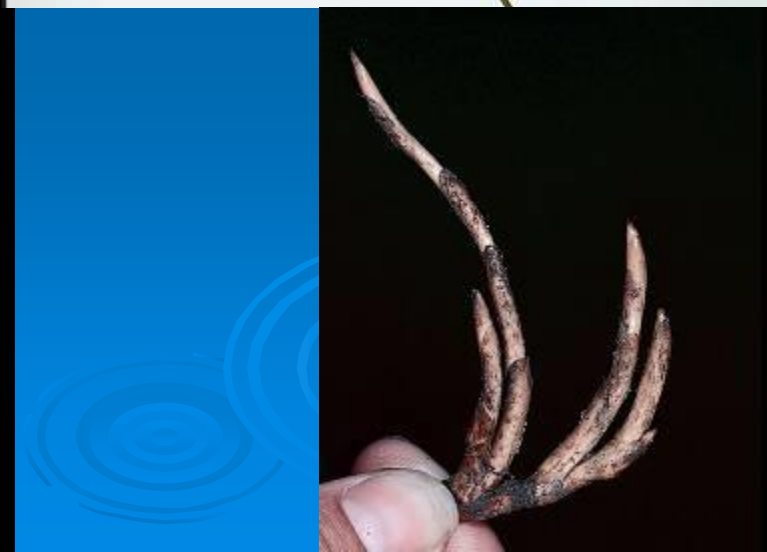
Curlyleaf pondweed
Potamogeton crispus

Curlyleaf pondweed (*Potamogeton crispus*)

Turion: vegetative propagule- produced in spring; disperses in summer/fall…sprouts in fall-winter.

Floatleaf pondweed
Potamogeton natans

American Pondweed
Potamogeton nodosus



American pondweed winter buds- from plants harvested in October

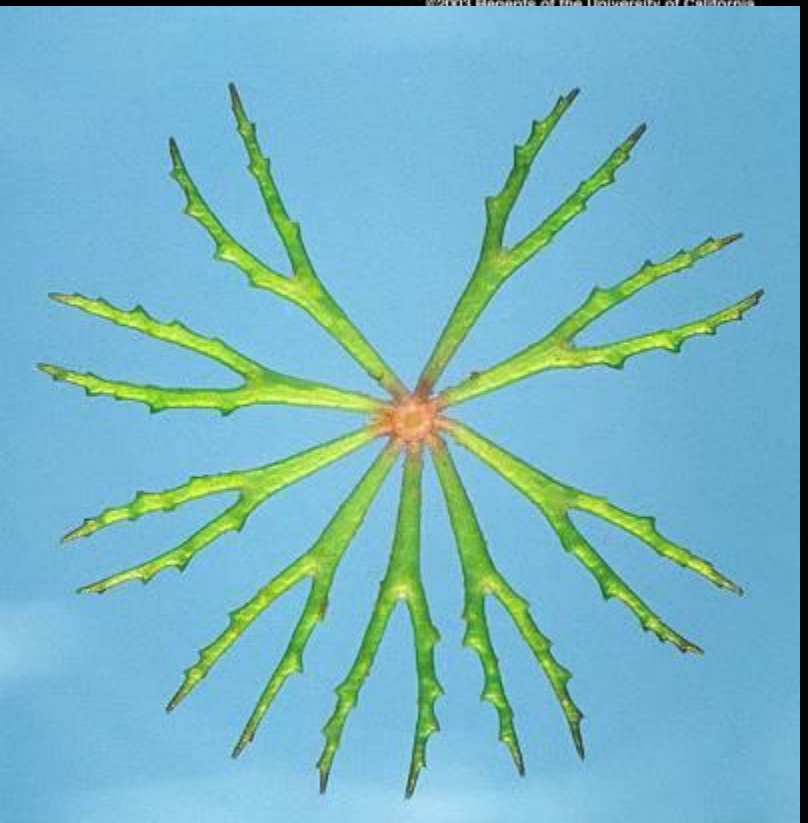
Winter buds formed on tips of rhizome

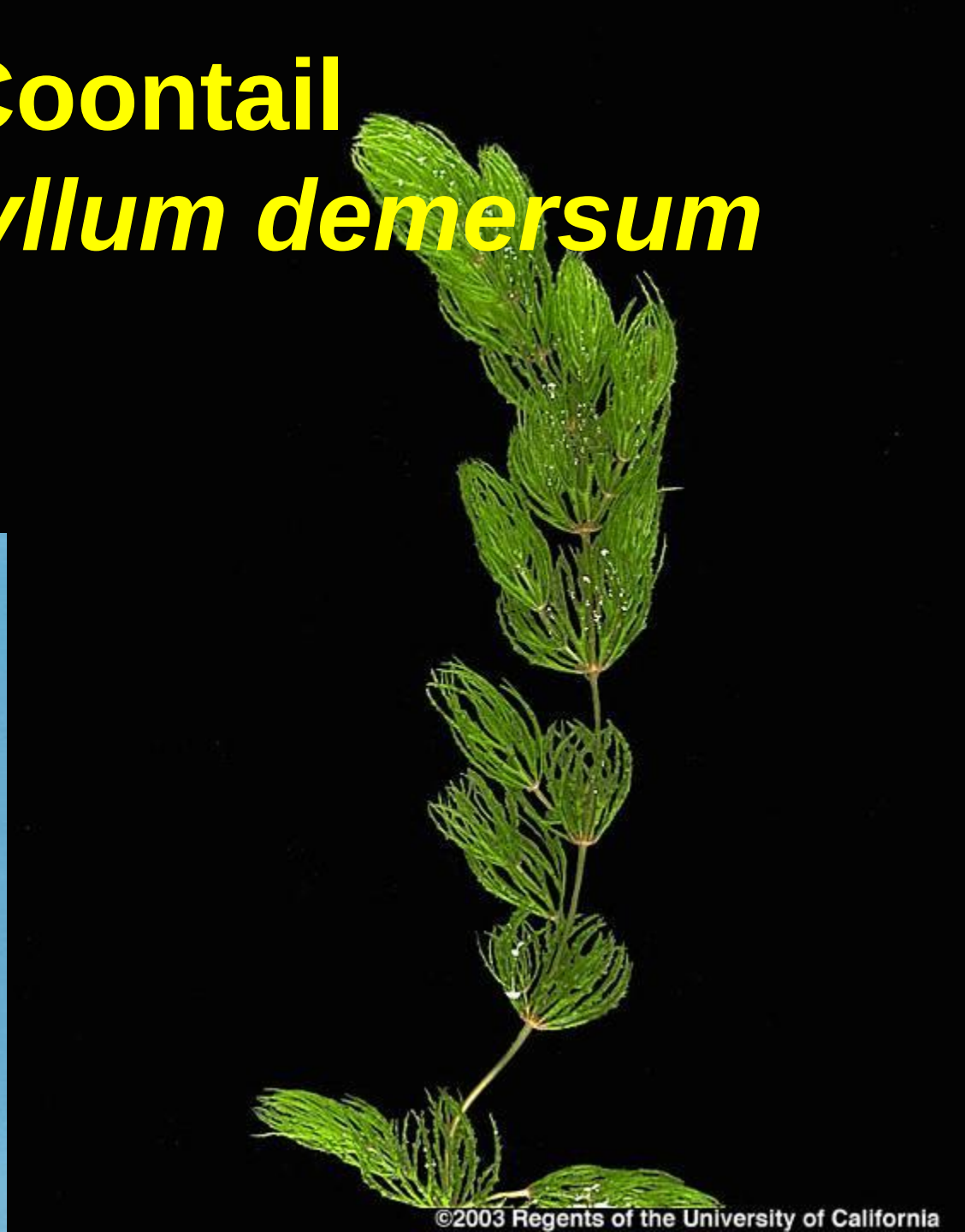
Each winter bud will sprout in spring to form a new plant

Coontail, Parrotfeather and Milfoils

Coontail

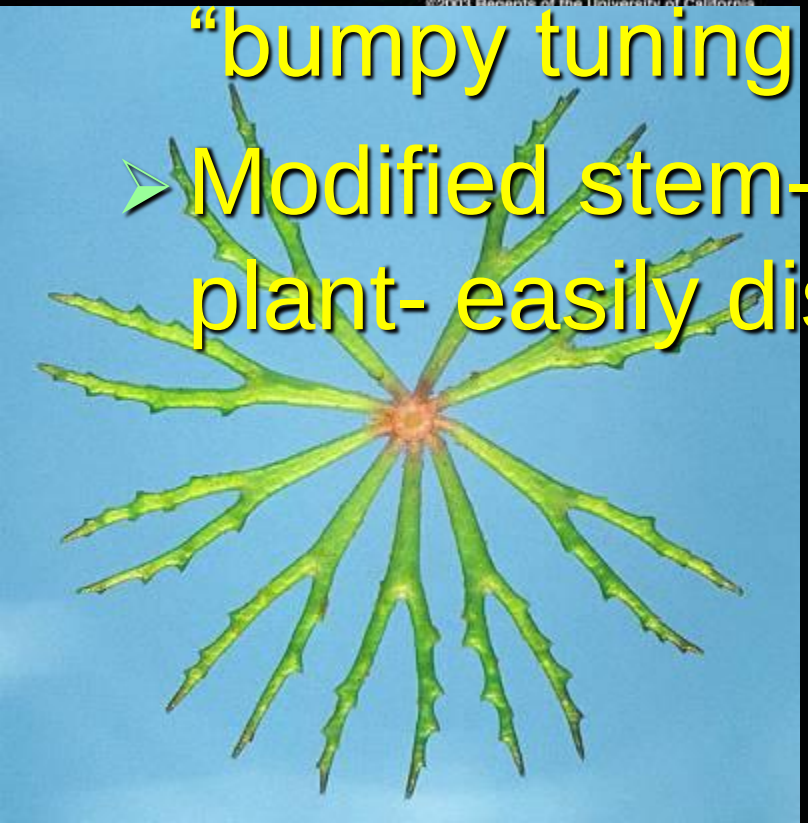
Ceratophyllum demersum





Coontail
Ceratophyllum demersum

- Native-annual to perennial
- Cross section- leaves look like "bumpy tuning fork"
- Modified stem-not roots lightly hold plant- easily dislodged



Parrotfeather
Myriophyllum aquaticum

Parrotfeather
Myriophyllum aquaticum

- Noxious perennial introduced from South America in late 1800's
- Emersed plant, can become semi-terrestrial
- Reproduces vegetatively only- by rhizome and stem fragments

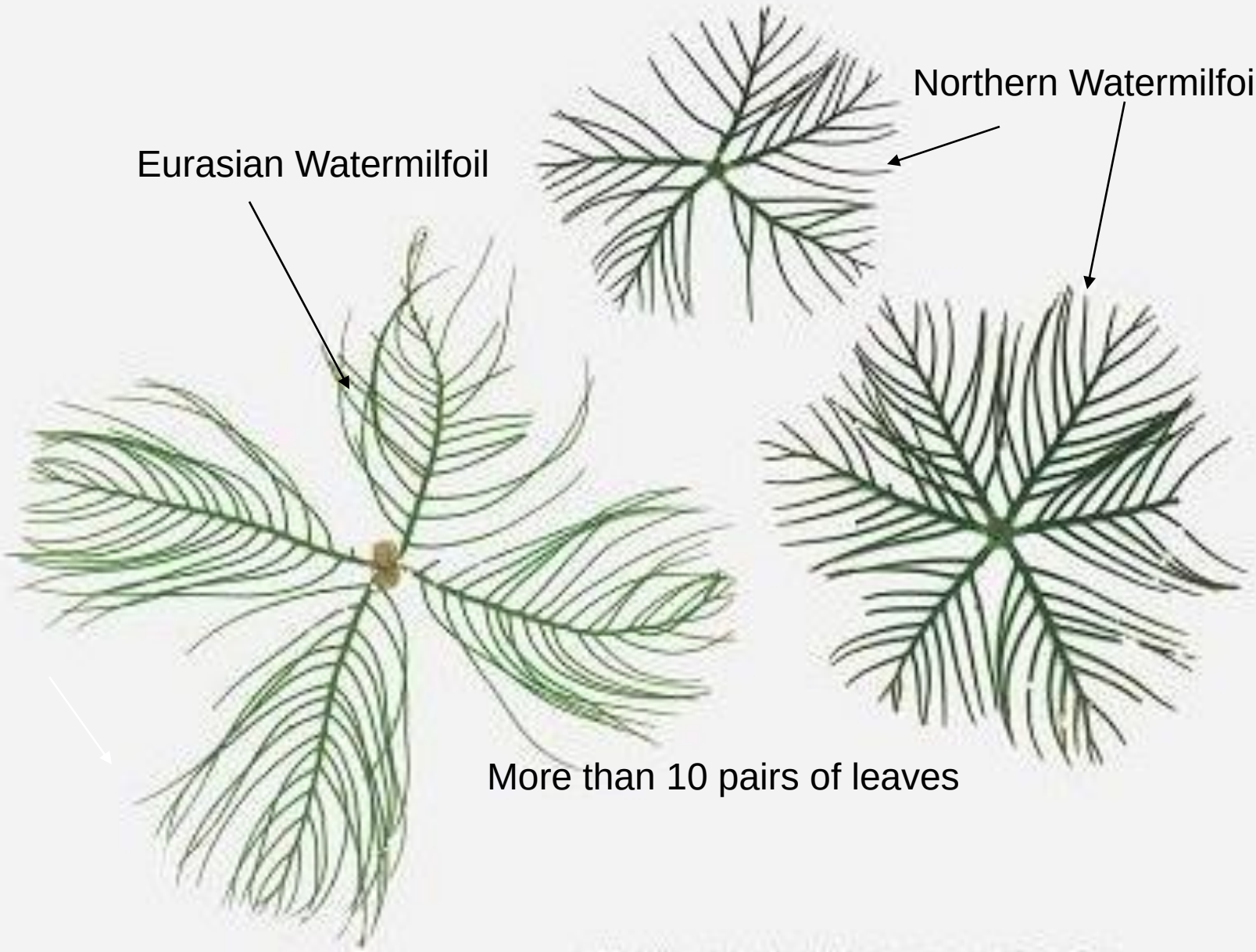

Eurasian watermilfoil
Myriophyllum spicatum

Eurasian watermilfoil *Myriophyllum spicatum*

- Noxious perennial propagated by rhizomes, axillary buds and seeds.
- Seeds can survive dormant for 7 years under dry conditions and are eaten and spread by birds.
- Introduced from Eurasia, probably late 1940's in aquarium trade.

Northern watermilfoil
Myriophyllum sibiricum

- Widespread native
- Produces turions-EWM does not
- Looks very similar to EWM- leaf lobes different-


Northern Watermilfoil
Eurasian Watermilfoil
More than 10 pairs of leaves

Elodea, Egeria, Hydrilla

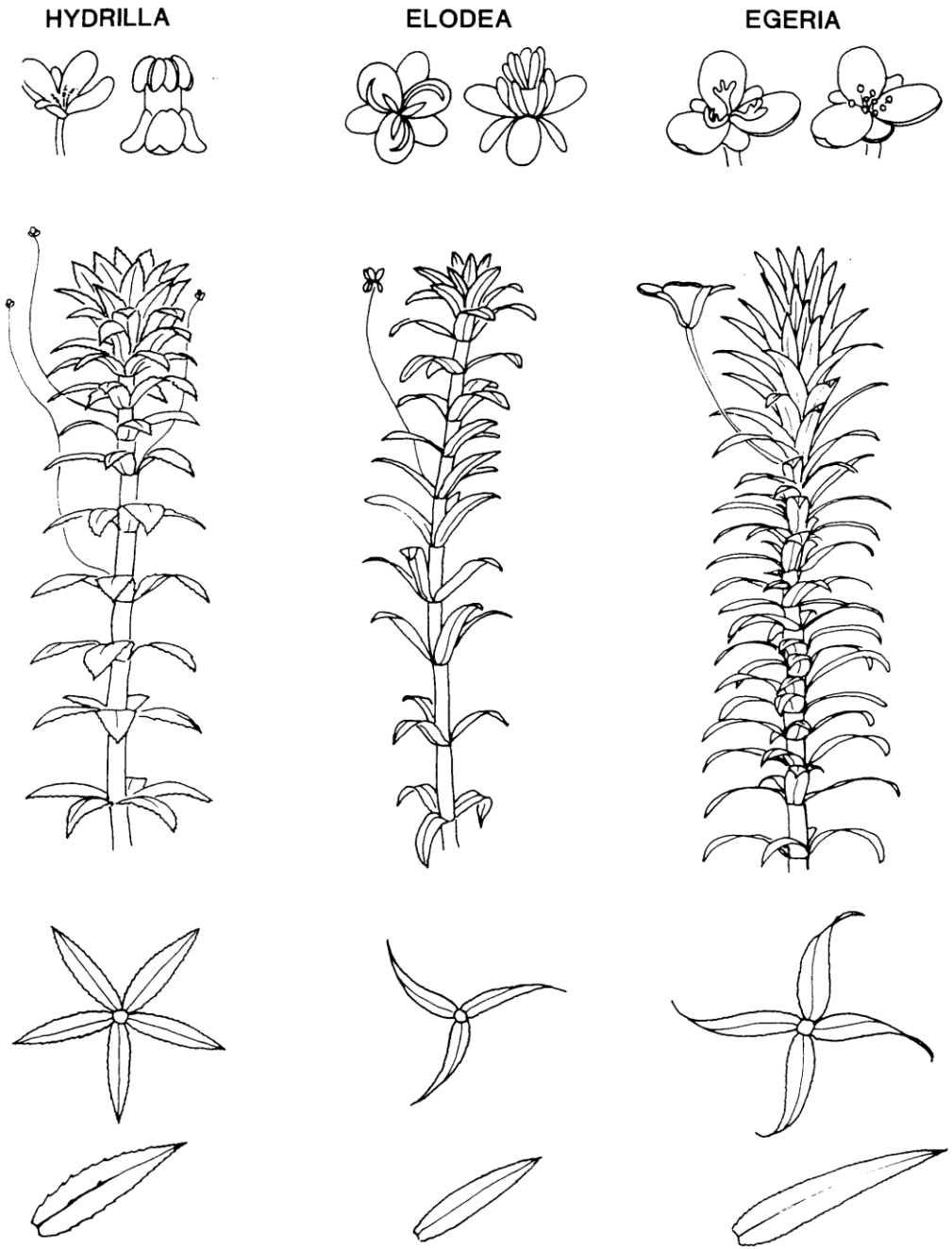
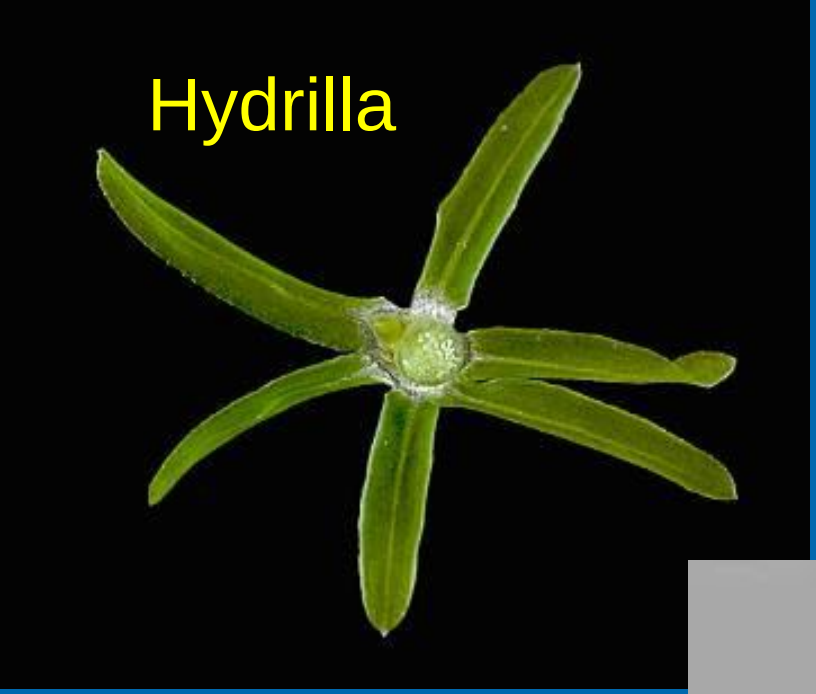


illustration provided by:
IFAS, Center for Aquatic Plants
University of Florida, Gainesville, 1990

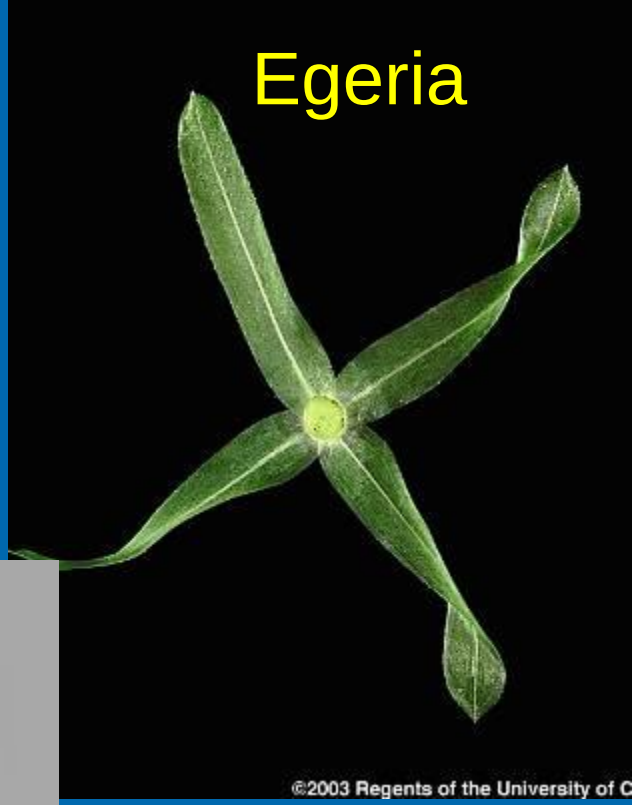
Elodea, Egeria, Hydrilla

- All are perennial an reproduce vegetatively
- Common elodea- Native to NA; important to habitat-rarley a problem-high P-
- Brazilian egeria- only male plants in US. Still sold for aquarium use. Can become problem when heavy infestation. Has large flower
- Hydrilla-Noxious -reproduces by stolon, stem fragments,turions and tubers- tubers can last up to 5 years. Very aggressive

Hydrilla



Egeria



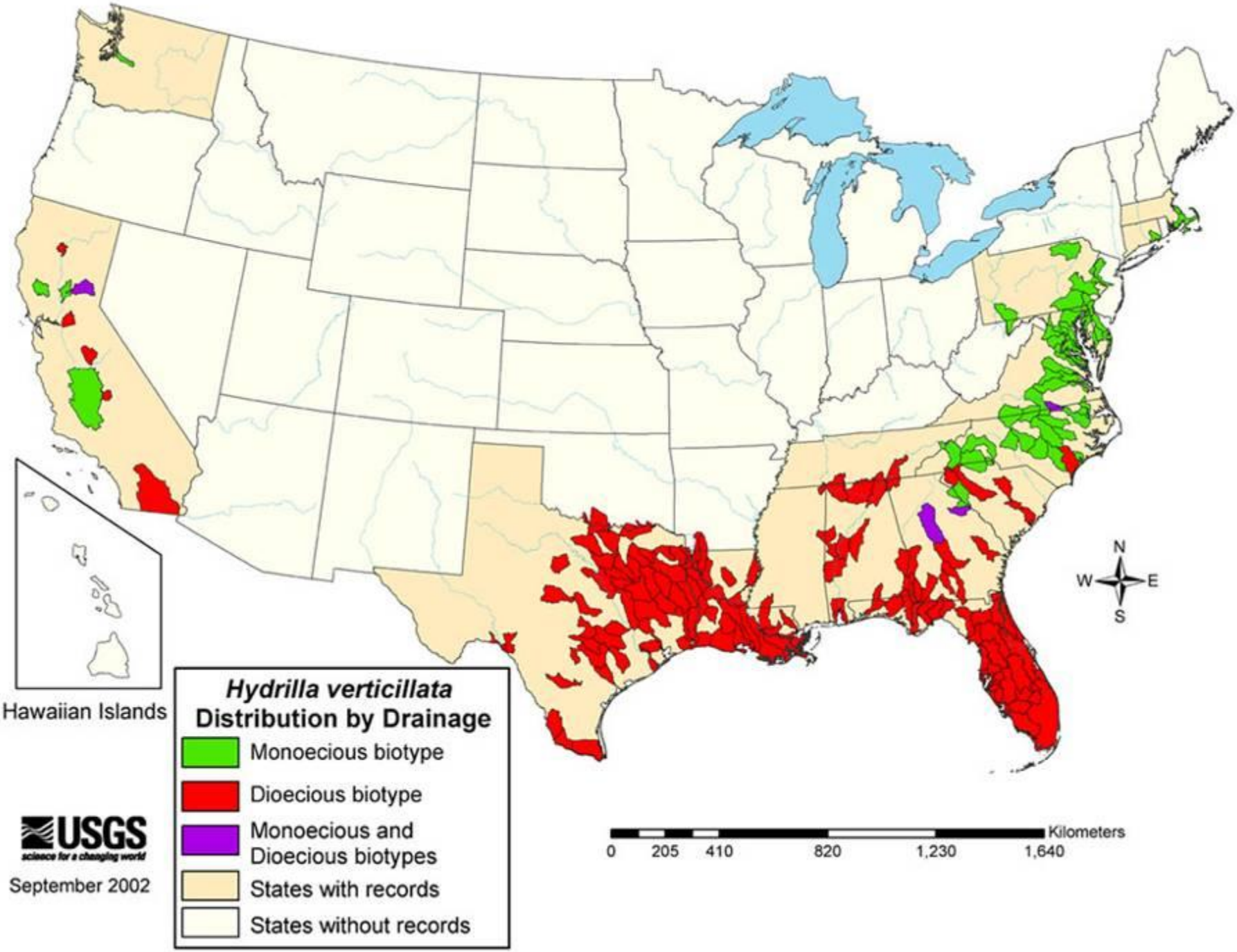
Elodea

Common elodea

Elodea canadensis

Brazilian Egeria
Egeria densa

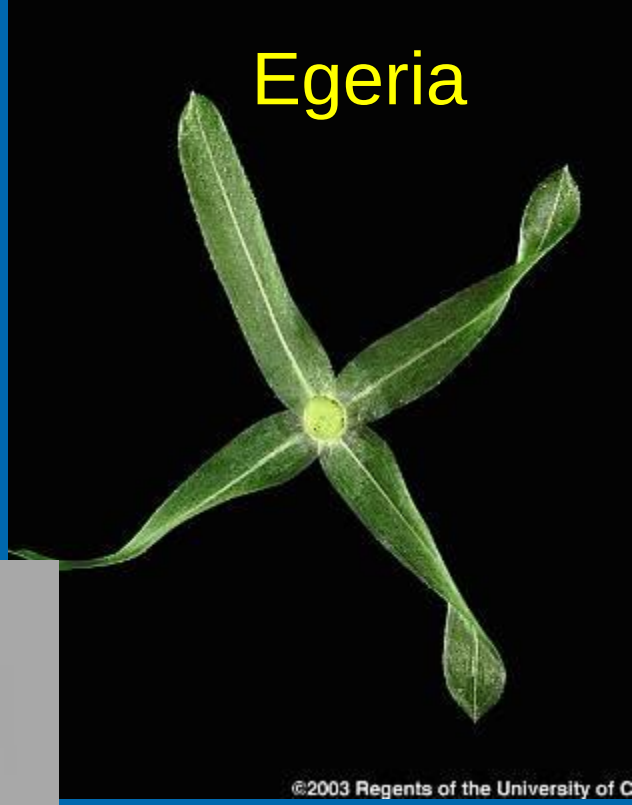
Hydrilla-*Hydrilla verticillata*


Hawaiian Islands
Hydrilla verticillata
Distribution by Drainage
Monoecious biotype
Dioecious biotype
Monoecious and
Dioecious biotypes
States with records
States without records
USGS
science for a changing world
September 2002
N
W
E
S
0
205
410
820
1,230
1,640
Kilometers

Hydrilla at Wakulla Springs, Florida
Hydrilla verticillata
Photo by Vic Ramey

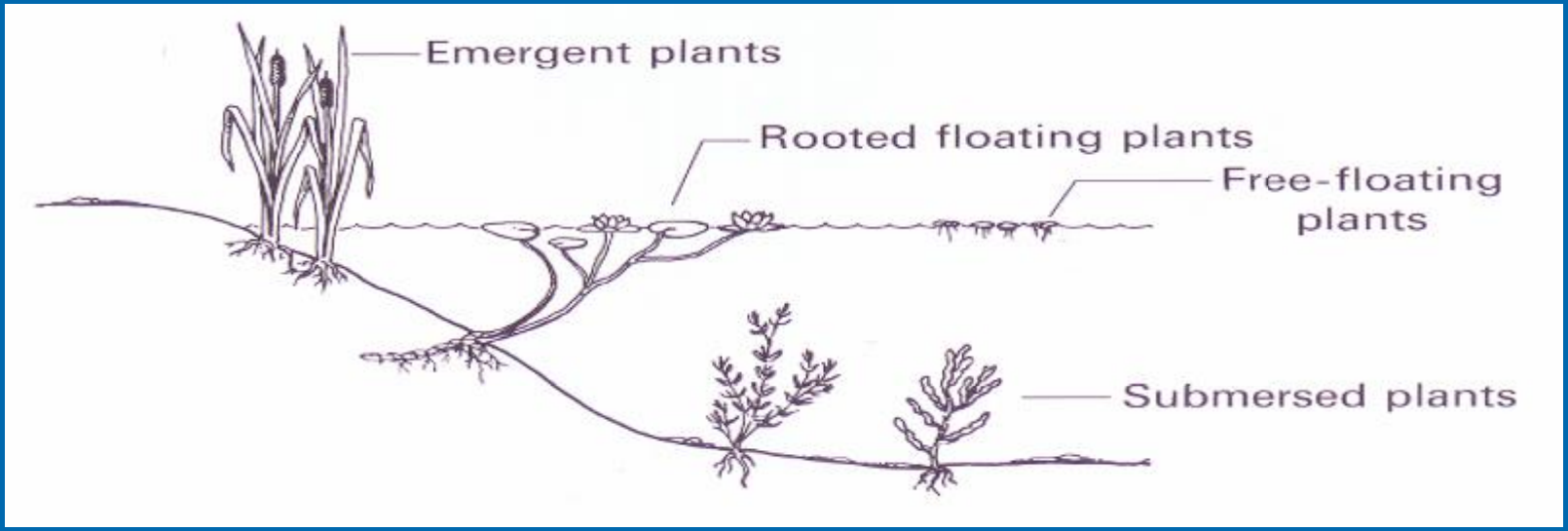
Hydrilla

Egeria



Elodea

Types of Aquatic Plants



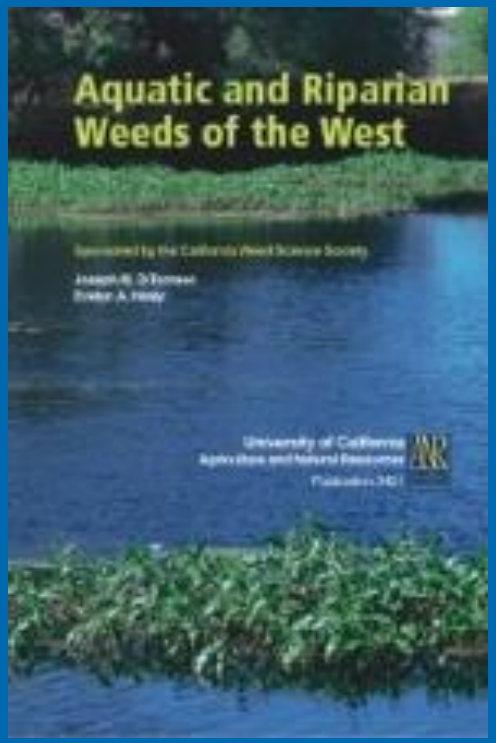
Rooted floating plants

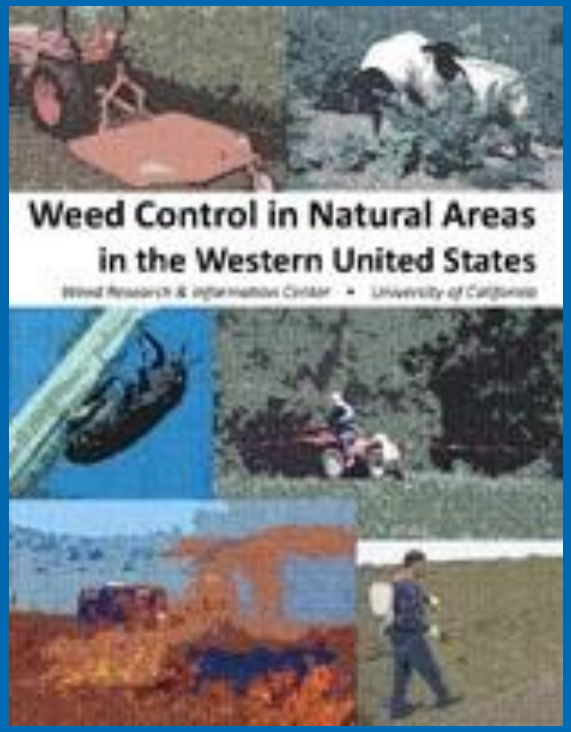
Creeping waterprimrose
Ludwigia peploides

Creeping waterprimrose *Ludwigia peploides*

- 3 species- one native to California
- Can develop thick mats that interfere with water flow
- Rooted in side of pond or canal
- Reproduces by seed, creeping stems and stem fragments

EMERGENT WEEDS


Aquatic and Riparian
Weeds of the West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Aizoaceae-Fabaceae
Weeds of
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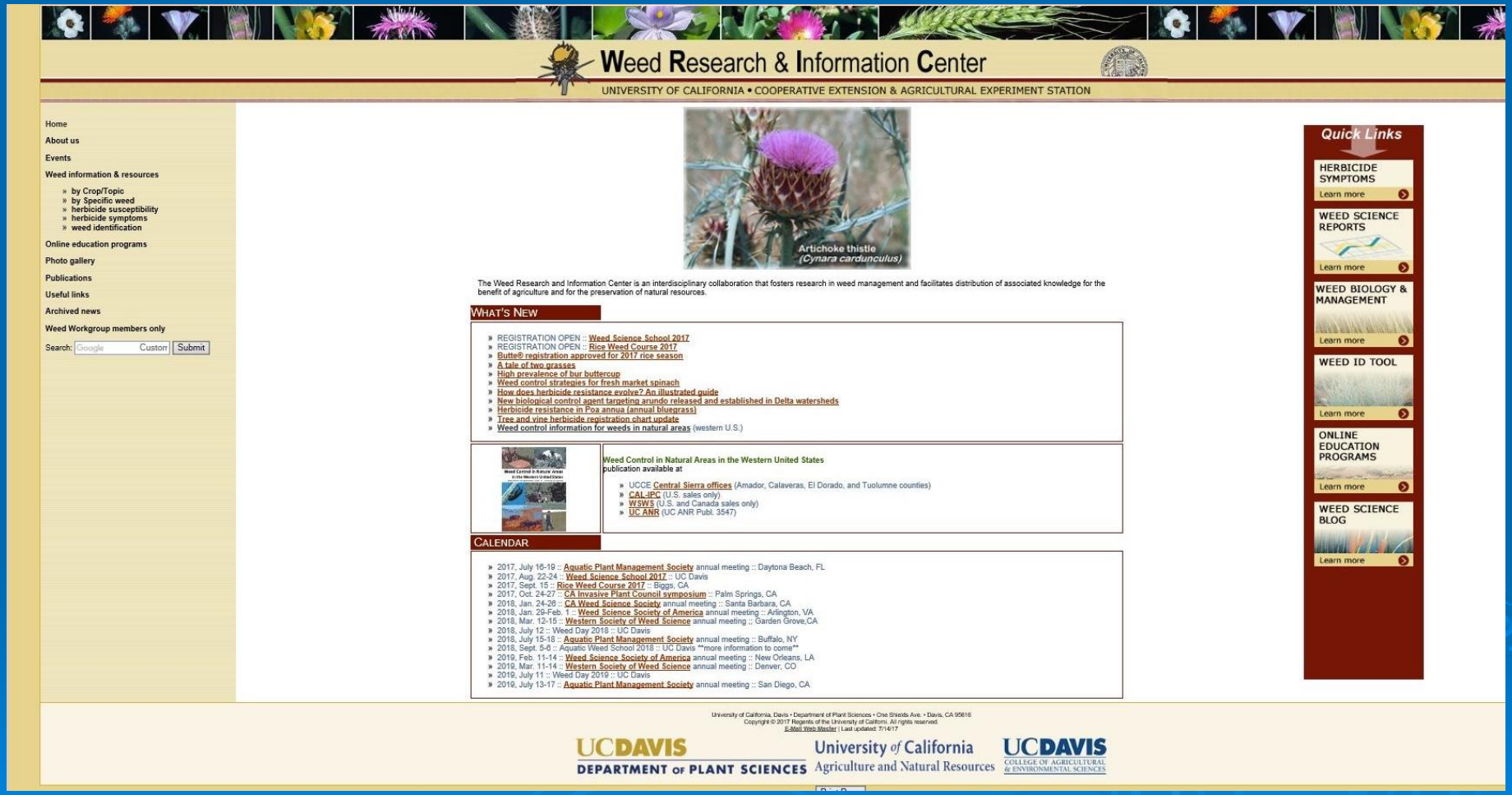
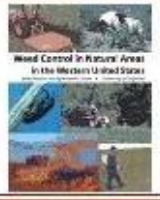
http://wric.ucdavis.edu



The Weed Research and Information Center is an interdisciplinary collaboration that fosters research in weed management and facilitates distribution of associated knowledge for the benefit of agriculture and for the preservation of natural resources.

What's New

- REGISTRATION OPEN :: Weed Science School 2017
- REGISTRATION OPEN :: Rice Weed Course 2017
- Butte® registration approved for 2017 rice season
- A tale of two grasses
- High prevalence of bur buttercup
- Weed control strategies for fresh market spinach
- How does herbicide resistance evolve? An illustrated guide
- New biological control agent targeting arundo released and established in Delta watersheds
- Herbicide resistance in Poa annua (annual bluegrass)
- Tree and vine herbicide registration chart update
- Weed control information for weeds in natural areas (western U.S.)



Weed Control in Natural Areas in the Western United States
publication available at

- UCCE Central Sierra offices (Amador, Calaveras, El Dorado, and Tuolumne counties)
- CAL-IPC (U.S. sales only)
- WSWS (U.S. and Canada sales only)
- UC ANR (UC ANR Publ. 3547)

Calendar

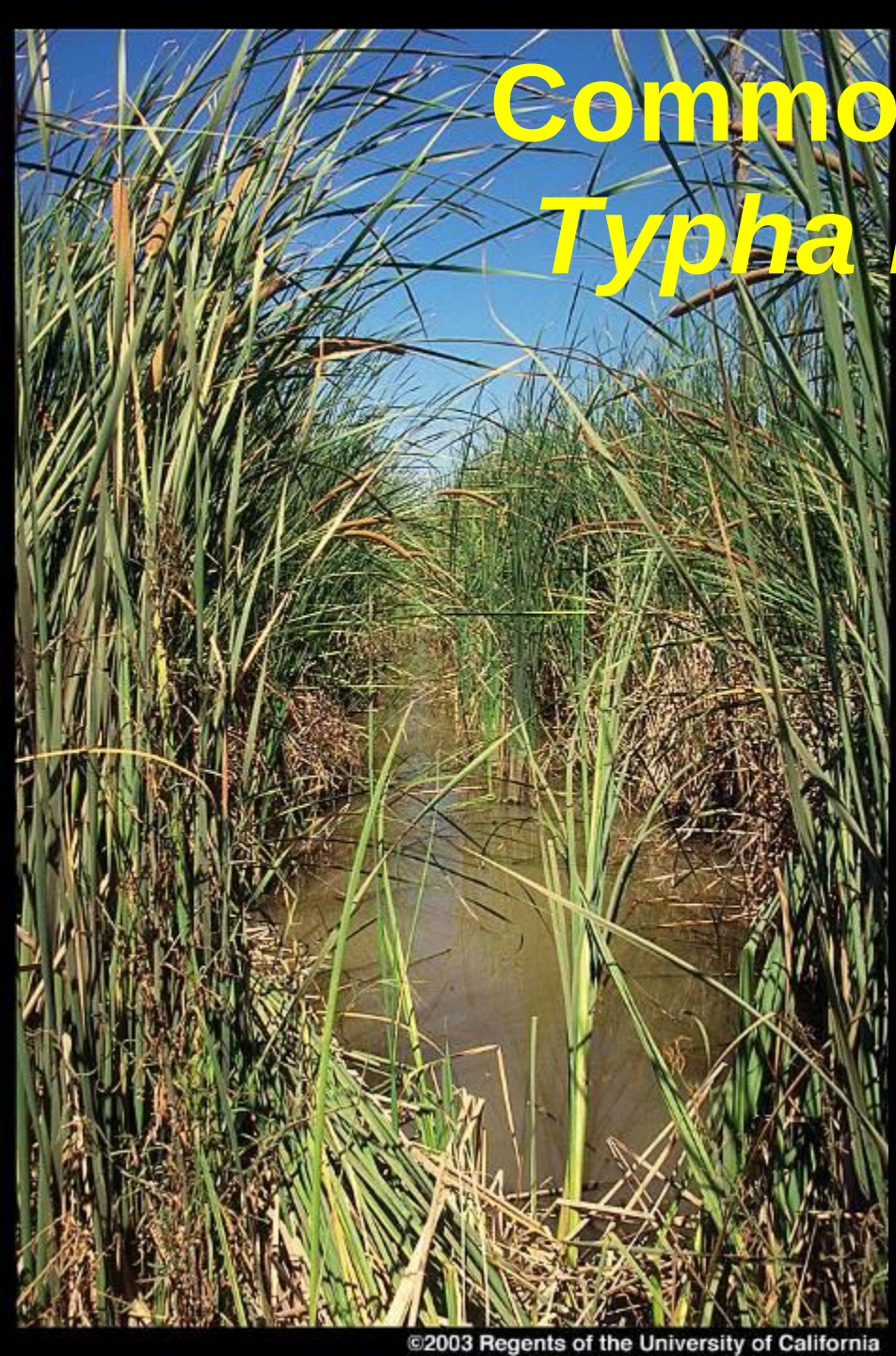
- 2017, July 16-19 :: Aquatic Plant Management Society annual meeting :: Daytona Beach, FL
- 2017, Aug. 22-24 :: Weed Science School 2017 :: UC Davis
- 2017, Sept. 15 :: Rice Weed Course 2017 :: Biggs, CA
- 2017, Oct. 24-27 :: CA Invasive Plant Council symposium :: Palm Springs, CA
- 2018, Jan. 24-26 :: CA Weed Science Society annual meeting :: Santa Barbara, CA
- 2018, Jan. 29-Feb. 1 :: Weed Science Society of America annual meeting :: Arlington, VA
- 2018, Mar. 12-15 :: Western Society of Weed Science annual meeting :: Garden Grove,CA
- 2018, July 12 :: Weed Day 2018 :: UC Davis
- 2018, July 15-18 :: Aquatic Plant Management Society annual meeting :: Buffalo, NY
- 2018, Sept. 5-6 :: Aquatic Weed School 2018 :: UC Davis **more information to come**
- 2019, Feb. 11-14 :: Weed Science Society of America annual meeting :: New Orleans, LA
- 2019, Mar. 11-14 :: Western Society of Weed Science annual meeting :: Denver, CO
- 2019, July 11 :: Weed Day 2019 :: UC Davis
- 2019, July 13-17 :: Aquatic Plant Management Society annual meeting :: San Diego, CA

University of California, Davis • Department of Plant Sciences • One Shields Ave. • Davis, CA 95616

E-Mail Web Master | Last updated: 7/14/17

UCDAVIS DEPARTMENT OF PLANT SCIENCES
University of California Agriculture and Natural Resources
UCDAVIS COLLEGE OF AGRICULTURAL & ENVIRONMENTAL SCIENCES

Common cattail
Typha latifolia



Common cattail
Typha latifolia

- Widespread desirable native – valuable source of food and shelter for wildlife- prevent shoreline erosion, and help remove excess nutrients from water.
- Spreads by seed and extensive rhizome system-
- "Everybody wants 2 feet of cattail- nobody wants 10 feet!"

Typha spp.

Cattails

Family: Typhaceae
Range: All western states.
Habitat: Freshwater wetlands throughout North America including lakeshores, river backwaters, ditches, bogs, fresh or brackish marshes, lakes, and ponds. Cattails tolerate nutrient rich, acidic, alkaline, and slightly saline conditions; generally not shade tolerant.
Origin: Most species are native to North America. Some populations are hybrids.
Impacts: Cattail control is largely dependent on land management goals. Cattails can behave like aggressive introduced weeds, but they are a native element in a variety of natural communities and can provide valuable wildlife habitat. Solid stands can limit biodiversity in wetlands, decrease recreation opportunities, and impede water movement. With sedimentation or changes in hydrology, shallow wetlands, ponds, and slow-moving streams may become vulnerable to cattail monocultures that eliminate open water.

Cattails are emergent perennials that can grow to 10 ft tall. The stems are erect, unbranched, rigid and solid. The leaves are alternate, most near stem bases, linear, thick, and spongy. Rhizomes are tough, creeping, branched, white with fibrous scale leaves. Roots from rhizomes are fibrous and shallow.

Inflorescences are cigar-shaped flower spikes, usually taller than the leaves and densely covered with numerous tiny male and female unisexual flowers. The male flowers are produced above the female flowers on the spike, wind pollinated, and self-compatible. One plant can produce approximately 250,000 soft downy seeds in fall. Seeds are said to remain viable in the seed-bank for up to 100 years, but it more likely that they only survive a couple of years. Seeds germinate primarily in late spring. Most seedlings emerge from the substrate in water to 14 inches deep, but some may emerge from water up to 2.5 ft deep. Local reproduction is primarily vegetative from rhizomes. Most rhizomes survive for less than 3 years. Rhizome fragments frequently disperse with water or substrate movement.

NON-CHEMICAL CONTROL

Mechanical (pulling, cutting, disking)	Cattails can be successfully controlled by physical removal. Hand-pulling or cutting cattails at the end of flowering followed by submergence of all cattail stems gave good control in several studies. Cutting plants below the water-line two to three times before flowering was also effective. It is important to remove all dead and live cattail stems. Crushing, shearing, or disking is effective for severing the aerenchyma (air filled cells) that link rhizomes with the leaves. To reduce plant survival, however, these techniques must be combined with flooding to induce stress from anaerobic starch conversion.
Cultural	If possible, removing sedimentation and increasing water depth will usually discourage cattail monocultures. Maintaining water levels 1.4 to 2 ft over the tops of existing shoots can kill established plants within a couple of years. Water depths over 2 ft can discourage cattail recruitment and seedling survival. Narrow-leaved cattail (*Typha angustifolia* L.) grows in deeper water and water levels need to be 4 ft or deeper to prevent seedling survival. Fire provides little or no cattail control. However, burning followed by reflooding to about 1 ft in spring controlled cattail in one study. Fire can be helpful for litter cleanup.
Biological	There are no available biological control agents for cattail control, primarily since the species are native to

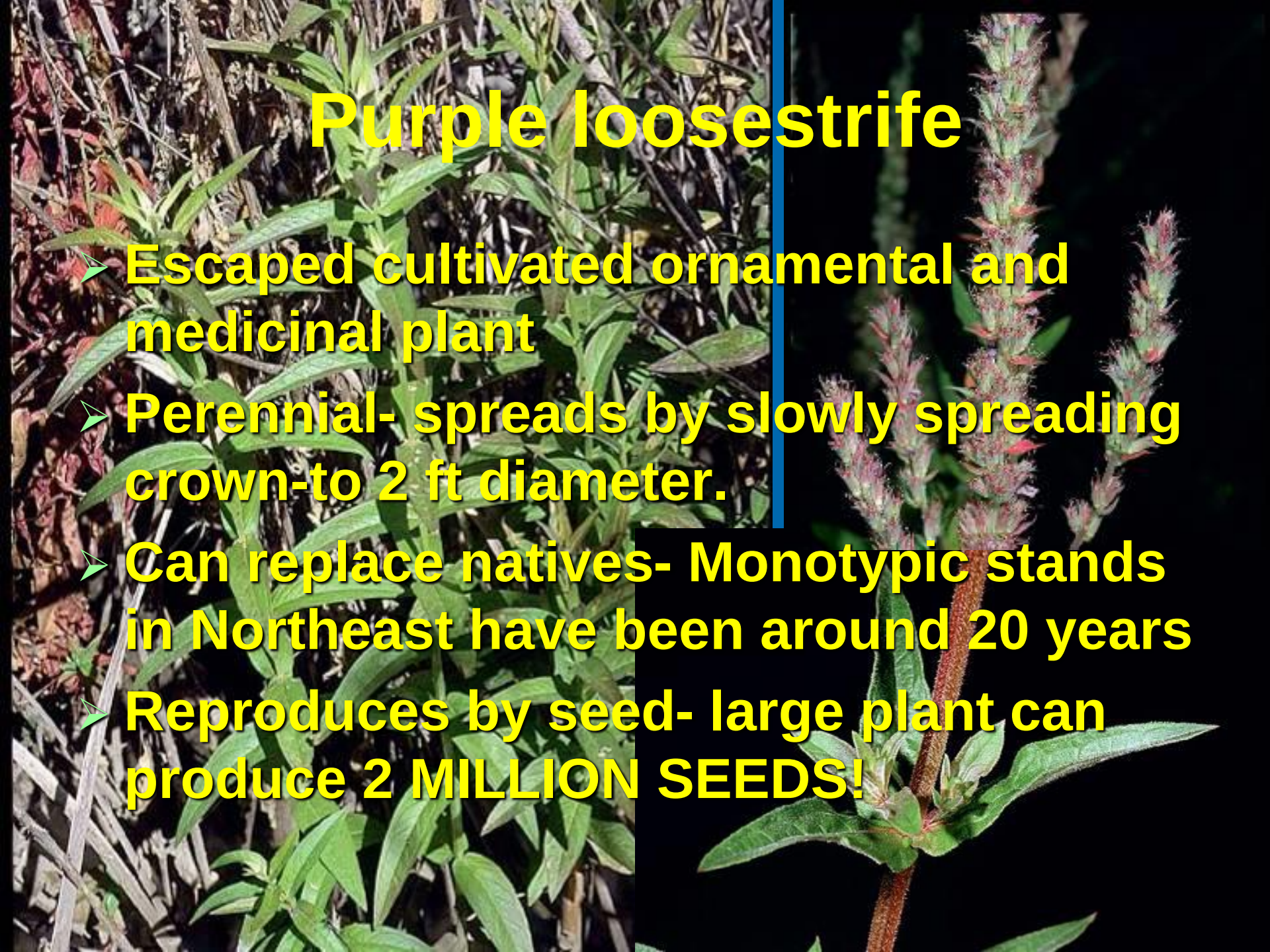
	North America.

CHEMICAL CONTROL

The following specific use information is based on published papers and reports by researchers and land managers. Other trade names may be available, and other compounds also are labeled for this weed. Directions for use may vary between brands; see label before use. Herbicides are listed by mode of action and then alphabetically. The order of herbicide listing is not reflective of the order of efficacy or preference.

AROMATIC AMINO ACID INHIBITORS	
Glyphosate *Aquamaster*, *Rodeo* and others	**Rate:** 3 to 4 qt product *Rodeo* or *Aquamaster*/acre (3 to 4 lb a.e./acre). Spot treatment: 2 % v/v. **Timing:** Postemergence, at flowering after heads are formed and before frost. **Remarks:** Glyphosate will not kill seeds or inhibit germination the following season. Glyphosate has no soil activity. Allow 7 days or longer before clipping or tillage. Flooding after herbicide application improved control in several studies. Adding a surfactant or emulsifier is recommended as cattails have a thick waxy coating on the leaf. Retreatment with herbicides is often necessary for complete control.
BRANCHED-CHAIN AMINO ACID INHIBITORS	
Imazamox *Clearcast*	**Rate:** 2 to 4 pt product/acre (0.25 to 0.5 lb a.i./acre) **Timing:** Postemergence, from new growth through killing frost. **Remarks:** Imazamox has mixed selectivity and controls several broadleaf and annual grass species. It is registered for control of vegetation in and around aquatic and non-cropland sites. It has irrigation and water use restrictions. Add a spray adjuvant, such as a methylated seed oil, to improve control.
Imazapyr *Habitat*	**Rate:** 0.5 to 2 qt product/acre (0.25 to 1 lb a.e./acre) **Timing:** Postemergence from boot to flowering. **Remarks:** *Habitat* is registered for aquatic use. Also effective following early season mowing and/or disking. It is a nonselective herbicide. Imazapyr has long soil residual activity and may leave more bare ground than other treatments, even a year after application. Add a spray adjuvant. Do not apply in the root zone of desirable trees.

Purple loosestrife
Lythrum salicaria



Purple loosestrife

- Escaped cultivated ornamental and medicinal plant
- Perennial- spreads by slowly spreading crown-to 2 ft diameter.
- Can replace natives- Monotypic stands in Northeast have been around 20 years
- Reproduces by seed- large plant can produce 2 MILLION SEEDS!

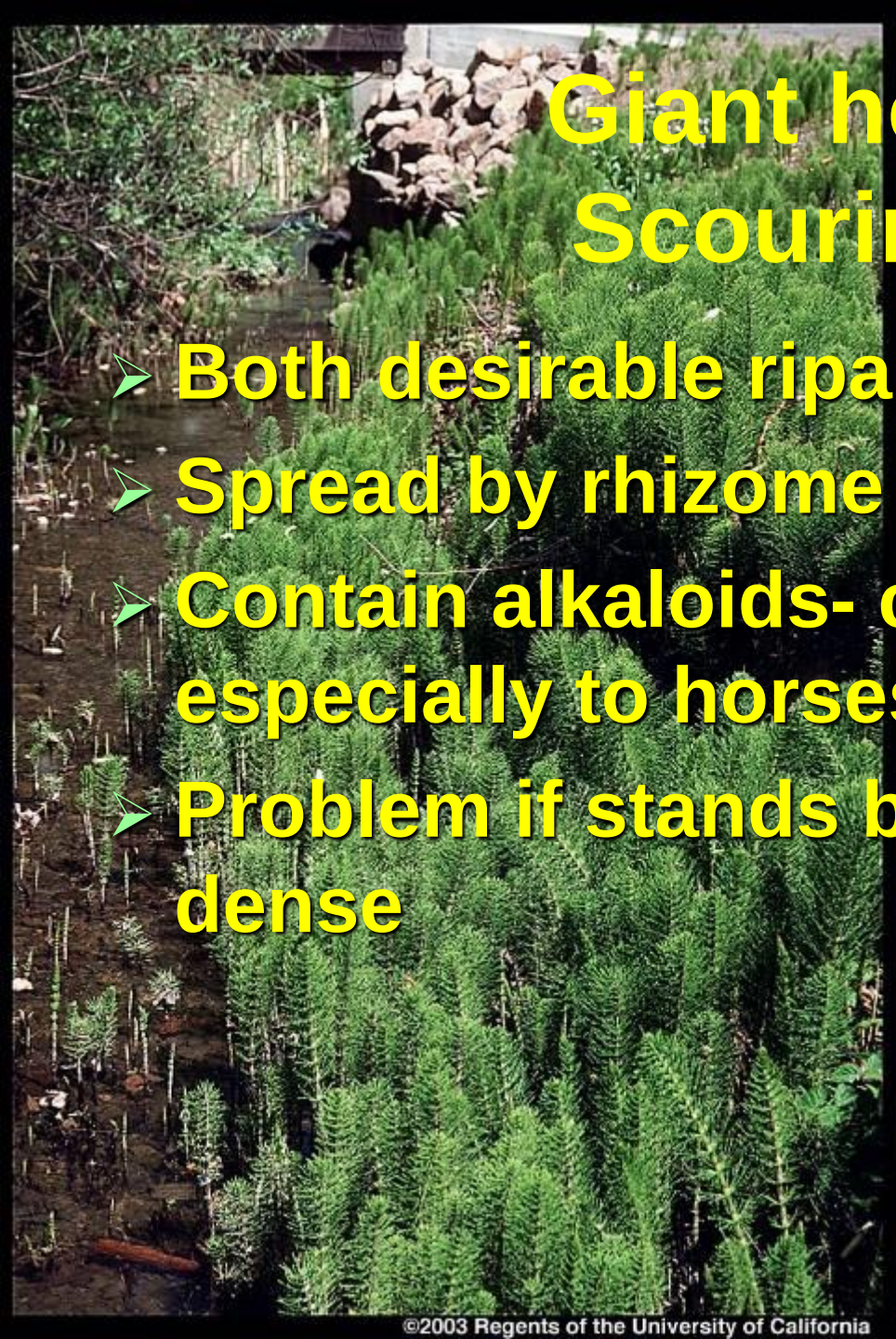
Giant horsetail
Equisetum telmateia ssp. *braunii*

Scouringrush

Equisetum hyemale* ssp. *affine

Giant horsetail
Scouringrush

- Both desirable riparian native-
- Spread by rhizome
- Contain alkaloids- can be toxic- especially to horses
- Problem if stands become excessively dense



Giant reed
Arundo donax

Seedhead

Sprouts from fallen branch

Giant reed
Arundo donax

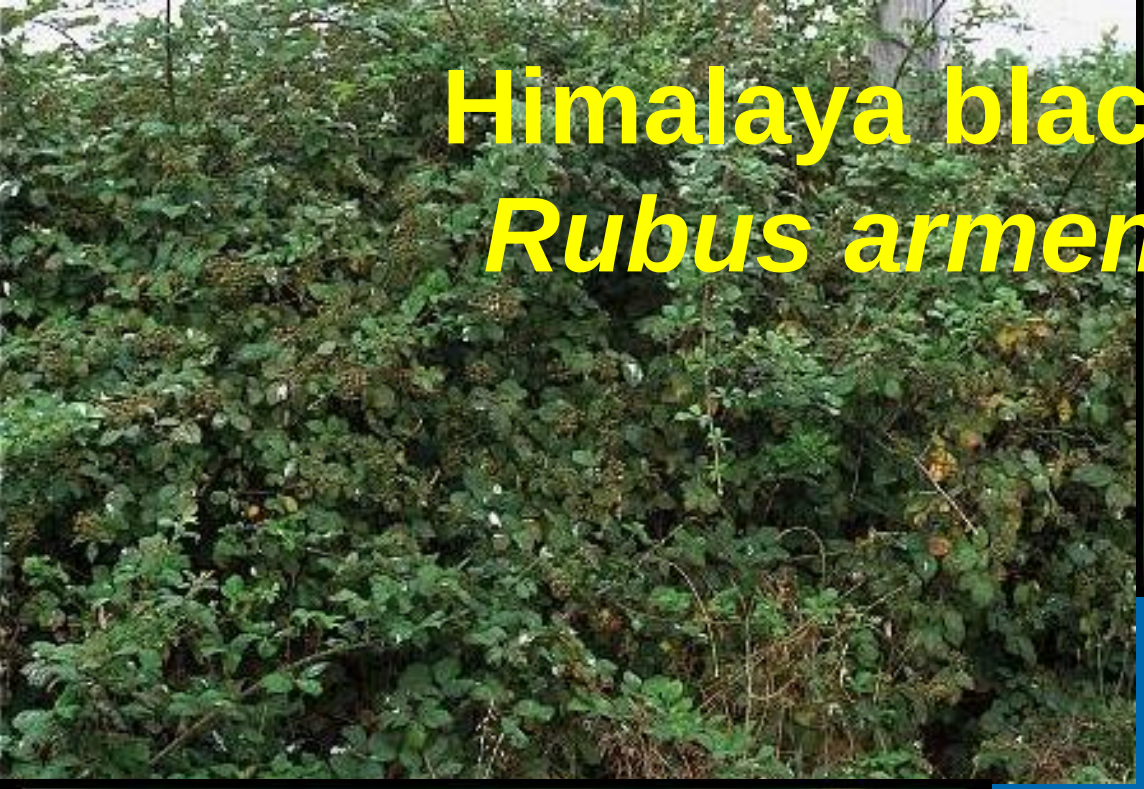
- Robust perennial grass- grows 6-30 feet high-spreads by rhizome- no viable seeds
- Brought to Los Angeles in 1820's used for roofing and fodder material
- Used for erosion control- now causes floods
- Displaces native plants and wildlife because of the large stands and monopolization of soil moisture-

Perennial pepperweed
Lepidium latifolium

Perennial pepperweed
Lepidium latifolium

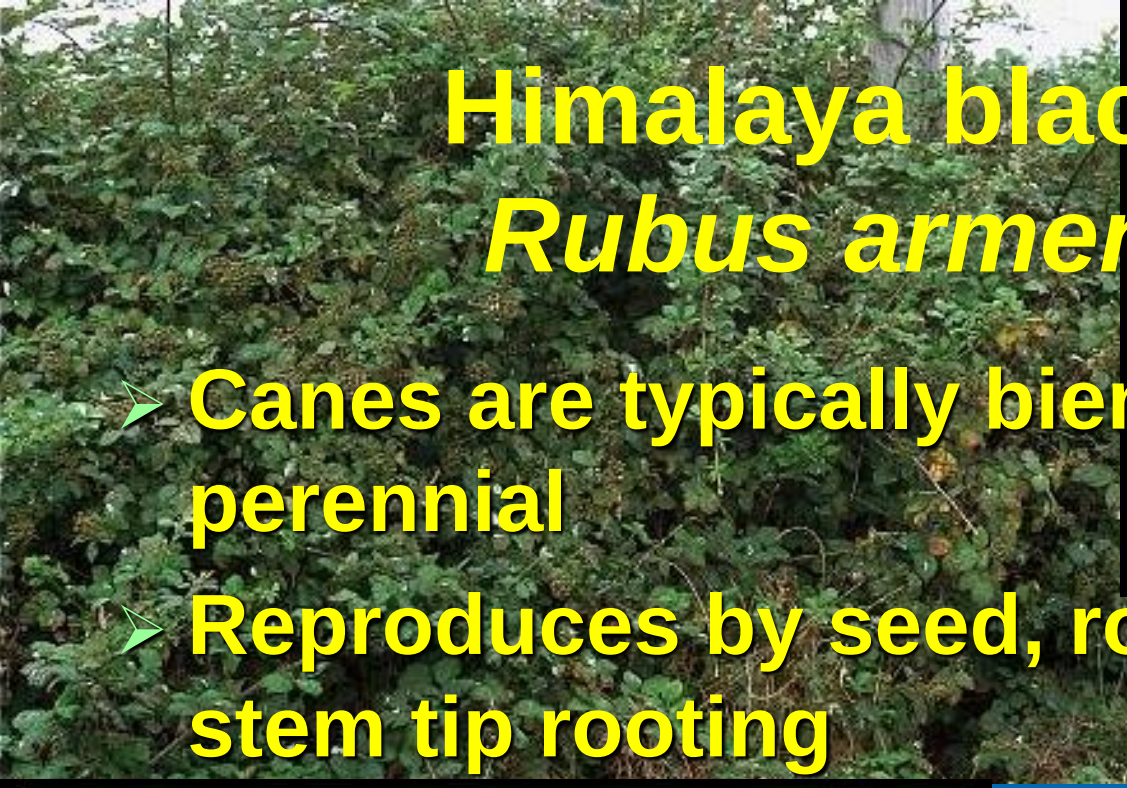
- Perennial spreads by root and seed
- Forms dense stands in brackish or alkaline wetlands- and other areas
- Introduced from Europe found in all counties in CA, except Del Norte, Humboldt and Imperial.

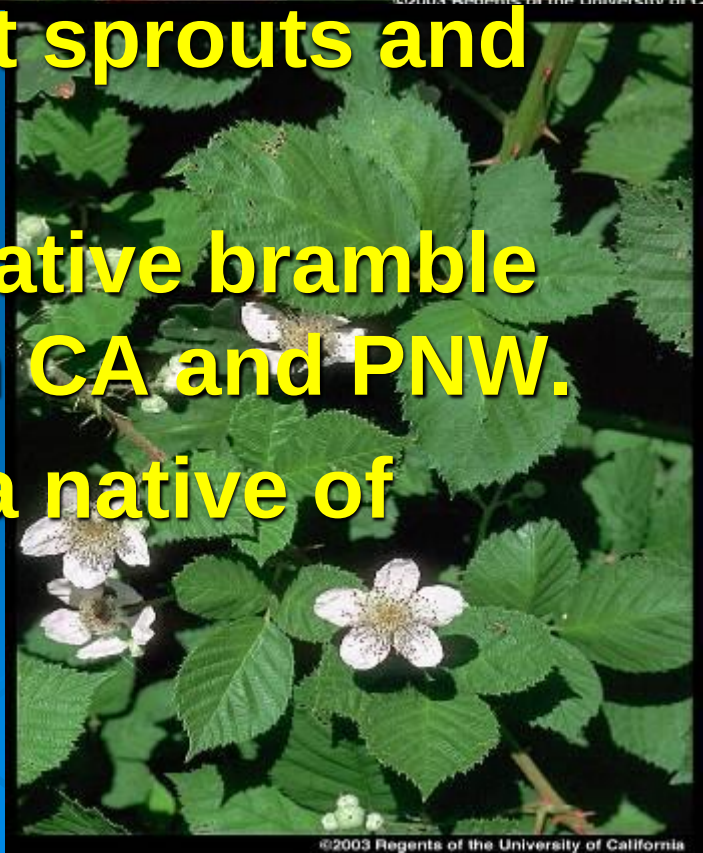
Himalaya blackberry
Rubus armeniacus



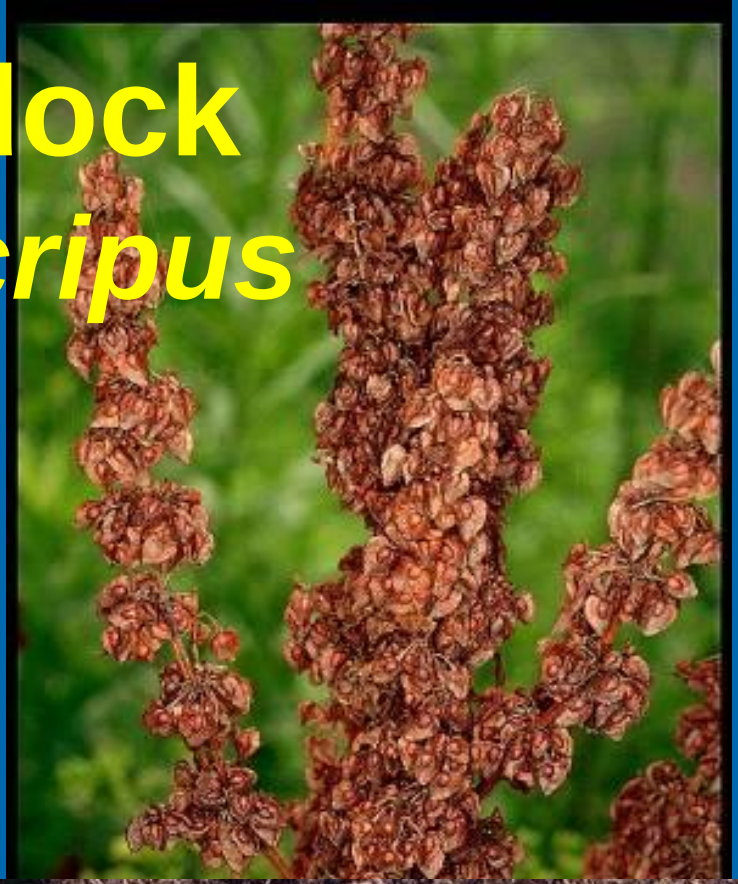
Himalaya blackberry
Rubus armeniacus

- Canes are typically biennial- roots are perennial
- Reproduces by seed, root sprouts and stem tip rooting
- The most common non-native bramble invading riparian areas in CA and PNW.
- Himalayan blackberry is a native of Armenia.?





Curly dock
Rumex cripus



Curly dock
Rumex cripus

- Perennial- can accumulate toxic level of oxalates and plants can (rarely) become poisonous to livestock when ingested in high quantity.
- Reproduces by seed- buried can survive 20 years or more.
- Seeds can survive ingestion by cattle and small birds- but not chickens-

Pale smartweed
Polygonum lapathifolium

Pale smartweed
Polygonum lapathifolium

- Desirable annual native that produces seeds that are an important food source for birds
- Can impede water movement when population becomes large and dense

Algae & Aquatic Weed Control


ALGAE CONTROL

Biology and Control of Aquatic Plants

A Best Management Practices Handbook: Third Edition

Lyn A. Gettys, William T. Haller and David G. Petty, editors

Chapter 13: The Biology and Management of Algae

Carole A. Lembi. Purdue University, West Lafayette IN, lembi@purdue.edu

Introduction

Algae are found in all salt and freshwaters worldwide. Although algae are very simple in their structure and sometimes consist only of a single cell floating in water, they are tremendously important for the health of our planet. Algae provide the base of food chains that support whales, seals, sharks and all other marine organisms in the oceans. In freshwaters, they also support food chains that lead to animals as diverse as bass, bald eagles and grizzly bears. Another essential role of algae is that they produce between 40-50% of the oxygen that we breathe through the process of photosynthesis!

The number of algae species is unknown, but it is likely more than 100,000, ranging from single cells to the large seaweeds found along our coastlines. Identification of freshwater algae can be difficult because the cells, or even clusters of cells, tend to be small and a microscope is usually required for accurate identification. In addition to cell shape and size, a key feature for proper identification is the color. Although all algae contain the green pigment chlorophyll, other pigments can also be present and can give the organisms different colors. Green algae are green because of chlorophyll, but diatoms and dinoflagellates are brown because xanthophyll pigments are present in higher concentrations than chlorophyll. The blue-green algae (also called the cyanobacteria)

Management Methods

- Nutrient Reduction
- Aeration
- Bacterial Competition
- Shading
- Algicides
- Barley Straw
- Biological Control – Triploid Grass Carp
- Biomanipulation

Lake Food Chain

FISH FEEDERS

PLANKTON FEEDERS

ZOOPLANKTON

NUTRIENTS

ALGAE

ALGAE ARE THE BASE OF FOOD CHAINS

Barley straw

Algae control agent?- conflicting results

The Centre for Aquatic Plant Management (CAPM) in the United Kingdom is promoting a method of controlling algae that involves the application of barley straw to lakes. As the straw decomposes in the lake, it releases a chemical which inhibits algal growth.

Algae Control -- Barley straw can be packed in onion mesh bags (7 lbs / bag). Photo courtesy Steve McComas, Blue Water Science, St. Paul, MN

http://ohioline.osu.edu/a-fact/0012.html

THE OHIO STATE UNIVERSITY EXTENSION

Extension FactSheet

A-12-02

School of Natural Resources, 2021 Coffey Road, Columbus, OH 43210-1085

Algae Control with Barley Straw

William E. Lynch Jr.
Extension Associate, Aquatic Ecosystem Management

Filamentous algae is the most common aquatic weed problem in Ohio ponds. Its "sudden" appearance as it floats off the bottom causes consternation to pond owners as it degrades the aesthetic and recreational value of their ponds. Additionally, large amounts of filamentous algae can lead to a fish kill if specific climatic conditions occur (see Ohio State University Extension Fact Sheet A-8-01, *Winter & Summer Fish Kills*). A number of mechanical, biological, and chemical control measures are available, each with their own advantages and disadvantages. A review of these measures can be found in Ohio State University Extension Fact Sheet A-3-98, *Controlling Filamentous Algae in Ponds*.

Barley straw has received considerable attention as an algaecide based on research done in England. Results showed that barley straw prohibits the growth of many types of algae, but not all. ***However, recent research in the United States has not yielded conclusively positive results.*** While research results are inconclusive, the use of barley straw to control pond algae has grown. The purpose of this fact sheet is to provide pond owners with application guidelines ***should they decide to try barley straw as an algae control technique.***

How Barley Straw May Work

The decomposition of barley straw in water produces and releases many compounds, one of which *may* control algae populations. The chemical compound does not eliminate existing algae cells but interferes with and prevents the growth of new algae cells. As "old" algae cells naturally die off, few new algae cells are produced and the algae population is controlled as long as the compound is being produced.

There are a number of other types of straws available, including wheat, linseed, and oil seed. However, research in England has shown that barley straw is the most effective straw and provides control for a longer period of time.

Note: pond owners should use dried straw, not barley hay or fresh barley. The addition of those materials actually releases nitrogen and phosphorus into the water which promotes algae growth. These fresher materials also decompose very quickly and can cause low oxygen problems in ponds.

How Much to Apply

The amount of straw to apply is based on pond surface area rather than volume (for calculation tips, see Ohio State University Extension Fact Sheet A-2-98, *Pond Measurements*). It is generally recommended that about 0.025 pounds of straw be used for every square yard of pond surface area. In a small ornamental pond of four square yards (about 100 square feet), only 0.01 pounds is needed. In a one-acre pond, the amount required would be about 107 pounds of straw or 2-3 standard bales. In a pond with a history of algae problems, a higher initial amount of 225 pounds per surface acre may be warranted.

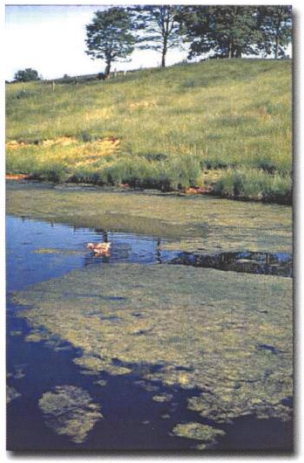
How and Where to Apply

The production of the critical compound during straw decomposition must occur in the presence of oxygenated water. In small ornamental ponds, simply place the small amount required loosely in a mesh bag and place in the water. A weight of some sort should be added so the bag is on the pond bottom.

In larger ponds, more effort is needed. Each bale should be broken up as much as possible so that nearly all decomposition will occur in the presence of oxygen. About 1/3 of a bale should be placed in a large, weighted permeable bag of some sort. If an intact bale is placed in the pond, only the decomposition occurring along the outside of the bale will occur in the presence of oxygen. Decomposition inside the "tight" bales will occur in the absence of oxygen and will not produce the chemical. In a one-acre pond, this will result in 6-9 loosely filled separate

APM-1-W

Aquatic Plant Management



Barley Straw for Algae Control

Carole A. Lembi, Professor of Botany
Botany and Plant Pathology, Purdue University
E-mail: lembi@purdue.edu

The use of barley straw for algae control has received a lot of publicity in recent years. It is now common to find small barley bales being sold in nurseries and garden shops for use in water gardens and small pools to control algae. The word-of-mouth reports of success with this method have led many people to suspect that barley might also control algae in ponds and lakes. What has research so far told us about the potential for barley to control algae in these larger bodies of water? And, what does the Environmental Protection Agency (EPA) say about using barley straw as an algicide? These topics will be addressed in this publication.

Where It All Started

The technique of using barley for algae control was developed in the early 1990s in England, where it is widely used in many bodies of water, including large reservoirs and canals. In general, it is thought that fungi decompose the barley in water, which causes a chemical to be released that prevents the growth of the algae. The specific chemical(s) has not been identified (oxidized polyphenolics and hydrogen peroxide are two decomposition products that have been suggested), and it is not clear whether the chemical is exuded from the barley itself or if it is a metabolic product produced by the fungi. The activity of barley straw is usually described as being algistatic (prevents new growth of algae) rather than algicidal (kills already existing algae).

Laboratory studies conducted by English researchers suggest that barley will not control the growth of all species of algae. In fact, some of the studies are contradictory, claiming that certain types of algae are susceptible while other studies claim that those algae are not susceptible. But, the field evidence from England does suggest that, in most cases, water clarity will improve over time and that this is due to reduction in algal populations.

http://www.btny.purdue.edu/Pubs/APM/APM-1-W.pdf

Reduce obvious nutrient inputs

In our example, over 6500 Canada geese and 4200 ducks (mostly mallards) added 616 pounds of nitrogen, (N) and 194 pounds of phosphorus (P) per year to Wintergreen Lake in southwestern Michigan, mostly during their migration.

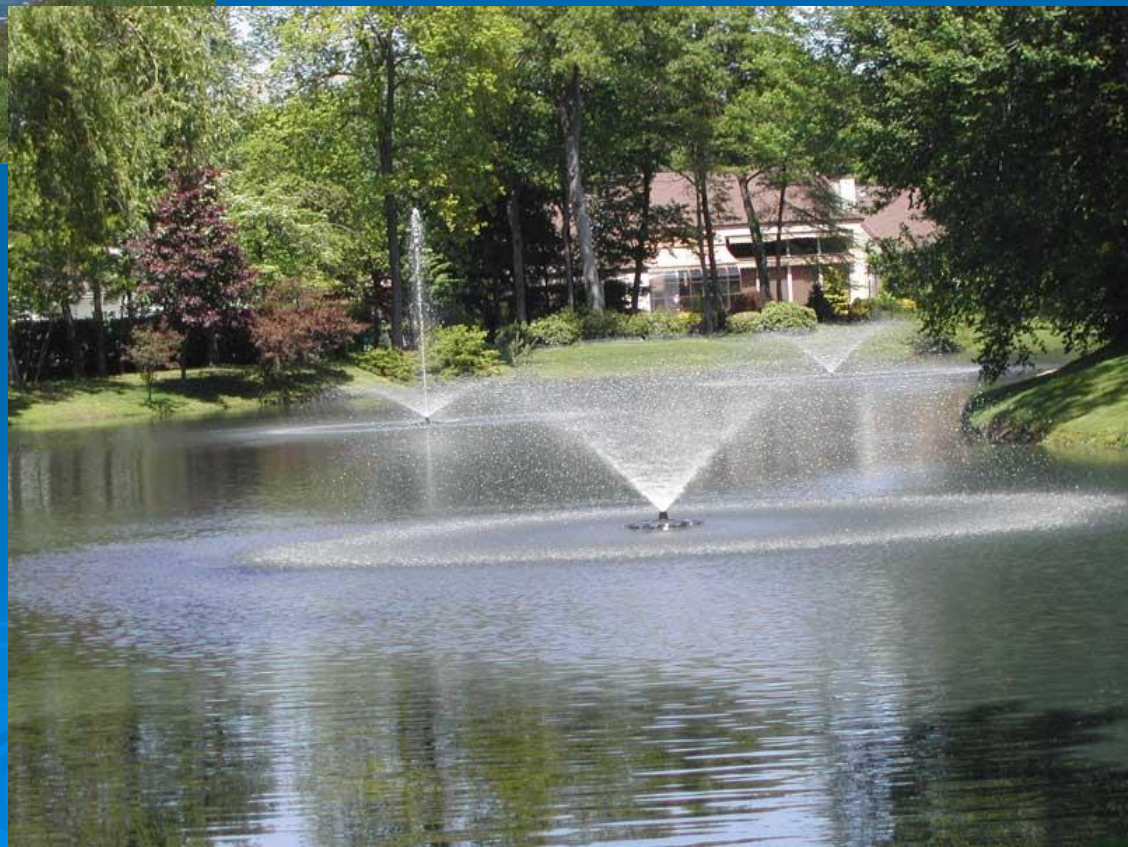
These amounts were 27% of all N, and 70% of all P that entered the lake from external sources.

Our procedure showed that waterfowl caused low water quality in Wintergreen Lake.

Manny *et al*. 1994. Hydrobiologia 279/280: 121.

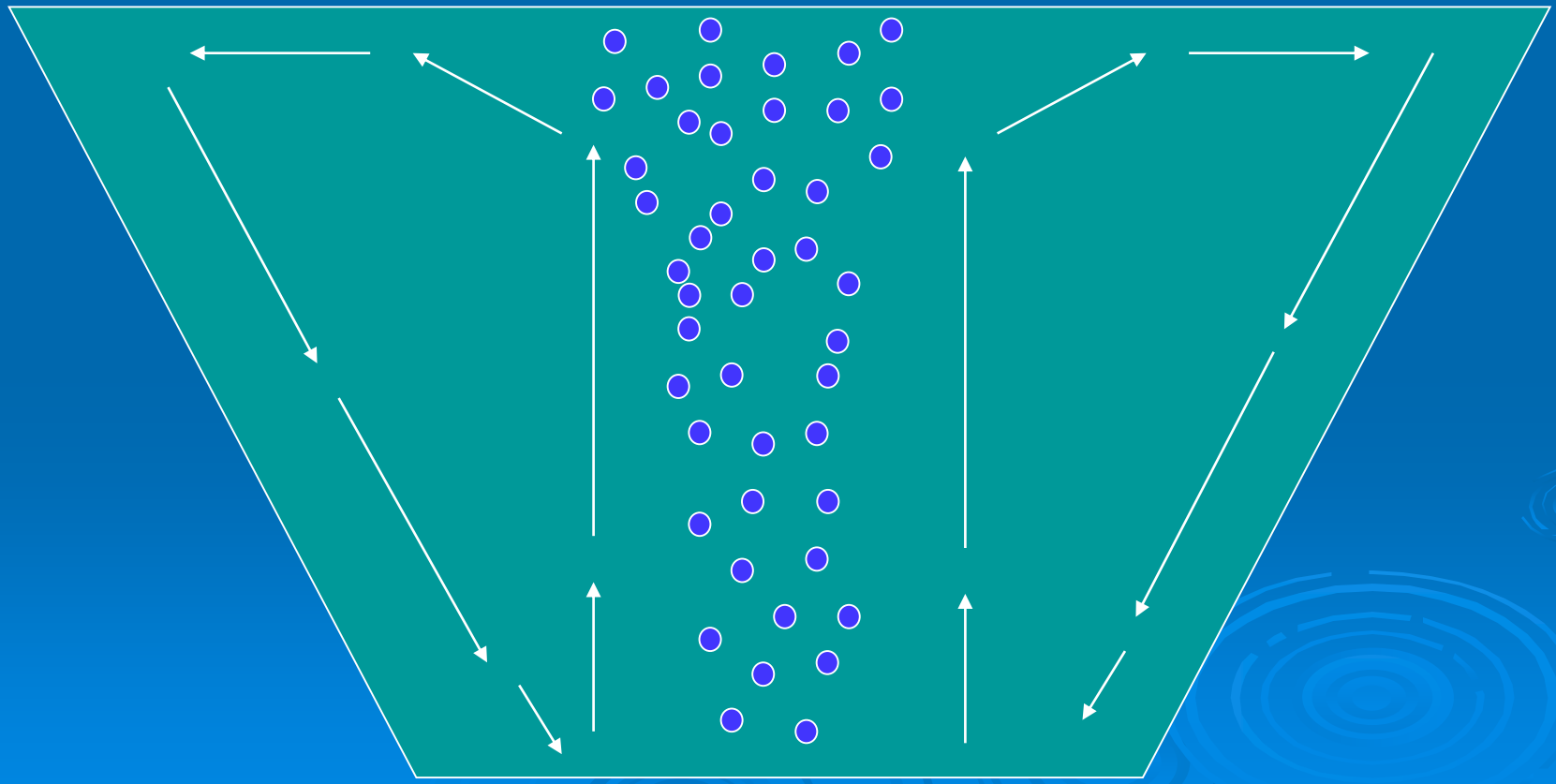

Buffer Strip
Reduce obvious nutrient inputs

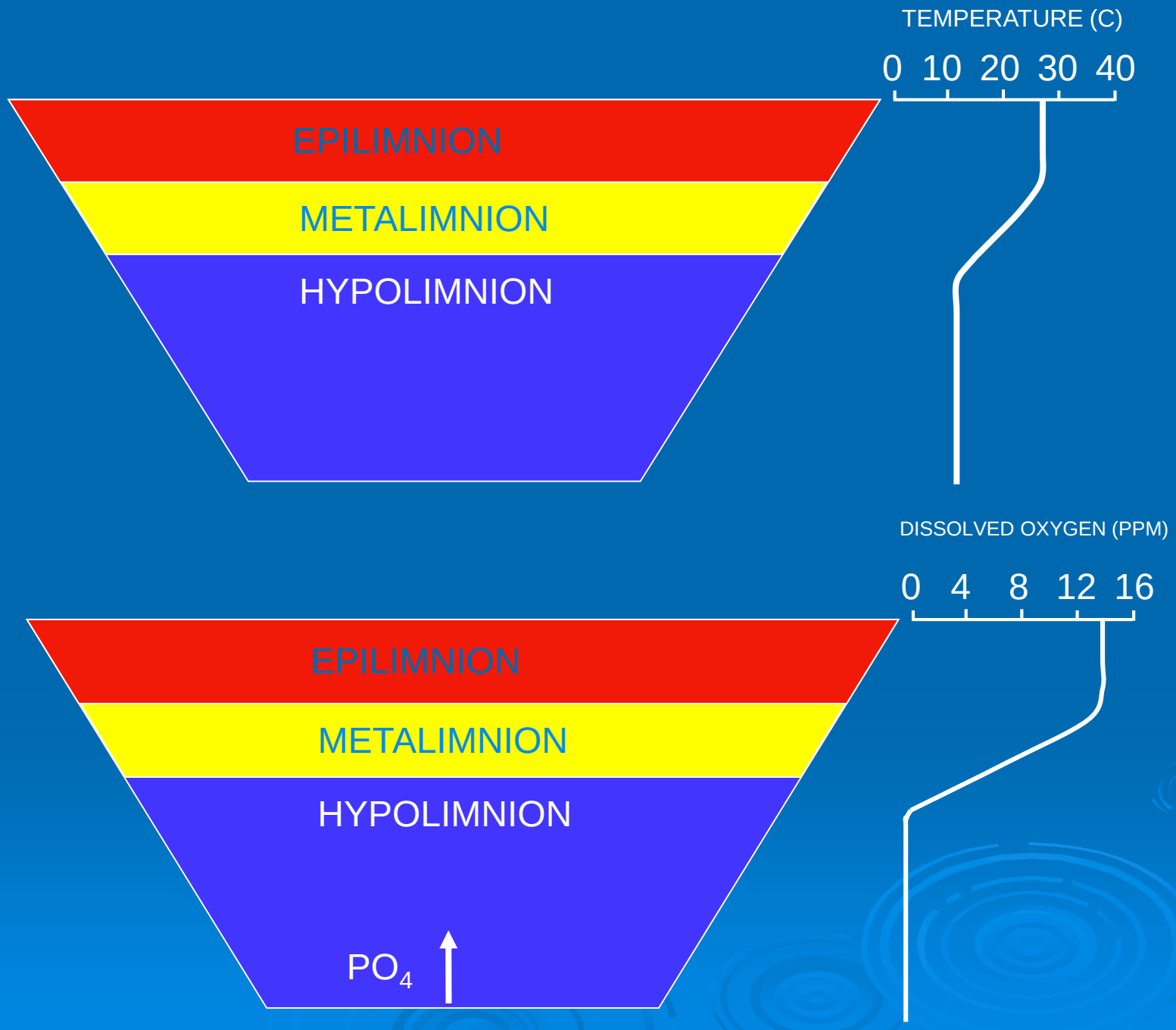
Aeration



Pictures from http//:pondguyinc.com

Aeration results in water movement and the addition of oxygen to deeper water. This inhibits release of nutrients from the sediments.




TEMPERATURE (C)
0 10 20 30 40
EPILIMNION
METALIMNION
HYPOLIMNION
DISSOLVED OXYGEN (PPM)
0 4 8 12 16
EPILIMNION
METALIMNION
HYPOLIMNION
PO4

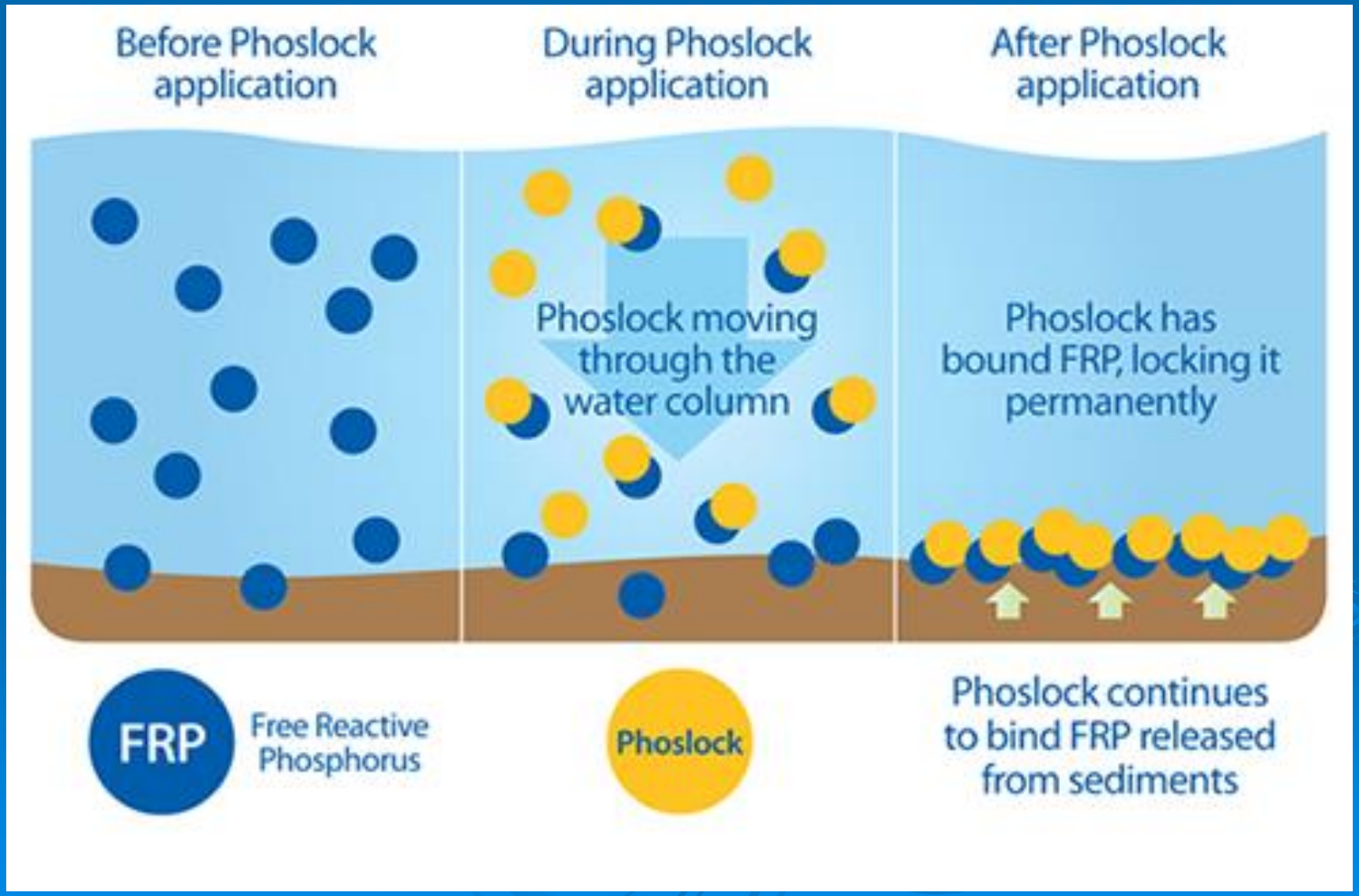
Ultrasonic Technology

Overview of Ultrasound

- Sound waves
- No permitting required
- Simple to install
- Inexpensive to run (draws 0.2 to 0.7 amps)
- Targets only algae
- Large bodies of water are no problem
- Easy to use with other control methods

Nutrient Inactivation

- Complex P with
  - Alum
  - Iron
  - Other
- Controls algae relatively inexpensively and can clarify water
- May not effect plants, particularly rooted ones
- Can adversely effect fish and other organisms


Before Phoslock application
During Phoslock application
After Phoslock application
Phoslock moving through the water column
Phoslock has bound FRP, locking it permanently
FRP
Free Reactive Phosphorus
Phoslock
Phoslock continues to bind FRP released from sediments

AQUATIC WEED CONTROL

Prevention

Eliminate shallow areas during construction

> 3 feet deep, except in designated swimming areas.

Prevent nutrients from entering the pond

point sources

use 10 - 20 foot wide grass buffer strips

fertilize areas adjacent to pond sparingly

prevent livestock from entering the pond directly

reduce the number of waterfowl

Site Considerations

- Pond Dimensions
- Average Depth
- Inflows / Outflows
- Location in the Floodplain
- Types of Fish
- Water Uses

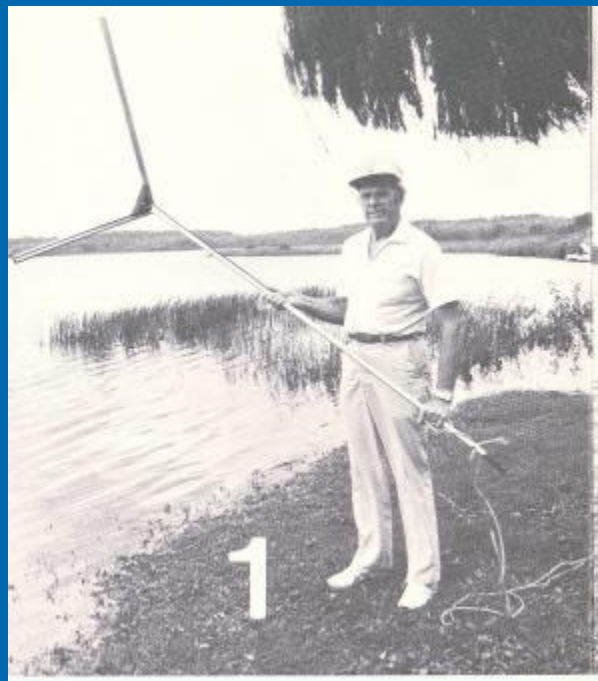
Aquatic Plant Management

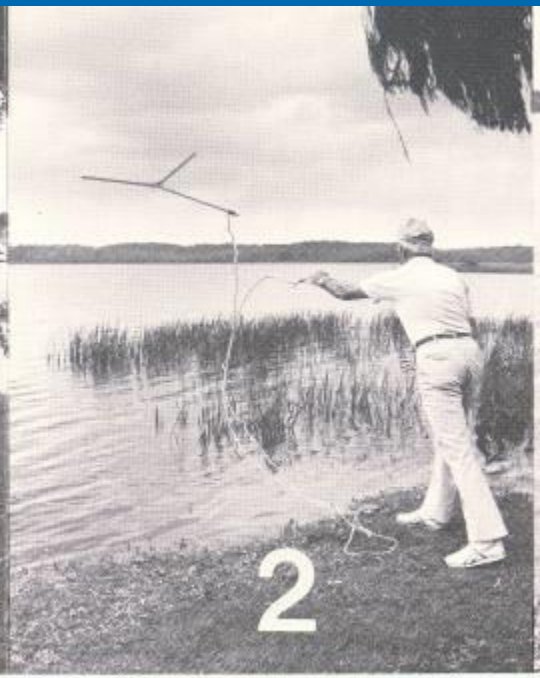
- Mechanical Control
- Cultural Control
- Biological Control
- Chemical Control

Mechanical Control

- Hand pulling and raking
- Cutting and harvesting
- Shredding
- Dredging
- Chaining
- Diver-operated suction harvesting
- Rotovating

Hand operated tools





HANDY MARKETING CO.

Dear Friend:

If you have a water weed problem, you already know what a job it is keeping the weed growth under control. Water weeds can greatly affect the use of your water property by inhibiting swimming, fishing and boating. Uncontrolled water weeds can also be an unsightly mess.

The AQUA WEED CUTTER will not only solve your water weed problems, but also help you do your part in preserving our nation's most valuable resource. If for any reason you are not satisfied in 30 days with the operation of the AQUA WEED CUTTER, return it to wherever you purchased it for a full refund. This is a no risk offer on your part.

The AQUA WEED CUTTER is manufactured with the highest degree of workmanship and the highest quality of materials. The AQUA WEED CUTTER is 100% manufactured in the United States. Zinc plating and the stainless steel resharpenable blades offer a high degree of corrosion resistance. We are so sure of the quality of materials and workmanship that goes into each AQUA WEED CUTTER that we have recently extended the limited warranty period from 90 days to 1 year.

Sincerely,

Don Breckenridge

Don Breckenridge,
President

SATISFIED CUSTOMERS

"Does a fantastic job - I figured I cleared more weeds in two hours than I've previously been able to in a whole summer."
-South Haven, MI

"My friend brought his AWC over to my house and I tried it. I thought it was great and I ordered one. The AWC is effective and easy to use."
-Webster, WI

"I like it very much. It does a very good job. I had to put a longer rope on it because I can throw it farther than the rope would permit. It's nice to be able to cut weeds without getting wet, especially when the water is cold."
-Aitkin, MN

"Gentlemen, I wish to inform you that your AQUA WEED CUTTER does a very good job and I am pleased. Several of the neighbors have also ordered them."
-Gowen, MI

"We have tried the AQUA WEED CUTTER and find it does an excellent job of cleaning the weeds in our beach, along the long pier and boat docks. We are very satisfied with the product and would recommend it to anyone who has a need."
-Claypool, IN

BEACHES • PONDS & SMALL LAKES CAN BE WEED FREE! SAFE, EASY-TO-USE • HELPS TO CONTROL WATER WEEDS

- Cuts a 48" path up to 20' deep (without operator getting wet!)
- Just throw it out and pull it in from **Any Dock or Shore!**

Stainless Steel Resharpenable Blades!
30-DAY MONEY BACK GUARANTEE!!

Cutting/Harvesting

Underwater cutting head

Not all pieces are captured-
Plant fragments may cause new infestation elsewhere

Shredding

- Shredders chop material in place, pieces too small to clog waterways
- Immediate relief
- A lot of biomass at bottom of canal-

Dredging

Removes nutrient-rich sediments

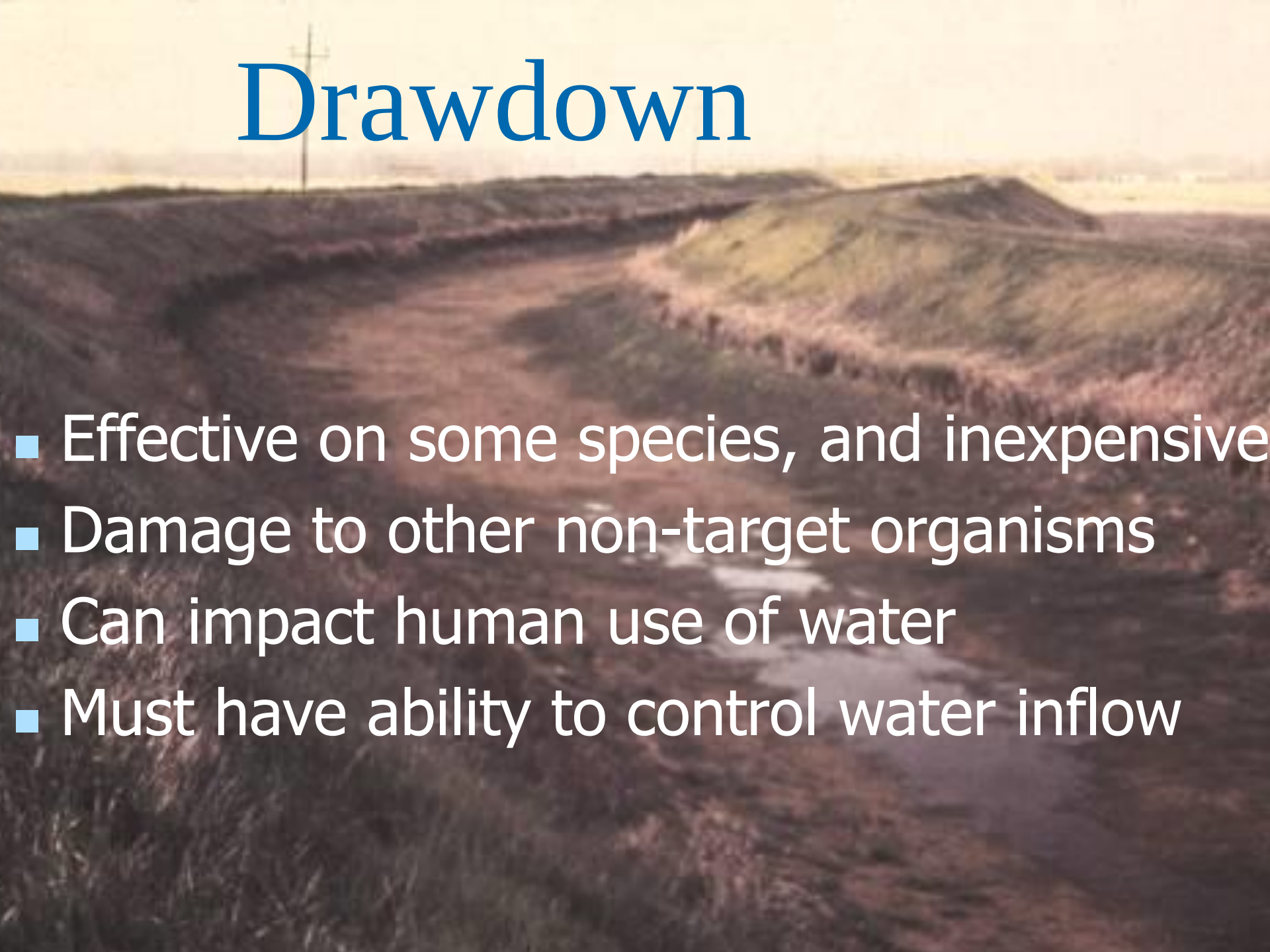
Exposes nutrient poor layers;

Deepens resulting in less light penetrating to the bottom.

Cultural Control

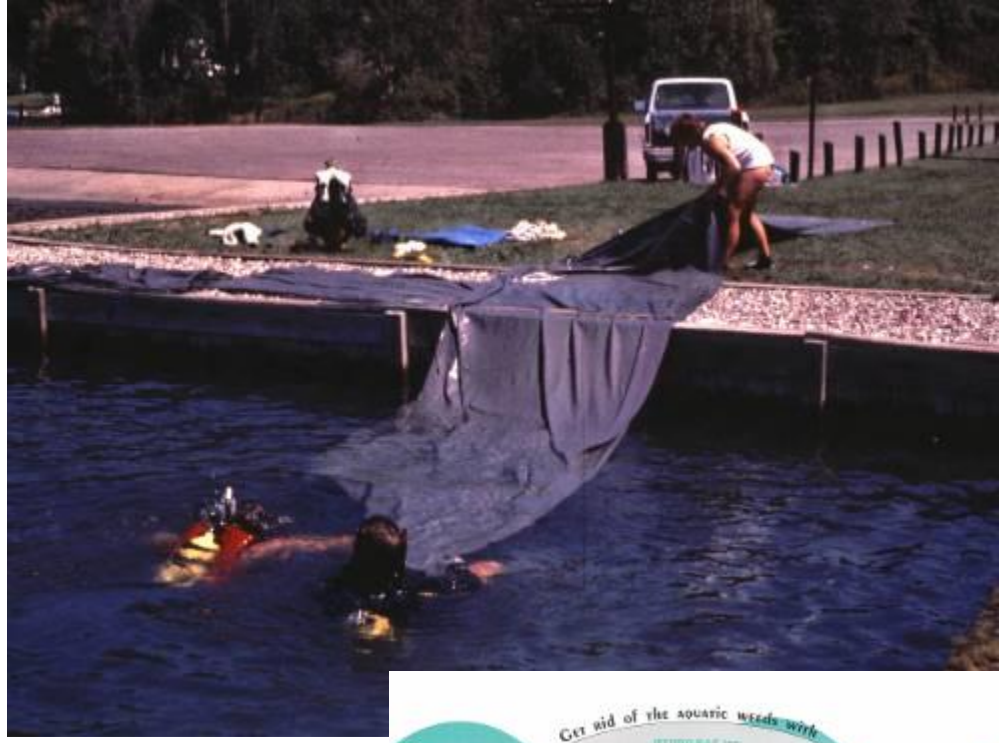
- Drawdown
- Benthic Barrier
- Shading
- Nutrient Inactivation
- Barley Straw

Drawdown



- Effective on some species, and inexpensive
- Damage to other non-target organisms
- Can impact human use of water
- Must have ability to control water inflow

Benthic Barrier

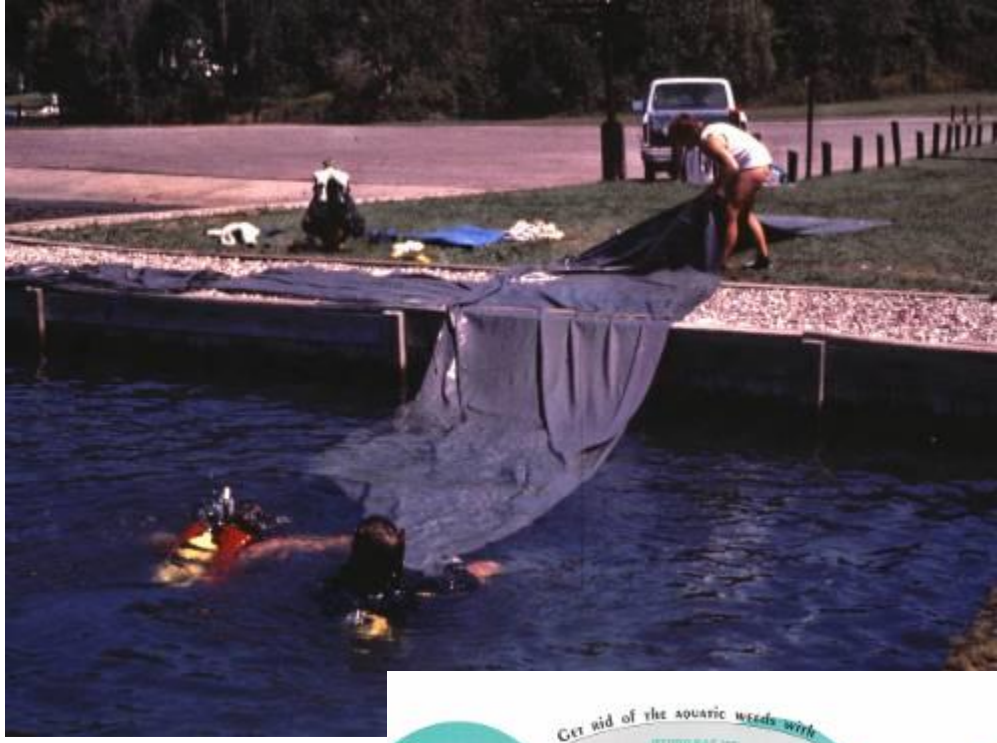


Advantages

-Last up to 10 years
-Frees areas for immediate use.
-Easy to install in small areas.
-Prevent new plant growth if used early in the spring.

-

Benthic Barrier



Disadvantages

-Habitat can be eliminated.
-Not suitable for large-scale (expensive)
-Must be removed
and cleaned in the fall.
-Too shallow an installation may
entangle props.
-Installation may be strenuous
especially in deep water!

Light Alteration as a Management Approach

Increase water depth by dredging.

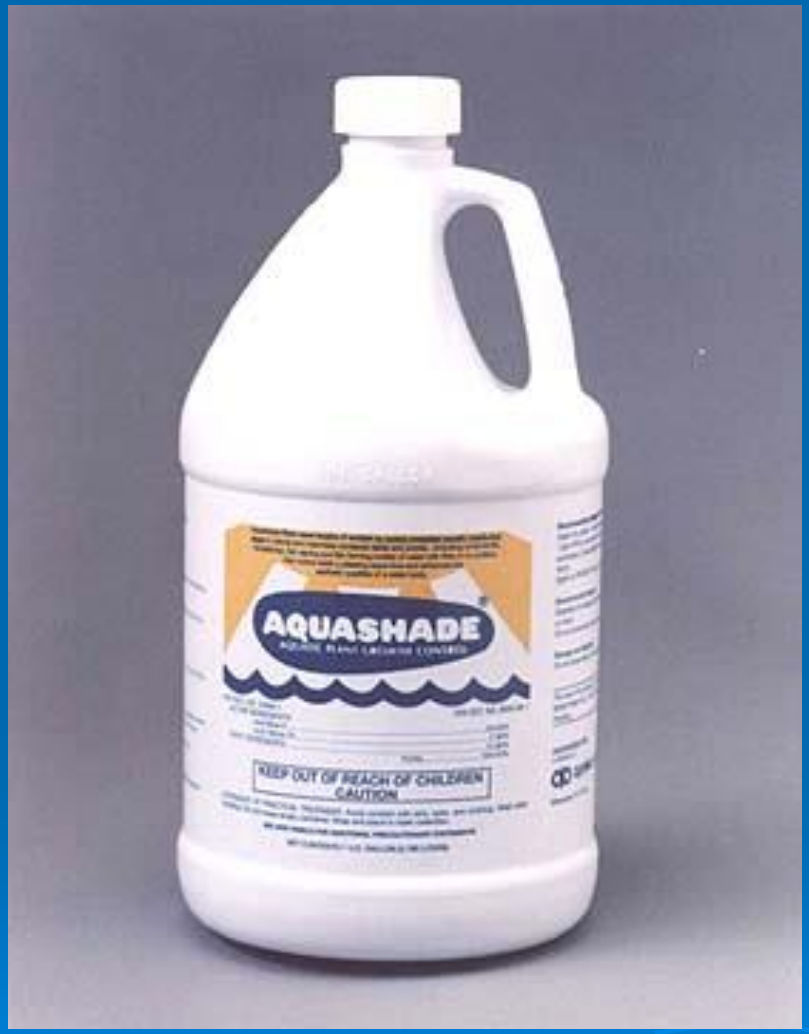
Increase shade from stream banks by planting tall grass, shrubs or trees.

Add nutrients to stimulate algal blooms.

Increase turbidity due to suspended clay.

Use light absorbing dyes.

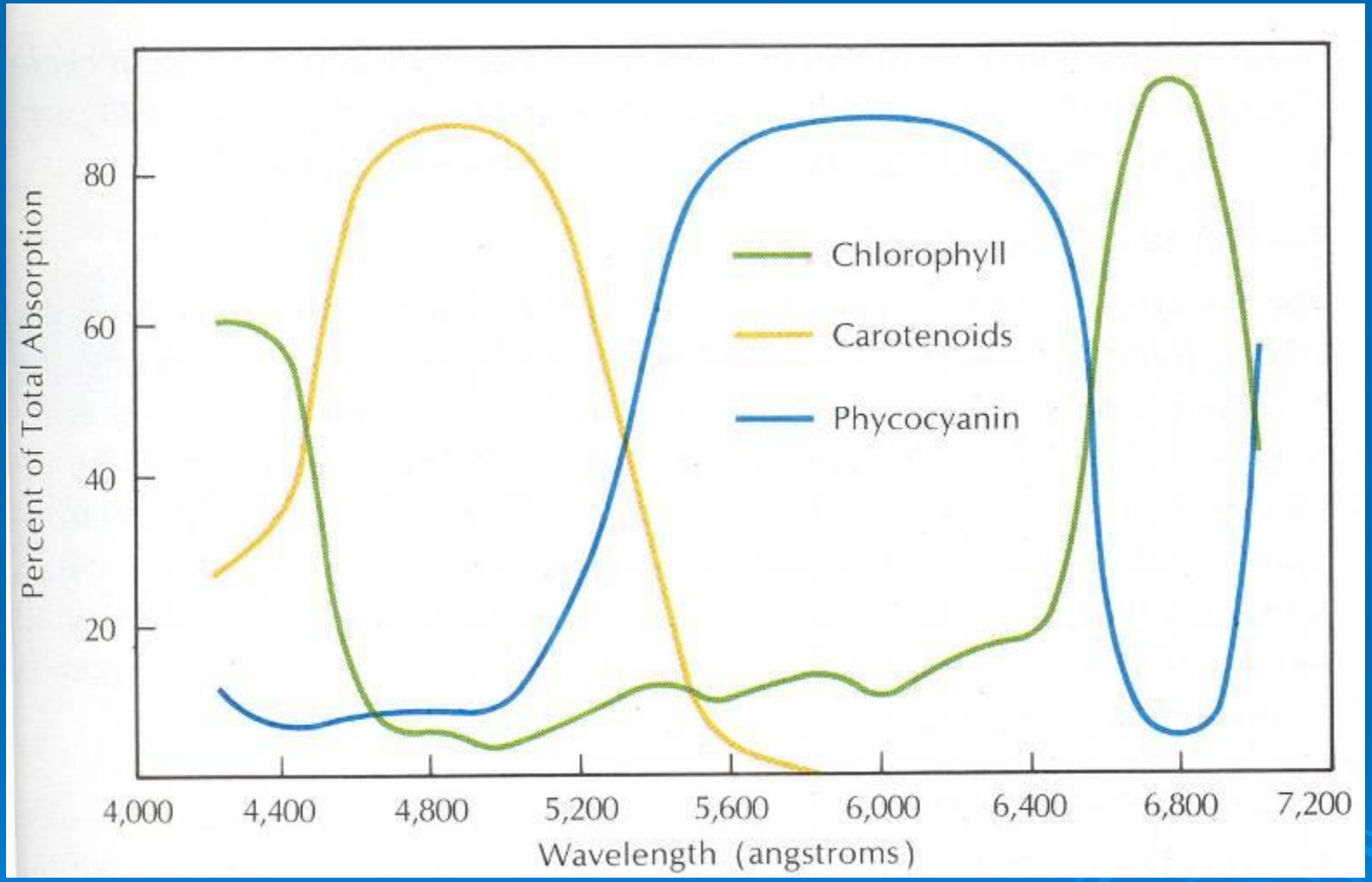
(slow water turnover, dilution, apply early in growing season, most effective in clear water, require minimum depths of > 0.5 to 2 m)



Shading

- Water-soluble dye
- Inexpensive
- Discoloration appears artificial

How colorants work



Block light wavelengths that plants need for growth

Biological Control

- Insects
  - Classical
  - Native
- Pathogens
  - Classical
  - Native
- Herbivorous Fish
  - Grass carp

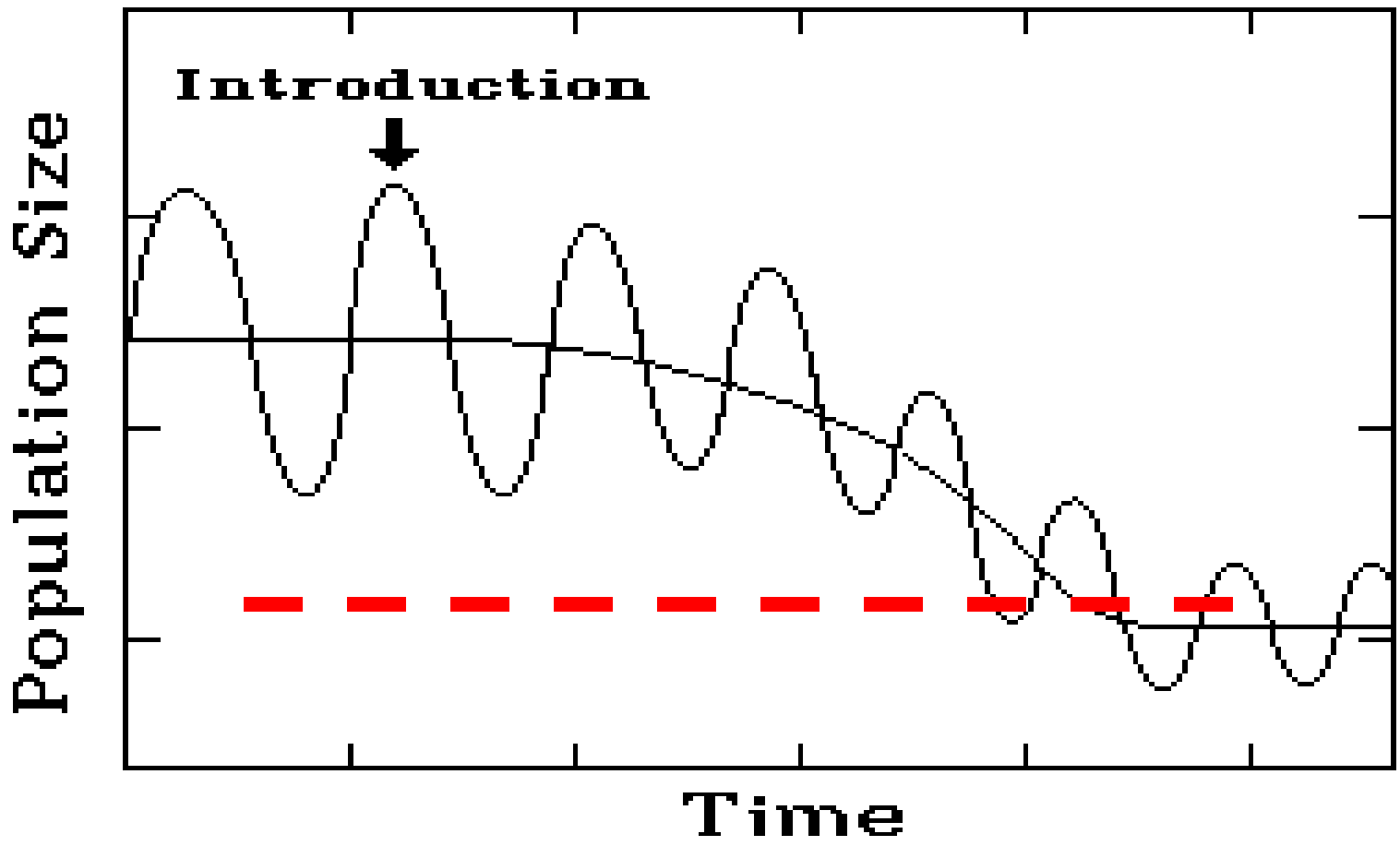
Pacific mosquitofern
Azolla filiculoides

- Azolla weevil Stenopelmus rufinasusis also native to California- not very effective.
- Can be ‘skimmed off’- gets heavy very quickly.

Classical Insect Control

- Advantages
  - Public perception
  - Low cost after R&D
  - Long-term
- Disadvantages
  - No agents for several target nonindigenous plants
  - Long time for R&D
  - Unpredictability of results

Goal of a Classical Insect Biological Control Program – Long term balance



Chemical control to submerged or floating leaf aquatics

Aquatic Herbicides

Read and follow the label!

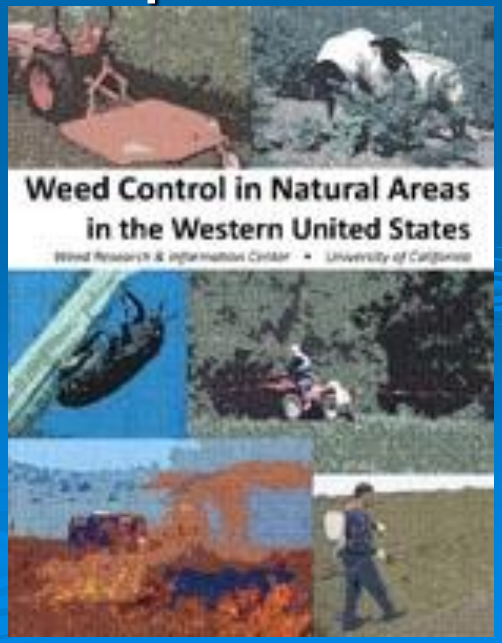
Check with Ag Commissioner for local use restrictions.

Chemical Control of Selected Weeds

Taken from ‘Weed Control in Natural Areas in the Western United States.’

* not all herbicides registered in California or not registered for use in all aquatic situations

Always Check Label and in many cases check with local Ag Commissioner or other water authorities.



Azolla spp.

Mosquitoferns

Family: Azollaceae
Range: Throughout most of the western United States, except Idaho, Wyoming, Montana and North Dakota.
Habitat: On still water or mud in ponds, small lakes, slow-moving streams and channels, ditches, rice fields, and sloughs. Often grow in eutrophic water. Do not tolerate saline water.
Origin: Native to the United States, including the western states. Mosquitoferns are sometimes sold as aquarium or pond ornamentals. In East Asia, mosquitofern is used as livestock feed and as a nitrogen source in rice fields.
Impacts: Native mosquitoferns are consumed by wildlife, especially waterfowl, and are usually a desirable component of natural aquatic communities. In addition, they provides breeding habitat for aquatic insects important to fisheries. In some human use areas, dense colonies can become a nuisance in certain situations by excluding other aquatic vegetation, encouraging the growth of algae, interfering with livestock drinking, and clogging water pumps.
Western states listed as Noxious Weed: Pinnate mosquitofern (*A. pinnata* R.Br.) is listed as a Federal Noxious Weed, but is not naturalized in the United States, although it may be cultivated as an aquarium plant. It is also a state listed Noxious Weed in California and Oregon

Mosquitofern species are small, annual to perennial, free-floating aquatic ferns that often occur in colonies. Pacific mosquitofern (*A. filiculoides* Lam.) and Mexican mosquitofern (*A. mexicana* C. Presl) are native species that occur in many western states. Upper leaf lobes are typically colonized by the nitrogen-fixing cyanobacterium *Anabaena azollae*. Stems are floating and are pinnately branched with roots suspended in the water column. Young plants are gray to green but turn red to brown with age and season.

Plants produce spores that disperse with wind, but the most common mechanism of dispersal is vegetative, with plant fragments moving in water or clinging to the feet or feathers of birds. Careless disposal of pond or aquarium contents can introduce plants to previously uninhabited areas. Colonies typically enlarge rapidly during the warmer months and diminish during the cool months.

NON-CHEMICAL CONTROL

Mechanical (floating booms, suction devices)	Small infestations of the weed in accessible areas may be removed using rakes and fine meshed nets. The disadvantage of mechanical control, however, is that under ideal conditions, the weed can double itself every 4 to 5 days. Thus, it must be repeated often. For small infestations (1 to 2 acres), floating booms can be dragged (preferably "down wind") from the shore or pushed by boats to consolidate mats of *Azolla* which can then be removed with rakes. *Azolla* provides good composting material. In large lakes, mechanical harvesters equipped with surface "skimmers" or surface suction devices can remove mats.
Cultural	The use of water-circulation devices can sometimes reduce accumulation of large biomass. Reducing nutrient inputs can also be helpful (e.g. divert runoff from turf or other areas that provide nutrients).
Biological	A native frond-feeding weevil, *Stenopelmus rufinasus*, has been used for control of *Azolla filiculoides* with some success outside the United States. Early research on the flea beetle *Pseudolampsis guttata* suggests

	it may also be useful. The triploid (sterile) grass carp (white amur) is a relatively nonselective herbivorous fish that will consume *Azolla* and other small floating plants (e.g. duckweeds). The fish do not selectively feed on "non-native" plants so careful monitoring of feeding impacts is necessary. In some Asian crop systems, use of fish and ducks are integrated to provide control of *Azolla* in rice production.

CHEMICAL CONTROL

The following specific use information is based on reports by researchers and land managers. Other trade names may be available, and other compounds also are labeled for this weed. Directions for use may vary between brands; see label before use. Herbicides are listed by mode of action and then alphabetically. The order of herbicide listing is not reflective of the order of efficacy or preference.

AROMATIC AMINO ACID INHIBITORS	
Glyphosate *Rodeo, Aquamaster*	**Rate:** Spot treatment: 2% v/v solution (*Rodeo* or *Aquamaster*) for foliar spray with approved aquatic surfactant (0.5%) **Timing:** Postemergence to foliage from spring to mid-summer. **Remarks:** Glyphosate is a slow-acting, systemic herbicide. *Azolla* often forms thick mats that can prevent glyphosate (or other foliar-applied herbicides) from penetrating the canopy and therefore unexposed fronds will reestablish the population.
BRANCHED-CHAIN AMINO ACID INHIBITORS	
Bispyribac-sodium *Tradewind*	**Rate:** 8 oz product/acre (6.4 oz a.i./acre). Allow 30 days between applications and apply up to four times per year. **Timing:** Postemergence to foliage from spring to mid-summer. **Remarks:** Bispyribac-sodium is a slow-acting herbicide and may take 4 to 6 weeks to show effects.
Imazamox *Clearcast*	**Rate:** Spot treatment: 2% v/v solution as a foliar spray plus 1% methylated seed oil (MSO) **Timing:** Postemergence to foliate from spring to mid-summer. **Remarks:** Use an approved surfactant.
Penoxsulam *Galleon*	**Rate:** 5.6 to 11.2 oz product/acre (1.4 to 2.8 oz a.i./acre), but most often used at 8 oz product/acre (2 oz a.i./acre). Apply in 20 to 100 gal spray solution/acre. **Timing:** Postemergence to foliage from spring to mid-summer. **Remarks:** Penoxsulam is a slow-acting herbicide and may take 4 to 6 weeks to show effects.
PIGMENT SYNTHESIS INHIBITORS	
Fluridone *Sonar*	**Rate:** For in-water treatment: 10 to 30 ppb **Timing:** Apply directly to water from spring to mid-summer (before large biomass has developed). **Remarks:** Fluridone is a slow-acting herbicide that may take several weeks to show effects.
CONTACT PHOTOSYNTHETIC INHIBITORS	
Diquat *Reward, Redwing*	**Rate:** 2 to 4 pt product/surface acre (0.5 to 1 lb a.i./surface acre) **Timing:** Postemergence to foliage from spring to mid-summer. **Remarks:** Diquat is a fast-acting contact herbicide. Repeated applications may be needed. *Azolla* often forms thick mats that can prevent diquat (or other foliar-applied herbicides) from penetrating the canopy and therefore unexposed fronds will reestablish the population.
Flumioxazin *Clipper*	**Rate:** For in-water treatments: 100 to 400 ppb **Timing:** Apply directly to water from early spring to early summer, during the plant's rapid growth phase. **Remarks:** Flumioxazin is rapidly degraded and is inactive if pH exceeds 8.5. Thus, it is important to only use if pH will not exceed 8.5. It is best to apply flumioxazin in the early morning when the pH is low.

RECOMMENDED CITATION: DiTomaso, J.M., G.B. Kyser et al. 2013. *Weed Control in Natural Areas in the Western United States*. Weed Research and Information Center, University of California. 544 pp.

Control* of Azolla

- Aromatic Amino Acid Inhibitors
  - Glyphosate (Rodeo, Aquamaster)
- Branch Chained Amino Acid inhibitors
  - Bispyribac-sodium (Tradewind)
  - Penoxsulam (Galleon)
  - Imazamox (Clearcast)
- Pigment synthesis inhibitor
  - Fluridone (Sonar)
- Contact Photosynthetic Inhibitors
  - Diquat (Reward)
  - Flumioxazin (Clipper)

Control* of Eurasian Watermilfoil

- Growth Regulators
  - 2,4-D (Weedar 6)
  - Triclopyr (Renovate)
- Branch Chained Amino Acid inhibitors
  - Bispyribac-sodium (Tradewind)
  - Penoxsulam (Galleon)
- Pigment synthesis inhibitor
  - Fluridone (Sonar)
- Contact Photosynthetic Inhibitors
  - Diquat (Reward)
  - Flumioxazin (Clipper)
- General Cell Toxicants
  - Endothall (Cascade, Teton and Aquathol K)
- Inorganic Herbicides
  - Chelated or inorganic copper

Control* of Waterprimrose

- Growth Regulators
  - 2,4-D (Weedar 6)
  - Triclopyr (Renovate)
- Aromatic Amino Acid Inhibitors
  - Glyphosate (Rodeo, Aquamaster)
- Branch Chained Amino Acid inhibitors
  - Imazapyr (Habitat)
  - Imazamox (Clearcast)
- Contact Photosynthetic Inhibitors
  - Diquat (Reward)

Costs of aquatic weed management

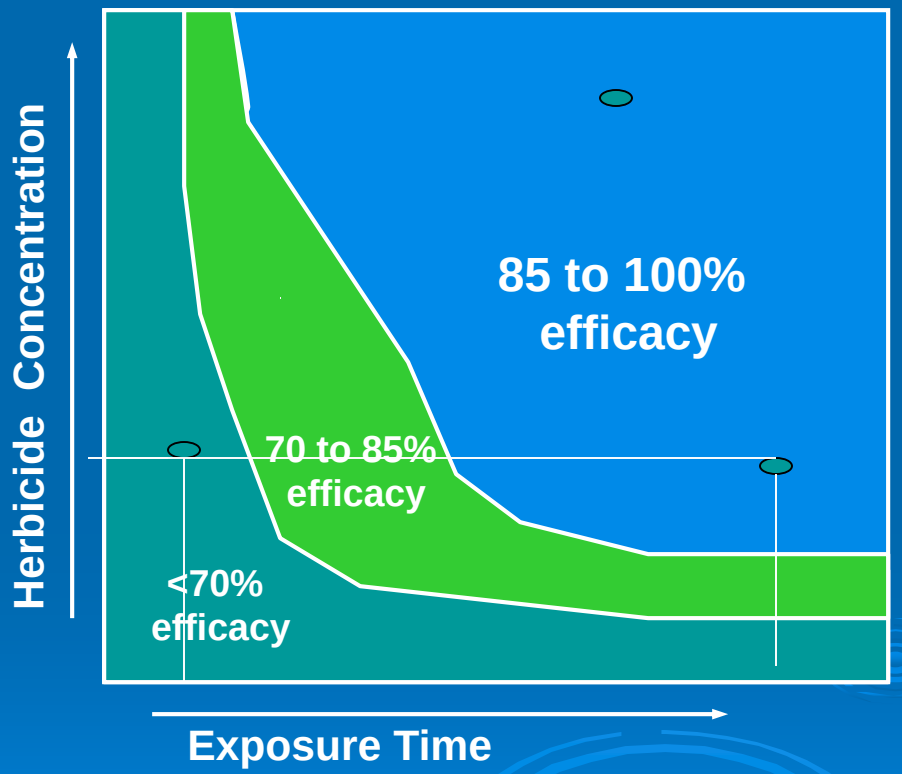
- Ranges from $500 to $3,000 per acre

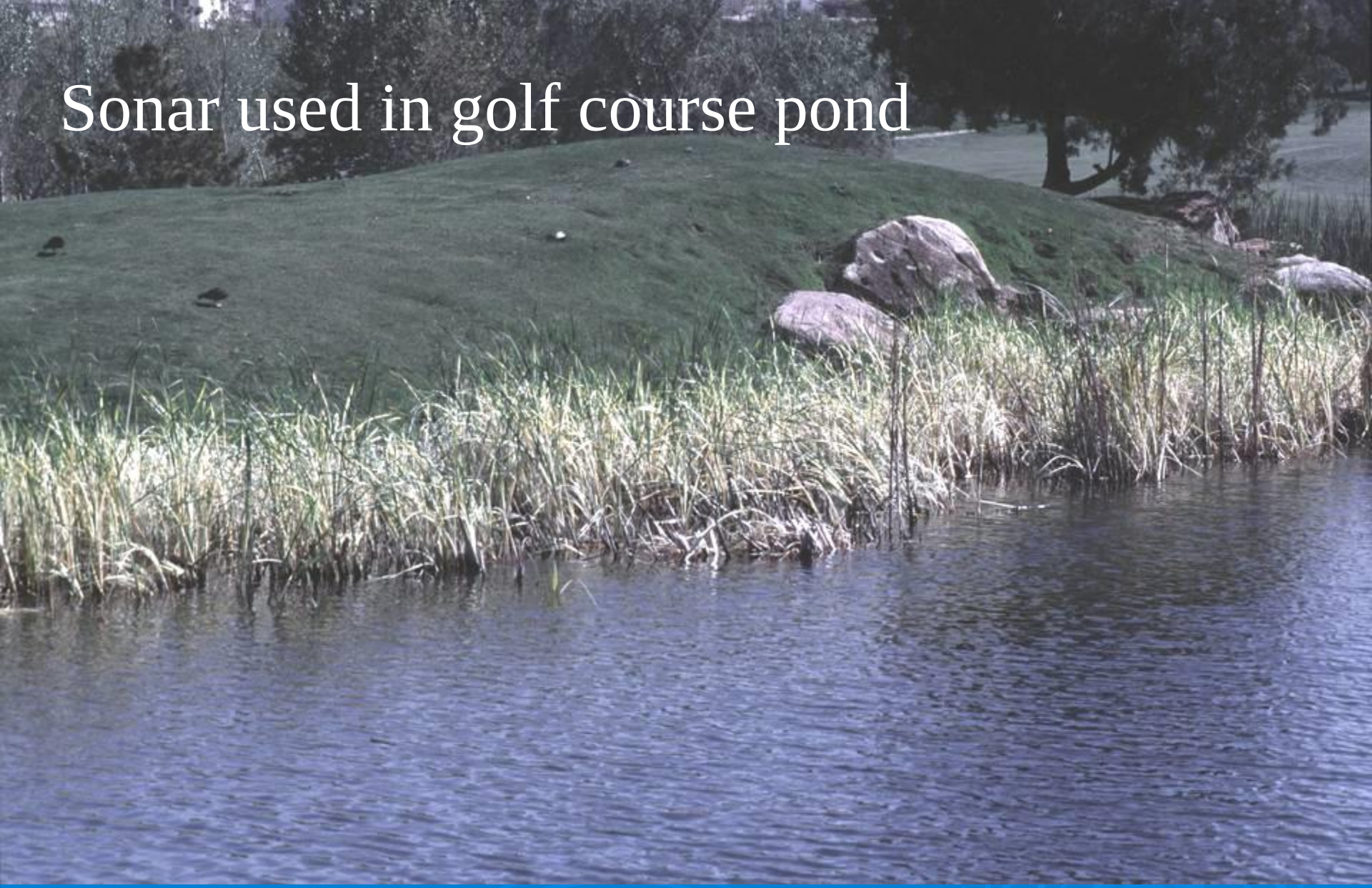
<u>What</u> are the costs associated with?

- **Consumable Materials (e.g. herbicides, fuel)**
- **Equipment (sprayers, harvesters, trucks, boats, safety gear)**
- **Personnel (salaries, training, insurance, benefits)**
- **Regulatory: NPDES-monitoring and compliance (sampling equipment, training, analysis, documentation, record storage)**

Submersed Plants: Dose & Exposure

- Herbicide efficacy and selectivity dependent on dose and length of exposure to target plant
- Relationships identified for hydrilla and milfoil
  - 2,4-D
  - Endothall
  - Fluridone
  - Triclopyr





Undesired effect –White Cattails

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