K-State Research and Extension

IPM

INTEGRATED PEST MANAGEMENT
& PESTICIDE SAFETY EDUCATION

Aquatic Pest Control

K-STATE
Kansas State University
Research and Extension

Kansas State University Agricultural Experiment Station
and Cooperative Extension Service

Category 5

Table of Contents

Directions for Using this Manual

This is a self-teaching manual. At the end of each major section is a list of study questions to check your understanding of the subject matter.

These study questions are representative of the type that are on the certification exam. By studying this manual and answering the study questions, you should be able to gain sufficient knowledge to pass the Kansas Commercial Applicators Certification examination. Correct answers appear on page 37.

Introduction

Numerous demands are placed on the state's aquatic resources. Water is used in various ways. Each use requires a certain quality and condition.

Sometimes a particular water use alters quality and condition, so other uses are impaired. Often, water contains a problem organism that must be eliminated or controlled to make it suitable for a particular use. The desired control method must be effective, economical, and above all, safe for the applicator, nontarget organisms, and the environment. Chemical control often is a choice among available pest control methods. This manual primarily addresses methods employing pesticide applications, but mentions alternatives.

Manufacture and use of pesticides for aquatic pests is minor compared with other chemical uses. Companies seldom invest resources to develop research data required by the Environmental Protection Agency to be considered for registration of a pesticide for aquatic use. A relatively small number of pesticides can legally be used in the aquatic environment, but many pesticides available for the terrestrial environment effectively kill aquatic pests. This has led aquatic workers to use any pesticide that will work and often results in destruction of nontarget organisms and residue levels in fish flesh and sediments. Activities like these are illegal and leave the applicator liable to both criminal and civil penalties.

Purpose and Content

The purpose of this training manual is to provide practical information on aquatic pest control in accordance with standards of competency provisions in the Federal Insecticide, Fungicide, and Rodenticide Act.

This manual contains information for several aquatic pests and their control:

- Aquatic vegetation
- Nuisance animals (invertebrates and vertebrates)
- Parasites and diseases of fish

Major emphasis is on use of pesticides for control, but alternative methods are usually considered. Although this publication provides a basic operating framework, it does not contain information necessary for identification and control of all aquatic pests. Study the suggested references at the end of the manual for more information.

Introduction

Standards of Competency

The Environmental Protection Agency in CFR 171.4, "Standards for Certification of Commercial Applicators," states:

> Commercial applicators in each category shall be particularly qualified with respect to the practical knowledge standard elaborated below:
>
> Applicators shall demonstrate practical knowledge of the secondary effects, which can be caused by improper application rates, incorrect formulations, and faulty application of restricted use pesticides used in this category. They shall demonstrate practical knowledge of various water use situations and the potential of downstream effects. Further, they must have practical knowledge concerning potential pesticide effects on plants, fish, birds, beneficial insects, and other organisms that may be present in aquatic environments. Applicators shall demonstrate practical knowledge of the principles of limited-area application.

Plants have adapted to thrive in diverse habitats. They are most obvious in the terrestrial environment, but they also can inhabit many types of aquatic environments. Aquatic plants are more numerous in the warm, swampy areas of the southern United States, but numerous examples can be found in Kansas.

Aquatic plants are a natural part of the aquatic ecosystem, used by many animals as food or a hiding place. Many people find aquatic plants interesting and attractive. As with all naturally occurring organisms, they may interfere with people's activities because of their overabundance or mere presence. When this occurs, the plants are considered "weeds," and some control is desired. Different problems occur in different types of waters. The main water types and associated aquatic plant problems are as follows:

Impounded Waters (Ponds, Lakes, and Reservoirs)

The most common aquatic vegetation problems occur in impounded waters. Abundant vegetation affects fish populations in these bodies of water. Small fish hide in the vegetation, making them unavailable to predators. This often results in overpopulation and stunting of certain species. Excessive vegetation interferes with fishing, swimming, and boating, and dead, decaying vegetation produces offensive odors. A more serious problem results from the oxygen deficiency caused by the decaying vegetation. This can occur at almost any time of year, but is most common in midsummer and in mid winter during ice cover.

Summer kills usually occur after periods of hot, calm, cloudy weather. During these times plants greatly reduce photosynthesis, but continue to respire and often die and decompose. Winterkills occur during periods of ice and snow cover. Ice usually allows enough light penetration for photosynthesis, but a layer of snow can block out most light. This light blockage prevents oxygen production, but respiration and decomposition continue, resulting in an oxygen shortage.

Flowing Water (Rivers, Streams, and Canals)

Aquatic vegetation is seldom a problem in the rivers and streams of Kansas. In fact, vegetation along the banks is beneficial because it protects the banks from erosion. Problems can occur in canals, which are designed to transport water. Plants growing along the edge, especially trees, can impede water flow.

Water Saturated Areas (Marshes, Seeps, and Drainage Ditches)

Aquatic plants usually are not a major problem in these areas. Encroaching vegetation may impede flow in drainage ditches. Marshes and seep areas usually cannot be used for conventional Kansas agriculture so the vegetation can be left alone for

wildlife habitat. Weed problems can occur in cultivated fields that border these wet areas, especially in abnormally wet years. During these times, the aquatic plants invade fields and cause special weed-control problems.

Classification of Aquatic Plants

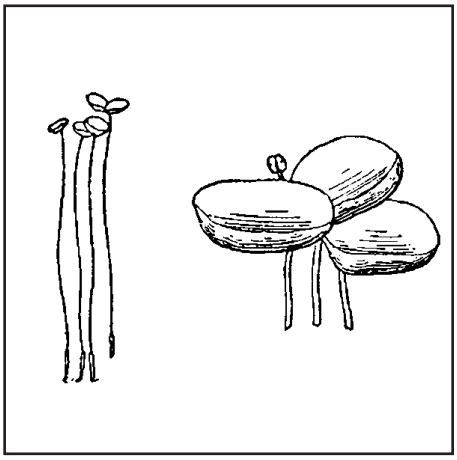
Problem weed species must be identified before an appropriate weed-control practice can be selected. Aquatic plants are classified by a similar growth habit as: algae, floating plants, submersed plants, emersed plants, and marginal plants.

Algae

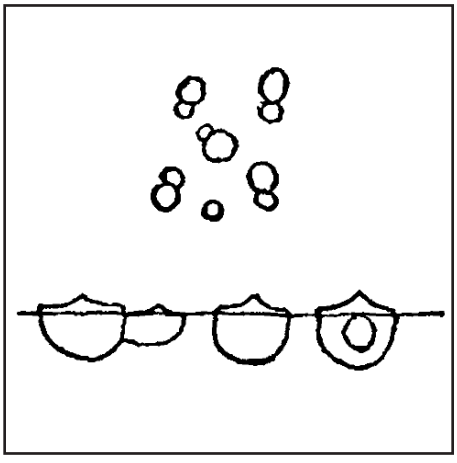
There are three major forms of freshwater algae: phytoplankton (planktonic), filamentous, and chara. Planktonic algae are usually beneficial unless water is used for human consumption. Planktonic and filamentous algae may clog filters in water treatment plants or produce undesirable tastes and odors in drinking water. Filamentous algae interfere with irrigation systems by clinging to structures and concrete linings and clogging weirs and screens. Common filamentous algae are *Spirogyra* spp. — slimy and green; *Cladaphora* spp. — cotton mat type; and *Pithophora* spp. — horsehair clump type. *Nitella* spp. and *Chara* spp. (also called muskgrass) are large green algae that are anchored to the bottom but do not extend above the surface. Stem-like, with thin, leaf-like structures, they are often confused with seed plants. When crushed, chara produces a musky odor.

Floating Plants

Some plants are free-floating while others, rooted in the bottom, have floating leaves that rise or fall with the water level. Many floating plants grow rapidly and are among the most troublesome aquatic plants. Duckweeds (*Lemna* spp.) and watermeal (*Wolffia* spp.) are true floating plants of this group whose roots feed from water rather than soil. Rooted plants with floating leaves include waterlilies (*Nymphaea* spp.) and American lotus (*Nelumbo* spp.). Many lotus leaves float, but some extend above the surface.

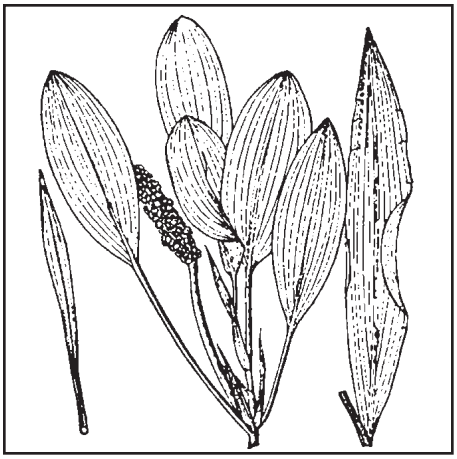


Duckweed

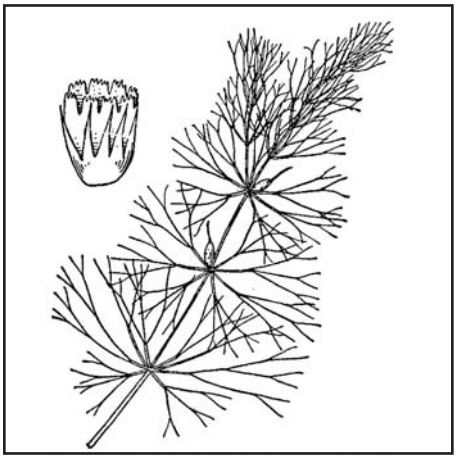


Watermeal

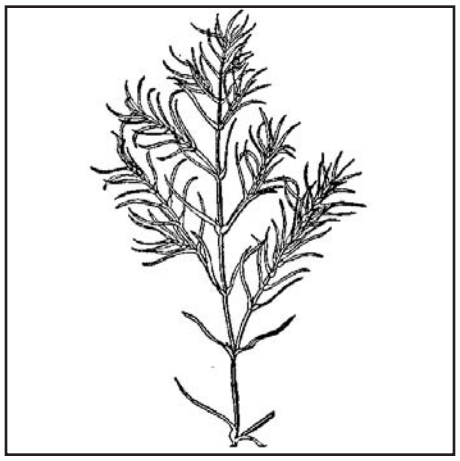
Submersed Plants
Submersed plants are true seed plants with roots, stems, and leaves. Rooted on the bottom, these plants grow chiefly below the surface, although their flowers and seeds and a few leaves may extend above it. A depth of 10 to 12 feet in clear water is the limited habitat for most submersed plants. Important submersed plants include: pondweeds (*Potamogeton* spp.), elodea (*Elodea* spp.), watermilfoil (*Myriophyllum* spp.), coontail (*Ceratophyllum* spp.), naiads (*Najas* spp.), hydrilla (*Hydrilla verticillata*) and bladderwort (*Utricularia* spp.).



Pondweed



Coontail



Naiad

Emersed Plants
Emersed plants are rooted in the bottom and produce most of their leaves and flowers at or above the surface. Leaf shape, size, and point of attachment are variable within this group. Leaves of emersed plants do not rise and fall with the water level as do those of attached floating plants. Important emersed plants include: watershield (*Brasenia* spp.), arrowhead (*Sagittaria* spp.), water primrose (*Ludwigia* spp.), and waterwillow (*Justicia* spp.).

Arrowhead

Aquatic Vegetation

Water Primrose

Smartweed

Marginal Plants

Marginal plants are emersed plants that grow on saturated soil beyond the water's edge. These plants vary in size, shape, and habitat. They may be found growing in moist soils along shorelines into water up to 2 feet in depth. Important marginal weeds are reeds (*Phragmites* spp.), sedge (*Carex* spp.), bulrush (*Scirpus* spp.), rush (*Juncus* spp.), cattails (*Typha* spp.), giant cutgrass (*Zizaniopsis* spp.), smartweeds (*Polygonum* spp.), purple loosestrife (*Lythrum* spp.), willow (Salix spp.), saltcedar or tamarisk (*Tamarix* spp.) and cottonwood (*Populus* spp.).

Identification

Target weeds in the water-use area must be correctly identified so appropriate control practices can be selected and applied. For identification of unfamiliar aquatic plants, take samples of entire plants (roots, stems, leaves and flowers if available) to your local K-State Research and Extension agent. If necessary, the agent can send the aquatic plants to the Herbarium, Division of Biology, for proper identification. Control information can be requested if you desire management practices for the aquatic plants based on the plant identification report.

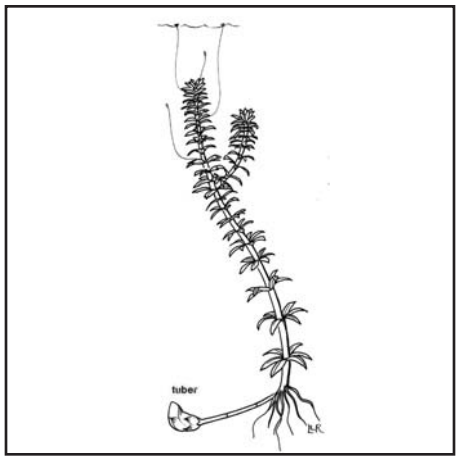
Bulrush

Aquatic Invasive Plants

Kansas has five invasive plant species that individuals should be aware of in aquatic environments. These plants pose a threat to the health of Kansas aquatic ecosystems and on the human use of those resources. In order to help prevent their spread, it is important to be aware of these plant species and their identifiable features.

Eurasian Watermilfoil

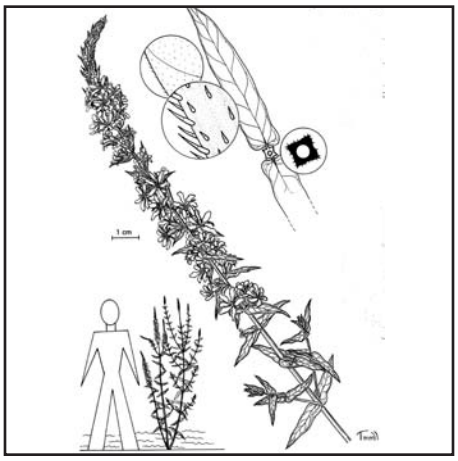
Eurasian Watermilfoil
Eurasian watermilfoil (*Myriophyllum spicatum*) is identified by the whorl arrangement of its three to five feather-like leaves. Each leaf contains 12 to 21 pair of leaflets. The stems branch near the water surface and it is most commonly found in waters less than 20 feet deep. Eurasian watermilfoil forms dense mats on the water surface, which competes with native aquatic vegetation and hinders recreational activities. Milfoil spreads when plant pieces break off and are carried by water currents, boats, trailers, and fishing gear to new locations. Early detection of current populations may help to prevent its spread.



Hydrilla

Hydrilla
Hydrilla (*Hydrilla verticillata*) has leaves that are small, pointed and arranged in whorls of four to eight along the stem. This plant is submersed with long, slender branches that branch and spread across the water. The leaf margins are distinctly saw-toothed making it rough to the touch. Hydrilla limits recreational activities because it forms a thick mat that interferes with boating, swimming, and fishing. It also slows the flow of water and clogs irrigation and flood-control canals. Hydrilla spreads to new waters as fragments on boats and trailers, so it is important to clean equipment.

Aquatic Vegetation

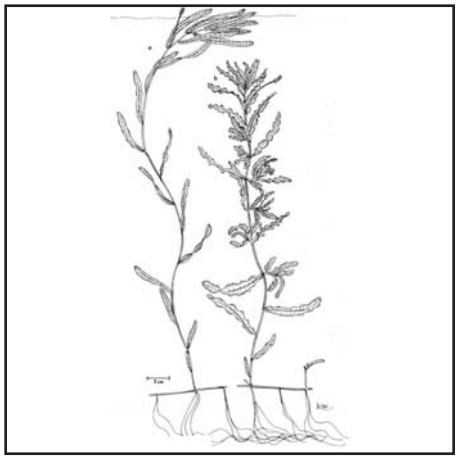


Purple Loosestrife

Purple Loosestrife
Purple loosestrife (*Lythrum salicaria*) is a perennial herb that can grow four to 10 feet high. During the summer, the plant produces a showy magenta-colored flower spike. The leaves are lance-shaped with a rounded or heart-shaped base. Loosestrife can produce over a million seeds, which can be moved by water, vehicles, and wildlife. This plant restricts other native wetland species and reduces habitat for waterfowl. Small infestations may be pulled by hand, but old plants will need to be spot treated with a herbicide.

Saltcedar

Saltcedar
Saltcedar (*Tamarix* spp.), sometimes called tamarisk, is a small tree or shrub that can reach 15 to 20 feet with red/brown stems. This plant produces pink flowers in May through October. Saltcedar forms a monoculture and dramatically affects vegetation structure and animal diversity. It can use up to 200 gallons of water a day, thus has a negative impact on the water flow. The plant also accumulates salt in its tissues, which is later released in the soil, creating an environment where other plants cannot grow. Saltcedar is extremely difficult to eradicate because it resprouts after being cut or burned.



Curly-Leaf Pondweed

Curly-Leaf Pondweed
Curly-leaf pondweed (*Potamogeton crispus*) is a fast-growing perennial that has simple, long, narrow leaves. The flattened stems are one to three inches long and ⅛ inch wide. In the spring, it forms dense mats which interfere with recreational activities and limit the growth of native species. Mechanical, biological and chemical control techniques can be effective.

Control

Control of aquatic weeds can be subdivided into four general categories: (1) prevention, (2) mechanical and physical, (3) biological, and (4) herbicides. Often a combination of these practices is necessary for adequate control.

Prevention
Effective planning and aquatic system management often eliminates, or greatly reduces, the need for costly and time-consuming weed-control practices. Aquatic weed problems typically occur in clear, shallow water that is high in nutrients. Ponds or lakes should be constructed so that shallow water areas are minimized by shaping the sides with a 3-to-1 slope (3 feet horizontal to 1 foot vertical drop) down to a depth of at least 3 feet. Existing ponds or lakes that have extensive shallow water areas can be dredged deeper, but a less expensive practice is to use a bulldozer to deepen shallow areas after the water level has receded below these areas.

Excessive nutrients should be prevented from getting into the water since they will stimulate rapid plant growth. Common sources of nutrients are runoff from livestock holding areas, septic tank drainage, and heavily fertilized fields.

Mechanical and Physical
Mechanical and physical control methods will be more effective in smaller bodies of water than in larger bodies of water. Pulling marginal plants by hand is an effective reduction practice to control cattails, willows, and cottonwood trees in small ponds. Small amounts of submersed plants can be pulled out or raked by hand. Larger amounts can be removed by pulling a long chain or cable across a pond between two tractors.

A device that is effective on submersed vegetation is a hand-pulled cutter, consisting of a v-shaped flat metal piece sharpened on the outer edge. A rod is fastened to the point and a rope attached to this. The device is thrown out into the vegetation and pulled in with a jerking motion. This cuts off the vegetation so it can float to shore where it can be raked out.

Submersed vegetation can also be controlled by shading it with fine meshed dark plastic screen similar to the type used to shade greenhouses. A large section of this material is placed over the vegetation and weighted down with rocks. This compresses and shades the vegetation so it dies. After about 2 weeks, the screen can be moved to another area. The advantage of this method is that fishing, swimming, and boating can take place over the screen.

Various types of weed harvesters have been used, including a cutting device on a floating barge. As the weeds are cut, they are brought up on a conveyor and deposited on the barge. Devices such as these are expensive and disposal of the wet, heavy plant material is a problem.

All mechanical and physical control methods are labor intensive and give only short-term relief.

They work best on small bodies of water that can be observed closely so control can take place before the problem gets too large. These methods are especially effective in home sewage lagoons. For more effective control, use mechanical and physical control practices in conjunction with biological or chemical control methods.

Biological

Herbivorous fish, the grass carp, sometimes called the white amur (*Ctenopharyngodon idella*), is an effective biological method to control aquatic vegetation. A member of the minnow family, this fish is native to large rivers of China and Siberia. It will not reproduce in ponds and lakes since it needs large, fast-flowing rivers for reproduction.

The young grass carp feed on small crustaceans and insects, but as they grow larger, they shift their diet almost completely to plant material. They prefer some plants over others, but will consume many species of floating and submerged plants found in Kansas. They will pull out and eat some of the emersed plants, but will not be able to control them. They have voracious appetites and grow rapidly until the plants are controlled and then their growth levels off.

The amount of grass carp needed for control of submersed vegetation depends on the infestation of aquatic plants. Grass carp at the rate of 20 fish per acre are needed if at least half of the area is normally covered by vegetation. For vegetation in only a narrow belt around the edge, five to 10 fish per acre are sufficient. Control is achieved within one year at these stocking levels. At half these levels, control may take up to two years.

Stocking new, clear ponds and lakes at three to five grass carp per acre can prevent development of aquatic weed problems. Grass carp need to be at least 10 to 12 inches long to avoid predation if predatory fish such as bass are in the pond or lake. The initial stocking should be effective for at least several years since these are long-lived fish. A few replacement fish can be stocked if aquatic weed infestation increases.

Only a few problems are associated with grass carp. They do not reproduce in standing water nor do they seem to compete or interfere with the game fish. They may, however, cause some loss of clarity of the water. Clear weedy ponds become less clear when stocked with grass carp. As the grass carp eat the vegetation, the nutrients are excreted through wastes. These in turn stimulate the production of planktonic algae, which decrease the clarity. Grass carp are indiscriminate feeders and can get so large that they consume most of the desirable vegetation in a pond and greatly reduce fish productivity.

Grass carp are highly mobile and they will readily leave a pond or lake during periods of heavy flow over the spillway. Use of mesh fence across the spillway can prevent loss of these fish. Some states have restrictions regarding the use of grass carp, but Kansas only requires that they be of nonreproductive triploid genetics.

Fertilizers added to water have been used to control aquatic weeds. Fertilizers stimulate the growth of planktonic algae, which in turn decreases the water clarity, and prevents growth of submersed vegetation. Although it appears to be a good practice, it usually creates other problems. Additional nutrients may cause an increase of marginal vegetation and also filamentous algae. Increased infestation of algae and other vegetation may cause oxygen depletion as the plants die and decay. Fertilization is not recommended in Kansas because most waters in Kansas lakes and ponds contain sufficient nutrients.

Waterfowl have also been used to control aquatic plants. Ducks, geese, and swans will eat aquatic vegetation. Many pond and lake owners enjoy waterfowl. But the large number of waterfowl needed for control of submersed and marginal plants results in a large amount of wastes, which fertilizes the water. This often results in algae problems.

Barley straw has been used by researchers in the United Kingdom to control a variety of planktonic and filamentous algae. Results in the United States are not consistent, but show that the decomposing straw must be subjected to well-oxygenated water for it to become anti-algal. The best control is obtained by suspending barley straw bales that have been broken apart and suspended in cages near the water surface. Use about 100 to 300 pounds of straw per acre but be aware that most waters in the Midwest are typically stagnant and oxygen-poor.

Introduction

Aquatic Vegetation

Study Questions

These study questions are to aid you in learning the material on pages 3 through 13.

1. *Use of terrestrial registered pesticides in an aquatic control program can result in:*
   a. destruction of nontarget organisms.
   b. residues in fish.
   c. residues in the sediments.
   d. all of the above.
2. *Aquatic plants are:*
   a. a natural part of the aquatic environment.
   b. seldom a problem in farm ponds.
   c. used by aquatic animals for food and hiding.
   d. a and c are correct.
3. *In Kansas, aquatic vegetation in flowing water is seldom a problem in:*
   a. canals used for transporting water.
   b. rivers and streams.
   c. stock watering tanks.
   d. farm ponds.
4. *There are ___ major forms of fresh water algae.*
   a. 1
   b. 2
   c. 3
   d. 4
5. *Important marginal plants include:*
   a. duckweeds and watermeal.
   b. coontail and bladderwort.
   c. arrowhead and waterwillow.
   d. willow and smartweeds.
6. *Control of aquatic weeds can be done by:*
   a. preventative methods.
   b. biological methods.
   c. mechanical and chemical methods.
   d. all of the above.
7. *For vegetation in a narrow belt around the edge of a lake, grass carp fish should be stocked at the rate of ___ per acre.*
   a. 1 to 3
   b. 5 to 10
   c. 12 to 17
   d. 19 to 22
8. *Aquatic weed control may vary as influenced by:*
   a. susceptibility of the weeds to herbicide.
   b. weed stage of growth.
   c. rate and time of application.
   d. all of the above.

Herbicides may be used to control aquatic weeds, but control may vary because of such factors as susceptibility of the aquatic weeds to the herbicide, stage of growth, rate of application, and the time of application. Some herbicides also may cause injury to fish if not applied properly. This publication provides information on alternative herbicides and their use for aquatic weed control.

Herbicides are frequently the preferred method for control of aquatic weeds in situations requiring fast results and control for several months. But even chemical methods frequently must be combined with hand or mechanical weeding to remove remaining weeds and to prevent future spread by seed or other plant parts.

Additional information on proper use of registered herbicides for most effective aquatic pest control and least or no effect on nontarget organisms or the environment can be obtained from the following sources: information from product labels and manufacturers of herbicides registered by the Environmental Protection Agency (EPA) for use in aquatic areas, K-State Research and Extension, and Kansas Department of Wildlife and Parks.

Improper Use

Improper Application Rates
Proper use of herbicides requires accurate application so water, vegetation, or soil in an aquatic area is covered uniformly at the rate recommended on the product label. Properly functioning, accurately calibrated equipment is essential.

Application of a herbicide below the rate recommended on the label can result in unsatisfactory control of target aquatic weeds. Herbicide application at a rate higher than the recommended rate for the product is illegal and can result in greater residue and/or toxicity. Herbicides applied at rates exceeding the recommended rate can create a hazard by contaminating water used for drinking, fish, livestock, other nontarget organisms, irrigation, or other purposes.

Incorrect Formulation
The use of an incorrect formulation can result in:

1. Use of a product that is not effective or safe.
2. Increased toxicity resulting in death or injury to fish and other nontarget organisms.
3. Increased hazard to humans during application.
4. Increased hazard of injury to desirable nontarget plants.

Faulty Application
Faulty application can be the result of the following:

1. Improperly calibrated equipment.
2. Use of improper herbicide.
3. Use of improper rate of recommended formulation.
4. Application at improper stage of plant growth of target weeds.
5. Application of foliar-applied herbicides when weeds are not growing rapidly due to unfavorable growing conditions.
6. Application to plants, water, or areas not registered for treatment on product label.
7. Application during windy or other undesirable weather conditions.
8. Improper determination of volume of lake or pond to be treated.
9. Failure to take into account that overflow from a pond or lake is flowing water.
10. Failure to determine downstream use patterns.

Proper Use

All chemicals used for aquatic pest control should be applied in accordance with the directions on the manufacturer's label, as registered under the Federal Insecticide, Fungicide and Rodenticide Act.

Most herbicides have a low acute oral toxicity, but a few aquatic herbicides are poisonous to human beings, livestock, and other non-target organisms. Some herbicides are toxic to fish, but most do not injure fish at concentrations required for weed control.

Proper use of herbicides will result in the most effective control of aquatic weeds and little or no effect on nontarget organisms or the environment. Follow these rules:

1. Select the appropriate herbicide to control the identified target weeds. Refer to Table 1 for weed response to selected aquatic herbicides.
2. Consult with Kansas Department of Wildlife and Parks or the U.S. Fish and Wildlife Service for advice if a proposed herbicide application might endanger wildlife, fish, or their habitat.
3. Apply the herbicide in accordance with all directions, warnings, and precautions on the label. Refer to the Table on page 18 for use restrictions of water treated with aquatic herbicides.
4. Store excess pesticides under lock and key — out of reach of children and animals — and away from food and feed.
5. Properly dispose of empty pesticide containers.

This manual contains pesticide recommendations that are subject to change at any time. These recommendations are provided as a guide. It is always the pesticide applicator's responsibility, by law, to read and follow all current label directions for the specific pesticide being used.

Due to constantly changing labels and product registration, some of the recommendations given in

this publication may no longer be legal by the time you read them. If any information in these recommendations disagrees with the label, the recommendation must be disregarded. No endorsement is intended for products mentioned, nor is criticism meant for products not mentioned.

Table 1. Response of Aquatic Weeds to Selected Herbicides[1] and Approximate Treatment Costs

		Aquatic Herbicide (Trade name)							
Aquatic Weed Classification	**Aquatic Weed**	**Copper Algaecides (Several)**	**2,4-D (Several)**	**Diquat (Reward & WeedtrineD)**	**Endothall (Aquathol and Hydrothol)**	**Fluridone (Sonar and Avast)**	**Glyphosate (Rodeo and Others)**	**Imazapyr (Habitat)**	**Triclopyr (Renovate)**
Algae	Chara	E	P	G	G[2]	P	P	P	P
	Filamentous	E	P	G	G[2]	P	P	P	P
	Planktonic	E	P	P	P	P	P	P	P
Floating Plants	Duckweed	P	G	G	P	E[3]	F	G	P
	Watermeal	P	P	F	P	G[3]	F		P
Rooted Floating Plants	Waterlillies	P	E	P	P	E	E	E	E
Submersed Plants	Bladderwort	P	F	E	P	E	P	P	P
	Coontail	P	G	E	E	E	P	P	P
	Elodea	P		E	F[2]	E	P	P	P
	Naiad	P	F	E	E	E	P	P	P
	Pondweeds	P	P	G	E	E	P	P	P
	Watermilfoil	P	G	G	G	E	P	P	E
Emersed Plants	Arrowhead	P	E	G	P	P	E	E	
	Water Primrose	P	E	F	P	F	E	G	E
Marginal Plants	Cattails	P	F	G	P	F	E	E	F
	Smartweeds	P	F	P	P	P	E	E	E
	Purple Loosestrife	P	F	P	P	P	E	E	G
	Willow	P	E	P	P	P	E	E	E
	Cottonwood	P	G	P	P	P	G	G	E
Approximate Cost[4]		$2.50-20/ Acre-ft	$7-65/ Acre-ft	$250-700/ Surface acre	$50-220/ Acre-ft	$60-150/ Acre-ft	$15-30/ Surface acre	$33-133/ Surface acre	$80-320/ Surface acre

[1] E = Excellent, G = Good, F = Fair, and P = Poor or none. Refer to product labels for specific recommendations.

[2] Hydrothol formulation only.

[3] AS formulation only.

[4] Herbicide cost varies with application rate, water depth, formulation, geography, and market fluctuations. Contact local supplier for current retail prices.

Herbicides for Aquatic Use

Copper Algaecides

Copper Sulfate
Products and manufacturers: Copper Sulfate — Chem One Corp and Phelps Dodge.

Copper Sulfate use information: Do not exceed 4 ppm in potable water. Copper sulfate controls microscopic algae, single-filament algae, and *Chara* (stonewort), but is not effective against submersed or emersed leafy weeds. Copper sulfate may be used in recommended concentrations without harm in waters for livestock and irrigation. Copper sulfate corrodes galvanized cans and most spraying equipment. Plastic sprinkling cans are convenient for applying copper sulfate.

Rate of application: Rates for algae control range from 0.67 to 5.32 pounds of copper sulfate per acre–foot of water. Four pounds of powder or crystals per acre–foot is generally strong enough to kill algae and stonewort in most waters. This concentration kills snails, but does not kill fish. In alkaline water, stronger concentrations may be necessary. Treatment is ineffective in waters with total alkalinity greater than 250 ppm. In moderate to high alkalinity waters (greater than 200 ppm), the copper chelated products are recommended. Use only 1.2 pounds of copper sulfate per acre–foot in very soft water as fish may be killed at the 4-pound rate.

How to apply: Copper sulfate is available in different crystal and granular grades depending on application needs. Crystals may be scattered by hand on the surface of small ponds or placed

Table 2. Water Use Restrictions with Aquatic Herbicides

Aquatic Herbicide	Human			Livestock			
	Drinking	Swimming	Fish Consumption	Dairy	Meat	Irrigation	Agricultural Spray
	(Number of days after treatment before use[1])						
Copper Sulfate	0[2]	0	0	0	0	0	0
Copper Chelate	0[2]	0	0	0	0	0	0
2,4-D	(Varies with formulation, consult the label)						
Diquat	3-5	0	0	1-5	1-5	5	5
Endothall	7-25	1	3	7-25	0	7-25	
Fluridone	X[3]	0	0		0	2-30	30
Glyphosate	2	0	0	0	0	0	0
Imazapyr	2	0	0	0	0	120	
Tricolpyr	X[4]	0	0	0	0	120	120
Aquatic Dyes	X	0	0	0	0	0	0

Always consult product labels for current restrictions.

[1] X = Do not use treated water for that purpose.

[2] Elemental copper concentration should not exceed 1.0 ppm if water is used for drinking.

[3] Do not apply within 0.25 mile of any functioning potable water intake.

[4] Refer to label.

in a burlap bag and towed behind a boat. Crystals or powder can be dissolved in water and applied by spraying the water surface. If a heavy growth of algae is present, treat only one-third or one-half of the pond at a time at weekly intervals. This prevents depleting the oxygen when the mass of dead organic matter decomposes. You may treat an isolated mass of stonewort or algae without treating the whole pond.

Caution: Residual copper is toxic to many aquatic animals. Frequent and continued use may result in the kill of a large part of the fish-food supply.

Copper Chelates
Products and manufacturer: Cutrine-Plus and Stocktrine II — Applied Biochemists, Inc., K-Tea and Komeen — Griffin, and others.

Herbicide use information: For use in lakes, private farm, fish and fire ponds; fish hatcheries; potable water reservoirs, irrigation systems, and stock tanks (Stocktrine). Apply to control algae including *Chara, Spirogyra,* and *Cladophora.* Chelates prevent precipitation of copper with carbonates or bicarbonates in the water.

To avoid suffocation of fish due to lack of oxygen caused by decay of heavy infestations treat only a third to half of the lake or pond at a time. Water treated with this product may be used for drinking, livestock watering, swimming or fishing immediately after treatment. Water treated with this product also may be used to irrigate turf, ornamental plants, or crops immediately after treatment. Copper chelates may be toxic to trout and other species of fish in soft water (<50 ppm carbonate hardness).

2,4-D

2,4-D Low Volatile Ester Granules

Products and manufacturers: Aqua-Kleen — Cerexagri; Navigate — Applied Biochemists, Inc.

Herbicide use Information: For use to control specified aquatic weeds (refer to product labels) in ponds and lakes. Granules sink to bottom and release weed-killing chemical in the critical root zone area. Apply 100 to 200 pounds per acre by portable spreader or mechanical spreader. During growth season, weeds decompose in a 2- to 3-week period following treatment.

Apply in spring and early summer during the time weeds start to grow. Do not apply to more than third to half of a lake or pond in any one month because of excess decaying vegetation which may deplete oxygen content of water, killing fish. Do not apply to waters used for irrigation, agricultural sprays, watering dairy animals, or domestic water supplies.

2,4-D Amine
Product and Manufacturer: Several

Herbicide use information: For use to control aquatic weeds and weeds adjacent to water. Apply for control of annual weeds, perennial weeds, and woody plants. Do not apply to more than a third to half of a lake or pond in any one month

because excess decaying vegetation may deplete oxygen content of water, killing fish. Do not apply to waters used for irrigation, agricultural sprays, watering dairy animals, or domestic water supplies.

Diquat

Products and manufacturers: Reward — Syngenta and Weedtrine D — Applied Biochemists.

Herbicide use information: May be fatal if swallowed, inhaled or absorbed through skin. Skin contact will cause severe skin irritation. Do not get material on skin, eyes, or clothing. Contact with skin may increase danger of absorption. For application only to ponds, lakes, and drainage ditches where there is little or no outflow of water and that are totally under control of product's user.

Diquat is rapidly absorbed by aquatic plants and begins to work immediately upon contact. Plant tissue is destroyed, causing wilting and loss of foliage. Do not use treated water for animal consumption, spraying, or irrigation for 14 days after treatment. Do not apply within ¼ mile of any functioning potable water intake.

Treatment of dense weed areas can result in oxygen loss from decomposition of dead weeds. Treat only a third to half of the dense weed area at a time to avoid fish suffocation from oxygen loss and wait 10 to 14 days between treatments. *Do not apply to muddy water.* Apply diquat in early season to control submersed weeds before weed growth has reached surface. Diquat will control the following submersed weeds infesting still ponds, lakes and ditches: bladderwort, coontail, elodea, naiad, pondweeds, and watermilfoil. Other aquatic weeds controlled include duckweed, cattails, and some filamentous algae.

Endothall

Products and manufacturers: Aquathol and Hydrothol 191 — Cerexagri.

Herbicide use information: Aquathol and Hydrothol 191 are different formulations of endothall and are both available as granular or liquid formulations. Hydrothol controls most algae and submersed plants, but is toxic to fish at dosages in excess of 0.3 ppm. Aquathol controls most submersed plants and is not toxic to fish, but does not control algae. Apply in late spring or early summer when weeds are actively growing. Do not use treated water for irrigation, agricultural sprays, livestock, or domestic purposes for at least 7 to 25 days after treatment.

Fluridone

Product and manufacturers: Sonar AS and Sonar SRP — SePRO, Avast — Griffin, Whitecap-Novasource.

Sonar use information: For management of aquatic weeds in fresh water ponds, lakes, reservoirs, drainage canals, and irrigation canals. Sonar is absorbed from water through leaves and shoots, and from hydrosoil by the roots. Sonar causes chlorosis at the terminal bud or growing points of plant, and then plants slowly deteriorate. Complete weed removal may require 30 to 90 days. Sonar AS is effective in controlling

duckweed; certain emersed weeds including spatterdock and waterlily; certain submersed weeds including bladderwort, coontail, elodea, naiads, pondweeds, and watermilfoil; and certain shoreline grasses. Sonar provides partial control of certain vascular aquatic weeds including American lotus, arrowhead, cattail, rush, and smartweed.

For best results, apply Sonar before initiation of weed growth or when weeds begin actively growing. **The Sonar label indicates users must consult with appropriate state or local water authorities before applying this product.** Do not apply in lakes, ponds, or other bodies of water where crayfish farming is performed. There are no label restrictions against swimming or fishing in water treated with Sonar. There are no restrictions on consumption of treated water by humans, pets, and livestock.

Glyphosate

Product and manufacturer: Rodeo — Dow AgroSciences, and others.

Glyphosate use information: This product may be used in and around aquatic sites, including all bodies of fresh and brackish water, which may be flowing, non-flowing or transient. This includes lakes, rivers, streams, ponds, seeps, irrigation and drainage ditches, canals, reservoirs, and similar sites. There is no restriction on use of water for irrigation, recreation, or domestic purposes. Apply Rodeo plus nonionic surfactant approved for aquatic sites as directed on the label to control or partially control marginal weeds, woody brush, and trees listed on the label. Aquatic plants controlled include cattails, annual and perennial smartweeds, spatterdock, and willow. Perennial plants generally are best controlled when treated during the flowering stage of growth. Do not apply this product within ½ mile upstream of potable water intakes, unless intake is turned off for a minimum of 48 hours after application.

Imazapyr

Product and manufacturer: Habitat — BASF.

Habitat use information: For control of most emerged and floating plants in and around standing or flowing water. Habitat does not control plants which are completely submerged or that have a majority of foliage under water. Apply in combination with a nonionic surfactant approved for aquatic sites as directed on the label. Habitat is a systemic herbicide that can be absorbed through the foliage or roots of plants. Plants will stop growing soon after application, but may not show symptoms or die for several days or weeks after treatment. Unintended application to the foliage or soil where roots of desirable plants occur can result in severe injury or death of the plants. There are no restrictions on the use of water treated with Habitat for recreation purposes or consumption by livestock. Water treated with Habitat may not be used for irrigation purposes until 120 days after application. Do not apply this product within ½ mile upstream of potable water intakes, unless intake is turned off for a minimum of 48 hours after application. Currently this product is approved for use

only by state and federal agencies or certified aquatic pest control applicators who are authorized by state or local governments.

Triclopyr

Product and manufacturer: Renovate — SePRO.

Renovate use information: For control of certain submersed, emersed, and marginal plants in and adjacent to aquatic sites with minimal outflow. Apply in combination with a nonionic surfactant approved for aquatic sites as directed on the label. There are no restrictions on the use of water treated with Renovate for recreation purposes or consumption by livestock. Water treated with Renovate may not be used for irrigation purposes until 120 days after application. Refer to the label for grazing restrictions following applications to terrestrial sites.

Aquatic dyes

Product and manufacturer: Aquashade — Applied Biochemists, and others.

Aquatic dye use information: These products are a mixture of blue and yellow dyes that intercept light penetration in water. Aquatic dyes do not directly control the plants through herbicidal activity, but limit growth of plants below the water surface through shading effect. Primarily for control of submersed, rooted weeds, and some algae. Should only be used in bodies of water with little or no through-flow, in order to maintain dye concentration. Products should be applied before foliage reaches the water surface. These products are nontoxic to fish, wildlife, livestock, humans, and turf. Do not use where water is used for human consumption. Safe for swimming after complete dispersal. May be undesirable to some individuals due to artificial appearance of water.

NPDES (National Pollutant Discharge Elimination System) permits maybe required for pesticide applications to and around water. The state contact at the Kansas Department of Health and Environment is Don Carlson at (785) 296-5547.

Environmental Considerations

The general considerations, restrictions, and problems mentioned earlier in the herbicide section also apply to other chemical usage. The use of the water and fish must be considered. Directions and restrictions on the pesticide label must be followed.

The publication contains common names and trade names for herbicides. No endorsement of named products is intended nor criticism implied of similar products which are not mentioned.

Study Questions

These study questions are to aid you in learning the material on pages 15 through 22.

1. *The improper application rate of herbicides in aquatic pest control can adversely affect:*
   a. irrigation water.
   b. drinking water.
   c. fish.
   d. all of the above.
2. *Improperly calibrated equipment can cause:*
   a. a faulty application.
   b. increased toxicity to fish and other nontarget organisms.
   c. safe application of the herbicide.
   d. both a and b.
3. *Treat ____ of a lake or pond at any one time with Cutrine-Plus Algaecide to avoid suffocation of fish due to oxygen depletion.*
   a. 0.1 to 0.2
   b. 0.3 to 0.5
   c. 0.6 to 0.8
   d. 0.9 to 1.0
4. *Copper sulfate is not effective against _____.*
   a. single-filament algae.
   b. submersed leafy weeds.
   c. emersed leafy weeds.
   d. both b and c.
5. *2,4-D low-volatile ester _____ can be applied to control weeds in ponds and lakes.*
   a. amine 4
   b. granules
   c. LV4
   d. postemergence herbicide
6. *Do not use Diquat treated water for animal consumption, spraying or irrigation for ____ days after treatment.*
   a. 5
   b. 9
   c. 14
   d. 20
7. *Aquashade contains a mixture of _____ dyes that intercept light penetration in the water.*
   a. orange and black
   b. blue and yellow
   c. red and green
   d. purple and white
8. *Water treated with Imazapyr or Triclpyr can not be used for irrigation until ____ days after application.*
   a. 5
   b. 25
   c. 30
   d. 120

Nuisance Animal Control

Occasionally the presence or activity of a type of animal interferes with the management objective for a body of water. Such animal species are normally present in the system but become too abundant, thus posing a problem, or they may be species that invade the body of water and their activities cannot be tolerated. This section presents some of the more common problems created by nuisance aquatic animals and discusses control methods.

Invertebrates

Certain invertebrates, other than parasite and disease organisms of fishes, can become problems in ponds and lakes used for recreation or for aquaculture.

In some cases snails may become the intermediate host for the parasite that causes swimmer's itch. It may be impractical to break the cycle by eliminating the final hosts (ducks and muskrats), but partial control can be achieved by reducing the snail population. This can be done chemically by copper sulfate used at the same dosage for control of algae. Non-chemical control methods include controlling aquatic vegetation and stocking with snail eating fish, such as catfish and redear sunfish.

Predaceous aquatic insects and crayfish are often a problem in aquaculture ponds that are stocked with newly hatched fish (fry). If these predators are not controlled, fish survival may be very low. Various chemicals are effective in controlling aquatic insects.

Regardless of the chemical used, care must be taken to avoid exposure to nontarget organisms and treated water must be isolated to prevent contamination of other water. Always follow label directions and precautions. The application of unapproved compounds could lead to water and soil contamination, kills of desirable organisms, and residues in fish flesh.

Nuisance Invertebrate Species
Zebra mussels – Zebra mussels (*Dreissena polymorpha*) usually are less than an inch long with a D-shaped shell and tend to resemble small clams. They use sticky byssal threads to attach tightly to any surface. The problem is they can attach to any solid substrate. The zebra mussel is responsible for clogging pipes at water treatment plants. They also filter large amounts of water, in order to eat plankton, which can lead to algal blooms and affect native populations of mussels. Zebra mussels are found in many water bodies in Kansas. Their spread can be prevented with proper precautions. Zebra mussels are spread primarily by the recreational activities. They can attach to a boat's hull and trailer. This is why it is important to drain all the water from boats, live wells, and bait wells. Wash the equipment in 140-degree water to help insure that you are not responsible for transporting this pest. Chemicals can be used to kill zebra mussels, but the chemicals will also have negative effects on fish and native mussels.

The rusty crayfish (*Orconectes rusticus*) and New Zealand mudsnails (*Potamopyrgus antipodarum*) are invertebrates

that have the potential to become invasive species in Kansas. Rusty crayfish have large black-tipped claws and colored spots on the carapace. If they are found in Kansas, they could potentially displace native crayfish and destroy plant diversity. The New Zealand mudsnail has brown or black cone-shaped shells with five whorls. It has the ability to reproduce quickly resulting in large densities, which compete with native invertebrates and fish. Report sightings of these species to the Kansas Department of Wildlife and Parks (KDWP). Further information about any of the aquatic nuisance species can be obtained from the KDWP website at *http://www.kdwp.state.ks.us/news/Fishing/Aquatic-Nuisance-Species.*

Fish

Fish populations frequently become unproductive from either an overabundance of stunted desirable fish or contamination by undesirable fish species. Adjustment of the fish population may bring it back into a productive situation. Other times it may be necessary to completely remove the fish population and start over. Complete removal can be accomplished by draining the body of water or by chemical treatment. Chemical removal of fish populations is a widely practiced management procedure applied to ponds and lakes used for recreation or for aquaculture.

Many chemicals are toxic to fish, but most of these affect nontarget organisms, cause environmental contamination, or later show up as residues in fish flesh. A few chemicals have undergone the testing required for registration. Table 3 gives approved formulations of the chemicals approved as fish-control agents.

Invasive Fish Species

Kansas has five invasive fish species to watch for in aquatic environments as well as others that are emerging. These fish threaten the health of Kansas aquatic ecosystems because they outcompete native fish for food and space. To help prevent their spread, it is important to be aware of these fish species and their identifiable features.

Table 3. Fish Control Agents Registered or Approved for Aquatic or Fishery Uses

Fish Control Agent	Fishery Use	Application Rate	Comments
Antimcycin	Piscicide	1-10 ppb active ingredient (0.4-4.3 fl. oz./acre foot)	Treatment rate dependent on water temperatures and pH. Not approved for use on fish intended for human or animal consumption.
Rotenone (Restricted)	Piscicide	1-5 ppm active ingredient (2.7-13.6 lb./acre foot)	Do not use in waters colder than 65 F. Not approved for use on fish intended for human or animal consumption.

White Perch – White perch (*Morone americana*) are usually less than 10 inches long with a variable coloring, but they are generally silvery green on the sides. They resemble the native white bass without looking at their characteristic differences. Walleye and white bass populations have been negatively impacted by this species. This fish can hybridize with the white bass. White perch are spread by illegal release into other bodies of water. If you catch a white perch, do not release them back into the water, instead eat or dispose of them.

Rudd – Rudd (*Scardinius erthtophthalmus*) is similar in appearance to a golden shiner. They can get up to 14 inches long with dark grey back, silver sides, and blood-red fins. This fish affects spawning areas for other species because they consume vegetation. Rudd may hybridize with the golden shiner. Rudd can be spread by anglers accidently using them as bait. Anglers need to learn to identify the rudd and make sure they dispose of unwanted bait on land. Early detection of isolated populations may help prevent their spread. Rudd are currently only found in two locations in Kansas.

Asian Carp – The bighead carp (*Hypophthalmichthys nobilis*), black carp (*Mylopharymgodon piceus*), and the silver carp (*Hypophthalmichthys molitrix*) are all species of Asian carp that can be found in Kansas. Bighead and silver carp have low-set eyes and a large upturned mouth without barbells. These two species also have a scaleless head and very small scales on the body. The black carp has a blackish brown body with large scales. Adults of these species can reach more than 60 pounds in weight and 4 feet in length. Asian carp grow quickly and have a voracious appetite. They directly compete with other fish for food resources. Do not release these fish back into the water.

Ruffe and Round Goby – The ruffe (*Gymneocephalus cernuus*) and the round goby (*Neogobius melanostomus*) are both nuisance species that have not been found in Kansas. The ruffe can resemble young walleye, sauger, or saugeye. The ruffe has a large continuous dorsal fin, which has spots between its rays. The round goby has a large head, soft bodies and dorsal fins without spines. They kind of resemble large tadpoles. Anglers may be the first to discover these fish because they are both commonly caught by hook and line. Report any sighting of these species to the Kansas Department of Wildlife and Parks. Further information about any of the aquatic nuisance species can be obtained from the KDWP website at: *http://www.kdwp.state.ks.us/news/Fishing/AquaticNuisance-Species.*

Amphibians

Amphibians are generally beneficial to the aquatic environment and are desired. In certain situations, salamanders and bullfrogs can become a problem in fish culture ponds. There are no pesticides registered for control of these animals. Control is limited to physical means in compliance with Kansas Department of Wildlife and Parks regulations.

Nuisance Animal Control

Reptiles

Aquatic turtles and snakes are common components of the aquatic ecosystem. In general they do not cause any problem to the fish population, and if left alone, do not injure humans. In certain situations some humans may find them annoying and in some aquaculture ponds they may reduce fish production. There are no pesticides registered for the control on aquatic reptiles. Control can usually be accomplished by fishing, trapping, and shooting. Before control is attempted, the current Kansas Department of Wildlife and Parks regulations should checked and followed.

Birds

Birds usually add to the esthetics of a body of water. In rare situations, aquatic birds can become a problem. Excessive waterfowl in a recreational pond or lake can cause disturbance and/or excessive nutrient enrichment of the water with their wastes (eutrophication). In aquaculture ponds and lakes, fish-eating birds can have a significant impact on the fish mortality. In both these types of situations, the migratory bird species involved are protected by state and federal law. Any control measure must be preceded by acquiring the proper permits. Obtain a permit from the U. S. Fish and Wildlife Service or check with the Kansas Department of Wildlife and Parks or the K-State Research and Extension wildlife control specialist for permit procedures.

Mammals

The aquatic mammals that cause the greatest problems are the rodents, such as beavers and muskrats. These rodents cause damage by burrowing into dikes, levees, and dams. This weakens the structures often causing cave-ins, leaks, and increases bank erosion. Also their damming activity can clog culverts, overflow structures, and streams.

The best control methods involve trapping during the legal furharvesting season. Other nonchemical methods include reducing the food supply, installing protective barriers, and shooting. Chemical control may consist of the use of repellants and fumigants. If using control methods other than trapping during the legal season contact the Kansas Department of Wildlife and Parks or the wildlife damage control specialist, Kansas State University, for details on current restrictions.

Nuisance Animal Control

Study Questions

These study questions are to aid you in learning the material on pages 24 through 27.

1. *Snails can be controlled with:*
   a. chemicals.
   b. catfish.
   c. redear sunfish.
   d. all of the above.
2. *Fish populations become unproductive from:*
   a. overabundance of stunted desirable fish.
   b. contamination by undesirable fish species.
   c. a and b above.
   d. too much food.
3. *In controlling fish, many chemicals are toxic but:*
   a. most affect nontarget organisms.
   b. cause environmental contamination.
   c. show up later as residues in fish.
   d. all of the above.
4. *The aquatic nuisance species that resembles the golden shiner is the:*
   a. Rudd.
   b. Asian carp.
   c. Ruffe.
   d. none of the above.
5. *There are _____ chemicals approved for the control of amphibians and aquatic reptiles.*
   a. no
   b. two
   c. five
   d. seven
6. *Aquatic nuisance species can have an impact on:*
   a. other fish populations.
   b. aquatic ecosystems.
   c. terrestrial ecosystems.
   d. both a and b.
7. *Excessive waterfowl in recreational ponds/lakes and fish eating birds in aquaculture ponds/lakes are usually classes of:*
   a. song birds.
   b. soaring birds.
   c. migatory birds.
   d. aqua avian foul.
8. *Aquatic mammals that cause the greatest problems in Kansas are:*
   a. muskrats.
   b. beavers.
   c. escaped polar bears.
   d. a and b above.

Parasites and Diseases of Fish

Fish in nature have a wide variety of parasites and diseases. Usually these do not have a major impact on the fish populations. When fish are crowded and placed under stressful conditions, as in the intensive culture of conservation agency fish hatcheries and private aquaculture, parasites and diseases can become a serious problem.

The best treatment, of course, is prevention. Sound culture management including good quality water and good nutrition usually result in healthy fish. Healthy fish are usually resistant to diseases.

At times parasite and disease problems occur that can best be treated with a chemical. Treatment compounds themselves can be potentially hazardous to the fish if used improperly. The details of diagnosis and treatment are highly technical and require additional training so they will not be covered

Table 4. Approved Drugs Used in Aquaculture

Active Drug	Supplier	Fishery Use	Application Rate	Comments
Formalin (Formalin-F, Paracide-F, Parasite-S and Formacide-B)	Natchez Animal Supply Company, Argent Laboratories, Inc., Western Chemical, Inc., B. L. Mitchell, Inc.	Control of external protozoa and monogenetic trematode parasites in finfish, salmon, trout, catfish, largemouth bass, and bluegill. Control of fungi family Saprolegniaceae on eggs. Control of external protozoan parasites on penaeid shrimp.	25 ppm in ponds (7.5 gals./acre foot) 125–250 ppm in tanks (1–2 pints per 1000 gals) for one hour 1,000–2,000 ppm for 15 minutes for egg treatment	Drug must not be subjected to temperatures below 40 degrees F. There is no mandatory withdrawal time prior to food or non-food fish harvest. Use in warm weather may cause oxygen depletion. Provide aeration during treatment to prevent low oxygen.
MS-222: tricaine methane-sulfonate (Finquel, Tricaine-S)	Argent Laboratories, Western Chemical, Inc.	Anesthetic – Temporary immobilization of aquatic cold-blooded animals and fish.	10–1,000 mg/L	21-day preslaughter interval. Water temperature over 50 degrees F.
Oxyytetracycline dehydrate (Terramycin 200)	Phibro Animal Health	Bactericide – Treat diseases in catfish, salmonids, and lobster.	2.5 3.75 g/100 lbs. of fish per day for 5 days in feed	Withdrawal time of 21 days for catfish and salmonids and 30 days for lobster. Check for specific temperature restrictions.
Ormetropin + Sulfadimethoxine (Romet 30 and Romet TC)	Aquatic Health Resources	Bactericide – Treat enteric septicemia of catfish and furnuculosis in salmonids.	2.3 g. active ingredient/100 lb. fish per day for 5 days	3-day withdrawal time for catfish, 42-day withdrawal time for salmonids. Use in feed.

(continued)

in this manual. Few chemicals are registered for use on food fish. Table 4 gives the approved drugs available for use in aquaculture.

Treatments can be classified as either therapeutic or prophylactic. Therapeutic treatments are used to reduce losses from an ongoing disease, while prophylactic treatments are preventative against future losses. It is important to know how water volume, flow, or quality influences treatment efficacy. Treatments must be handled properly and safely to protect workers as well as the treated fish. It is also important to know the level of chemical in the hatchery effluent.

Table 4. Approved Drugs Used in Aquaculture (continued)

Active Drug	Supplier	Fishery Use	Application Rate	Comments
Florfenicol (Aquaflor)	Intervet Schering-Plough Animal Health Corp.	Control of mortality due to enteric septicemia or columnaris disease in catfish. Control of mortality in salmonids due to coldwater disease or funrunculosis.	10 mg per kg fish for 10 days	Veterinary Feed Directive (VFD) drug. 12–15 day withdrawal interval depending on fish species.
Oxytetracycline HCL (Oxytetracycline HCL Soluble Power-343, Terramycin 343, Tetroxy	IVX Animal Health, Aquatic Health Resources, Bimeda	Mark skeletal tissues in finfish fry and fingerlings.	200–700 mg per L of water for 2-6 hours	None
Hydrogen Peroxide (35 % Perox-Aid)	Western Chemical Inc.	Control of mortality due to saprolegniasis in finfish eggs. Control of mortality due to bacterial gill in salmonids and control of mortality dye to external columnaris in catfish.	500–1,000 mg per L depending on type of water and system for finfish eggs. 50–100 mg per L for 60 min. once per day on alternate days. Consult the label for specific directions.	Initial bioassay on a small number of fish recommended before treating the entire group. 0 day withdrawal time.
Chorionic gonadotropin (Chorulon)	Western Chemical Inc.	Aid in improving spawning function.	Consult veterinarian.	Intramuscular injection. Prescription product restricted to use by or on the order of a licensed veterinarian.

Study Questions

These study questions are to aid you in learning the material on pages 29 through 30.

1. The best treatment for fish diseases and parasites is:

a. prevention.

b. mechanical removal.

c. chemical removal.

d. bright lights.

2. What type of treatment is used to prevent an outbreak of a disease?

a. therapeutic

b. INAD use

c. prophylactic

d. all of the above

3. The drug _____can only be used by or on the order of a licensed veterinarian.

a. Terramycin 200

b. Chorulon

c. Aquaflor

d. Both b and c

4. A bactericide used to treat diseases in fish is:

a. Romet 30.

b. acetic acid (vinegar).

c. formalin.

d. none of the above.

Calculations

Table 5. Conversion Units and Equivalents

1 acre-foot	= 1 acre of surface water 1 foot deep = 43,560 cubic feet of water = 2,718,144 pounds of water = 326,000 gallons of water
1 cubic foot	= 7.5 gallons = 62.4 pounds of water = 28,355 grams of water
1 gallon	= 8.34 pounds of water = 128 fluid ounces = 3,785 milliliters or cubic centimeters = 3,785 grams of water
1 cubic foot per second (cfs)	= 7.5 gallons per second = 450 gallons per minute = 28.3 liters per second
1 quart	= 946 milliliters or cubic centimeters = 946 grams of water
1 pound	= 453.6 grams (454) = 16 ounces
1 ounce	= 28.35 grams
1 part per million (ppm) requires	2.7 pounds per acre foot 0.0038 grams per gallon 0.0283 grams per cubic foot 0.000062 pounds per cubic foot 1 milligram per liter

Proper chemical treatment requires accurate determination of the area and volume of the body of water.

Area

Some chemicals are applied at a certain rate per surface area (square feet or acres). Surface area can be determined with the use of aerial photographs, global positioning system (GPS) measurements, or actual measurements. Calculate area by multiplying average length times average width. This is easy if the body of water is rectangular or oval in shape. If a more accurate estimate is desired, or if the body of water is an irregular shape, use the graph paper method.

Measure length and width in several places. Transfer measurements onto a sheet of graph paper according to a scale. Draw the shoreline with the proper curvatures. Determine the area by counting the squares and multiplying by the scale area for each square. For example: if the scale is such that the side of one square is 5 feet, then the area of one square is 5 × 5 or 25 square feet. The area then can be expressed as square feet or acres. One acre = 43,560 square feet.

$$\text{Surface area of pond in acres} = \frac{\text{pond area in square feet}}{43{,}560}$$

Volume

Most herbicides are applied on the basis of volume as a certain number of parts per million (ppm) or as a certain amount per acre-foot (1 acre of surface water that is 1 foot deep). To find volume, determine average depth by taking numerous evenly spaced depth measurements. The accuracy of the average depth estimate increases the more depth measurements taken. Shallow measurements must be included or the estimate will be too high.

Multiply calculated average depth by the surface area determined by the method described earlier. If all measurements were made in feet, the calculated volume will be in cubic feet. Use this number to calculate the amount of herbicide product recommended on the label. Aquatic herbicide application is often expressed on a per acre-foot basis, but can be changed to the units expressed on the label by using the conversion table (Table 5). Dosage amounts can be determined with the formulas given in Table 6, page 33.

Flow

If a chemical must be applied to flowing water (canal or stream) the flow rate needs to be determined. Based on the concentration desired in the water, calculate the chemical introduction rate using formulas given in Table 7, page 33.

Calculate the flow rate by picking a section of the canal or stream with straight sides and a fairly even bottom to take the necessary measurements. Measure width and a transect of evenly spaced

depth measurements. Muliply width times the average depth to get the cross section area. The surface velocity of the flow should be measured at several places along this transect to get the average velocity. This can be done by timing an object as it flows over a measured distance of several feet or using a flow meter.

Multiply the velocity in feet per second by the cross section area (in square feet) to get flow in cubic feet per second (cfs). Then multiply by a bottom friction factor (a) to reduce the amount. For a smooth, even bottom this factor equals 0.9; for a rough or rocky bottom this factor equals 0.8.

Because of the flowing nature of treated stream, the chance of contaminating nontreatment areas is very high. A detoxification program may have to be incorporated into the treatment program. Also, due to the difficulty of accurate stream flow determinations and length of time to treat, the applicator should check with the state fish and game agency and/or the state department of health and environment before treating any flowing water.

Table 6: Table of Formulas Used in Chemical Application to Ponds and Lakes

Volume of pond in cubic feet = surface area in square feet × average depth in feet

Volume of pond in acre feet = $\frac{\text{volume of pond in cubic feet}}{43{,}560}$

Total ponds of active ingredient (a.i.) required = acre feet × 2.7 × ppm desired

Amount of formulation to apply = $\frac{\text{amount of active ingredient to apply} \times 100}{\text{\% of a.i. in formulation}}$

Total gallons of formulations required = $\frac{\text{acre feet} \times 2.7 \times \text{ppm desired}}{\text{pounds a.i. per gallon of formulation}}$

Table 7: Table of Formulas Useful in Chemical Applications to Flowing Water

Cross section area of channel in square feet = width in feet × average depth in feet

Stream flow in cubic feet per second (cfs) = cross section in square feet × average velocity in feet per second × friction factor (a) a = 0.9 in smooth bottom, 0.8 in rough bottom

Pounds of active ingredient (a.i.) per cfs = ppm desired × 0.0000623.

Pounds of formulation per minute = $\frac{\text{ppm desired} \times \text{stream flow in cfs} \times 60 \text{ (sec/min)} \times 0.0000623 \times 100}{\text{\% of active ingredient in formulation}}$

Calculations

Example problems

Pond volume: A pond is measured to have an average length of 210 feet, an average width of 120 feet, and an average depth of 3.3 feet. What is the volume in acre feet?

$$\text{Volume} = \frac{210 \text{ feet} \times 120 \text{ feet} \times 3.3 \text{ feet}}{43{,}560 \text{ cubic feet/acre feet}} = 1.91 \text{ acre feet}$$

Pond treatment: A pond needs to be treated for aquatic vegetation. The label states that 4.5 pounds of the material is needed per acre foot. The volume of the pond is 3.1 acre foot. How many pounds of the material should be applied?

Pounds to be applied = 4.5 pounds/acre feet × 3.1 acre feet = 14 pounds

Pond treatment: A pond needs to be treated at a rate of 2 ppm active ingredient. The volume of the pond is 4.2 acre feet. The chemical is available as a 25% active ingredient formulation. How many pounds of the formulation should be applied for proper treatment? (1 ppm = 2.7 pounds/acre feet)

Pounds of formulation =

$$\frac{2 \text{ ppm} \times 4.2 \text{ acre feet} \times 2.7 \text{ pounds/acre feet} \times 100}{25\%} = 90.7 \text{ pounds}$$

Stream flow: A stream is 9.6 feet wide, has an average depth of 1.8 feet, a flow velocity of 1.2 feet per second, and a smooth bottom. What is the stream flow in cfs?

$$\text{Stream flow} = 9.6 \text{ feet} \times 1.8 \text{ feet} \times 1.2 \text{ feet/sec} \times 0.9 = 18.66 \text{ cfs}$$

Stream treatment: A canal needs to be treated at 1 ppm active ingredient. The chemical comes as an 80% formulation. The canal has a flow of 20 cfs. How many pounds of this formulation should be metered into the canal each minute?

Pounds of formulation =

$$\frac{1 \text{ ppm} \times 20 \text{ cfs} \times 0.0000623 \text{ pounds per cubic foot} \times 100}{80\%} = 0.093 \text{ pounds per minute}$$

Study Questions

These study questions are to aid you in learning the material on pages 32 through 34.

1. The area of a lake or pond can be determined by:

a. aerial photographs.

b. multiplying average length by average width.

c. several measurements transferred to graph paper.

d. all of the above.

2. The most important thing in determining the volume of a body of standing water is:

a. subtracting the volume of fish.

b. taking numerous, evenly spaced depth measurements.

c. subtracting the volume of algae.

d. measuring the flow rate.

3. What do the initals cfs stand for?

a. chemical formulation standard

b. cubic foot per second

c. cubic feet in streams

d. none of the above

4. In order to determine the flow rate of a stream, the necessary measurements include:

a. stream width.

b. surface velocity.

c. stream depth.

d. all of the above.

Calculations

Additional Information

Additional information on aquatic plants and their control is available from the following sources:

1. K-State Research and Extension
   www.ksre.ksu.edu
2. Kansas Department of Wildlife and Parks
   www.kdwp.state.ks.us
3. Kansas State University Weed Management
   www.agronomy.ksu.edu/extension/DesktopDefault.aspx?tabid=69
4. Missouri Department of Conservation
   mdc.mo.gov/nathis/plantpage/flora/wetplant
5. Texas A&M Aquaplant
   aquaplant.tamu.edu

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USFWS AADAP Program, the AFS Fish Culture Section, AFS Fish Health Section, and FDA Center for Veterinary Medicine. 2008. A Quick Reference Guide To: Approved Drugs for Use in Aquaculture: *http://www.fda.gov/downloads/AnimalVeterinary/ResourcesforYou/AnimalHealthLi%20teracy/UCM109808.pdf*. Accessed February 1, 2010.

Answers to Study Questions

Pages 3–13

1. d, 2. d, 3. b, 4. c, 5. d, 6. d, 7. b, 8. d

Pages 15–22

1. d, 2. d, 3. b, 4. d, 5. b, 6. c, 7. b, 8. d

Pages 24–27

1. d, 2. c, 3. d, 4. a, 5. a, 6. d, 7. c, 8. d

Pages 29–30

1. a, 2. c, 3. d, 4. a

Pages 32–34

1. d, 2. b, 3. b, 4. d

Notes

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Illustrations

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